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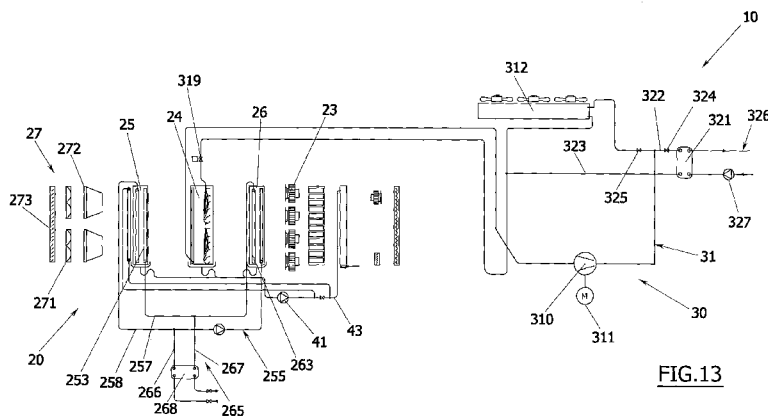


FIG. 13

(57) Abstract: An apparatus (10) for production of water from atmospheric air comprises a condensation unit (20) comprising: and inlet opening (21) of the moist air, an outlet opening (22) of the dehumidified air, at least a ventilator (23) configured so as to force an air flow to enter through the inlet opening (21) and exit from the outlet opening (22), a heat exchange plate (24), interposed between the inlet opening (21) and the outlet opening (22) so as to intercept the air flow and able to be crossed by the air flow, and a pair of heat exchangers (25,26), able to be crossed in series by the air flow, of which a first heat exchanger (25) and a second heat exchanger (26), respectively located upstream and downstream of the heat exchange plate (24) in the crossing direction thereof by the air flow, the pair of heat exchangers (25,26) being connected by means of a hydraulic circuit (255) comprising a recycling pump (256) of a heat exchange liquid contained in the hydraulic circuit (255).

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WATER PRODUCTION APPARATUS

TECHNICAL FIELD

The present invention relates in general to production of potable water from atmospheric air, more in particular to an apparatus for production of potable water from atmospheric air loaded with moisture at ambient temperature.

PRIOR ART

As is known, for production of water, for example potable water, in places where the water supply sources are poor or difficult to reach, apparatus are used for obtaining a quantity of water, for example potable water, from dehumidification of the atmospheric air.

These known-type apparatus generally comprise a casing, for example a box casing, in which are arranged, in special predefined spaces, at least a condensation unit able to be crossed by a flow of ambient air, possibly pre-cooled, which is essentially constituted by a heat exchanger which defines an evaporator for a cooling fluid circulating in an appropriate refrigerating circuit, provided, apart from with the above-mentioned evaporator, a condenser thereof and an expansion valve.

In practice the heat exchanger is defined by a plate on which the moisture present in the atmospheric air condenses to form drops of water that are then collected in an appropriate collecting tub.

To pre-cool the air flow entering the condensation unit heat exchangers are known that are of the air-air type, with crossed-over exchange that in practice exploit the cold dehumidified air which has crossed the condensation plate for pre-cooling the moist air which is to cross the plate itself.

The use of these crossed-over heat exchangers, however, exhibits the drawback that the dehumidified air flow, which has to be forcedly re-channelled internally of the heat exchanger, owing to the tortuous passages imposed on the air by the re-channelling, finishes by having a negative impact on the distribution of the condensation on the plate and therefore on the efficiency of condensation of the plate itself.

In particular, it has been observed that owing to the forced pathway which is

applied to the dehumidified air towards the zone upstream of the condensation unit, the air flow crossing the condensation plate is denser in some zones of the plates and more rare, when not absent, in other zones of the plates which therefore remains inefficient.

An aim of the present invention is to obviate the above-mentioned drawbacks in the prior art, with a solution that is simple, rational and relatively inexpensive. The aims are attained by the characteristics of the invention reported in the independent claims. The dependent claims delineate preferred and/or particularly advantageous aspects of the invention.

DESCRIPTION OF THE INVENTION

The invention in particular relates to an apparatus (10) for production of water from atmospheric air which comprises a condensation unit (20) comprising:

- an inlet opening of moist air,
- an outlet opening of dehumidified air,
- at least a ventilator configured so as to force an air flow to enter through the inlet opening and exit from the outlet opening,
- a heat exchange plate, which is interposed between the inlet opening and the outlet opening, so as to intercept the air flow and able to be crossed by the air flow, and
- a pair of heat exchangers, able to be crossed in series by the air flow, of which a first heat exchanger and a second heat exchanger, respectively located upstream and downstream of the heat exchange plate in the crossing direction thereof by the air flow, the pair of heat exchangers being connected by means of a hydraulic circuit comprising a recycling pump of a heat exchange liquid contained in the hydraulic circuit.

With this solution, the air entering from the inlet opening and directed to the heat exchange plate can be pre-cooled, by means of an air-liquid exchanger, before arriving at the heat exchange plate, making the production of water thereby more efficient; further, the cold air exiting from the heat exchange plane crosses the second heat exchanger, which has the double function of rendering heat - which has accumulated in the liquid from the first exchanger - to the dehumidified air, so as to keep the liquid contained in the hydraulic circuit

at a low temperature, and to function as a coalescent membrane for the small drops of condensation water transported by the air flow beyond the heat exchange plate.

In an aspect of the invention, the heat exchange plate is advantageously fixed by means of threaded organs to the pair of heat exchangers, so as to define a compact sandwich structure.

With this solution, the replacement and/or the removal for maintenance or cleaning of the heat exchange plate and/or the heat exchangers is particularly easy and rapid.

The threaded organs can advantageously be stud screws having an axis parallel to the advancement direction of the air flow along the condensation unit and inserted in through-holes and aligned and realised in the heat exchange plate and in the pair of heat exchangers, the opposite ends of the stud screws being screwed to lock nuts able to block the pack in a sandwich pack structure.

With this solution, the number of screws can be contained and, therefore, personnel costs for assembly and maintenance of the condensation unit can be limited.

In a further aspect of the invention, the apparatus can comprise at least a collecting tub located inferiorly of the condensation unit for collecting condensation water separating from the air flow.

The collecting tub is advantageously slidably associated to the condensation unit with respect to a horizontal sliding direction perpendicular to the advancement direction of the air flow along the condensation unit.

With this detail, the tub can be easily inspectable from the outside of the condensation unit and removable when required, for example for periodic cleaning thereof.

In an aspect of the invention, the bottom of the collecting tube is inclined with respect to the horizontal plane.

In this way the natural outflow of the water in a lowered storage zone improves the collecting of the water itself from the collection tub.

In an advantageous aspect of the invention, the apparatus might comprise a

plurality of collecting tubs, of which a main tub located inferiorly of the heat exchange plate, a first auxiliary tub located inferiorly of the first exchanger and, for example, a second auxiliary tub located inferiorly of the second exchanger. With this solution, the collecting tubs can be independent of one another, for example each extracted independently for the respective maintenance and/or cleaning operations.

The heat exchange plate can advantageously comprise a first parallelepiped body arranged with the main dimension vertical and provided with a front face, with respect to the advancement direction of the air flow from the inlet opening, and an opposite rear face.

This configuration, substantially vertical, of the heat exchange plate enables optimising the performance of the heat exchange and, therefore, obtaining water from the moist air, of the heat exchange and at the same time the minimising of the space occupied thereby.

In an aspect of the invention, between the front face and the rear face the first parallelepiped body comprises a through-channel in the air flow direction imposed by the ventilator, and closed in a transversal direction.

The first parallelepiped body is advantageously crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator, by a first tube bundle (for example subdivided into a plurality of parallel ranks), which defines a branch of a refrigerating circuit of a refrigerating unit in which the refrigerating fluid evaporates so as to cool the heat exchange plate crossed by the air flow, i.e. condensating the moisture present in the air crossing the heat exchange plate.

In a further aspect of the invention, the condensation unit can comprise a plurality of ventilators located posteriorly of the rear face of the second heat exchanger, with respect to the advancement direction of the air flow along the condensation unit, and uniformly distributed with respect to the surface of the rear face.

With this solution, the efficiency of the heat exchange and therefore the water production by the heat exchange plate and the heat exchangers is optimised and made uniform for the whole transversal surface thereof, as the air flow is

uniformly distributed over the whole frontal area of the heat exchange plate and the heat exchangers.

For example, the ventilators of the plurality of ventilators are flanked and aligned to one another along a vertical direction.

In an advantageous aspect of the invention, each heat exchanger comprises a respective second parallelepiped body having a main dimension vertical and provided with a front face, with respect to the advancement direction of the air flow along the condensation unit, and a respective opposite rear face in which between the front face and the rear face respective through-channels are defined in the air flow direction imposed by the ventilator, and closed in a transversal direction.

Each second parallelepiped body is preferably crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator, by a second tube bundle each of which defines a branch of the hydraulic circuit in which the heat exchange liquid circulates.

With this solution, the first and the second exchanger exhibit a simple structure that is simple to the structure of the heat exchange plate to which they are fixed in a pack, as described in the foregoing.

The inlet opening of the condensation unit is advantageously defined by the front face of the second parallelepiped body defining the first exchanger and the outlet opening is defined at the rear face of the second parallelepiped body defining the second exchanger, the sandwich structure constituted by the first parallelepiped body and by the pair of second parallelepiped bodies defines a tunnel, closed in a transversal direction to the fluid crossing direction imparted by the ventilators and open exclusively at the inlet opening and the outlet opening.

The hydraulic circuit advantageously comprises a branch which connects an outlet of the first exchanger with the inlet of the second exchanger, in which the heat exchange liquids heated by the moist air flow entering by the inlet opening, a further closed hydraulic circuit, wherein the heat exchange liquid circulates, deriving from the branch being connected to a user for heating thereof.

With this solution, the cooling of the heat exchange fluid can be effectively improved before it crosses the second heat exchange plate, at the same time improving the efficiency the pre-cooling of the water of the moist air of the first exchanger and the use of the heating apparatus for of the user.

In a further aspect of the invention, the outlet opening of one or the first modules comprises an accelerator element of the dehumidified air flow which exits from the outlet opening.

With this solution, the cold dehumidified air exiting the condensation unit can be directed also to a remote point for use thereof, for example for cooling a condenser of a refrigerating unit associated to the condensation unit or another user.

The accelerator element advantageously comprises a converging nozzle, associated to a downstream end of the ventilator with respect to an advancement direction of the air flow, imposed by the same ventilator.

The apparatus can preferably comprise at least a filter able to intercept the inlet opening for filtering the air flow entering therefrom.

In this way the moist air in inlet to the condensation unit can be cleaned of any pollutants present therein, in this way obtaining a clean condensation water usable for various purposes.

With the aim of reducing the concentration of these micro-pollutants of the air, before the air flow crosses the condensation unit, in an aspect of the invention the apparatus can advantageously comprise a chemical treatment unit of the air which for example is interposed between the filter apparatus and the heat exchange plate in the advancement direction of the air flow imposed by the ventilator, and is able to intercept the inlet opening for filtering the air flow entering therefrom into the condensation unit.

For example, the chemical treatment unit of the air comprises an air-permeable membrane comprising Zeolite.

BRIEF DESCRIPTION OF THE DRAWINGS

Further characteristics and advantages of the invention will emerge from a reading of the following description, provided by way of non-limiting example with the aid of the figures illustrated in the appended tables of drawings.

Figure 1 is an axonometric view of a first embodiment of an apparatus according to the invention.

Figure 2 is a view from above of figure 1.

Figure 3 is a section view along line III-III of figure 2.

Figure 4 is a frontal elevation of figure 1.

Figure 5 is a section view along line V-V of figure 3.

Figure 6 is a section view along line VI-VI of figure 3.

Figure 7 is a section view along line VII-VII of figure 3.

Figure 8a is an axonometric view of a first embodiment of a condensation unit according to the invention.

Figure 8b is an axonometric view of a second embodiment of a condensation unit according to the invention.

Figure 9 is a view from above of figure 1.

Figure 10 is an view from above of a second embodiment of the apparatus according to the invention.

Figure 11 is a view from above of a third embodiment of the apparatus according to the invention.

Figure 12 and figure 13 are hydraulic diagrams of the apparatus according to the invention.

BEST WAY OF CARRYING OUT THE INVENTION

With particular reference to the figures, reference numeral 10 denotes in its entirety an apparatus for production of water, for example potable water, from the atmospheric air loaded with moisture, which is able to obtain a quantity of water by condensation of the moisture present in the atmospheric air. The apparatus 10 is able, for example, to obtain from 2.5 m³ of water a day to 10.0 m³ of water a day, in standard atmospheric condition, i.e. at ambient temperature of 30°C and relative humidity of 70%.

The apparatus 10 comprises a condensation unit 20 configured for condensing a quantity of water present in the atmospheric air.

The condensation unit 20 comprises an inlet opening 21 in which the moist air to be dehumidified enters, and an opposite outlet opening 22 from which the dehumidified air exits.

The condensation unit 20 comprises at least a ventilator 23, which for example is located at the outlet opening 22, and is configured so as to force an air flow to enter through the inlet opening 21 and exit from the outlet opening 22.

The condensation unit 20 comprises a heat exchange plate 24, which is interposed between the inlet opening 21 and the outlet opening 22, so as to intercept the air flow and able to be crossed by the air flow.

The heat exchange plate 24 comprises a first parallelepiped body 240 arranged with the main dimension vertical and provided with a front face 241, with respect to the advancement direction of the air flow from the inlet opening 21 to the outlet opening 22, and an opposite rear face 242.

The front face 241 and the rear face 242 are for example rectangular with a vertical longitudinal axis.

Between the front face 241 and the rear face 242 the first parallelepiped body 240 defines a through-channel 243 that is open at the faces 241,242, which crosses the first parallelepiped body 240 in the direction, perpendicular to the faces 241, 242, that the ventilator 23 imposes on the air flow entering from the inlet opening 21. The through-channel 243 is closed in the transversal direction (laterally, inferiorly and superiorly), so that the air flow can be directed only in the longitudinal direction along the through-channel, crossing the first parallelepiped body 240 itself from the front face 241 and exiting therefrom only from the rear face 242.

The first parallelepiped body 240 is crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator 23, by a first tube bundle 244, for example bent in a serpentine shape so as to cross the whole transversal section of the first parallelepiped body 240 several times and, for example, extending over the whole height and for the whole thickness thereof. In this way, the first tube bundle 244 is sprayed by the air flow crossing the heat exchange plate 24.

The first parallelepiped body 240, like the tube bundle 244, is made of a metal material having high heat conductivity and being resistant to oxidation, such as for example stainless aluminium, of a type suitable for use with food.

The condensation unit 20 comprises a pair of heat exchangers 25,26, which

are interposed between the inlet opening 21 and the outlet opening 22 and are able to be crossed in series by the air flow which is forced by the ventilator 23. In practice, the condensation unit 20 comprises a first exchanger 25 located upstream of the heat exchange plate 24, in the crossing direction thereof by the air flow, and a second exchanger 26, located downstream of the heat exchange plate 24.

The heat exchange plate 25,26 comprises a second parallelepiped body 250,260 arranged with the main dimension vertical and provided with a front face 251,261, with respect to the advancement direction of the air flow from the inlet opening 21 to the outlet opening 22, and an opposite rear face 252,262.

Each front face 251, 252 and each rear face 252, 262, is for example rectangular with the longitudinal axis vertical and having a like shape to the shape of the faces 241, 242 of the first parallelepiped body 240.

Between the front face 251,261 and the rear face 252,262 of each second parallelepiped body 250,260 are defined respective through-channels 253,263 (entirely alike to the ones shown in the first parallelepiped body 240), which are open at the faces 251,252, 261,262 and cross the respective second parallelepiped body in the direction, perpendicular to the faces, that the ventilator 23 imposes on the air flow entering from the inlet opening 21. The through-channels 243 are closed in the transversal direction (laterally, inferiorly and superiorly), so that the air flow can be directed only in the longitudinal direction along the through-channels 253, 263, crossing each second parallelepiped body 250,260 entering in the second parallelepiped body 250, 260 from the front face 251,261 and exiting therefrom only from the rear face 252,262.

Each second parallelepiped body 250,260, is for example made of a metal material having high heat conductivity and being resistant to oxidation, such as for example stainless aluminium, of a type suitable for use with food.

The inlet opening 21 of the condensation unit 20 is defined by the front face 251 of the second parallelepiped body 250 which defines the first exchanger 25 and the outlet opening 22 is defined by the rear face 262 of the second

parallelepiped body 260 defining the second exchanger 26.

The condensation unit 20 further comprises a filter apparatus 27 which, located so as to intercept the inlet opening 21 and occupying all the air passage surface, is able to be crossed by the whole moist air flow which enters the inlet opening 21, i.e. in the front face 251 of the second parallelepiped body 250, so as to remove any solid particulate and/or any pollutant and/or any saline residues and/or other impurities.

In the illustrated example, the filter apparatus 27 comprises in particular one or more first filters 271, for example of the anti-particulate type, downstream of which one or more second filters 272 can be present, for example of the rigid pocket type. Upstream of the first filters 271, the filter apparatus 27 can also include the presence of a protection grid 273.

A chemical air treatment unit 275 can be included between the filter apparatus 27 and the condensation unit 20, as illustrated in figures 8a and 8b.

This chemical treatment unit 275 is useful as the ambient air can contain contaminants having variable composition both in terms of the natural climatic and biological alterations (organic putrefaction, volcanic eruptions etc.) and due to the anthropic presence deriving from civic and industrial activity such as extraction industries, petro plants, craft workshops and agricultural activities (animal husbandry or use of fertilisers, disinfectants, phytopharmaceutical products, herbicides, etc.) which cause diffusion of micro-pollutants which are dispersed in the air.

The micro-pollutants can belong to various categories, among which: Ammonia, Volatile Organic Compounds (hydrocarbons in various forms: Aliphatics, Aromatics, Halogenates, etc.) cations and anions in ionic form or saline form (Potassium, Hydrogen Sulphide, Nitrogen Oxide, etc.) or Aerosols in general containing elements and dissolved molecules belonging to the above-indicated families of compounds.

The chemical treatment unit 275 reduces the concentration of the micro-pollutants before the air flow crosses the condensation unit 20, so that at the most a minimal quantity thereof is left in the water, thus facilitating the successive steps of purification and potabilisation. In practice, the chemical

treatment unit 275 protects and prevents the contamination of the whole condensation unit.

The chemical treatment unit 275 can comprise, for example, an air-permeable membrane, which occludes the inlet 21 of the condensation unit 20 so as to intercept all the air flow directed internally and eliminate the concentration of micro-pollutants.

The permeable membrane can be for example crossed by only Zeolite (for example carbalite and/or phillipsite) so as to realise a step of zeolitic catalysis, or by only activated charcoal, so as to realise an adsorption step of the micro-pollutants.

Alternatively, the permeable membrane might be made from a mixture of Zeolite and activated charcoal, so as to carry out both steps and obtain a better elimination of the airborne micro-pollutants. Should the presence of contaminants be particularly high, it is possible to include installation in series of one or more permeable membranes made of Zeolite, activated charcoal or mixtures thereof according to the treatments to be made.

In practice, the treatment unit 275 might comprise a container or a series of containers, in box or cylinder form, containing the above-mentioned permeable membranes, which can be arranged parallel to one another in order to be crossed in series by the air flow, and each of which can be composed of or will contain the suitable materials for the treatment to be carried out, i.e. Zeolite, activated charcoal or a mixture thereof. These containers are preferably structured in such a way as to be easily removed from the structure, so that a replacement of the porous membranes can be made with fresh or regenerated ones.

In the example, the heat exchange plate 20 comprises a plurality of ventilators 23 located posteriorly of the rear face 262 of the second heat exchanger 26, with respect to the advancement direction of the air flow from the inlet opening 21 to the outlet opening 22.

The ventilators 23 are such as to occupy the whole passage surface of the air on the rear face 262 of the second exchanger 26, in practice being uniformly distributed with respect to the surface of the rear face itself.

In the example, the ventilators 23 are flanked and aligned to one another along a vertical direction, i.e. along the prevalent extension direction of the outlet opening 22 and of the heat exchange plate 24.

Each second parallelepiped body 250,260 is crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator 23, by a respective second tube bundle 254,264, for example bent in a serpentine shape so as to cross the whole transversal section of the second parallelepiped body 240 several times and, for example, extending over the whole height and for the whole thickness thereof. In this way, the first tube bundle 254,264 is lapped by the air flow crossing the heat exchange plate 25,26.

The heat exchangers 25, 26 and in particular the second tube bundles 254, 264 thereof are connected to one another by means of a hydraulic circuit 255 provided with a recycling pump 256 able to recycle a heat exchange liquid, for example water, in the hydraulic circuit 255 and then between the second tube bundles 254, 264. For example, the hydraulic circuit 255 is a closed circuit.

The second tube bundles 254,264, are for example made of a metal material having high heat conductivity and being resistant to oxidation, such as for example stainless aluminium, of a type suitable for use with food.

The hydraulic circuit 255 can comprise a first portion 257 which connects the inlet of the second tube bundle 254 of the first exchanger 25 with the outlet of the second tube bundle 26 and a second portion 258 which connects the outlet of the second tube bundle 254 of the first exchanger 25 with the inlet of the second tube bundle 264 of the second exchanger 26.

In practice, the heat exchange liquid present in the hydraulic circuit 255 circulates, by means of the thrust exerted by the recycling pump 256, and in succession crosses the second tube bundle 264 of the second exchanger 26, where it is cooled by the dehumidified air flow which exits from the heat exchange plate 24, the first portion 257 (cold), the second tube bundle 254 of the first exchanger 25, in which by exchanging heat with the moist air flow it pre-cools the air flow and correspondingly heats up, and the second portion 258 (hot).

In some embodiments it is possible to use the heat of the cold heat exchange liquid circulating in the first portion 257, entirely or only in part (if in a quantity of lower than the total in circulation) for cooling a second liquid of a further hydraulic circuit 265, for example closed, in which the heat exchange liquid circulates, destined to serve a user, for example the water of a cooling plant or the like.

In practice, the further hydraulic circuit 265 comprises a first branch 267, provided with a respective opening and closing valve, which branches from the first portion 257, and a second branch 266, also provided with a respective opening and closing valve, which enters the second portion 258 in an injection point downstream of the branching point of the first branch 267 in the exchange liquid flow direction along the second portion 258.

A heat exchanger can be included between the first branch 267 and the second branch 266, for example of a liquid-liquid type, used for cooling a liquid of an appropriate user.

The heat exchange plate 24, the first heat exchanger 25 and the second heat exchanger 26 are arranged in succession and aligned in a pack, so that the rear face 262 of the second parallelepiped body 260 defines the outlet opening 22 of the condensation unit 20, while the front face 251 of the first parallelepiped body 250 defines the inlet opening 21.

The heat exchange plate 24 is advantageously fixed by means of threaded organs to the pair of heat exchangers 25,26, so as to define a compact sandwich structure.

The threaded organs, for example, can be stud screws 28 (see figure 8a) having axes parallel to the advancement direction of the air flow from the inlet opening 21 to the outlet opening 22.

In practice, the stud screws 28 exhibit a length only slightly greater than the sum of the thicknesses of the heat exchangers 25,26 and the heat exchange plate 24 and exhibit threaded opposite ends, able to project out of the sandwich structure.

Each stud screw 28 is insertable in a series (in the example four in number located at the vertices of the front faces 241,251,261 and of the rear faces

242,252,262) of through-holes 280 (see figure figures 5-7), for example completed by hollow tubular elements, aligned with one another and realised in the heat exchange plate 24 and in the pair of heat exchangers. The opposite ends of the stud screws 28 are screwed to lock nuts 281 able to block the sandwich pack structure constituted by the heat exchange plate 24 and the pair of heat exchanger 25,26.

Alternatively or additionally, each parallelepiped body 245,250,260 comprises a perimeter flange able to border each of the front faces 241,251,261 and of the rear faces 242,252,262, for example projecting externally of the respective parallelepiped body 240,250,260.

For example, the parallelepiped bodies 240,250,260 can be coupled to one another by means of the respective perimeter flanges, for example solidly (e.g. by welding).

For example, each parallelepiped body 240,250,260 can comprise one or more inspection windows provided with openable and/or removable caps for inspection and periodic cleaning of the parallelepiped bodies 240,250,260 (as shown for example in figure 8b).

In practice, the sandwich structure constituted by the first parallelepiped body 240 and by the pair of second parallelepiped bodies 250, 260 defines a tunnel, closed in a transversal direction to the fluid crossing direction imparted by the ventilators 23 and open exclusively at the inlet opening 21 (i.e. the front face 251) and the outlet opening 22 (i.e. the rear face 262).

Downstream of the ventilators 23 an accelerator element of the dehumidified air flow can be fixed, which exits from the outlet opening.

For example, the accelerator element can comprise a converging nozzle 230, i.e. a converging connection provided with a broadened end associated to the downstream end of the ventilator 23 and a free tapered end located downstream of the advancement direction of the air flow, imposed by the same ventilator 23.

The condensation unit 20 further comprises at least a collecting tub 291,292,293 located inferiorly thereof at least at the heat exchange plate 24 for collecting the condensation water separating from the air flow which

crosses the heat exchange plate.

For example the condensation unit 20 comprises a plurality of collecting tubs 29, of which a main tub 291 located inferiorly of the heat exchange plate 24, a first auxiliary tub 292 located inferiorly of the first exchanger 25 and a second auxiliary tub 293 located inferiorly of the second exchanger 26.

The second auxiliary tub 293, notwithstanding the fact that the condensation function of the second exchanger 26 is substantially nil or in any case very small, collects the water that deposits on the second exchanger, as it performs a coalescent function of coalescing and collecting and making the smallest drops of condensate bigger, the said smallest drops being deposited on the first exchanger 25 and/or on the heat exchange plate 24, and being transported by the air flow towards the outlet opening 22, so that once made larger they fall into the second auxiliary tub 293.

Each collecting tub 291,292,293 is slidably associated to the respective parallelepiped body 240,250,260 with respect to a horizontal sliding direction perpendicular to the advancement direction of the air flow along the condensation unit 20.

For example, a sliding guide 294 is included below each parallelepiped body 240,250,260, for example formed by a pair of opposite profiles having a C-shaped transversal section, able to define a sliding coupling with a respective collecting tub 29.

For example, the connection between the parallelepiped body 240,250,260 and the respective collecting tub 291,292,293 is made substantially sealed or in any case isolated from outside by means of removable and/or openable padding (shown for example in figure 8b).

The bottom of each collecting tub 291,292,293 is inclined with respect to a horizontal plane, so as to make the water converge towards a lowered collection point.

The condensation unit 20 is for example arranged internally of a first parallelepiped module 200, i.e. an imaginary volume having a parallelepiped shape in which the condensation unit 20 is contained.

The first module 200, for example, is bordered by a tubular frame, for example

formed by rectangular portals 201 (for example two in number) parallel to one another and joined by at least four longitudinal cross-members 202 parallel to the advancement direction of the air flow imposed by the ventilator 23. For example the cross members 202 are able to join the vertices of the portals 201. The portals 201 exhibit a vertical longitudinal axis and have a slightly greater dimension with respect to the faces 241,251,261; 242,252,262 of the parallelepiped bodies 240,250,260.

The two portals 201 are for example parallel to the faces 241,251,261; 242,252,262 of the parallelepiped bodies 240, 250, 260 and, respectively, externally border the front face 251, which defines the inlet opening 21, and the rear face 262 which defines the outlet opening 22.

In practice the rear face of the first module 200, i.e. the face which borders the rear face 262 of the second exchanger 26 and is proximal thereto, defines an interconnecting face of the first module 200, the opposite face to the interconnecting face of the first module 200 (bordered by the front portal 201) borders and is proximal to the front face 251 of the first exchanger 25 and each contiguous face (for example four in number, of which two lateral, one upper and one lower) to the interconnecting face of the first module 200 is bordered by a pair of cross-members 202 parallel to one another.

The opposite face to the interconnecting face of the first module 200 (and possibly also the interconnecting face itself) is provided with filler sheets able to fill any interspace between the portal 201 and the inlet opening 21 (and, respectively, the outlet opening 22), so that the air flow forced by the ventilator 23 is totally conveyed along the tunnel defined by the sandwich structure of the heat exchangers 25,26 and the heat exchange plate 24.

Each contiguous face to the interconnecting face can be provided with filler sheets, for example fixed sheets or mobile sheets, for example of a hatch or door type. At least one of the filler sheets closing a contiguous lateral face is advantageously openable for removal of the collecting tubs 291,292,293 along the sliding direction and/or for removing, along the sliding direction, one or more of the parallelepiped bodies 240,250,260 for cleaning or replacing them. The first module 200 exhibits a width, for example defined by the extension of

a short side (horizontal) of the front portal 201, which extension is $W/2$, in which W is for example a maximum width of the internal compartment of a container of standard dimensions (for example 234 cm), for example transportable by sea.

In the example W is a little smaller than the maximum width of the internal compartment of a container of standard dimensions and preferably is substantially 220 cm.

The length L of the first module 200, in the parallel direction to the advancement direction of the air flow along it, can be greater than the width W .

The apparatus 10 further comprises a refrigerating unit 30.

The refrigerating unit 30 can be based on any known cooling technology, though in the majority of applications a conventional refrigerating compressing cycle of steam will be the sturdiest and most versatile system. For this reason, the refrigerating unit 30 generally comprises a refrigerating circuit 31 in which a refrigerating fluid circulates, for example R-134a, through a compressor 310, a condenser 312, an expansion valve 319 and an evaporator.

The compressor 310 is configured to increase the pressure of the refrigerating fluid to the state of vapour coming from the evaporator. The compressor 310 can be a rotary screw compressor or a compressor of any other type. The compressor 310 is moved by a motor 311, for example by an electric motor connected to an electric distribution grid or a generator. The compressor 310 might also be of type normally called "semi-hermetic", i.e. having an electric motor inserted in the compressor body. It is however possible for the motor 311 to be an internal combustion engine, for example a diesel engine.

The condenser 312 is configured such as to cause condensation of the high-pressure refrigerating fluid coming from the compressor 310, losing heat to the external environment. The condenser 312 can be a tube and/or fin condenser, and can be provided with one or more fans 314 able to create a forced-air flow through the condenser 312, facilitating dissipation of the heat produced by the condensation of refrigerating fluid.

The pressure valve 319 is configured so as to lower the pressure of the

refrigerating fluid coming from the condenser 312. The expansion valve 319 can be a fixed-geometry valve or a variable-geometry valve, for example having an electro-mechanical activation. In particular, the expansion valve 319 can be a regulatable valve, for example a thermostatic valve.

The evaporator is configured to cause evaporation of the lower-pressure refrigerating fluid coming from the expansion valve 319, subtracting heat from the surrounding atmosphere.

In the example the evaporator of the refrigerating unit 30 is defined by the heat exchange plate 24 of the condensation unit 20, i.e. by the tube bundle 244, so that the evaporation of the refrigerating fluid can directly cool the environmental air flow to be dehumidified.

In practice, the tube bundle 244 defines a branch of the refrigerating circuit 31 which receives the refrigerating fluid in the liquid state and at low pressure in outlet from the expansion valve 319 and sends it to the vapour state towards the compressor.

As it evaporates internally of the tube bundle 244, the refrigerating fluid cools the air flow which, as it crosses the condensation unit 20, laps the external surface of the tube bundle 244.

It is however possible that in other embodiments the evaporator of the refrigerating unit 30 is separated from the heat exchange plate 24 of the condensation unit 20. For example, the evaporator of the refrigerating unit 30 can be used to cool a vector fluid, for example a mixture of water and glycol, which is circulated by a further pump in an auxiliary hydraulic circuit connected with the heat exchange plate 24. In this way, in the heat exchange plate 24, the air flow is cooled by the vector fluid and not directly by the refrigerating fluid, avoiding contamination of the condensation water in a case of small faults in the heat exchange plates 24. In other embodiments, the refrigerating unit 30 can also comprise a further evaporator for cooling an air flow internally of a second condensation unit 20 for production of water.

In practice, this further evaporator is the heat exchange plate 24 of a second condensation unit 20 substantially identical to the one described in the foregoing.

The two heat exchange plates 24 of this embodiment can be connected to the refrigerating circuit 31 so as to be arranged reciprocally in parallel with respect to the heat exchange plate 24, i.e. so that the refrigerating fluid circulating in a heat exchange plate 24 does not circulate in the other and vice versa.

The pressure of the refrigerating fluid flowing in the further heat exchange plate 24 is regulated by a further expansion valve 319 located at the inlet of the heat exchange plate 24 of the second condensation unit 20, for example a further thermostatic valve.

This embodiment can be particularly useful in all cases in which the climatic conditions or production needs can require a lower refrigerating power in order to obtain the condensation of the water present in the air. In this case, the second condensation unit 20 can be set in function on reaching a under-exploiting condition of the power the compressor 310 can develop.

In some embodiments, the refrigerating unit 30 can also comprise a second condenser 321 configured so as to enable condensation of the refrigerating fluid coming from the compressor 310. The second condenser 321 can be connected to the refrigerating circuit 31 so as to be arranged in parallel with respect to the first condenser 312, i.e. so that the refrigerating fluid circulating in the second condenser 321 does not circulate in the first condenser 312 and vice versa.

In practice, the second condenser 321 can comprise an inlet for the refrigerating fluid, which is hydraulically connected by means of a branch conduit 322 to a portion of the refrigerating circuit 31 comprised between the outlet of the compressor 310 and the inlet of the first condenser 312 and an outlet for the refrigerating fluid, which is hydraulically connected by means of a delivery conduit 323 to a portion of the refrigerating circuit 31 comprised between the outlet of the first condenser 312 and the inlet of the expansion valve 319.

The flow of refrigerating fluid flowing at the inlet of the second condenser 321 is regulated by an intercept valve 324 located in the branch conduit 322. A further intercept valve 325 can also be positioned in the portion of the refrigerating circuit 31 comprised between the attachment point of the branch

conduit 322 and the inlet of the first condenser 312. Each of the intercept valves 324 and 325 can be an electrical actuating valve. Alternatively the two valves 324 and 325 might be replaced by a single valve of the three-way type which exchanges with a single activation.

In the second condenser 321 the refrigerating fluid is in heat exchange relation with a further vector fluid, for example water or a mixture of water and glycol, which circulates in an auxiliary circuit 326 activated by a pump 327. In the illustrated example, the auxiliary circuit 326 comprises a storage tank 328 able to store the vector fluid, while the second condenser 321 is configured as an exchanger (of any type) in which the refrigerating fluid is able to exchange heat with the vector fluid, with no direct contact. In other embodiments, the second condenser 321 might however be configured as a tube bundle immersed directly in the storage tank 328. In other embodiments, the second condenser 321 might be an exchanger in which the refrigerating fluid exchanges heat directly with the air used as a heat vector fluid destined to other uses or to a room to be heated.

In any case the condensation of the refrigerating fluid internally of the second condenser 321 supplies heat to the vector fluid, which therefore heats up. This high-temperature vector fluid can therefore be advantageously used for many purposes.

One of these aims, for example the aim of realising a defrosting system enabling thawing the ice which in determined functioning conditions that will be more fully clarified in the following, can form in the heat exchange plate 24 of the condensation unit 20, and also in the first and second exchanger 25 and 26.

For this purpose, the auxiliary circuit 326 can comprise a delivery conduit 329 which connects an outlet of the storage tank 328 with the inlet of a further tube bundle 330, formed by one or more tube arrays, which is located internally of the first parallelepiped body 240 of the heat exchange plate 24, between the arrays of the first tube bundle 244. The auxiliary circuit 326 also comprises a return conduit which connects an outlet of the tube bundle 330 with an inlet of the storage tank 328, passing through the pump 327 and the second

condenser 321.

To extend the defrosting system also to the heat exchangers 25 and 26, the auxiliary circuit 326 can be hydraulically connected to the hydraulic circuit 255, in such a way that the hot fluid coming from the storage tank 328 can selectively circulate also internally of each of the second tube bundles 254 and 264. In this way, the heat exchange liquid circulating normally between the first and the second exchanger 25 and 26 coincides with the vector fluid which circulates in the auxiliary circuit 326 and in the storage tank 328. It is however possible that in other embodiments, the first and the second exchanger 25 and 26 can each comprise a further tube bundle connected to the auxiliary circuit 326 independently of the hydraulic circuit 255, in a substantially like way to what is described for the heat exchange plate 24.

The refrigerating unit 30 (with the exception of the evaporator, i.e. the heat exchange plate 24) is for example arranged internally of a first parallelepiped module 300, i.e. an imaginary volume having a parallelepiped shape in which the condensation unit 20 is contained.

The second module 300, for example, is bordered by a tubular frame, for example formed by rectangular portals 301 (for example two in number which can be defined by the rectangular portals 201 themselves bordering the first module 200) parallel to one another and joined by at least four longitudinal cross-members 302 parallel to the advancement direction of the air flow imposed by the ventilator of the first module 200. For example the cross members 302 are able to join the vertices of the portals 301.

The portals 301 exhibit a vertical longitudinal axis and lie on parallel planes to the faces 241,251,261; 242,252,262 of the parallelepiped bodies 240,250,260 of the condensation unit 20.

In practice, each portal 301 delimits an interconnecting face of the second module 300, able to interconnect, as will be more fully described in the following, at least with the interconnecting face of a first module 200.

Each contiguous face to the interconnecting face (for example four in number of which two lateral, one upper and one lower) of the second module 300 can be provided with filler sheets, for example fixed sheets or mobile sheets, for

example of a hatch or door type. At least one of the lateral filler sheets is advantageously openable for aspirating, by the fans 314, air from the environment surrounding the second module.

The second module 300 exhibits a width (in a perpendicular direction to the advancement direction of the air flow along the first module 200), for example defined by the extension of a horizontal side of the front portal 301, which extension is W , in which W is for example a maximum width of the internal compartment of a container of standard dimensions (for example 234 cm), for example transportable by sea.

In the example W is a little smaller than the maximum width of the internal compartment of a container of standard dimensions and preferably is substantially 220 cm.

In practice, the second module 300 exhibits a width W (in the transversal direction to the crossing direction of the first module 200 by the air flow) that is twice the width $W/2$ of the first module.

The length L of the first module 200, in the parallel direction to the advancement direction of the air flow along it, can be smaller than the width W .

The second module 300 and the first module 200 exhibit a same height, for example a maximum length of the internal compartment of a container of standard dimensions, for example transportable by sea.

The first module 200 and the second module 300 are joined to one another and reciprocally fixed by means of a respective interconnecting face, which are able to match substantially parallel to one another.

In practice, the interconnecting face of the first module 200 occupies a half of the surface of one of the interconnecting faces of the second module 300 to which it is fixed.

The interconnecting faces can be fixed to one another by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the longitudinal members defining the portals 201 of the first module 200 and the portals 301 of the second module 300.

The dissipating fans 314 of the condenser 312 of the refrigerating unit 30 are,

for example, located on an upper contiguous face of the second module 300. One or both the lateral contiguous faces of the second module 300 can exhibit an access opening (closable at least partially by an openable hatch) from which the ambient air drawn from the fans 314 enters).

The width of the access opening, the rotation velocity and the overall flow rate of the ventilators 23, the rotation velocity and the overall flow rate of the dissipating fan 214 are configured so as to define an air mixture substantially comprising 2/3 of ambient air entering the second module 300 from the access opening and 1/3 of dehumidified air entering the second module 300 by means of the ventilator 23 and exiting from the first module 200.

The apparatus 10 further comprises a purification unit 40, which is able to make the condensation water collected by the condensation unit 20 potable.

The purification unit 40 comprises a sourcing pump 41 which, by means of a tube 42, is able to collect the condensation water collected on the bottom of the collecting tub 291,292,293 and send it to a purifier 43.

The purifier 43 can be provided with one or more filters, of which for example an anti-particulate filter, an anti-bacterial filter and/or a filter for removing the organic substance that might be present in the water, an activated charcoal filter and/or other filter elements.

Further, the purifier 43 can comprise a steriliser, for example functioning with UV rays or ozone.

Further, the purifier 43 can comprise a mineraliser, for example located downstream of the filters and suitable for adding condensation water filtered from mineral salts or other organoleptic elements.

The purifier 43 can lastly comprise a tank 44 in which the water purified by the purifier 43 is stored, which tank 44 comprises an emptying stopcock 45.

The condensation unit 40 is for example arranged internally of a first parallelepiped module 400, i.e. an imaginary volume having a parallelepiped shape in which the condensation unit 20 is contained.

The third module 400, for example, is bordered by a tubular frame, for example formed by rectangular portals 401 (for example two in number) parallel to one another and joined by at least four longitudinal cross-members 402 parallel to

the advancement direction of the air flow imposed by the ventilator 23 along the first module 200. For example the cross members 402 are able to join the vertices of the portals 401.

The portals 401 exhibit a vertical longitudinal axis and lie on parallel planes to the faces 241,251,261; 242,252,262 of the parallelepiped bodies 240,250,260 of the condensation unit 20.

In practice, each portal 401 delimits an interconnecting face of the second module 400, able to interconnect, as will be more fully described in the following, at least with the interconnecting face of the second module 300.

Each contiguous face to the interconnecting face (for example four in number of which two lateral, one upper and one lower) of the third module 400 can be provided with filler sheets, for example fixed sheets or mobile sheets, for example of a hatch or door type.

For example, the emptying stopcock 45 is accessible from one of the above-mentioned contiguous faces, from externally of the third module 400, for example lateral.

In a first embodiment shown in figures from 1 to 9, the third module 400 exhibits a width, for example defined by the extension of a short side (horizontal) of the front portal 401 (in relation to the crossing direction of the first module 200 by the air flow), which extension is $W/2$, in which W is for example a maximum width of the internal compartment of a container of standard dimensions (for example 234 cm), for example transportable by sea.

As mentioned, in the example W is a little smaller than the maximum width of the internal compartment of a container of standard dimensions and preferably is substantially 220 cm.

In practice, in the first embodiment, the third module 400 exhibits a width $W/2$ (in the transversal direction to the crossing direction of the first module 200 by the air flow) that is equal to the width $W/2$ of the first module 200 and half the width W of the second module 300.

The length L of the third module 400, in the parallel direction to the advancement direction of the air flow along the first module 200, in the first embodiment, is equal to the length L of the first module 200.

The third module 400 and the first module 200 exhibit a same height, for example a maximum length of the internal compartment of a container of standard dimensions, for example transportable by sea.

In practice, in this embodiment, the first module 200 and the third module 300 exhibit a same external dimension and a same external shape.

The third module 400 and the second module 300 are joined to one another and reciprocally fixed by means of a respective interconnecting face, which are able to match substantially parallel to one another.

The interconnecting faces can be fixed to one another by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the longitudinal members defining the portals 301 of the second module 300 and the portals 401 of the third module 400.

In practice, the interconnecting face of the third module 300 occupies a half (that is, in the first embodiment, the half left free by the first module 200) of the surface of one of the interconnecting faces of the second module 300 to which the first module 200 is fixed.

A contiguous lateral face of the third module 400 is, also, fixed to a contiguous lateral face of the first module 200.

The above-mentioned contiguous lateral faces can be fixed to one another by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the cross members 202 and 402 defining the contiguous lateral faces, respectively of the first module 200 and the third module 400.

In practice, in the first embodiment, the apparatus 10 is constituted by one first module 200, one second module 300, one third module 400, fixed to one another as described above.

In a second embodiment shown in figure 10, in which the above-described water flow and the power of the apparatus 10 are substantially double with respect to the apparatus 10 of the first embodiment, the third module 400 exhibits a width, for example defined by the extension of a short side (horizontal) of the front portal 401 (in relation to the crossing direction of the first module 200 by the air flow), which extension is W , in which W is for example a maximum width of the internal compartment of a container of

standard dimensions (for example 234 cm), for example transportable by sea. In the example W is a little smaller than the maximum width of the internal compartment of a container of standard dimensions and preferably is substantially 220 cm.

In practice, in the second embodiment, the third module 400 exhibits a width W (in the transversal direction to the crossing direction of the first module 200 by the air flow) that is equal to the width W of the first module 300 and double the width W of the second module 200.

The length L of the third module 400, in the parallel direction to the advancement direction of the air flow along the first module 200, in the second embodiment can be less than the above-mentioned dimension W and, for example substantially equal to the length L of the second module 300.

The third module 400, the second module 300 and the first module 200 exhibit a same height, for example a maximum length of the internal compartment of a container of standard dimensions, for example transportable by sea.

In practice, in the second embodiment, the apparatus 10 is constituted by two first modules 200, two second modules 300, two third modules 400, fixed to one another as described above.

One of the second modules 300 exhibits one of the fixed interconnecting faces (as described above for the first embodiment) to the interconnecting face of each of the two first modules 200.

In practice, each interconnecting face of a first module 200 occupies (and is fixed) to half the surface of the interconnecting face of one of the second modules 300.

The first modules 200 are fixed to one another by a respective contiguous lateral face, for example they can be fixed to one another by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the cross members 202 defining the contiguous lateral faces.

The further interconnecting face of the second module 300 opposite the face fixed to the first modules 200, is fixed to the interconnecting face of the further second module 300. The interconnecting faces of the two second modules 300 can be fixed to one another by bolts or another threaded organ and/or by

means of appropriate weld seams which interconnect the longitudinal members defining the portals 301 of the second modules 300

The further interconnecting face of the second module 300 opposite the face fixed to the second module 300, is fixed to the interconnecting face of the third module 400.

The interconnecting faces of the third module 400 and the second module 300 can be fixed to one another by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the longitudinal members defining the portals 301 of the further second module 300 and the portals 401 of the third module 400.

Each refrigerating unit 30 of each second module 300 is connected, as described in the foregoing, to each heat exchange plate 24 of one of the two condensation units 20.

In the second embodiment, a converging nozzle 230 is connected to each ventilator 23 of the condensation unit 20 more distant from the respective refrigerating unit 30 (and respect second module 300), so that the dehumidified air exiting from the first module 200 is accelerated and sent on towards the more distant second module 300.

Obviously the purification plant 40 will receive the water to be purified from each collecting tub 291,292,293 of each condensation unit 20.

In a third embodiment shown in figure 11, in which the above-described water flow and the power of the apparatus 10 are substantially double with respect to the apparatus 10 of the second embodiment, the third module 400 exhibits a width, for example defined by the extension of a short side (horizontal) of the front portal 401 (in relation to the crossing direction of the first module 200 by the air flow), which extension is W , in which W is for example a maximum width of the internal compartment of a container of standard dimensions (for example 234 cm), for example transportable by sea.

In practice, in the third embodiment, the third module 400 exhibits a width W (in the transversal direction to the crossing direction of the first module 200 by the air flow) that is equal to the width W of the second module 300 and double the width W of the first module 200.

The length L of the third module 400, in the parallel direction to the advancement direction of the air flow along the first module 200, in the second embodiment can be less than the above-mentioned dimension W and, for example substantially equal to the length L of the second module 300.

The third module 400 and the first module 200 exhibit a same height, for example a maximum length of the internal compartment of a container of standard dimensions, for example transportable by sea.

In practice, in the third embodiment, the apparatus 10 is constituted by four first modules 200, four second modules 300, and at least one, for example two third modules 400.

In this embodiment, two third modules 400 are fixed to one another by means of a respective interconnecting face, for example by bolts or another threaded organ and/or by means of appropriate weld seams which interconnect the longitudinal members defining the portals 401 of the third modules.

As described above in relation to the second embodiment, two respective second modules 300 are joined and fixed to both interconnecting free faces of the third modules 400 (opposite the interconnecting face joining the third modules) to faces of which free interconnecting faces further interconnecting faces of two further second modules 300 are respectively fixed.

As described above in relation to the second embodiment, two interconnecting faces of two first modules 200 are respectively fixed to each free interconnecting surface of the second modules 300, which two interconnecting faces are fixed to one another by two contiguous lateral faces, as described in the foregoing for the second embodiment.

In practice, in the third embodiment, the apparatus 10 exhibits a symmetrical distribution of the first and second modules 200,300 with respect to a perpendicular plane to the air flow advancement direction, along the first modules 200 and passing through the contact plane between the two third modules 400.

In this case too, each refrigerating unit 30 of each second module 300 is connected, as described in the foregoing for the second embodiment, to each heat exchange plate 24 of one of the two condensation units 20.

In the second embodiment, a converging nozzle 230 is connected to each ventilator 23 of the condensation unit 20 most distant from the respective refrigerating unit 30 (and respect second module 300), so that the dehumidified air exiting from the first module 200 is accelerated and sent on towards the most distant second module 300.

Obviously each purification plant 40 arranged in the respective third module 400 will receive the water to be purified from each collecting tub 291,292,293 of each closest condensation unit 20.

For example, the first, second and third module 200, 300, 400, once fixed reciprocally as described in the foregoing define a substantially single-block apparatus having a width W of slightly less than the maximum width of the internal compartment of a container of standard dimensions (for example 220 cm), for example transportable by sea; a height of slightly less than the maximum height of the internal compartment of a container of standard dimensions (for example 263 cm), for example transportable by sea, and having a variable length as a function of the flow rate and/or power requested, which is substantially 495 cm for the first embodiment, 905 cm for the second embodiment and 1810 cm for the third embodiment, so as to be able to be inserted in a standard container for transportation thereof.

Functioning of the apparatus

In the normal functioning of the apparatus 10, the ventilators 23 are set in operation so as to generate a continuous air flow that crosses the condensation unit 20, in particular the heat exchange plate 24 and the heat exchangers 25 and 26.

At the same time, the compressor 310 and the condenser 312 of the refrigerating unit 30 are also set in operation, so that the evaporation of the refrigerating unit in the heat exchange plate 24 is able to cool the air flow to a lower temperature than the dew point temperature, thus causing condensation of the vapour in the air flow, which vapour accumulates in the form of water in the collecting tub 291 and is then sent on to the purification unit 40.

At the same time the recycling pump 256 is also set in operation, so as to cause the heat exchange liquid to flow internally of the closed hydraulic circuit

255 connecting the heat exchangers 25 and 26. In this way, the cold and dehumidified air flow exiting the heat exchange plate 24 cools the heat exchange liquid which is in the second exchanger 26. This cold liquid is sent upstream of the first exchanger 25 where it is heated by the air flow in inlet before returning back to the second exchanger 26. In this way, the air flow crossing the first exchanger 25 is pre-cooled before reaching the heat exchange plate 24. Owing to this pre-cooling, the air flow can be brought to a temperature equal to or near to the dew point, without using energy directly produced by the refrigerating unit 30, but simply by recuperating a part of the heat energy which otherwise would be lost in the air.

Note here that the vapour in the air flow can condensate not only in the heat exchange plate 24 but also in part in the first heat exchanger 25. The water produced in the first heat exchanger 25 accumulates in the relative collecting tub 292 and is thence also sent on to the purification unit 40.

The cold and dehumidified air flow that exits the condensation unit 20, downstream of the ventilators 23, can be conveyed into the refrigerating unit 30, so as to pass it through the condenser 312, where it can cool the refrigerating fluid in the gaseous state by means of the heat exchange plate 24, causing condensation thereof.

Alternatively, the cold and dehumidified cold air flow from the condensation unit 20, or a part thereof, can be deviated and conveyed towards other users. For example, the air flow can be used for supplying other air treatment plants and/or for supply conditioning/cooling plants of buildings or other structures.

In these and other cases, the condenser 312 of the refrigerating unit 30 can be supplied wholly or in part by a second flow of ambient air coming directly from outside the plant 10, for example entering by the access opening of the second module 300. As mentioned in the foregoing, it is preferable for a mixture of air substantially comprising 2/3 of ambient air and 1/3 of cold and dehumidified air coming from the condensation unit 20 to be made to cross the condenser 312.

With the aim of making this functioning effective, all the active components of

the apparatus 10, such as for example the compressor 310, the condenser 312 and the expansion valve 319 of the refrigerating unit 30, as well as the heat exchange plate 24 and the heat exchangers 25 and 26 and the ventilators 23 of the condensation unit 20, are generally dimensioned so as to obtain a certain water production in determined standard environmental conditions. For example, the plant 10 can be dimensioned so as to obtain about 100 litres of water per hour, in standard atmospheric conditions, i.e. with ambient air at temperatures of about 30°C and relative humidity at about 70%.

In order to obtain these performances in standard atmospheric conditions, the refrigerating unit 30 can be made to function so that the saturated vapour temperature of the refrigerating fluid is about 5.5°C (at the compressor 310 inlet), while the ventilators 23 of the condensation unit 20 can be made to function at a predefined velocity able to generate an air flow of about 8000 m³/h.

During the above-described functioning, the apparatus 10 can also be used to heat the vector fluid which circulates in the auxiliary circuit 326, which (as mentioned) can in turn be used internally of a heating plant or as hot sanitary water.

In this case, the intercept valve 324 and possibly the intercept valve 325 is regulated so that the refrigerating fluid at high temperature coming from the compressor 310 can flow into the second condenser 321. In particular the refrigerating fluid can be entirely deviated into the second condenser 321, completely bypassing the condenser 312. In this way, a total recuperation of the condensation heat generated by the preceding compression of the refrigerating fluid is obtained in the second condenser, which heats the vector fluid of the auxiliary circuit 326.

As mentioned in the foregoing, the hot vector fluid obtained in the second condenser 321 might be used for defrosting the heat exchange plate 24 and, for example, also the heat exchangers 25 and 26. This need can be manifested when the plant 10 is used for production of water starting from air having a dew point temperature of less than 0°C. In these climatic conditions, as the air condensation point is lower than the water freezing point, ice can be directly

obtained which progressively accumulates on the tubes of the tube bundle 244 of the heat exchange plate 24. In these cases, while the apparatus 10 functions to produce water/ice, the refrigerating fluid coming from the condenser 310 is deviated into the second condenser 321, so as to heat the vector fluid in the storage tank 328. By opening appropriate valves in the auxiliary circuit 326, the vector fluid accumulated can then be cyclically sent to the tube bundle 330 which is internal of the heat exchange plate 24, obtaining thawing of the ice and therefore the production of water which accumulates in the respective collecting tub 291,292,293. In particular, the frequency with which the hot vector fluid is sent to the tube bundle 330 can be regulated by a central control unit on the basis of the temperature of the air flow in outlet from the condensation unit 20.

As with the reduction of the air temperature it is progressively more difficult to thaw the ice, this operation can be accelerated and made more efficient, enabling the hot vector fluid of the storage tank 328 to circulate also in the hydraulic circuit 255, so that the heat exchangers 25 and 26 in fact become heating elements that effectively aid the thawing of the ice.

The invention as it is conceived is susceptible to numerous modifications, all falling within the scope of the inventive concept.

Further, all the details can be replaced with other technically-equivalent elements.

In practice the materials used, as well as the contingent shapes and dimensions, can be any according to requirements, without forsaking the scope of protection of the following claims.

CLAIMS

1. An apparatus (10) for production of water from atmospheric air which comprises a condensation unit (20) comprising:
 - an inlet opening (21) of moist air,
 - an outlet opening (22) of dehumidified air,
 - at least a ventilator (23) configured so as to force an air flow to enter through the inlet opening (21) and exit from the outlet opening (22),
 - a heat exchange plate (24), which is interposed between the inlet opening (21) and the outlet opening (22), so as to intercept the air flow and able to be crossed by the air flow, and
 - a pair of heat exchangers (25,26), able to be crossed in series by the air flow, of which a first heat exchanger (25) and a second heat exchanger (26), respectively located upstream and downstream of the heat exchange plate (24) in the crossing direction thereof by the air flow, the pair of heat exchangers (25,26) being connected by means of a hydraulic circuit (255) comprising a recycling pump (256) of a heat exchange liquid contained in the hydraulic circuit (255).
2. The apparatus (10) of claim 1, wherein the heat exchange plate (24) is fixed by means of threaded organs to the pair of heat exchangers (24), so as to define a compact sandwich structure.
3. The apparatus (10) of claim 2, wherein the threaded organs are stud screws (28) having an axis parallel to the advancement direction of the air flow along the condensation unit (20) and inserted in through-holes (280) and aligned and realised in the heat exchange plate (24) and in the pair of heat exchangers (25,26), the opposite ends of the stud screws (28) being screwed to lock nuts (281) able to block the pack in a sandwich pack structure.
4. The apparatus (10) of any one of the preceding claims, characterised in that it comprises at least a collecting tub (291,292,293) located inferiorly of the condensation unit (20) for collecting condensation water separating from the air flow.
5. The apparatus (10) of claim 4, wherein the collecting tub (291,292,293) is slidably associated to the condensation unit (20) with respect to a horizontal

sliding direction perpendicular to the advancement direction of the air flow along the condensation unit 20.

6. The apparatus (10) of claim 4 or 5, wherein the bottom of the collecting tube (291,292,293) is inclined with respect to the horizontal plane.

7. The apparatus (10) of any one of claims from 4 to 6, characterised in that it comprises a plurality of collecting tubs (291,292,293), of which a main tub (291) located inferiorly of the heat exchange plate (24), and a first auxiliary tub (292) located inferiorly of the first exchanger (25).

8. The apparatus (10) of claim 7, characterised in that it comprises a second auxiliary tub (293) located inferiorly of the second exchanger (26).

9. The apparatus (10) of any one of the preceding claims, wherein the heat exchange plate (24) comprises a first parallelepiped body (240) arranged with the main dimension vertical and provided with a front face (241), with respect to the advancement direction of the air flow from the inlet opening (20), and an opposite rear face (242).

10. The apparatus (10) of claim 9, wherein between the front face (241) and the rear face (242) the first parallelepiped body (240) comprises a through-channel (243) in the air flow direction imposed by the ventilator, and closed in a transversal direction.

11. The apparatus (10) of any one of claims 9-10, wherein the first parallelepiped body (240) is crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator (23), by a first tube bundle (244), which defines a branch of a refrigerating circuit (31) of a refrigerating unit (30) which the refrigerating fluid evaporates so as to cool the heat exchange plate (24) crossed by the air flow.

12. The apparatus (10) of claims 9-11, characterised in that it comprises a plurality of ventilators (23) located posteriorly of the rear face (242) of the second heat exchanger (24), with respect to the advancement direction of the air flow along the condensation unit (20), and uniformly distributed with respect to the surface of the rear face (242).

13. The apparatus (10) of claim 12, wherein the ventilators (23) of the plurality of ventilators are flanked and aligned to one another along a vertical

direction.

14. The apparatus (10) of any one of the preceding claims, wherein each heat exchanger (25,26) comprises a respective second parallelepiped body (250,260) having a main dimension vertical and provided with a front face (251,261), with respect to the advancement direction of the air flow along the condensation unit, and a respective opposite rear face (252,262) in which between the front face (251,261) and the rear face (252,262) respective through-channels (253,263) are defined in the air flow direction imposed by the ventilator (23), and closed in a transversal direction.

15. The apparatus (10) of claim 14, wherein each second parallelepiped body (250,260) is crossed transversally, with respect to the crossing direction of the air flow imposed by the ventilator (23), by a second tube bundle (254,264), each of which defines a branch of the hydraulic circuit (255) in which the heat exchange liquid circulates.

16. The apparatus (10) of claim 14 or 15, wherein the inlet opening (21) of the condensation unit (20) is defined by the front face (251) of the second parallelepiped body (250) defining the first exchanger (25) and the outlet opening (22) is defined at the rear face (262) of the second parallelepiped body (260) defining the second exchanger (26), the sandwich structure constituted by the first parallelepiped body (240) and by the pair of second parallelepiped bodies (250, 260) defines a tunnel, closed in a transversal direction to the fluid crossing direction imparted by the ventilators (23) and open exclusively at the inlet opening (21) and the outlet opening (22).

17. The apparatus (10) of any one of the preceding claims, wherein the hydraulic circuit (255) comprises a branch (258) which connects an outlet of the first exchanger (25) with the inlet of the second exchanger (26), in which the heat exchange liquids heated by the moist air flow entering by the inlet opening (21), a further closed hydraulic circuit (265), wherein the heat exchange liquid circulates, deriving from the branch (258) being connected to a user for heating thereof.

18. The apparatus (10) of any one of the preceding claims, wherein the outlet opening (22) comprises an accelerator element (230) of the dehumidified air

flow which exits from the outlet opening (22).

19. The apparatus (10) of claim 17, wherein the accelerator element comprises a converging nozzle (230), associated to a downstream end of the ventilator (23) with respect to an advancement direction of the air flow, imposed by the same ventilator (23).

20. The apparatus (10) of any one of the preceding claims, characterised in that it comprises at least a filter apparatus (27) able to intercept the inlet opening (21) for filtering the air flow entering therefrom.

21. The apparatus (10) of any one of the preceding claims, characterised in that it comprises a chemical treatment unit of the air (275).

22. The apparatus (10) of claim 21, wherein the chemical treatment unit of the air (275) is interposed between the filter apparatus (27) and the heat exchange plate (24) in the advancement direction of the air flow imposed by the ventilator (23), and is able to intercept the inlet opening (21) for filtering the air flow entering therefrom into the condensation unit (20).

23. The apparatus (10) of claim 21 or 22, wherein the chemical treatment unit of the air (275) comprises an air-permeable membrane comprising Zeolite.

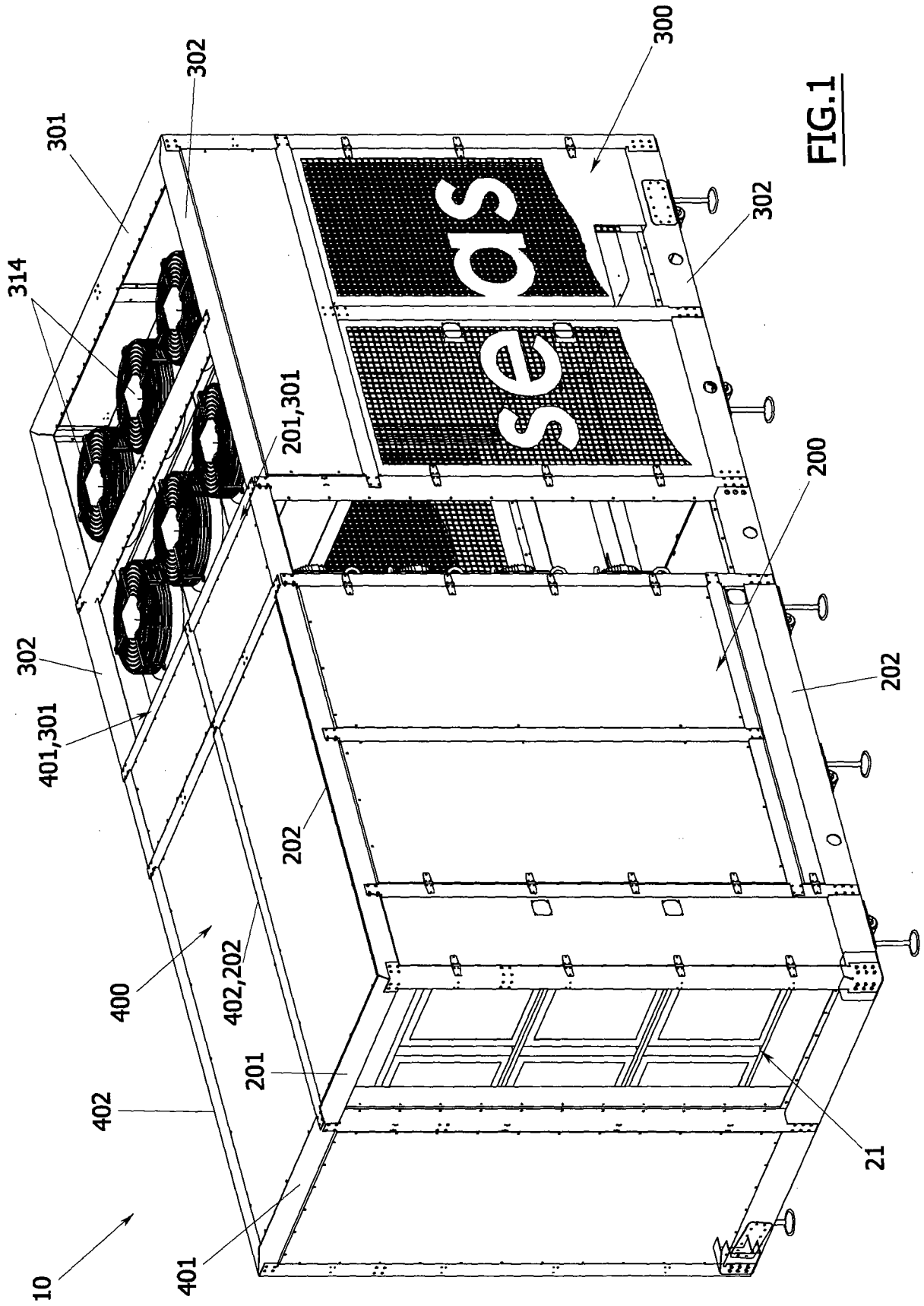
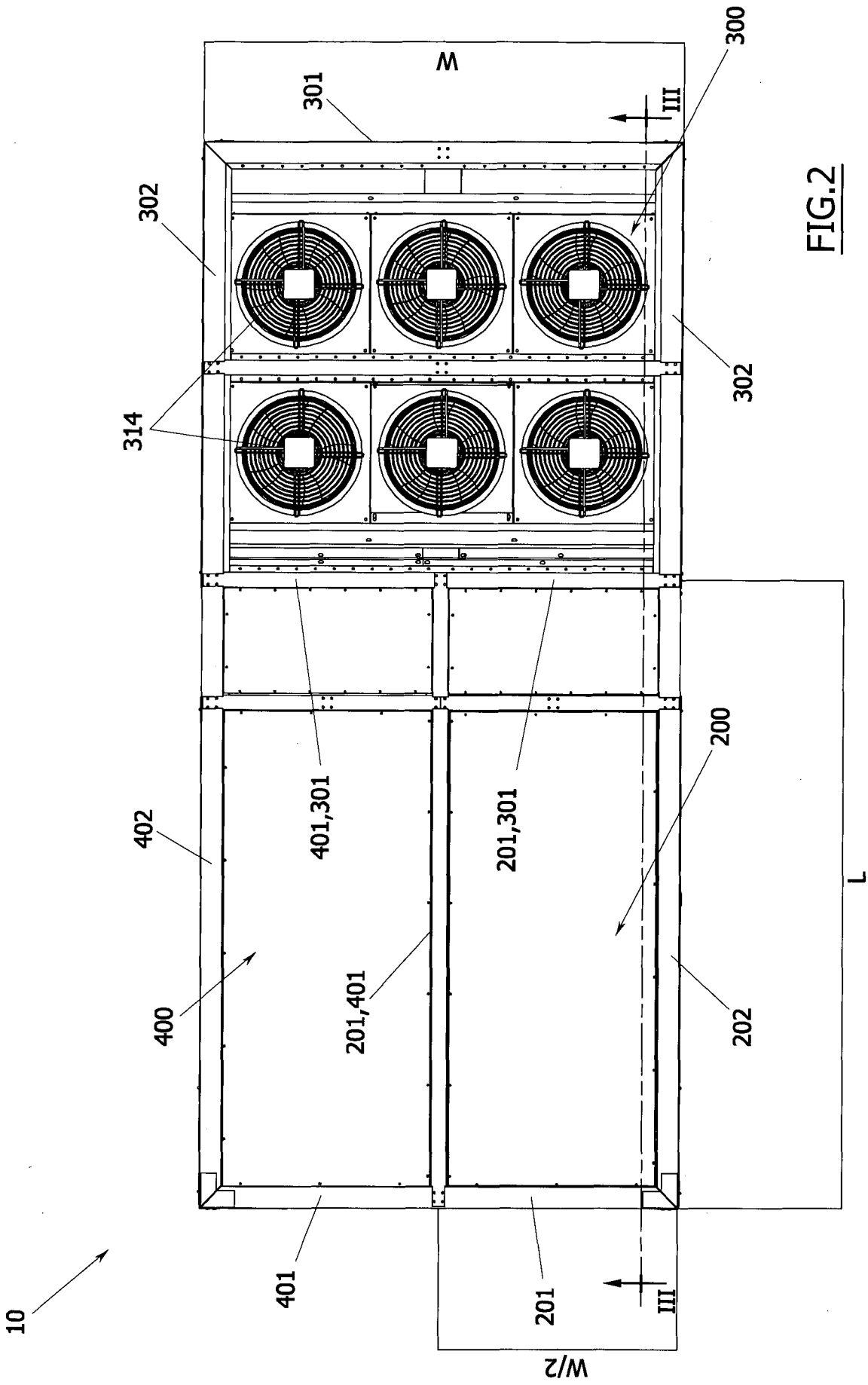


FIG.1



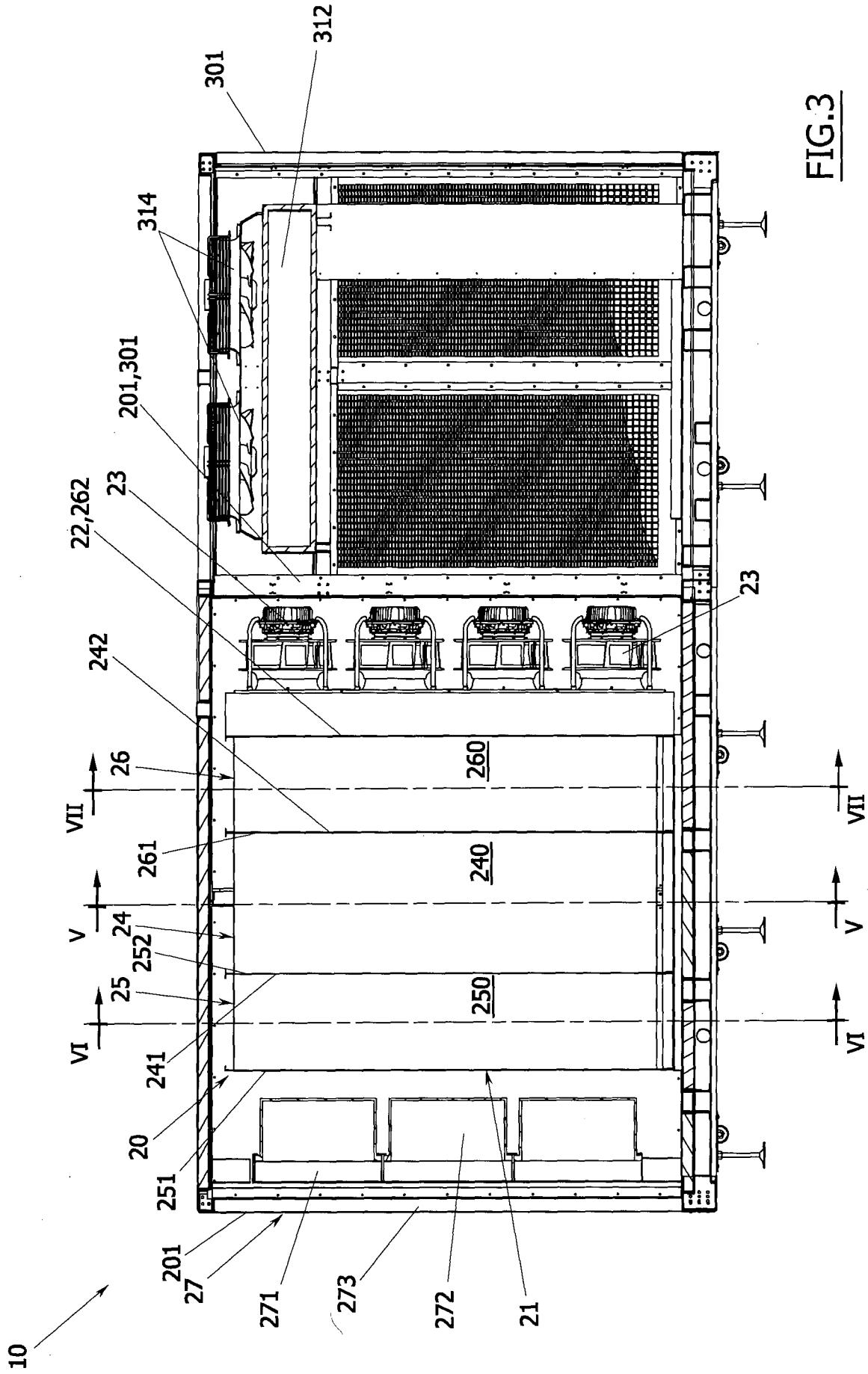


FIG.3

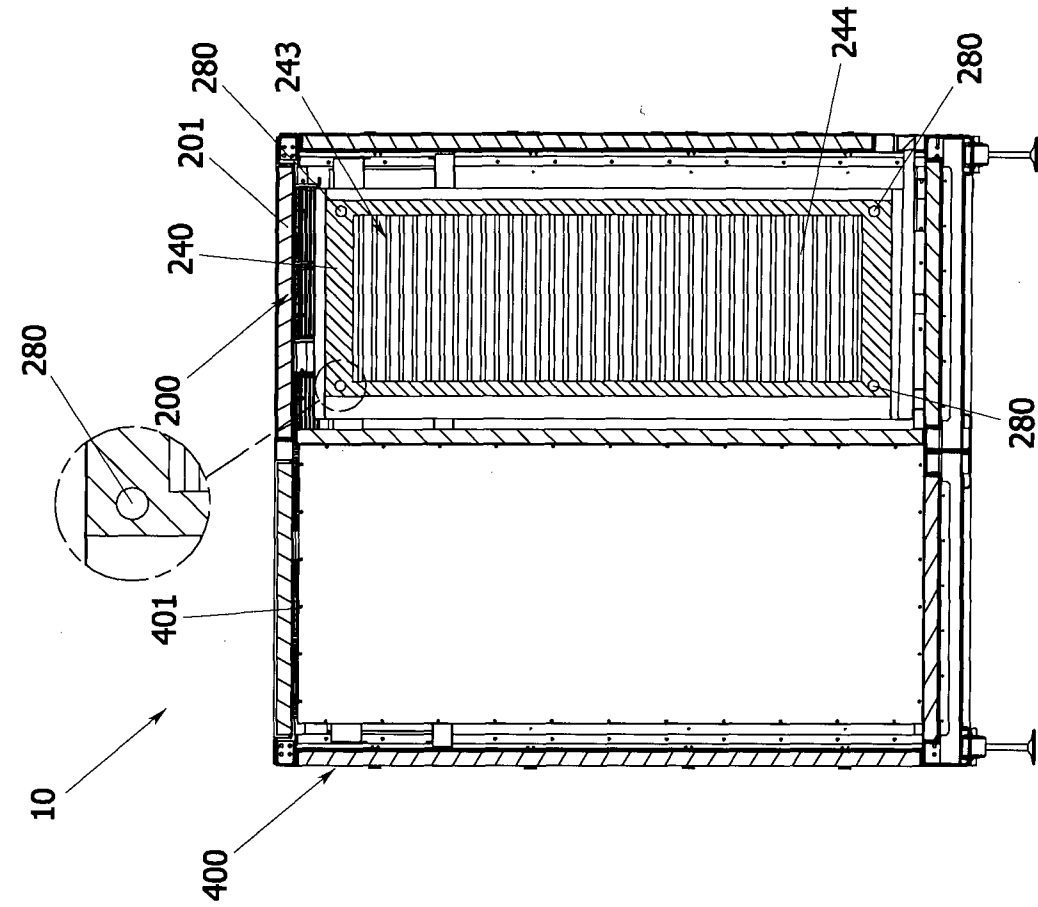


FIG.4

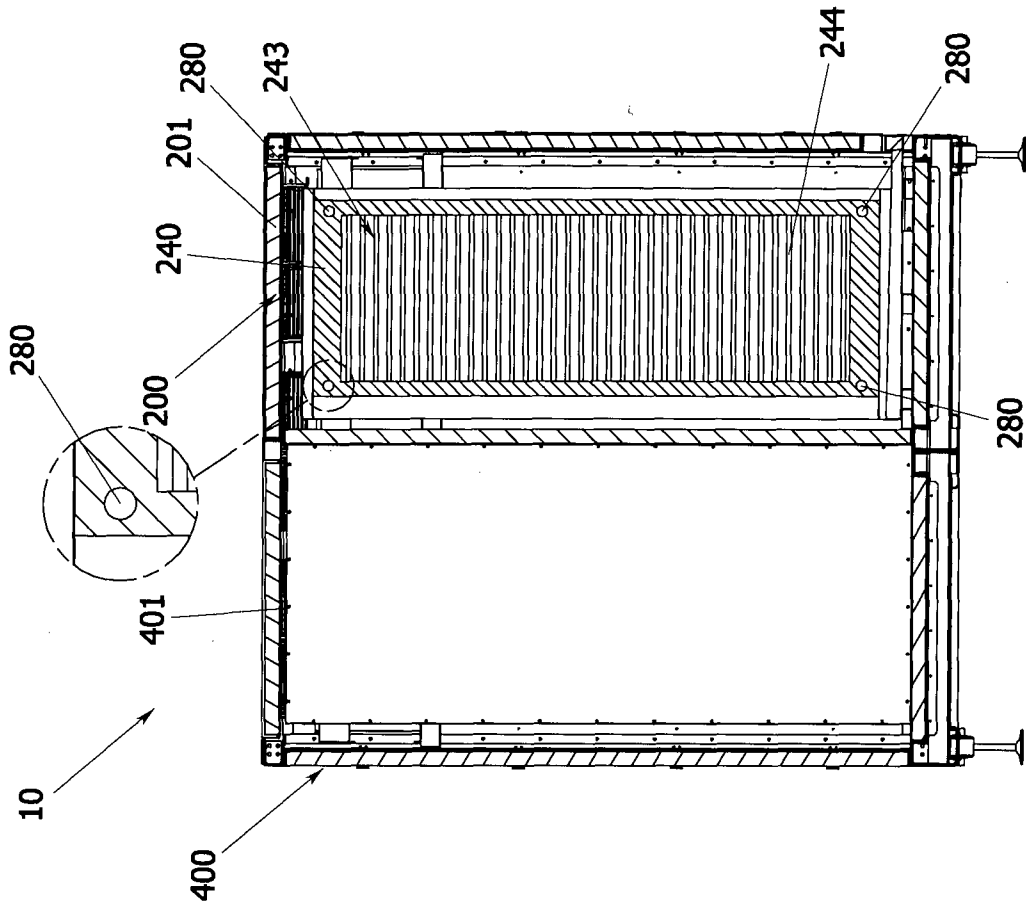
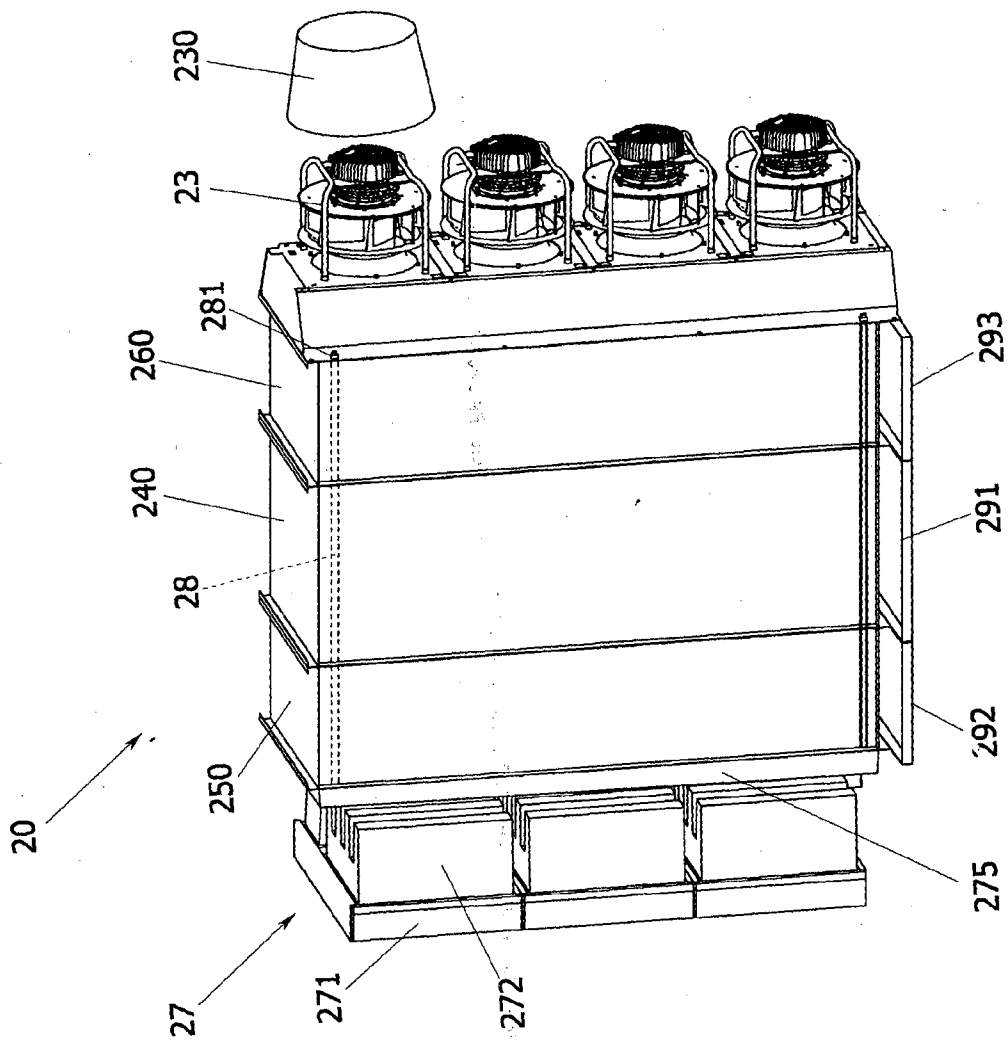
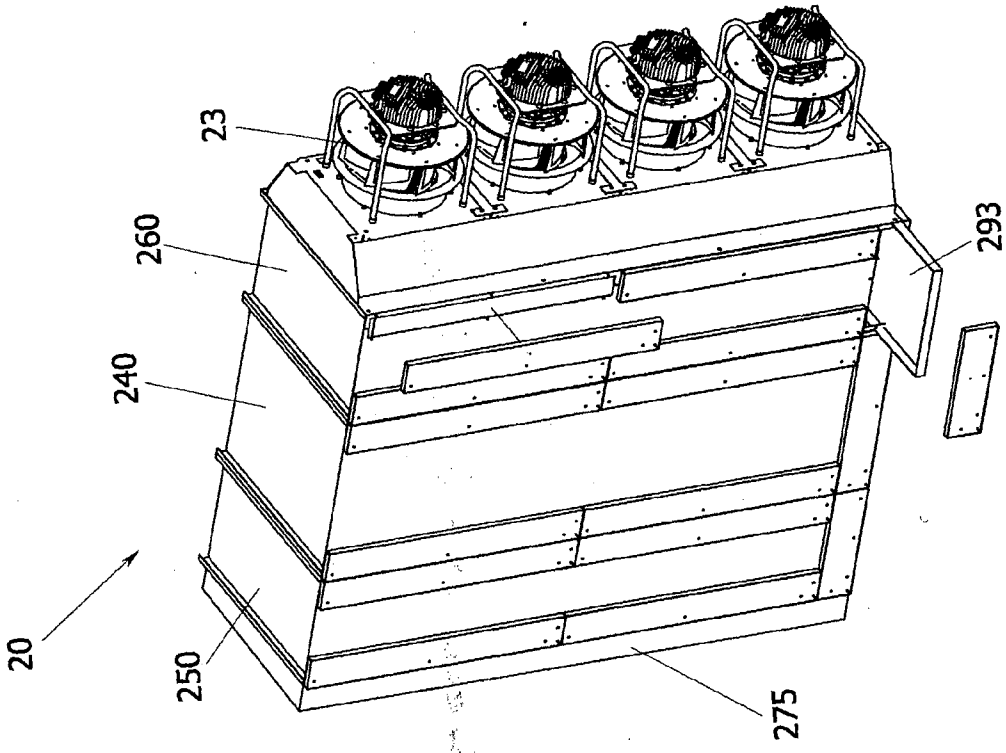


FIG.5



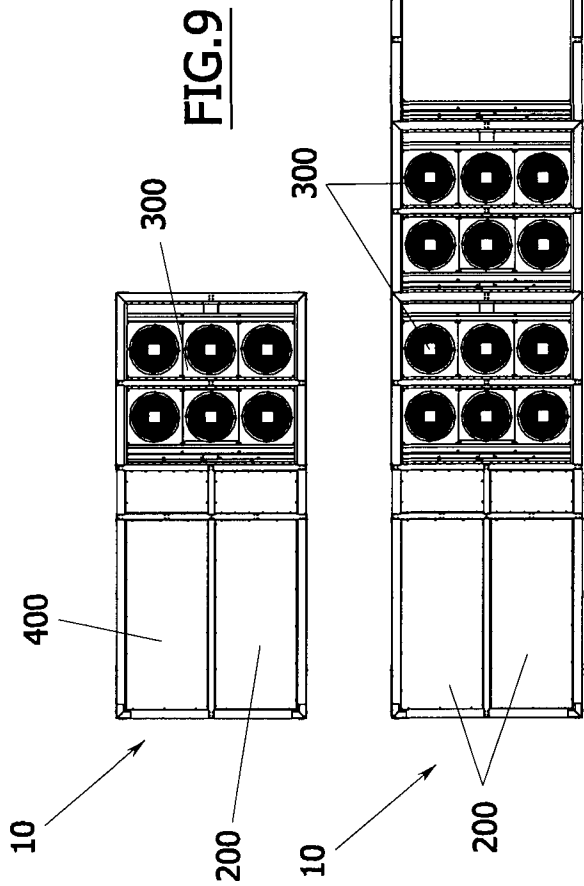


FIG. 10

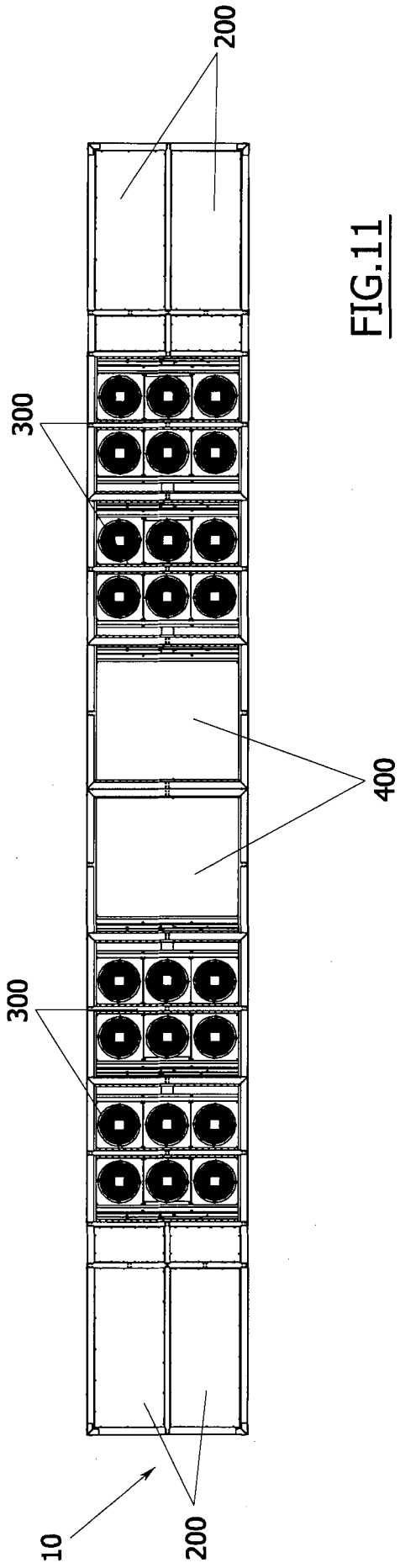
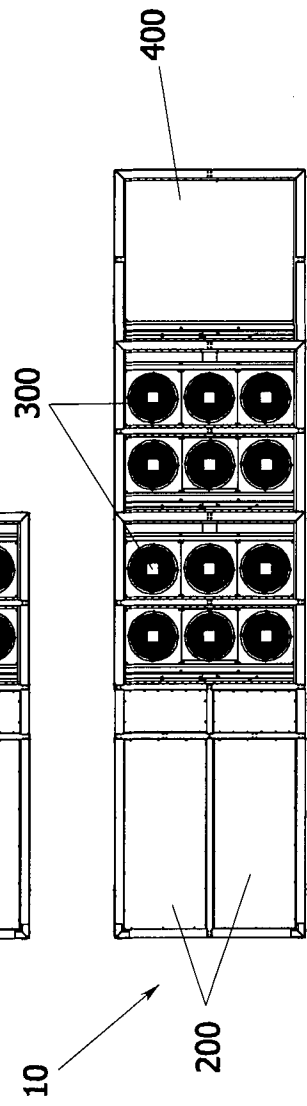
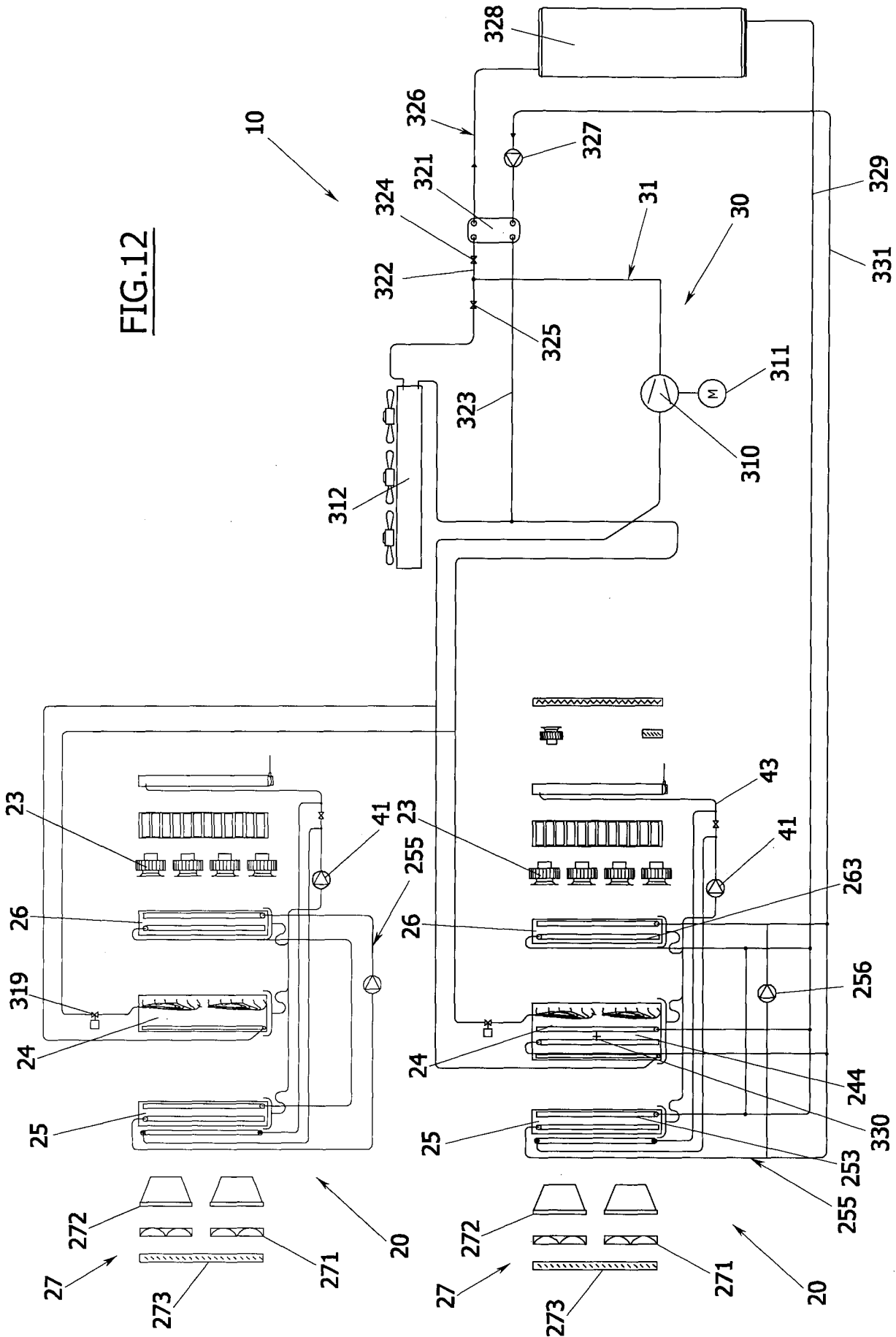


FIG.12



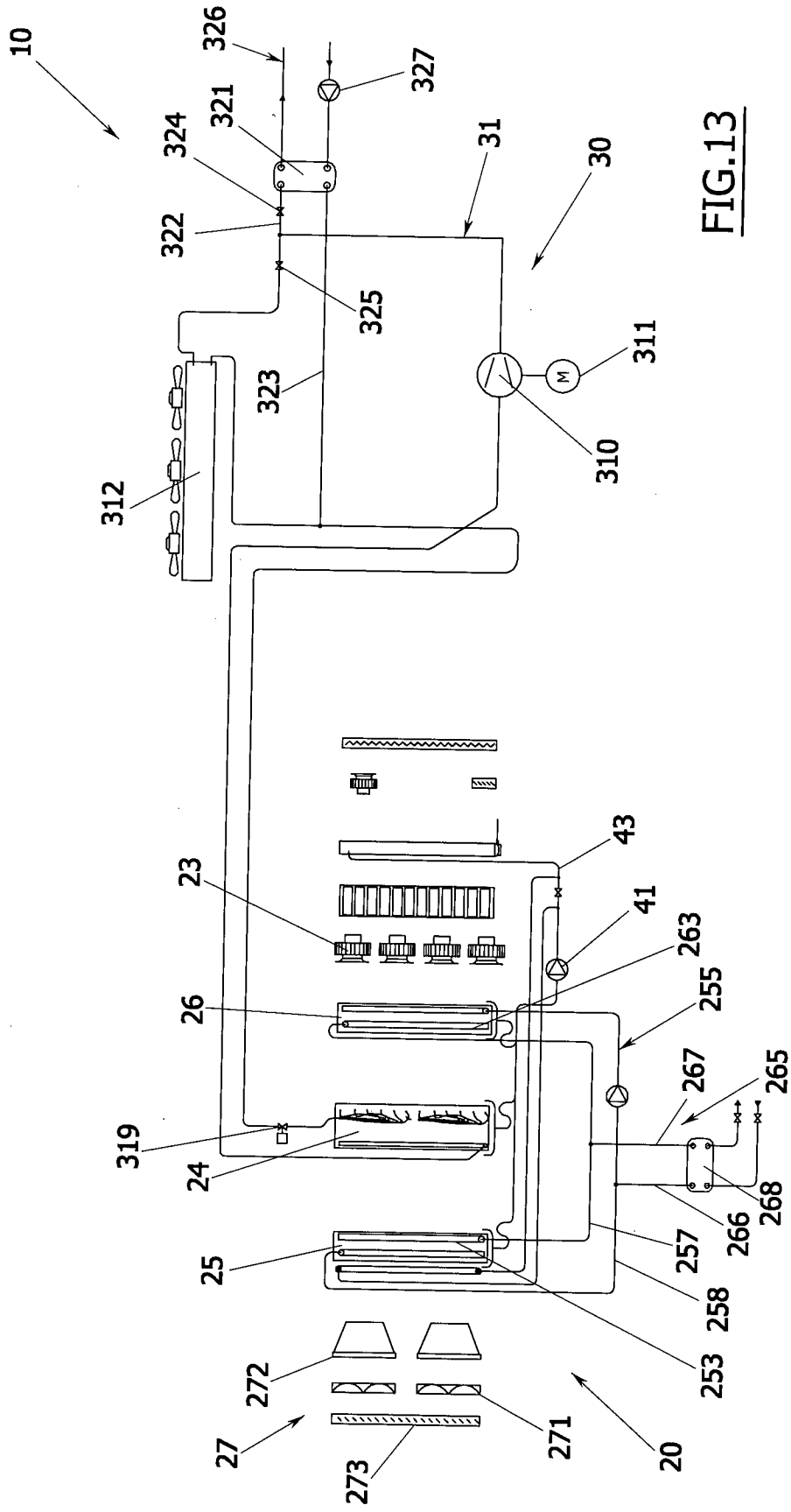


FIG.13

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/000710

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D5/00 E03B3/28 F24F3/14
ADD.
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)
B01D E03B F24F

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	WO 2004/099685 A1 (SWILION B V [NL]; OOSTERLING PIETER ADRIAAN [NL]; GARDNER FRED ERNST [] 18 November 2004 (2004-11-18) fig.1, page 3 line 27 - page 6 line 28 -----	1-23
X	EP 1 382 756 A1 (ROMANOVSKY VLADIMIR FEDOROVICH [RU]; BOYAROV MIKHAIL VLADIMIROVICH [RU] 21 January 2004 (2004-01-21) fig.4, par.1,39-42,50 -----	1-23
A	US 2004/244398 A1 (RADERMACHER REINHARD K [US] ET AL) 9 December 2004 (2004-12-09) figures 1,3 -----	1-23

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search 2 February 2016	Date of mailing of the international search report 10/02/2016
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/IB2015/000710

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