

Description

Title of Invention: AIR DRYER INCLUDING VORTEX TUBE

Technical Field

- [1] The following disclosure relates to an air dryer, and in particular, to an air dryer including a vortex tube, which circulates cooled and compressed air to supply dry air.

Background Art

- [2] A pneumatic system includes intimately combined pneumatic driving devices to appropriately operate the pneumatic driving devices. Such a pneumatic system includes a pneumatic source, a purification device, a control valve, and the other devices. The pneumatic driving devices convert compressed air energy into mechanical translational kinetic energy or rotational kinetic energy.
- [3] Since compressed air, generated at a compressor as a pneumatic source, reaches a temperature from about 150 °C to about 250 °C through adiabatic air compression, the compressed air is cooled at a rear cooler, and then, introduced into a tank. Impurities and moisture are removed from the compressed air passing through the tank through a filter functioning as the purification device, the compressed air is decompressed at a pressure control valve, moisture is completely removed from the compressed air through the air dryer, and then, the air is supplied to the pneumatic driving device.
- [4] Such air dryers are classified into adsorption-type air dryers, absorption-type air dryers, and refrigeration-type air dryers according to a drying method.
- [5] According to dehumidifying operation of adsorption-type air dryers, moisture saturated in external air is sucked and compressed by a compressor while compressing air, a cooler cools and condenses the compressed air to primarily remove moisture, and moisture of wet air containing saturated water vapor is adsorbed to adsorbent such as silica gel, alumina gel, or synthetic zeolite. Absorption-type air dryers use moisture absorption liquid (lithium chloride water solution and triethylene glycol) to remove moisture. According to dehumidifying operation of refrigeration-type air dryers, wet air containing saturated water vapor is re-condensed through heat exchanging.
- [6] However, air dryers of prior art consume a lot of energy. Also, refrigeration-type air dryers pollute the environment with hazardous refrigerant such as CFC or HCFC, and facilities and driving thereof which requires refrigerant recycle are complicated.
- [7] Vortex tubes, invented by French physicist George Ranque in 1933, uses compressed air to cross rapid vortex and slow vortex and separate cool air from hot air, in which the separated cool air is used as refrigerant. Vortex tubes are used for industrial or laboratory spot cooler.

Disclosure of Invention

Technical Problem

- [8] Accordingly, the present disclosure provides an air dryer that rotates supplied compressed air in an air drying chamber to remove moisture and impurities from the compressed air using Coanda effect.
- [9] The present disclosure also provides an air dryer having increased efficiency.

Solution to Problem

- [10] In one general aspect, an air dryer includes: a compressor; an air drying chamber rotating compressed air supplied from the compressor to remove moisture from the compressed air using Coanda effect force and dry the compressed air, and simultaneously to accelerate and discharge the compressed air; a vortex tube dividing the dried and compressed air, discharged from the air drying chamber, into cool air and hot air, and discharging the cool air and the hot air; and an external discharge member collecting the dried hot air and the dried cool air, discharged from the vortex tube, and discharging the dried hot air and the dried cool air at a constant pressure to the outside.
- [11] In another general aspect, an air dryer includes: a compressor; a first air drying chamber rotating compressed air supplied from the compressor to remove moisture from the compressed air using Coanda effect and primarily dry the compressed air, and simultaneously, to accelerate and discharge the compressed air; a vortex tube dividing the dried and compressed air, discharged from the first air drying chamber, into cool air and hot air, and discharging the cool air and the hot air; a second air drying chamber rotating the hot air discharged from the vortex tube to remove moisture from the hot air using the Coanda effect and secondarily dry the hot air, and to accelerate the hot air and discharge the accelerated hot air together with the cool air discharged from the vortex tube; and an external discharge member collecting the dried hot air and the dried cool air, discharged from the second air drying chamber, and discharging the dried hot air and the dried cool air at a constant pressure to the outside.
- [12] Other features and aspects will be apparent from the following detailed description, the drawings, and the claims.

Advantageous Effects of Invention

- [13] According to the embodiments of the present invention, the air dryer including the vortex tube circulates supplied air as refrigerant to cool hot air and collect cool air and hot air, thus improving efficiency of the air dryer without environmental pollution.
- [14] In addition, the air dryer including the vortex tube removes moisture and impurities through multi processes to obtain dry air. Thus, an expensive device such as an after-cooler is not required. Compressed air is used as refrigerant, unlike a refrigerant-type air dryer using refrigerant, thereby reducing production costs and facilitating driving of the air dryer.

- [15] In addition, the air dryer including the vortex tube stores obtained dry air in the air storing tank to control the driving of the compressor according to the amount of used dry air, thus preventing power consumption due to unnecessary driving of the compressor.

Brief Description of Drawings

- [16] FIG. 1 is a schematic view illustrating an air dryer according to an embodiment of the present invention.
- [17] FIG. 2 is a perspective view illustrating an air discharging tube according to the embodiment of FIG. 1.
- [18] FIG. 3 is a schematic view illustrating rotation wings of an external discharge part according to the embodiment of FIG. 1.
- [19] FIG. 4 is a schematic view illustrating operation of a vortex tube according to an embodiment of the present invention.
- [20] FIG. 5 is a schematic view illustrating an air dryer according to another embodiment of the present invention.
- [21] FIG. 6 is a schematic view illustrating connection between a first EVA tube and a second EVA tube according to an embodiment of FIG. 5.

Best Mode for Carrying out the Invention

- [22] Hereinafter, exemplary embodiments will be described in detail with reference to the accompanying drawings. Throughout the drawings and the detailed description, unless otherwise described, the same drawing reference numerals will be understood to refer to the same elements, features, and structures. The relative size and depiction of these elements may be exaggerated for clarity, illustration, and convenience. The following detailed description is provided to assist the reader in gaining a comprehensive understanding of the methods, apparatuses, and/or systems described herein. Accordingly, various changes, modifications, and equivalents of the methods, apparatuses, and/or systems described herein will be suggested to those of ordinary skill in the art. Also, descriptions of well-known functions and constructions may be omitted for increased clarity and conciseness.
- [23] FIG. 1 is a schematic view illustrating an air dryer according to an embodiment of the present invention.
- [24] Referring to FIG. 1, the air dryer according to the current embodiment includes a compressor (not shown), an air drying chamber 100, the vortex tube 200, and an external discharge part 300.
- [25] The air drying chamber 100 rotates compressed air supplied from the compressor to remove moisture and impurities from the compressed air using Coanda effect and dry the compressed air, and simultaneously, to accelerate and discharge the compressed air

to the vortex tube 200. The upper portion of the air drying chamber 100 has a cylindrical shape provided with an oblique and cylindrical injection port for compressed air, and the lower portion of the air drying chamber 100 has a cone shape to increase the rotation speed of compressed air.

- [26] The air drying chamber 100 includes an air discharging tube 110 inducing the rotated compressed air to the vortex tube 200 to discharge the air, a spiral ethylene vinyl acetate copolymer (EVA) tube 120 surrounding the air discharge tube 110 to discharge cool air from the vortex tube 200 to the external discharge part 300, and a moisture discharging part 130 discharging moisture and impurities removed from the compressed air to the outside.
- [27] Referring to FIG. 2, the air discharging tube 110 includes a metal mesh 111 primarily cooling moved and compressed air with cool air of the EVA tube 120, and a spiral cooling coil 112 disposed in the metal mesh 111 to secondarily cool the primarily cooled air, so as to cool compressed air discharged to the vortex tube 200.
- [28] The vortex tube 200 divides dried and compressed air discharged from the air drying chamber 100 into cool air and hot air, discharges the cool air to the EVA tube 120, and discharges the hot air to the external discharge part 300. The vortex tube 200 includes a rotation chamber (not shown), cooling fins 210, an adjustment valve 220. The rotation chamber divides compressed air into hot air and cool air, and separately discharges the hot air and the cool air. The cooling fins 210 cool the discharged hot air. The adjustment valve 220 adjusts the amount of hot air discharged from the rotation chamber to the external discharge part 300.
- [29] The external discharge part 300 collects dry cool air discharged from the EVA tube 120 of the air drying chamber 100, and hot air discharged from the vortex tube 200, and discharges the cool air and the hot air at a constant pressure to the outside. In this case, since the cool air and the hot air are different from each other in pressure, the external discharge part 300 includes a plurality of oblique wing parts 311 that are spaced by a constant distance from each other to collect the cool air and the hot air.
- [30] The air dryer further includes an air storage tank (not shown) that temporarily stores dry air discharged from the external discharge part 300 to control driving of the compressor according to the amount of used dry air and prevent power consumption due to unnecessary driving of the compressor. The air storage tank includes a pressure sensing part (not shown), a solenoid valve (not shown), and a control member (not shown). The pressure sensing part detects the maximum and minimum set pressures in the air storage tank. The solenoid valve adjusts the amount of air, introduced into the air storage tank, according to pressure variation of dry air stored in the air storage tank. The control member controls driving on/off of the compressor according to sensed pressure in the air storage tank.

- [31] Hereinafter, operation of the air dryer configured as described above will now be described with reference to the accompanying drawings according to the current embodiment.
- [32] Prior to the description of the operation, referring to FIG. 4, a vortex tube theory applied to the present invention will now be described. When air compressed at a predetermined pressure is supplied to a vortex tube inlet 201 through the air discharging tube 110, the compressed air is introduced into a tube-type vortex rotation chamber 202 and primarily rotates at a high speed of several million RPM.
- [33] The rotating air (hereinafter, referred to as a primary vortex) is partially discharged through a hot air outlet 203, the rest is returned by the adjustment valve 220 to form a secondary vortex in the primary vortex, and is discharged through a cool air outlet 204 on the opposite side to the hot air outlet 203.
- [34] That is, vortices moving in opposite directions to each other along the longitudinal direction of the vortex tube 200 occur respectively at the inner and outer portions in the vortex tube 200.
- [35] At this point, the secondary vortex loses heat, passing through a region having a relatively low pressure in the flow of the primary vortex, and moves to the cool air outlet 204.
- [36] The two vortices rotate in an identical direction and at an identical angular velocity. Since the time taken for an air particle of the inner flow (the secondary vortex) to rotate once is the same as the time taken for an air particle of the outer flow (the primary vortex) to rotate once, the actual speed of the inner flow is less than that of the outer flow. The difference in the speed means the loss in kinetic energy. Lost kinetic energy is converted into heat to increase air temperature of the outer flow (the primary vortex) and further decrease air temperature of the inner flow (the secondary vortex).
- [37] A spiral arrow (moving right) at the outer portion in the vortex tube 200 of FIG. 4 denotes the flow of the primary vortex, and a spiral arrow (moving left) at the inner portion denotes the flow of the secondary vortex.
- [38] Hereinafter, the operation of the air dryer including the vortex tube 200 will now be described.
- [39] Referring to FIG. 1, when compressed air discharged from the compressor is introduced through the oblique injection port of the air drying chamber 100, the compressed air starts to rotate. At this point, since the upper portion of the air drying chamber 100 has a cylindrical shape, and the lower portion has a cone shape, the compressed air rotating and moving downward along the cylindrical shape is gradually accelerated, and the Coanda phenomenon occurs. Accordingly, moisture and impurities included in the compressed air are adsorbed to a wall surface of the air drying chamber 100, and dropped to the moisture discharging part 130 by gravity.

- [40] Thereafter, the compressed air is moved upward through the air discharging tube 110, introduced into the vortex tube 200, and divided into hot air and cool air in the vortex tube 200 as described above. The hot air is discharged to the external discharge part 300. The cool air is introduced into the spiral EVA tube 120 surrounding the air discharging tube 110, is heat-exchanged with compressed air in the air discharging tube 110 to condense moisture in the compressed air, and is discharged to the external discharge part 300.
- [41] Since the cool air and the hot air are different from each other in pressure, the external discharge part 300 collects the cool air and the hot air and discharges them at a constant pressure to the outside through the oblique wing parts 311 that are spaced a constant distance from each other. That is, when the cool air having a high pressure strongly pushes the wing parts 311, a rotation fan 310 rotates to generate sucking force that attracts the hot air having a low pressure to naturally mix the hot air with the cool air.
- [42] The air storage tank temporarily stores dry air discharged from the external discharge part 300 to control the driving of the compressor according to the amount of used dry air, thus preventing power consumption due to unnecessary driving of the compressor.
- [43] That is, when the pressure sensing part, detecting the maximum and minimum set pressures in the air storage tank, detects the maximum pressure, the solenoid valve is closed to shut off air introduced into the air storage tank, and simultaneously, the control member turns the compressor off. On the contrary, when the pressure sensing part detects the minimum pressure, the solenoid valve is opened to introduce air into the air storage tank, and simultaneously, the control member turns the compressor on.
- [44] FIG. 5 is a schematic view illustrating an air dryer including the vortex tube 200, according to another embodiment of the present invention.
- [45] Referring to FIG. 5, the air dryer according to the current embodiment includes a compressor, a first air drying chamber 400, the vortex tube 200, a second air drying chamber 500, and the external discharge part 300.
- [46] The first air drying chamber 400 rotates compressed air supplied from the compressor to remove moisture from the compressed air using the Coanda effect and primarily dry the compressed air, and simultaneously, to accelerate and discharge the compressed air. To this end, the air dryer according to the current embodiment further includes a first air discharging tube 410, a first EVA tube 420, and a first portion of the moisture discharging part 130. The first air discharging tube 410 induces and discharges the rotated compressed air to the vortex tube 200. The first EVA tube 420 surrounds the first air discharging tube 410 to move cool air, discharged from the vortex tube 200, to the second air drying chamber 500. The first portion of the moisture discharging part 130 primarily discharges moisture, removed from the

compressed air, to the outside.

- [47] The vortex tube 200 divides compressed dry air discharged from the first air drying chamber 400 into cool air and hot air, discharges the cool air to the first air drying chamber 400, and discharges the hot air to the second air drying chamber 500. The vortex tube 200 includes a rotation chamber (not shown) and the adjustment valve 220. The rotation chamber divides compressed air into hot air and cool air, and separately discharges the hot air and the cool air. The adjustment valve 220 adjusts the amount of hot air discharged from a connection pipe to the second air drying chamber 500.
- [48] The second air drying chamber 500 rotates hot air discharged from the vortex tube 200 to remove moisture from the hot air using the Coanda effect and secondarily dry the hot air, and simultaneously, to accelerate the hot air and discharge the accelerated hot air together with cool air discharged from the vortex tube 200. To this end, the air dryer according to the current embodiment further includes a second air discharging tube 510, a spiral second EVA tube 520, and a second portion of the moisture discharging part 130. The second air discharging tube 510 induces and discharges the rotated hot air to the external discharge part 300. The second EVA tube 520 surrounds the second air discharging tube 510 to move cool air, discharged from the first air drying chamber 400, to the external discharge part 300. The second portion of the moisture discharging part 130 secondarily discharges moisture, removed from the hot air, to the outside.
- [49] The upper portions of the first and second air drying chambers 400 and 500 have cylindrical shapes provided with inclined injection ports for compressed air or hot air, and the lower portions of the first and second air drying chambers 400 and 500 have cone shapes to increase the rotation speed of compressed air or hot air.
- [50] Referring to FIG. 2, each of the first and second air discharging tubes 410 and 510 of the first and second air drying chambers 400 and 500 includes the metal mesh 111 primarily cooling moved and compressed air or heat air with cool air of the first and second EVA tubes 420 and 520, and the spiral cooling coil 112 disposed in the metal mesh 111 to secondarily cool the primarily cooled compressed air or hot air.
- [51] Since the first and second air drying chambers 400 and 500 connect the first and second EVA tubes 420 and 520 to each other, cool air flows through the first and second EVA tubes 420 and 520. Referring to FIG. 5, the first and second EVA tubes 420 and 520 may be connected to each other such that cool air moves from the upper portion of the first EVA tube 420 to the lower portion thereof, and then, moves from the lower portion of the second EVA tube 520 to the upper portion thereof. Referring to FIG. 6, the first and second EVA tubes 420 and 520 may be connected to each other such that cool air moves from the lower portion of the first EVA tube 420 to the upper portion thereof, and then, moves from the lower portion of the second EVA tube 520 to

the upper portion thereof.

[52] The external discharge part 300 collects dry cool air and hot air discharged from the second air drying chamber 500 and discharges the cool air and the hot air at a constant pressure to the outside. Since the cool air and the hot air are different from each other in pressure, the external discharge part 300 includes the rotation fan 310 provided with the oblique wing parts 311 that are spaced a constant distance from each other to collect the cool air and the hot air, as illustrated in FIG. 3.

[53] The air dryer according to the current embodiment further includes an air storage tank that is the same as that of the previous embodiment, and thus, a description thereof will be omitted.

[54] Hereinafter, operation of the air dryer configured as described above will now be described with reference to the accompanying drawings according to the current embodiment.

[55] Referring to FIG. 5, when compressed air discharged from the compressor is introduced through the oblique injection port of the first air drying chamber 400, the compressed air starts to rotate. The upper portion of the first air drying chamber 400 has a cylindrical shape, and the lower portion has a cone shape that quickly decreases in width. Thus, the compressed air, rotating and moving downward along the cylindrical shape, is gradually accelerated, and the Coanda phenomenon occurs. Accordingly, moisture and impurities included in the compressed air are adsorbed to a wall surface of the first air drying chamber 400, and dropped to the moisture discharging part 130 by gravity.

[56] Thereafter, the compressed air is moved upward through the first air discharging tube 410, is introduced into the vortex tube 200, and is divided into hot air and cool air in the vortex tube 200 as described above. The hot air is discharged to the second air drying chamber 500. The cool air is introduced into the first spiral first EVA tube 420 surrounding the first air discharging tube 410, is heat-exchanged with compressed air in the first air discharging tube 410 to condense moisture in the compressed air, and is discharged to the second EVA tube 520 of the second air drying chamber 500.

[57] When the hot air discharged from the vortex tube 200 is introduced through the oblique injection port, the hot air starts to rotate in the second air drying chamber 500. The upper portion of the second air drying chamber 500 has a cylindrical shape, and the lower portion has a cone shape that quickly decreases in width, like the first air drying chamber 400. Thus, the hot air, rotating and moving downward along the cylindrical shape, is gradually accelerated, and the Coanda phenomenon occurs. Accordingly, moisture and impurities included in the hot air are adsorbed to a wall surface of the second air drying chamber 500, and dropped to the moisture discharging part 130 by gravity.

- [58] Cool air discharged from the first EVA tube 420 of the first air drying chamber 400 is heat-exchanged with hot air in the second air discharging tube 510 through the second EVA tube 520. Thus, the cool air and the hot air are discharged, as warm air, to the external discharge part 300.
- [59] Thereafter, since the cool air and the hot air are different from each other in pressure, the external discharge part 300 collects the cool air and the hot air and discharges them at a constant pressure to the outside through the oblique wing parts 311 that are spaced a constant distance from each other. That is, when the cool air having a high pressure strongly pushes the wing parts 311, the rotation fan 310 rotates to generate sucking force that attracts the hot air having a low pressure to naturally mix the hot air with the cool air. Thus, since the discharge amount of dry air including hot air and cool air is greater than that of a single type of dry air, that is, of only cool air or only hot air, the efficiency of the air dryer is improved.
- [60] The air storage tank temporarily stores dry air discharged from the external discharge part 300 to control the driving of the compressor according to the amount of used dry air, thus preventing power consumption due to unnecessary driving of the compressor.
- [61] That is, when a pressure sensing part, detecting the maximum and minimum set pressures in the air storage tank, detects the maximum pressure, a solenoid valve is closed to shut off air introduced into the air storage tank, and simultaneously, a control member turns the compressor off. On the contrary, when the pressure sensing part detects the minimum pressure, the solenoid valve is opened to introduce air into the air storage tank, and simultaneously, the control member turns the compressor on.
- [62] A number of exemplary embodiments have been described above. Nevertheless, it will be understood that various modifications may be made. For example, suitable results may be achieved if the described techniques are performed in a different order and/or if components in a described system, architecture, device, or circuit are combined in a different manner and/or replaced or supplemented by other components or their equivalents. Accordingly, other implementations are within the scope of the following claims.

Industrial Applicability

- [63] According to the present invention, dry air is efficiently supplied without refrigerant, which may be applied to medical fields, measurement/control appliances, powder coating fields, pneumatic fields, and sand blasting fields.
- [64] Particularly, applications to pneumatic fields will be diversified. In addition, the air dryer will be widely and actively applied to machine tools, pneumatic and air cylinders, automatic processes, typical painting, precise painting, measurement facilities, fiber industries, raw material transport, powder painting, precise part drying

lines, semiconductor electronic devices, medicine industries, ultra-precise industries, chemical industries, medical industries, optical industries, food industries, and dairies.

[65]

Claims

- [Claim 1] An air dryer comprising:
a compressor;
an air drying chamber rotating compressed air supplied from the compressor to remove moisture from the compressed air using Coanda effect and dry the compressed air, and simultaneously to accelerate and discharge the compressed air;
a vortex tube dividing the dried and compressed air, discharged from the air drying chamber, into cool air and hot air, and discharging the cool air and the hot air; and
an external discharge member collecting the dried hot air and the dried cool air, discharged from the vortex tube, and discharging the dried hot air and the dried cool air at a constant pressure to the outside.
- [Claim 2] The air dryer of claim 1, wherein the air drying chamber comprises:
an air discharging tube inducing the rotated and compressed air to the vortex tube to discharge the compressed air;
a spiral ethylene vinyl acetate copolymer (EVA) tube surrounding the air discharging tube to discharge cool air from the vortex tube to the external discharge member; and
a moisture discharging member discharging moisture removed from the compressed air to the outside.
- [Claim 3] The air dryer of claim 2, wherein the air discharging tube comprises:
a metal mesh primarily cooling moved and compressed air with cool air of the EVA tube;
a spiral cooling coil disposed in the metal mesh to secondarily cool the primarily cooled air.
- [Claim 4] The air dryer of claim 1, wherein the air drying chamber has a cylindrical upper portion provided with an oblique injection port through which compressed air is injected, and a cone-shaped lower portion increasing a rotation speed of compressed air.
- [Claim 5] The air dryer of claim 1, wherein the vortex tube comprises:
a connection pipe dividing the compressed air into hot air and cool air and separately discharging the hot air and the cool air;
a cooling fin cooling the separately discharged hot air; and
an adjustment valve adjusting an amount of the hot air discharged from the connection pipe to the external discharge member.
- [Claim 6] The air dryer of claim 1, wherein the external discharge member

comprises a rotation fan that includes a plurality of oblique wing parts spaced a constant distance from each other to collect hot air and cool air different from each other in pressure.

[Claim 7] The air dryer of claim 1, further comprising an air storage tank that temporarily stores dry air discharged from the external discharge member.

[Claim 8] The air dryer of claim 7, wherein the air storage tank comprises:
a pressure sensing member detecting maximum and minimum set pressures in the air storage tank;
a solenoid valve adjusting an amount of air introduced into the air storage tank according to pressure variation of the stored dry air; and
a control member controlling driving on/off of the compressor according to sensed pressure in the air storage tank.

[Claim 9] An air dryer comprising:
a compressor;
a first air drying chamber rotating compressed air supplied from the compressor to remove moisture from the compressed air using Coanda effect and primarily dry the compressed air, and simultaneously, to accelerate and discharge the compressed air;
a vortex tube dividing the dried and compressed air, discharged from the first air drying chamber, into cool air and hot air, and discharging the cool air and the hot air;
a second air drying chamber rotating the hot air discharged from the vortex tube to remove moisture from the hot air using the Coanda effect and secondarily dry the hot air, and to accelerate the hot air and discharge the accelerated hot air together with the cool air discharged from the vortex tube; and
an external discharge member collecting the dried hot air and the dried cool air, discharged from the second air drying chamber, and discharging the dried hot air and the dried cool air at a constant pressure to the outside.

[Claim 10] The air dryer of claim 9, wherein the first air drying chamber comprises:
a first air discharging tube inducing the rotated and compressed air to the vortex tube to discharge the compressed air;
a spiral first ethylene vinyl acetate copolymer (EVA) tube surrounding the first air discharging tube to discharge cool air from the vortex tube to the second air drying chamber; and

- a first moisture discharging member primarily discharging moisture, removed from the compressed air, to the outside.
- [Claim 11] The air dryer of claim 9, wherein the second air drying chamber comprises:
- a second air discharging tube inducing the rotated hot air to the external discharge member to discharge the hot air;
 - a spiral second EVA tube surrounding the second air discharging tube to discharge cool air from the first air drying chamber to the external discharge member; and
 - a second moisture discharging member secondarily discharging moisture, removed from the hot air, to the outside.
- [Claim 12] The air dryer of claim 10, wherein the first air discharging tube comprises:
- a metal mesh primarily cooling moved and compressed air with cool air of the first EVA tube;
 - a spiral cooling coil disposed in the metal mesh to secondarily cool the primarily cooled air.
- [Claim 13] The air dryer of claim 9, wherein the first and second air drying chambers each has a cylindrical upper portion provided with an oblique injection port through which air is injected, and a cone-shaped lower portion increasing a rotation speed of compressed air.
- [Claim 14] The air dryer of claim 9, wherein the first and second air drying chambers move cool air through first and second EVA tubes connected to each other.
- [Claim 15] The air dryer of claim 9, wherein the vortex tube comprises:
- a connection pipe dividing the compressed air into hot air and cool air and separately discharging the hot air and the cool air; and
 - an adjustment valve adjusting an amount of hot air discharged from the connection pipe to the external discharge member.
- [Claim 16] The air dryer of claim 9, wherein the external discharge member comprises a rotation fan that includes a plurality of oblique wing parts spaced a constant distance from each other to collect hot air and cool air different from each other in pressure.
- [Claim 17] The air dryer of claim 9, further comprising an air storage tank that temporarily stores dry air discharged from the external discharge member.
- [Claim 18] The air dryer of claim 17, wherein the air storage tank comprises:
- a pressure sensing member detecting maximum and minimum set

pressures in the air storage tank;
a solenoid valve adjusting an amount of air introduced into the air storage tank according to pressure variation of the stored dry air; and
a control member controlling driving on/off of the compressor according to sensed pressure in the air storage tank.

[Claim 19]

The air dryer of claim 11, wherein the second air discharging tube comprises:

a metal mesh primarily cooling moved and compressed air with cool air of the second EVA tube;

a spiral cooling coil disposed in the metal mesh to secondarily cool the primarily cooled air.