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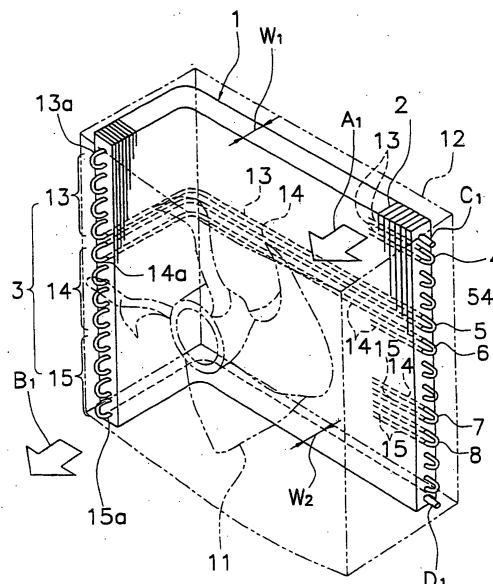
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(54) **HEAT EXCHANGER, HEAT EXCHANGER MANUFACTURING METHOD, AND AIR
CONDITIONER**

(57) The object of the present invention is to provide a plate fin heat exchanger that achieves better heat transfer efficiency by both making the diameter of the heat transfer tubes on the liquid side of the heat exchanger smaller than the diameter of the heat transfer tubes on the gaseous side and curbing the decline in the heat transfer rate at the outside of the heat transfer tubes that results from deviating from the optimum dimensional ratio between the tube diameter and the fin width. It is also the object of the present invention to provide a manufacturing that is well-suited to such a heat exchanger. The heat exchanger (1) is provided with a plurality of plate fins (2) that are arranged with a prescribed spacing there-between in the thickness direction thereof and a plurality of heat transfer tubes (3) that are installed in such a manner as to pass through the plate fins (2) in said thickness direction of the plate fins (2). As shown in Figures 4 and 5, the plate fins (2) are shaped such that the width thereof decreases from a fin width W_1 to a fin width W_2 in a continuous manner as one moves from one end to the other. The heat transfer tubes (3) are provided in at least two different diameter sizes, each individual heat transfer tube (3) having only one of said diameter sizes. The larger diameter heat transfer tubes are arranged in the upper portion of the heat exchanger (1) and the smaller diameter heat transfer tubes are arranged in the lower portion of the heat exchanger (1).

Fig. 4



Description

Technical Field

[0001] The present invention relates to a heat exchanger, a method of manufacturing the heat exchanger, and an air conditioner employing the heat exchanger.

Background Art

[0002] One type of conventional heat exchanger is the cross fin heat exchanger. Cross fin heat exchangers are often used in the indoor units and outdoor units of air conditioners. An example of a cross fin heat exchanger is the L-shaped heat exchanger shown in Figure 1, which is configured to be installed in an outdoor unit of an air conditioner.

[0003] A propeller fan 61 produces an air flow (indicated by the arrows A0 and B0) that flows from the rear panel side of the casing 62 of the outdoor unit toward the front panel side of the same. The heat exchanger 51 exchanges heat with the air flow and is used to evaporate or condense a refrigerant that flows inside the heat transfer tube of the heat exchanger 51.

[0004] The heat exchanger 51 comprises a plurality of plate fins 52 that are arranged with a prescribed spacing there-between in the thickness direction thereof and a plurality of heat transfer tubes 53 that are installed so as to pass through the plate fins 52 in said thickness direction. Normally, as shown in Figures 1 and 2, each plate fin 52 is a thin rectangular plate having a prescribed width W0 and provided with a plurality of holes 52a for passing the heat transfer tubes 53 arranged along the lengthwise direction thereof. Each of the plurality of heat transfer tubes 53 has a hairpin shaped hairpin part 53a at one end and the heat exchanger 51 presented here has a total of 12 heat transfer tubes 53. The end of each heat transfer tube 53a opposite the hairpin part 53a is connected to the adjacent heat transfer tube 53 with a U-shaped tube 54.

[0005] A manufacturing method for the heat exchanger 51 will now be described. The manufacturing processes for manufacturing the heat exchanger 51 include a fin manufacturing process for manufacturing the plurality of plate fins 52 and an assembly process in which the heat exchanger 51 is assembled by installing the plurality of heat transfer tubes 53 in such a manner that the heat transfer tubes 53 pass through the plate fins 52 in said thickness direction.

[0006] In a conventional fin manufacturing process for manufacturing plate fins 52, a thin sheet-like work piece is fed in one direction and formed into the prescribed fin shape using a die. More specifically, in order to manufacture rectangular plate fins 52 from a sheet-like work piece X0 that is fed in one direction (direction indicated by arrow E0) as shown in Figure 3, the sheet-like work piece X0 is die formed in such a manner that the long sides of the plate fins 52 are aligned with the E0 direction

(i.e., the lengthwise direction of the sheet-like work piece X0) and the short sides of the plate fins 52 are aligned with the direction perpendicular to the E0 direction (i.e., the widthwise direction of the sheet-like work piece X0). Hereinafter, this method of die forming the plate fins 52 will be called the "longitudinal feed method." While the sheet-like work piece X0 is fed in the E0 direction, it is subjected sequentially to a "burring" process, a perforation applying process, a side cut process, and a cut off process so as to manufacture a plurality of plate fins 52.

[0007] The "burring" process is a process in which the plurality of through holes 52a for passing the heat transfer tubes are formed in the sheet-like work piece X0 using a two-step die forming procedure. The perforation applying process is a process in which perforations 59 are made in the sheet-like work piece X0 at positions corresponding to the short dimensions (fin width W0) of the plate fins 52. The side cut process is a process in which the sheet-like work piece X0 is cut at the positions where the perforations 59 are located. The cut off process is a process in which the sheet-like work piece X0 is cut in the direction perpendicular to the E0 direction after the length of the portions cut in the side cut process have reached the lengthwise dimension of the plate fin 52, thus producing a plurality of plate fins 52 having a prescribed length dimension and width dimension (fin width W0).

[0008] The operation of the heat exchanger 51 will now be described with reference to Figure 1. When the indoor unit (not shown) of the air conditioner operates in cooling mode, the heat exchanger 51 functions as a condenser with respect to the refrigerant. Meanwhile, when the indoor unit (not shown) of the air conditioner operates in heating mode, the heat exchanger 51 functions as an evaporator with respect to the refrigerant. When the heat exchanger 51 functions as a condenser, gaseous refrigerant flows into the heat transfer tube 53 from the tube end C0 and flows through the heat transfer tubes 53 while exchanging heat with the air flowing over the outside of the heat transfer tubes 53. The gaseous refrigerant condenses into a liquid state and flows out from the tube end D0. Conversely, when the heat exchanger 51 functions as an evaporator, liquid refrigerant flows into the heat transfer tube 53 from the tube end D0 and flows through the heat transfer tubes 53 while exchanging heat with the air flowing over the outside of the heat transfer tubes 53. The liquid refrigerant evaporates into a gaseous state and flows out from the tube end C0.

[0009] Regardless of whether the heat exchanger is functioning as a condenser or an evaporator, the inside of the heat transfer tubes of the heat exchanger can be divided into a portion through which the refrigerant flows as a gas (gaseous side) and a portion through which the refrigerant flows as a liquid (liquid side). In order to curb the pressure drop of the heat exchanger, the diameters of all the heat transfer tubes of the heat exchanger --

from the gaseous side to the liquid side -- are designed to a pipe diameter suited to the gaseous side based on the flow speed of the refrigerant in the gaseous side. Consequently, the diameter of the heat transfer tubes is oversized on the liquid side of the heat exchanger. Also, from the perspective of transferring heat to and from the inside of the heat transfer tubes of the heat exchanger, it is preferable for the diameter of the heat transfer tubes to be small. Therefore, from both the perspective of the pressure drop of the heat exchanger and the perspective of transferring heat to and from the inside of the heat transfer tubes of the heat exchanger, it is preferable to make the diameter of the heat transfer tubes on the liquid side of the heat exchanger smaller than the diameter of the heat transfer tubes on the gaseous side of the heat exchanger.

[0010] Meanwhile, in conventional heat exchangers, the diameter of the heat transfer tubes and the width of the plate fins are designed to an optimum dimensional ratio in view of the heat transfer at the outside of the heat transfer tubes. Consequently, if a conventional heat exchanger is merely modified such that the diameter of the heat transfer tubes on the liquid side is smaller than that on the gaseous side, the optimum dimensional ratio between the diameter of the heat transfer tubes and the width of the plate fins will not be obtained because the width of the plate fins is constant over the entire length of the plate fins. As a result, there is the possibility that the heat transfer rate at the outside of the heat transfer tubes will decline. Thus, there is a need for a heat exchanger design that both reduces the diameter of the heat transfer tubes on the liquid side of the heat exchanger relative to the diameter of the heat transfer tubes on the gaseous side and curbs the decline in the heat transfer rate at the outside of the heat transfer tubes, thereby improving the heat transfer efficiency of the heat exchanger as a whole.

[0011] Additionally, when one attempts to manufacture such a heat exchanger in which the diameters of the heat transfer tubes are smaller on the liquid side than on the gaseous side, it is necessary to die form through holes having different diameters along the lengthwise direction of the plate fins in order to accommodate the different diameters of the heat transfer tubes. However, since the longitudinal feed method is used to manufacture conventional plate fins, it is difficult to die form through holes having different diameters along the lengthwise direction of the plate fins.

Disclosure of the Invention

[0012] The object of the present invention is to provide a heat exchanger that achieves improved heat transfer efficiency by both making the diameter of the heat transfer tubes on the liquid side of the heat exchanger smaller than that on the gaseous side and curbing the decline in the heat transfer rate at the outside of the heat transfer tubes. It is also the object of the present invention to

provide a manufacturing method that is well-suited to such a heat exchanger.

[0013] The heat exchanger described in claim 1 is provided with a plurality of plate fins arranged with a prescribed spacing there-between in the thickness direction thereof and a plurality of heat transfer tubes installed in such a manner as to pass through the plate fins in said thickness direction of the plate fins. The plate fins are shaped such that the width thereof becomes smaller in either a continuous or a step-like manner as one moves from one end to the other. The heat transfer tubes are provided in at least two different diameter sizes, each individual heat transfer tube having only one of said diameter sizes. The larger diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is larger and the smaller diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is smaller.

[0014] Since the plate fins are shaped such that the width thereof becomes smaller in either a continuous or a step-like manner as one moves from one end to the other and since larger diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is larger and the smaller diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is smaller, the ratio between the diameter of the heat transfer tubes and the width of the plate fins can be held as constant as possible. As a result, this heat exchanger can both reduce the diameter of the heat transfer tubes on the liquid side of the heat exchanger relative to the diameter of the heat transfer tubes on the gaseous side and curb the decline in the heat transfer rate at the outside of the heat transfer tubes that results from deviating from the optimum ratio between the diameter of the heat transfer tubes and the width of the plate fins, thereby improving the heat transfer efficiency of the heat exchanger as a whole.

[0015] The heat exchanger described in claim 2 is a heat exchanger in accordance with claim 1, wherein the ratio of the fin width at the narrowest portion to the fin width at the widest portion of each plate fin is equal to or larger than 0.25 and less than or equal to 0.67.

[0016] With this heat exchanger, since the ratio of the fin width at the narrowest portion to the fin width at the widest portion of each plate fin is equal to or larger than 0.25 and less than or equal to 0.67, the effect of curbing the decline in the heat transfer rate at the outside of the heat transfer tubes and improving the heat transfer efficiency of the heat exchanger as a whole is even more marked.

[0017] The heat exchanger described in claim 3 is a heat exchanger in accordance with either claim 1 or claim 2, wherein the plate fins are shaped such that when a plurality of plate fins are die formed in such a manner as to be arranged side by side during die forming, the plate fins can be arranged such that they are neither overlapping each other in the widthwise direction nor separated from each other by gaps in the widthwise

direction.

[0018] With this heat exchanger, the amount of material loss of the sheet-like work piece that occurs when the plate fins are die formed from the sheet-like work piece can be reduced.

[0019] The heat exchanger described in claim 4 is a heat exchanger in accordance with claim 3, wherein the plate fins are shaped in such a manner that by arranging the plate fins such that each plate fin is rotated 180 degrees with respect to the adjacent plate fin(s), the plate fins can be arranged such that they are neither overlapping each other in the widthwise direction nor separated from each other by gaps in the widthwise direction.

[0020] The heat exchanger manufacturing method described in claim 5 is a manufacturing method for a heat exchanger in accordance with claim 3 or 4, the manufacturing method including the following processes:

a fin manufacturing process in which a sheet-like work piece is fed in one direction and plate fins are manufactured by means of sequential die forming in which the die is oriented in a direction perpendicular to the direction in which the sheet-like work piece is fed; and

an assembly process in which the heat exchanger is assembled by installing the plurality of heat transfer tubes in such a manner that the heat transfer tubes pass through the plate fins in said thickness direction of the plate fins.

[0021] With this heat exchanger manufacturing method, since the plate fins are manufactured by means of sequential die forming in which the die is oriented in the direction perpendicular to the direction in which the sheet-like work piece is fed (hereinafter called "transverse feed method"), a die whose shape is well-suited to the shape of the plate fins can be used for die forming the plate fins. Thus, it is possible to make through holes having different diameters along the lengthwise direction of the plate fins while die forming the plate fins such that the width thereof becomes smaller in either a continuous or a step-like manner as one moves from one end to the other.

[0022] The air conditioner described in claim 6 is provided with a heat exchanger in accordance with any one of claims 1 to 4.

[0023] With this air conditioner, the air conditioning performance of the air conditioner as a whole can be improved because the heat transfer efficiency of the heat exchanger has been improved.

Brief Descriptions of the Drawings

[0024]

Figure 1 is a schematic perspective view of an out-

door unit of an air conditioner in which a conventional heat exchanger has been employed.

Figure 2 is a view of a plate fin of the conventional heat exchanger taken along a line of sight corresponding to the thickness direction of the plate fin. Figure 3 is a diagram illustrating the processes used to manufacture the plate fins of the conventional heat exchanger.

Figure 4 is a schematic perspective view of an outdoor unit of an air conditioner in which a heat exchanger in accordance with a first embodiment of the present invention is employed.

Figure 5 is a view of a plate fin of a heat exchanger in accordance with the first embodiment of the present invention taken along a line of sight corresponding to the thickness direction of the plate fin. Figure 6 is a diagram illustrating the processes used to manufacture the plate fins of a heat exchanger in accordance with the first embodiment of the present invention.

Figure 7 is a view of a plate fin of a heat exchanger in accordance with a second embodiment of the present invention taken along a line of sight corresponding to the thickness direction of the plate fin. Figure 8 is a view of a plate fin of a heat exchanger in accordance with a third embodiment of the present invention taken along a line of sight corresponding to the thickness direction of the plate fin.

Preferred Embodiments of the Invention

[First Embodiment]

[0025] A first embodiment of the present invention will now be described with reference to the drawings.

(1) Structure of the Heat Exchanger

[0026] Figure 4 is a schematic perspective view of an outdoor unit of an air conditioner in which a heat exchanger 1 in accordance with the first embodiment of the present invention has been employed. The heat exchanger 1 is L-shaped and a propeller fan 11 produces an air flow (indicated by the arrows A1 and B1) that flows from the rear panel of the casing 12 of the outdoor unit toward the front panel of the same. The heat exchanger 1 exchanges heat with said air flow and serves to evaporate or condense a refrigerant that flows inside the heat transfer tubing of the heat exchanger 1.

[0027] The heat exchanger 1 comprises a plurality of plate fins 2 that are arranged with a prescribed spacing there-between in the thickness direction thereof and a plurality of heat transfer tubes 3 that are installed so as to pass through the plate fins 2 in said thickness direction. As shown in Figures 4 and 5, the width of each plate fin 2 tapers in a continuous manner from a larger fin width W1 to a smaller fin width W2 from one end to the other (more specifically, from the top of the outdoor unit

to the bottom of the same). Each plate fin 2 is provided with a plurality of through holes through which the heat transfer tubes 3 are passed. The through holes are formed in at least two different diameter sizes, each individual through hole having only one of said diameter sizes. The larger diameter through holes are arranged along the portions of the plate fins where the fin width is larger and the smaller diameter through holes are arranged along the portions of the plate fins where the fin width is smaller. In this embodiment, the through holes 2a, 2b, 2c are provided in three different diameter sizes. The through holes 2a are eight in number and arranged from the top of the plate fin 2 (the end where the width W1 exists) downward; the through holes 2b are eight in number, smaller than the through holes 2a, and arranged below the through holes 2a; the through holes 2c are eight in number, smaller than the through holes 2b, and arranged on the bottom portion of the plate fin 2 (the end where the width W2 exists).

[0028] The heat transfer tubes 3 are provided in at least two different diameter sizes, each individual heat transfer tube 3 having only one of said diameter sizes. The larger diameter heat transfer tubes are arranged on the upper part of the heat exchanger 1 and the smaller diameter heat transfer tubes are arranged on the lower part of the heat exchanger 1. In this embodiment, the heat transfer tubes 13, 14, 15 are provided in three different diameter sizes. Each of the heat transfer tubes 13, 14, 15 has a hairpin shaped hairpin part 13a, 14a, 15a at one end thereof. There are four of each diameter of heat transfer tube 13, 14, 15 and the heat transfer tubes 13, 14, 15 are arranged in positions corresponding to the different diameter through holes 2a, 2b, 2c, respectively, formed in the plate fins 2. Thus the heat transfer tubes 13 have the largest diameter, the heat transfer tubes 14 have a smaller diameter than the heat transfer tubes 13, and the heat transfer tubes 15 have a smaller diameter than the heat transfer tubes 14. The end of each heat transfer tube 13 opposite the hairpin part 13a is connected to an end of the adjacent heat transfer tube 13 with a U-shaped tube 4. The end of the heat transfer tube 13 that is adjacent to a heat transfer tube 14 is connected to the end of the heat transfer tube 14 with a U-shaped tube 5. The U-shaped tube 5 comprises a U-shaped tube having a diameter corresponding to the heat transfer tube 13 and a reducer provided on one end of the U-shaped tube serving to match the diameter of the heat transfer tube 14. The ends of adjacent heat transfer tubes 14 are connected together with U-shaped tubes 6. The end (i.e., the end opposite the hairpin part 14a) of the heat transfer tube 14 that is adjacent to a heat transfer tube 15 is connected to the end of the heat transfer tube 15 with a U-shaped tube 7 provided with a reducer, similarly to the U-shaped tube 5. The ends of adjacent heat transfer tubes 15 are connected together with U-shaped tubes 8.

[0029] Thus, the plate fins 2 of the heat exchanger 1 are shaped such that their widths decrease from the top

toward the bottom and the plurality of heat transfer tubes 3 is made up of tubes 13, 14, 15 of different diameters arranged in a manner corresponding to the width of the plate fins 2.

[0030] A specific example of the width dimension of the plate fins 2 will now be described. The fin width W1 (width at the widest portion of each plate fin 2) and the fin width W2 (width at the narrowest portion of the each plate fin 2) are set in accordance with the diameters of the heat transfer tubes 3. For example, plate fins 2 having a fin width W1 in the range from 12 mm to 30 mm and a fin width W2 in the range from 3 mm to 20 mm is used. Thus, the ratio of the fin width W2 to the fin width W1 ($W2/W1$) is in the range from 0.25 to 0.67.

(2) Manufacture of the Heat Exchanger

[0031] The method of manufacturing the heat exchanger 1 will now be described. The manufacturing processes for the heat exchanger 1 includes a fin manufacturing process for manufacturing a plurality of plate fins 2 and an assembly process in which the heat exchanger 1 is assembled by installing the heat transfer tubes 3 (made up of heat transfer tubes 13, 14, 15 having different diameters) in such a manner that the heat transfer tubes 3 pass through the plate fins 2 in the thickness direction of the plate fins 2.

[0032] In the fin manufacturing process, a thin sheet-like work piece is fed in one direction and a press die is used to die form plate fins 2 having a prescribed shape. More specifically, in order to manufacture plate fins 2 from a sheet-like work piece X1 that is fed in one direction (E1 direction) as shown in Figure 6, the sheet-like work piece X1 is die formed in such a manner that the long sides of the plate fins 2 are aligned with the direction perpendicular to the E1 direction (i.e., the widthwise direction of the sheet-like work piece X1) and the short sides (fin widths W1 and W2) of the plate fins 2 are aligned with the E1 direction (i.e., the lengthwise direction of the sheet-like work piece X1). In short, the transverse feed method is used as die forming method of each plate fin 2. While the sheet-like work piece X1 is fed in the E1 direction, it is subjected sequentially to a burring process, a perforation applying process, a side cut process, and a cut off process so as to manufacture a plurality of plate fins 2.

[0033] The burring process is a process in which the different diameter through holes 2a, 2b, 2c for passing the heat transfer tubes are die formed in the sheet-like work piece X1. More specifically, plate fins 2 shaped as shown in Figure 5 are die formed in such a manner that the plate fins 2 are lined up with no widthwise gaps in-between. This is accomplished by arranging the plate fins 2 such that each plate fin 2 is rotated 180 degrees with respect to the adjacent plate fin(s) 2. The die used to perform the burring is designed to work on a plurality of plate fins 2 at a time (two plate fins 2 at a time in this embodiment). The perforation applying process is a

process in which perforations 9 are made in the sheet-like work piece X1 at positions corresponding to the shape of the plate fins 2.

[0034] The side cut process is a process in which the sheet-like work piece X1 is cut along the portions of the perforations 9 corresponding to the end edges (short sides) of the plate fins 2.

[0035] The cut off process is a process in which the portions of the sheet-like work piece X1 corresponding to the side edges (long sides) of the plate fins 2 are cut in the direction perpendicular to the feed direction, thus producing a plurality of plate fins 2 having a prescribed shape.

[0036] Afterwards, in the assembly process, the heat exchanger 1 is assembled by installing the heat transfer tubes 3 (made up of heat transfer tubes 13, 14, 15 having different diameters) in such a manner that the heat transfer tubes 3 pass through the plate fins 2 in the thickness direction of the plate fins 2 and connecting the ends of adjacent heat transfer tubes 3 with U-shaped tubes.

(3) Operation of the Heat Exchanger

[0037] The operation of the heat exchanger 1 will now be described with reference to Figure 4. When the indoor unit (not shown) of the air conditioner operates in cooling mode, the heat exchanger 1 functions as a condenser with respect to the refrigerant. Meanwhile, when the indoor unit (not shown) of the air conditioner operates in heating mode, the heat exchanger 1 functions as an evaporator with respect to the refrigerant. When the heat exchanger 1 functions as a condenser, gaseous refrigerant flows into the heat transfer tubes 3 from the tube end C1 and flows through the heat transfer tubes 3 while exchanging heat with the air flowing over the outside of the heat transfer tubes 3. The gaseous refrigerant condenses into a liquid state and flows out from the tube end D1. Conversely, when the heat exchanger 1 functions as an evaporator, liquid refrigerant flows into the heat transfer tubes 3 from the tube end D1 and flows through the heat transfer tubes 3 while exchanging heat with the air flowing over the outside of the heat transfer tubes 3. The liquid refrigerant evaporates into a gaseous state and flows out from the tube end C1.

(4) Features of the Heat Exchanger and Manufacturing Method

[0038] A heat exchanger and a manufacturing method thereof in accordance with this embodiment have the following features.

[1] Improved heat transfer efficiency

[0039] With a heat exchanger 1 in accordance with this embodiment, since the width of the plate fins 2 decreases in a continuous manner as one moves from one end to the other and since the large diameter heat trans-

fer tubes 13 are arranged where the width of the plate fins 2 is larger and the small diameter heat transfer tubes 15 are arranged where the width of the plate fins 2 is smaller, the dimensional relationship between width of the plate fins 2 and the diameter of the heat transfer tubes 3 (i.e., the heat transfer tubes 13, 14, 15 having different diameters) can be held as close as possible to the optimum relationship. Thus, the diameter of the heat transfer tubes 15 on the liquid side of the heat exchanger 1 is reduced relative to the diameter of the heat transfer tubes 13 on the gaseous side while curbing the decline in the heat transfer rate at the outside of the heat transfer tubes 3 that results from disturbing the aforementioned dimensional relationship, thereby improving the heat transfer efficiency of the heat exchanger as a whole. Likewise, the air conditioning performance of an air conditioner equipped with such a heat exchanger is also improved.

[2] Reduced pressure drop at the outside of the heat transfer tubes

[0040] With a heat exchanger 1 in accordance with this embodiment, as shown in Figure 5, the fin width W1 at the end each plate fin 2 corresponding to the gaseous side of the heat exchanger 1 is the same or slightly larger than the fin width W0 of the conventional heat exchanger 51 (more specifically, the fin width W0 is in the range from 10 mm to 30 mm). Meanwhile, the fin width W2 at the end of each plate fin 2 corresponding to the liquid side of the heat exchanger 1 is smaller than the fin width of the conventional heat exchanger 51. Consequently, the pressure drop at the outside of the heat transfer tubes 3 of the heat exchanger 1 can be reduced in comparison with the conventional heat exchanger 51.

[3] Plate fin manufacturing method uses transverse feeding

[0041] With a heat exchanger 1 in accordance with the present invention, the plate fins 2 are manufactured using transverse feeding. That is, the direction in which the plate fins 2, and thus the dies, are oriented when the plate fins 2 are die formed is perpendicular to the feed direction of the sheet-like work piece X1 and the plate fins 2 are formed in a sequential manner. As a result, a die whose shape is well-suited to the shape of the plate fins 2 can be used for die forming. Thus, it is possible to make through holes having different diameters along the lengthwise direction of the plate fins 2 while forming the plate fins 2 such that the width thereof becomes smaller in a continuous manner as one moves from one end to the other.

[0042] Additionally, the plate fins 2 are shaped such that when a plurality of plate fins 2 are die formed in such a manner as to be arranged side by side during die forming, the plate fins 2 can be arranged such that they are neither overlapping each other in the widthwise direction

nor separated from each other by gaps in the widthwise direction. As result, the amount of material loss of the sheet-like work piece X1 can be reduced. The productivity is also improved because more than one plate fin 2 is die formed at a time.

[Second Embodiment]

[0043] Although the width of the plate fins 2 is varied in a continuous manner in the first embodiment, as shown in Figure 5, it is also acceptable to shape the plate fins 22 such that the width varies from a larger width W1 to a smaller width W2 in a step-like manner from one end to the other as shown in Figure 7. In such a case, the same effects are obtained as in the case of the first embodiment.

[Third Embodiment]

[0044] Although the plate fins 2 of the first and second embodiments shown in Figures 5 and 7 are shaped in such a manner as to be symmetrical with respect to the longitudinal centerlines thereof, it is also acceptable for the plate fins to be shaped such that a rectangular shape is formed when two plate fins are arranged side by side. An example of such a plate fin is the plate fin 32 shown in Figure 8. This shape of plate fin makes it possible to reduce the material loss of the sheet-like work piece even more than that accomplished by the first and second embodiments.

[Other Embodiments]

[0045] While selected embodiments of the present invention have been presented herein with reference to the drawings, the specific constituent features of the present invention are not limited to those of the embodiments. Various changes and modifications can be made without departing from the scope of the invention.

[0046] For example, the number of heat transfer tubes provided in the heat exchanger and the number of different tube diameters used for the heat transfer tubes are not limited to the numbers presented in the foregoing three embodiments.

Industrial Applicability

[0047] Since the plate fins are shaped such that the width thereof becomes smaller in either a continuous or a step-like manner as one moves from one end to the other and since larger diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is larger and the smaller diameter heat transfer tubes are arranged along the portions of the plate fins where the fin width is smaller, employing the present invention enables the ratio between the diameter of the heat transfer tubes and the width of the plate fins to be held as constant as possible. As a result, the diameter

of the heat transfer tubes on the liquid side of the heat exchanger can be reduced relative to the diameter of the heat transfer tubes on the gaseous side and the decline in the heat transfer rate at the outside of the heat transfer tubes that results from deviating from the optimum ratio between the diameter of the heat transfer tubes and the width of the plate fins can be curbed, thereby improving the heat transfer efficiency of the heat exchanger as a whole.

Claims

1. A heat exchanger, provided with:

a plurality of plate fins (2, 22, 32) that are shaped such that the width thereof becomes smaller in either a continuous or a step-like manner as one moves from one end to the other and arranged with a prescribed spacing therebetween in the thickness direction thereof; and

a plurality of heat transfer tubes (3) that are installed in such a manner as to pass through the plate fins (2, 22, 32) in said thickness direction of the plate fins and including at least two different diameter sizes of heat transfer tube (13, 14, 15),

the larger diameter heat transfer tubes being arranged along the portions of the plate fins (2, 22, 32) where the fin width is larger and the smaller diameter heat transfer tubes being arranged along the portions of the plate fins (2, 22, 32) where the fin width is smaller.

2. The heat exchanger as recited in claim 1, wherein the ratio (W2/W1) of the fin width (W2) at the narrowest portion to the fin width (W1) at the widest portion of each plate fin (2, 22, 32) is equal to or larger than 0.25 and less than or equal to 0.67.

3. The heat exchanger as recited in claim 1 or 2, wherein the plate fins (2, 22, 32) are shaped such that when a plurality of plate fins (2, 22, 32) are die formed in such a manner as to be arranged side by side during die forming, the plate fins (2, 22, 32) can be arranged such that they are neither overlapping each other in the widthwise direction nor separated from each other by gaps in the widthwise direction.

4. The heat exchanger as recited in claim 3, wherein the plate fins (2, 22, 32) are shaped in such a manner that by arranging the plate fins (2, 22, 32) such that each plate fin (2, 22, 32) is rotated 180 degrees with respect to the adjacent plate fin(s) (2, 22, 32), the plate fins (2, 22, 32) can be arranged such that they are neither overlapping each other in the width-

wise direction nor separated from each other by gaps in the widthwise direction.

5. A method of manufacturing a heat exchanger in accordance with claim 3 or 4, the manufacturing method including the following processes: 5

a fin manufacturing process in which a sheet-like work piece (X1) is fed in one direction and plate fins (2, 22, 32) are manufactured by means of sequential die forming in which the die is oriented in a direction perpendicular to the direction in which the sheet-like work piece (X1) is fed; and 10

an assembly process in which the heat exchanger is assembled by installing the plurality of heat transfer tubes (3) in such a manner that the heat transfer tubes (3) pass through the plate fins (2, 22, 32) in said thickness direction of the plate fins (2, 22, 32). 15 20

6. An air conditioner equipped with a heat exchanger as recited in any one of claims 1 to 4. 25

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Fig. 1

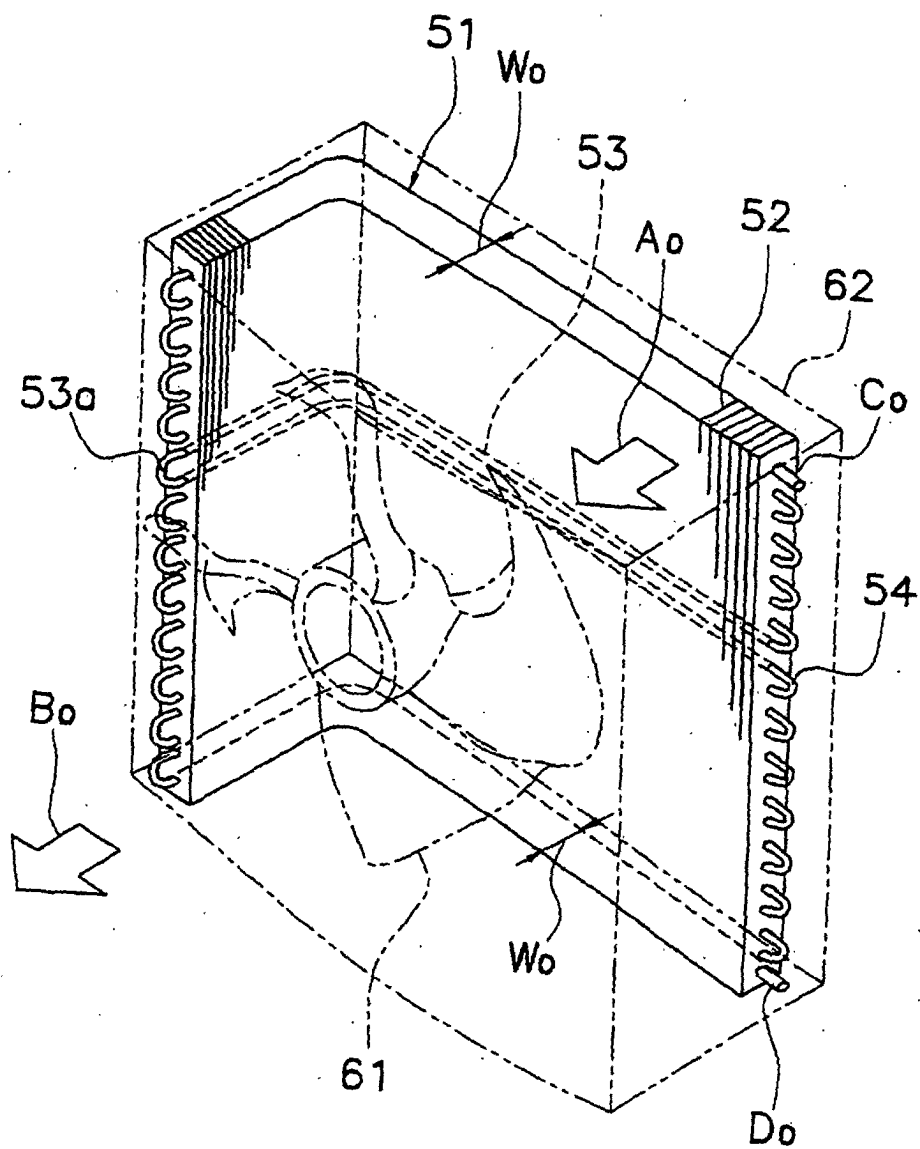


Fig. 2

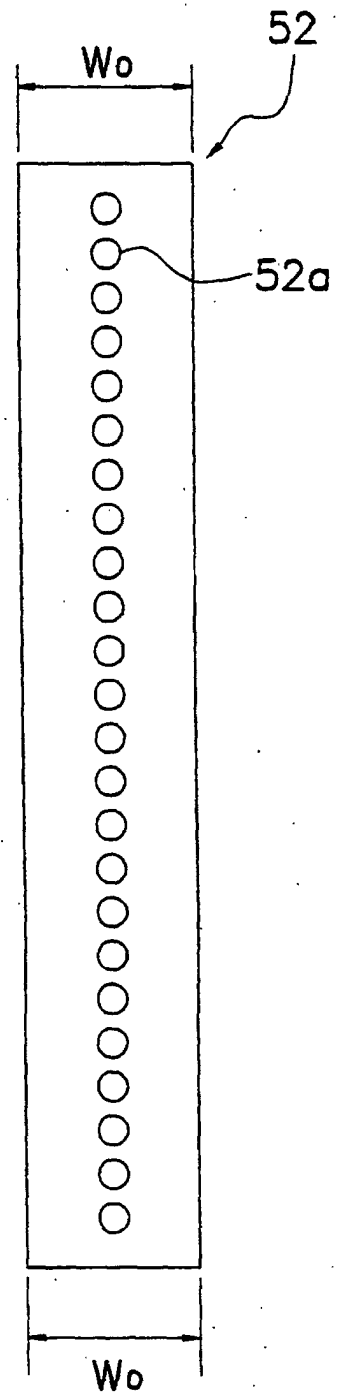


Fig. 3

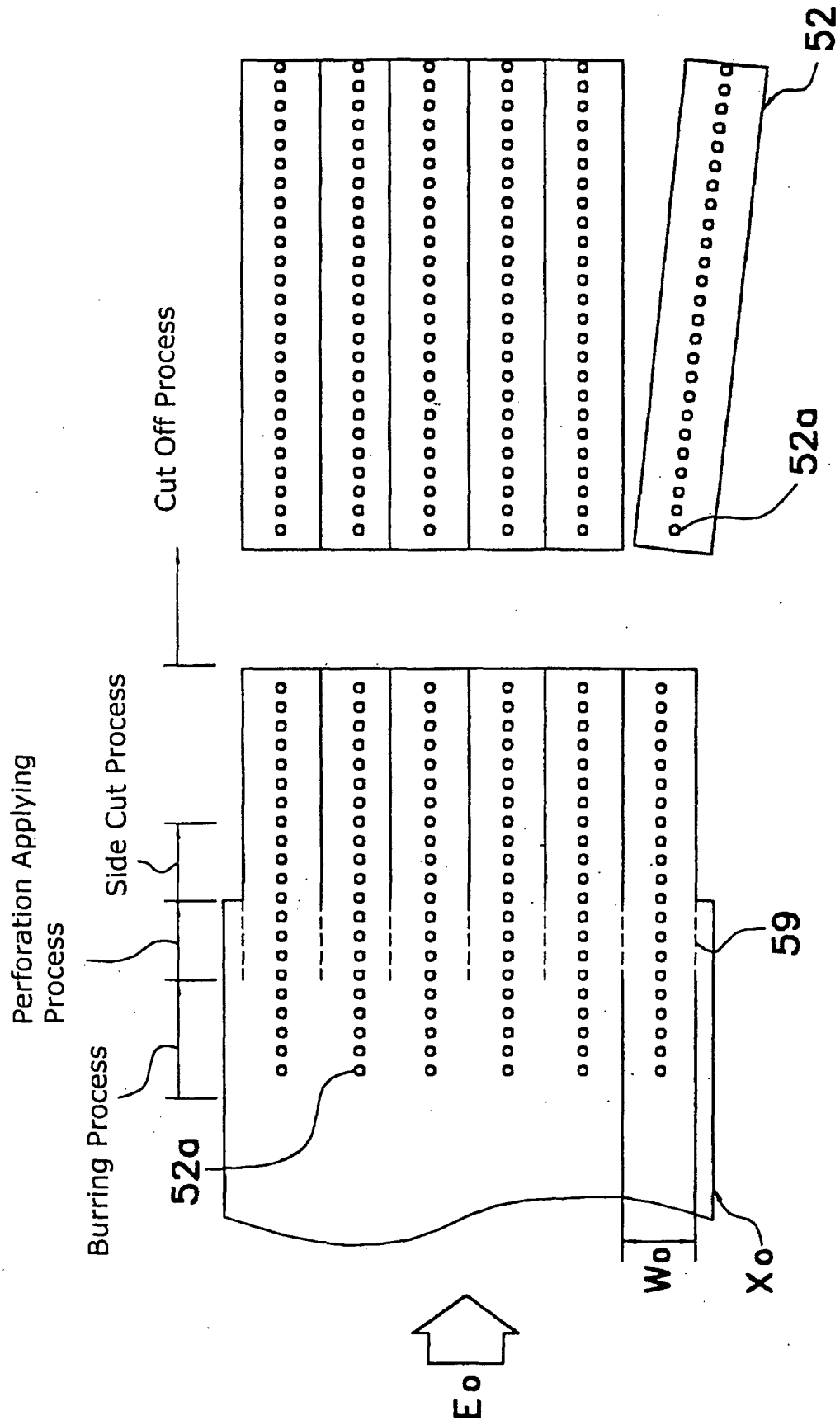


Fig. 4

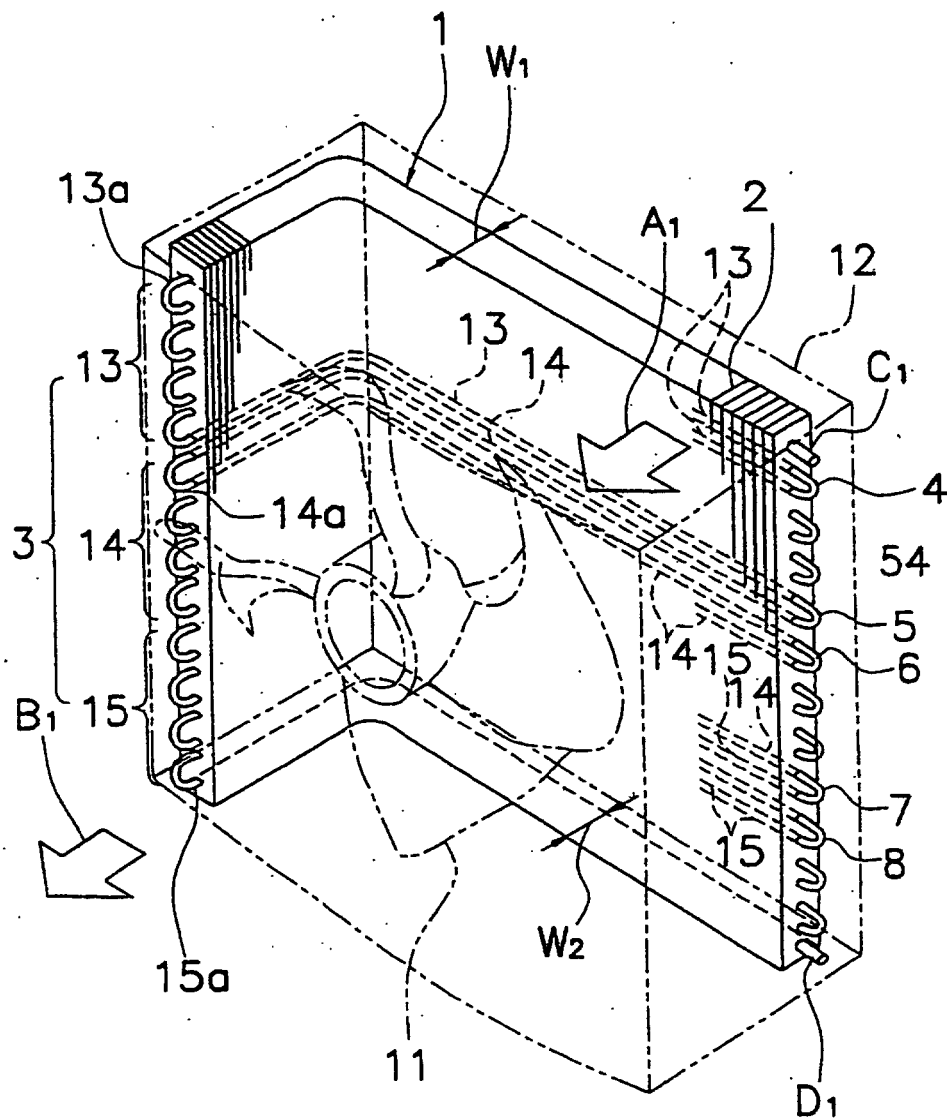


Fig. 5

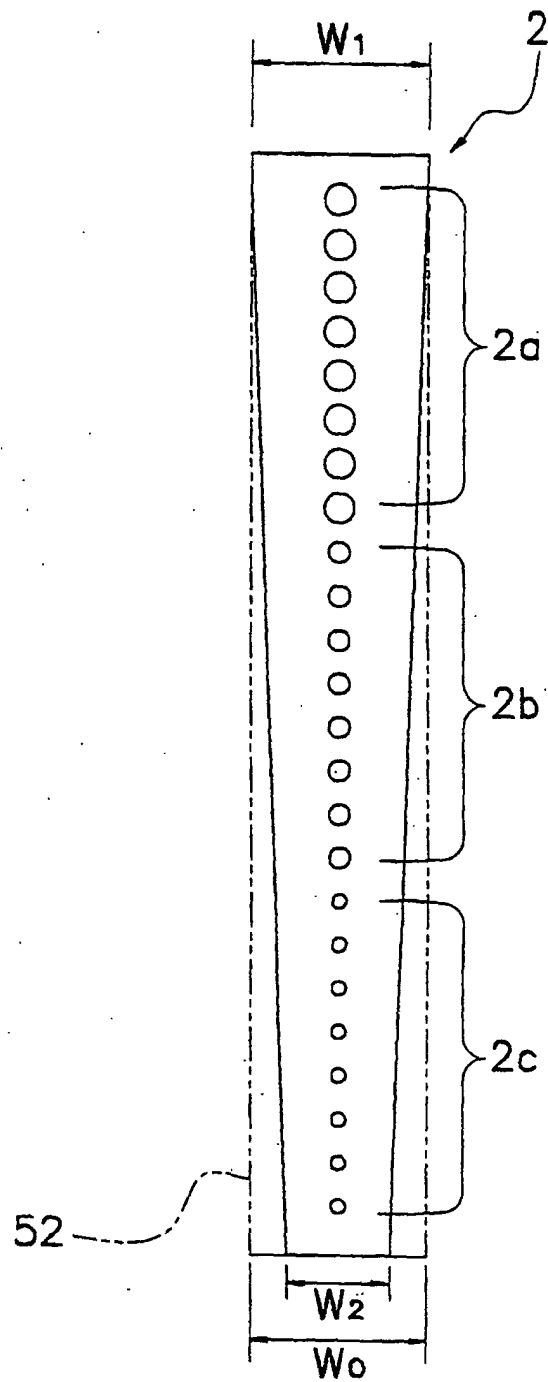


Fig. 6

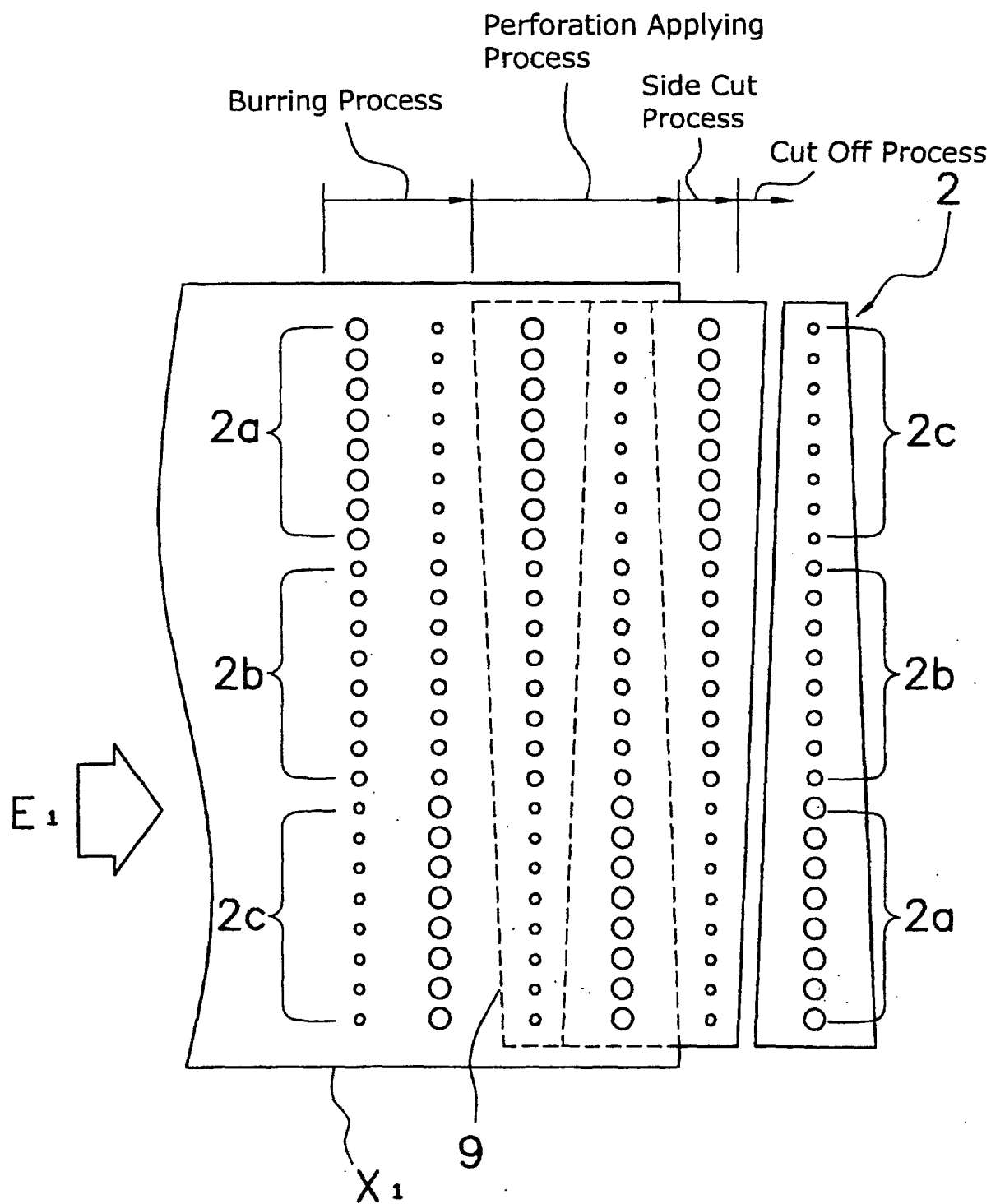


Fig. 7

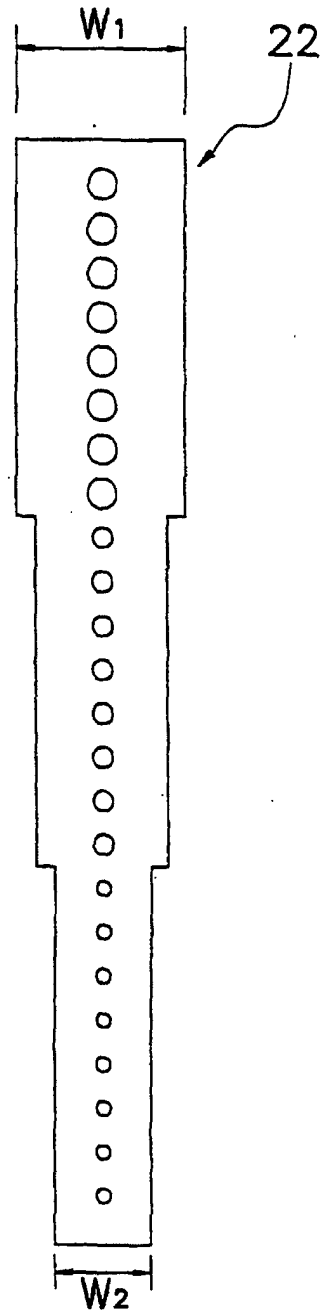
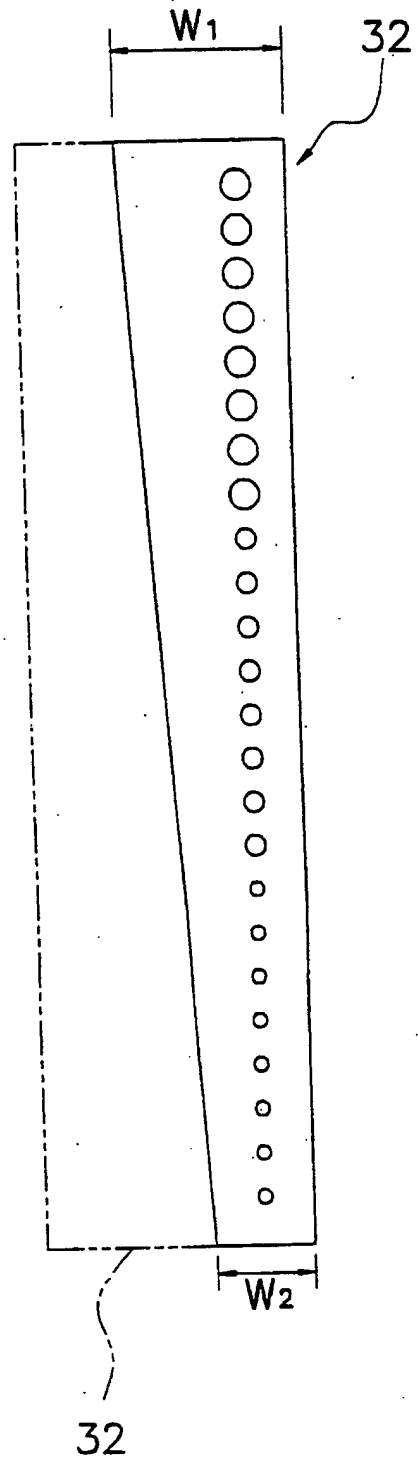


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP03/01396

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ F28F1/32, B21D53/08														
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) Int.Cl ⁷ F28F1/32, B21D53/08														
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2003 Kokai Jitsuyo Shinan Koho 1971-2003 Jitsuyo Shinan Toroku Koho 1996-2003														
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 7-98165 A (Toshiba Corp.), 11 April, 1995 (11.04.95), All pages (Family: none)	1-3, 6												
Y	US 5157941 A (NIHAT O. CUR), 27 October, 1992 (27.10.92), All pages (Family: none)	1-3, 6												
Y A	JP 63-251795 A (Hitachi, Ltd.), 19 October, 1988 (19.10.88), All pages (Family: none)	3 4, 5												
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.														
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier document but published on or after the international filing date</td> <td>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&" document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> </tr> </table>			* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier document but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means		"P" document published prior to the international filing date but later than the priority date claimed	
* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention													
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"P" document published prior to the international filing date but later than the priority date claimed														
Date of the actual completion of the international search 13 May, 2003 (13.05.03)		Date of mailing of the international search report 27 May, 2003 (27.05.03)												
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer												
Facsimile No.		Telephone No.												

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