DEHUMIDIFYING AND VENTILATING METHOD AND AIR CONDITIONER THEREWITH

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ABSTRACT

This invention refers to a dehumidifying and ventilating method. By this means, ascending gas membrane of the water vapor and dynamic solid film with adsorbent particles are formed due to the heat exchange between the water in the reactor of the dehumidifying chamber and the refrigerant in the condensing coil, for separating the indoor air. As a result, the water vapor and the dry air of the indoor air have different speeds when moving to the dehumidifying chamber, the movement of the dry air is delayed, and consequently the aim of dehumidifying is achieved. The dehumidifying and ventilating units in the air conditioners can combine with various indoor units to form refrigerant electric wires. The refrigerant electric wires can be used for cooling, dehumidifying, dehumidifying and ventilating, refrigerating, preparing nanoparticles for industry, freshwater recovery and seawater desalting to freshwater.
Fig 7

Fig 8
DEHUMIDIFYING AND VENTILATING METHOD AND AIR CONDITIONER THEREWITH

TECHNICAL FIELD

[0001] The invention relates to a refrigeration apparatus, particularly an air conditioner capable of refrigerating, moisture removing, dehumidifying and ventilating.

BACKGROUND OF THE INVENTION

[0002] A well-known prior example of split type refrigerating air conditioner comprises of an outdoor condensing unit and an indoor evaporation unit. The two units are connected with each other by refrigerant pipes and electric wires. In the outdoor condensing unit, the condenser, air-cooled. In the indoor evaporation unit, the evaporator works in an air-refrigeration mode. The surface of the evaporator in the indoor evaporation unit has a temperature lower than the dew point of the air indoors when the evaporator adsorbs heat to reduce the room temperature; therefore the hot air is cooled down and dehumidified as it passes through the evaporator. Some of the water vapor in the air is condensed into drops flowing out of the building wall through water pipe.

[0003] However, due to the restricted surface area of outer fins of the evaporator tube, the amount of the water vapors that can be condensed into drops attaching to the fins is limited. As a result, moisture removal effect may not be achieved in big space. Furthermore, the split type refrigerating air conditioner only circulates the air indoors, while there is no air exchange between the indoor and outdoor environment. Meanwhile, in order to maintain the room temperature, room doors and windows are kept close; consequently the room is not ventilated and oxygen deficient is frequent in the room. Therefore, people would easily get “Air conditioning disease”. In addition, because various odors and dusts cannot be exhausted out, harmful bacteria grow quickly.

SUMMARY OF THE INVENTION

[0004] To overcome the defects of the prior refrigerating air conditioner, the present invention provides an air conditioner, in which a water-cooled dehumidifying ventilator can be combined with various multifunctional indoor apparatus. The air conditioner according to the present invention is used not only for refrigerating, cooling and dehumidifying the indoor air, but also extracting out the moisture, odors, and dusts, while allowing the outdoor fresh air to enter the room and be mixed with the indoor air. Then the mixed air will be extracted out of the room, so that the indoor air is kept fresh and circulated.

[0005] In one aspect, the present invention provides the following method to solve the problems in prior art:

[0006] A) A fan draws air indoors and water vapor in a vacuum vessel to the inner wall and outer wall of an air inlet of the vacuum vessel respectively, wherein the water vapor forms a gas membrane in a continuous phase at the inner wall of the air inlet. The gas membrane separates the indoor air entering the vessel from the outer wall of the air inlet. As the density of the water vapor inside the air inlet increases, water vapor in the indoor air and the gas membrane impinge with each other and are combined into multimolecular water, then the multimolecular water enters the vessel and moves towards the fan, whereas the speed of the dry air passing through the gas membrane is decreased;

[0007] B) Drum flights hit adsorbent particles from the inner wall to the outer wall of the air inlet of the vacuum vessel, resulting in a solid particle membrane in a continuous phase to separate the indoor air. As the density of the solid particle membrane increases, the water vapor in the indoor air and the solid particle membrane are combined with each other, fall into a water container, and are lifted by a submersible pump to transfer heat with refrigerant. Then drum flights separate out the resulting particles. The speed of the dry air passing through the solid particle membrane is decreased; and

[0008] C) The water vapor and the dry air of the indoor air have different speeds when moving to the vessel due to the gas membrane and the solid particle membrane. The movement of the dry air is delayed.

[0009] In another aspect, in an air conditioner applying the method according to the present invention, a water-cooled dehumidifying ventilator for carrying out the aforementioned method comprises a compressor, a water-cooled dehumidifying chamber, and a water supply device.

[0010] As described hereinafter, “dehumidifying ventilator” refers to a water-cooled dehumidifying ventilator; and “dehumidifying chamber” means a water-cooled dehumidifying chamber.

[0011] An enclosure of the dehumidifying chamber and a water container can be connected with each other in any manner. The outer shell shapes of the enclosure and the water container comprise all kinds of column shapes. A centrifugal fan is positioned on the top of the enclosure. The edge of a top opening of a cylinder is seal-connected with an air inlet of the centrifugal fan. The edge of a bottom opening of the cylinder is seal-connected with a contact surface inside the enclosure. The cylinder has an air inlet on its wall. An air distributor is positioned in an annular air passage and above the air inlet on the cylinder wall. A condensing coil is positioned in the cylinder. A reservoir is connected with the water container. A water tank and the reservoir are positioned on different height levels. The water tank and the reservoir comprise all kinds of control device for water intake, control device for water discharge, and control device for stopping water intake when the amount of water exceeding a predetermined value. A water discharge pipe of the water tank and a water intake pipe of the reservoir are connected with each other in any manner. The enclosure and the water container are jointed in a convex-concave manner. A convex plate of the enclosure is broader than a water inlet of the water container, and extends along the water inlet of the water container until under the water. The parts where the bottom and the convex plate of the enclosure contact to the water container and the water are sealed. The air inlet on the cylinder wall comprises of rectangular mouths.

[0012] The reservoir is a bottle-type column. Each of the three sides surrounding a reservoir opening side, and a sill are connected with the outer wall of the water container. The upper edge of the opening side and the sill are curved so as to accord with the outer wall of the water container. The top of the reservoir is in a position lower than the top of the water container, and the bottom of the reservoir is in a position lower than the bottom of the water container.
The water tank comprises: a horizontal-type upper section, wherein the projection area of the upper section is larger than the total area of the compressor and the reservoir; a barrel-type middle section, wherein the projection of the middle section has the same shape with the reservoir; a column-type lower section, wherein the projection area of the lower section is smaller than reservoir. The water discharge pipe of the water tank is connected with the water intake pipe of the reservoir via a hollow column. The inlet/outlet extension pipes of the condenser pipe are positioned below the convex plate and within a slot at the curved edge of the upper side of the reservoir. A float valve is placed between the water tank and the reservoir. The connecting rod of the float valve is positioned in the hollow column. An electromagnetic water intake valve is embedded on the top of the water tank. An air discharge tube with a double water level pressure switch is connected with the water tank. The submersible pump is connected with the bottom of the water container.

The cover, the water container, the cylinder, the reservoir, and the water tank are made of polyvinyl chloride, polyethylene, polypropylene, or ferroconcrete.

The dehumidifying ventilator is located outdoors. The air inlet of the dehumidifying chamber is connected with a suction pipe entering a room. The air outlet of the centrifugal fan in the dehumidifying chamber directly opens to the atmosphere outside the room.

When the dehumidifying ventilator is located in a room, the air outlet of the centrifugal fan in the dehumidifying chamber is connected with an air discharge pipe extended into the atmosphere outside the room. When the dehumidifying ventilator is located in an inner room, the air inlet of the dehumidifying chamber will be connected with the suction pipe entering the room, and the air outlet of the centrifugal fan in the dehumidifying chamber will be connected with an air discharge pipe extended into the atmosphere outside the room.

Dusts indoors can be combined to the gas membrane of the water vapor, and can be extracted out of the room.

The dehumidifying ventilator can be used for preparing industrial nanoparticles.

The dehumidifying ventilator can be used in combination with an indoor unit.

The water discharge pipe of the evaporator in the indoor unit may be connected with the reservoir or the water tank in the dehumidifying ventilator.

The dehumidifying ventilator may be used in combination with a still.

During the operation of the air conditioner, plain water may exchange heat with refrigerant in the dehumidifying chamber and be evaporated into water vapor, then the water vapor and the gas membrane may be combined together into multimolecular water so as to exchange heat with the refrigerant in the still and be condensed into plain water. Alternatively, seawater may exchange heat with refrigerant in the dehumidifying chamber, and be separated into water vapor and salt by the centrifugal fan and the drum, then the water vapor and the gas membrane may be combined together into multimolecular water so as to exchange heat with the refrigerant in the still and be condensed into plain water. The dehumidifying ventilator may be used in combination with a refrigerating chamber.
The dehumidifying ventilator may be used in combination with an air-cooled air evaporation chamber, and the indoor unit.

An outlet divider may be provided on the pipes connecting the heat exchanger of the compressor with the heat exchanger of the dehumidifying chamber and the heat exchanger of the air-cooled air evaporation chamber. A throttling gear is provided on the pipe entering the heat exchanger in the air-cooled air evaporation chamber;

When both of the heat exchangers in the dehumidifying chamber and the air-cooled air evaporation chamber are used as a condenser, and the heat exchanger in the indoor unit is used as an evaporator, the refrigerant flows in the pipe sections a-e-g-h-i-j-k-l and b-d-j-k-l, respectively;

When the heat exchanger of the dehumidifying chamber is used as a condenser, and the heat exchanger in the indoor unit is used as an evaporator, the refrigerant flows in the pipe sections b-d-j-k-l;

When the heat exchanger in the air-cooled air evaporation chamber is used as a condenser, and the heat exchanger in the indoor unit is used as an evaporator, the refrigerant flows in the pipe sections a-e-g-h-i-j-k-l;

When the heat exchanger of the dehumidifying chamber is used as a condenser, and the heat exchanger in the air-cooled air evaporation chamber is used as an evaporator, the refrigerant flows in the pipe sections b-e-c-f-h-m-l.

The dehumidifying ventilator and the air-cooled air evaporation chamber may be placed in the same frame. A reversal valve is provided on the air outlet of the dehumidifying chamber. A branch pipe thereof is connected with the air-cooled air evaporation chamber via a conveying pipe. The air-cooled air evaporation chamber is provided with a cooling water pipe.

The dehumidifying ventilator may be used in combination with an air evaporation still. The dehumidifying ventilator and the air evaporation still may be positioned on different height levels and placed in the same frame. The air outlet of the dehumidifying chamber is connected with the air evaporation still via the conveying pipe. The air evaporation still is provided with the cooling water pipe.

During the operation of the air conditioner utilizing the aforementioned combination of the dehumidifying ventilator with the air-cooled air evaporation chamber and the indoor unit or the aforementioned combination of the dehumidifying ventilator with the air evaporation still, the multimolecular water may be fluidized with the outdoor air and then brought into the heat exchanger functioning as an evaporator, so as to exchange heat with the refrigerant, and thus turn into plain water.

The heat exchanger in the evaporator box, the heat exchanger in the air-cooled air evaporation chamber, the heat exchanger in the air evaporation still may have both of evaporation and distillation functions. The openings of their conveying pipes may be round at one end, and rectangular at the other end. The cooling water pipe may be connected with the water tank, reservoir, or an additional container.

The dehumidifying ventilator may be used in combination with a still and an indoor unit.

The dehumidifying ventilator may be used in combination with a refrigerating chamber and an indoor unit.

The dehumidifying ventilator may be used in combination with a still and a refrigerating chamber.

The dehumidifying ventilator may be used in combination with a still, a refrigerating chamber, and an indoor unit.

The dehumidifying ventilator may be used in combination with a water chiller evaporator.

Embodiments of the invention will be explained in detail with reference to the drawings and the description below.

FIG. 1 shows a concept view of the invention.

FIG. 2 shows a front view of the structure of a first dehumidifying ventilator according to the concept shown in FIG. 1.

FIG. 3 shows a right view of the structure shown in FIG. 2.

FIG. 4 shows a partial sectional view taken along line B-B in FIG. 3.

FIG. 5 shows a front view of the structure of a second dehumidifying ventilator according to the concept shown in FIG. 1.

FIG. 6 shows a front view of the structure of a third dehumidifying ventilator according to the concept shown in FIG. 1.

FIG. 7 shows a structural view of the second dehumidifying ventilator combined with a still in the same frame.

FIG. 8 shows a structural view of the third dehumidifying ventilator combined with a still in the same frame.

FIG. 9 shows a structural view of the third dehumidifying ventilator combined with an air-cooled air evaporation chamber in the same frame.

FIG. 10 shows a structural view of the third dehumidifying ventilator combined with an air-cooled air evaporation chamber having distillation function in the same frame.

FIG. 11 shows a concept view of a combination of a dehumidifying ventilator with an air-cooled air evaporation chamber and an indoor unit.

FIG. 12 shows an auxiliary view of an overfall dam.

FIG. 13 shows a right view of the structure shown in FIG. 10

FIG. 14 shows a right view of the structure of the third dehumidifying ventilator combined with an air evaporation still in the same frame.

FIG. 15 shows a concept view of a combination of a dehumidifying ventilator with a still and an indoor unit.
FIG. 16 shows a concept view of a combination of a dehumidifying ventilator with a still, a refrigerating chamber, and an indoor unit.

FIG. 17 shows an auxiliary view of a conveying pipe.

BEST MODE FOR CARRYING OUT THE INVENTION

As shown in FIG. 1, a dehumidifying ventilator 1 is located outdoors, an indoor unit 8 is located indoors, and they are connected with each other by refrigerant pipes and electric wires. An air inlet 5 of a dehumidifying chamber 2 in the dehumidifying ventilator 1 is connected with a suction pipe 7 entering the room through a wall. An air outlet 6 of the dehumidifying chamber 2 directly opens to the atmosphere outside the room.

FIG. 1 shows 6 kinds of gas/liquid circulation or movement comprising: a) a refrigerant circulation via a compressor 3, a condenser 4, a capillary tube 9, an evaporator 10, etc; b) an indoor air circulation via a fan 11 and the evaporator 10 in the indoor unit 8, for cooling and removing moistures; c) a circulation of the outdoor fresh air, and mixed indoor and outdoor cool air via the dehumidifying chamber 2, in which the outdoor fresh air is drawn in and mixed with the indoor air, and when the mixed air moves towards the dehumidifying chamber 2, the movement of the dry air is delayed by the water vapor membrane, achieving the effects of dehumidification and ventilation; d) a water circulation via a water container of the dehumidifying chamber, the condenser 4 and a submersible pump, for increasing the heat transferring area of the refrigerant, improving the efficiency of the refrigerant, and thus allowing the water to be continuously vaporized into the water vapor membrane and particles; e) a water circulation in which indoor water vapor is condensed into water dew by the evaporator 10 in the indoor unit, then flows into a reservoir of the dehumidifying ventilator via a pipe 12, to participate the above-mentioned water circulation via the water container of the dehumidifying chamber; and f) a particle circulation, in which particles leave the reaction kettle, adsorb the water vapor and return to the reaction kettle.

The first dehumidifying ventilator 1 as shown in FIG. 2, FIG. 3, and FIG. 4, comprises the compressor 3, the dehumidifying chamber 2, the reservoir 13, and a water tank 14, etc. The compressor 3 is provided in a position parallel to the dehumidifying chamber 2. The compressor 3 and reservoir 13 are in the front and back positions. The water tank 14 and reservoir 13 are in the top and bottom positions. In the figures, a serpentine condensing coil 20 is presented in circles.

The dehumidifying chamber as well as the parts therein relate to a separation/recombination equipment in chemical engineering facilities.

The dehumidifying chamber 2 comprises an outer shell and a hollow cylinder 18, condensing coil 20, drum 21, fan 22, motor 23, submersible pump 24, and sprayer 25, etc. The outer shell of the dehumidifying chamber consists of a chamber enclosure 15 and the water container 16. The shapes of the enclosure and water container comprise all kinds of column shapes. A centrifugal fan 17 is embedded in the top center of the chamber enclosure 15. The air outlet of the centrifugal fan is used as the air outlet 6 of dehumidifying chamber. A hollow tube that is fit on the top of the sidewall of the chamber enclosure is used as the air inlet 5 of dehumidifying chamber, and is connected with the suction pipe 7 entering the room through a wall (see FIG. 1).

The body of the reservoir 13 consists of a bottle-shaped neck 27 and a quadrilateral container with an opening side. This opening side has a sill 26 at the bottom (see FIG. 12). The other three sides surrounding the opening side, and the sill 26 are seal-connected with the outer wall of the water container 16. The top of the reservoir is in a position lower than the top of the water container, and the bottom of the reservoir is in a position lower than the bottom of the water container. The upper edge of the opening side and the sill are curved so as to accord to the outer wall of the water container.

On the wall of the water container within the area defined by the edges of the reservoir's opening side, there is a rectangular water inlet 28 of the water container. A L-shaped plate 29 that attaches to the water container extends along the perimeter of the outer wall of the water container to form a channel. The bottom edge of the chamber enclosure is fit to the channel of the water container in a convex-concave manner. A convex plate 30 at the bottom of the enclosure is made wider than the water inlet 28 of the water container, and extends into the water in the water container along vertical channels located besides the water inlet on the outer wall of the water container. The reservoir and the water container are constructed to form an overflow dam at the rectangular water inlet, so as to speed up the water flowing towards the water container, and to facilitate the circulation of the water in the water container. Rubber seal is provided between the lower edge of the enclosure and the L-shaped plate.

The outer shell of the dehumidifying chamber is sealed, except for the air inlet and air outlet of the dehumidifying chamber. Accordingly, both of the outer shell of the dehumidifying chamber and the suction pipe entering the room become the extending parts of the air inlet of the centrifugal fan.

The cylinder neck at the upper part of hollow cylinder 18 and the air inlet of the centrifugal fan 17 are seal-connected. The cylinder is perpendicular to the bottom of the water container 16. The lower edge of the cylinder is higher than the bottom of the water container, but lower than the water level in the water container. Thus, the cylinder in the enclosure 15 can be considered as a liner with bottom sealed. Rectangular mouths 19 are provided in the middle of the sidewall of the cylinder 18.

The above described structure according to the present invention is designed to allow the indoor air to enter the cylinder via the suction pipe, and an annular air passage formed by the inner wall of the chamber enclosure and the outer wall of the cylinder, as well as to allow water to enter the cylinder and keep the opened bottom of the cylinder sealed. It is very important to seal the opened bottom of the cylinder in this manner, which ensures that the ascending water vapor turns into a densified gas membrane to block up the rectangular mouths and separate the indoor air, as described below.

Rotational guider 31 is connected with the bottom of the water container 16 at the center. The rotational guider
is used for guiding the motor bearing. The condensing coil 20 winds between the rotational guider 31 and the hollow cylinder 18. The bottom portion of the coil 20 is positioned higher that the bottom of the water container, but at the same level as the water level. The middle portion of the coils is positioned higher than the water level, but lower than the lower edges of the rectangular mouths 19. The top portion of the coil is positioned higher than the upper edges of the rectangular mouths 19, but lower than the shoulder of the cylinder 18. The coil near the rectangular mouth has a pitch larger than that of the coil located higher or lower than the rectangular mouth. This structure is designed to ensure an efficient opening area of the rectangular mouth.

The motor 23 is located on a beam above the enclosure. The motor bearing is perpendicular to the lid of the fan 17 and the rotational guider 31 in the center. The fan 22 and the rotating taper reverse drum 21 are fixed on the bearing of the motor 23. The bottom part of the drum 21 is located in the rotating guide bushing of the rotational guider 31. Alternatively, the outer shell of the motor and the fan can be connected together by injection molding with plastic, such that the beam can be eliminated.

Two vertical flights 32 on the rotating taper reverse drum 21 are positioned opposite to each other. Each bottom end of the vertical flights 32 is positioned at the same level of the center of the rectangular mouths 19. This important construction ensures that particles hit by the vertical flights can leave the reaction kettle from the upper part of the rectangular mouths of the cylinder, leading to a tangential impingement between the particles and the air stream, and the combined particles and air stream can enter the reaction kettle from the lower part of the rectangular mouths of the cylinder by the attraction force generated by the centrifugal fan, without any resistance from the vertical flight.

In the dehumidifying chamber, the hollow cylinder, condensing coil, rotating taper reverse drum, flights, and motor together can be treated as the reaction kettle. The hollow cylinder, rotating taper reverse drum, flight, and motor together can be treated as a centrifugal settling machine. The reaction kettle and centrifugal settling machine together can be treated as a suspended centrifugal separation dryer.

The crescent mouth of the sprayer 25 is extended more than half of a circle, which is positioned above the middle portion of the condensing coil 20 but below the lower edge of the rectangular mouths 19. The submersible pump 24 is positioned on the container's bottom between the enclosure 15 and the cylinder 18. The water intake tube of the sprayer 25 is connected with the submersible pump 24 through the cylinder's wall.

When the sprayer operates, the serpentine condensing coil turns into a combined mode with the middle portion of the coil being a spray mode and the bottom portion being an immersion mode. As described below, the refrigerant in the condensing coil can freely exchange heat with water in the sealed area below the lower edge of the rectangular mouth, such that the water vapor carrying salt-containing droplets is drawn into a centrifugal drying area by the fan or is brought into the centrifugal drying area by a tangential air stream above the sealed area. Thus by using this vapor-drying method, the particle size of the salts becomes even smaller, resulting in nanoparticles. In the annular container formed by the inner wall of the water container and the outer wall of the rotational guider in the dehumidifying chamber, the water sprayed by the sprayer falls back into the container, such that the concentration of the salts in water in the water container increases, which facilitates the formation of particles.

An air distributor 41 is located on the outer wall of the cylinder in the annular air passage above the rectangular mouths 19. The inlet/outlet extension pipes of the condensing coil 20, and wires of the submersible pump are located beneath the convex plate 30 at the bottom of the enclosure, and leave the dehumidifying chamber 2 and reservoir 13 from the overfall dam and the slot 33 at the curved edge of the upper side of the reservoir (see FIG. 12).

Therefore, all of the parts of the dehumidifying chamber are sealed connected respectively except for the air inlet and air outlet. As described later, this important construction has the following advantages: 1) the dehumidifying chamber can be vacuumed, such that water evaporation and salt particle formation can be carried out at lower temperature; 2) there will be no loss in the suction power of the centrifugal fan. Those parts in the dehumidifying chamber can be connected in various ways, as long as they are sealed.

The water tank 14 comprise three sections with different shapes: a horizontal-type upper section 34 is located above compressor, wherein the orthographic projection area of the upper section 34 is larger than the total area of the compressor and the reservoir; a barrel-type middle section 35 is arranged with the compressor side-by-side, wherein the orthographic projection area of the middle section 35 has the same shape with the reservoir; the lower section is constructed as the water discharge pipe 36, wherein the orthographic projection area of the lower section is smaller than reservoir. This construction is designed to reach the maximum water storage capacity within the limited space.

A float valve 38 is provided between the water tank 14 and reservoir 13 as a water discharge-controlling device of the water tank, to control the water level in the water container mechanically. An electromagnetic water intake valve 37 is provided on the top of the water tank 14 and connected with a tap water supply pipe as a water intake-controlling device of the water tank, to control the water level in the water container electronically. An air intake hose of a double water level pressure switch 39 functioning as an electro-gas-type water storage level-controlling device is connected with the bottom of the water tank 14 to control the electromagnetic water intake valve 37. This construction is designed to ensure a smooth operation of the water supply system.

The upper part of a hollow column 40 covers the lower part of the water discharge tube 36 of the water tank, wherein the two parts are connected by way of a transitional fit. The lower part of the hollow column 40 and the neck 27 of the reservoir are screw connected or connected in a convex-concave manner. The hollow column acts as a movable guide sleeve to guide water, and also acts like a gate thereby to control the float valve bar. A water discharge pipe 12 of the evaporator in the indoor unit passed through the room wall and is connected with the reservoir 13 in dehumidifying ventilator 1 or the water tank. Each power cord of the motor, electromagnetic water intake valve,
double water level pressure switch, reservoir water level sensor are connected with the control panel of a circuit box. The dehumidifying ventilator 1 and the indoor unit 8 are connected via pipes and wires, thus the refrigerant can be circulated.

[0084] The refrigerant extruded from the compressor 3 at high temperature and high pressure enters the coil and exchange heat with the tap water in the water container, during which the refrigerant emits heat, and is condensed into high pressure liquid. Then the refrigerant passes through the pipe connecting the indoor/outdoor units at the liquid pipe side; and enters the indoor unit and releases its pressure in the capillary tube 9 in the indoor unit 8. Subsequently, the refrigerant liquid at low temperature and lower pressure adsorbs heat in the evaporator of the indoor unit, and is evaporated into gas. Meanwhile, the indoor air passes by the evaporator 10 in the indoor unit under the force generated by a fan 11, thus is cooled down, and then is blown out by the fan. As a result, the room temperature drops. Some of the indoor water vapor is condensed into water dew on the surface of the evaporator, and then flows into the reservoir 13 of the dehumidifying ventilator via the pipe 12, thus the indoor moisture is removed. The evaporated refrigerant in gas state returns to the compressor 3 via the pipe connecting the indoor/outdoor units at the gas pipe side, and a liquid container, thus the refrigerant is recycled.

[0085] Meanwhile, due to the operation of the centrifugal fan 17, the dehumidifying chamber 2 and the suction pipe 7 connecting to the room are under negative pressure, thus the indoor air moves towards the dehumidifying chamber 2.

[0086] In the reaction kettle, due to the heat exchange between water in the water container and the refrigerant in the bottom portion of the condensing coil, the water from the water container is evaporated and goes up. Water that is sprayed down by the sprayer forms a water film at a place near the middle portion of the condensing coil, where the water film exchanges heat with the refrigerant in the coil, thus the water from the sprayer is evaporated and goes up, too. The two ascending water vapor streams and the salt-containing droplets therein form an ascending gas membrane in a continuous phase within the rectangular mouths located in the middle of the cylinder wall.

[0087] At this point, if the indoor air entered the reaction kettle from the rectangular mouth, the indoor air would have to be guided by the outer wall of the cylinder. On the other hand, if the gas membrane were used to separate the indoor air that enters the reaction kettle from the rectangular mouth, the gas membrane would have to use the inner wall of the cylinder as a support. Therefore, with respect to the indoor air that would enter the reaction kettle through the outer wall of the cylinder, the inner and outer walls of the cylinder from bottom to top become a support to the gas membrane, i.e., the so-called support layer. The ascending gas membrane in a continuous phase with the air inlet wall as its support layer according to the present invention is thus distinguished from a gas membrane of the prior art.

[0088] The gas membrane of the prior art is described as follows. "The gas filled in the pores of a hydrophobic porous polymer film comprises of a separating media. When the film carrying the gas is used to separate two kinds of aqueous solutions, the volatile solute contained in one aqueous solution can rapidly diffuse through the film and then can be accumulated in the other aqueous solution or can be separated out." (See Reference 1)

[0089] As described below, the above construction according to the present invention plays a key role, such that when the indoor air is drawn by the fan and enters the reaction kettle via the rectangular mouth, the indoor air has to break through the gas membrane first. Meanwhile, the gas membrane in the reaction kettle becomes a barrier to the indoor air.

[0090] Thus, a gas-gas impinging stream utilized during a chemical engineering unit operation is formed.

[0091] As described in Reference 1, "A membrane is a thin barrier with some physical and/or chemical properties. It can form a discontinuous region with one or two adjacent fluid(s), and affect the diffusing rate of each component in the fluid(s). Therefore, the membrane can be treated as a media for separation. According to the phase states of a membrane, it can be classified as solid particle membrane, liquid membrane, and even gas membrane."

[0092] First of all, according to the present invention, one membrane is composed of water vapor, namely, the membrane is a gas membrane. Therefore, the water vapor membrane can be utilized, "such that the size and distribution of the free generated passages can be controlled to delay the movement of one component while accelerate the movement of the other component, thus the two components are separated", as described in Reference 1.

[0093] As described in Reference 2, "when air directly contacts with water, a moisture-saturated-air layer is generated due to the random motion of the water molecules approximate to the water surface or around the water droplet. The temperature of the moisture-saturated-air layer is close to that of the water surface. If the boundary layer has a temperature higher than that of the surrounding air, heat is transferred from the boundary layer to the surrounding air; on the contrary, if the boundary layer has a temperature lower than that of the surrounding air, heat is transferred from the surrounding air to the boundary layer. If the water vapors of the boundary layer have a partial pressure higher than that of the water vapors of the surrounding air, more water vapor molecules move from the boundary layer to the surrounding air than from the surrounding air to the boundary layer. Thus, water is evaporated to the surrounding air, and the air is humidified. On the other hand, when less water vapor molecules move from the boundary layer to the surrounding air than from the surrounding air to the boundary layer, the water molecules in the surrounding air are condensed, and the air is dried. When there is a concentration difference (i.e., partial pressure difference) between the water vapors in the unsaturated air and the water vapors in the boundary layer, water vapor molecules will move from the region having higher concentration to the region having lower concentration".

[0094] Because moist air is defined as a mixed gas of dry air and water vapor, the air in nature is moist air.

moist air = dry air + water vapor

[0095] According to the Dalton law in physics, the total pressure of the mixed gas is a sum of each partial pressure of the gas components, i.e.,

\[ P = P_d + P_w \]
[0097] Therefore, the partial pressure of the water vapor at a particular temperature can indicate the amount of the water vapor in the air, thus indicate the humidity of the air.

[0098] A water molecule is composed of a relatively negative charged oxygen atom and two relatively positive charged hydrogen atoms. As described in Reference 3, “in a water molecule, the centers of the electrostatic attraction forces for the negative charge and positive charge are not superimposed, such that the water molecule is dipolar, where the oxygen is at the negative end, and the hydrogen atoms are at the positive end. The bond formed between two water molecules via the electrostatic attraction is so called hydrogen bond. Thus water molecules interact with each other via hydrogen bonds. The hydrogen bond is saturable and orientable property. The water molecules in nature exist as individual molecules only when they are in gaseous state”.

[0099] As described in Reference 4, “a water molecule is a polar molecule, where the two hydrogen atoms are partially positive charged, and the oxygen atom is partially negative charged. Because the dipole moment in a water molecule is large, strong hydrogen bonds can be formed between water molecules. Each water molecule can form four hydrogen bonds with four adjacent water molecules, wherein each water molecule has two hydrogen bonds at the positive end and two other water molecules, and the oxygen at the negative end has two lone electron pairs, which can form hydrogen bonds with two other water molecules. Most gaseous water molecules are individual molecules. Various unique properties of water are contributed by its structure”.

[0100] The present invention takes advantage of the strong polarity of water molecule and the strong hydrogen bonding between water molecules. In addition, the water vapor in the reaction kettle and the water vapor in the indoor air of the same kind. Therefore, the water vapor in the indoor air that will enter the reaction kettle through the rectangular mouths interacts with the ascending water vapor membrane and turn into multimolecular water, and then enter the reaction kettle and become a part of the membrane. As the water is continuously evaporated, the water vapor in the indoor air is combined with the water vapor membrane in a continuous phase.

[0101] Thus, the water vapor in the indoor air entering through the rectangular mouths, is combined with the membrane of water vapor and water droplets inside the mouth, and becomes a part of the membrane, thus is brought into the reaction kettle and then discharged from the dehumidifying chamber. On the other hand, the rectangular mouths are blocked by the thus formed multimolecular water in a continuous phase. Therefore, a filter membrane for separating the dry air in the indoor air forms at the rectangular mouths. The amount of the passages available for the dry air to pass through the rectangular mouths is few, thus the dry air can only pass through the gaseous filter membrane via the gaps between the water vapor molecules in the membrane. However, as the density of water vapor membrane increase, the possibility of the dry air to pass through the membrane become smaller, thus the movement of the indoor dry air towards the dehumidifying chamber is delayed.

[0102] Therefore, the water vapor and the dry air in the indoor air have different speeds when moving towards the dehumidifying chamber. As a result, the amount of the water vapor in the indoor air moving towards the dehumidifying chamber is more that the amount of the dry air in the indoor air moving towards the dehumidifying chamber, and the indoor air tends to be dried.

[0103] As described in Reference 1, “when water vapor is diffused trough a polymer membrane, due to the hydrogen bonds between the water molecules and the repelling interaction between water and polymer, water molecules cannot pass through the polymer membrane as individual molecules, but rather as molecule clusters composed of two, three, four or more molecules each, which is so called cluster migration”. The polymers of interest described in Reference 1 comprise polyethylene, polypropylene, and the like. It is suggested in Reference 1 that the water vapor passes through the membrane as clusters, and the association between water molecules is very strong.

[0104] Examples can be found in the real world that individual water molecules impinge with each other and turn into multimolecular water. Specifically speaking, when water vapor is stopped by a hand close to the water vapor source, the water vapor on the hand turns into drops, wherein the water vapor can be generated from cold water by using an atomizer with pressure, or by using a commercial ultrasonic humidifier. Drops are formed because when a coming water molecule impinges with a water molecule previously stopped by the hand, the two water molecules bond to each other due to hydrogen bonding.

[0105] The gas-gas impinging stream is generated when the gas membrane of the water vapor separates the indoor air. In the region where the indoor air as a mixed gas tangentially impinges the gas membrane, recombination occurs as the density of the gas membrane increases. The water vapor in the mixed gas impinges with the gas membrane, and strengthens the hydrogen bonding force, resulting in multimolecular water, which becomes a part of the main stream gas membrane.

[0106] As the density of the main stream gas membrane increase, the speed of the dry air in the mixed gas passing through the membrane decreases, and is slower than the speed of the main stream gas membrane. In fact, the speed of the dry air passing through the membrane is inversely proportional to the density of the gas membrane.

[0107] Therefore, “rapid gas” and “slow gas” are generated, namely, the water vapor and the dry air pass the gas membrane with different speed, and thus are separated. The hydrogen bonding force can only be strengthened as the water vapor in the indoor air impinge with the gas membrane, such that the water vapor in the indoor becomes a part of the ascending main stream gas membrane.

[0108] Secondly, according to the present invention, another membrane is composed of ionic salt particles, namely, the membrane is a solid particle membrane. The salt-containing droplets carried by the water vapor impact onto the top portion of the condensing coil which is hot and dry, thus the convection heat transfer is forced to carry out again. The droplets are dried up, thus salts are precipitated. When the vertical flights on the wall of the rotating taper reverse drum and the centrifugal fan are running, the water
vapor and ionic salt particles are separated. The water vapor goes up along the wall of the rotating taper reverse drum under the inertial centrifugal force, and is drawn out of the dehumidifying chamber by the centrifugal fan.

[0109] The ionic salt particles are associated together after nucleation and accumulation. The suspended associated particles are forced to move to the cylinder wall by the rotating taper reverse drum flights, leaving the reaction kettle along a hollow channel above the rectangular mouths in the middle of the cylinder wall. Then the associated particles enter a space formed by the outer wall of the cylinder, the chamber enclosure, the inner wall of the water container, and the water surface, i.e., an impingement cabinet. Thus an annular, dynamic, ionic salt particle layer (i.e., a solid particle membrane) having high density and high specific area is formed.

[0110] Since the salt component of the droplet, from which the ionic salt particles is formed, is originated from the tap water, it can be concluded that the particles are nanoparticles of carbonates and phosphates.

[0111] The indoor air evenly enters the impingement cabinet via the air distributor, and tangentially impinges with the ionic salt particle stream. As this point, the solid particle membrane functions to separate the air that will enter the reaction kettle.

[0112] Thus, a gas-solid impinging stream utilized during a chemical engineering unit operation is formed.

[0113] a. Since the water vapor in the air has a temperature lower than that of the ionic salt particles, the ionic salt particles convey heat to the air. Upon being heated, the speed of the water vapor increases. Because the ionic salt particles become drier, and have a lower partial pressure of water vapor at the particle surface, the water vapor in the air is adsorbed by the ionic salt particles. One part of the ionic salt particles fall down after adsorbing the water vapors, and are combined with the gas membrane via a hollow channel below the rectangular mouth and a fluid-bed formed on the top of the impact onto the top portion of the condensing coil which is hot and dry;

[0114] The other part of the ionic salt particles impinge with each other after adsorbing the water vapors, resulting in particles with higher weight. As described in Reference 7, “the particle surface is wetted to increase the adsorption between the impinging particles, which facilitate the association of the particles. The particles fall down due to gravity when their size reach a critical value.” The particles can then fall into the water container, and reenter the reaction kettle with the moving water or using a submersible pump.

[0115] The two parts of the ionic salt particles that have adsorbed the water vapors re-participate condensation, resulting in a cycle of solid-gas adsorption, and solid-liquid or solid-gas desorption, which is also a reversible physical regeneration process.

[0116] b. The dry air can only pass through the gaps between the particles. But as the salt concentration in the water container increase, the density of the dynamic particle layer increase within the limited space of the impingement cabinet. Thus the gaps become narrower, and the possibility of the dry air passing through the gaps is reduced. Apparently, the water vapor in the air will not be completely adsorbed by the ionic salt particles, thus there will be some water vapor that can pass through the gaps between the particles together with the dry air, such that the passage for the dry air to pass through can be also narrowed, slowing down the dry air movement.

[0117] The ionic salt particles adsorb water vapor via van der Waals force. As described in Reference 5, “due to weak van der Waals force, the adsorption is not very strong and is reversible. Van der Waals force can affect on more than a single molecule, leading to an adsorption of a multimolecular layer, which is so called physical adsorption.” As described in Reference 6, “the molecular interaction between an adsorbate and an adsorbent results in the adsorption, which occurs to the gaseous adsorbate on the surface of the solid adsorbent, thus is affected by the surface properties of the solid adsorbent.”

[0118] In the dehumidifying chamber, the suspended ionic salt particles attach to the inner wall, turning into scale. As described in Reference 8, “since the sample scale can adsorb moisture, deliquescence should be prevented.” Ionic salt particles adsorb water vapor because the partial pressure of the water vapor on the particle surface is low, thus the particles has affinity to the water vapor.

[0119] Therefore, the ionic salt particles dried out from the water vapors can act as an adsorbent. Thus the particles recited in the Claims are expressed as “particles having properties of adsorbent”.

[0120] When the indoor air enters the impingement cabinet through eight holes on the air distributor, a single level eight-impinging stream contactor is generated, and a piston flowing container is formed between the outer wall of the reaction kettle, the enclosure, the inner wall at the water container, and the water surface. As described in Reference 7, “a lot of mixing areas are generated due to the direct impingement of streams. In the impingement area, particles from one stream permeate into another stream of the opposite direction, where the speed of the particles is reduced, and then increased in the opposite direction. Thus both of the average retaining time of the particles and the relative velocity between two phases increase. The particles oscillate in the impingement area, such that the concentration of the particles in the impingement area is 20-28 times more than that of the particles at the inlet.” As a result, the convection heat transfer from particles to the air is accelerated, the adsorption of water vapor by the particles is strengthened, and the size of the passage for the dry air to pass through is reduced.

[0121] As described in Reference 9, “the evaporation temperature of water decreases as the pressure decreases, therefore low temperature evaporation can be effected under vacuum. When under a constant pressure, the speed of drying can be accelerated only if more liquid are evaporated”.

[0122] The dehumidifying chamber is under low vacuum, which facilitates the low temperature evaporation of water to form a densified water vapor membrane, and allows drier particles, thus facilitates the adsorption of the indoor water vapor by the particles.

[0123] One of the ten Breakthroughs of the Year 2004 by Science Magazine (American) is directed to the structure of water molecule, wherein each water molecule only forms
two hydrogen bonds with two adjacent water molecules. Based on that theory, since the boiling point decreases when the molecular weight becomes less, the boiling point of water will be changed, which will facilitate water to evaporate at low temperature and form a membrane, and also facilitate the formation of particles.

[0124] The ionic salt particle layer is a dynamic solid particle membrane, which can separate and filtrate gas, reduce the amount of the dry air passing through the membrane, adsorb water vapor, and increase the amount of water vapor passing through the membrane.

[0125] The membrane of water vapor is formed as a continuously ascending gas membrane, and separates the water vapors and the dry air in the indoor air. Thus the present invention provides a new moisture removal technique based on a new principle that is totally distinguished from the prior moisture removal means, such as, a rotary wheel dehumidifier based on a moisture removal theory using solid adsorbent, dry cooling system with Dunkle cycle, dehumidifying device using liquid desiccant (as described in Reference 6), and the like. The present invention provides a more direct moisture removal means having advantages of high efficiency, improved cooling/evaporating system, and low production cost.

[0126] When the air conditioner according to the present invention is used to cool down the room temperature, doors and windows are generally kept close. Since the room is seal-connected with the dehumidifying chamber, and the indoor air pressure is lower than the outdoor air pressure, the outdoor fresh air enters the room through the gaps of the doors or windows, and therefore is mixed with the cycling air (i.e. the return air) formed by the fan in the indoor unit, resulting in a new mixed cool air that enter the dehumidifying chamber via the connecting pipe. During the air transfer process, various indoor odors and dusts move towards the dehumidifying chamber as well, and pass through or are combined with the water vapor membrane, and are discharged to the atmosphere outside the room, resulting in purified indoor air.

[0127] Problems regarding the loss of the indoor cool air when the cool air enters the dehumidifying chamber after mixing can be solved in the following ways:

[0128] 1. The heat energy of the water vapor that is adsorbed by the refrigerant during condensing is transferred to the dry air, thus the room temperature drops quickly. 2. The indoor cool air entering the dehumidifying chamber participates in the heat transfer process for the refrigerant in the condensing coil, thus the endothermic loss of the indoor refrigerant is transformed via the heat emission of the indoor cool air and the refrigerant in the dehumidifying chamber. 3. The part of the refrigerant in the indoor evaporator that is used to condense the water vapor in the air absorbs heat, and the condensed water droplets flow into the reservoir and the temperature of the water in the reservoir is reduced and the amount of water increases, thus the loss of the indoor air is transformed, too.

[0129] A testing machine according the invention has been successfully used to separate the ionic salt particles from the tap water, during which there are a large amount of moistures and heat at the air outlet of the centrifugal fan. It is shown that the testing machine has achieved a significant effect of dehumidification on the tested room, and the room is dried quickly. Wetted clothes can be dried quickly indoors by the testing machine, even during a raining season when the humidity outdoors is very high. When using the testing machine, no mosquitoes are found in the room, thus it is not necessary to use a mosquito net, which means that the amount of the indoor water vapor is reduced, and it is not easy for mosquitoes to survive under such environment. In addition, people in the room can easily breath, which indicates that the room is oxygen-enriched. The quality of the water that was used in the testing machine is type IV according to the “Environmental quality standard for surface water” GB3838-2002 (P.R. China).

[0130] Therefore, the reasons that the room tends to dry are as follows. First of all, the gas membrane of water vapor in the reaction kettle can separate the air, delaying the movement of the indoor dry air to the dehumidifying chamber. Secondly, the solid particle membrane of the ionic salt particles can separate the air, and when the water vapor is adsorbed by the particles, both of the density of the pores in the solid particle membrane and the friction increase, thus the dry air is blocked. Thirdly, the solid particle membrane of the ionic salt particles repel the dry air, thus prevent the dry air from passing through. With the above reasons, the dry air and the water vapor have different speeds when moving to the dehumidifying chamber.

[0131] If it is unnecessary to dehumidify or ventilate, the reversal valve on the suction pipe will be opened, and pipes towards indoors will be closed and pipes towards outdoors will be opened.

[0132] The following embodiment of the present invention is a modification of the first dehumidifying ventilator mentioned above:

[0133] Two reaction kettles and two centrifugal fans can be provided in the dehumidifying chamber. In order to increase the range and effects of air suction and refrigeration, one water supply system can be used to supply water to two dehumidifying chambers at both sides of the reservoir.

[0134] The following two embodiments of the present invention are also modifications of the first dehumidifying ventilator mentioned above:

[0135] The second dehumidifying ventilator is shown in FIG. 5.

[0136] The bottom portion of the condensing coil is located underneath the water in the water container; the middle portion of the condensing coil 20 is located above the water surface but below the water distributor 42; the top portion of the condensing coil 20 is located higher than the rectangular mouth 19; the water distributor 42 is located above the middle portion of the condensing coil but lower than the rectangular mouth 19; the water distributor 42 is connected with a support column of the submersible pump 24; the submersible pump is located at the center of the bottom of the container; the following parts are vertically positioned in the order of (from bottom to top): the submersible pump 24, water distributor 42, rotating taper reverse drum 21, dehumidifying fan 22, and motor 23.

[0137] The rotating taper reverse drum 21 and dehumidifying fan 22 are fixed to the extended axis of the submersible
pump 24. Alternatively, the rotating taper reverse drum and dehumidifying fan are fixed on the extended axis of the motor. The extended axis of the motor and the extended axis of the submersible pump are jointed in a convex-concave manner, to facilitate assembling and dismantling. The submersible pump, rotating taper reverse drum, and dehumidifying fan use the same motor. Thus, both of the submersible pump and drum can use the motor of the dehumidifying fan to lift the water in the water container and separate the salt particles in the plain water and seawater. The water distributor sprays water in radial direction due to the repulsive force of the water lifted in the support column of the submersible pump. The liner of each of the two dehumidifying chambers mentioned above is the same.

[0138] The third dehumidifying ventilator is shown in FIG. 6.

[0139] The lower shoulder edge 43 of the hollow cylinder 18 is seal-connected with the inner wall of the enclosure 15. The rectangular mouths 19 are positioned on the wall above the lower shoulder edge of the hollow cylinder 18. The air distributor 41 is positioned above the rectangular mouths 19 and in the annular air passage formed by the inner wall of the enclosure 15 and the outer wall of the hollow cylinder 18. The lumen of the enclosure 15 has a shape of a vertical round bottle, and the annular air passage allowing air to enter is located above the lower shoulder edge of the hollow cylinder, resulting in a compact structure and a larger lumen, which is advantageous to arrange pipes.

[0140] The water distributor 42 is located above the condensing coil 20 but below the lower shoulder edge 43 of the hollow cylinder 18. The submersible pump 24 is located at the center of the bottom of the container. The following parts are vertically positioned in the order of (from bottom to top): the submersible pump 24, water distributor 42, taper reverse column 44, dehumidifying fan 22, and motor 23. The submersible pump and dehumidifying fan use the same motor.

[0141] There is no flight on the wall of the taper reverse column 44 either above or below the rectangular mouths in the cylinder, such that the ascending water vapor is shaped at the rectangular mouths into a water vapor membrane with larger density and thinner thickness, thus it is difficult for the dry air to pass through. The taper reverse column can be fixed to the bearing so as to move with the bearing. Alternatively, the taper reverse column can be fixed to the inner wall of the cylinder 18 via the support frame of the taper reverse column 44, where the bearing is rotationally cooperated with the center hole of the taper reverse column. However, the latter taper reverse column can’t be rotated.

[0142] For all three of the dehumidifying ventilators described above, the connections of the water supply system and the reservoir with the water container are the same. The outer shell of the dehumidifying chamber can be of an ellipse type column or a square type column, both of which can achieve the same water-condensing effect as a round type column.

[0143] In the first and second dehumidifying ventilators, the dehumidifying chamber may use either plain water or seawater for condensation. However, in the third dehumidifying ventilator, it is better to use plain water for condensation.

[0144] In the first and second dehumidifying ventilators 1, the water container 16, reservoir 13, compressor 3 are all fixed on a sliding plate 45. The sliding plate is located on the bottom plate of the frame, but between the two left and right locating plates. The sliding plate can be pulled out of the frame along the tracks formed by the two left and right locating plates, so as to open the chamber enclosure. A recovery basket 46 is located between the inner wall of the chamber enclosure 15 and the outer wall of the reaction kettle. The reverse hanging plate of the recovery basket 46 is hooked up with the lower edge of the rectangular mouths 19, such that the recovery basket won’t fall into the water container. When salt particles leave the reaction kettle and enter the impingement cabinet as the drum flights operate, the salt particles are attached to the recovery basket, thus when cleaning the dehumidifying chamber, the recovery basket may be removed and then salt particles may be scratched off from recovery basket. It is necessary to use Austenitic stainless steel pipe or titanium alloy pipe for the heat exchange pipe for seawater condensation in order to prevent corrosion.

[0145] The above dehumidifying ventilator 1 is located outdoors. The air inlet 5 of the dehumidifying chamber is connected with the suction pipe 7 entering the room. In the dehumidifying chamber, the air outlet 6 of the centrifugal fan directly opens to the atmosphere outside the room. The dehumidifying chamber may use a centrifugal turbine fan or vertical fan;

[0146] If the dehumidifying ventilator 1 is located indoors, the air outlet 6 of the centrifugal fan in the dehumidifying chamber is connected with an air discharge pipe extended into the atmosphere outside the room. If the dehumidifying ventilator is located in an inner room (e.g., kitchen, laundry room, or sealed balcony), the air inlet 5 of the dehumidifying chamber is connected with the suction pipe 7 entering the room, and the air outlet 6 of the centrifugal fan in the dehumidifying chamber is connected with an air discharge pipe extended into the atmosphere outside the room. In the latter two cases, the dehumidifying chamber must use a centrifugal turbine fan.

[0147] By establishing a mathematical model to the above dehumidifying ventilator, scaling up the dehumidifying chamber, reservoir and water tank, the present invention can be applied to grain or tobacco depots in association with industrial nanoparticle preparation.

[0148] It is necessary to maintain dry and ventilation in a grain depot. Thus a industrial nanoparticle factory and a cold storage or ice-making facilities may be built beside the grain depot, where the suction pipe is connected with the grain depot, the evaporator is installed in the cold storage or ice-making facilities, while the dehumidifying chamber is used to industrial nanoparticles. For example, a solution of mixed salts in water is added to the water in the water container of the dehumidifying chamber. The solution of mixed salts in water is the precursor of particles for adsorbing water vapor and for the industrial nanoparticle preparation. With water as carrier, both of a water vapor membrane and mixed salt particles in nanometer scale can be formed. A chamber enclosure that can be opened like a door is formed. Alternatively, in case of a large-scale dehumidifying chamber, a person can have the water in the water container discharged first, and then get into the enclosure from the
water inlet to remove the particles attached to the inner wall of the enclosure using a shovel.

[0149] For a small scale dehumidifying chamber, the enclosure, water container, cylinder, reservoir and water tank can be injection molded using for example polyvinyl chloride, polyethylene, polypropylene. For a large scale dehumidifying chamber, the enclosure, water container, cylinder, reservoir and water tank can be molded by casting with ferroconcrete, where the enclosure and water container are integrated into a outer shell, the serpentine condensing coil is wound in the cylinder, and the upper edge of the water inlet in the water container should be positioned lower that the water level to keep the water inlet sealed.

[0150] There is a modified embodiment of the above-described method for separating the indoor air with the gas membrane of water vapor, wherein the sprayer is positioned above the rectangular mouth. The falling water sprayed by the sprayer forms a liquid membrane at the rectangular mouths, thus the indoor air impinges with the liquid membrane, resulting in a gas-liquid impinging stream to separate the indoor air, provided that the gravity of the falling water is larger than the drag force of gas. This modified embodiment can be considered as a high-density gas membrane.

[0151] In addition, instead of utilizing heat exchange between water and refrigerant, water vapors can be generated by an atomizer with pressure or by ultrasonics to form a gas membrane for separating the indoor air.

[0152] The above-mentioned dehumidifying ventilator can be made into a dust-removing central air conditioner for use in a house.

[0153] The above-mentioned dehumidifying ventilator can be used in combination with various indoor apparatus for various applications.

Example 1: a Combination of Dehumidifying Ventilator with Indoor Unit, as Described in the Above Embodiments.
Example 2: a Combination of Dehumidifying Ventilator with Still.

[0154] In example 2, the air conditioner utilizes the combination of dehumidifying ventilator and still via the connections of electric wires and refrigerant pipes thereof, in which one condenser is combined with one evaporator.

[0155] FIG. 7 shows a structural view of the second dehumidifying ventilator 1 positioned at the bottom and the still 47 positioned on the top in the same frame. The still 47 consists of an evaporator box 48 and a conveying fan 49. The air outlet 6 of the dehumidifying chamber is connected with the air inlet of the evaporator box 48 via a conveying pipe 50. The air outlet of the evaporator box 48 is connected with the air inlet of the conveying fan 49 via conveying pipe 50. The conveying fan 49 is connected with the bearing of the motor 23 in the dehumidifying chamber. In the above-described design, the air outlet 6 of the dehumidifying chamber is thus extended to the air outlet of the conveying fan.

[0156] When the multimolecular clusters formed from the combination of the water vapor membrane in the dehumidifying chamber 2 and the water vapor in the indoor air are drawn out and conveyed by the dehumidifying fan 22, the gas volume needs to be shaped. The cross-section of the volume of the multimolecular water at the air outlet 6 of the dehumidifying chamber is round and is reshaped by the conveying pipe 50 to rectangular. Thus the multimolecular water can enter the evaporator box 48 evenly, and exchange heat with the refrigerant in the pipe of the heat exchanger, such that the heat exchanging area is larger and the heat exchange efficiency is improved.

[0157] The cross-section of the volume of multimolecular water at the air outlet of the evaporator box 48 is rectangular and is reshaped by the conveying pipe 50 to round. The multimolecular water then enters the conveying fan 49. The trumpet-like conveying pipe is round at one end, and is rectangular at the other end. An air distributor is provided in the air inlet of the evaporator box 48 to facilitate an even heat-exchange between gas and the refrigerant in the pipe. The multimolecular water and the refrigerant exchange heat in the evaporator box, thus the multimolecular water will be condensed into liquid water. The conveying pipe can also be a round type and connected with an air distributor box where the trumpet-like air distributor is round at one end, and is rectangular or round at the other end, so as to reshape the gas.

[0158] The dehumidifying chamber as shown in FIG. 7 can use plain water or seawater for condensation. The cooling water pipe 51 of the evaporator box 48 is provided with a valve that can split a inlet pipe into two outlet pipes, in which one outlet pipe is connected with the water tank 14, the other outlet pipe is connected with an additional container 52 outside the frame. In case of using plain water for condensation, cooling water flows into the water tank 14 via cooling water pipe, such that the dehumidification is in a water-cycling mode. In case of using seawater for condensation, cooling water flows into the additional container 52 via cooling water pipe. When centrifugation and drying are carried out by running the drum, the salt concentration in water vapor is very low, and the purity of the thus formed cooling water is very high. Thus the water can be used for industrial application or for household.

[0159] However, for the dehumidifying ventilator as shown in FIG. 8, it is better to use plain water for condensation.

[0160] Water in the dehumidifying chamber water container exchanges heat with refrigerant and is evaporated into the water vapor membrane to separate the water vapor in the indoor air from the dry air, resulting in multimolecular water. The resulted multimolecular water is drawn out of the reaction kettle by the dehumidifying fan, and enters the evaporator box in the still, to exchange heat with the refrigerant again. The refrigerant is evaporated and returns to the compressor, while the multimolecular water is condensed into water. Thus, water can be recycled. The heat exchanger in the evaporator box has functions of both of evaporation and distillation.

[0161] It is determined by the location of the still that whether or not the air outlet of the conveying fan is connected with the air discharge pipe. In case of using a large-scale combination, the dehumidifying ventilator can be separated from the still, but the vertical position of the still should be higher than that of the water tank, the additional container or the reservoir, such that cooling water can easily flow in. In case of using a small combination, the fan can be eliminated, and conveying to the evaporator box
can be carried out by the dehumidifying fan directly, and the water vapor and multimolecular water may exchange heat with the refrigerant as well, so as to be condensed.

[0162] This air conditioner utilizing the combination that is just described above can be used specially for indoor dehumidification ventilation, for example in residence, tobacco depot, and grain depot, and the like. There are two kinds of cycles in the air conditioner, namely, refrigerant cycle and water cycle. The air conditioner is convenient for use, which can be placed indoors, outdoors, or in an inner room. In comparison to the rotary wheel dehumidifier and the refrigerating/drying dehumidifier, the air conditioner has higher efficiency and lower cost.

Example 3: a Combination of Dehumidifying Ventilator with Refrigerating Chamber.

[0163] In example 3, the air conditioner utilizes the combination of dehumidifying ventilator with refrigerating chamber via the connections of electric wires and refrigerant pipes thereof, in which one condenser is combined with one evaporator.

[0164] The high temperature/high pressure refrigerant compressed by the compressor exchanges heat with the water in the dehumidifying chamber. Then the refrigerant flows into the pipe of the refrigerating chamber via outlet pipe, where the refrigerant exchanges heat with stuffs through the evaporator of the refrigerating chamber. Thus, the refrigerant is evaporated and returns to the compressor. The suction pipe of the dehumidifying chamber is used for dehumidification and ventilation indoors, while the refrigerating chamber is used for refrigeration.

[0165] It is most advantageous to use this air conditioner in a farmers market, where fish and meat products need to be frozen, and fruits and vegetables need to be stored under dehumidification ventilation. Thus, a dehumidifying chamber using seawater for condensation can be used.

Example 4: a Combination of Dehumidifying Ventilator with Air-Cooled Air Evaporation Chamber and Indoor Unit.

[0166] As shown in FIG. 9, a dehumidifying ventilator 1 and an air-cooled air evaporation chamber 53 are parallel provided in the same frame. The air-cooled air evaporation chamber 53 comprises evaporator 54, fan 55, and the like. The frame is placed outdoors. The fan 56 of the dehumidifying ventilator 2 in the dehumidifying ventilator 1 is of vertical type.

[0167] As shown in FIG. 11, an outlet divider 7 is provided on the outlet pipe of the compressor 3. One branch pipe is connected with the section a of the inlet extension pipe of the air condenser pipe via a two-way magnetic valve 7. The section a of the inlet extension pipe is connected with the section e of the inlet extension pipe of the air condenser pipe via a two-way magnetic valve 7. The section e of the inlet extension pipe is connected with the section g of the inlet extension pipe of the air condenser pipe and the capillary tube f via a three-way magnetic valve 5. The section g and the capillary tube f are connected with the section h of the air condenser pipe. The section h is connected with the section i of the outlet extension pipe of the air condenser pipe via a three-way magnetic valve 6. The section j is connected with the section k via a two-to-one divider 8.

[0168] Another branch pipe is connected with the section b of the inlet extension pipe of the water-cooled coil via two-way magnetic valve 2. The outlet extension pipe of the water-cooled coil is connected with a branch pipe c via a three-way magnetic valve 4. The branch pipe c is connected with the section e of the inlet extension pipe of the air condenser pipe via the three-way magnetic valve 3. A branch pipe d is connected with the section j via the two-to-one divider 8.

[0169] The section j is connected with the section k via the capillary tube 9 and the evaporator 10 in the indoor unit 8. The section k is connected with the inlet pipe 1 of the compressor 3 via an inlet divider 9. In addition, the section h is connected with the section m of the outlet extension pipe of the air condenser pipe via the three-way magnetic valve 5. The section m is connected with the inlet pipe 1 of the compressor 3 via an inlet divider 9. The arrow signs representing the directions of the three-way magnetic valves are shown in FIG. 11. Any two pipes whose directions are represented by the same sign do not communicate to each other under any circumstances.

[0170] The high temperature/high pressure refrigerant compressed by the compressor 3 in the dehumidifying ventilator 1 is divided by the outlet divider 7 into two ways. Then the running direction of the refrigerant in the pipes is controlled by the magnetic valves shown in FIG. 11. There are four possible operating modes as described below.

[0171] In the first mode, the refrigerant runs sequentially in the pipe sections a-e-g-h-i-j-k-l and b-d-j-k-l respectively, which form a cycle. Both of the heat exchangers in the dehumidifying chamber 2 and the air-cooled air evaporation chamber 53 are used as a condenser. The heat exchanger in the indoor unit 8 is the evaporator 10. Thus, there are two condensers. Very strong effects can be achieved for indoor cooling, moisture removal, dehumidification and ventilation.

[0172] In the second mode, in the two-way magnetic valve 1, the way towards the section a of the inlet extension pipe of the air condenser pipe is closed. In addition, in three-way magnetic valve 4, the way towards the section c is closed. Thus the refrigerant runs sequentially in the pipe sections b-d-j-k-l, which form a cycle. The heat exchanger in the dehumidifying chamber 2 is used as a condenser. The heat exchanger in the indoor unit 8 is the evaporator 10. Medium effects can be achieved for indoor cooling, moisture removal, dehumidification and ventilation.

[0173] In the third mode, in the two-way magnetic valve 2, the way towards the section b of the inlet extension pipe of water-condenser pipe is closed. In addition, in the three-way magnetic valve 5, the way towards the capillary tube f is closed. The refrigerant runs sequentially in the pipe sections a-e-g-h-i-j-k-l, which form a cycle. The heat exchanger in the air-cooled air evaporation chamber 53 is used as a condenser. The heat exchanger in the indoor unit 8 is the evaporator 10. Medium effects can be achieved for indoor cooling and moisture removal.

[0174] In the forth mode, in the two-way magnetic valve 1, the way towards the section a is closed. In addition, in the three-way magnetic valve 4, the way towards the section d is closed. Furthermore, in the three-way magnetic valve 5,
the way towards the section g is closed. The refrigerant runs sequentially in the pipe sections b-e-f-h-m, which form a cycle. The heat exchanger in the dehumidifying chamber 2 is used as a condenser. The heat exchanger in the air-cooled air evaporation chamber 53 functions as an air evaporator. Effects of indoor dehumidification and ventilation can be achieved even when cooling is not necessary.

[0175] In an additional fifth mode, the compressor 3, air-cooled air evaporation chamber 53, and indoor unit 8 stop running. The room is ventilated under the operation of the fan in the dehumidifying chamber 2.

[0176] The aforementioned dehumidifying ventilator can be positioned parallel to multiple air-cooled air evaporation chambers, wherein the arrangement of pipes thereof is essentially the same. The air-cooled air evaporation chamber may be placed outdoors or may be hung on an outdoor wall. The dehumidifying ventilator may be placed outdoors, indoors or in an inner room.

[0177] As shown in FIGS. 10 and 13, the dehumidifying ventilator 1 is positioned at the bottom and air-cooled air evaporation chamber 53 is positioned on the top, and they are in the same frame. A one-to-two valve 57 is provided to the air outlet 6 of the dehumidifying chamber 2 in the dehumidifying ventilator 1, wherein one branch pipe is connected and opened to the air-cooled air evaporation chamber 53 via the conveying pipe 58. When cooling is not necessary, the multimolecular water is directed to the air-cooled air evaporation chamber 53. Under the operation of the fan 55 of the air-cooled air evaporation chamber, the outdoor air stream 59 and the multimolecular water are allowed to impinge with each other and are fluidized, then pass through the heat exchanger in the air-cooled air evaporation chamber 53.

[0178] Thus, the refrigerant exchanges heat with two streams of gas, therefore two cycles are maintained as follows. In one of the cycles, i.e., the refrigerant cycle, the refrigerant is evaporated and returns to the compressor. In the other cycle, i.e., the water cycle, multimolecular water and outdoor water vapor are condensed into liquid, and flow into the water tank, thus the amount of water storage may even increase.

[0179] As this point, the heat exchanger in the air-cooled air evaporation chamber 53 has both functions of evaporation and distillation. The cooling water pipe of the evaporator 54 is connected with the water tank; alternatively it may be connected with the additional container or the reservoir.

Example 5: a Combination of Dehumidifying Ventilator and Air Evaporation Still.

[0180] As shown in FIG. 14, the air conditioner utilizes the combination of the dehumidifying ventilator 1 and air evaporation still 60 via the connections of refrigerant pipes thereof. The one-to-two valve 57 on the air outlet 6 of the dehumidifying chamber 2 that is shown in FIG. 13 is eliminated in this air conditioner. The air outlet 6 of the dehumidifying chamber 2 is directly connected with the air evaporation still 60 via the conveying pipe 58. The water vapor and multimolecular water are directed to the air evaporation still 60, thus the outdoor air stream 59 and the water vapors and multimolecular water are allowed to impinge with each other and are fluidized, then pass through the heat exchanger in air evaporation still 60.

[0181] As described above, the refrigerant exchanges heat with two streams of gas, therefore two cycles are maintained as follows. In one of the cycles, i.e., the refrigerant cycle, the refrigerant is evaporated and returns to the compressor. In the other cycle, i.e., the water cycle, multimolecular water and outdoor water vapor are condensed into liquid, thus the amount of water storage may increase as well. The heat exchanger in the air evaporation still 60 has both functions of evaporation and distillation. The cooling water pipe of the air evaporation still 60 is connected with the water tank; alternatively, it may be connected with the additional container or the reservoir. Thus, the dehumidifier may be used especially outdoors.

Example 6: a Combination of Dehumidifying Ventilator with Still and Indoor Unit.

[0182] As shown in FIG. 15, the air conditioner utilizes the combination of dehumidifying ventilator 1 with still 47 and indoor unit 8 via the connections of electric wires and refrigerant pipes thereof. The water discharge pipe 12 of the indoor unit 8 is connected with the reservoir 13 in the dehumidifying ventilator 1. For the refrigerant cycle, one condenser is combined with two evaporators, wherein one evaporator is used for condensing water vapors in the still, and the other evaporator is used for cooling down the indoor unit.

[0183] The refrigerant compressed by the compressor exchanges heat with the water in the dehumidifying chamber, then is divided by the outlet divider 61, thus flows separately towards the still 47 and the indoor unit 8 under the control of the magnetic valve. There are three possible operating modes as described below.

[0184] In the first mode, the two-way magnetic valves 62 and 63 are opened, allowing the refrigerant to enter the still 47 and the indoor unit 8 at the same time, and then be recombined by the inlet divider 64 and return to compressor 3. This air conditioner has functions of cooling, moisture removal, dehumidification, and ventilation indoors. During the operation of the air conditioner, water is evaporated and then condensed, or alternatively, seawater is desalted into plain water.

[0185] In the second mode, the two-way magnetic valve 63 is closed, while the two-way magnetic valve 62 is opened, allowing the refrigerant to enter the indoor unit 8 only, and then return to the compressor 3. This air conditioner has functions of cooling, moisture removal, dehumidification, and ventilation indoors.

[0186] In this mode, when seawater is used for condensation, the amount of salt contained in the discharged water vapor won’t be harmful to the environment, since the seawater is desalted.

[0187] In the third mode, the two-way magnetic valve 62 is closed, while the two-way magnetic valve 63 is opened, allowing the refrigerant to enter the still 47 only, and then return to the compressor 3. This air conditioner has functions of dehumidification and ventilation indoors. During the operation of the air conditioner, water is evaporated and then condensed, or alternatively, seawater is desalted into plain water.
It is most advantageous to use this air conditioner for general air-conditioning in residences and manufactories in coastal area. When using this air conditioner in coastal area, plain water for supply can be prepared from seawater, by utilizing peak load shifting occurrence, switching the magnetic valve, and controlling the flow direction of the refrigerant.

Example 7: a Combination of Dehumidifying Ventilator with Refrigerating Chamber and Indoor Unit.

The air conditioner utilizes the combination of dehumidifying ventilator 1 with refrigerating chamber and indoor unit 8 via the connections of electric wires and refrigerant pipes thereof. For the refrigerant cycle, one condenser is combined with two evaporators, wherein one evaporator is used for refrigerating stuffs via the refrigerating chamber, and the other evaporator is used for cooling down the indoor unit.

The refrigerant compressed by the compressor exchanges heat with the water in the dehumidifying chamber 2, then is divided by the outlet divider, thus flows separately towards the refrigerating chamber and the indoor unit 8 under the control of the magnetic valve. There are three possible operating modes as described below.

In the first mode, the refrigerant is allowed to enter the still and the refrigerating chamber at the same time, and then be recombined by the inlet divider and return to compressor. During the operation of the air conditioner, water is evaporated and then condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for refrigerating stuffs via the refrigerating chamber, and indoor dehumidifying and ventilating via the suction pipe entering the room.

In the second mode, the refrigerant is allowed to enter the still only, and then return to the compressor. During the operation of the air conditioner, water is evaporated and then condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for indoor dehumidifying and ventilating via the suction pipe entering the room.

In the third mode, the refrigerant is allowed to enter the refrigerating chamber only, and then return to the compressor. This air conditioner is used for refrigerating stuffs via the refrigerating chamber, and indoor dehumidifying and ventilating via the suction pipe entering the room.

It is most advantageous to use this air conditioner on an overseas fishing vessel, where the refrigerating chamber is used to keep fresh fishes frozen, the still is used to condense water vapor and desalt seawater into plain water, and the suction pipe is used to dehumidify and ventilate the storages connected thereto so as to present the storages from getting rusty.

Example 9: a Combination of Dehumidifying Ventilator with Still, Refrigerating Chamber, and Indoor Unit.

As shown in FIG. 16, the air conditioner utilizes the combination of the dehumidifying ventilator 1 with still 47, refrigerating chamber 65 and indoor unit 8 via the connections of electric wires and refrigerant pipes thereof. For the refrigerant cycle, one condenser is combined with three evaporators, wherein one evaporator is used for condensing water vapors in the still, one evaporator is used for refrigerating stuffs via the refrigerating chamber, and the other evaporator is used for cooling down the indoor unit.

The refrigerant compressed by the compressor 3 exchanges heat with the water in the dehumidifying chamber 2, then is divided by the outlet divider 66, thus flows separately towards the still 47, the refrigerating chamber 65, and the indoor unit 8 under the control of the magnetic valve. There are seven possible operating modes as described below.

In the first mode, the two-way magnetic valves 67, 68 and 69 are opened, allowing the refrigerant to enter the still 47, the refrigerating chamber 65 and the indoor unit 8 at the same time, and then be recombined by the outlet divider 70 and return to compressor 3. During the operation of the
air conditioner, in the still 47, water vapor is condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for refrigerating stuffs in the storage C via the refrigerating chamber 65, cooling and removing moistures in room A via the indoor unit 8, and dehumidifying and ventilating room B via the suction pipe 7.

0204 [In the second mode, the two-way magnetic valve 68 is closed and the two-way magnetic valves 67 and 69 are opened, allowing the refrigerant to enter the still 47 and the indoor unit 8, and then be recombined by the inlet divider 70 and return to compressor 3. During the operation of the air conditioner, in the still, water vapor is condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for cooling and removing moister in room A via the indoor unit 8, and dehumidifying and ventilating room B via the suction pipe 7.]

0205 [In the third mode, the two-way magnetic valve 69 is closed and the two-way magnetic valves 67 and 68 are opened, allowing the refrigerant to enter the refrigerating chamber 65 and the indoor unit 8 at the same time, and then be recombined by the inlet divider 70 and return to compressor 3. This air conditioner is used for refrigerating stuffs in the storage C via the refrigerating chamber, cooling and removing moister in room A via the indoor unit 8, and dehumidifying and ventilating room B via the suction pipe 7.]

0206 [At this point, the reversal valves on the air outlet of the dehumidifying chamber and the air inlet of the still need to be reversed, allowing water vapor to be discharged to the atmosphere outside the room from the air outlet of the dehumidifying chamber.]

0207 [In the forth mode, the two-way magnetic valve 67 is closed and the two-way magnetic valves 68 and 69 are opened, allowing the refrigerant to enter the still 47 and the refrigerating chamber 65, and then be recombined by the inlet divider 70 and return to compressor 3. During the operation of the air conditioner, in the still 47, water vapor is condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for refrigerating stuffs in the storage C via the refrigerating chamber 65, and dehumidifying and ventilating room B via the suction pipe 7.]

0208 [In the fifth mode, the two-way magnetic valves 68 and 69 are closed and the two-way magnetic valve 67 is opened, allowing the refrigerant to enter the indoor unit 8 and return to compressor. This air conditioner is used for cooling and removing moister in room A via the indoor unit 8, and dehumidifying and ventilating room B via the suction pipe 7.]

0209 [In the sixth mode, the two-way magnetic valves 68 and 69 are closed and the two-way magnetic valve 67 is opened, allowing the refrigerant to enter the still 47 and return to compressor. During the operation of the air conditioner, in the still 47, water vapor is condensed, or alternatively, seawater is desalted into plain water. This air conditioner is also used for dehumidifying and ventilating room B via the suction pipe 7.]

0210 [In the seventh mode, the two-way magnetic valves 67 and 69 are closed and the two-way magnetic valve 68 is opened, allowing the refrigerant to enter the refrigerating chamber 65 and return to compressor. This air conditioner is used for refrigerating stuffs in the storage C via the refrigerating chamber, and dehumidifying and ventilating room B via the suction pipe 7.]

0211 This air conditioner has comprehensive functions. It is most advantageous to use this air conditioner on a marine ship. When using this air conditioner, in accordance with the programs in the CPU module, comprehensive effects can be achieved by utilizing peak load shifting occurrence, switching the magnetic valve, and controlling the flow direction of the refrigerant. Every unit room is provided with detecting devices, thus when the power load is over the required level in a unit room, the magnetic valve on a pipe entering the unit room is closed, while the magnetic valve on a pipe entering another unit room is opened via the control of the CPU module, thereby the peak load for each unit room is shifted.

Example 10: a Combination of Dehumidifying Ventilator with Evaporator of a Water Chiller.

0212 [In this air conditioner, the inlet/outlet extension pipes of the condenser pipe of the dehumidifying chamber in the dehumidifying ventilator are connected with the inlet/outlet pipes of the dry expansion shell-and-tube evaporator, forming a refrigerant cycle. The heat exchanger of the dehumidifying chamber is as a condenser, and the heat exchanger of the water chiller is as an evaporator.]

0213 The refrigerant from the condenser pipe of the dehumidifying chamber flows into the pipe of the dry expansion shell-and-tube evaporator, and exchanges heat with the water in the cylinder. Then the refrigerant evaporates into gas and return to the compressor of the dehumidifying ventilator, while the water as secondary refrigerant is brought to distant rooms. After the room is cooled down, the water returns to the cylinder and exchanges heat with the refrigerant again. The dehumidifying chamber can be used for dehumidifying each room.

0214 A double-pipe evaporator may be used instead of dry expansion shell-and-tube evaporator. Both of the double-pipe evaporator and dry expansion shell-and-tube evaporator are classified as water chiller evaporator. This air conditioner is suitable for use in buildings, such as hotels, office buildings, Villas etc.

0215 Depending on the selection of the dehumidifying chamber, the above air conditioners may use plain water or seawater for condensation.

INDUSTRIAL APPLICABILITY

0216 The principle of the present invention is based on the hydrogen bonds between the water molecules and the adsorption of adsorbent particles to water vapor, wherein water is used as a carrier, and the ascending gas membrane of water vapor and dynamic solid particle membrane are used to separate the water vapor and the dry air of the indoor air. The present invention provides a solution to the moisture removal problem with high efficiency of dehumidification and low cost. The present invention can be applied to improve both of the industrial and living environments.

33: A method for dehumidification and ventilation, wherein,

a) a fan draws air indoors and water vapor in a vacuum vessel to a inner wall and an outer wall of an air inlet of the vacuum vessel, respectively, wherein the water vapor forms a gas membrane in a continuous phase at the inner wall of the air inlet; the gas membrane separates the indoor air entering the vessel from the outer wall of the air inlet; as the density of the water vapor inside the air inlet increases, water vapor in the indoor air and the gas membrane impinge with each other and are combined into multimolecular water, then the multimolecular water enters the vacuum vessel and moves towards a fan, whereas the speed of the dry air passing through the gas membrane is decreased;

b) drum flights hit adsorbent particles from the inner wall to the outer wall of the air inlet of the vacuum vessel, resulting in a solid particle membrane in a continuous phase to separate the indoor air; as the density of the solid particle membrane increases, the water vapor in the indoor air and the solid particle membrane are combined with each other, fall into a water container, and are lifted by a submersible pump to transfer heat with refrigerant; then drum flights separate out the resulting particles; the speed of the dry air passing through the solid particle membrane is decreased; and

c) the water vapor and the dry air of the indoor air have different speeds when moving to the vacuum vessel due to the gas membrane and the solid particle membrane; and the movement of the dry air is delayed.

34: An air conditioner comprising a water-cooled dehumidifying ventilator, the ventilator comprising a compressor, a water-cooled dehumidifying chamber, and a water supply device, wherein the air conditioner applies the method according to claim 33.

35: The air conditioner according to claim 34, wherein an enclosure of the dehumidifying chamber and a water container are connected with each other in any manner; the outer shell shapes of the enclosure and the water container comprise all kinds of column shapes; a centrifugal fan is positioned on the top of the enclosure; a hollow tube is fit on the top of the sidewall of the chamber enclosure;

the edge of a top opening of a cylinder is seal-connected with an air inlet of the centrifugal fan; the edge of a bottom opening of the cylinder is seal-connected with a contact surface inside the enclosure; the cylinder has an air inlet on its wall; and

a reservoir is connected with the water container; a water tank and the reservoir are positioned on different height levels; the water tank and the reservoir comprise all kinds of control device for water intake, control device for water discharge, and control device for stopping water intake when the amount of water exceeding a predetermined value; a water discharge pipe of the water tank and a water intake pipe of the reservoir are connected with each other in any manner.

36: The air conditioner according to claim 35, wherein, the enclosure and the water container are jointed in a convex-concave manner; a convex plate of the enclosure is broader than a water inlet of the water container, and extends along the water inlet of the water container until under the water; the parts where the bottom and the convex plate of the enclosure contact to the water container and the water are sealed; the air inlet on the cylinder wall comprises of rectangular mouth; an air distributor is positioned in an annular air passage and above the air inlet on the cylinder wall; a condensing coil is positioned in the cylinder;

the reservoir is a bottle-type column; each of the three sides surrounding the reservoir opening side, and a sill, are connected with the outer wall of the water container; the upper edge of the opening side and the sill are curved so as to accord with the outer wall of the water container; the top of the reservoir is in a position lower than the top of the water container, and the bottom of the reservoir is in a position lower than the bottom of the water container;

the water tank comprises: a horizontal-type upper section, wherein the projection area of the upper section is larger than the total area of the compressor and the reservoir; a barrel-type middle section, wherein the projection of the middle section has the same shape with the reservoir; a column-type lower section, wherein the projection area of the lower section is smaller than reservoir; the water discharge pipe of the water tank is connected with the water intake pipe of the reservoir via a hollow column; the inlet/outlet extension pipes of the condenser pipe are positioned below the convex plate and within a slot at the curved edge of the upper side of the reservoir; and

a float valve is placed between the water tank and the reservoir; the connecting rod of the float valve is positioned in the hollow column; an electromagnetic water intake valve is embedded on the top of the water tank; an air discharge tube with a double water level pressure switch is connected with the water tank; the submersible pump is connected with the bottom of the water container; and the compressor, the dehumidifying chamber, the reservoir, and the water tank are constructed in the same frame.

37: The air conditioner according to claim 36, wherein the bottom of the cylinder is beneath the water level; each bottom end of the vertical flights is positioned at the same
level of the center of the rectangular mouths; the pitch of the condensing coil near the rectangular mouths is larger than the pitch of the top portion or bottom portion of the coil; the bottom portion of the coil is positioned above the bottom of the water container and under the water; the top portion of the coil is positioned higher than the rectangular mouth; and the dehumidifying ventilator is equipped with a sliding plate and a recovery basket.

38. The air conditioner according to claim 37, wherein the submersible pump is positioned on the bottom of the water container and between the enclosure and the cylinder; the middle portion of the coil is positioned above the water level but below a sprayer; the sprayer is positioned above the middle portion of the coil but below the rectangular mouth; the water intake pipe of the sprayer is connected with the submersible pump through the cylinder wall; and the column of the drum is put in a rotating guide bushing.

39. The air conditioner according to claim 37, wherein the middle portion of the coil is positioned above the water level but below the water distributor; the water distributor is positioned above the middle portion of the coil but lower than the rectangular mouth; the following parts are vertically placed in the following order, from bottom to top: the submersible pump, the water distributor, the drum, the dehumidifying fan, and a motor; and the submersible pump, the water distributor, the drum, and the dehumidifying fan share the same motor.

40. The air conditioner according to claim 36, wherein a lower shoulder edge of the cylinder is seal-connected with the inner wall of the cover; a lumen of the enclosure has a bottle-like shape; the water distributor is positioned above the coil but lower than the rectangular mouth; the following parts are vertically placed in the following order, from bottom to top: the submersible pump, the water distributor, the dehumidifying fan, and the motor; the submersible pump, the water distributor, and the dehumidifying fan share the same motor; and a taper reverse column is positioned above the water distributor but below the upper edge of cylinder.

41. The air conditioner according to claim 35, wherein the cover, the water container, the cylinder, the reservoir, and the water tank are made of polyvinyl chloride, polyethylene, polypropylene, or ferrocement.

42. The air conditioner according to claim 34, wherein the dehumidifying ventilator is located outdoors; the air inlet of the dehumidifying chamber is connected with a suction pipe entering a room; and the air outlet of the centrifugal fan in the dehumidifying chamber directly opens to the atmosphere outside the room.

43. The air conditioner according to claim 34, wherein when the dehumidifying ventilator is located in a room, the air outlet of the centrifugal fan in the dehumidifying chamber is connected with an air discharge pipe extended into the atmosphere outside the room; when the dehumidifying ventilator is located in an inner room, the air inlet of the dehumidifying chamber is connected with the suction pipe entering the room, and the air outlet of the centrifugal fan in the dehumidifying chamber is connected with an air discharge pipe extended into the atmosphere outside the room.

44. The air conditioner according to claim 34, wherein the dehumidifying ventilator is used for preparing industrial nanoparticles.

45. The use of the air conditioner according to claim 34, wherein the dehumidifying ventilator is used for indoor ventilation, which allows outdoor fresh air to enter the room, and allows the indoor air to be extracted out to the atmosphere outside the room, thus generates a continuous cycle of the air.

46. The use according to claim 45, wherein dusts indoors can be combined to the gas membrane of the water vapor, and can be extracted out of the room.

47. The air conditioner according to claim 34, wherein the dehumidifying ventilator is used in combination with an indoor unit.

48. The air conditioner according to claim 47, wherein the water discharge pipe of the evaporator in the indoor unit is connected with the reservoir or the water tank in the dehumidifying ventilator.

49. The air conditioner according to claim 48, wherein water dew on the evaporator in the indoor unit flows into the reservoir in the dehumidifying chamber and participates in the condensation process.

50. The air conditioner according to claim 47, wherein the dehumidifying ventilator is used in combination with a still.

51. The air conditioner according to claim 50, wherein the dehumidifying ventilator and the still are positioned on different height levels and are positioned in the same frame; the air outlet of the dehumidifying chamber is connected with the air inlet of an evaporator box via a conveying pipe; the air inlet of the evaporator box are connected with the air inlet of the conveying fan via a conveying pipe; the conveying fan is connected with a motor shaft of the dehumidifying chamber; and the evaporator box has a cooling water pipe.

52. The air conditioner according to claim 51, wherein plain water exchanges heat with refrigerant in the dehumidifying chamber and is evaporated into water vapor, then the water vapor and the gas membrane are combined together into multimolecular water so as to exchange heat with the refrigerant in the still and be condensed into plain water; alternatively, seawater exchanges heat with refrigerant in the dehumidifying chamber, and is separated into water vapor and salt by the centrifugal fan and the drum, then the water vapor and the gas membrane are combined together into multimolecular water so as to exchange heat with the refrigerant in the still and be condensed into plain water.

53. The air conditioner according to claim 34, wherein the dehumidifying ventilator is used in combination with a refrigerating chamber.

54. The air conditioner according to claim 47, wherein the dehumidifying ventilator is used in combination with an air-cooled air evaporation chamber, and the indoor unit; an outlet divider is provided on the pipes connecting the heat exchanger of the compressor with the heat exchanger of the dehumidifying chamber and the heat exchanger of the air-cooled air evaporation chamber; a throttling gear is provided on the pipe entering the heat exchanger in the air-cooled air evaporation chamber;

when both of the heat exchangers in the dehumidifying chamber and the air-cooled air evaporation chamber are used as a condenser, and the heat exchanger in the indoor unit is used as an evaporator, the refrigerant flows in pipe sections a-e-g-h-i-j-k-l and b-d-j-k-l, respectively;

when the heat exchanger of the dehumidifying chamber is used as a condenser, and the heat exchanger in the
indoor unit is used as an evaporator, the refrigerant flows in pipe sections b-d-j-k-l; when the heat exchanger in the air-cooled air evaporation chamber is used as a condenser, and the heat exchanger in the indoor unit is used as an evaporator, the refrigerant flows in pipe sections a-e-g-h-i-j-k-l; and when the heat exchanger of the dehumidifying chamber is used as a condenser, and the heat exchanger in the air-cooled air evaporation chamber is used as an evaporator, the refrigerant flows in pipe sections b-c-e-d-b-m-l.

55: The air conditioner according to claim 54, wherein the dehumidifying ventilator and the air-cooled air evaporation chamber are placed in the same frame.

56: The air conditioner according to claim 55, wherein the dehumidifying ventilator and the air-cooled air evaporation chamber are positioned on different height levels; the reversal valve is provided on the air outlet of the dehumidifying chamber; a branch pipe thereof is connected with the air-cooled air evaporation chamber via a conveying pipe; and the air-cooled air evaporation chamber is provided with a cooling water pipe.

57: The air conditioner according to claim 34, wherein the dehumidifying ventilator is used in combination with an air evaporation still; and the air outlet of the dehumidifying ventilator is connected with the air evaporation still via a conveying pipe.

58: The air conditioner according to claim 57, wherein the dehumidifying ventilator and the air evaporation still is positioned on different height levels and placed in the same frame; and the air evaporation still is provided with a cooling water pipe.

59: The air conditioner according to claim 56, wherein the multimolecular water is fluidized with the outdoor air and then brought into the heat exchanger having function of distillation, so as to exchange heat with the refrigerant in the still and be condensed into plain water.

60: The air conditioner according to claim 58, wherein the multimolecular water is fluidized with the outdoor air and then brought into the heat exchanger having function of distillation, so as to exchange heat with the refrigerant in the still and be condensed into plain water.

61: The air conditioner according to claim 51, wherein the heat exchangers have functions of both evaporation and distillation; the openings of their conveying pipes are round at one end, and rectangular at the other end; and the cooling water pipe is connected with the water tank, reservoir, or an additional container.

62: The air conditioner according to claim 56, wherein the heat exchangers have functions of both evaporation and distillation; the openings of their conveying pipes are round at one end, and rectangular at the other end; and the cooling water pipe is connected with the water tank, reservoir, or an additional container.

63: The air conditioner according to claim 58, wherein the heat exchangers have functions of both evaporation and distillation; the openings of their conveying pipes are round at one end, and rectangular at the other end; and the cooling water pipe is connected with the water tank, reservoir, or an additional container.

64: The air conditioner according to claim 47, wherein the dehumidifying ventilator is used in combination with a still and an indoor unit.

65: The air conditioner according to claim 50, wherein the dehumidifying ventilator is used in combination with a still and an indoor unit.

66: The air conditioner according to claim 47, wherein the dehumidifying ventilator is used in combination with a refrigerating chamber and an indoor unit.

67: The air conditioner according to claim 53, wherein the dehumidifying ventilator is used in combination with a refrigerating chamber and an indoor unit.

68: The air conditioner according to claim 50, wherein the dehumidifying ventilator is used in combination with a still and a refrigerating chamber.

69: The air conditioner according to claim 53, wherein the dehumidifying ventilator is used in combination with a still and a refrigerating chamber.

70: The air conditioner according to claim 47, wherein the dehumidifying ventilator is used in combination with a still, a refrigerating chamber, and an indoor unit.

71: The air conditioner according to claim 50, wherein the dehumidifying ventilator is used in combination with a still, a refrigerating chamber, and an indoor unit.

72: The air conditioner according to claim 53, wherein the dehumidifying ventilator is used in combination with a still, a refrigerating chamber, and an indoor unit.

73: The air conditioner according to claim 34, wherein the dehumidifying ventilator is used in combination with a water chiller evaporator.

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