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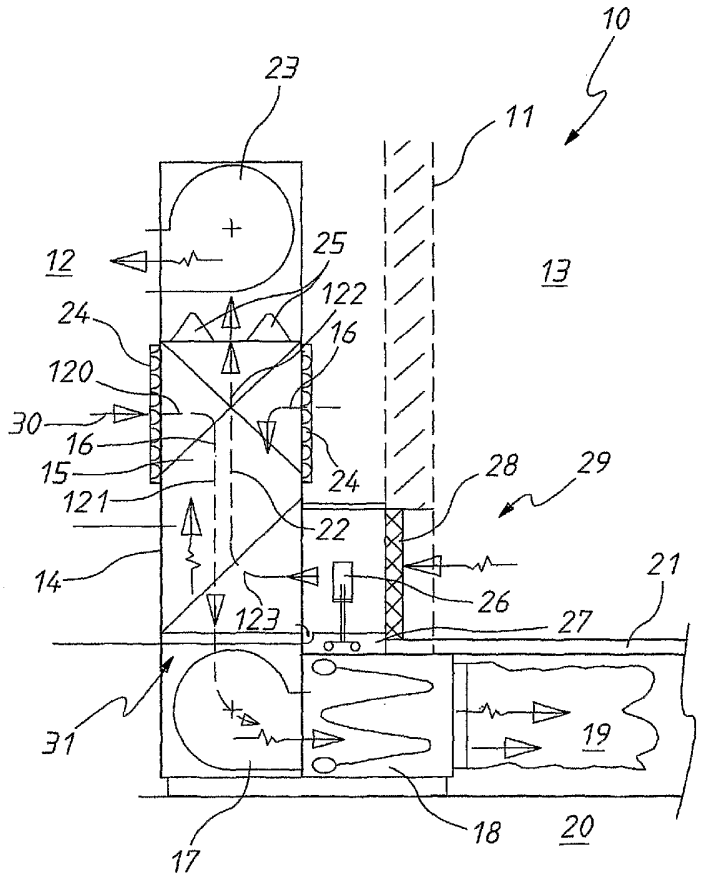

(57) Abstract: A heat exchanger (15) comprising a plurality of generally parallel passages through which air is to pass in a first direction through a first set of passages (16) and in an opposite direction to said first direction through a second set of said passages (22), the passages of said first set (16) being located adjacent the passages of said second set (22). The heat exchanger (15) further comprising sheet material that separates the first set (16) from the second set (22), and provides for the transfer of heat between said first set (16) and said second set of passages (22).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

A HEAT EXCHANGER

Technical Field

The present invention relates to heat exchangers and more particularly but not exclusively to heat exchangers employed in air conditioning apparatus, the heat exchangers including sensible and enthalpy heat exchangers.

Background of the Invention

Described in Australian Patent Application Nos. 200140356, 2003204948 and 2004903172 as well as International Application PCT/AU2004/000103 are various heat exchangers and air conditioning apparatus. In respect of these heat exchangers, it can be noted they are enthalpy and sensible heat exchangers with parallel co-extensive passages. The passages are linear and are divided by sheet material that provides for the transfer of heat between air moving through adjacent passages.

The above mentioned air conditioning apparatus includes devices that treat the air prior to it entering and/or after it has left the heat exchanger. As these heat exchangers are typically used for offices and class rooms, it is preferable that they project horizontally as least as possible. This has necessitated the heat exchanger having inlet and outlet chambers that increase the height and/or horizontal width of the air conditioning apparatus. This is a distinct disadvantage as is preferable the apparatus occupy a smaller volume as possible.

To ensure air passing through the passages has the same dwell time the passage are co-extensive and linear.

Object of the Invention

It is the object of the present invention to overcome or substantially ameliorate the above disadvantage.

Summary of the Invention

There is disclosed herein a heat exchanger including:

a plurality of generally parallel passages through which air is to pass in a first direction through a first set of said passages and in an opposite direction to said first direction through a second set of said passages, the passages of said first set being located adjacent the passages of said second set;

sheet material separating the first set from the second set, and providing for the transfer of heat between said first set and said second set of passages; and wherein

the passages of at least one of the sets each have a first length, the first lengths including co-extensive length portions, and a second length with the air passing through the passages changing in direction when passing between the first and second lengths, and said apparatus includes flow restriction means in at least some of the passages of said at least one of the sets.

Preferably, the flow restriction means are arranged so that the time required for air to pass through the passages of the at least one set is substantially the same.

Preferably, the first lengths extend longitudinally generally normal to the second lengths, with the first lengths being joined to the second lengths by arcuate portions.

Preferably, the flow restriction means are located in at least some of the arcuate portion.

In an alternative preferred form said flow restriction means are located at end portions of said passages.

Preferably, said heat exchanger is a sensible heat exchanger with said sheet material inhibiting the transfer of moisture between the sets.

Preferably, said sheet material is foil or plastic material film.

Preferably, said heat exchanger is an enthalpy heat exchanger with said sheet material provides for the transfer of moisture between the sets.

Preferably, said sheet material is paper or cloth.

Preferably, said heat exchanger includes a plurality of stacked frames, each frame providing a respective one of the sets, with adjacent frames being separated, and each frame includes a plurality of generally parallel walls separating the passages.

Preferably, sheet materials separate the frames.

Preferably, each passage has a substantially constant transverse cross-section, with the flow restriction means being a reduction in the cross section.

There is further disclosed herein a frame being generally planar and including a plurality of generally parallel walls that are transversely spaced to provide a plurality of passages through which air passes to pass through the frame, each passage including a first length that extends to a second length with the first lengths having co-extensive portions, and wherein the first lengths are longitudinally inclined to the second lengths, and at least some of the passages have a flow restriction means.

Preferably, each passage has a substantially constant cross-section, with the flow restriction means being a reduction in the cross-section.

Preferably, the flow restriction means is a projection that projects into the passages to reduce the transverse cross section thereof.

In another preferred form, the flow restriction means is a web that varies thickness and that extends across said walls.

Preferably, said frame is moulded from plastics material.

Preferably, said first lengths extend at approximately 90° to said second lengths.

Preferably, the parallel walls are joined by longitudinal end walls so that in transverse cross section the parallel walls and end walls are of a sinusoidal configuration.

Preferably, the flow restriction means aid in maintaining equal dwell time for air passing through the co-extensive portions.

There is further disclosed herein an air conditioning apparatus including:

a hollow body having a longitudinal side extending between opposite first and second sets;

a heat exchanger located in said body between said ends, the heat exchanger including a first set and a second set of passages, with each passage having an inlet opening and an outlet opening, with the inlet openings of each set being adjacent so as to be arranged in a group, each group being located adjacent said side so that the passages extending from the inlet openings thereof toward said first end, and the passages of said second set extending from the inlet openings thereof to said second end;

a first fan, said first fan being at said first end and drawing air from first set of passages;

a second fan, said second fan being located at said second end and drawing air from said second set of passages; and wherein

said first set of passages are provided to take air from within a room, with the air then being delivered by said first fan to outside the room, and said second set of passages being provided to take air from outside the room, which air is then delivered by said second fan to said room.

Preferably, said inlet openings are located in a plane, said plane being generally parallel to said side.

Preferably, a filter is located to filter air delivered to said first set of passages.

Preferably, said side is provided with a panel displaceable to provide access to said filter.

Preferably, said housing has a first inlet extending to a first duct, said first duct extending to the inlet openings of said first passages.

Preferably, said housing has an outlet through which air is delivered to said room, said outlet communicating with said first fan.

Preferably, said body has a further inlet that delivers air to a further duct, said further duct providing air to said second set passages.

There is further disclosed herein an installation including:

a building having a room and an enclosed roof cavity; and

an air conditioning apparatus including a heat exchanger having a first set of passages and a second set of passages, the passages being arranged for heat transfer between the two sets, said first set extending from an inlet that receives air from the room to an outlet communicating with said cavity, with said second set extending from an inlet positioned outside said cavity and room to an outlet delivering air to said room, and water delivery means to deliver water to said first set to cool the air passing therethrough to thereby cool air passing through said second set so that cooled air is delivered to said room.

Preferably, said water delivery means includes a nozzle assembly to deliver a water mist to said first set.

Preferably, said water delivery means includes a pad to which water is delivered and through which air passes to be delivered to said first set so that air leaving said pad is cooled.

Preferably, said pad saturates air passing therethrough.

Preferably, said heat exchanger is a sensible heat exchanger.

Preferably, said air conditioning apparatus includes a heating means is operable to heat the air delivered to said room from the second set.

Preferably, said heating means includes tubes through which heated water passes.

Preferably, said installation further includes a solar hot water heater that delivers heated water to said heating means.

Preferably, said installation includes a first fan to cause air to pass through said first set and a second fan to cause air to pass through said second set.

Preferably, the fans are driven by electric motors.

Preferably, said installation includes a solar cell assembly that delivers electric current to the fans to drive the fans.

There is further disclosed herein an air conditioning apparatus including:

a hollow body having an upper end and a lower end;

a heat exchanger located in the body between said ends, the heat exchanger including a first set and a second set of passages, the passages being arranged for heat transfer between the two sets, each set extending from an air inlet to an air outlet, with the inlet of said first passages being higher than the outlet of said first passages;

means to deliver water to the inlet of said first set to cool air passing from the first set inlet to the first set outlet; and

water collection means to collect any water leaving the first set outlet.

Preferably, a pump means to deliver the water from the water collection means to said water delivery means.

Preferably, said water delivery means is a spray nozzle assembly.

Preferably, said water delivery means includes a pad, with air passing through said pad and then a water droplet stream issuing from said nozzle assembly with the air then delivered to said first set inlet.

There is further disclosed herein an installation including:

a building including a room;

the above air conditioning apparatus, and wherein;

said first set inlet receives air from said room and said first set outlet delivers air to outside said room, and said second set inlet receives air from outside said room and said second set outlet delivers air to said room so that air delivered to said room is cooled by air passing through said first set.

Preferably, said installation includes a ceiling cavity, and air from said first set outlet is delivered to said cavity.

Brief Description of the Drawings

Preferred embodiments of the present invention will now be described by way of example with reference to the accompanying drawings wherein:

Figure 1 is a schematic side elevation of an air conditioning apparatus employing a heat exchanger;

Figure 2 is a schematic side elevation of a second air conditioning apparatus employing a heat exchanger:

Figure 3 is a schematic side elevation of a third air conditioning apparatus employing a heat exchanger:

Figure 4 is a schematic sectioned side elevation of a fourth air conditioning apparatus;

Figure 5 is a schematic side elevation of a fifth air conditioning apparatus of Figure 5;

Figure 6 is an isometric view of portion of the heat exchangers employed in the apparatus of Figures 1 to 5;

Figure 7 is a schematic plan view of a frame employed in the heat exchanger of the apparatus of Figure 1 to 5;

Figure 8 is a schematic side elevation of the frame of Figure 7;

Figure 9 is a schematic end elevation of the frame of Figure 7;

Figure 10 is a schematic plan view of portion of the frame of Figure 7;

Figure 11 is a schematic sectioned side elevation of a sixth air conditioning apparatus;

Figure 12 is a schematic side elevation of a modification of the air conditioning apparatus of Figure 11;

Figure 13 is a schematic top plan view of the air conditioning apparatus of Figures 11 and 12;

Figure 14 is a schematic sectioned side elevation of a modification of the air conditioning apparatus of Figure 11;

Figure 15 is a schematic sectioned side elevation of a modification of the air conditioning apparatus of Figure 11;

Figure 16 is a schematic sectioned side elevation of a modification of the air conditioning apparatus of Figure 11;

Figure 17 is a schematic plan view of a frame employed in the heat exchanger of the apparatus of Figures 1 to 5 or Figures 11 to 16;

Figure 18 is a schematic end elevation of the frame of Figure 17;

Figure 19 is a schematic sectioned illustration of a house employing the air conditioning apparatus of Figure 1;

Figure 20 is a schematic sectioned side elevation of an installation including a building and an air conditioning apparatus therefore; and

Figure 21 is a schematic sectioned side elevation of the air conditioning apparatus of Figure 20.

Detailed Description of the Preferred Embodiments

In Figure 1 there is schematically depicted an air conditioning apparatus 10. The apparatus 10 is installed adjacent a room wall 11 separating the exterior 12 from the interior of a room 13. The apparatus 10 includes a hollow housing 14 within which there is located a heat exchanger 15. The heat exchanger 15 may be a sensible heat exchanger or an enthalpy heat exchanger. The heat exchanger 15 includes a plurality of first passages 16 that receive air from the exterior 12 and deliver the air to a fan 17. The fan 17 creates the pressure difference to draw air from the exterior 12 and deliver the air to a heater 18. Typically the heater 18 is a gas heater. Air passing through the heater 18 is then delivered to an air duct 19 located between the ground 20 and the floor 21 of the room 13. The duct 19 would extend to air outlets communicating with the room 13.

The heat exchanger 15 has second passages 22 that are located adjacent the passages 16 so that heat can be transferred therebetween. The passages 22 extend from an air inlet 29 taking air from the room 13, and deliver air to a fan 23 that exhausts the air to the exterior 12. The fan 23 creates the pressure difference to draw air into the passages 22. The passages 16 receive air from filters 24.

Located above the heat exchanger 15, and more particularly above the upper extremities of the passages 22 are spray nozzles 25 that deliver water in droplet form to the interior of the passages 22 to thereby aid in cooling air passing through the passages 16. Water is delivered to the nozzles 25 by a pump 26 drawing water from a reservoir 27. The reservoir 27 would receive excess water exiting the lower end of the passages 22, with the reservoir being topped up by water delivered from a mains supply. As an alternative to or in addition to the nozzles 25 there is provided an evaporative cooling pad 28. The pad 28 would receive water from the pump 26.

In operation of the above described apparatus 10, air passing through the passages 22 is cooled by water via the nozzles 25 and/or pad 28. Accordingly this cool air passing through the passages 22 cools the air passing through passages 16, which is

delivered to the room 13. If so required, the air temperature can be raised by means of selective operation of the heater 18.

As a particular example, the heat exchanger 15 could be a sensible heat exchanger. Accordingly, water is not transferred to the passages 16 from the passages 22. As one specific example air entering the inlet 29 would be approximately 24°C and 16.4°C wet bulb in temperature. Air exiting the fan 23 would be approximately 17°C. Air entering the passages 16 would be approximately 40°C and 21.6°C wet bulb. Air passing through the passages 22 would become saturated and have a temperature of approximately 17°C. Water would be at approximately 17°C and air delivered to the duct 19 would be 17°C and 13.9°C wet bulb. Air flows would be in the vicinity of 800 to 2000 litres per second, but could be higher to suit other units.

The air conditioning apparatus of Figure 2 is a modification of the apparatus 10. The apparatus 50 of Figure 2 is associated with a wall 51 separating a room 52 from the exterior 53. The apparatus 50 includes a housing 54 that contains a heat exchanger 55. The heat exchanger 55 would be a sensible heat exchanger however the apparatus 50 could also be adapted so that the heat exchanger 55 is an enthalpy heat exchanger in which case the nozzles 55 would be omitted together with pad 28.

The heat exchanger 55 has first passages 56 that take air from the exterior 53 and deliver it to a fan 57. The fan 57 provides a pressure differential to draw air through the passages 56. The air from the fan 57 is delivered to a heating or cooling coil 58 through which a refrigerant is passed and is either expanded or allowed to condense to heat or cool the air passing therethrough. Air leaving the coil 58 is delivered to a duct 59. The duct 59 would deliver air to the interior of the room 52.

The heat exchanger 55 includes second passages 60 that take air from an inlet 61 in the room 52. Air leaving the passages 60 is delivered to a coil 68. The coil 68 could be a condenser coil that is cooled by air passing therethrough. Typically the coil 68 would be operatively associated with the coil 58 together with an expansion valve and compressor 64. Air leaving the coil 68 is taken by the fan 62 and delivered to the exterior 53. The fan 62 provides the pressure differential to take air from the room 52 and deliver to the exterior 53. The passages 56 and 60 are located adjacent each other so as to provide for heat transfer therebetween. In this particular embodiment, the heat exchanger 55 is a sensible heat exchanger and therefore there is no moisture transfer between the passages 55 and 60.

Located above the passages 60 are spray nozzles 63 that deliver water in droplet form to the upper end of the passages 60 so that the water flows down the passages 60 to aid in cooling the air passing therethrough and therefore cooling the air passing through the passages 56. Water for the nozzles 63 is provided by a pump 65 taking water from a reservoir 66. Water in the reservoir 66 is provided by water passing through the lower end of the passages 60 as well as water from a mains supply. In an alternative arrangement the nozzle 63 could be located adjacent the inlet 61.

Typically, the passages 56 would receive air from a filter 67.

If the above described heat exchanger 55 is an enthalpy heat exchanger then there would be water transfer between the passages 55 and 60.

In Figure 3 there is schematically depicted a further air conditioning apparatus 70. The apparatus 70 includes a housing 71 containing a heat exchanger 72. The heat exchanger 72 provides passages 73 to take air from a room 74 and delivers the air to a fan 75. The fan 75 provides the pressure differential to draw air through the passages 73 and deliver it under pressure to a condenser coil 76. The heat exchanger 72 provides further passages 77 that are in contact with the passages 73 to provide for the transfer of heat therebetween. In this example, the heat exchanger 72 would be an enthalpy heat exchanger and therefore there is moisture transfer between the passages 73 and 77. The passages 77 take air from the interior 74 and deliver it to a fan 79.

The fan 79 provides the pressure gradient to draw air in through the passages 77 and deliver the air under pressure to an evaporative coil 80. Air passes through the evaporative coil 80 to be delivered to the interior of the room 74. A compressor 81 is operatively associated with the coils 76 and 80 so as to pass a refrigerant therethrough.

If so required, the fan 75 can also take air from the exterior 78 via an inlet 82.

In the above described preferred embodiment, air leaving the room 74 via the passages 73 is cooled and cools air passing through the passages 77. This air is further cooled by the evaporative coil 80 if so required. Air leaving the passages 73 and delivered to the coil 76 by the fan 75 aids in heating the refrigerant passing through the condenser coil 76.

Figure 4 shows a further embodiment of the present invention. More particularly, Figure 4 shows an air conditioning apparatus 80 having a housing 81 within which there is located a heat exchanger 83. The heat exchanger 83 provides passages 84 that take air from the exterior 85 and deliver it to a fan 86. The fan 86 provides the

pressure gradient to draw air in through the passages 84 and deliver the air to a heater, such as a gas heater 87. Air leaving the gas heater 87 is delivered to a duct 88 extending to a room 89. The heat exchanger 83 has further passages 90 that take air from the room 89 through an evaporative cooling pad 91. Air from the passages 90 is delivered to a fan 92 that provides the pressure gradient to draw air through the passages 90 and deliver the air to an outlet 93 to the exterior 85. The outlet 93 could deliver air to the roof space of a building to aid in cool the room balance.

A nozzle 94 delivers water droplets to the extremities of the passages 90 so that the water droplets enter the passages 90 to thereby cool the air passing through the passages 90. The heat exchanger 83 is a sensible heat exchanger.

In operation of the above described apparatus 80, air being delivered to the room 89 is at least partly heated by the air passing through the passages 90 and if so required is further heated by the heater 87. Moisture is added to the air via the nozzle 94, with no moisture transfer taking place from the passages 90 to the passages 84.

In Figure 5 a further embodiment is illustrated. This embodiment is an air conditioning apparatus 100 including a housing 101. The housing 101 contains a heat exchanger 102. The heat exchanger 102 provides passages 103 that take air from the exterior 104 and deliver the air to a fan 105. The fan 105 provides the pressure gradient to draw air through the passages 103 and deliver the air to a heater, such as a gas heater 106. The gas heater 106 having a flue 107. Air leaving the heater 106 is delivered to a room 108.

The heat exchanger 102 has further passages 109 that take air from the room 108 through a cooling evaporative pad 110. The pad 110 receives water from a pump 111 taking water from a reservoir 112. The reservoir 112 would receive water from a mains supply.

Air is drawn through the passages 109 by a fan 113 that delivers the air to the exterior 104. Located at the extremity of the passages 109 are nozzles 114 that deliver water in droplet form to the passages 109.

Preferably, the heat exchanger 102 is a sensible heat exchanger and therefore there is no moisture transfer from the passages 109 to the passages 103. Any water finding its way through the passages 109 is delivered to the reservoir 112.

Each of the heat exchangers 15, 55, 72, 83 and 102 are of a similar construction, however the sheet material employed therein will determine whether they are an enthalpy

heat exchanger or a sensible heat exchanger. As can be noted from the Figures, each of these heat exchangers has its passages of a configuration 20 that air passing therethrough changes direction. For example in the embodiment of Figure 1, each of the passages 16 provides a first length 120 that is generally normal to a second length 121. In respect of the passages 22, they have a first length 122 and a second length 123 generally normal to the first length 122. The lengths 121 and 122 have co-extensive portions. The heat exchanger 55 is of a substantially similar construction.

In the embodiment of Figure 3, again air passing through the passages 73 changes direction as does air passing through the passages 77. However, the passages 77 and 73 have co-extensive portions.

In the embodiment of Figure 4, still again air passing through the passages 84 and 90 changes direction with the passages 84 and 90 having co-extensive portions. The same can be said for the heat exchanger of Figure 5.

Each of the above described heat exchangers consists of a stack of frames 120 (Figure 7). Each frame 120 is moulded from plastics material and includes a plurality of parallel walls 124 (Figure 6) that form a "sinusoidal" arrangement so that the walls 124 are joined by end walls 129. Accordingly a plurality of pockets 130 are provided, which pockets 130 provide the longitudinally extending previously mentioned passages 16, 22, 56, 60, 73,77, 84, 90, 103 and 109. The frame 120 has the walls 124 arranged so as to provide first lengths 125 that extend to second lengths 126 via arcuate portions 127.

The walls 124 are held in a generally spaced parallel relationship by cross braces 128.

As mentioned previously, the frames 120 are stacked. Located between the frames 120 is sheet material such as foil or paper as discussed previously depending on whether the heat exchanger is a sensible or enthalpy heat exchanger.

The frames 120 are of two configurations, that is frames 131 and 132. The frames 132 have recesses 133 that are engaged by projections 134. The sheet material 135 is located therebetween and secured in position by being pinned in the recesses 133 by the projections 134. In this respect it should be noted that the pockets 130 have an open length that is closed by the sheet material 135. For a sensible heat exchanger the material 135 would prevent moisture transfer, while if an enthalpy heat exchanger, moisture transfer can take place. If an enthalpy heat exchanger the material 135 would be paper or cloth.

As the first lengths 125 are inclined to the second lengths 126, the lengths 125 and 126 vary in length. For example, the first length 125 adjacent the side frame member 136 is longer than the first length 125 adjacent the frame member 137. In respect of the lengths 126, they increase in length toward the side frame member 138. To ensure equal dwell time in respect of air passing through the passages provided with the lengths 125 and 126 there are provided flow restriction devices 139. Accordingly, air takes the same time to pass through the frame 120 irrespective of which passage the air is traveling through. Accordingly the flow restrictors 139 vary in the degree they restrict air flow, for example there are no flow restrictors in respect of the passages adjacent the side frame member 136 while adjacent the side frame member 137 there is maximum restriction to slow the air flow.

The frame 120 is generally planar and is formed of plastics material with the flow restriction devices 139 being projections that project into the passages to reduce the transverse cross section thereof. In this respect the passages are of substantially constant transverse cross section throughout their length.

The first lengths 125 have co-extensive portions 140.

In respect of each of the above described heat exchangers, each heat exchanger is provided by a stack of frames 120. Each of the frames 120 provides for the flow or air in a particularly direction only. Adjacent frames 120 have air flowing in opposite directions so that heat and optionally moisture is transferred between the passages of adjacent frames. The heat and moisture transfer taking place through the sheet material 135. Accordingly each frame 120 provides a set of passages that are essentially located in a single plane. Accordingly in respect of each set the air travels in the same direction.

Each end of each passage is provided with an opening. In respect of the passages providing for the flow of air in a particular direction, the inlet openings are generally planar as are the outlet openings. For example, in respect of the embodiment of Figure 1 the passages 16 have openings at the inlet 130, which openings are generally coplanar. Again in respect of the passages 16, the openings at the outlet 31 are also generally coplanar. The same can be said for the inlet and outlet openings for the passages 22.

In Figure 11 there is schematically depicted an air conditioning apparatus 178. The apparatus 178 is intended to be located adjacent a ceiling 141 of a room 142 having an external wall 143. The apparatus 178 includes a horizontally elongated hollow housing 144 containing a heat exchanger 145. The heat exchanger 145 may be a sensible

heat exchanger or an enthalpy heat exchanger. The heat exchanger 145 includes a plurality of first passages 146 that receive air from the exterior 147 and deliver air to a fan 148. The fan 148 creates the pressure difference to draw air from the exterior 147 and cause it to flow through the heat exchanger 145, and past a coil 149 that may be part of a reverse cycle air conditioning system. The coil 149 may also heat or cool air passing therethrough with the use of hot or cold water.

The heat exchanger 145 has second passages 150 that are located adjacent the passages 146 so that heat can be transferred therebetween. The passages 150 extend from an air inlet 151 taking air from the room 142, and deliver air to a fan 152 that exhausts the air to the exterior 147. The fan 152 creates the pressure difference to draw air from the room 142 and deliver the air to the exterior 147.

The passages 150 have inlets along the horizontal length 153 of the heat exchanger 145, while the passages 146 have inlet openings along the length 154. In both instances the inlet openings of the lengths 153 and 154 are downwardly facing and arranged in a generally horizontal plane.

The inlet 151 is a grid that provides for the delivery of air to the inlet openings of the length 153.

The inlet openings of the passages 146 receive air from a duct 155 extending to an inlet 156 again provided by a grid. The inlet 156 communicates with the exterior 147.

If so required, air leaving the passages 146 may be supplemented by air entering via passage 157 communicating with the interior 142.

The divider 158 and blade 179 separate the duct 159 from the duct 155.

In the above described embodiment of Figure 11, the air conditioning apparatus 178 is located adjacent the ceiling 141 and is generally horizontally elongated. In operation of the apparatus 178, air delivered to the room 142 from the fan 148 can be heated or cooled by the coil 149.

Preferably, a filter 160 is provided to filter air entering the passages 146 and 150. The filter 160 would cover the lengths 153 and 154. As seen in Figure 11, in this embodiment the filter 160 angles downwardly below the length 153.

The filter 160 has a blade 179 that abuts the divider 158.

In the embodiment of Figure 12, the air conditioning apparatus 140 is located above the ceiling 141 so as to be located in a roof cavity. Accordingly the fan 152 would

deliver air to a duct 161 extending to the exterior 147. A duct 162 would extend from the exterior 147 to the inlet 156. A duct 163 would extend to the room 142.

In the apparatus of Figures 11 to 13, preferably the housing 144 would have a removable panel 161 providing access to the filter 160.

The embodiment of Figure 14 is particular a modification of the embodiment of Figure 11. In the embodiment of Figure 14 the coil 149 has been removed.

The embodiment of Figure 15 is essentially a modification of the embodiment of Figure 14 however the coil 149 has been removed. The embodiment of Figure 16 is a still further modification of the embodiment of Figure 12. In this embodiment the fan 148 exhausts downwardly to the interior of the room 142.

In the embodiments of Figures 11 to 16 the inlet grid 151 is removable enabling removal of the filter.

In Figures 17 and 18 there is schematically illustrated a modification of the frame of Figure 7. In this embodiment the frame 120 does not have the restriction devices 139. Instead the embodiment of Figures 17 and 18 has an end web 164 that varies in thickness so as to taper from the frame member 137 to the frame member 136. Accordingly the web 164 provides a varying resistance to the air passing through the previously mentioned passages 16, 22, 56, 60, 73, 77, 84, 90, 103 and 109. That is the inlet apertures vary in size to ensure equal dwell time in respect of air passing through the total length, the lengths 125 and 126. Accordingly air takes the same time to pass through the frame 120 irrespective of which passage the air is traveling through.

In Figure 19 there is schematically depicted a house 170. The house 170 has walls 171, a floor 172, a ceiling 173 and a roof 174. Located between the roof 174 and ceiling 173 is a roof cavity 175. The house 170 includes the air conditioning apparatus of Figure 1 or 2. However the apparatus 10, 50 exhausts air through a duct 176 extending to the roof cavity 175 so that air is delivered thereto to cool or heat the roof cavity 175.

The duct 19 delivers air to outlets 177 so that conditioned air is delivered to the interior of the house 170.

In Figures 20 and 21 there is schematically depicted an installation 200. The installation 200 includes a building 201, the building 201 having a room 202 beneath a ceiling cavity 203. The ceiling cavity 203 is located between a ceiling 204 and a roof 205. Mounted on the roof 205 is a solar cell assembly 206 that produces an electric current, and a solar water heater assembly 207 that provides heated water.

The room 204 has a wall 208 upon which there is mounted an air conditioning apparatus 209.

The apparatus 209 includes a hollow body 210 within which there is located a heat exchanger 211. The heat exchanger 211 is similar to the heat exchangers previously provided in that it includes a first set of passages 212 and a second set of passages 213, with the passages 212 and 213 being arranged for heat transfer therebetween.

The first set 212 has an inlet 214 from which the passages 212 extend downwardly to an outlet 215. The second set 213 has an inlet 216 from which the passages 213 extend upwardly to an outlet 217. Adjacent the outlet 217 is a heater 218. In this embodiment the heater 218 is a plurality of tubes that receive heated water from the solar hot water heater 207.

Adjacent the inlet 214 is a water delivery means 219 that includes a pad 220 to which water is delivered. Adjacent the pad 220 is a nozzle assembly 221 that delivers a stream of water droplets 222 to an area adjacent the inlet 214 so that air passing from the room 202 to the inlet 214 becomes saturated with water. Accordingly air passing through the first set 212 cools air passing through the set 213.

The cooled air leaving the outlet 217 is delivered to the room 202 via a fan 223.

A fan 224 draws air through the passages 212 to deliver the cooled air to the ceiling cavity 203.

Located below the outlet 212 is a water collection means 225 that includes a tray 226 from which water is taken via a pump 227. The pump 227 delivers the water to the pad 220 and nozzle assembly 221. Accordingly the water collected in the tray 226 is cooled. The inlet 216 receives air from an inlet duct 228 that takes air from the outside environment, that is, the space 229 outside the room 202.

The fans 223 and 224 as well as the pump 227 receive electric current from the solar cell assembly (photo voltaic cell assembly) 206.

As can be appreciated from the above, air being delivered to the room 202 by the fan 223 can be cooled by the heat exchanger 212 or heated by the heater 218.

Cool air delivered to the ceiling cavity 203 is allowed to pass through the cavity 203 by the use of vents 229.

CLAIMS:

1. A heat exchanger including:

a plurality of generally parallel passages through which air is to pass in a first direction through a first set of said passages and in an opposite direction to said first direction through a second set of said passages, the passages of said first set being located adjacent the passages of said second set;

sheet material separating the first set from the second set, and providing for the transfer of heat between said first set and said second set of passages; and wherein

the passages of at least one of the sets each have a first length, the first lengths including co-extensive length portions, and a second length with the air passing through the passages changing in direction when passing between the first and second lengths, and said apparatus includes flow restriction means in at least some of the passages of said at least one of the sets.

2. The heat exchanger of claim 1, wherein the flow restriction means are arranged so that the time required for air to pass through the passages of the at least one set is substantially the same.

3. The heat exchanger of claim 1 or 2, wherein the first lengths extend longitudinally generally normal to the second lengths, with the first lengths being joined to the second lengths by arcuate portions.

4. The heat exchanger of claim 1, 2 or 3, wherein the flow restriction means are located in at least some of the arcuate portion.

5. The heat exchanger of claim 1, 2 or 3, wherein said flow restriction means are located at end portions of said passages.

6. The heat exchanger of claims 1 to 5, wherein said heat exchanger is a sensible heat exchanger with said sheet material inhibiting the transfer of moisture between the sets.

7. The heat exchanger of claim 6, wherein said sheet material is foil or plastic material film.

8. The heat exchanger of claims 1 to 5, wherein said heat exchanger is an enthalpy heat exchanger with said sheet material provides for the transfer of moisture between the sets.

9. The heat exchanger of claim 8, wherein said sheet material is paper or cloth.

10. The heat exchanger of any one of claims 1 to 9, wherein said heat exchanger includes a plurality of stacked frames, each frame providing a respective one of the sets, with adjacent frames being separated, and each frame includes a plurality of generally parallel walls separating the passages.

11. The heat exchanger of claim 10, wherein sheet materials separate the frames.

12. The heat exchanger of claims 1 to 11, wherein each passage has a substantially constant transverse cross-section, with the flow restriction means being a reduction in the cross section.

13. A frame for a heat exchanger, the frame being generally planar and including a plurality of generally parallel walls that are transversely spaced to provide a plurality of passages through which air passes to pass through the frame, each passage including a first length that extends to a second length with the first lengths having co-extensive portions, and wherein the first lengths are longitudinally inclined to the second lengths, and at least some of the passages have a flow restriction means.

14. The frame of claim 13, wherein each passage has a substantially constant cross-section, with the flow restriction means being a reduction in the cross-section.

15. The frame of claim 13 or 14, wherein the flow restriction means is a projection that projects into the passages to reduce the transverse cross section thereof.

16. The frame of claim 13 or 14, wherein the flow restriction means is a web that varies thickness and that extends across said walls.

17. The frame of any one of claims 13 or 16, wherein said frame is moulded from plastics material.

18. The frame of any one of claims 13 to 17, wherein said first lengths extend at approximately 90° to said second lengths.

19. The frame of any one of claims 13 to 18, wherein the parallel walls are joined by longitudinal end walls so that in transverse cross section the parallel walls and end walls are of a sinusoidal configuration.

20. The frame of any one of claims 13 to 19, wherein the flow restriction means aid in maintaining equal dwell time for air passing through the co-extensive portions.

21. An air conditioning apparatus including:

a hollow body having a longitudinal side extending between opposite first and second sets;

a heat exchanger located in said body between said ends, the heat exchanger including a first set and a second set of passages, with each passage having an inlet opening and an outlet opening, with the inlet openings of each set being adjacent so as to be arranged in a group, each group being located adjacent said side so that the passages extending from the inlet openings thereof toward said first end, and the passages of said second set extending from the inlet openings thereof to said second end;

a first fan, said first fan being at said first end and drawing air from first set of passages;

a second fan, said second fan being located at said second end and drawing air from said second set of passages; and wherein

said first set of passages are provided to take air from within a room, with the air then being delivered by said first fan to outside the room, and said second set of passages being provided to take air from outside the room, which air is then delivered by said second fan to said room.

22. The apparatus of claim 21, wherein said inlet openings are located in a plane, said plane being generally parallel to said side.

23. The apparatus of claim 21 or 22, wherein a filter is located to filter air delivered to said first set of passages.

24. The apparatus of claim 23, wherein said side is provided with a panel displaceable to provide access to said filter.

25. The apparatus of any one of claims 21 to 24, wherein said housing has a first inlet extending to a first duct, said first duct extending to the inlet openings of said first passages.

26. The apparatus of any one of claims 21 to 25, wherein said housing has an outlet through which air is delivered to said room, said outlet communicating with said first fan.

27. The apparatus of any one of claims 21 to 26, wherein said body has a further inlet that delivers air to a further duct, said further duct providing air to said second set passages.

28. An installation including:

a building having a room and an enclosed roof cavity; and

an air conditioning apparatus including a heat exchanger having a first set of passages and a second set of passages, the passages being arranged for heat transfer between the two sets, said first set extending from an inlet that receives air from the room to an outlet communicating with said cavity, with said second set extending from an inlet positioned outside said cavity and room to an outlet delivering air to said room, and water delivery means to deliver water to said first set to cool the air passing therethrough to thereby cool air passing through said second set so that cooled air is delivered to said room.

29. The installation of claim 28, wherein said water delivery means includes a nozzle assembly to deliver a water mist to said first set.

30. The installation of claim 29, wherein said water delivery means includes a pad to which water is delivered and through which air passes to be delivered to said first set so that air leaving said pad is cooled.

31. The installation of claim 29 or 30, wherein said pad saturates air passing therethrough.

32. The installation of any one of claims 28 to 31, wherein said heat exchanger is a sensible heat exchanger.

33. The assembly of any one of claims 28 to 32, wherein said air conditioning apparatus includes a heating means is operable to heat the air delivered to said room from the second set.

34. The installation of claim 33, wherein said heating means includes tubes through which heated water passes.

35. The installation of claim 34, wherein said installation further includes a solar hot water heater that delivers heated water to said heating means.

36. The installation of any one of claims 28 to 35, wherein said installation includes a first fan to cause air to pass through said first set and a second fan to cause air to pass through said second set.

37. The installation of claim 36, wherein the fans are driven by electric motors.

38. The installation of claim 37, wherein said installation includes a solar cell assembly that delivers electric current to the fans to drive the fans.

39. An air conditioning apparatus including:

a hollow body having an upper end and a lower end;

a heat exchanger located in the body between said ends, the heat exchanger including a first set and a second set of passages, the passages being arranged for heat transfer between the two sets, each set extending from an air inlet to an air outlet, with the inlet of said first passages being higher than the outlet of said first passages;

means to deliver water to the inlet of said first set to cool air passing from the first set inlet to the first set outlet; and

water collection means to collect any water leaving the first set outlet.

40. The apparatus of claim 39, further including a pump means to deliver the water from the water collection means to said water delivery means.

41. The apparatus of claim 39 or 40, wherein said water delivery means is a spray nozzle assembly.

42. The apparatus of claim 40, wherein said water delivery means includes a pad, with air passing through said pad and then a water droplet stream issuing from said nozzle assembly with the air then delivered to said first set inlet.

43. An installation including:

a building including a room;

the air conditioning apparatus of any one of claims 39 to 42, and wherein;

said first set inlet receives air from said room and said first set outlet delivers air to outside said room, and said second set inlet receives air from outside said room and said second set outlet delivers air to said room so that air delivered to said room is cooled by air passing through said first set.

44. The installation of claim 43, wherein said installation includes a ceiling cavity, and air from said first set outlet is delivered to said cavity.

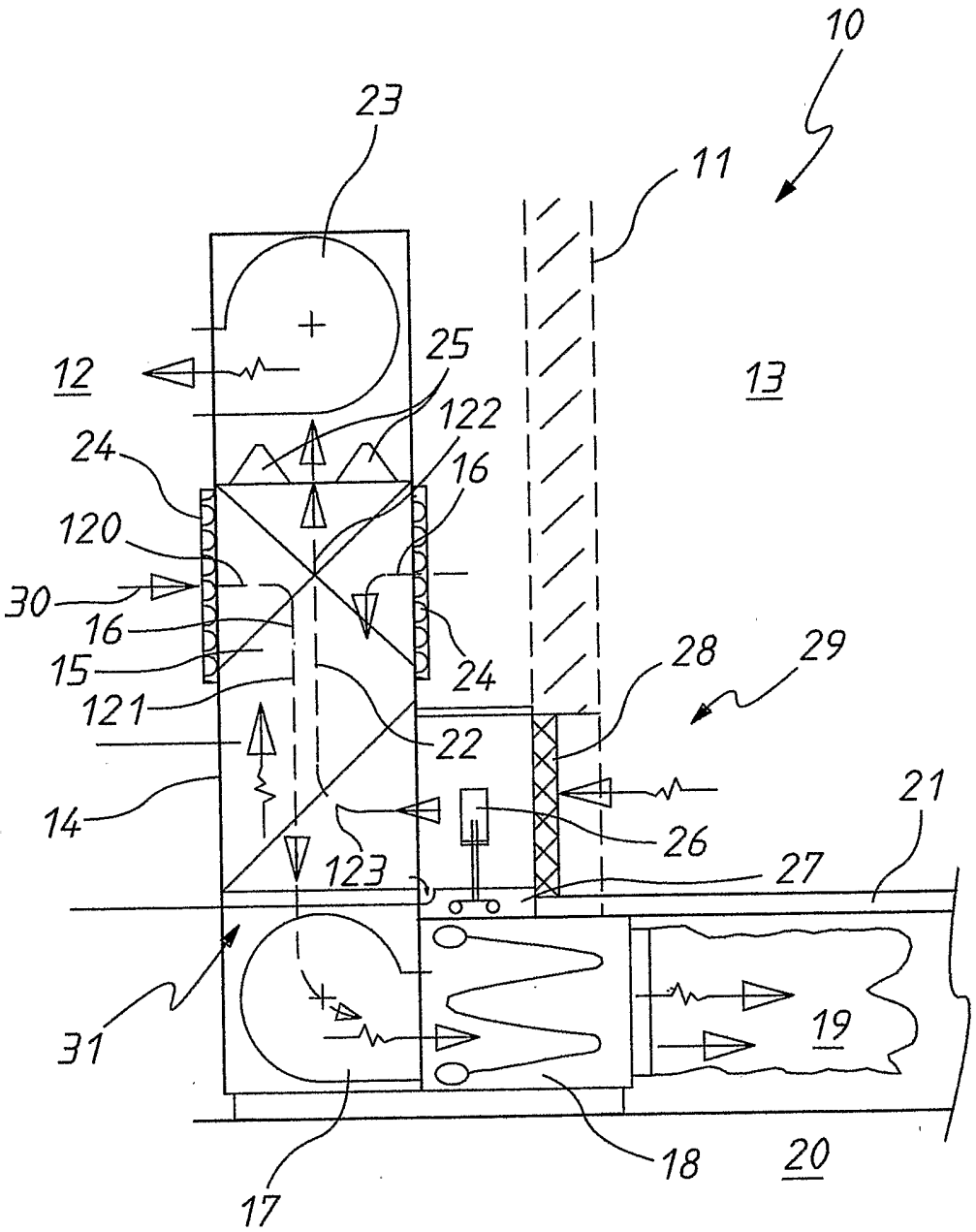
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FIG. 1

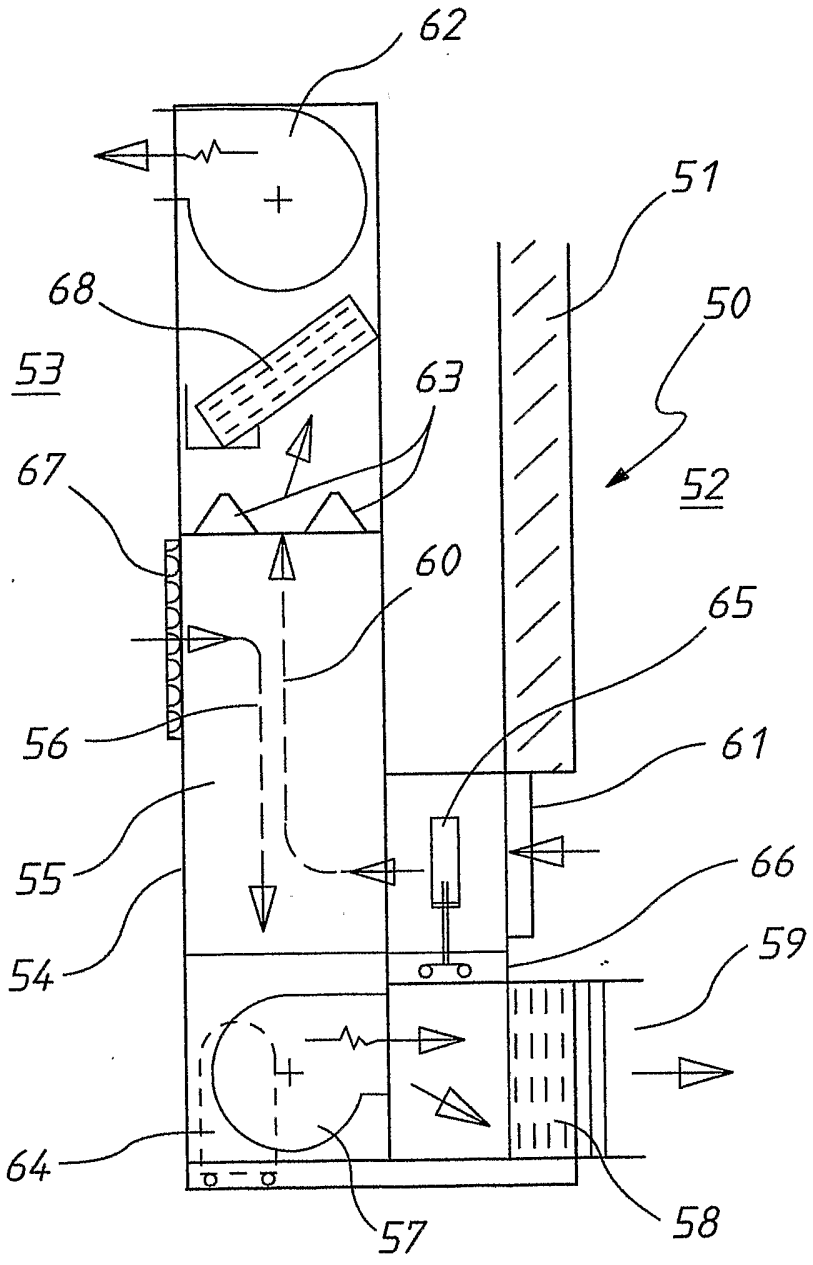

FIG.2

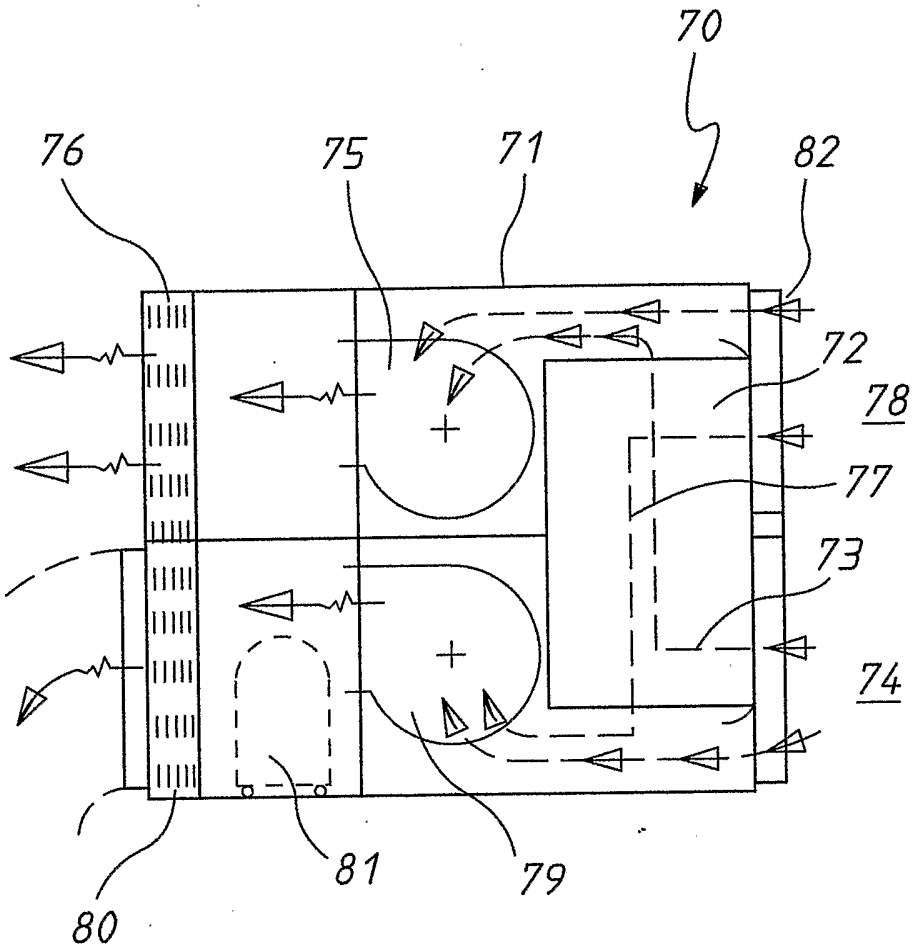

FIG.3

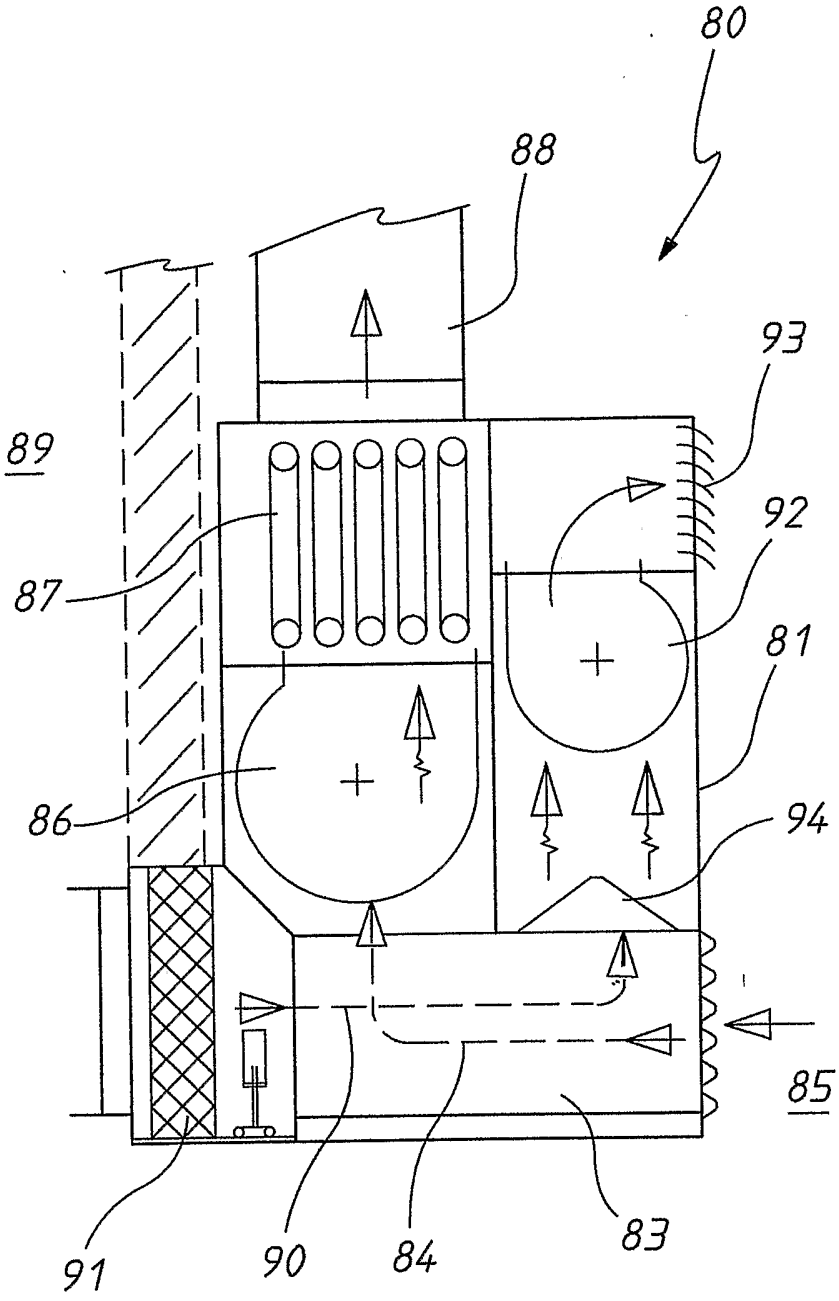

FIG.4

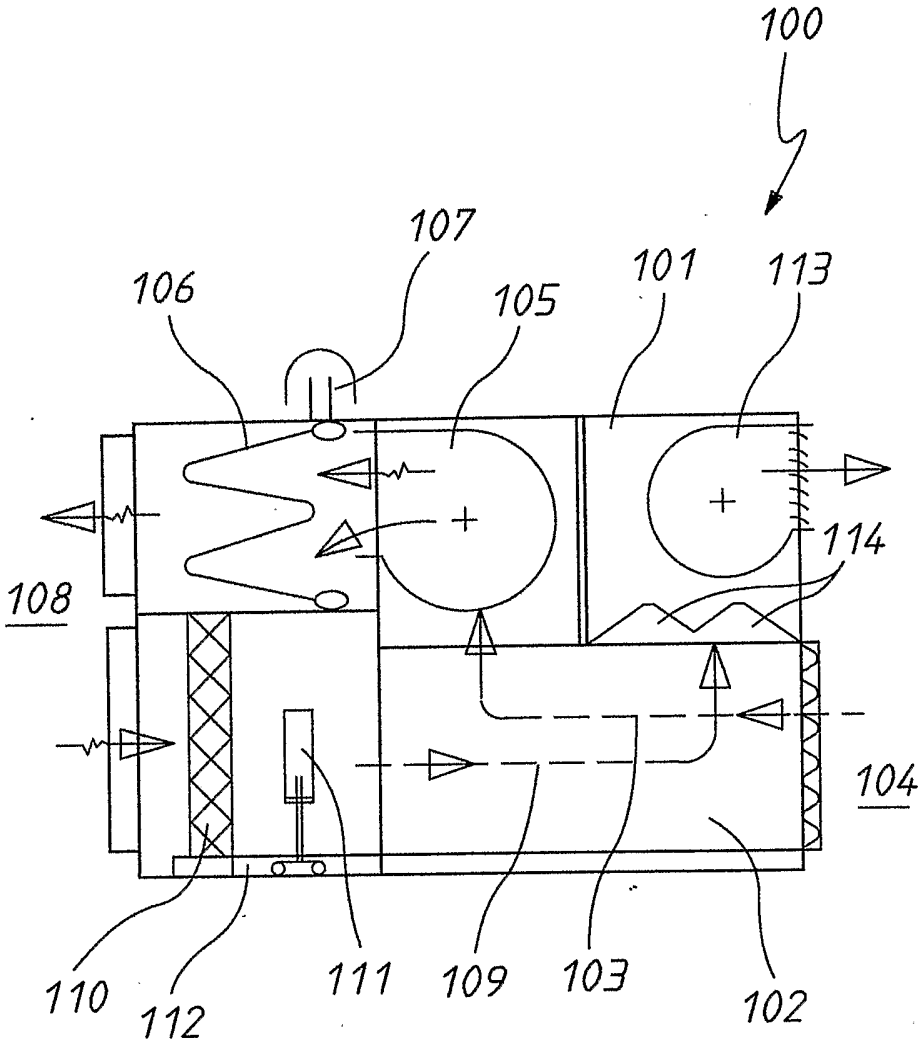

FIG.5

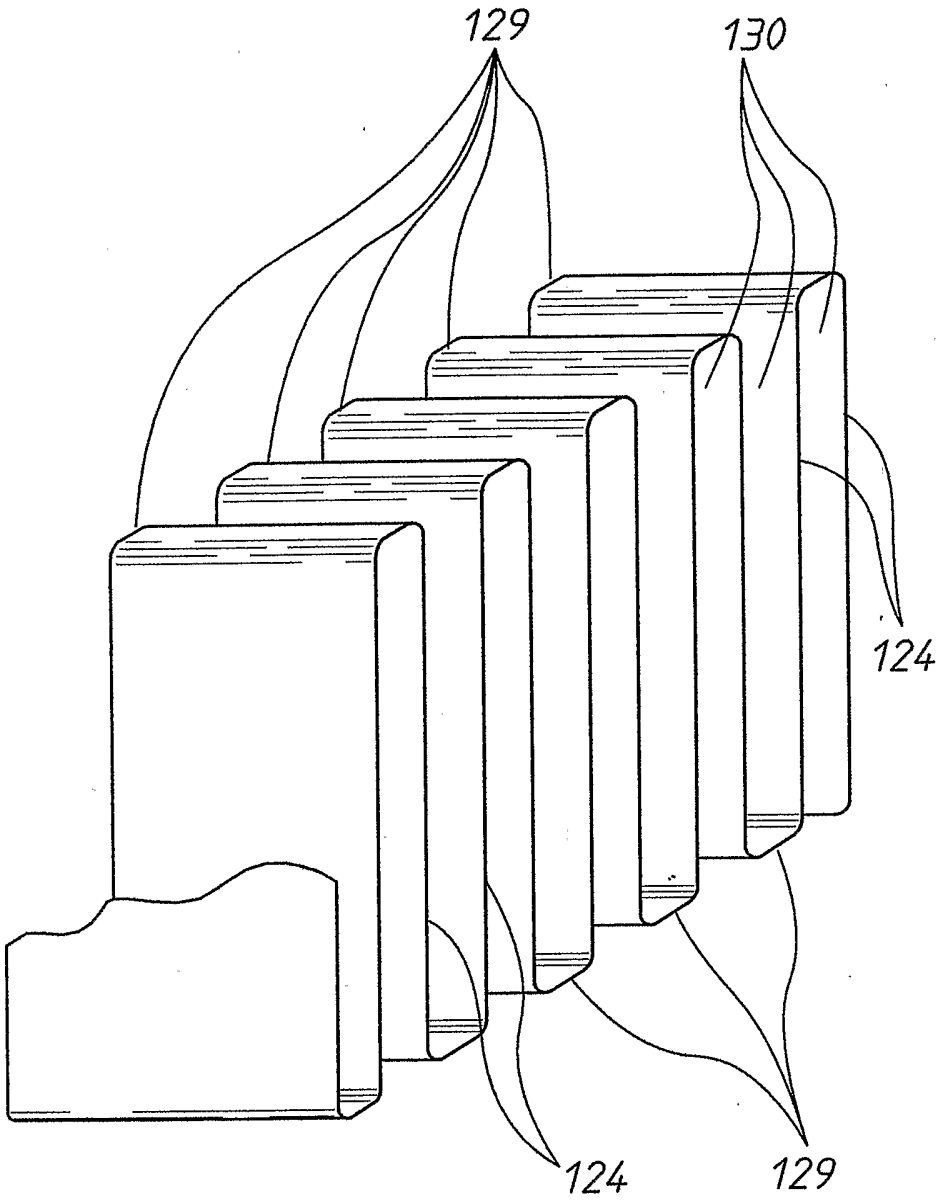

FIG.6

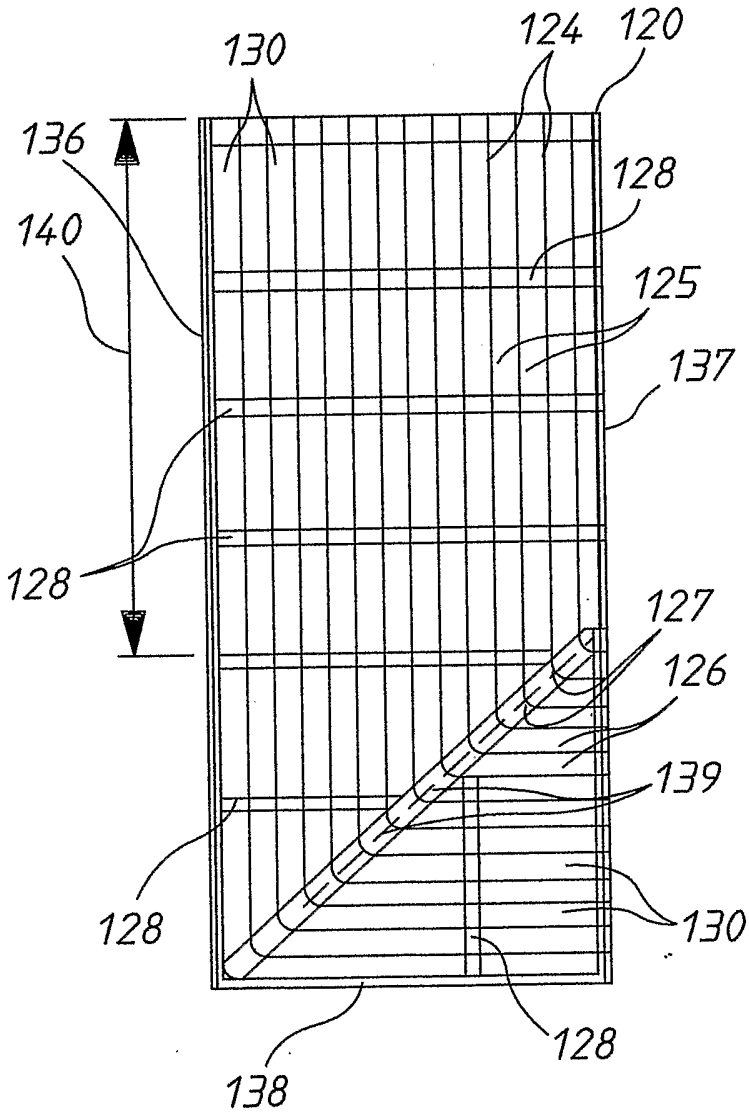

FIG.7

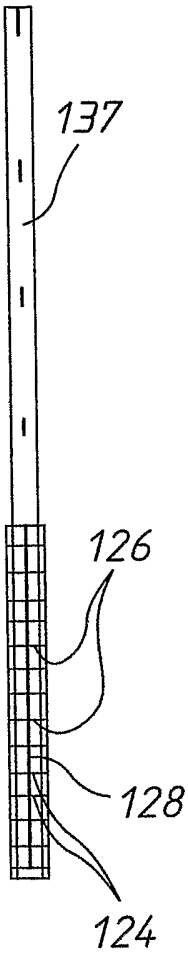

FIG.8

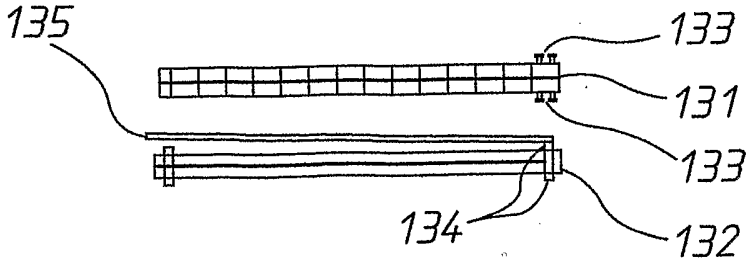

FIG.9

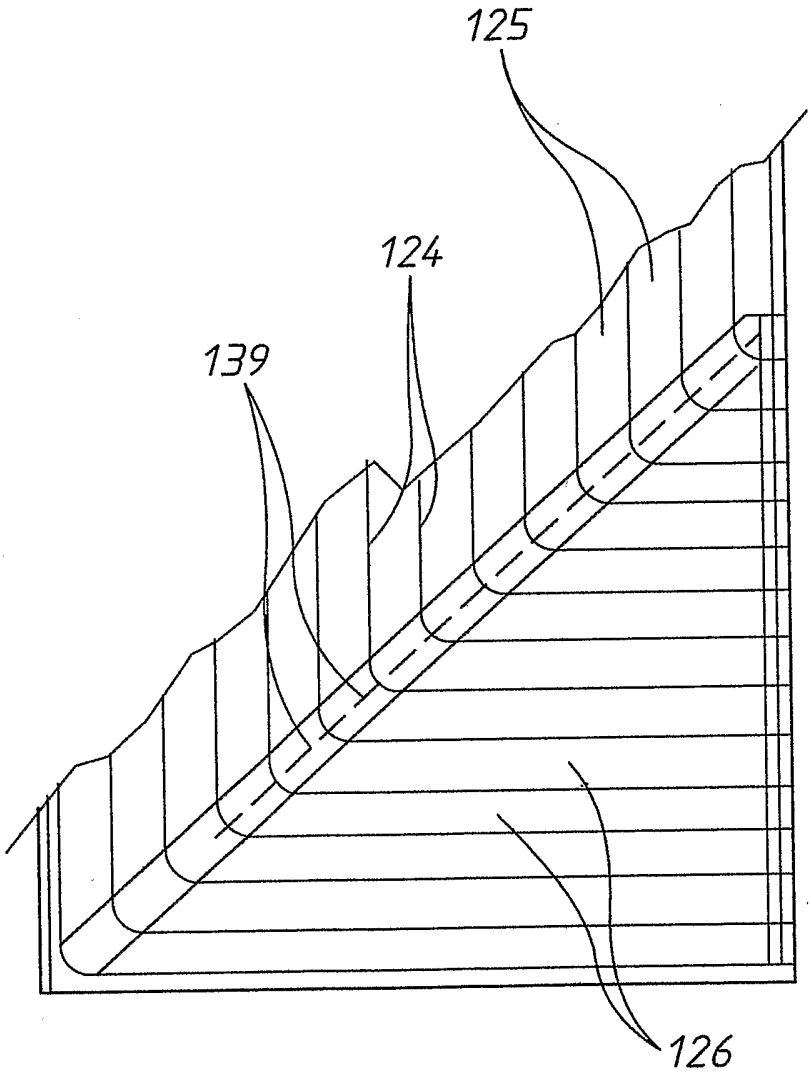

FIG. 10

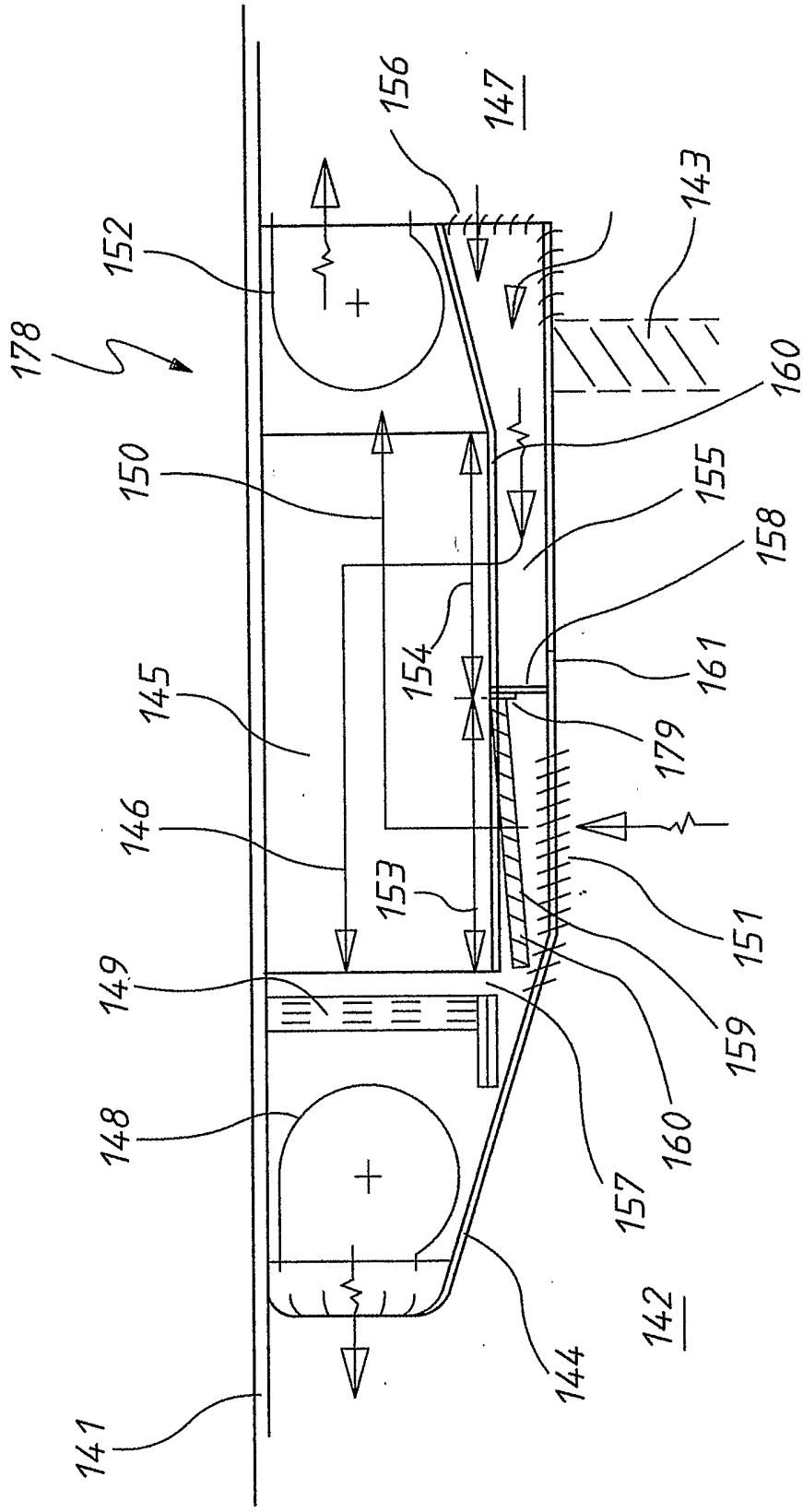
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FIG. 11

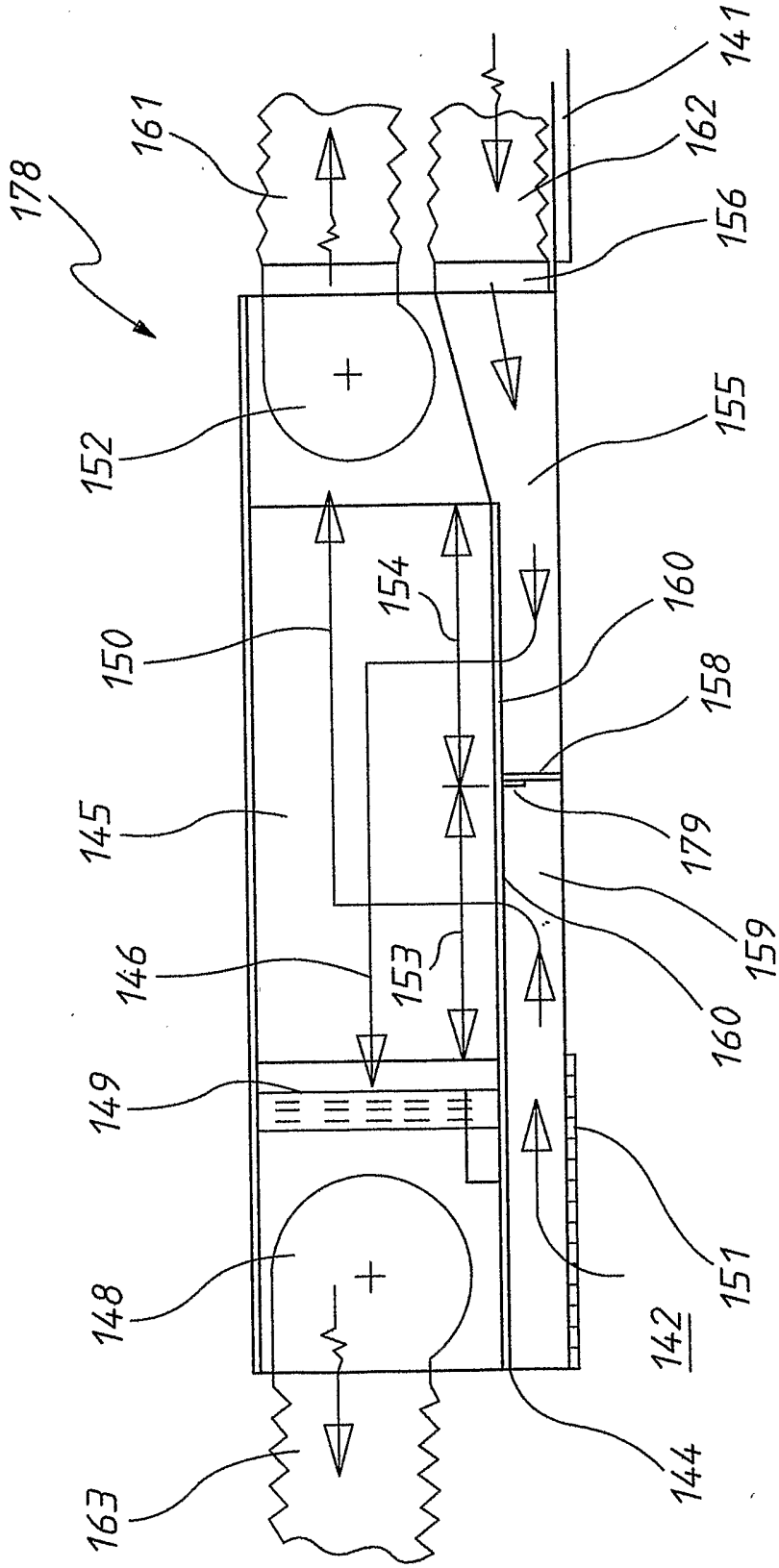
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FIG. 12

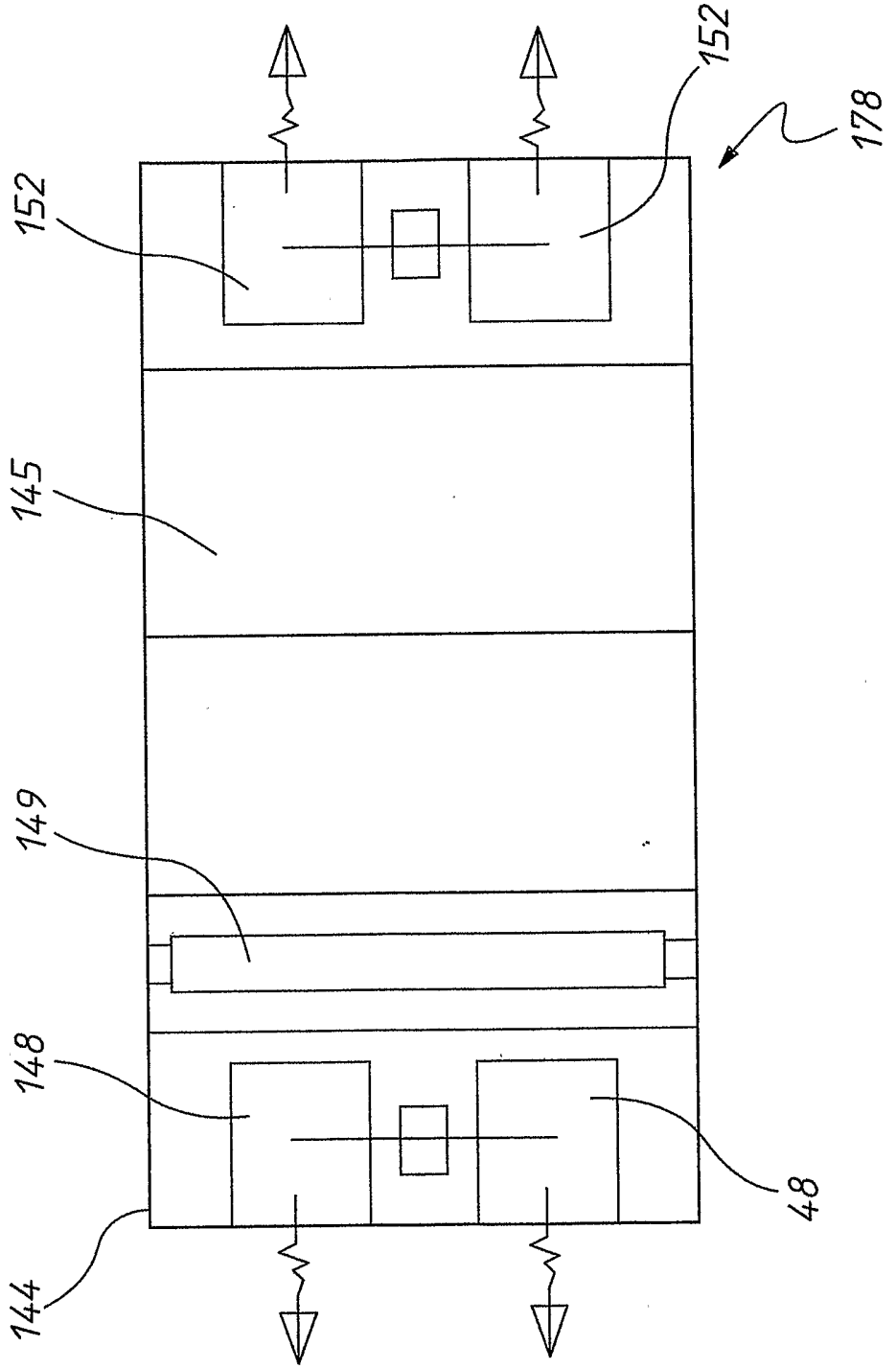

FIG. 13

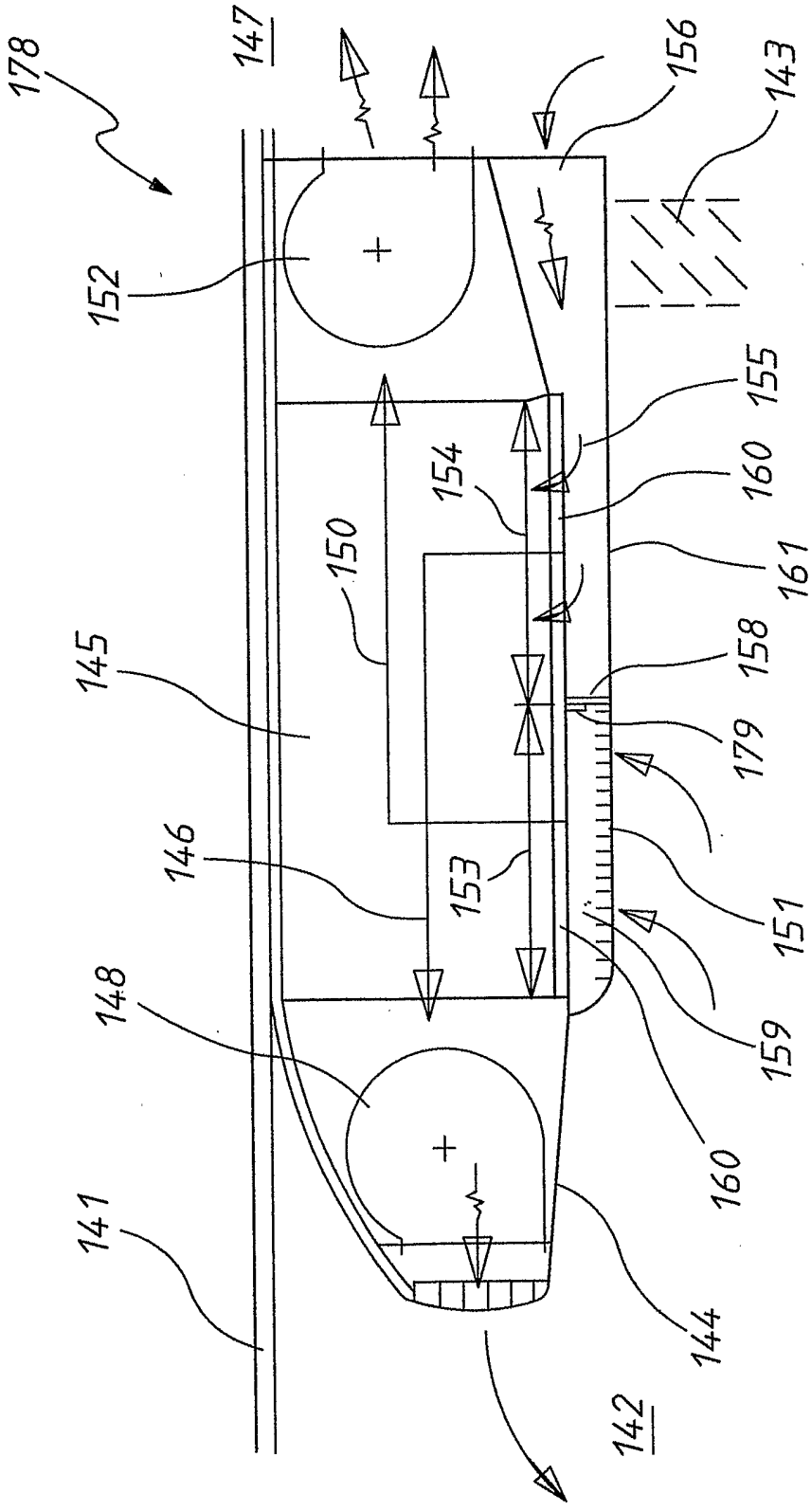
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FIG. 14

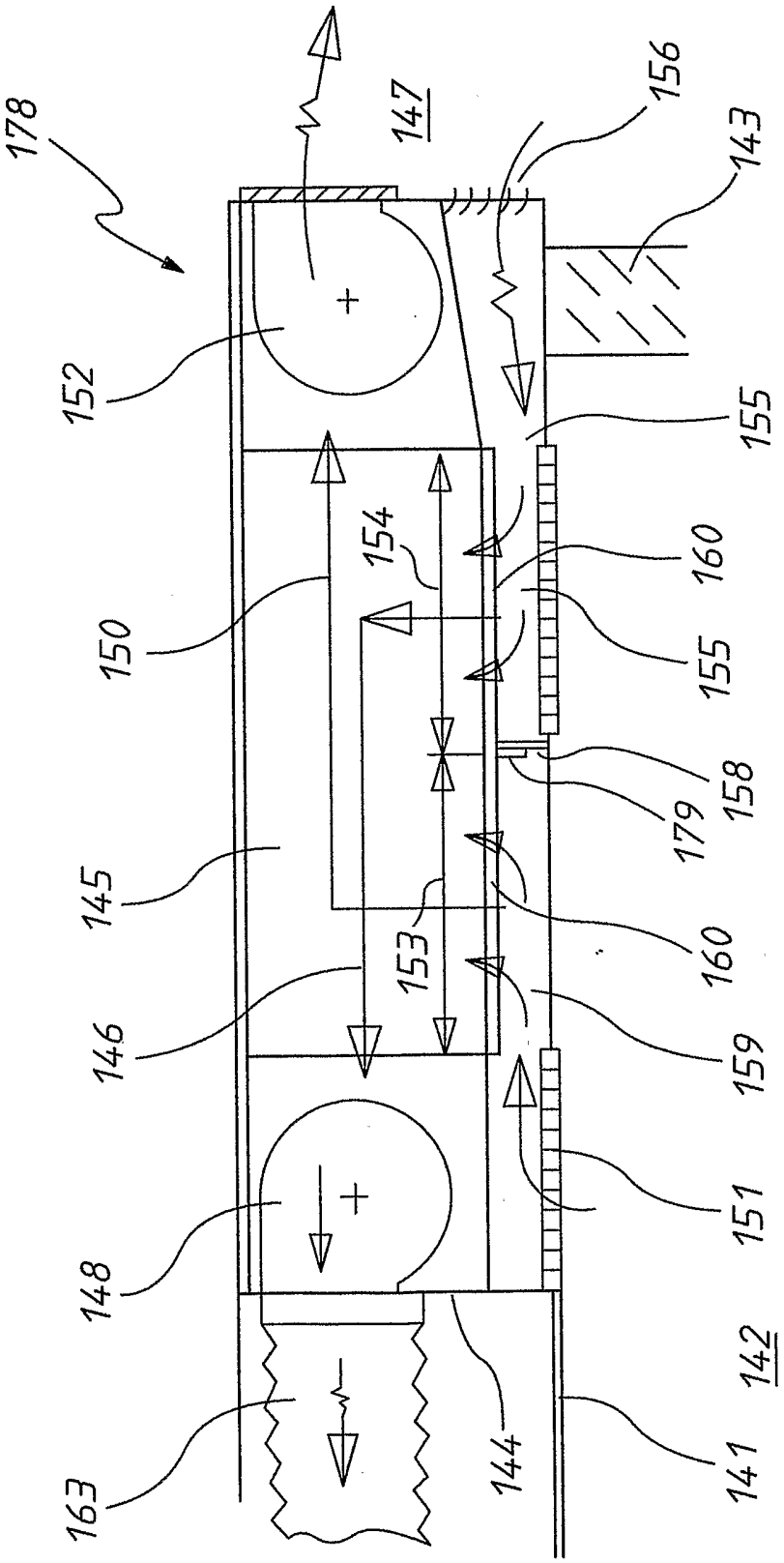
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FIG. 15

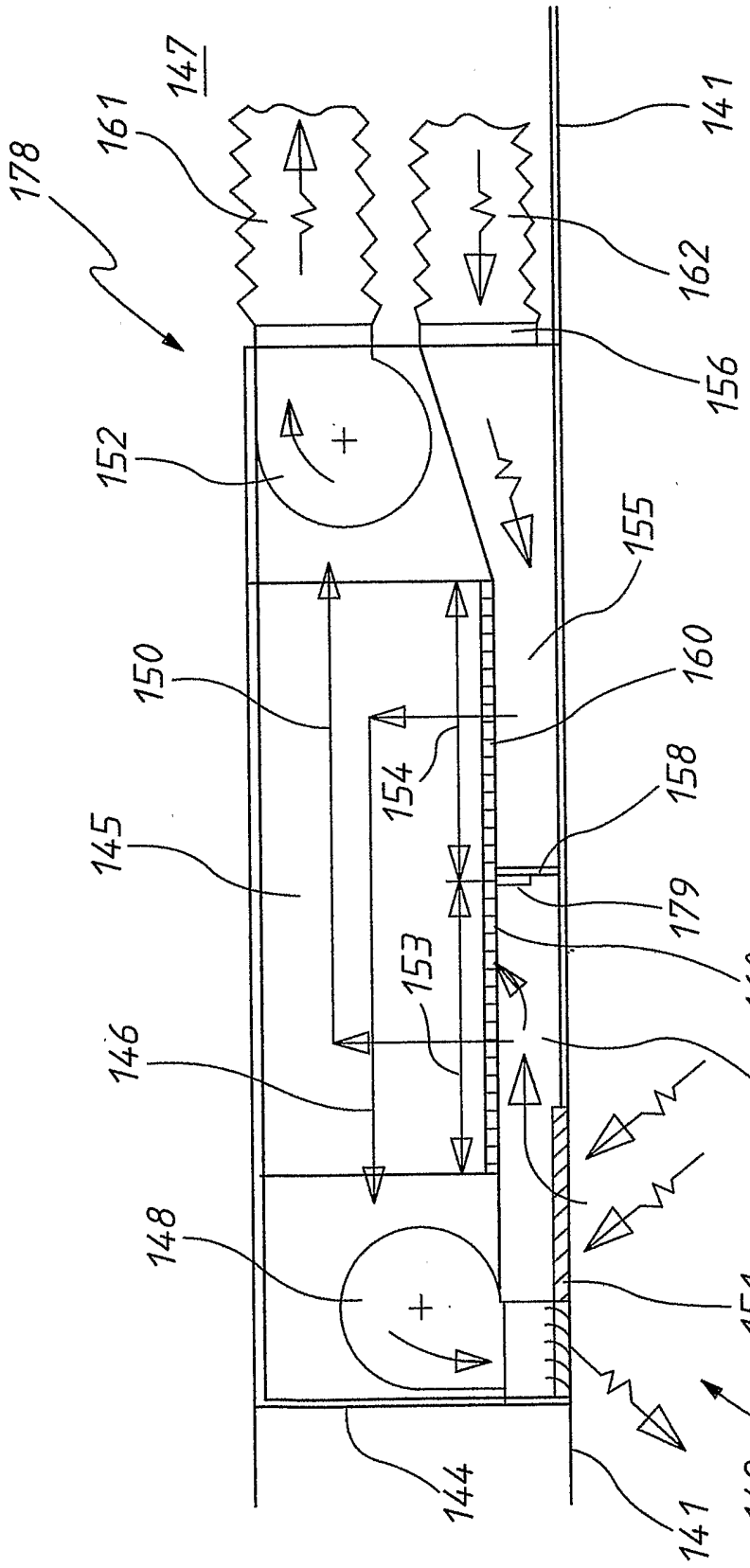
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FIG. 16

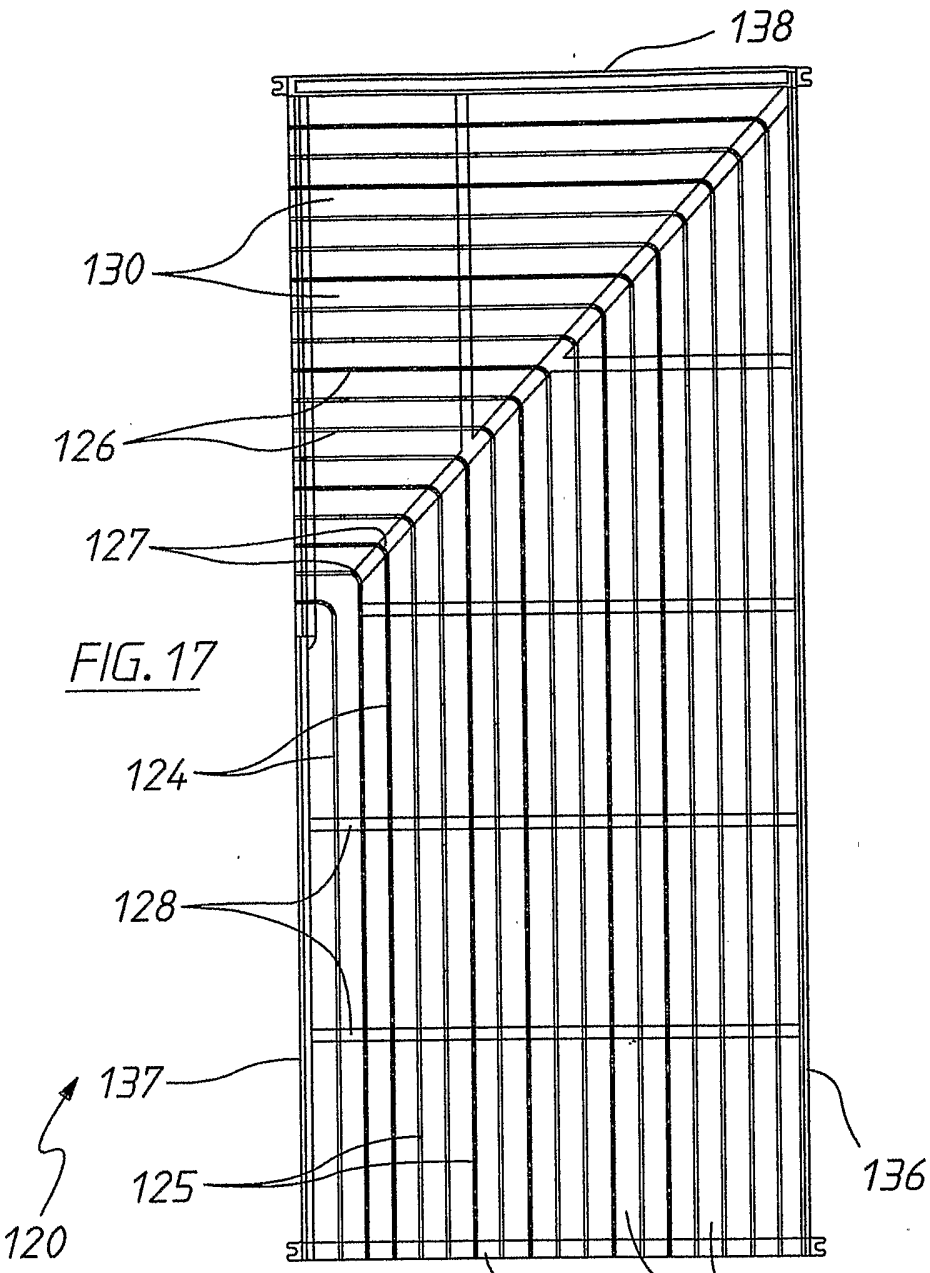
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FIG. 17

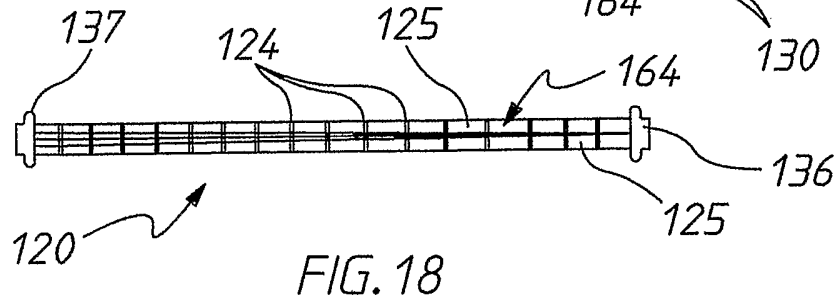
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FIG. 18

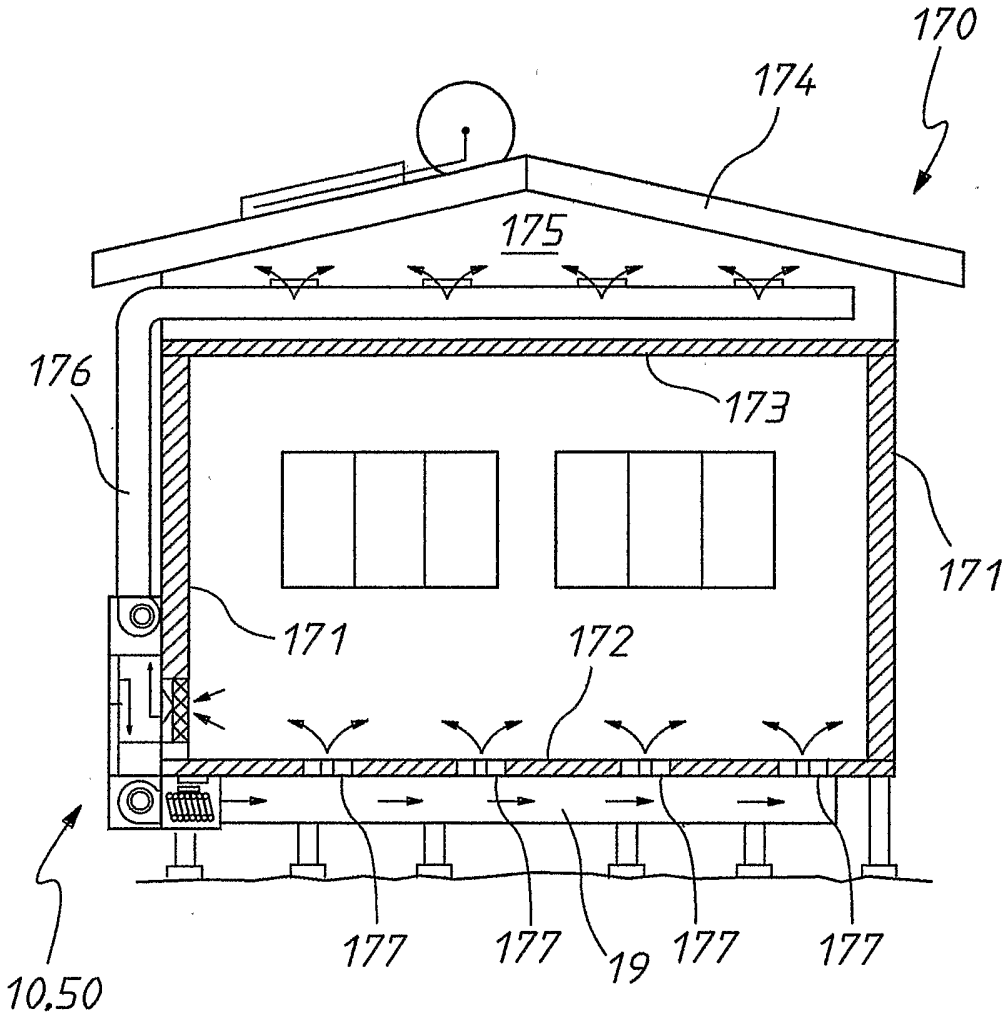

FIG. 19

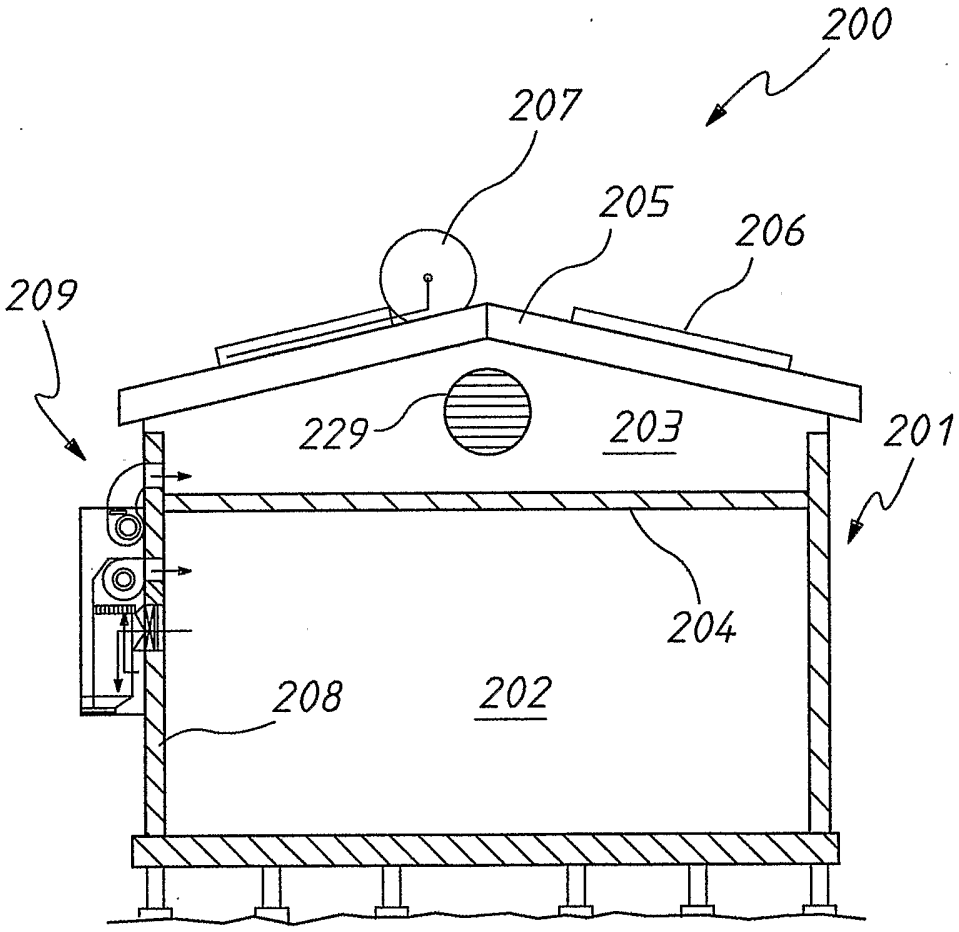

FIG.20

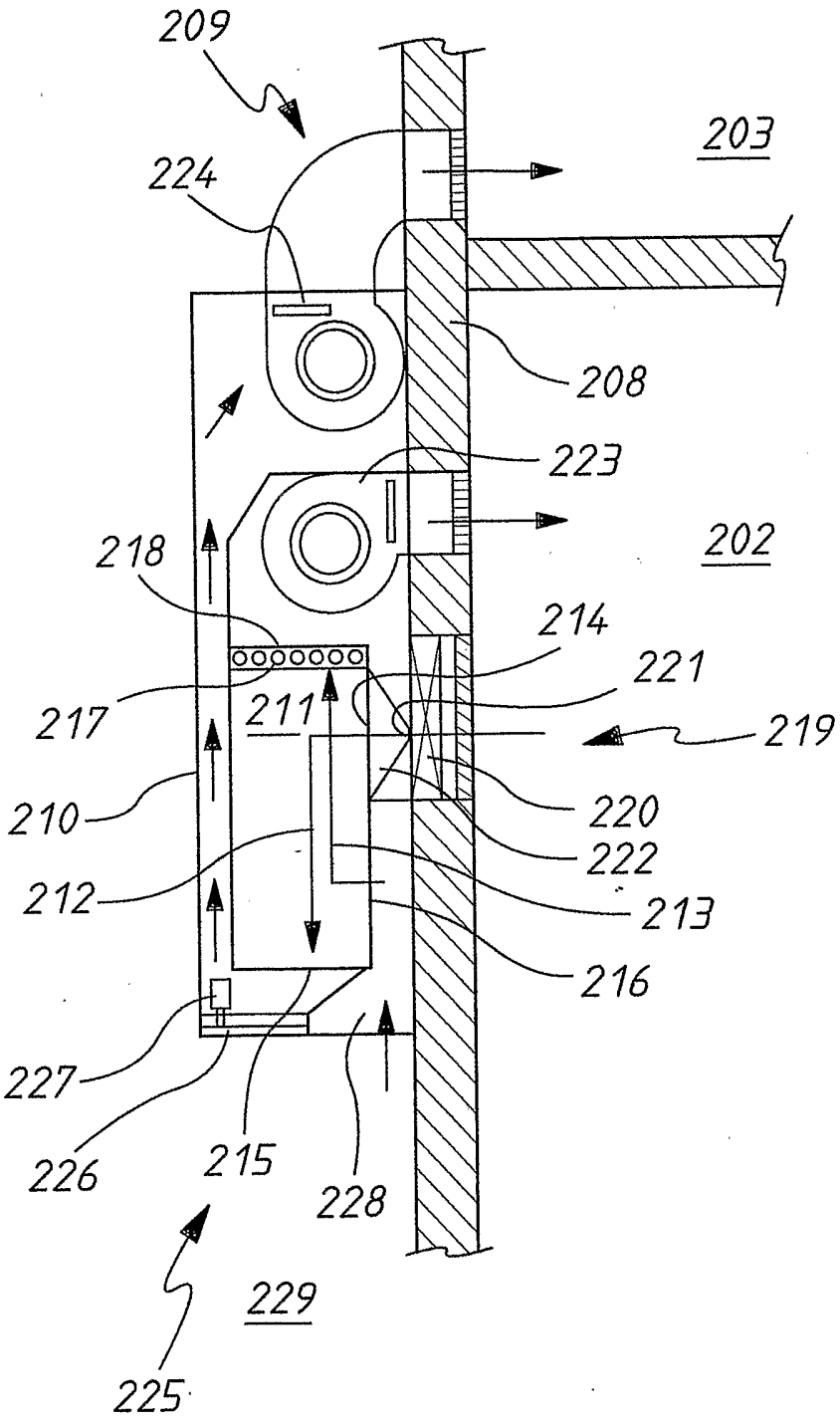
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FIG.21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001097

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F24F 12/00

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)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: IPC F24F 12/00, F28D 9/00, F28F 3/08 & Keywords (duct+, conduit+, passage+, path+, restric+, barrier+, baffle+, orifice+, venturi+, sinuous+, sinusoidal+, zigzag+, tortuous+, bent+)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E,A	WO 2004/076941 A (AIR-CHANGE PTY LIMITED) 10 September 2004 Whole document	28-44
A	WO 2001/069154 A (AIR-CHANGE PTY LIMITED) 20 September 2001 Whole document	1-44
A	EP 0393937 B (JOHN FRANCIS URCH) 21 February 1996 Whole document	1-44
A	WO 1993/018360 A (JOHN FRANCIS URCH) 16 September 1993 Whole document	1-44

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"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
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2005	28 SEP 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **Tharu Fernando** Telephone No : (02) 6283 2486

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/001097

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4823867 A (POLLARD ET AL) 25 April 1989 Whole document	1-44
A	GB 1498621 A (WILLIAM RONALD PAGE) 25 January 1978 Whole document	1-44

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2005/001097

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2004/076941	NONE					
WO	2001/069154	AU	40356/01	AU	57789/01	CA	2403169
		CN	1429331	EP	1269098	US	6829900
		US	2002134087				
EP	0393937	AU	52472/90	CA	2014610	CN	1046598
		IL	93994	JP	3001094	NZ	233192
		SU	1831648	US	5078208		
WO	1993/018360	AU	36219/93	CA	2131392	CN	1077275
		EP	0629282	IL	104994	NZ	249433
		US	5829513				
US	4823867	AU	87443/82	EP	0074740	NZ	201673
		PH	19182	ZA	8206505		
GB	1498621	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX