



(11) **EP 3 561 430 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.10.2019 Bulletin 2019/44

(51) Int Cl.:
F28F 1/02 (2006.01) **F28F 13/00 (2006.01)**
F28D 1/02 (2006.01) **F28D 1/053 (2006.01)**

(21) Application number: **19169686.3**

(22) Date of filing: **16.04.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(30) Priority: **25.04.2018 JP 2018083667**

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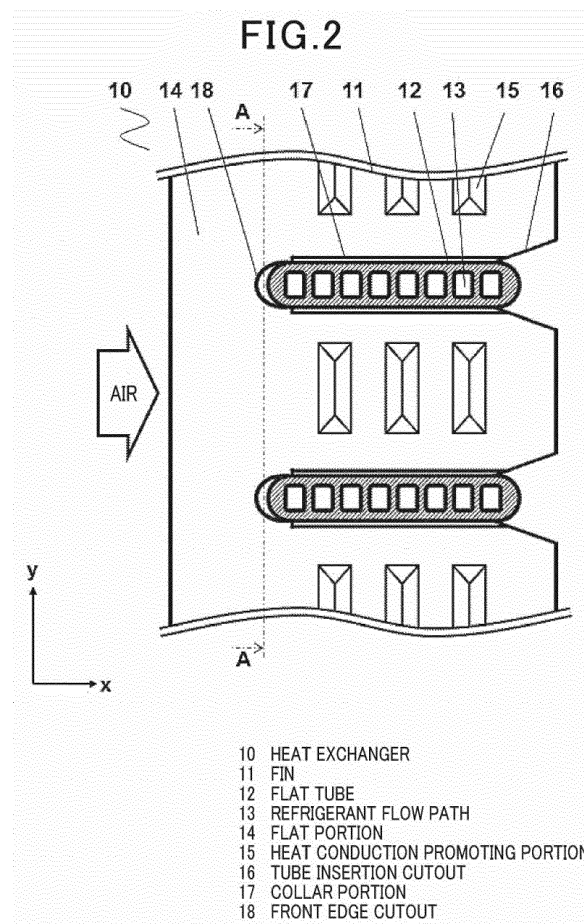
(54) **HEAT EXCHANGER**

(57) [Problem to be Solved]

In a condition in which frost formation is likely to occur as in a cold region or at midwinter, frost formation cannot be suppressed, and there are involved generation of air blockade, an increase in draft resistance, and a reduction in an amount of air passing through the heat exchanger, resulting in deterioration in heat exchange performance.

[Solution]

Front edge cutouts 18 are provided in a plate-like fin 11 including a flat portion 14, tube insertion cutouts 16, and collar portions 17, the front edge cutouts 18 extending from at least a part of airflow upstream side surfaces of flat tubes 12 inserted in the tube insertion cutouts 16 to the flat portion 14.



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Description

[Technical Field]

[0001] The present invention relates to a heat exchanger which includes a plurality of plate-like fins and a plurality of flat tubes having a plurality refrigerant flow paths and which effects heat exchange between air flowing between the plurality of fins and refrigerant flowing through the refrigerant flow paths of the plurality of flat tubes.

[Background Art]

[0002] Conventionally, there has been known a heat exchanger including plate-like fins and a plurality of flat tubes having a plurality of refrigerant flow paths and being perpendicularly inserted in tube insertion cutouts provided so as to be parallel to each other on the airflow downstream side of the fins.

[0003] Regarding a heat exchanger of this type, there has been disclosed a heat exchanger having fins provided with a flat portion (See, for example, Patent Literature 1).

[0004] Fig. 17 is a plan view taken along an x-y plane of the conventional heat exchanger disclosed in Patent Literature 1. The x-direction is the air flow direction, and the y-direction is the flat tube arrangement direction.

[0005] As shown in Fig. 17, a heat exchanger 1 includes plate-like fins 2, and a plurality of flat tubes 5 having a plurality of refrigerant flow paths 4 and being inserted at right angles in tube insertion cutouts 3 provided parallel to each other on the airflow downstream side (in the +x-direction) of the fins, with a flat portion 6 being provided on the airflow upstream side (in the -x-direction) of the tube insertion cutouts 3 of each fin 2.

[0006] As a result, the distance from the flat tubes 5 to the front edge portion of the fin 2 is longer, so that in the case where the heat exchanger is used in an environment where frost formation occurs, there is slowness in the heat conduction from the refrigerant flowing through the refrigerant flow paths 4 of the flat tubes 5 to the airflow upstream side (-x-direction) of the fin 2 where the humidity amount in the air is large and frost formation is likely to occur, making it possible to suppress an air blockade due to the frost.

[Citation List]

[Patent Literature]

[0007] [Patent Literature 1]
Japanese Patent Laid-Open No. 2012-233680

[Summary of Invention]

[Technical Problem]

[0008] In a condition in which frost formation is likely to occur as in a cold region or at midwinter, however, the conventional structure is still insufficient in sufficiently suppressing frost formation, and involves generation of air blockade, an increase in draft resistance, and a reduction in the amount of air passing through the heat exchanger, resulting in deterioration in heat exchange performance.

[0009] The present invention has been made to solve the above problem in the prior art. It is an object of the present invention to provide a heat exchanger employing a flat tube which can achieve an improvement in terms of heat exchange performance by promoting heat conduction on an airflow upstream side in the flat tube while reducing the fin efficiency on the airflow upstream side and suppressing frost formation on the upstream side in the fin airflow.

[Solution to Problem]

[0010] In order to solve the above problem in the prior art, a heat exchanger in accordance with the present invention includes a plurality of plate-like fins arranged at predetermined intervals, and a plurality of flat tubes having a plurality of refrigerant flow paths, each of the fins including a flat portion, tube insertion cutouts formed to be parallel to each other to allow insertion of the flat tubes on an airflow downstream side, and collar portions with which the respective flat tubes are in contact, wherein the heat exchanger further includes front edge cutouts extending from at least part of airflow upstream side surfaces of the flat tubes inserted in the tube insertion cutouts to the flat portion.

[0011] As a result, at least part of the airflow upstream side surfaces of the flat tubes ceases to come into contact with the fins, and air exists between the airflow upstream side surfaces of the flat tubes and the fins, whereby heat conduction from the airflow upstream side surfaces of the flat tubes to front edge portions of the fins becomes slow.

[Advantageous Effects of Invention]

[0012] Even in a condition in which frost formation is more likely to occur as in a cold region or at midwinter, the heat exchanger of the present invention can suppress the frost formation on the fins on the upstream side in the fin airflow where the humidity amount in the air is large, so that it is possible to suppress a reduction in the amount of air passing through the heat exchanger due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[Brief Description of Drawings]

[0013]

Fig. 1 is a perspective view of a heat exchanger according to Embodiment 1 of the present invention.

Fig. 2 is a plan view of a fin of the heat exchanger of Embodiment 1 of the present invention taken along an x-y plane.

Fig. 3 is a side view of the fin, as seen from the x-direction and taken along a z-y plane, of the heat exchanger of Embodiment 1 of the present invention.

Fig. 4 is a plan view of an internal structure of an outdoor unit to which the heat exchanger is applied.

Fig. 5 is a plan view of the internal structure of the outdoor unit to which the heat exchanger is applied.

Fig. 6 is a plan view of a fin of a heat exchanger of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 7 is an enlarged view of a fin of the heat exchanger of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 8 is a plan view of a fin of a heat exchanger according to Modification 1 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 9 is a plan view of a fin of a heat exchanger according to Modification 2 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 10 is a plan view of a fin of a heat exchanger according to Modification 3 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 11 is a plan view of a fin of a heat exchanger according to Modification 4 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 12 is a plan view of a fin of a heat exchanger according to Modification 5 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 13 is a plan view of a fin of a heat exchanger according to Modification 6 of Embodiment 2 of the present invention taken along the x-y plane.

Fig. 14 is a plan view of a fin of a heat exchanger of Embodiment 3 of the present invention taken along the x-y plane.

Fig. 15 is a plan view of a fin of a heat exchanger according to Modification 1 of Embodiment 3 of the present invention taken along the x-y plane.

Fig. 16 is a plan view of a fin of a heat exchanger according to Modification 2 of Embodiment 3 of the present invention taken along the x-y plane.

Fig. 17 is a plan view of a fin of a conventional heat exchanger taken along the x-y plane.

[Description of Embodiments]

[0014] According to a first aspect of the invention, there is provided a heat exchanger including a plurality of plate-like fins arranged at predetermined intervals, and a plurality of flat tubes having a plurality of refrigerant flow

paths, each of the fins including a flat portion, tube insertion cutouts formed parallel to each other to allow insertion of the flat tubes on an airflow downstream side, and collar portions with which the respective flat tubes are in contact; and front edge cutouts are provided so as to extend from at least part of airflow upstream side surfaces of the flat tubes inserted in the tube insertion cutouts to the flat portion.

[0015] As a result, at least part of the airflow upstream side surfaces of the flat tubes ceases to come into contact with the fin, and there exists air between the airflow upstream side surfaces of the flat tubes and the fin, whereby heat conduction from the airflow upstream side surfaces of the flat tubes to the front edge portions of the fins becomes slow.

[0016] As a result, even in a condition in which frost formation is more likely to occur as in a cold region or at midwinter, it is possible to suppress the frost formation on the fins on the airflow upstream side where the humidity amount in the air is large, so that it is possible to suppress a reduction in the amount of air passing through the heat exchanger due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0017] Further, at least a part of the collar portions of the fins is cut, and air comes into direct contact with the airflow upstream side surfaces of the flat tubes, so that it is possible to promote the heat conduction on the airflow upstream side of the flat tubes, making it possible to achieve a further improvement in terms of heat exchange performance.

[0018] According to a second aspect of the invention, assuming that a flat tube side opening width of the front edge cutouts is h , and that a height of the flat tubes is H , there are provided the front edge cutouts in which $h < H$.

[0019] As a result, the height of the flat tubes is larger than a flat tube side openings of the front edge cutouts, and when the flat tubes are inserted, the flat tubes come into contact with the flat tube side openings of the front edge cutouts and are fixed thereto.

[0020] Thus, it is possible to insert a plurality of flat tubes by a predetermined amount, so that at the time of a heating operation when the external temperature is low, it is possible to suppress frost formation as a result of local reduction in temperature at the front edge portions of the fins due to variation in a flat tube insertion amount, and a reduction in the amount of air passing through the heat exchanger due to an increase in draft resistance is suppressed, making it possible to achieve an improvement in terms of heat exchange performance.

[0021] According to a third aspect of the invention, there are provided drain cutouts including a gravitational direction component at the front edge cutouts.

[0022] As a result, condensed water generated on the airflow upstream side of the flat tubes and having flowed into the front edge cutouts flows along the drain cutouts downwardly in the gravitational direction to grow, increases in a water amount, and the gravitational force applied

to the dew condensation water increases, with the result that the water flows down quickly.

[0023] Thus, even during high load operation in which a generation amount of condensed water is large, it is possible to suppress the remaining of the dew condensation water, and to prevent a reduction in the amount of air passing through the heat exchanger due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0024] Further, during heating operation when the external temperature is low, the condensed water quickly flows down without freezing, so that it is possible to prevent the heat exchanger from freezing to stop the heating operation, thus making it possible to achieve an improvement in terms of heating capacity.

[0025] Further, the fins are cut by the drain cutouts, and the heat conduction from the airflow upstream side surfaces of the flat tubes to the front edge portions of the fins becomes slow, so that even in a condition in which frost formation is more likely to occur, it is possible to suppress frost formation on the fins on the airflow upstream side where the amount of humidity in the air is large, and a reduction in the amount of air passing through the heat exchanger due to an increase in draft resistance is suppressed, making it possible to achieve an improvement in terms of heat exchange performance.

[0026] In the following, embodiments of the present invention will be described with reference to the drawings. The present invention is not limited by these embodiments.

(Embodiment 1)

[0027] Fig. 1 is a perspective view of a heat exchanger according to Embodiment 1 of the present invention. An x-direction is an airflow direction, a y-direction is a flat tube arrangement direction, and a z-direction is a fin arrangement direction.

[0028] In Fig. 1, a heat exchanger 10 includes a plurality of plate-like fins 11 arranged at predetermined intervals, and a plurality of flat tubes 12 which are perpendicularly inserted in the plurality of fins 11 and which are arranged parallel to each other. Heat exchange is effected between air flowing between the plurality of fins 11, and refrigerant flowing through a plurality of refrigerant flow paths 13 formed in the plurality of flat tubes 12.

[0029] As the refrigerant, there is employed, for example, R410A, R32, or mixture refrigerant containing R32.

[0030] Fig. 2 is a plan view of a fin of the heat exchanger of Embodiment 1 of the present invention taken along an x-y plane, and Fig. 3 is a side view of the fin, as seen from the x-direction and taken along a z-y plane, of the heat exchanger of Embodiment 1 of the present invention and is a sectional view taken along the line A-A of Fig. 2.

[0031] The fin 11 includes a flat portion 14, heat conduction promoting portions 15, tube insertion cutouts 16 which allow insertion of the flat tubes 12 on an airflow downstream side (+x-direction) and which are formed

parallel to each other, collar portions 17 with which the respective flat tubes 12 are in contact, and front edge cutouts 18 formed to extend from at least part of an airflow upstream side surfaces (-x-direction) of the flat tubes 12 inserted in the tube insertion cutouts 16 toward the flat portion 14.

[0032] The heat conduction promoting portions 15 are raised toward an airflow path side (+z-direction) from the flat portion 14 of the fin 11 and are chevron-shaped. They are provided between a plurality of flat tubes 12 adjacent to each other and between the front edge portions of the flat tubes 12 and the rear edge portions of the flat tubes 12.

[0033] In order to facilitate the insertion of the flat tubes 12, openings of the tube insertion cutouts 16 are larger than a height of the flat tubes 12 (a length in the y-direction).

[0034] The collar portions 17 are raised substantially perpendicularly from the flat portion 14 of the fin 11 toward the airflow path side (+z-direction), and are held in contact with a surface of the adjacent fin 11, thus maintaining an interval between the fins 11 adjacent to each other. They are soldered to the flat tubes 12 by brazing.

[0035] Instead of causing the collar portions 17 to come into contact with the surface of the adjacent fin 11, cut-and-raised portions such different from the collar portions 17 such as tabs (not shown) may be brought into contact with the surface of the adjacent fin 11, thereby maintaining an interval between the fins 11 adjacent to each other.

[0036] Next, flow of air will be described. Part of the air having flowed into the heat exchanger 10 impinges upon the front edge portions of the fins 11, and the remaining portion of the air passes between the plurality of fins 11 adjacent to each other without impinging upon the fins 11.

[0037] The air impinges upon the front edge portions of the fins 11, and a boundary layer becomes thinner, so that heat conductivity becomes higher. The air having impinged upon the front edge portions of the fins 11 passes between the plurality of fins 11 adjacent to each other.

[0038] Part of the air having flowed into between the plurality of fins 11 adjacent to each other flows so as to impinge upon the flat tubes 12, and the remaining portion of the air passes between the plurality of flat tubes 12 without impinging upon the flat tubes 12 adjacent to each other.

[0039] Since the collar portions 17 are cut by the front edge cutouts 18, the air having flowed toward the flat tubes 12 does not come into contact with the collar portions 17 but comes into direct contact with the airflow upstream side surfaces (-x-direction) of the flat tubes 12.

[0040] The air having come into contact with the airflow upstream side (-x-direction) surfaces of the flat tubes 12 performs heat exchange with the refrigerant flowing through the refrigerant flow paths 13 on the airflow upstream side (-x-direction) of the flat tubes 12, and then passes between the plurality of flat tubes 12 adjacent to each other.

[0041] The air passing between the plurality of flat tubes 12 adjacent to each other impinges upon the heat conduction promoting portions 15 provided on the fins 11, thus promoting the heat conduction with respect to the fins 11.

[0042] Next, regarding the utilization of the present embodiment, a case will be described in which the heat exchanger 10 of the present embodiment is utilized in an outdoor unit 20 of an air conditioner.

[0043] Fig. 4 is a z-x plan view illustrating an internal structure of an outdoor unit 20 to which the heat exchanger 10 of the present embodiment is applied, and Fig. 5 is a z-y front view illustrating the internal structure of the outdoor unit 20 to which the heat exchanger 10 of the present embodiment is applied.

[0044] As shown in Figs. 4 and 5, the outdoor unit 20 includes a compressor 21, a change-over valve 22, an outdoor expansion valve 23, a blower 24, and the heat exchanger 10. The outdoor unit 20 and the indoor unit (not shown) are connected to each other through a liquid pipe 25 and a gas pipe 26.

[0045] In the heat exchanger 10, a plurality of flat tubes 12 are arranged in a horizontal directions (a z-direction and an x-direction) so as to be parallel to each other along an axial direction (a y-direction) of header pipes 27a and 27b, and the refrigerant flow paths 13 in the flat tubes 12 communicate with an interior of the header pipes 27a and 27b.

[0046] The header pipe 27a is connected to the change-over valve 22 via refrigerant piping 28a, and to the outdoor expansion valve 23 via refrigerant piping 28b. A partition 29 is provided inside the header pipe 27a, and a refrigerant flow path is divided into an axially upper side (+y-direction) and an axially lower side (-y-direction) of the header pipe 27a.

[0047] First, in the case where a cooling operation is performed, the heat exchanger 10 functions as a condenser. Gas refrigerant which is sent from the compressor of the outdoor unit 20 is caused to flow into the header pipe 27a from the refrigerant piping 28a via the change-over valve 22. This gas refrigerant passes through the interior of the header pipe 27a, and flows into a plurality of refrigerant flow paths 13 of the plurality of flat tubes 12 connected to the axially upper side (+y-direction) of the header pipe 27a before flowing in the horizontal direction (+z-direction and +x-direction) to flow out into the header pipe 27b.

[0048] The refrigerant having flowed into the header pipe 27b flows into the refrigerant flow paths 13 of the plurality of flat tubes 12 connected to the axially lower side (-y-direction) of the header pipe 27b, and flows in the horizontal direction (-x-direction and -z-direction). In the flat tubes 12, the refrigerant radiates heat and is condensed through heat exchange with air sent from the blower 24.

[0049] The condensed refrigerant flows into the header pipe 27a, and passes through the outdoor expansion valve 23 and the liquid pipe 25 from the refrigerant piping

28b before flowing out into the indoor unit.

[0050] The condensed refrigerant having flowed out into the indoor unit absorbs heat and is evaporated through heat exchange with the air at an indoor heat exchanger (not shown). The evaporated refrigerant passes through the gas pipe 26 and is circulated to the compressor 21 via the change-over valve 22.

[0051] In the case where a heating operation is performed, the heat exchanger 10 functions as an evaporator. The gas refrigerant sent from the compressor 21 of the outdoor unit 20 passes through the gas pipe 26 via the change-over valve 22, and flows out into the indoor unit.

[0052] The gas refrigerant having flowed out into the indoor unit radiates heat and is condensed through heat exchange with the air at the indoor heat exchanger provided in the indoor unit. The condensed refrigerant passes through the liquid pipe 25 and the outdoor expansion valve 23 to become gas-liquid two-phase refrigerant before flowing into the header pipe 27a from the refrigerant piping 28b.

[0053] The gas-liquid two-phase refrigerant flows from the header pipe 27a into the refrigerant flow paths 13 of the plurality of flat tubes 12 connected to the axially lower side (-y-direction) of the header pipe 27a, and flows in the horizontal direction (+z-direction and +x-direction) before flowing out into the header pipe 27b.

[0054] The refrigerant having flowed out into the header pipe 27b flows into the refrigerant flow paths 13 of the plurality of flat tubes 12 connected to the axially upper side (+y-direction) of the header pipe 27b, and flows in the horizontal direction (-x-direction and -z-direction). In the flat tubes 12, the refrigerant absorbs heat and is evaporated through heat exchange with the air sent from the blower 24.

[0055] The evaporated refrigerant flows into the header pipe 27a, passes through the interior, and is circulated to the compressor 21 from the refrigerant piping 28a via the change-over valve 22.

[0056] In the case where the heat exchanger 10 functions as an evaporator, low temperature refrigerant flows through the refrigerant flow paths 13 of the flat tubes 12, and heat exchange is effected with the air. The water in the air adheres to surfaces of the fins 11 and the flat tubes 12, and condensed water is generated. In particular, in a lower external temperature condition as in a cold region or at midwinter, the condensed water freezes as frost.

[0057] In the heat exchanger constructed as described above, at least a part of the airflow upstream side (-x-direction) surfaces of the flat tubes 12 ceases to come into contact with the fins 11, and due to the presence of air between the airflow upstream side (-x-direction) surfaces of the flat tubes 12 and the fins 11, the heat conduction from the airflow upstream side (-x-direction) surfaces of the flat tubes 12 to the front edge portions of the fins 11 becomes slow.

[0058] Thus, even in a condition in which frost formation is more likely to occur as in a cold region or at mid-

winter, it is possible to suppress the frost formation on the fins 11 on the airflow upstream side (-x direction) where a humidity amount in the air is large, so that it is possible to suppress a reduction in an amount of the air passing through the heat exchanger 10 due to increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0059] Further, at least a part of the collar portions 17 of the fins 11 is cut, and air comes into direct contact with the airflow upstream side (-x-direction) surface of the flat tubes 12, so that it is possible to promote the heat conduction on the airflow upstream side (-x-direction) of the flat tubes 12, making it possible to achieve a further improvement in terms of heat exchange performance.

(Embodiment 2)

[0060] Fig. 6 is a plan view of a fin of a heat exchanger of Embodiment 2 of the present invention taken along the x-y plane, and Fig. 7 is an enlarged view of a fin of the heat exchanger of Embodiment 2 of the present invention taken along the x-y plane and is an enlarged view of portion B of Fig. 6.

[0061] As shown in Figs. 6 and 7, assuming that an opening width of the front edge cutouts 18 on a flat tube 12 side is h, and that a y-direction height of the flat tubes 12 is H, $h < H$.

[0062] Thus, the y-direction height of the flat tubes 12 is larger than openings of the front edge cutouts 18 on the flat tube 12 side. When the flat tubes 12 are inserted, the flat tubes 12 come into contact with the openings of the front edge cutouts 18 on the flat tube 12 side, and are fixed in position.

[0063] Thus, it is possible to insert the flat tubes 12 by a predetermined amount, so that at the time of a heating operation when the external temperature is low, it is possible to suppress frost formation as a result of a local reduction in temperature at the front edge portions of the fins 11, and to suppress a reduction in an amount of the air passing through the heat exchanger 10 due to an increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0064] It is preferable for h to be at least 0.1 mm or more. When soldering the fins 11 and the flat tubes 12 to each other by brazing, this makes it possible to suppress the brazing material from flowing into the front edge cutouts 18 due to a capillary phenomenon to fill the front edge cutouts 18 with the brazing material.

[0065] Further, it is preferable for h to be still larger. The collar portions 17 of the fins 11 on the airflow upstream side (-x-direction) of the flat tube 12 are thus greatly cut, and the area thereof coming into direct contact with the airflow upstream side (-x-direction) of the flat tube 12 increases, so that the heat conduction from the airflow upstream side (-x-direction) surfaces of the flat tube 12 to the front edge portions of the fins 11 becomes slower while promoting the heat conduction on the airflow upstream side (-x-direction) of the flat tube

12, and it is possible to further suppress frost formation on the fins 11 on the airflow upstream side (-x-direction) where the humidity amount in the air is large, and it is possible to suppress a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0066] Further, assuming that the position where the center plane a passing through a central portion of the y-direction height of the flat tubes 12 and parallel to the airflow direction (x-direction) and the front edge portions of the fins 11 cross each other is a point C, that the front edge portions of the flat tubes 12 is a point D, and that an airflow most upstream side (-x-direction) of the front edge cutouts 18 is a point E, it is preferable for the point E to be provided at the airflow downstream side (+x-direction) than an intermediate position between the points C and D.

[0067] As a result, it is possible to secure the distance from the front edge portions of the fins 11 to the front edge cutouts 18, so that when the flat tubes 12 are inserted into the fins 11, it is possible to secure strength of the fins 11, and to prevent fracture and breakage of the fins 11.

[0068] It is preferable for the distance from the point E to the point D to be at least 0.1 mm or more. When the fins 11 and the flat tubes 12 are soldered to each other by brazing, this helps to suppress the brazing material from flowing into the front edge cutouts 18 due to the capillary phenomenon to fill the front edge cutouts 18 with the brazing material.

[0069] Fig. 8 is a plan view of a fin of a heat exchanger according to Modification 1 of Embodiment 2 of the present invention taken along the x-y plane; Fig. 9 is a plan view of a fin of a heat exchanger according to Modification 2 of Embodiment 2 of the present invention taken along the x-y plane; Fig. 10 is a plan view of a fin of a heat exchanger according to Modification 3 of Embodiment 2 of the present invention taken along the x-y plane; Fig. 11 is a plan view of a fin of a heat exchanger according to Modification 4 of Embodiment 2 of the present invention taken along the x-y plane; Fig. 12 is a plan view of a fin of a heat exchanger according to Modification 5 of Embodiment 2 of the present invention taken along the x-y plane; Fig. 13 is a plan view of a fin of a heat exchanger according to Modification 6 of Embodiment 2 of the present invention taken along the x-y plane.

[0070] As shown in Fig. 8, it goes without saying that the front edge cutouts 18 provide a similar effect if they are provided at positions shifted in a tube arrangement direction (y-direction), using as a reference the center plane a passing through the central portion in the y-direction height of the flat tubes 12 and parallel to the airflow direction (x-direction).

[0071] As shown in Figs. 9 and 10, the front edge cutouts 18 may be of a triangular or a rectangular configuration. This helps to enlarge a cut area of the front edge cutouts 18, and the amount of air existing between the

airflow upstream side (-x-direction) surfaces of the flat tubes 12 and the fins 11 increases, and the heat conduction from the airflow upstream side (-x-direction) surfaces of the flat tubes 12 to the front edge portions of the fins 11 becomes still slower, so that it is possible to further suppress frost formation on the fins 11 on the airflow upstream side (-x-direction) where the amount of humidity in the air is large, and to suppress a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0072] As shown in Figs. 11 and 12, the front edge cutouts 18 may be inclined in the gravitational direction (-y-direction) with respect to the airflow direction (+x-direction).

[0073] With this structure, condensed water having flowed into the front edge cutouts 18 flows in the gravitational direction (-y-direction), so that the condensed water is quickly drained from the front edge cutouts 18, and it is possible to suppress dew condensation water from remaining, and it is possible to prevent a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0074] As shown in Fig. 13, the plurality of front edge cutouts 18 may be provided for one flat tube 12.

[0075] With this structure, the cut portions of the fins 11 increase, and the heat conduction to the front edge portions of the fins 11 becomes slower, so that it is possible to further suppress frost formation on the fins 11 on the airflow upstream side (-x-direction) where the amount of humidity in the air is large, and a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance is suppressed, making it possible to achieve an improvement in terms of heat exchange performance.

(Embodiment 3)

[0076] Fig. 14 is a plan view of a fin of a heat exchanger of Embodiment 3 of the present invention taken along the x-y plane.

[0077] As shown in Fig. 14, drain cutouts 19 including a gravitational direction (-y-direction) component are provided at the front edge cutouts 18.

[0078] As a result, the condensed water generated on the airflow upstream side (-x-direction) of the flat tubes 12 and having flowed into the front edge cutouts 18 flows along the drain cutouts 19, and flows in the gravitational direction (-y-direction) to grow. Thus, an amount of water increases, and the gravitational force applied to the dew condensation water increases, whereby the water flows down quickly.

[0079] Thus, even during a high load operation in which a generation amount of the condensed water increases, it is possible to suppress the dew condensation water

from remaining, and to prevent a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0080] Further, during a heating operation when the external temperature is low, the condensed water quickly flows down without freezing, so that it is possible to prevent the heating operation from being stopped due to the freezing of the heat exchanger 10, making it possible to achieve an improvement in terms of heating capacity.

[0081] Further, due to the drain cutouts 19, the heat conduction to the front edge portions of the fins 11 from the airflow upstream side (-x-direction) surfaces of the flat tubes 12 becomes slower, so that even in a condition in which frost formation is more likely to occur, it is possible to suppress frost formation on the fins 11 on the airflow upstream side (-x-direction) where the humidity amount in the air is large, and to suppress a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0082] It is preferable for an opening width w of the drain cutouts 19 to be at least 0.1 mm or more. When the fins 11 and the flat tubes 12 are soldered to each other by brazing, this helps to suppress the brazing material from flowing into the drain cutouts 19 due to the capillary phenomenon to fill the front edge cutouts 19 with the brazing material.

[0083] Further, assuming that the point where a center plane b passing through the central portion of the adjacent flat tubes 12 and parallel to the airflow direction (x-direction) and the front edge portions of the fins 11 cross each other is a point F , that an angle made by the center plane a and the line connecting the points F and D is θ , that the lowermost point in the gravitational direction (-y-direction) of the drain cutouts 19 is a point G , and that the position where the center plane a and the shortest line connecting the center plane a to point G cross each other is a point H , it is preferable for the following condition to hold true:

$$GH \geq \tan \theta \geq \times DH.$$

[0084] As a result, at the front edge portions of the fins 11, there are provided portions where the fins 11 are cut between the front edge portions (point D) of the flat tubes 12 and a position at a minimum distance from the flat tubes 12 (point C), and between the front edge portions (point D) of the flat tubes 12 and a position at a maximum distance from the flat tubes 12 (point F), so that the heat conduction from the flat tubes 12 to the front edge portions of the fins 11 becomes slow, and it is possible to further suppress frost formation over the entire front edge portions of the fins 11 on the airflow upstream side (-x-direction) where the humidity amount in the air is large,

and to suppress a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0085] Fig. 15 is a plan view of a fin of a heat exchanger according to Modification 1 of Embodiment 3 of the present invention taken along the x-y plane.

[0086] As shown in Fig. 15, the drain cutouts 19 are formed so as to extend solely in the gravitational direction (-y-direction).

[0087] As a result, the condensed water generated on the airflow upstream side (-x-direction) of the flat tubes 12 and having flowed into the front edge cutouts 18 flows along the drain cutouts 19, and flows more smoothly in the gravitational direction (-y-direction) to grow, with the amount of water increasing and the gravitational force applied to the dew condensation water increasing, with the result that the water flows down quickly.

[0088] Thus, even during a maximum load operation in which the generation amount of the condensed water further increases, it is possible to suppress remaining of the dew condensation water, and it is possible to prevent a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[0089] Further, it is possible to secure the distance from the front edge portions of the fins 11 to the drain cutouts 19, so that when the flat tubes 12 are inserted into the fins 11, it is possible to secure the strength of the fins 11, making it possible to suppress fracture and breakage of the fins 11.

[0090] Fig. 16 is a plan view of a fin of a heat exchanger according to Modification 2 of Embodiment 3 of the present invention taken along the x-y plane.

[0091] As shown in Fig. 16, instead of forming the drain cutouts 19 on the airflow upstream side (-x-direction) of the front edge cutouts 18, the drain cutouts 19 may be formed on the airflow upstream side (-x-direction) of the flat tubes 12.

[0092] This helps to further secure the distance from the front edge portions of the fins 11 to the drain cutouts 19, so that when the flat tubes 12 are inserted into the fins 11, it is possible to further secure the strength of the fins 11, making it possible to prevent fracture and breakage of the fins 11.

[0093] Further, the drain cutouts 19 are formed at the lower end in the gravitational direction (-y-direction) of the front edge cutouts 18, so that the portions of the front edge cutouts 18 where the condensed water is maintained are reduced, and the condensed water can be drained more quickly, and it is possible to prevent a reduction in the amount of air passing through the heat exchanger 10 due to the increase in draft resistance, making it possible to achieve an improvement in terms of heat exchange performance.

[Industrial Applicability]

[0094] According to the present invention, there is provided a heat exchanger employing flat tubes, wherein the heat conduction on the airflow upstream side of the flat tubes is promoted while lowering a fin efficiency on the airflow upstream side and suppressing frost formation on the airflow upstream side of the fins, whereby it is possible to achieve an improvement in terms of heat exchange performance. The heat exchanger is applicable to a refrigerator, air conditioner, hot-water-supply/air-conditioning combined apparatus, etc.

[Reference Signs List]

[0095]

1	heat exchanger
2	fin
3	tube insertion cutout
4	refrigerant flow path
5	flat tube
6	flat portion
10	heat exchanger
11	fin
12	flat tube
13	refrigerant flow path
14	flat portion
15	heat conduction promoting portion
16	tube insertion cutout
17	collar portion
18	front edge cutout
19	drain cutout
20	outdoor unit
21	compressor
22	change-over valve
23	outdoor expansion valve
24	blower
25	liquid pipe
26	gas pipe
27a, 27b	header pipe
28a, 28b	refrigerant piping
29	partition

Claims

1. A heat exchanger **characterized by** comprising a plurality of plate-like fins (11) arranged at predetermined intervals, and a plurality of flat tubes (12) having a plurality of refrigerant flow paths (13), each of the fins including a flat portion (14), tube insertion cutouts (16) formed to be parallel to each other to allow insertion of the flat tubes on an airflow downstream side, and collar portions (17) with which the respective flat tubes are in contact, wherein the heat exchanger further comprises front edge cutouts (18) extending from at least part of airflow upstream side

surfaces of the flat tubes inserted in the tube insertion cutouts to the flat portion.

2. The heat exchanger according to claim 1, wherein, assuming that an opening width of the front edge cutout on a flat tube side is h , and that a height of the flat tubes is H , $h < H$. 5
3. The heat exchanger according to claim 2, wherein the front edge cutouts are each provided with a drain cutout (19) including a gravitational direction component. 10

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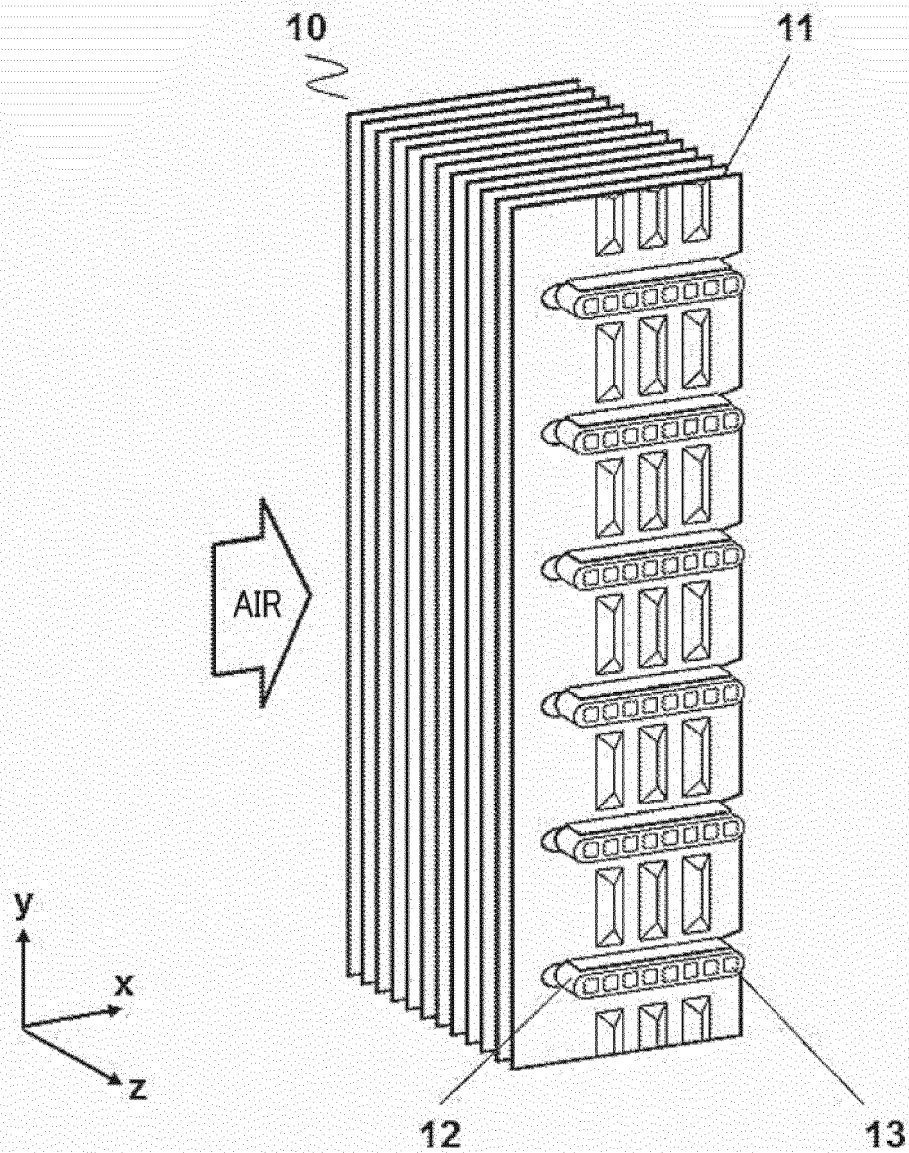
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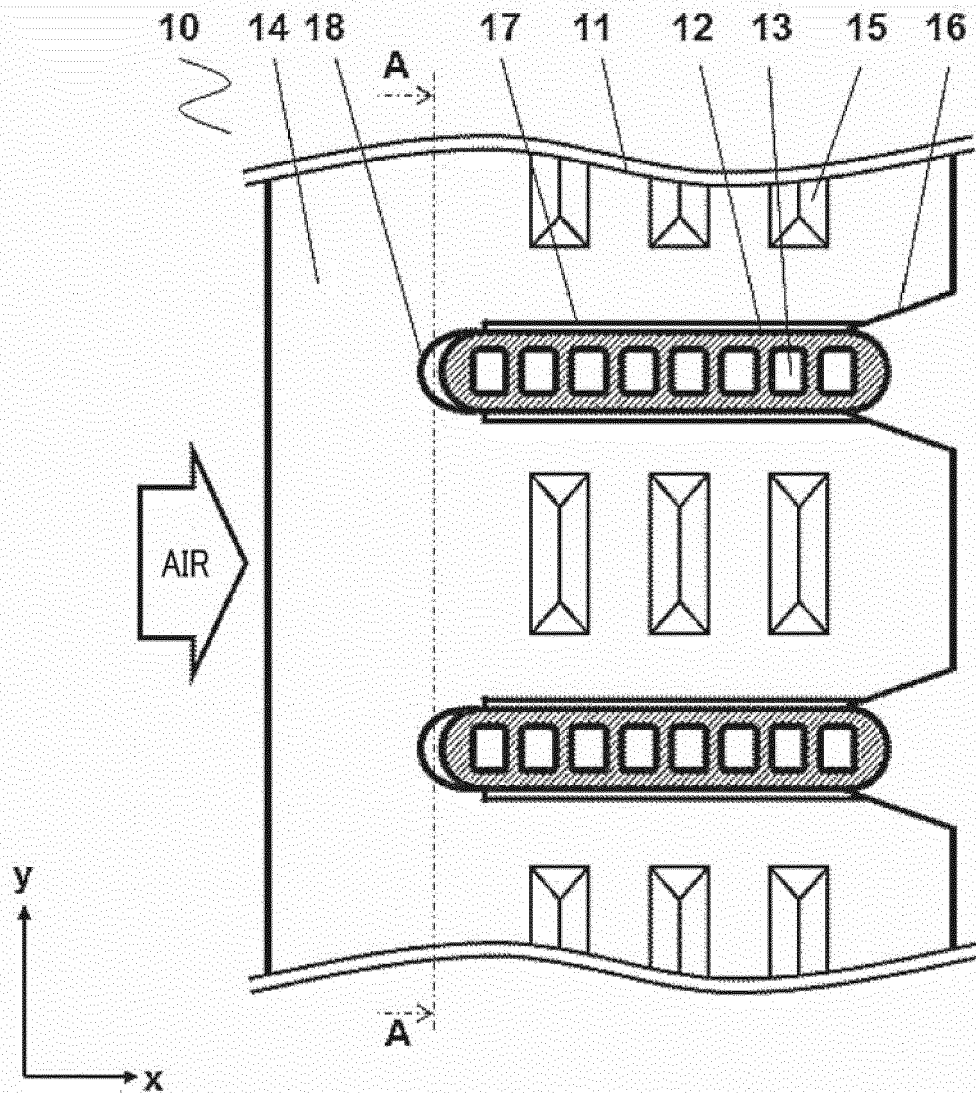
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FIG. 1



- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH

FIG.2



- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.3

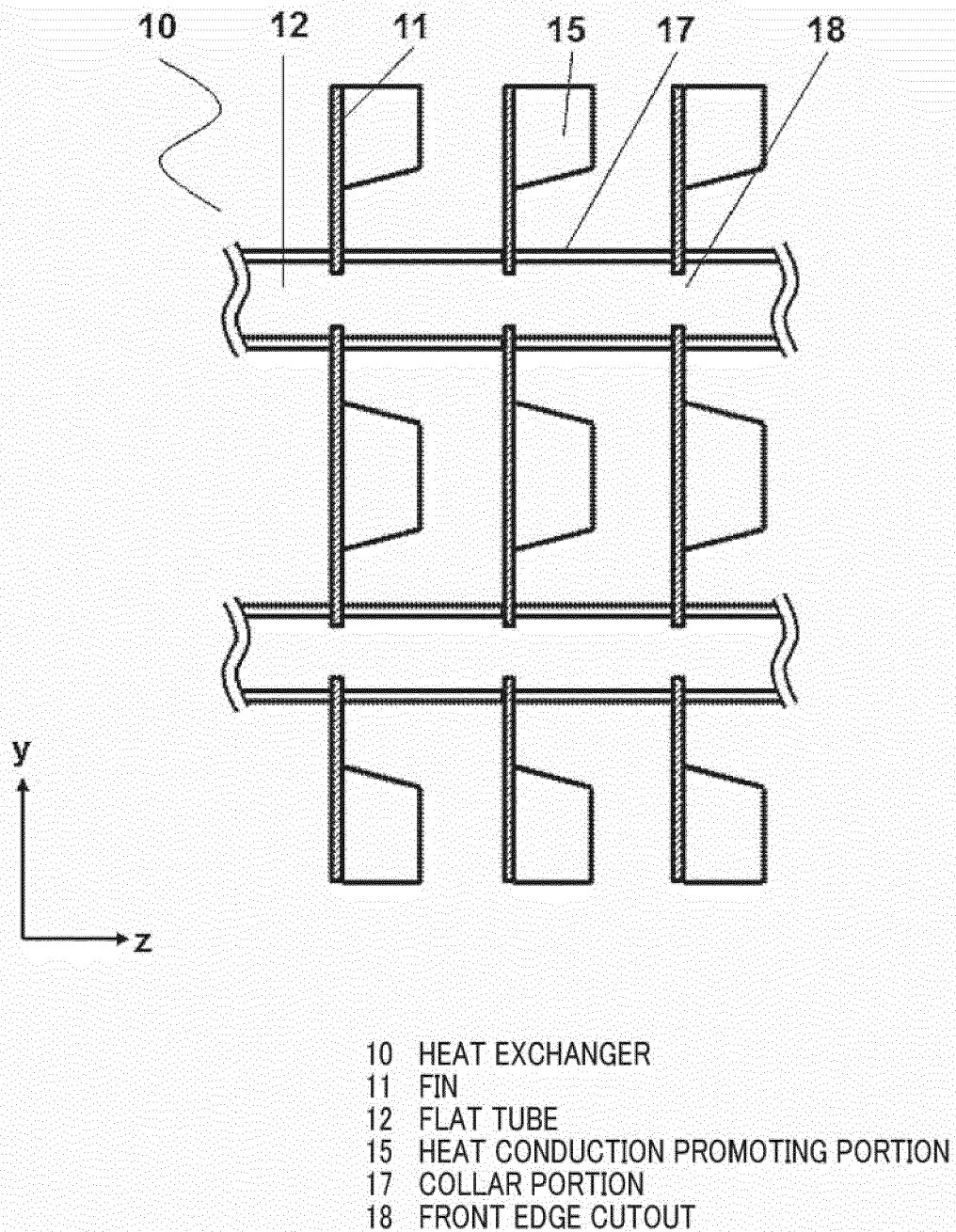
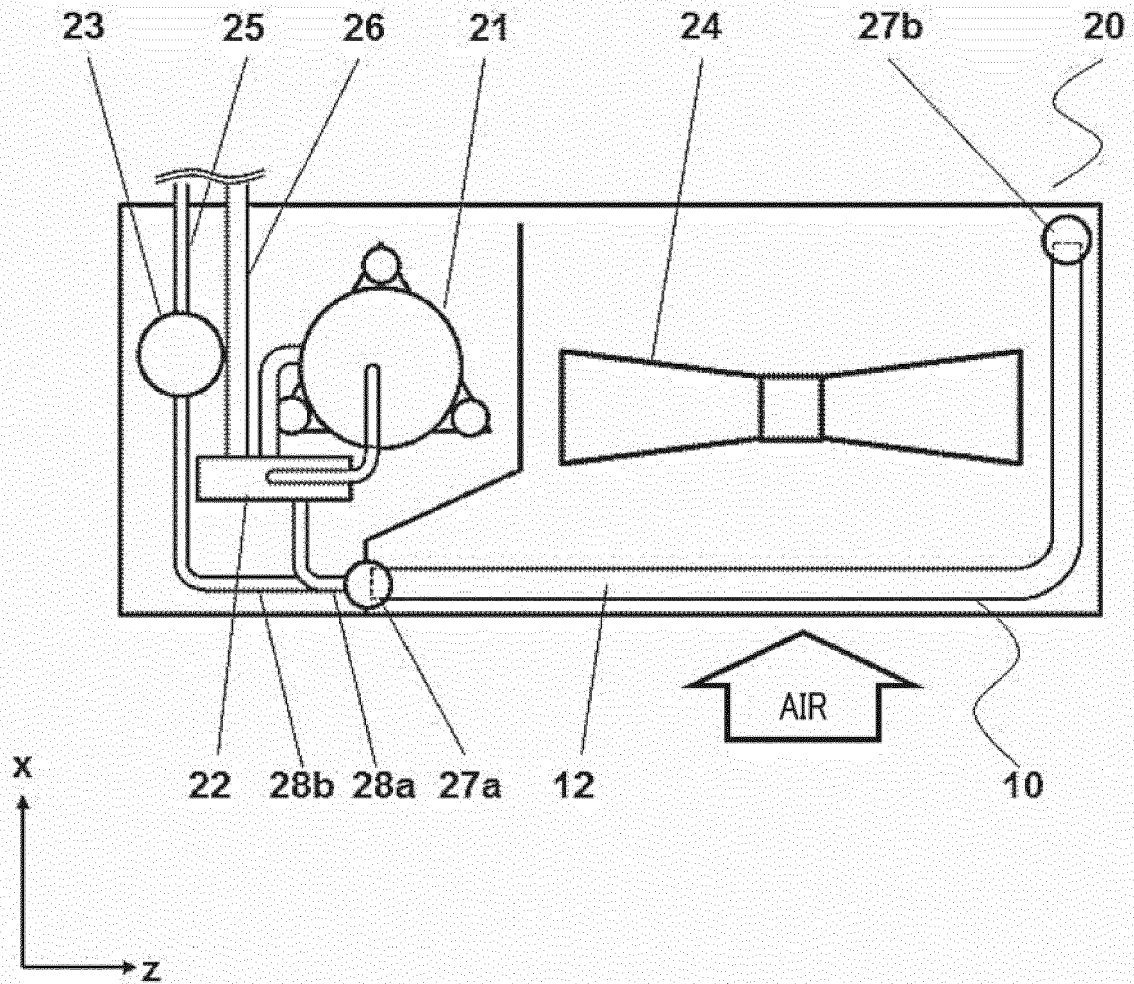
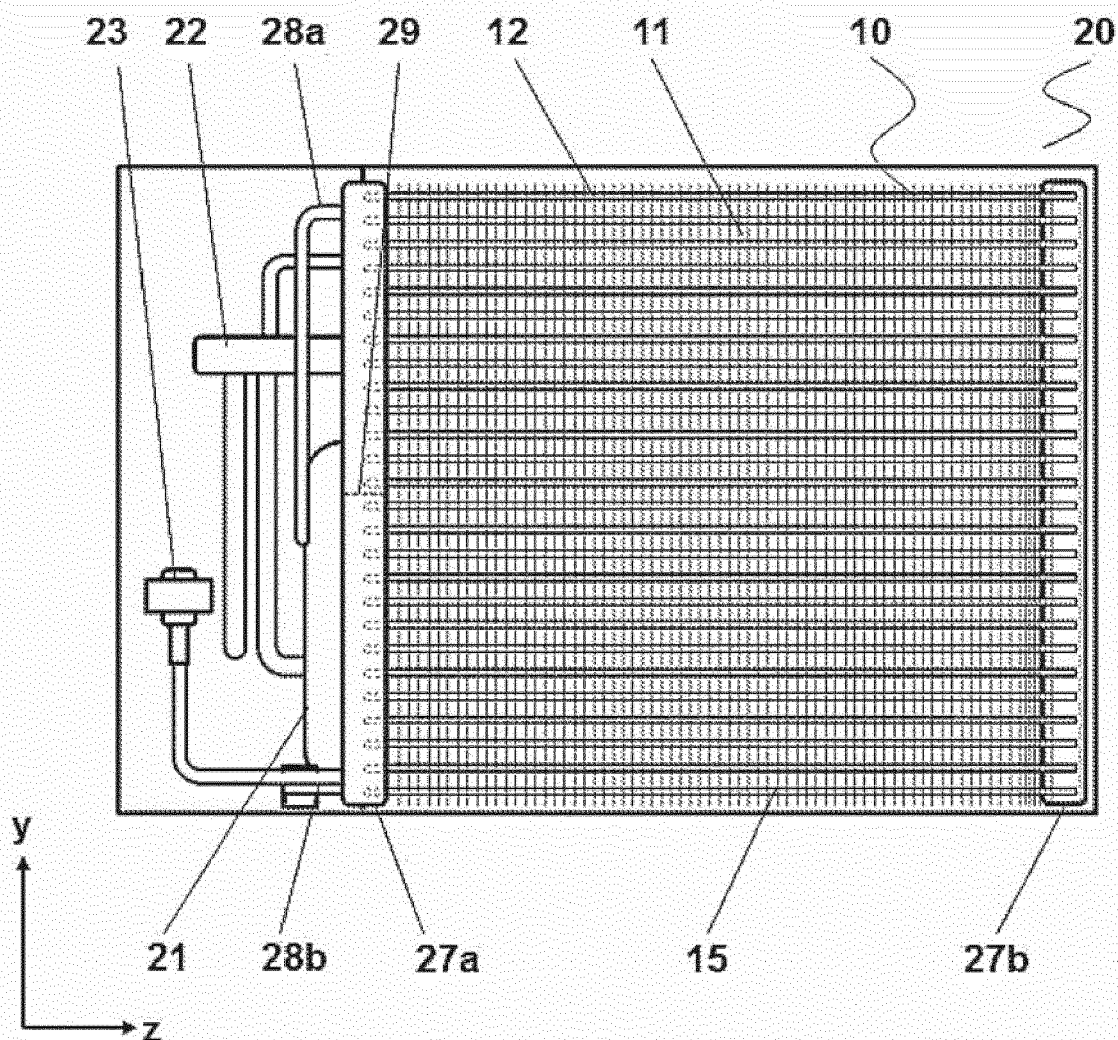


FIG. 4



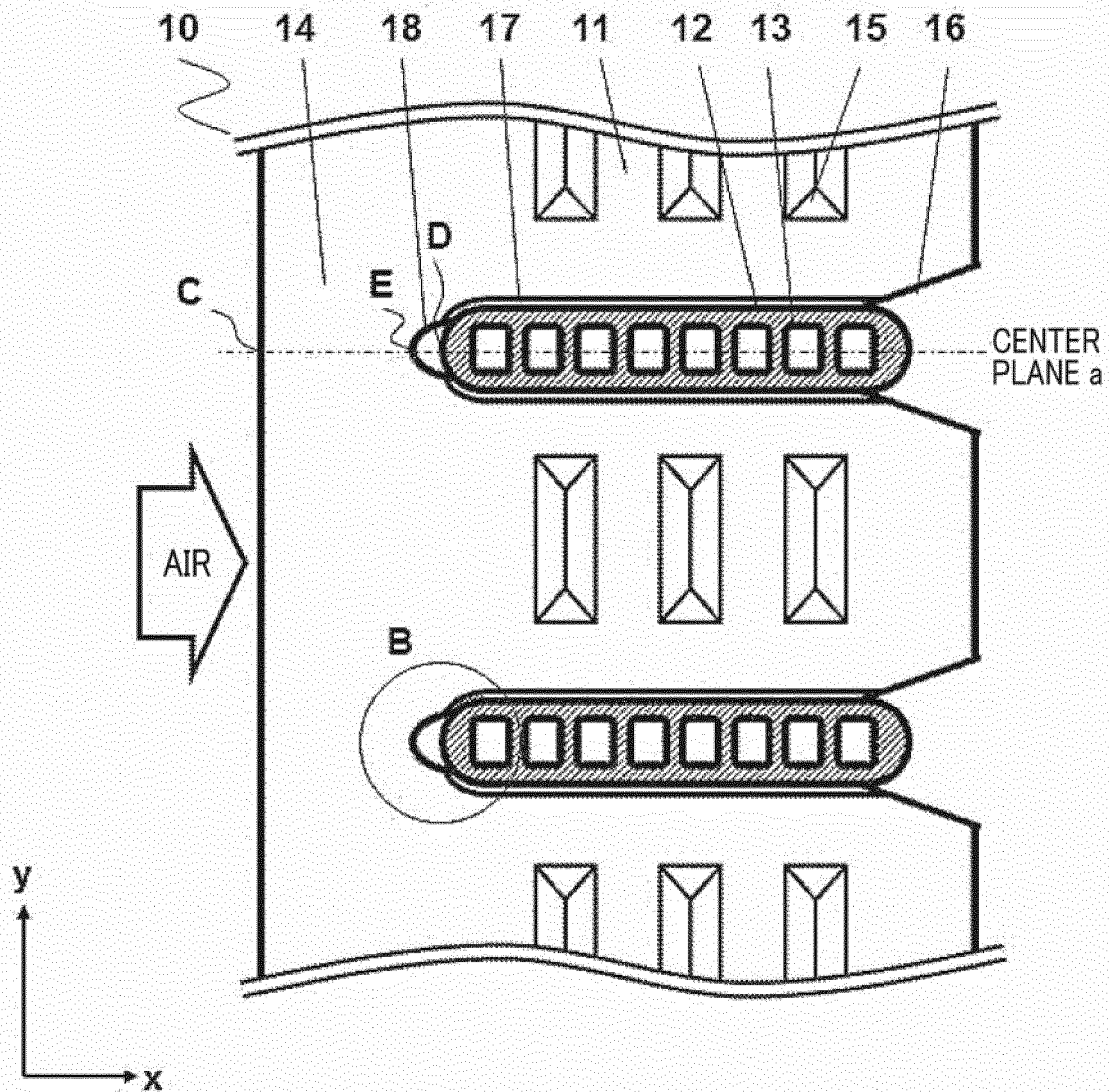
- 10 HEAT EXCHANGER
- 12 FLAT TUBE
- 20 OUTDOOR UNIT
- 21 COMPRESSOR
- 22 CHANGE-OVER VALVE
- 23 OUTDOOR EXPANSION VALVE
- 24 BLOWER
- 25 LIQUID PIPE
- 26 GAS PIPE
- 27a, 27b HEADER PIPE
- 28a, 28b REFRIGERANT PIPING

FIG. 5



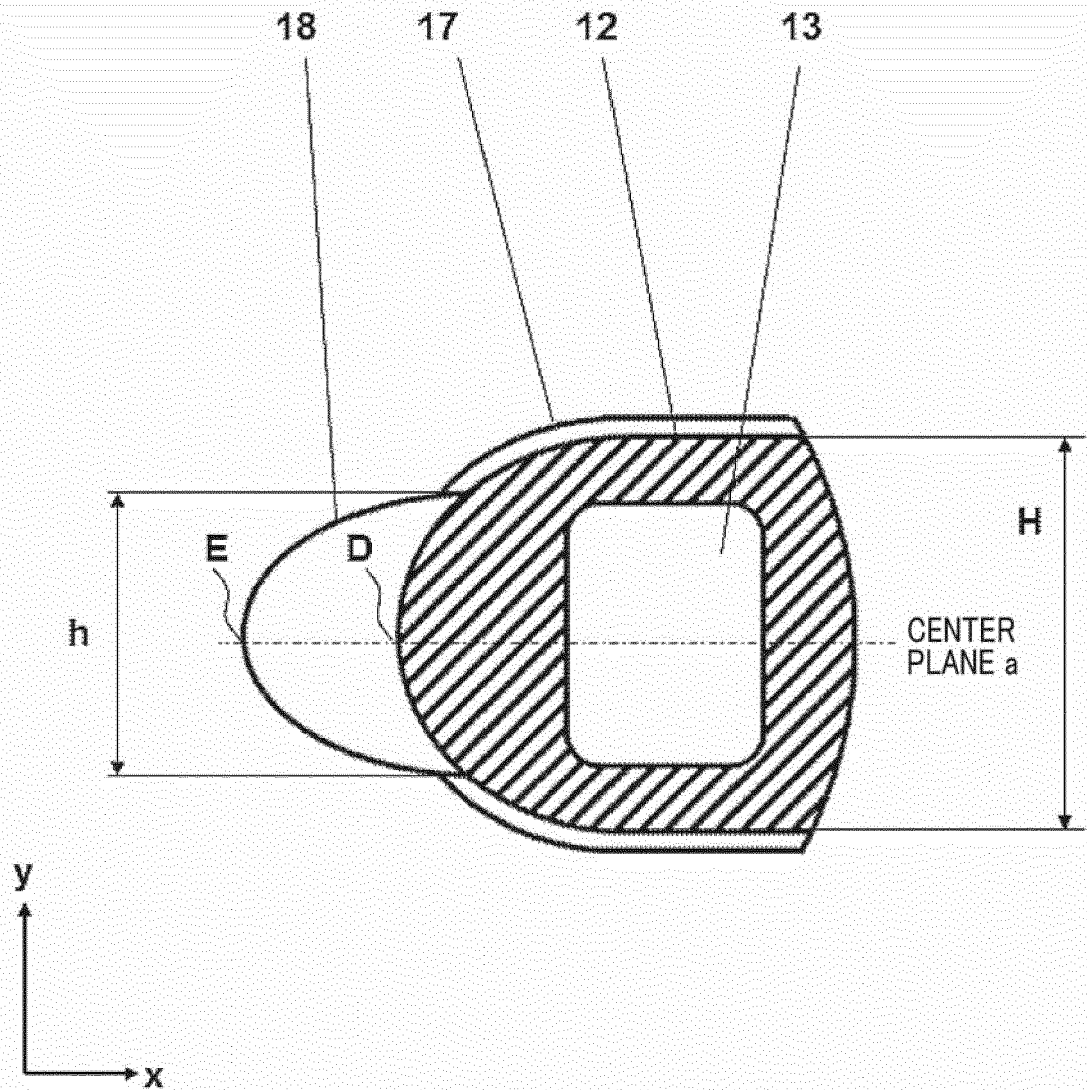
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 20 OUTDOOR UNIT
- 21 COMPRESSOR
- 22 CHANGE-OVER VALVE
- 23 OUTDOOR EXPANSION VALVE
- 27a, 27b HEADER PIPE
- 28a, 28b REFRIGERANT PIPING
- 29 PARTITION

FIG.6



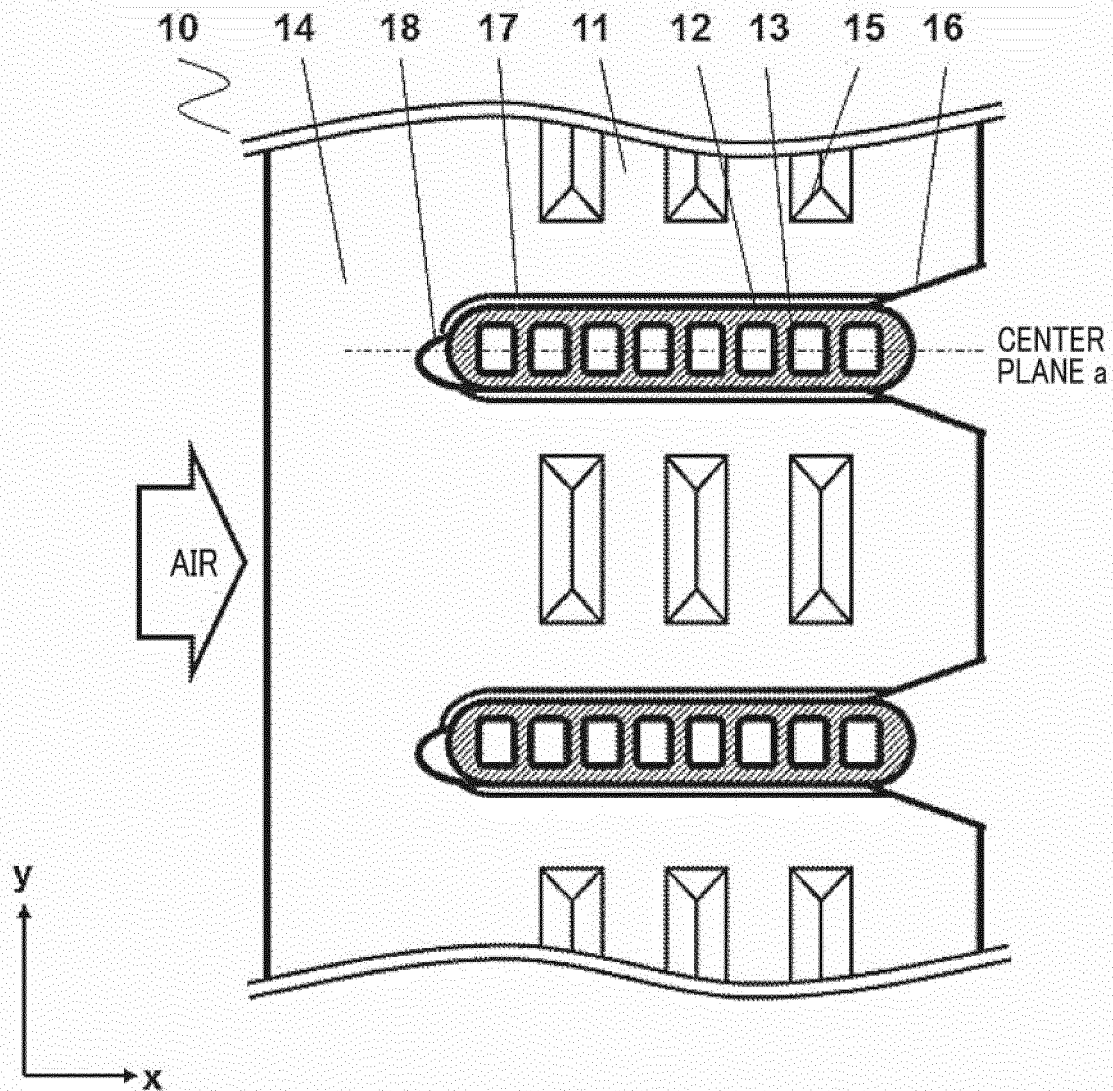
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG. 7



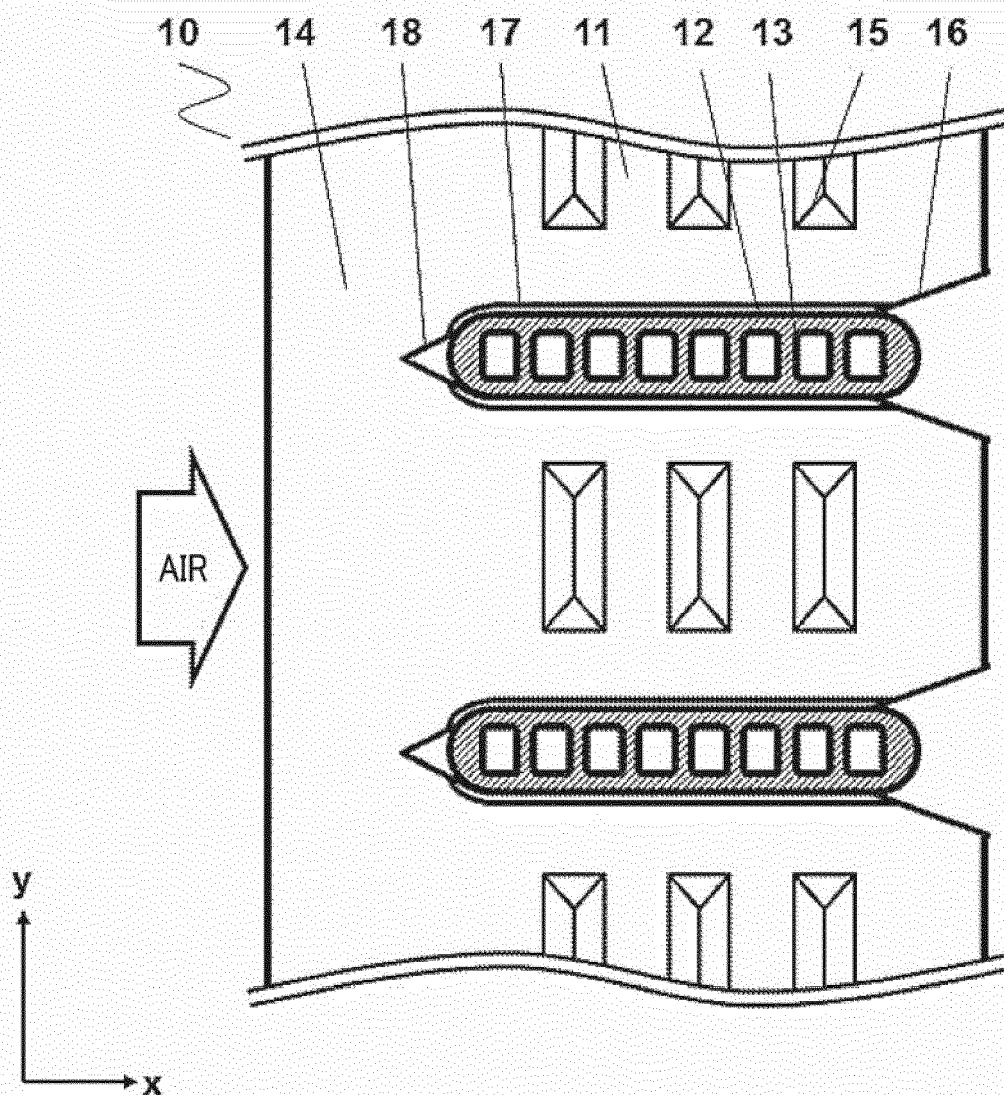
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.8



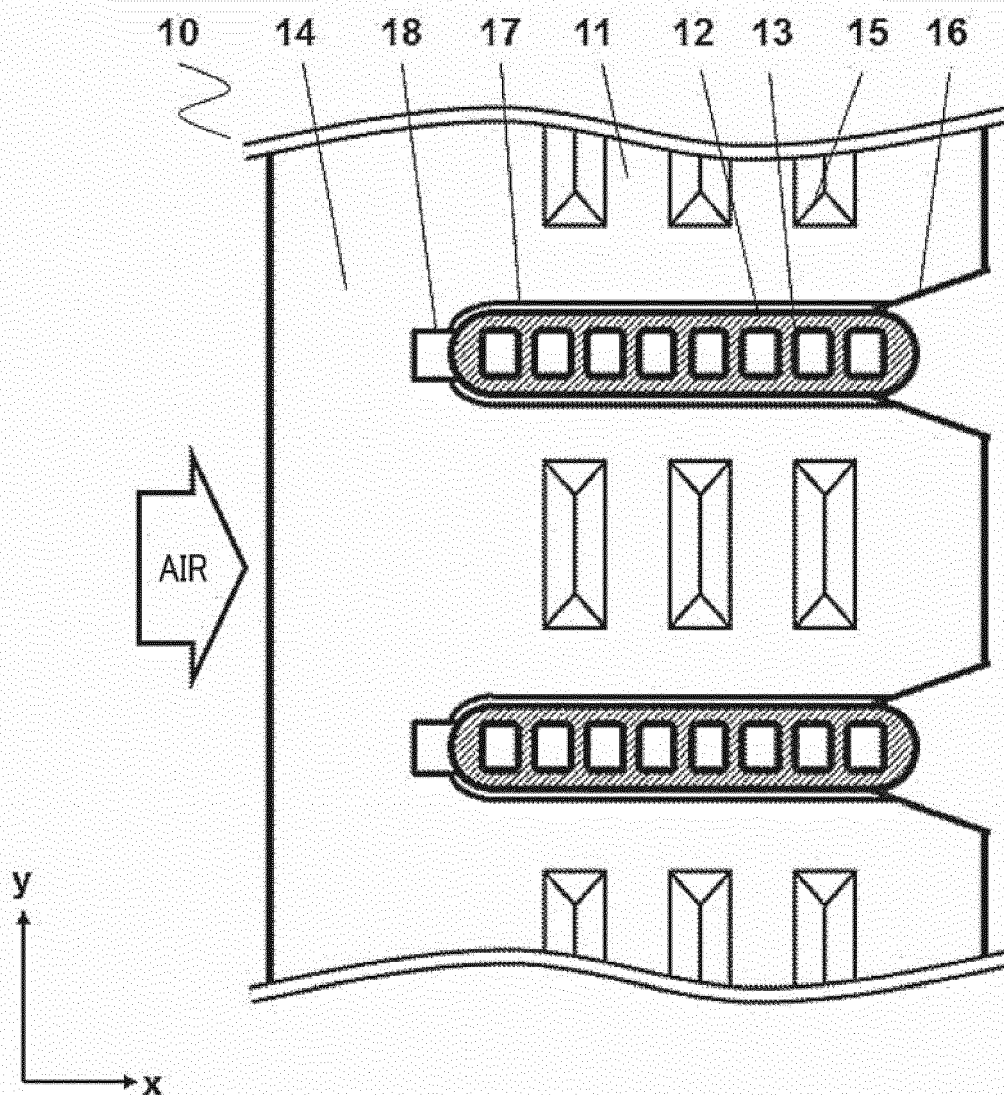
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- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.9



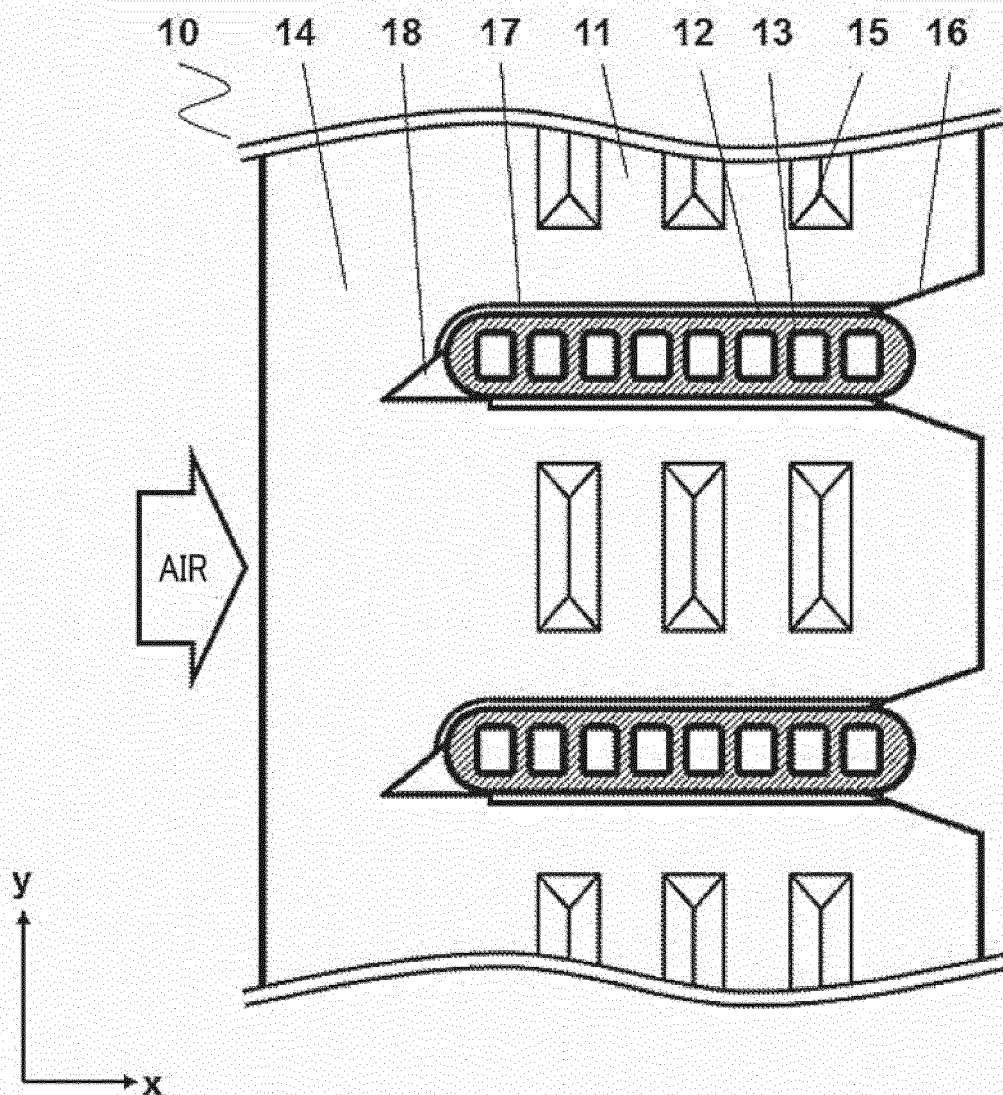
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.10



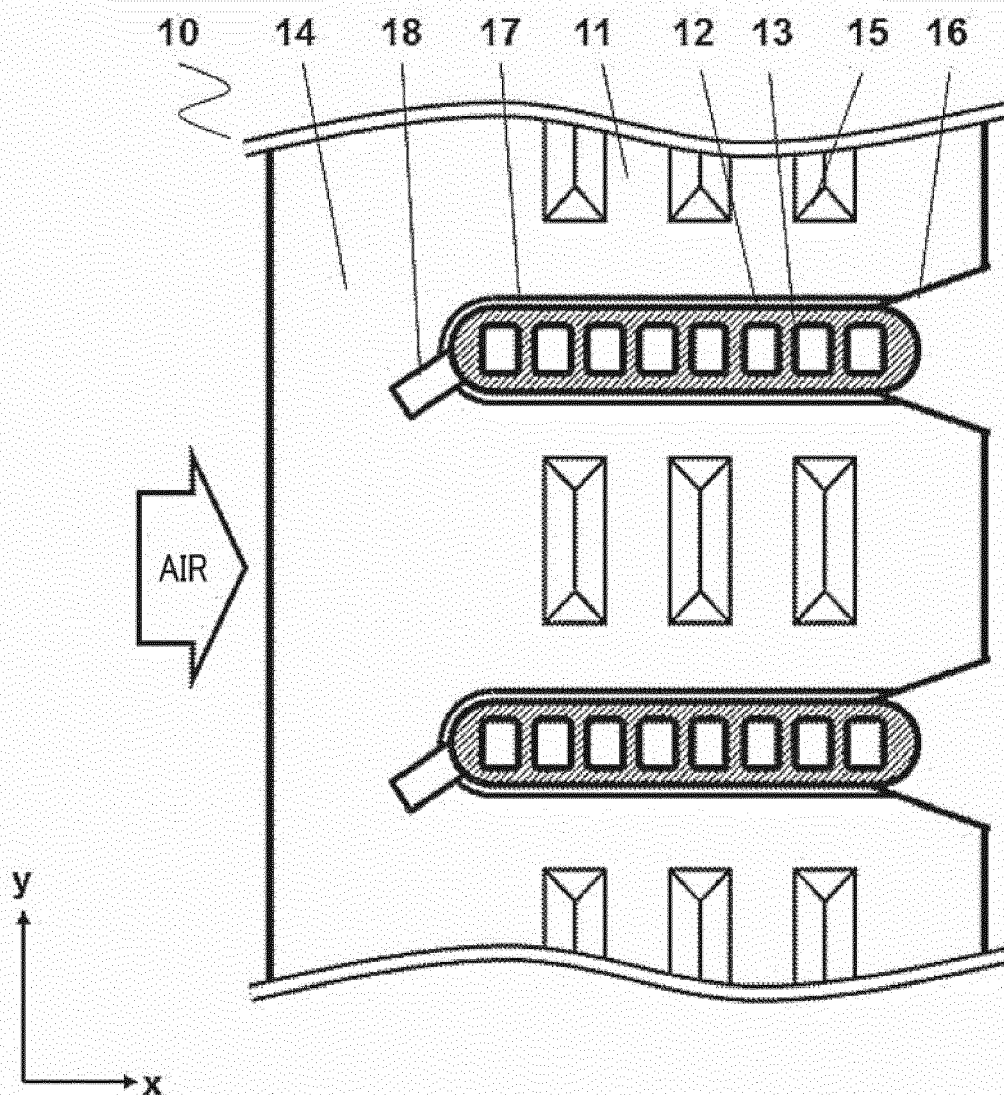
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.11



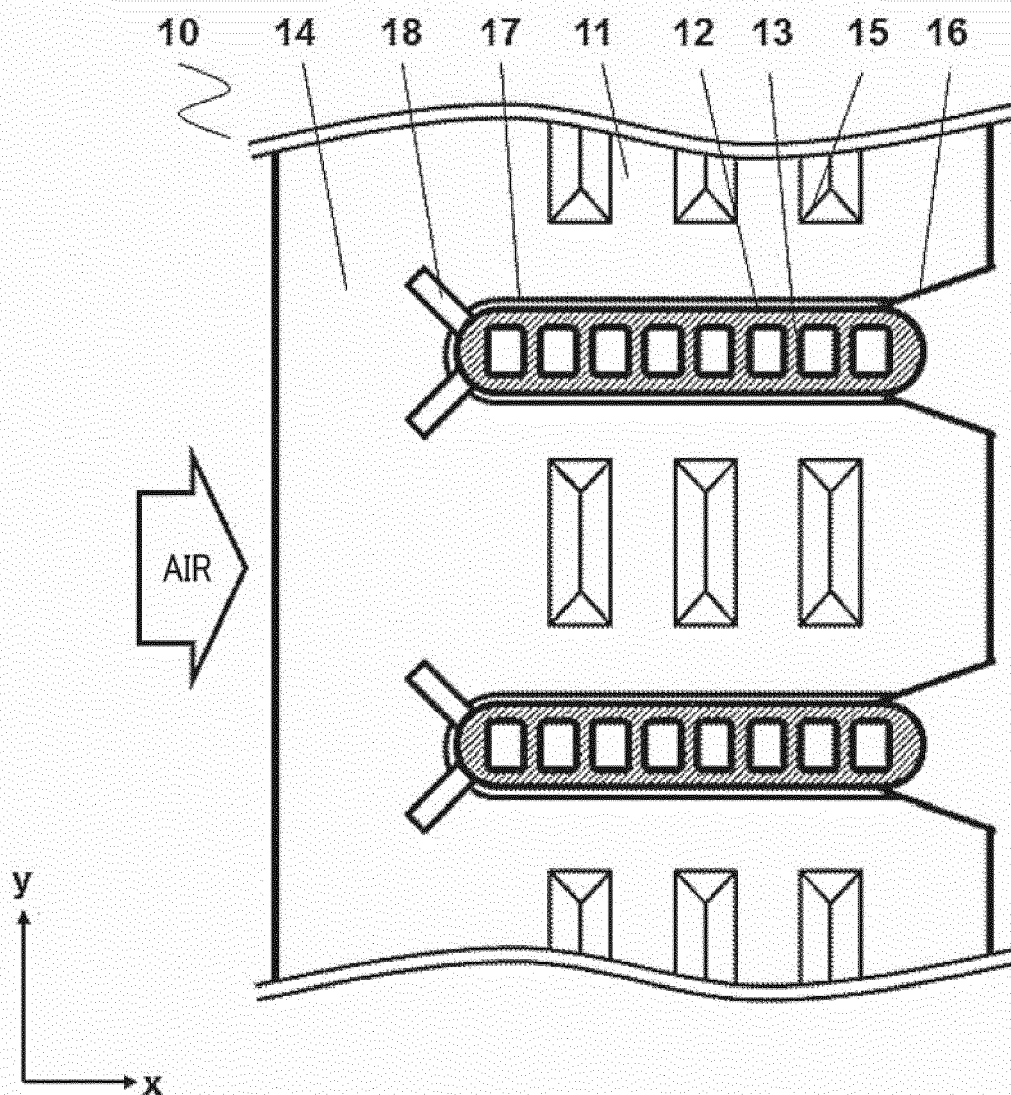
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.12



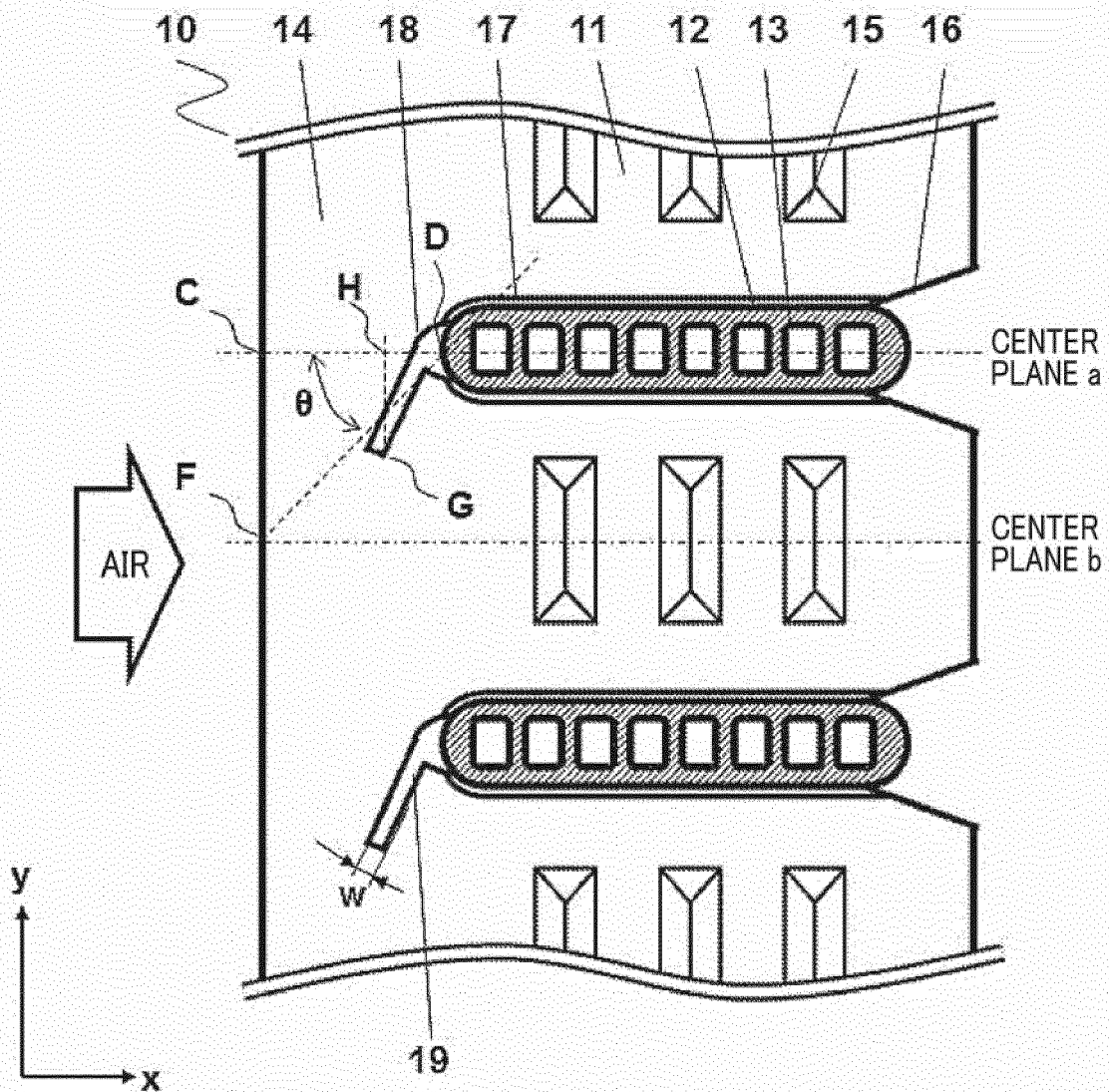
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.13



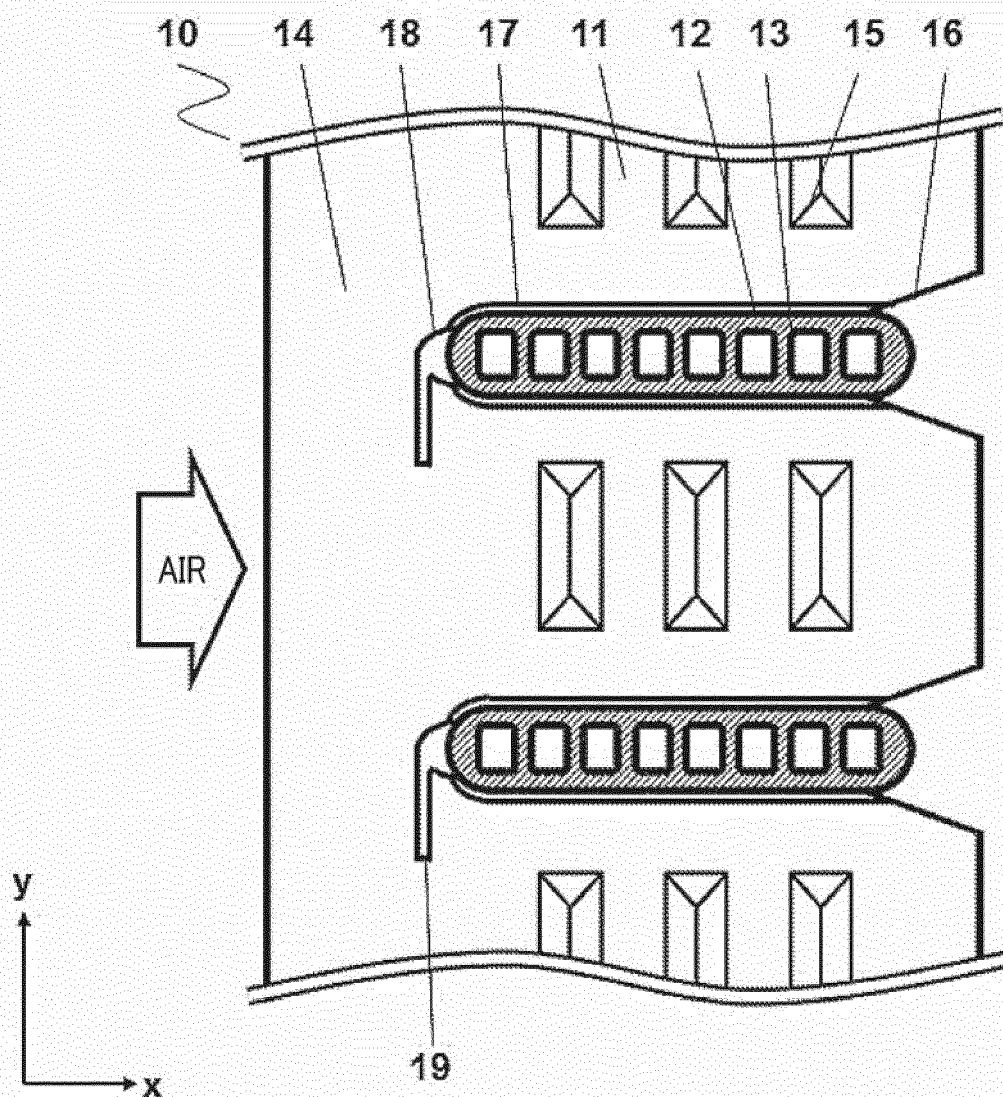
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT

FIG.14



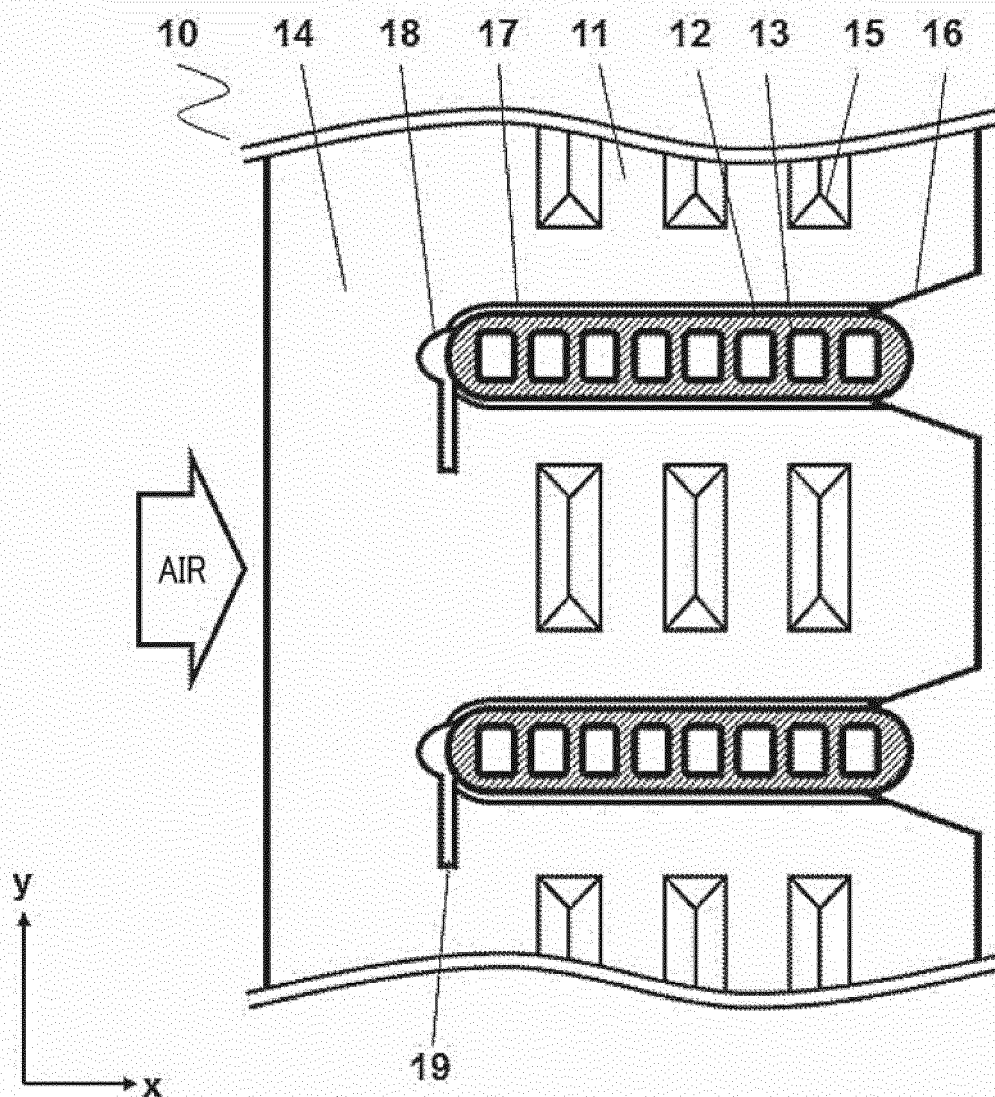
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT
- 19 DRAIN CUTOUT

FIG.15



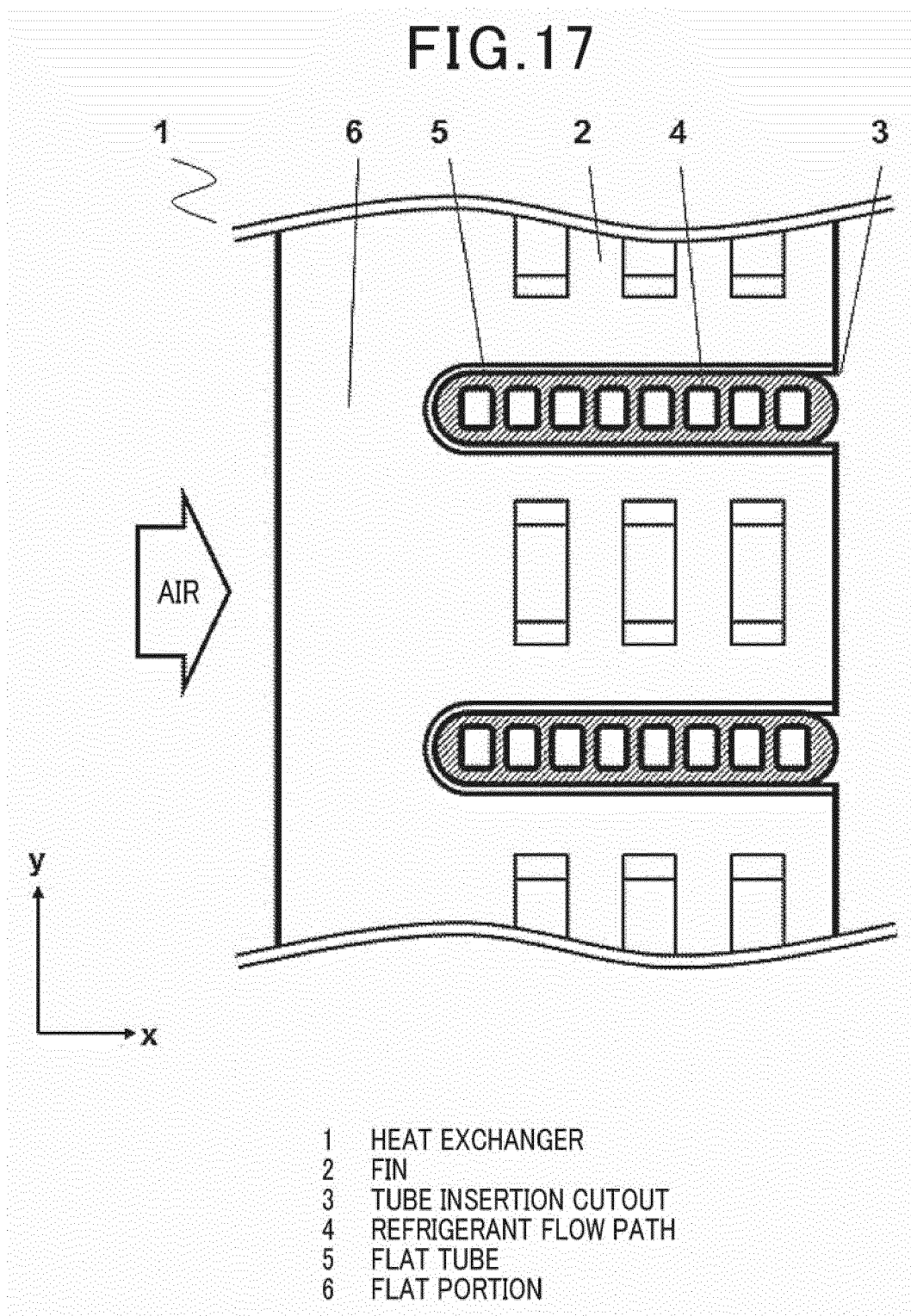
- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT
- 19 DRAIN CUTOUT

FIG.16



- 10 HEAT EXCHANGER
- 11 FIN
- 12 FLAT TUBE
- 13 REFRIGERANT FLOW PATH
- 14 FLAT PORTION
- 15 HEAT CONDUCTION PROMOTING PORTION
- 16 TUBE INSERTION CUTOUT
- 17 COLLAR PORTION
- 18 FRONT EDGE CUTOUT
- 19 DRAIN CUTOUT

FIG.17



REFERENCES CITED IN THE DESCRIPTION

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