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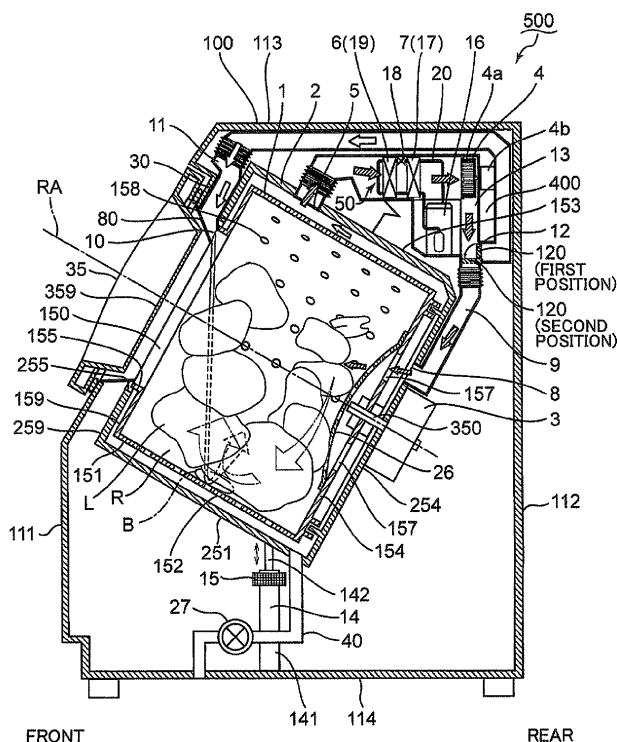
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(54) **Laundry dryer and washing and drying machine**

(57) Provided are a laundry dryer and a washing and drying machine including a rotary drum (1) for agitating laundry, an air supplier (400) for supplying dry air to the rotary drum (1), a nozzle (30) for blowing out the dry air, which is sent by the air supplier (400), in a first direction

from an outside of the rotary drum (1), and a guider (80) which comes in contact with the dry air blown out in the first direction and changes a flow direction of the dry air to a second direction toward an interior of the rotary drum (1).

FIG.1



Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention is related to a laundry dryer for drying laundry, and a washing and drying machine with washing functions and laundry drying functions.

Description of the Related Art

[0002] A laundry dryer and a washing and drying machine (both are hereinafter referred to as the "drum-type drying machine") comprising a drum in which laundry is stored, and a duct which guides dry air into the drum to dry the laundry are widely used. The dry air flowing into the drum through the duct comes in contact with the laundry stored in the drum to remove moisture from the laundry. Consequently, while the laundry is dried, a humidity of the dry air goes up. The humid dry air is exhausted to the duct, which is situated outside the drum.

[0003] Fig. 12 is a schematic diagram of a drum-type drying machine disclosed in JP 10-263295 A. The conventional drum-type drying machine (laundry dryer and washing and drying machine) is described with reference to Fig. 12.

[0004] The drum-type drying machine 900 shown in Fig. 12 comprises a drum 300 configured to store laundry. A feed opening is formed on the drum 300. A user may feed or take out the laundry into or from the drum through the feed opening.

[0005] The drum-type drying machine 900 comprises a door 310 configured to cover in the feed opening of the drum 300. The door 310 includes a transparent window 311 which is fitted into the feed opening of the drum 300. While the door 310 keeps the laundry inside the drum 300, the user may visually access the laundry inside the drum 300 through the window 311.

[0006] The drum-type drying machine 900 comprises a blower 330 which blows the dry air into the drum 300 to dry the laundry, and a nozzle 320 from which the dry air is blown out by the blower 330. The dry air blown out from the nozzle 320 comes in contact with the window 311. Consequently, the dry air moves toward the interior of the drum 300.

[0007] Fig. 13 is a schematic diagram of another drum-type drying machine disclosed in JP 2009-50338 A and JP 2010-75216 A. A conventional drum-type drying machine is described with reference to Fig. 13.

[0008] The drum-type drying machine 950 shown in Fig. 13 comprises a drum 305 in which laundry is stored, and a nozzle 325 which is opened toward the interior of the drum 305. The dry air blown out from the nozzle 325 comes in direct contact with the laundry stored in the drum 305.

[0009] The dry air flowing in the drum-type drying machine 900 shown in Fig. 12 comes in contact with the window 311 before flowing into the drum 300, so that thermal energy of the dry air is partially transferred to the window 311.

Thus, the thermal energy of the dry air is not used sufficiently and effectively.

[0010] The drum-type drying machine 950 shown in Fig. 13 uses the nozzle 325 to direct the dry air into the drum 305. In order to facilitate the direct contact between the laundry and the dry air, the nozzle 325 has to protrude into the drum 305. The laundry is moved by the rotating drum 305. Accordingly, the laundry often comes in contact with the nozzle 325 protruding inside the drum 305. Thus, it may be a problem that the drum-type drying machine 950 shown in Fig. 13 damages the laundry.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide a laundry dryer, and a washing and drying machine which dries laundry with little damage to the laundry.

[0012] The laundry dryer according to one aspect of the present invention includes a rotary drum configured to agitate laundry; an air supplier configured to supply dry air to the rotary drum; a nozzle from which the dry air is blown out by the air supplier in a first direction, the nozzle situated outside the rotary drum; and a guider which comes in contact with the dry air blown out in the first direction and changes a flow direction of the dry air to a second direction toward an interior of the rotary drum.

[0013] The washing and drying machine according to another aspect of the present invention comprises the aforementioned laundry dryer, and a water tub which encloses the rotary drum and stores wash water.

[0014] The aforementioned laundry dryer and the washing and drying machine may dry the laundry with little damage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a schematic longitudinal cross sectional view of a washing and drying machine according to one embodiment;
 Fig. 2 is a schematic enlarged cross section around a guider of the washing and drying machine shown in Fig. 1;
 Fig. 3 is a schematic perspective view mainly showing the right side of a water tub of the washing and drying machine shown in Fig. 1;
 Fig. 4 is a schematic rear perspective view mainly showing the internal structure of the water tub of the washing and drying machine shown in Fig. 1;
 Fig. 5 is a schematic front view of the water tub;
 Fig. 6 is a schematic block diagram of the washing and drying machine shown in Fig. 1;
 Fig. 7 is a schematic timing chart showing duct switching operation of the washing and drying machine shown in Fig. 1;
 Fig. 8 is a schematic timing chart showing other duct switching operation of the washing and drying machine shown in Fig. 1;
 Fig. 9 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1;
 Fig. 10 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1;
 Fig. 11 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1;
 Fig. 12 is a schematic side view of a cross section of a conventional drum-type washing and drying machine; and
 Fig. 13 is a schematic side view of a cross section of another conventional drum-type washing and drying machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] A drum-type washing and drying machine is described with reference to the accompanying drawings. Details such as structures, arrangements, shapes of the washing and drying machine described hereinafter are not intended to limit principles of the washing and drying machine.

<Configurations of Washing and Drying Machine>

[0017] Fig. 1 is a schematic view of a vertical cross section of the drum-type washing and drying machine. The washing and drying machine is described with reference to Fig. 1.

[0018] The washing and drying machine 500 shown in Fig. 1 comprises a housing 100 configured to store various elements for washing and drying laundry L. The housing 100 includes a front wall 111, a rear wall 112 opposite to the front wall 111, a top wall 113 which forms the top surface of the housing 100 between the front and rear walls 111, 112, and a bottom wall 114 opposite to the top wall 113. The washing and drying machine 500 further comprises a pivotal door 35 attached to the front wall 111. A user may open the door 35 to access the laundry L in the housing 100.

[0019] The washing and drying machine 500 further comprises a drum 1 situated in the housing 100. The laundry L is stored in the drum 1, which includes a substantially cylindrical peripheral wall 151. The peripheral wall 151 defines a storage room R in which the laundry L is stored. The peripheral wall 151 includes a front wall portion 159 which faces the door 35. The front wall portion 159 includes a periphery 155 which defines a substantially circular feed opening 150. The user may open the door 35 to feed or take out the laundry L into or from the drum 1 through the feed opening 150. The drum 1 includes a bottom wall 154 opposite to the front wall portion 159 which defines the feed opening 150. In the present embodiment, the bottom wall 154 is exemplified as the bottom.

[0020] The door 35 includes a transparent window 359 which protrudes inside the housing 100. If the door 35 is closed, the window 359 at least partially covers in the feed opening 150, so that the laundry L is appropriately kept in the drum 1. It should be noted that the user may visually access the laundry L in the drum 1 through the window 359 of the closed door 35.

[0021] The washing and drying machine 500 further comprises a water tub 2 which encloses the drum 1. The water tub 2 includes a substantially cylindrical peripheral wall 251, and a bottom wall 254 along the bottom wall 154 of the drum 1. The peripheral wall 251 of the water tub 2 includes a front wall portion 259 along the front wall portion 159 of the drum 1. The front wall portions 259, 159 of the water tub 2 and the drum 1 define the feed opening 150 together.

[0022] The washing and drying machine 500 further comprises a watering pipe (not shown), which is connected to the water tub 2, and a watering valve (not shown), which is mounted on the watering pipe. If the watering valve is opened, wash water is stored in the water tub 2 to wash the laundry L. The washing and drying machine 500 further comprises a drainage pipe 40, which is connected to the water tub 2, and a drain valve 27, which is mounted on the drainage pipe 40. If the drain valve 27 is opened, the wash water is drained from the water tub 2.

[0023] The washing and drying machine 500 further comprises a drive motor 3 mounted on the bottom wall 254 of the water tub 2. The drive motor 3 includes a rotating shaft 350 which extends through the bottom wall 254 of the water tub 2 and is connected to the bottom wall 154 of the drum 1. The drum 1 is rotated in the water tub 2 by the drive motor

3 to agitate the laundry L. The rotation axis RA of the drum 1 is inclined so that the rotation center of the front wall portion 159 of the drum 1 is higher than the rotation center of the bottom wall 154 of the drum 1. In the present embodiment, the drum 1 is exemplified as the rotary drum.

[0024] The washing and drying machine 500 further comprises an air supplier 400 which supplies the dry air into the drum 1 to dry the laundry L. The air supplier 400 comprises a blower 4 which blows the dry air into the drum 1. The dry air blown into the drum 1 removes moisture from the laundry L and becomes humid.

[0025] A lot of air holes 158 are formed on the peripheral wall 151 of the drum 1. An exhaust port 5 is formed on the peripheral wall 251 of the water tub 2. The air supplier 400 comprises a circulatory duct 13 connected to the exhaust port 5. The dry air drying the laundry L in the drum 1 is discharged from the drum 1 through the air holes 158. The dry air is then exhausted outside the water tub 2 through the exhaust port 5, and flows along the circulatory duct 13.

[0026] The air supplier 400 comprises a dehumidifier 6 situated in the circulatory duct 13. The dehumidifier 6 dehumidifies the discharged dry air from the exhaust port 5.

[0027] The air supplier 400 comprises a heater 7 after the dehumidifier 6. The heater 7 heats the dry air dehumidified by the dehumidifier 6.

[0028] The circulatory duct 13 branches into a first duct 9 and a second duct 11 after the blower 4. The air supplier 400 comprises a switcher 12 situated at the bifurcation of the first and second ducts 9, 11. The switcher 12 selectively switches a supply route of the dry air between the first and second ducts 9, 11, so that the dry air is guided by the first or second duct 9, 11, and once again flows into the drum 1.

[0029] The first duct 9 includes a first outlet 8 formed on the bottom wall 254 of the water tub 2. The second duct 11 includes a second outlet 10 formed in the feed opening 150. The washing and drying machine 500 comprises a nozzle 30 which is attached to the tip of the second duct 11 of the water tub 2 and situated on the front wall portion 259. In the present embodiment, the nozzle 30 defines the blowing direction of the dry air, which is exemplified as the first direction. The dry air is blown out from the nozzle 30 in the first direction from the outside of the drum 1.

[0030] The washing and drying machine 500 further comprises a guider 80 situated near the tip of the nozzle 30. The dry air blown in the first direction from the nozzle 30 collides with the guider 80, and then travels toward the storage room R in the drum 1. In the present embodiment, the flow direction of the dry air after the collision with the guider 80 is exemplified as the second direction. The guider 80 changes the flow direction of the dry air, which is then preferably guided into the drum 1.

[0031] The first outlet 8 of the first duct 9 has a larger bore than the second outlet 10 of the second duct 11. Accordingly, a pressure loss of the dry air blown from the bottom wall 154 of the drum 1 through the first outlet 8 is less than a pressure loss of the dry air blown into the drum 1 through the second outlet 10. The blower 4 is controlled so that a flow volume of the dry air blown out from the first outlet 8 while the switcher 12 guides the dry air to the first duct 9 becomes greater than a flow volume of the dry air blown out from the second outlet 10 while the switcher 12 guides the dry air to the second duct 11. As described above, since the first outlet 8 has a relatively large bore, it is suitable to supply a large flow volume of the dry air into the drum 1.

[0032] The second outlet 10 of the second duct 11 has a smaller bore than the first outlet 8 of the first duct 9. The blower 4 is controlled so that pressure and velocity of the dry air blown out from the second outlet 10 while the switcher 12 guides the dry air to the second duct 11 become greater than those of the dry air blown out from the first outlet 8 while the switcher 12 guides the dry air to the first duct 9. As described above, the smaller bore of the second outlet 10 preferably facilitates to supply the rapid dry air at high-pressure into the drum 1.

[0033] Fig. 2 is a schematic enlarged cross sectional view around the guider 80. The guider 80 is described with reference to Figs. 1 and 2.

[0034] As shown in Fig. 2, the nozzle 30 connected to the second duct 11 is formed between the front wall 111 of the housing 100 and the front wall portion 259 of the water tub 2. The guider 80 includes a guide plate 80a, which has a base end 801 fixed to the front wall 111 of the housing 100 nearby the tip of the nozzle 30, and a support plate 80b which supports the guide plate 80a. The support plate 80b is connected to the front wall 111 of the housing 100.

[0035] The nozzle 30 includes an inner surface 30a which defines a bore of the nozzle 30. The inner surface 30a is bent at the tip of the nozzle 30 and directed toward the storage room R which is defined by the drum 1. The guide plate 80a substantially straightly extends from the elbow of the inner surface 30a of the nozzle 30 along the front wall 111, so that the guide plate 80a is also inclined toward the storage room R.

[0036] The guide plate 80a includes a tip 802 opposite to the base end 801. A second outlet 10 is formed between the tip 802 and the inner surface 30a of the nozzle 30 along the front wall portion 259 of the water tub 2.

[0037] The dry air blown out from the tip of the nozzle 30 collides with the guide plate 80a. The guide plate 80a guides the dry air toward the storage room R. The dry air is thereafter blown into the drum 1 through the second outlet 10. As described above, the second outlet 10 has the smaller bore than the first outlet 8. Accordingly, the rapid dry air at high-pressure may be more easily blown out from the second outlet 10 into the drum 1 than the first outlet 8. The first outlet 8 of the first duct 9 has the larger bore than the second outlet 10. Therefore, the pressure loss of the dry air blown out from the first outlet 8 is less than the pressure loss of the dry air blown out from the second outlet 10. Accordingly, a

large flow volume of the dry air may be more easily blown out from the first outlet 8 into the drum 1 than the second outlet 10.

[0038] Fig. 3 is a schematic perspective view mainly showing the right side of the water tub 2. Fig. 4 is a schematic rear perspective view mainly showing the internal structure of the water tub 2. The water tub 2 is described with reference to Figs. 1 to 4.

[0039] As shown in Figs. 3 and 4, in the present embodiment, the nozzle 30 is mounted on an upper right portion of the front wall portion 259 of the water tub 2 (i.e. upper right with respect to the rotation axis RA of the drum 1).

[0040] A concavity is formed at the upper right portion of the peripheral wall 251 of the water tub 2. The second duct 11 is connected to the concavity. The concavity formed on the water tub 2 functions as the aforementioned nozzle 30. In the present embodiment, the nozzle 30 and the water tub 2 are integrally formed. Alternatively, the nozzle 30 may be formed separately from the water tub 2.

[0041] In the present embodiment, the guide plate 80a is an arc plate member. The support plate 80b of the guider 80 is mounted on the housing 100 so that the guide plate 80a is placed along the drum 1 (c.f. Fig. 1), which defines the circular feed opening 150, and the peripheries 155, 255 of the water tub 2.

[0042] As described above, the nozzle 30 is formed outside the drum 1. The dry air blown by the blower 4 is discharged from the nozzle 30 outside the drum 1. Thereafter, the dry air blown out from the nozzle 30 directly collides with the guider 80 situated between the drum 1 and the housing 100. The guider 80 changes the flow direction of the dry air to the second direction at between the drum 1 and the housing 100. Consequently, the dry air is appropriately guided into the drum 1.

[0043] As shown in Fig. 1, the guider 80 is situated between the nozzle 30 and the window 359 of the door 35. Accordingly, unlike the aforementioned conventional technologies, the dry air flows into the storage room R without the collision with the window 359. Thus, little thermal energy of the dry air is discharged outside the washing and drying machine 500 via the window 359. The effective use of the thermal energy of the dry air results in high drying efficiency of the laundry.

[0044] As described above, the nozzle 30 is formed outside the drum 1. The guider 80 deflects the dry air blown out from the nozzle 30 so that the dry air is guided into the drum 1. Accordingly, unlike the aforementioned conventional technologies, the tip of the nozzle 30 is positioned outside the drum 1 without protruding inside the storage room R. Therefore, it becomes less likely that the laundry L in the storage room R comes in contact with the nozzle 30. Consequently, there is little damage to the laundry L.

[0045] As described above, the guide plate 80a of the guider 80 is formed in an arc shape along the peripheries 155, 255 which define the feed opening 150. As shown in Fig. 3, the nozzle 30 has a rectangular cross section. The dry air travels from the nozzle 30 with the rectangular bore toward the arc second outlet 10 along the peripheries 155, 255, and eventually flows into the storage room R. Accordingly, the dry air from the arc-shaped second outlet 10 is less likely to spread than the dry air blown out from a rectangular bore.

[0046] As shown in Fig. 1, the drum 1 includes a first portion 152 which defines the lower half of the storage room R, and a second portion 153 which defines the upper half of the storage room R. In the present embodiment, the dry air directed in the second direction by the guider 80 flows toward the lowest area B on the first portion 152 (below the rotation axis RA of the drum 1).

[0047] Fig. 5 is a schematic front view of the water tub 2. Movements of the laundry L and the dry air in the drum 1 are described with reference to Figs. 1 and 5.

[0048] In Fig. 5, the drum 1 is represented with the dotted line. In the present embodiment, the drive motor 3 rotates the drum 1 clockwise. Fig. 5 shows an arbitrary point P1 on the peripheral wall 151 of the drum 1, a point P2 on the inner wall of the water tub 2 below the rotation axis RA, a point P3 on the inner wall of the water tub 2 above the rotation axis RA, and a point P4 on the inner wall of the water tub 2 at the upper right portion with respect to the rotation axis RA. As described above, while the drive motor 3 rotates the drum 1 clockwise, the point P 1 sequentially faces the points P2 to P4. Meanwhile, the dry air is blown out from the nozzle 30.

[0049] As shown in Fig. 5, the drum 1 is rotated clockwise. Meanwhile, the laundry L vertically moves in the storage room R. Most of the laundry L falls to the lowest area B due to the action of gravity. The laundry L thereafter is bounced up by the rotation of the drum 1.

[0050] The dry air blown out from the second outlet 10 flows toward the lowest area B as described above. Meanwhile, the dry air comes in direct contact with the laundry L bounced up by the rotation of the drum 1 to dry the laundry L.

[0051] The dry air is blown upward after the collision with the first portion 152 of the drum 1 which forms the lowest area B. The dry air comes in contact with the laundry L dropping toward the lowest area B to dry the laundry L. Consequently, the laundry L may be efficiently dried. Since the moving direction of the laundry L and the flow direction of the dry air are opposite to each other, a relative velocity between the laundry L and the dry air goes up. Accordingly, the laundry L is preferably stretched to reduce the wrinkles of the laundry L.

[0052] In the present embodiment, the second outlet 10 formed by the guider 80 is directed toward the lowest area B. Alternatively, the second outlet 10 may be directed to the left side of the lowest area B (lower left of the rotation axis RA of the drum 1). The blowing direction of the rapid dry air at high-pressure from the nozzle 30 may be appropriately

adjusted according to characteristics such as rotation speed and shape of the drum 1. Consequently, the rapid dry air at high-pressure is blown out in the opposite direction to the laundry L vertically moving in the drum 1.

[0053] In the present embodiment, the drum 1 is rotated clockwise. Alternatively, the drum may be rotated counterclockwise. If the drum is rotated counterclockwise, it may be preferable to mount the nozzle on an upper left portion of the front wall portion of the water tub to obtain the aforementioned advantageous effects under the counterclockwise rotation of the drum.

[0054] In general, a washing and drying machine is designed so that a space between a front wall portion of a water tub and the front wall of a housing becomes as narrow as possible in order to prevent laundry from entering the space between the front wall portion of the water tub and the front wall of the housing while the laundry is moved by the rotation of the drum.

[0055] In the present embodiment, the nozzle 30 connected with the second outlet 10, which has the small bore, is placed in the space between the front wall portion 259 of the water tub 2 and the front wall 111 of the housing 100, instead of a nozzle with a large bore outlet to cause little pressure loss. Consequently, the rapid dry air at high-pressure is appropriately blown to the lowest area B, so that the relative velocity between the laundry L and the dry air may appropriately works to reduce the wrinkles of the laundry.

[0056] As shown in Fig. 1, there is a space large enough to dispose the first duct 9 including the first outlet 8 with the large bore, between the bottom wall 254 of the water tub 2 and the rear wall 112 of the housing 100. Openings 157 which allow the dry air to flow from the first outlet 8 into the drum 1 are formed on the bottom wall 154 of the drum 1. The drum 1 comprises a cover 26 mounted on the inner surface of the bottom wall 154. The cover 26 covers the opening 157 and the rotating shaft 350 of the drive motor 3. It should be noted that the cover 26 is formed with a lot of apertures to allow the dry air, which is passed through the opening 157 of the bottom wall 154, to flow into the storage room R. The cover 26 has an aperture ratio high enough to facilitate to dry the laundry L.

[0057] As described above, the rotation axis RA of the drum 1 is inclined so that the rotation center of the front wall portion 159 of the drum 1 is higher than the rotation center of the bottom wall 154 of the drum 1. Short laundry L such as socks, handkerchiefs, and briefs is likely to converge around the lowest area B while long laundry L such as long-sleeved underwear, long pants, long-sleeved dress shirts, and long-sleeved pajamas is likely to converge near the front wall portion 159 of the drum 1 rather than the lowest area B. If both the short laundry L and the long laundry L are stored in the drum 1, a large flow volume of the dry air blown out from the first outlet 8 formed on the bottom wall 254 of the water tub 2 comes in contact first with the short laundry L, which converges around the bottom wall 154 of the drum 1. The dry air thereafter passes through the short laundry L and comes in contact with the long laundry L, which converges near the front wall portion 159 of the drum 1. Consequently, both the short laundry L and the long laundry L are efficiently dried. It should be noted that the short laundry L is less likely to wrinkle than the long laundry L in the drying process.

[0058] For example, the long laundry L has portions which are easily twisted such as the sleeve.

[0059] Accordingly, the long laundry L becomes easily wrinkled. As described above, the long laundry L is likely to converge near the front wall portion 159 of the drum 1. In the present embodiment, the dry air is also blown out from the second outlet 10 formed by the guider 80 mounted near the front wall portion 159 of the drum 1. The dry air blown out from the second outlet 10 more efficiently dries the long laundry L than the dry air blown out from the first outlet 8. As described above, the dry air, which is blown out from the second outlet 10, has higher velocity and higher pressure than the dry air blown out from the first outlet 8. Accordingly, the long laundry L that directly collides (comes in contact) with the dry air blown out from the second outlet 10 is facilitated to spread. Since the dry air blown out from the second outlet 10 moves the long laundry L a lot, the wrinkles of the long laundry L may be effectively reduced.

[0060] As described above, the circulatory duct 13 branches into the first and second ducts 9, 11 at the downstream of the blower 4. The switcher 12 at the bifurcation of the first and second ducts 9 selectively switches the supply route of the dry air between the first and second ducts 9, 11. The switcher 12 includes a pivotal switching valve 120, which is attached to the bifurcation of the first and second ducts 9, 11, and a driver (not shown), which drives the switching valve 120. Fig. 1 shows the switching valve 120 existing at the first position and the switching valve 120 existing at the second position. The switching valve 120 at the first position closes the second duct 11 whereas the switching valve 120 opens the first duct 9. The switching valve 120 at the second position closes the first duct 9 whereas the switching valve 120 opens the second duct 11. If the switching valve 120 exists at the first position, the dry air passes through the first duct 9 to flow into the drum 1. If the switching valve 120 exists at the second position, the dry air passes through the second duct 11 to flow into the drum 1.

[0061] The blower 4 and the switching valve 120 are situated in the circulatory duct 13. The dry air from the exhaust port 5 of the water tub 2 sequentially passes through the dehumidifier 6 and the heater 7. The dry air is then blown out toward the switching valve 120 by the blower 4. The dry air is guided to the first or second duct 9, 11 in response to the position (first or second position) of the switching valve 120. The dry air then passes through the first or second duct 9, 11, to flow into the drum 1 once again. As described above, the laundry in the drum 1 are dried by the dry air circulating in the housing 100.

[0062] The blower 4 is situated between the heater 7 and the switcher 12. The blower 4 blows the dry air, which is

heated by the heater 7, toward the switcher 12. The blower 4 comprises a fan 4a and a fan motor 4b which rotates the fan 4a. The fan motor 4b rotates the fan 4a so that a flow volume of the dry air flowing along the first duct 9 while the switching valve 120 exists at the first position becomes greater than a flow volume of the dry air flowing along the second duct 11 while the switching valve 120 exists at the second position. The fan motor 4b rotates the fan 4a so that a velocity of the dry air blown out from the second outlet 10 of the second duct 11 while the switching valve 120 exists at the second position becomes greater than a velocity of the dry air blown out from the first outlet 8 of the first duct 9 while the switching valve 120 exists at the first position. For example, if the velocity of the dry air blown out from the first outlet 8 is approximately 10 m/s, the fan motor 4b is controlled so that the velocity of the dry air blown out from the second outlet 10 becomes about 50 m/s. It should be noted that the velocity of the dry air blown out from the first and second outlets 8, 10 may be different values as long as the velocity of the dry air blown out from the second outlet 10 is set to be higher than the velocity of the dry air blown out from the first outlet 8.

[0063] The switching valve 120 is rotated in the drying process to dry the laundry L. The circulation path of the dry air is switched between the first and second ducts 9, 11 in response to the rotation of the switching valve 120. The rotational speed of the fan motor 4b is adjusted in coordination with the rotation of the switching valve 120. Consequently, the flow volume of the dry air flowing along the first duct 9 becomes greater than the flow volume of the dry air flowing along the second duct 11 while the switching valve 120 exists at the second position. The velocity of the dry air blown out from the second outlet 10 of the second duct 11 becomes greater than the velocity of the dry air blown out from the first outlet 8 while the switching valve 120 exists at the first position.

[0064] The exhaust port 5 of the peripheral wall 251 of the water tub 2 is farther from the first outlet 8 than the second outlet 10. In other words, the exhaust port 5 is closer to the second outlet 10 than the first outlet 8. Since the exhaust port 5 is closer to the front wall portion 159 of the drum 1 than the bottom wall 254 of the water tub 2 on which the first outlet 8 is formed, a travelling distance of the dry air in the drum 1 lengthens. Therefore, it is facilitated to dry the laundry L in the drum 1. It should be noted that the exhaust port 5 closer to the front wall portion 159 of the drum 1 results in a longer distance between the first outlet 8 and the exhaust port 5.

[0065] The exhaust port 5 is formed above the drum 1 to efficiently discharge the dry air upward, which comes in contact with the laundry L. It should be noted that if the principles of the present embodiment is applied to a laundry dryer without washing functions, the exhaust port may be formed at a given position if the dry air coming in contact with the laundry is discharged. The washing and drying machine 500 of the present embodiment stores the wash water in the water tub 2. Therefore, the exhaust port 5 is formed above the water level of the wash water in the water tub 2 to cause little wash water to flow into the circulatory duct 13.

[0066] The washing and drying machine 500 comprises a damper 14 situated below the water tub 2. The damper 14 which supports the water tub 2 damps vibration of the water tub 2. For example, if the laundry L converges to a given portion in the drum 1 in spin-drying processes, the drum 1 and the water tub 2 become unbalanced. Meanwhile, the rotation of the drum 1 often causes the vibrations of the drum 1 and the water tub 2. The damper 14 preferably damps the vibration, which is transmitted from the drum 1 and the water tub 2 to the housing 100.

[0067] The damper 14 includes a cylindrical outer shell 141, and a shaft 142 protruding from the outer shell 141. The shaft 142 vertically moves in response to weight of the laundry L in the drum 1. The damper 14 further includes a detector 15 configured to detect a displacement amount of the shaft 142 (i.e. an amount of the laundry in the drum 1).

[0068] The washing and drying machine 500 of the present embodiment comprises a heat pump device 50 configured to dehumidify and heat the dry air by means of refrigerant. The heat pump device 50 comprises a compressor 16 configured to compress the refrigerant. The refrigerant compressed by the compressor 16 becomes high-temperature and high-pressure. The heat pump device 50 further comprises a radiator 17 configured to emit the heat of the high-temperature refrigerant. The radiator 17 corresponds to the aforementioned heater 7.

[0069] The heat pump device 50 includes a choke 18, which reduces the pressure of the refrigerant pressurized by the compressor 16. The refrigerant depressurized by the choke 18 becomes a low temperature. The heat pump device 50 further comprises a heat sink 19 which uses the low-temperature refrigerant to remove the heat from the dry air. The heat sink 19 corresponds to the aforementioned dehumidifier 6. The heat pump device 50 further comprises a pipeline 20, which guides the refrigerant to the compressor 16, the radiator 17, the choke 18 and the heat sink 19 in sequence. The refrigerant dehumidifies and heats the dry air while the refrigerant passes through the compressor 16, the radiator 17, the choke 18 and the heat sink 19.

[0070] In the present embodiment, the aforementioned washing and drying machine 500 dries the laundry L by means of the heat pump device 50. Alternatively, the dry air may be dehumidified and heated by means of other methods. For example, a water cooler which sprays water directly to the dry air may be used as the dehumidifier 6. An electric heater may be used as the heater 7.

[0071] Fig. 6 is a schematic block diagram of the washing and drying machine 500. The washing and drying machine 500 is further described with reference to Figs. 1 and 6.

[0072] As shown in Fig. 6, the washing and drying machine 500 comprises a setting interface 32. A user may input setting information via the setting interface 32 to set up desired operations of the washing and drying machine 500. The

washing and drying machine 500 further comprises a controller 70. The controller 70 receives not only the setting information from the setting interface 32 but also information about operations of the washing and drying machine 500 from various sensors (for instance, a liquid level sensor) mounted to the washing and drying machine 500. The controller 70 controls a series of operations of the washing and drying machine 500 such as washing, rinsing, spin-drying and drying on the basis of the setting information from the user and the operation information from the various sensors. The washing and drying machine 500 comprises a detector 15 configured to send signals to the controller 70 so that the controller 70 uses the signals for the control. The detector 15 and the control in response to the signals are described hereinafter.

[0073] The washing and drying machine 500 further comprises a motor drive circuit 22 configured to drive the drive motor 3. For example, the controller 70 controls the rotation of the drive motor 3 via the motor drive circuit 22 in the drying process. The controller 70 further controls operations of the heat pump device 50 and the blower 4 to adjust the flow volume, humidity and temperature of the dry air. The controller 70 controls the switching operation of the switcher 12 to flow the dry air into the drum 1 through the first or second duct 9, 11.

[0074] The controller 70 may include, for example, a CPU (Central Processing Unit: not shown), a ROM (Read Only Memory) which stores programs used for the aforementioned control, a RAM (Random Access Memory) which stores data generated during execution of various processes for the aforementioned control, an interface which is used for input and output of control data, and a bus for connecting these elements. The controller 70 further comprises a timer 71. The timer 71 measures first and second periods as described later. The timer 71 may be an internal timer built into the controller 70 to measure a time. Alternatively, the timer may be a timer device, which is provided separately from the controller.

[0075] In the present embodiment, the first duct 9 comprises a single first outlet 8. Alternatively, the first duct may comprise several first outlets.

[0076] In the present embodiment, the second duct 11 comprises a single second outlet 10. Alternatively, the second duct may comprise several second outlets.

<Operation of Washing and Drying Machine>

[0077] Operations of the aforementioned washing and drying machine 500 and resultant effects from the operations of the washing and drying machine 500 are described.

(Principles of Wrinkling)

[0078] The principles of wrinkling while the laundry is dried are described.

[0079] It is difficult to keep the laundry stretched in a narrow space of the drum. Consequently, the laundry is likely to wrinkle while the laundry is dried in the narrow space. In particular, laundry containing much cotton is likely to wrinkle, which results in worse finish of the drying process. Users are dissatisfied with a lot of the wrinkles on the laundry.

[0080] A lot of moisture intervening among the fibers facilitates to move the fibers. If agitation force caused by the rotation of the drum works to stretch the folded laundry, it becomes likely that the wrinkles of the folded laundry are removed.

[0081] Progress of the drying process means a decrease in moisture in the fibers. On the other hand, a bonding force between the fibers goes up, so that it becomes difficult for the fibers to move. If the agitation force caused by the rotation of the drum is applied to the laundry and folds the fibers, it becomes likely that the fibers are kept bent. Subsequently, if the drying process further advances to decrease the moisture in the fibers, the fibers maintain their bent state so that the fibers are not easily stretched out even if the force working to stretch the laundry is thereafter applied. Such conditions where the wrinkles are maintained are referred to as the "fixation of wrinkles" in the following descriptions.

[0082] As described above, the moisture is evaporated if the laundry is dried. The reduction in moisture, however, leads to the fixation of wrinkles. An increase in fixation of wrinkles means worse finish of the laundry after the drying process.

[0083] If laundry is stored in a narrow space of a drum, the fibers are usually bent. In order to reduce the fixation of wrinkles, it is necessary to reduce a number of wrinkles and avoid strong fixation of wrinkles (sharp bending of the fibers). It may be preferable to repeat a cycle that the bent fibers are stretched while other fibers are bent, because bending positions are frequently changed. Once the drying process is advanced so that the fibers keep their stretched state, the high bonding strength between the fibers under little moisture prevents new wrinkles even if a force is thereafter applied to bend the fibers.

[0084] It is figured out from the aforementioned descriptions that it depends on a dryness level (dryness factor) of the laundry how easy the fixation of wrinkles happens. If the dryness factor of the laundry made from cotton fibers, which is likely to wrinkle, is within a range between about 85% and 100%, the laundry is likely to wrinkle. In particular, if the dryness factor of the laundry made from the cotton fibers is within a range between about 90% and 100%, the laundry

is more likely to wrinkle. The following equation shows the dryness factor (%).

[Equation 1]

$$\text{Dryness Factor (\%)} = (\text{Mass of Standard Laundry} / \text{Mass of Laundry Containing Moisture}) \times 100$$

[0085] It should be noted that the term "mass of standard laundry" means the mass of laundry balanced under the following conditions; namely, temperature of 20°C and humidity of 65%.

[0086] Considering a single piece of cloth, it becomes less likely that the cloth is uniformly dried. Rather, dry spots usually occur in the cloth. For example, it takes a long time to dry an area below the armpit of a long-sleeve shirt. Accordingly, the target dryness factor at the completion of the drying process is not set to 100%, but is generally set to be over 100% (about 102% to 105%: excessive dryness).

[0087] In the following descriptions, the drying process is divided into the "early drying phase", the "middle drying phase" and the "late drying phase". The term "early drying phase" means a period soon after spin-drying until the dryness factor becomes about 90%. The term "middle drying phase" means a period while the dryness factor falls in a range between about 90% and 100%. The term "late drying phase" means a period while the dryness factor exists in a range over about 100%. It should be noted that the laundry is less likely to wrinkle in the "early drying phase" due to a lot of moisture in the fibers of the laundry. In the "middle drying phase", the laundry becomes likely to wrinkle due to the decreased moisture between the fibers. In the "late drying phase", the laundry is less likely to wrinkle due to the increased bonding force between the fibers.

[0088] In the present embodiment, the controller 70 causes the switcher 12 to select the first duct 9 if the dryness factor of the laundry is less than about 90% (c.f. Fig. 1). If the dryness factor of the laundry exceeds about 90%, the controller 70 causes the switcher 12 to select the second duct 11. In the present embodiment, the value of about 90% is exemplified as a predetermined value used as criteria in the switching operation of the switcher 12. Alternatively, the switching operation of the switcher 12 may be controlled on the basis of another value.

[0089] By the aforementioned control of the controller 70, in the middle drying phase, the dry air is blown out from the second outlet 10 of the second duct 11 toward the lowest area B (c.f. Fig. 1). Since the rapid dry air at high-pressure is blown out from the second outlet 10 in a direction to face the laundry bounced up from the lowest area B by the rotation of the drum 1, the laundry are significantly stretched to effectively reduce the wrinkles of the laundry.

[0090] In the middle drying phase (a period while the dryness factor is in a range between about 90% and 100%), as described above, the wrinkles are facilitated to fix. The laundry becomes lighter in the middle drying phase than in the early drying phase. Accordingly, the laundry in the middle drying phase is moved a lot by the rotation of the drum 1. In the middle drying phase (a period while the dryness factor is within a range between about 90% and 100%), since the rapid dry air at high-pressure is blown out from the second outlet 10 formed by the guider 80, the relative velocity between the laundry and the dry air goes up to cause a force strong enough to stretch the laundry and preferably reduce the wrinkles of the laundry.

[0091] According to the present embodiment, the controller 70 causes the switcher 12 to select the first duct 9 in at least one of the early and late drying phases. Meanwhile, a large flow volume of the dry air flows into the drum 1 from the first outlet 8 of the first duct 9. Because of little pressure loss of the dry air blown out from the first outlet 8, little power may be consumed to dry the laundry. Accordingly, the switching operation of the switcher 12 under the control of the controller 70 reduces wrinkles and power consumption.

[0092] The early, middle and late drying phases defined in the drying process may be estimated on the basis of an elapsed time from the start of the drying process. In the present embodiment, the controller 70 measures the elapsed time from the start of the drying process on the basis of the output signal from the timer 71. The controller 70 estimates the early, middle and late drying phases on the basis of the measured elapsed time. The controller 70 controls the switching operation of the switcher 12 in response to the resultant estimation about the early, middle and late drying phases.

[0093] In the present embodiment, the controller 70 determines a period from when the drying process starts to when the foregoing first period passes as the early drying phase. The foregoing second period is set to be longer than the first period. The controller 70 determines a period from the end of the first period to the lapse of the second period as the middle drying phase. The controller 70 determines a period from when the second period passes to when the drying process ends as the late drying phase.

[0094] A conventional washing and drying machine usually drives two fan motors in order to blow rapid dry air at high-pressure into the drum and increase a flow volume of the dry air.

[0095] Unlike the conventional washing and drying machine, the switcher 12 of the washing and drying machine 500 of the present embodiment switches the circulation path of the dry air between the first and second ducts 9, 11 under

the control of the controller 70. Thus, the wrinkles may be effectively reduced by means of the single blower 4. In comparison to the conventional washing and drying machine, the washing and drying machine 500 of the present embodiment consumes less power on the whole to reduce the wrinkles of the laundry. In other words, the washing and drying machine 500 according to the present embodiment may achieve a preferable dry finish with less power consumption.

[0096] As described above, the exhaust port 5 is formed near the second outlet 10, which is formed by the guider 80 mounted on the front wall portion 259 of the water tub 2. Since the exhaust port 5 is formed near the front wall portion 159 of the drum 1, a distance between the first outlet 8 and the exhaust port 5 is lengthened. Therefore, the dry air blown out from the first outlet 8 formed on the bottom wall 254 of the water tub 2 may easily spread throughout the storage room R in the drum 1 to come in contact with the laundry in the drum 1. Thus, the laundry may be efficiently dried with little power consumption.

[0097] The dry air blown out from the second outlet 10 has high-pressure and high-velocity. Accordingly, the dry air discharged from the second outlet 10 does not directly flow toward the exhaust port 5 formed near the second outlet 10, but reaches a vicinity (i.e. the lowest area D) of the bottom wall 154 of the drum 1. Accordingly, the dry air efficiently comes in contact with the laundry in the drum 1 to effectively reduce the wrinkles of the laundry with less power consumption.

(Operation of Washing and Drying Machine)

[0098] Fig. 7 is a schematic timing chart showing duct switching operation of the washing and drying machine 500. The operation of the washing and drying machine 500 is described with reference to Figs. 1, 6 and 7.

[0099] The controller 70 controls the switcher 12 to open the first duct 9, and then starts the drying operation. Consequently, the dry air is circulated through the first duct 9 with the large bore during a period from the start of the drying process until the first period passes (early drying phase). Because of little pressure loss of the dry air passing through the first duct 9, a large flow volume of the dry air is blown out from the first outlet 8 formed on the bottom wall 254 of the water tub 2, and then comes in contact with the laundry.

[0100] Once the drying process starts, the controller 70 activates the timer 71 to measure an elapsed time from the start time of the drying process. The controller 70 keeps the first duct 9 opened from the start time of the drying process until the first period passes. As aforementioned, due to little pressure loss of the dry air passing through the first duct 9, the controller 70 may slowly rotate the fan motor 4b to consume little power. Even if the blower 4 is driven under the decreased power consumption, the large flow volume of the dry air flows into the drum 1 to shorten the drying time of the early drying phase, which results in the reduced power consumption.

[0101] The controller 70 determines that the drying process steps into the middle drying phase if the first period passes from the start time of the drying process. Once the middle drying phase starts, the controller 70 causes the switcher 12 to select the second duct 11. The controller 70 keeps the second position of the switcher 12 until the end of the late drying phase. The controller 70 increases the rotation of the fan motor 4b.

[0102] An amount of moisture in the laundry immediately after the spin-drying process largely depends on a type or weave of laundry fibers. For example, if the laundry contains numerous chemical fibers, there is little moisture just after the spin-drying process. Thus, the initial dryness factor becomes high (ex. about 90 % of the dryness factor). The laundry with the high initial dryness factor is susceptible to the fixation of wrinkles in the early and middle drying phases. However, since the rapid dry air at high-pressure is blown out from the second outlet 10 of the second duct 11 in the middle drying phase, the laundry are preferably spread out to reduce the wrinkles.

[0103] In the middle and late drying phases, the dry air is blown out from the second outlet 10, which has the smaller bore than the first outlet 8. Due to the increased rotational speed of the fan motor 4b during these periods, the dry air from the second outlet 10 becomes high-velocity and high-pressure.

[0104] Once the first period passes from the start time of the drying process, the controller 70 controls the switcher 12 to open the second duct 11. Meanwhile, the controller 70 also controls the blower 4 to increase the rotational speed of the fan motor 4b. Subsequently, the controller 70 keeps the second duct 11 opened until the end of the drying process. Thus, the dry air appropriately stretches the laundry in the middle and late drying phases to reduce the wrinkles of the laundry.

[0105] A conventional washing and drying machine always drives two fan motors in order to blow rapid dry air at high-pressure into the drum and increase flow volume of the dry air.

[0106] Unlike the conventional washing and drying machine, the washing and drying machine 500 of the present embodiment directs the rapid dry air at high-pressure to face the moving direction of the laundry in the drum 1. Thus, the washing and drying machine 500 of the present embodiment may consume less power on the whole to decrease the wrinkles of the laundry. In short, the washing and drying machine 500 may achieve preferable dry finish with less power consumption.

[0107] Fig. 8 is a schematic timing chart showing other duct switching operation of the washing and drying machine

500. The other operation of the washing and drying machine 500 is described with reference to Figs. 1, 6 and 8.

[0108] In the early drying phase (period from the start time of the drying process until the first period passes) and the middle drying phase (period from the end of the first period until the second period passes) of the drying process, the dry air may be circulated through the second duct 11. The controller 70 controls the switcher 12 to open the second duct 11, and then starts the drying process. The controller 70 rotates the fan motor 4b at a high rotational speed. Consequently, the rapid dry air at high-pressure is blown out from the second outlet 10, which has the small bore, and comes in contact with the laundry in the early and middle drying phases.

[0109] Once the drying process starts, the controller 70 activates the timer 71 to measure an elapsed time from the start time of the drying process. The controller 70 keeps the second duct 11 opened from the start time of the drying process until the second period passes. In the early and middle drying phases, the rapid dry air at high-pressure is directed to face the moving direction of the laundry in the drum 1. Thus, the dry air may apply a force strong enough to stretch the laundry and effectively reduce the wrinkles of the laundry.

[0110] If the second period passes from the start time of the drying process, the drying process steps into the late drying phase. The controller 70 controls the switcher 12 to switch the circulation path of the dry air to the first duct 9.

[0111] In the late drying phase, the laundry contains little moisture. In the late drying phase, it becomes less frequently that the moisture in the laundry collides with the dry air. Therefore it takes a long time to evaporate the moisture in the laundry. In the present embodiment, a large flow volume of the dry air is supplied into the drum 1 in the late drying phase. Thus, it becomes more frequently that the moisture in the laundry collides with the dry air in the late drying phase.

[0112] As aforementioned, in the late drying phase, the circulation path of the dry air is switched to the first duct 9 with the large bore. Because of little pressure loss of the dry air passing through the first duct 9, in the late drying phase, a large flow volume of the dry air is supplied into the drum 1 from the first outlet 8 formed on the bottom wall 254 of the water tub 2 with low power consumption, and comes in contact with the laundry.

[0113] If the second period passes from the start time of the drying process, the controller 70 controls the switcher 12 to open the first duct 9. Meanwhile the controller 70 controls the blower 4 as well to reduce the rotational speed of the fan motor 4b. Subsequently, the controller 70 keeps the first duct 9 opened until the end of the drying process. Because of little pressure loss of the dry air passing through the first duct 9, a large flow volume of the dry air flows into the drum 1 even under the decreased rotational speed of the fan motor 4b (i.e. even under the decreased power consumption of the blower 4) to shorten the drying time in the late drying phase and reduce the power consumption during the drying cycle. In comparison to the conventional washing and drying machine (the washing and drying machine which always drives two fan motors to blow the rapid dry air at high-pressure into the drum and increase the flow volume of the dry air), the washing and drying machine 500 of the present embodiment may consume less power to reduce the wrinkles of the laundry (i.e. improve the finish of the drying process).

[0114] Fig. 9 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine 500. The other operation of the washing and drying machine 500 is described with reference to Figs. 1, 6 and 9.

[0115] The controller 70 controls the switcher 12 to open the first duct 9, and then starts the drying process. Consequently, in the early drying phase (period from the start time of the drying process until the first period passes) of the drying process, the first duct 9, which has the large bore, is used to circulate the dry air. A large flow volume of the dry air is blown out from the first outlet 8 formed on the bottom wall 254 of the water tub 2 due to the reduced pressure loss of the dry air.

[0116] Once the drying process starts, the controller 70 activates the timer 71 to measure an elapsed time from the start time of the drying process. The controller 70 continues to open the first duct 9 from the start time of the drying process until the first period passes. As described above, because of little pressure loss of the dry air passing through the first duct 9, the controller 70 may slowly rotate the fan motor 4b. Thus, the driven blower 4 may consume little power to blow a large flow volume of the dry air into the drum 1. Accordingly, the drying time of the early drying phase is shortened, which results in the decreased power consumption in the early drying phase.

[0117] If the first period passes from the start time of the drying process, the drying process steps into the middle drying phase. In the middle drying phase, the controller 70 moves the switcher 12 to the second position to switch the circulation path of the dry air to the second duct 11. The controller 70 increases the rotational speed of the fan motor 4b in the middle drying phase to blow the rapid dry air at high-pressure from the second outlet 10, which has the smaller bore than the first outlet 8.

[0118] If the first period passes from the start time of the drying process, the controller 70 controls the switcher 12 to open the second duct 11. The controller 70 also controls the blower 4 to increase the rotational speed of the fan motor 4b. The controller 70 keeps the second duct 11 opened from the end of the first period until the second period passes. Accordingly the rapid dry air at high-pressure is directed to face the moving direction of the laundry in the drum 1 during the middle drying phase to cause a force strong enough to stretch the laundry and effectively reduce the wrinkles of the laundry.

[0119] If the second period passes from the start time of the drying process, the drying process steps into the late drying phase. In the late drying phase, the controller 70 moves the switcher 12 to the first position to switch the circulation

path of the dry air to the first duct 9.

[0120] In the late drying phase, the laundry contains little moisture. In the late drying phase, it becomes less frequent that the moisture in the laundry collides with the dry air. Therefore it takes a long time to evaporate the moisture in the laundry. In the present embodiment, a large flow volume of the dry air is supplied into the drum 1 during the late drying phase to more frequently collide the moisture in the laundry with the dry air during the late drying phase.

[0121] As aforementioned, in the late drying phase, the circulation path of the dry air is switched to the first duct 9 with the large bore. Because of little pressure loss of the dry air passing through the first duct 9, in the late drying phase, a large flow volume of the dry air is supplied into the drum 1 from the first outlet 8 formed on the bottom wall 254 of the water tub 2 with low power consumption, and comes in contact with the laundry.

[0122] If the second period passes from the start time of the drying process, the controller 70 controls the switcher 12 to open the first duct 9. The controller 70 also controls the blower 4 to reduce the rotational speed of the fan motor 4b. The controller 70 keeps the first duct 9 opened until the end of the drying process. Because of little pressure loss of the dry air blown out from the first duct 9, a large flow volume of the dry air flows into the drum 1 even under the reduced rotational speed of the fan motor 4b (i.e. even under the reduced power consumption of the blower 4). Therefore, the drying time in the late drying phase is shortened to decrease the power consumption during the drying cycle. Thus, in comparison to the conventional washing and drying machine (the washing and drying machine which always drives two fan motors to blow the rapid air flow at high-pressure into the drum and increase the flow volume of the dry air), the washing and drying machine 500 according to the present embodiment consumes less power to reduce the wrinkles of the laundry (i.e. improve the finish of the drying process).

[0123] Figs. 10 and 11 are schematic timing charts showing other duct switching operations of the washing and drying machine 500. Fig. 10 shows the operation of the washing and drying machine 500 under a small amount of the laundry in the drum 1. Fig. 11 shows the operation of the washing and drying machine 500 under a large amount of the laundry in the drum 1. The other operations of the washing and drying machine 500 are described with reference to Figs. 1, 6, 10 and 11.

[0124] As described above, the controller 70 determines the early, middle and late drying phases of the drying process on the basis of the elapsed time (first and second periods) from the start time of the drying process. The controller 70 may change a time length of the overall drying process in response to an amount of the laundry in the drum 1. Alternatively, the controller 70 may change a length of the early, middle and late drying phases.

[0125] As described with reference to Fig. 1, the detector 15 detects an amount of the laundry in the drum 1. The controller 70 changes lengths of the first and second periods in response to the detection results of the detector 15. Since the first and second periods are used as the criteria of the early, middle and late drying phases, these drying phases are appropriately set in response to the amount of the laundry in the drum 1.

[0126] The detector 15 detects a position of the shaft 142 of the damper 14 while the water tub 2 is empty (under absences of water and laundry from the water tub 2 and the drum 1, respectively), and the position of the shaft 142 of the damper 14 while the laundry are loaded in the drum 1 before water supply into the water tub 2. The detector 15 detects the amount (mass) of the laundry loaded in the drum 1 in response to a difference between the detected positions of the shaft 142 of the damper 14.

[0127] The controller 70 sets the first and second periods on the basis of the detection results of the detector 15. As shown in Fig. 10, if there are little laundry in the drum 1, the controller 70 sets a length of the first period to "A1", and a length of the second period to "A2". As shown in Fig. 11, if there is a lot of the laundry in the drum 1, the controller 70 sets the length of the first period to "B1", and the length of the second period to "B2".

[0128] With the large amount of the laundry in the drum 1, the timing at which the dryness factor falls in a range between 90% and 100% is delayed. Accordingly, the lengths of the first and second periods set by the controller 70 preferably satisfy the following inequalities.

$$A1 < B1$$

[Equation 3]

$$A2 < B2$$

[0129] The controller 70 may extend the first and second periods in response to an increase in amount of the laundry.

[0130] Under the optimization of the early, middle and late drying phases in response to the amount of the laundry in the drum 1, the circulation path of the dry air is switched between the first and second ducts 9, 11 during the drying

process. Thus, in comparison to the conventional washing and drying machine (the washing and drying machine which always drives two fan motors to blow the rapid dry air at high-pressure into the drum and increase the flow volume of the dry air), the washing and drying machine 500 according to the present embodiment may consume less power to reduce the wrinkles of the laundry (i.e. improve the finish of the drying process).

[0131] The adjustment of the first and second periods on the basis of the detection results in response to the amount of the laundry in the drum 1 may be applied to the operations of the washing and drying machine 500 described with reference to Figs. 7 to 9.

[0132] In the present embodiment, the detector 15 detects the vertical displacement amount of the shaft 142 of the damper 14. Alternatively, an amount of the laundry in the drum 1 may be detected on the basis of a change in load to the drive motor 3, which may be obtained from operation parameters such as rotation speed, drive current and torque of the drive motor 3 during the rotation of the drum 1.

[0133] In the present embodiment, the controller 70 automatically adjusts the lengths of the first and second periods on the basis of the detection results from the detector 15. Alternatively, the lengths of the first and second periods may be adjusted without the detector 15. For example, if a user uses the setting interface 32 to input an amount of the laundry, the controller 70 may adjust the lengths of the first and second periods in response to the user's input.

[0134] The principles according to the present embodiment are described with reference to the washing and drying machine 500, which has washing and drying functions. The principles according to the present embodiment may also be applied to a laundry dryer without the washing functions. A machine without the washing functions of the washing and drying machine 500 shown in Fig. 1 is preferably exemplified as a laundry dryer. Such a machine, in which the watering pipe and the drainage pipe 40 connected to the water tub 2 shown in Fig. 1 are removed, may be suitably used as the laundry dryer. An element corresponding to the water tub functions as an outer tub for protecting the drum. The other elements described in the context of the washing and drying machine 500 may be likewise used in the laundry dryer without the washing functions.

[0135] The principles according to the present embodiment are described with reference to the drum-type washing and drying machine. Alternatively, the principles according to the present embodiment may also be applied to non-drum-type washing and drying machines.

[0136] The aforementioned embodiment mainly includes the laundry dryer and washing and drying machine having the following configurations. The laundry dryer and washing and drying machine with the following configurations may dry the laundry with little damage to the laundry.

[0137] The laundry dryer according to one aspect of the aforementioned embodiment includes a rotary drum configured to agitate laundry; an air supplier configured to supply dry air to the rotary drum; a nozzle configured to blow out the dry air, which is sent by the air supplier, in a first direction from an outside of the rotary drum; and a guider which comes in contact with the dry air blown out in the first direction and changes a flow direction of the dry air to a second direction toward an interior of the rotary drum.

[0138] According to the aforementioned configuration, the air supplier supplies the dry air to the rotary drum which agitates the laundry. The air supplier blows the dry air from the nozzle so that the dry air flows in the first direction from the outside of the drum. The guider comes in contact with the dry air blown out in the first direction so that the dry air flows to the second direction toward the interior of the rotary drum. Since the guider changes the flow direction of the dry air, the dry air blown from the outside of the rotary drum is appropriately guided into the drum. Accordingly, it becomes less likely that contact between the laundry and the nozzle damages the laundry.

[0139] In the aforementioned configuration, preferably, the laundry dryer further comprises a housing configured to store the rotary drum, wherein the guider changes the flow direction at between the housing and the rotary drum.

[0140] According to the aforementioned configuration, the guider changes the flow direction of the dry air at between the rotary drum and the housing configured to store the rotary drum. The dry air therefore comes in contact with the guider situated in the housing and turns to the second direction. Therefore, it becomes likely that little thermal energy of the dry air is released outside the housing. The effective use of the dry air heat results in an effective drying process.

[0141] In the aforementioned configuration, preferably, the rotary drum includes a peripheral wall defining a storage room where the laundry is agitated, the peripheral wall includes a first portion which defines a lower portion of the storage room, and a second portion which defines an upper portion of the storage room, and the dry air directed toward the second direction by the guider travels toward the first portion.

[0142] According to the aforementioned configuration, the peripheral wall defining the storage room where the laundry are agitated includes a first portion, which defines a lower portion of the storage room, and a second portion, which defines an upper portion of the storage room. The dry air directed toward the second direction by the guider travels toward the first portion. The dry air collided with the first portion is thereafter blown upward. The laundry agitated in the rotary drum falls to the first portion by the action of gravity. Thus, the flow direction of the dry air collided with the first portion becomes opposite to the moving direction of the laundry falling to the first portion. Consequently, a relative velocity between the dry air and the laundry goes up, so that the laundry may be preferably spread. Consequently, the laundry is less likely to wrinkle.

[0143] In the aforementioned configuration, preferably, the peripheral wall includes a periphery defining a feed opening through which the laundry is fed, the rotary drum includes a bottom opposite to the feed opening, the air supplier includes: a first duct provided with a first outlet which is used to blow the dry air from the bottom; a second duct provided with a second outlet formed on the feed opening; a switcher configured to selectively guide the dry air to the first or second duct; and a blower configured to blow the dry air, a flow volume of the dry air blown out from the first outlet while the switcher guides the dry air to the first duct is greater than a flow volume of the dry air blown out from the second outlet while the switcher guides the dry air to the second duct, and pressure and velocity of the dry air blown out from the second outlet while the switcher guides the dry air to the second duct are greater than pressure and velocity of the dry air blown out from the first outlet while the switcher guides the dry air to the first duct.

[0144] According to the aforementioned configuration, the peripheral wall includes a periphery defining a feed opening through which the laundry is fed. The rotary drum includes a bottom opposite to the feed opening. The air supplier includes a first duct provided with a first outlet which is used to blow the dry air from the bottom, a second duct provided with a second outlet formed on the feed opening, a switcher which selectively guides the dry air to the first or second duct, and a blower which blows the dry air. The flow volume of the dry air blown out from the first outlet while the switcher guides the dry air to the first duct is greater than the flow volume of the dry air blown out from the second outlet while the switcher guides the dry air to the second duct. The pressure and velocity of the dry air blown out from the second outlet while the switcher guides the dry air to the second duct are greater than the pressure and velocity of the dry air blown out from the first outlet while the switcher guides the dry air to the first duct. Accordingly, characteristics of the dry air are adjusted according to progress of the laundry drying process.

[0145] In the aforementioned configuration, preferably, the laundry dryer further comprises a door configured to at least partially cover in the feed opening, wherein the guider is situated between the nozzle and the door.

[0146] According to the aforementioned configuration, the door at least partially covers in the feed opening to appropriately store the laundry in the rotary drum. The guider situated between the nozzle and the door guides the dry air into the rotary drum without colliding with the door to reduce radiation outside the housing via the door. Consequently, the laundry may be efficiently dried.

[0147] In the aforementioned configuration, preferably, the first outlet has a larger bore than the second outlet.

[0148] According to the aforementioned configuration, the first outlet which has the larger bore than the second outlet causes little pressure loss of the dry air blown out from the first outlet. Accordingly, it is facilitated to blow out a large flow volume of the dry air from the first outlet. Consequently, the laundry is efficiently dried while the dry air is blown out from the first outlet.

[0149] In the aforementioned configuration, preferably, the guider forms the second outlet.

[0150] According to the aforementioned configuration, since the pressure and velocity of the dry air blown out from the second outlet formed by the guider are greater than the pressure and velocity of the dry air blown out from the first outlet, a force great enough to eliminate the wrinkles may be applied to the laundry.

[0151] In the aforementioned configuration, preferably, the laundry dryer further comprises a controller configured to control switching operation of the switcher, wherein the controller causes the switcher to select the first duct if a dryness factor of the laundry is less than a predetermined value, and causes the switcher to select the second duct unless the dryness factor of the laundry is less than the predetermined value.

[0152] According to the aforementioned configuration, the controller of the laundry dryer causes the switcher to select the first duct if the dryness factor of the laundry is less than the predetermined value, and causes the switcher to select the second duct unless the dryness factor of the laundry is less than the predetermined value. Since the large flow volume of the dry air is blown out from the first outlet while the dryness factor of the laundry is less than the predetermined value, the laundry may be efficiently dried. If the dryness factor of the laundry becomes no less than a predetermined value, the laundry becomes lighter due to a decrease in moisture in the laundry. Accordingly, the laundry may be facilitated to move in the drum. Since the controller causes the switcher to select the second duct unless the dryness factor of the laundry is less than the predetermined value, the relative velocity between the laundry and the dry air goes up. Accordingly, a force great enough to reduce the wrinkles may be applied to the laundry.

[0153] In the aforementioned configuration, preferably, if the dryness factor is within a range between 90% and 100%, the controller causes the switcher to select the second duct so that the dry air is blown out from the nozzle.

[0154] According to the aforementioned configuration, since the controller causes the switcher to select the second duct so that the dry air is blown out from the nozzle if the dryness factor is within a range between 90% and 100%, the laundry is less likely to fixedly wrinkle.

[0155] In the aforementioned configuration, preferably, the guider is formed along the periphery.

[0156] According to the aforementioned configuration, since the guider is formed along the periphery, it is less likely that contact between the laundry and the guider damages the laundry.

[0157] The washing and drying machine according to another aspect of the aforementioned embodiment comprises the aforementioned laundry dryer, and a water tub which encloses the rotary drum and stores wash water.

[0158] In the aforementioned configuration, since the washing and drying machine comprises the aforementioned

laundry dryer, and the water tub which encloses the rotary drum and stores wash water, the wrinkles of the laundry may be effectively eliminated.

Industrial Applicability

[0159] The principles according to the embodiment may be applied to various devices used for drying laundry.

Claims

1. A laundry dryer, comprising:

a rotary drum (1) configured to agitate laundry;
 an air supplier (400) configured to supply dry air to the rotary drum (1);
 a nozzle (30) configured to blow out the dry air, which is sent by the air supplier (400), in a first direction from an outside of the rotary drum (1); and
 a guider (80) which comes in contact with the dry air blown out in the first direction and changes a flow direction of the dry air to a second direction toward an interior of the rotary drum (1).

2. The laundry dryer according to claim 1, further comprising:

a housing (100) configured to store the rotary drum (1), wherein
 the guider (80) changes the flow direction at between the housing (100) and the rotary drum (1).

3. The laundry dryer according to claim 1 or 2, wherein the rotary drum (1) includes a peripheral wall (151) defining a storage room (R) where the laundry is agitated,
 the peripheral wall (151) includes a first portion (152) which defines a lower portion of the storage room (R), and a second portion (153) which defines an upper portion of the storage room (R), and
 the dry air directed toward the second direction by the guider (80) travels toward the first portion (152).

4. The laundry dryer according to claim 2, wherein
 the peripheral wall (151) includes a periphery (155) defining a feed opening (50) through which the laundry is fed,
 the rotary drum (1) includes a bottom (154) opposite to the feed opening (150),
 the air supplier (400) includes:

a first duct (9) provided with a first outlet (8) which is used to blow the dry air from the bottom (154);
 a second duct (11) provided with a second outlet (10) formed on the feed opening (150);
 a switcher (12) configured to selectively guide the dry air to the first or second duct (9, 11); and
 a blower (4) configured to blow the dry air,
 a flow volume of the dry air blown out from the first outlet (8) while the switcher (12) guides the dry air to the first duct (9) is greater than a flow volume of the dry air blown out from the second outlet (10) while the switcher (12) guides the dry air to the second duct (11), and
 pressure and velocity of the dry air blown out from the second outlet (10) while the switcher (12) guides the dry air to the second duct (11) are greater than pressure and velocity of the dry air blown out from the first outlet (8) while the switcher (12) guides the dry air to the first duct (9).

5. The laundry dryer according to claim 4, further comprising:

a door (35) configured to at least partially cover in the feed opening (150), wherein
 the guider (80) is situated between the nozzle (30) and the door (35).

6. The laundry dryer according to claim 4 or 5, wherein
 the first outlet (8) has a larger bore than the second outlet (10).

7. The laundry dryer according to any one of claims 4 to 6, wherein
 the guider (80) defines the second outlet (10).

8. The laundry dryer according to any one of claims 4 to 7, further comprising:

a controller (70) configured to control switching operation of the switcher (12), wherein the controller (70) causes the switcher (12) to select the first duct (9) if a dryness factor of the laundry is less than a predetermined value, and causes the switcher (12) to select the second duct (11) unless the dryness factor of the laundry is less than the predetermined value.

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9. The laundry dryer according to claim 8, wherein
if the dryness factor is within a range between 90% and 100%, the controller (70) causes the switcher (12) to select the second duct (11) so that the dry air is blown out from the nozzle (30).
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10. The laundry dryer according to claim 5, wherein
the guider (80) is formed along the periphery (155).
11. A washing and drying machine, comprising:
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- the laundry dryer according to claim 1; and
a water tub (2) which encloses the rotary drum (1) and stores wash water.

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FIG. 1

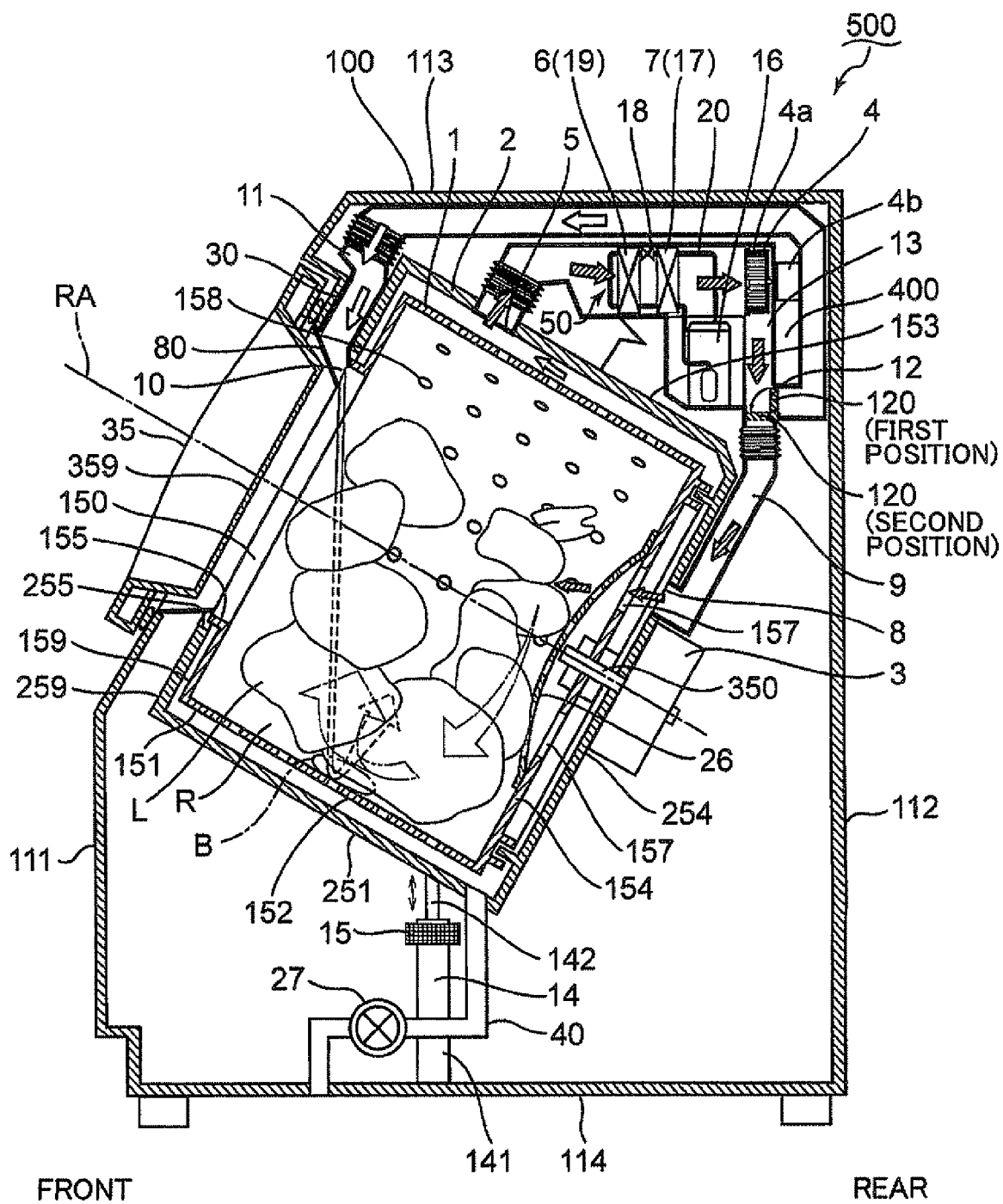


FIG. 2

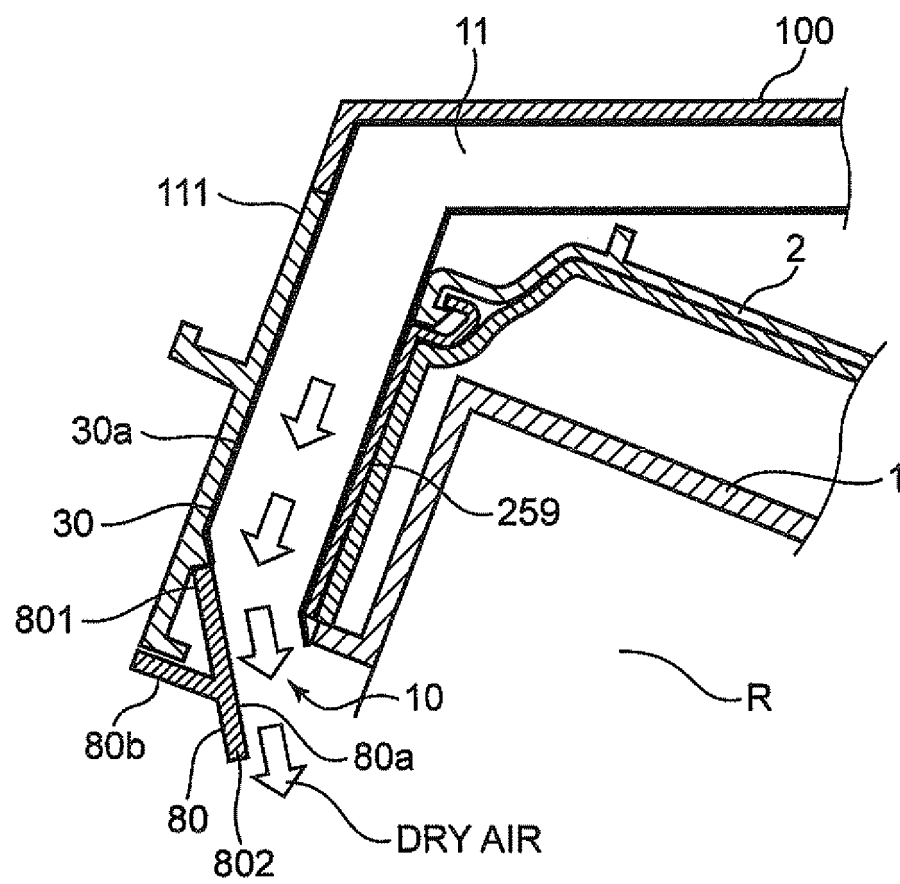


FIG.3

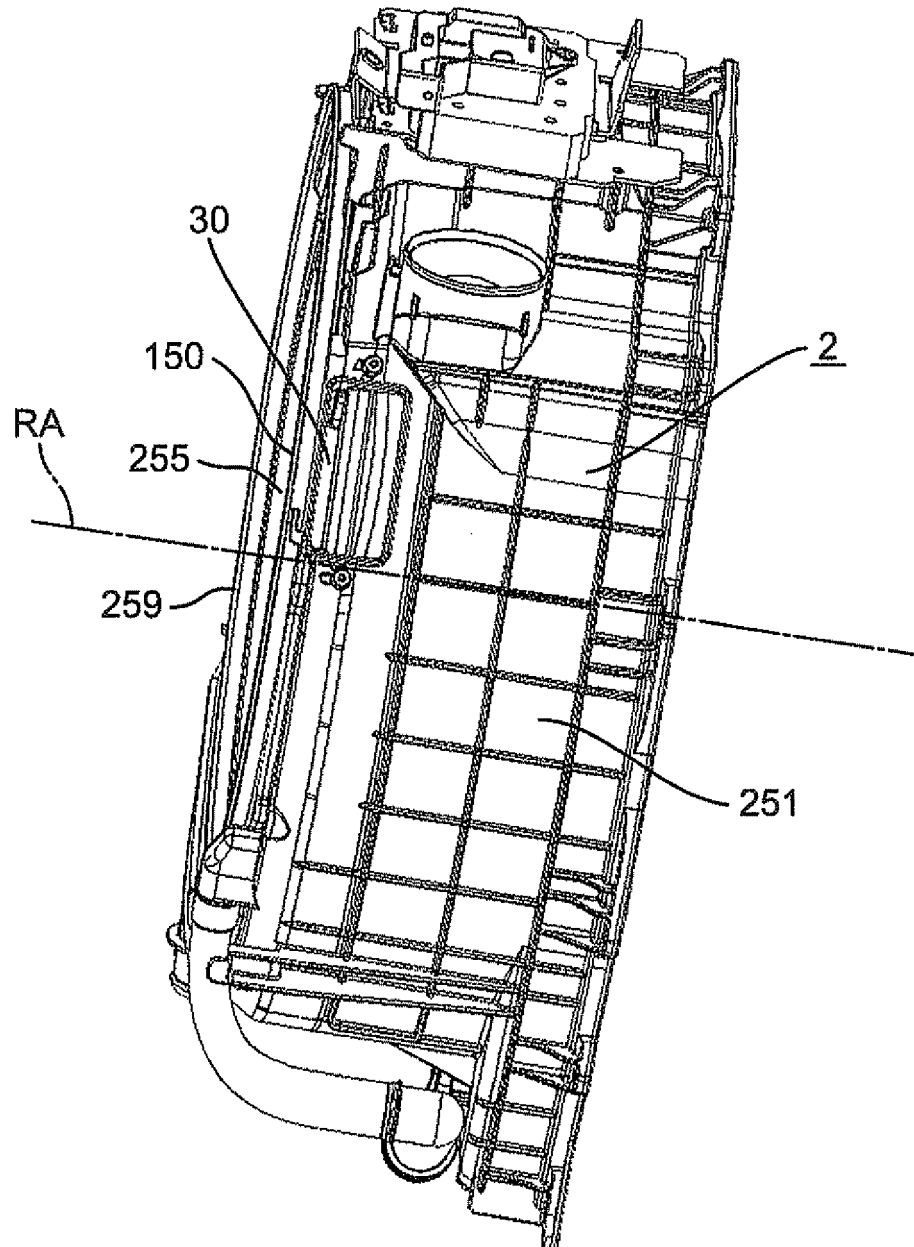


FIG.4

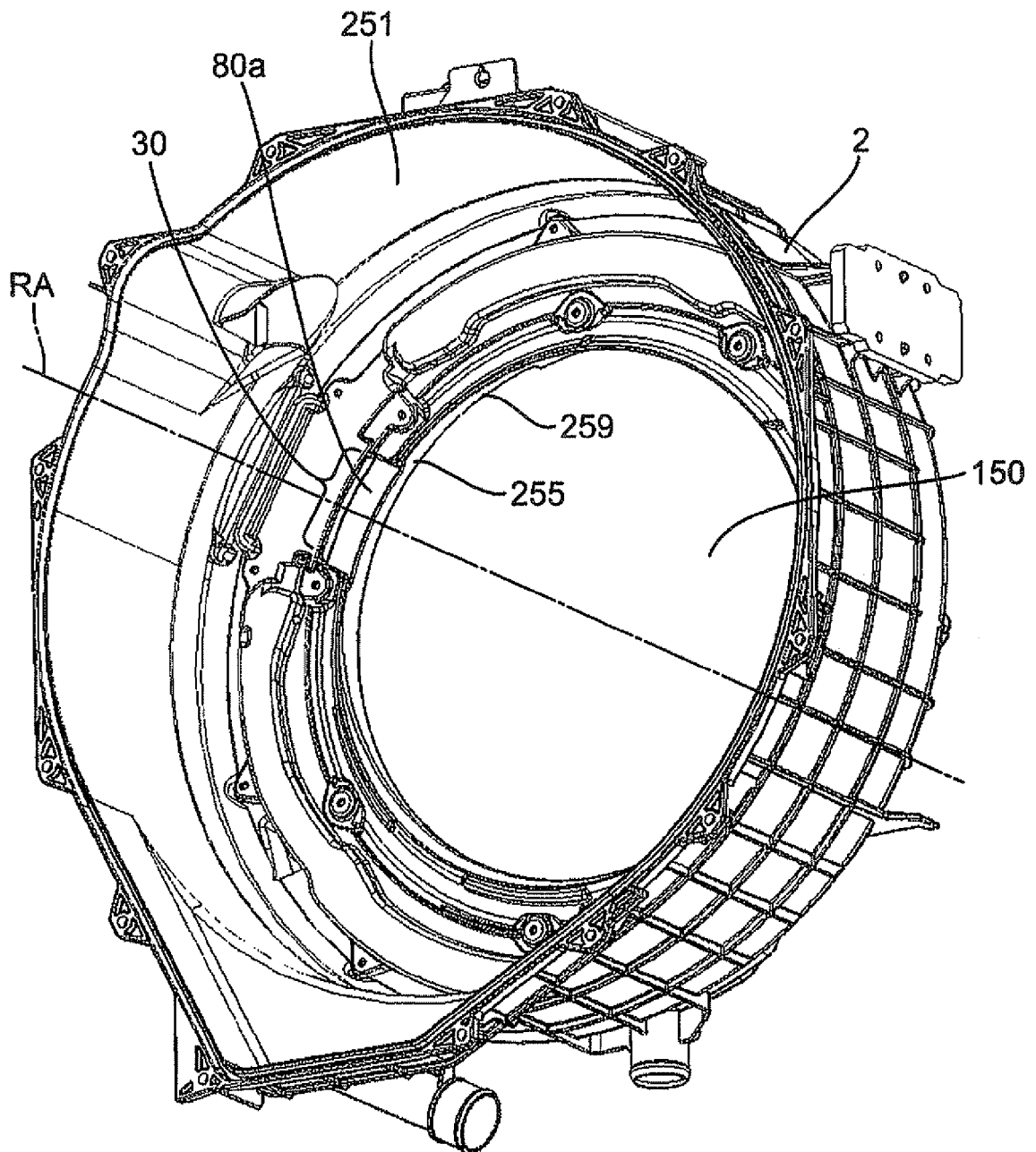


FIG.5

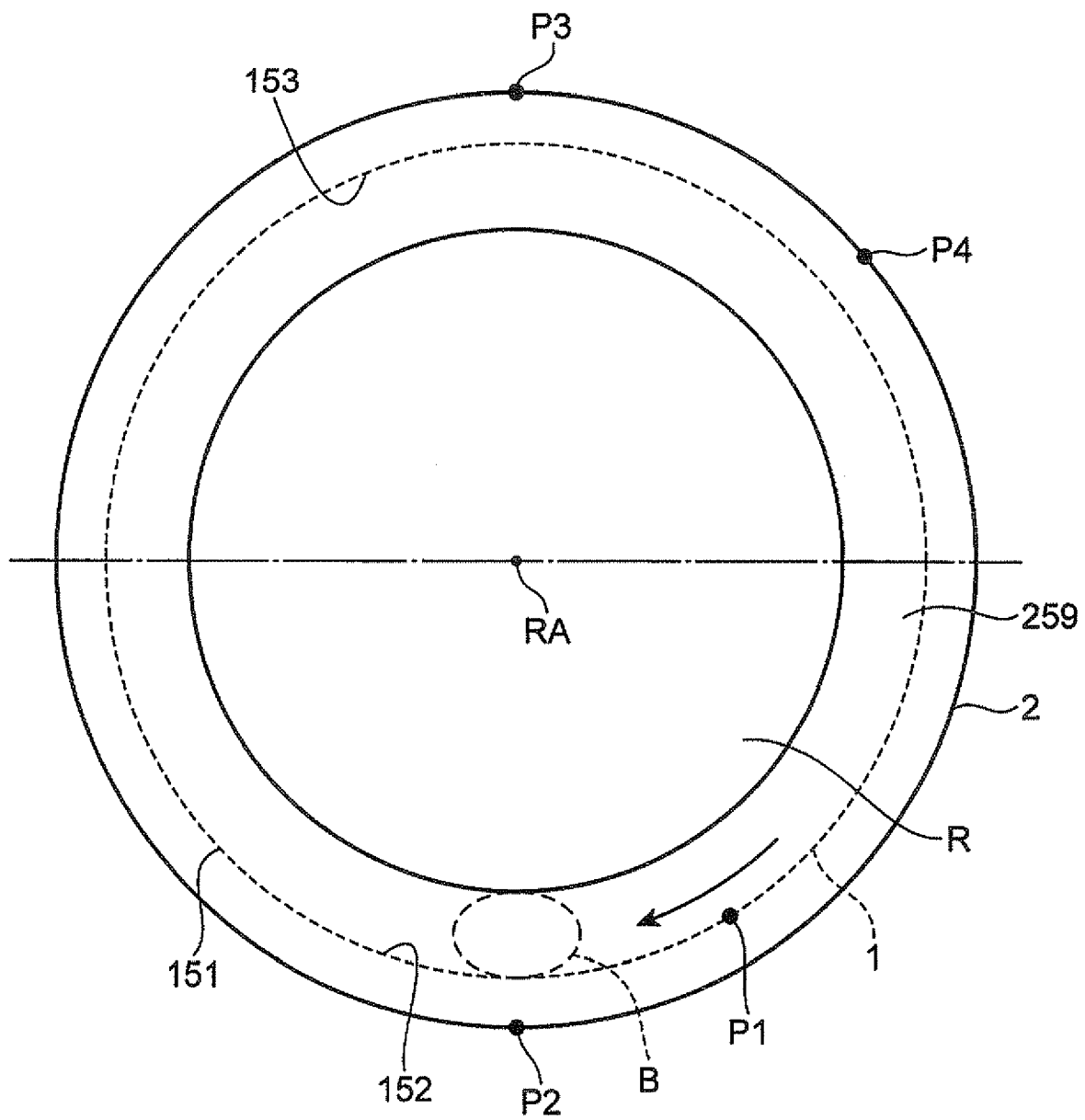


FIG.6

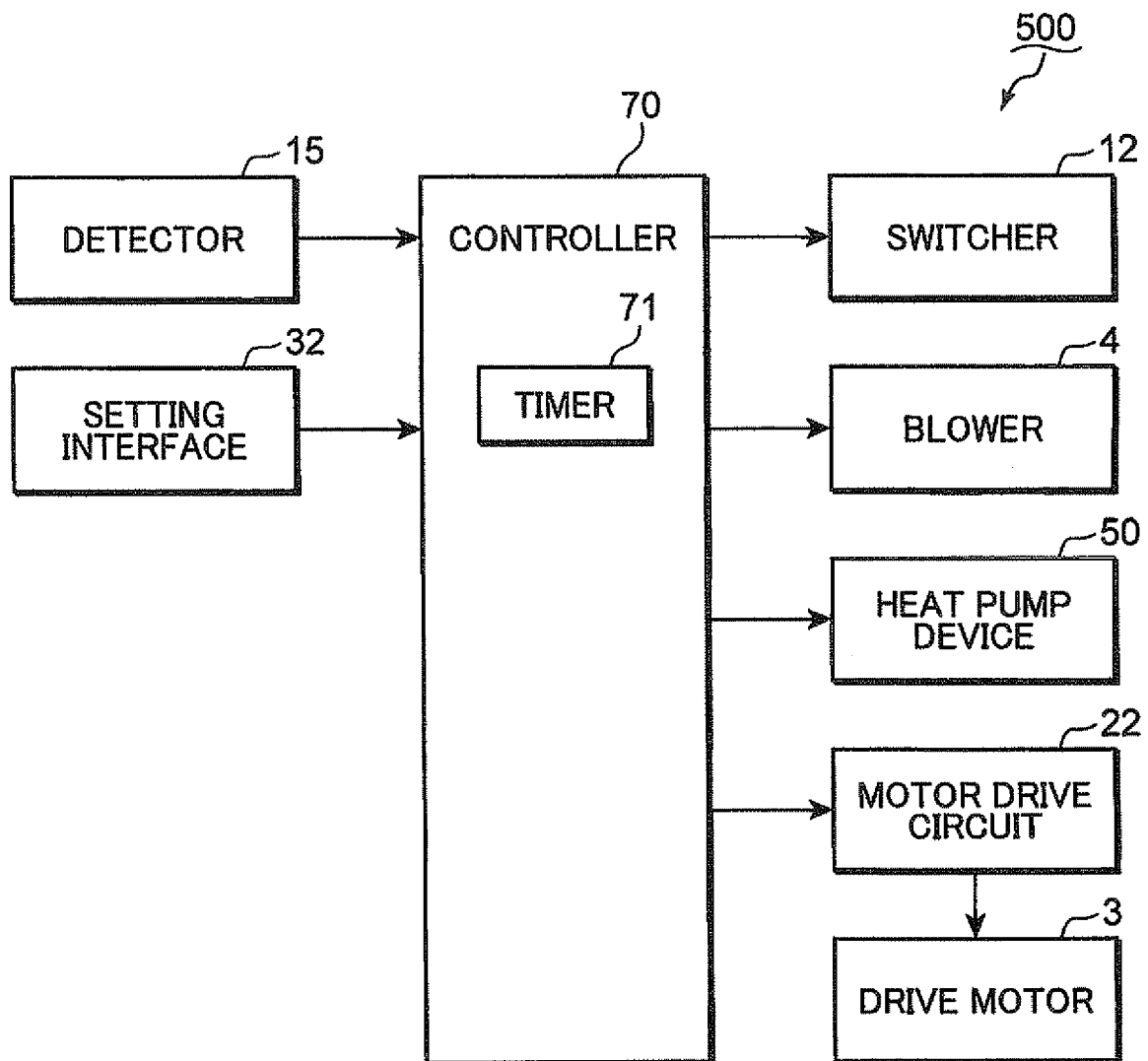


FIG.7

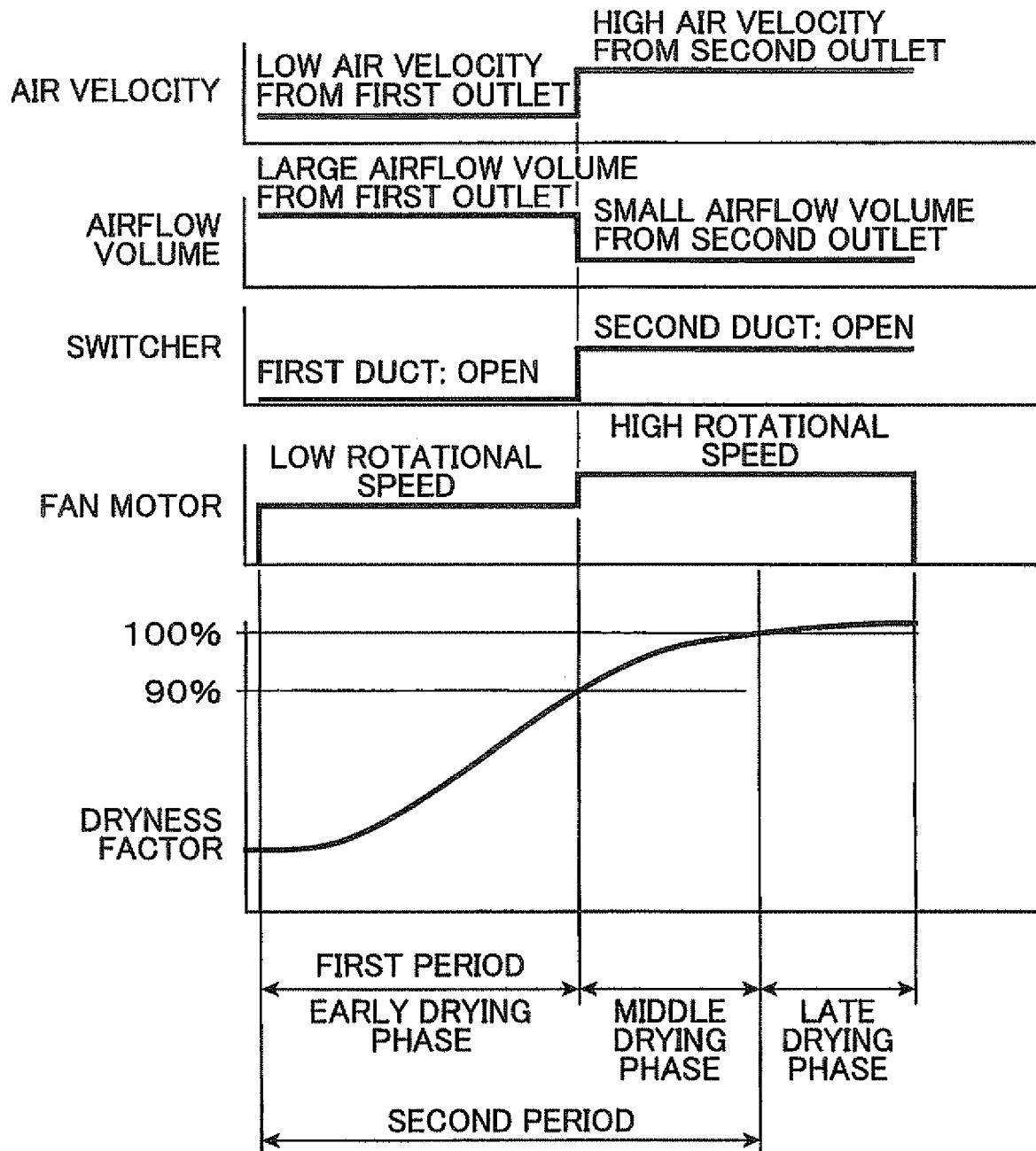


FIG.8

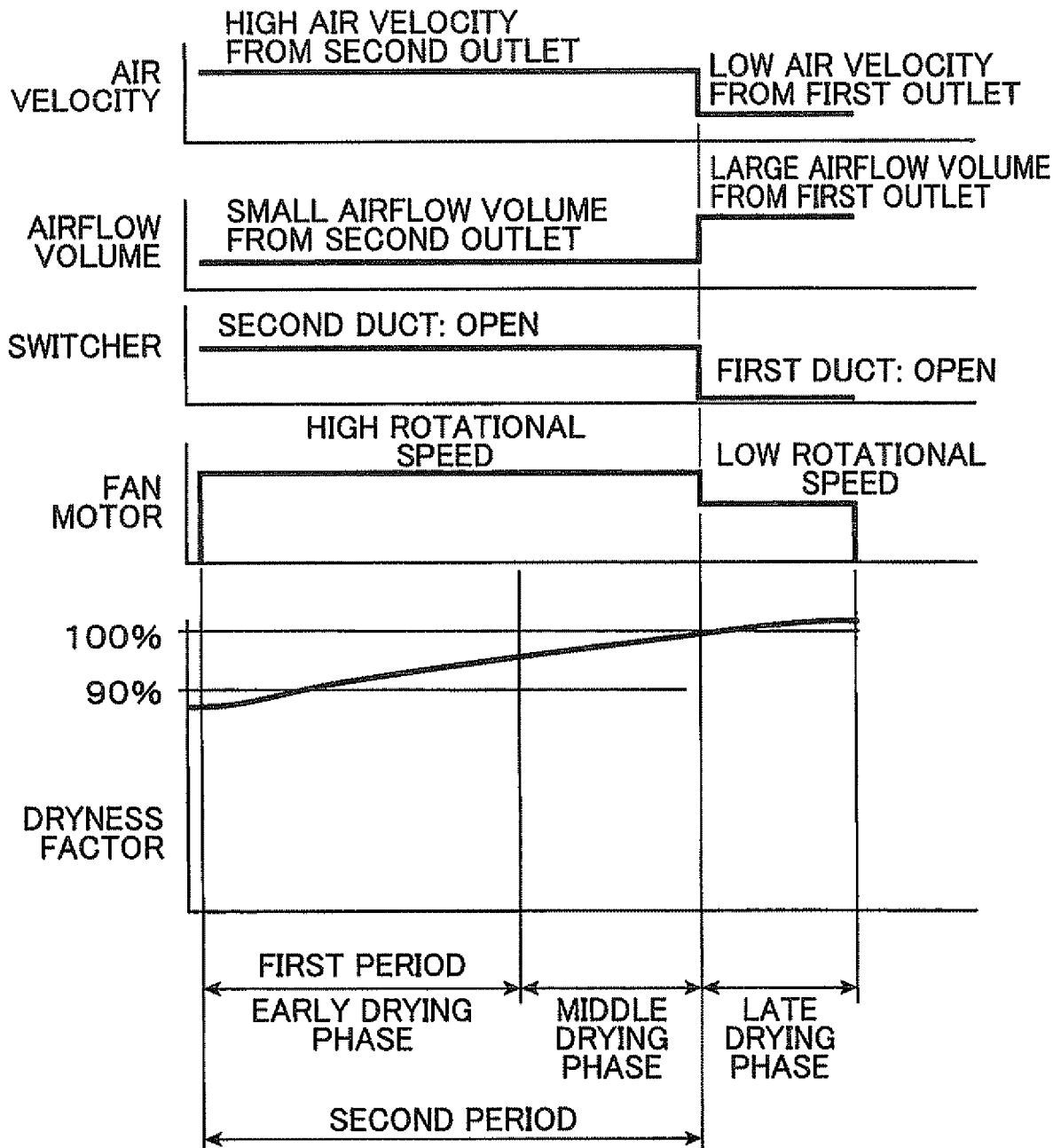


FIG.9

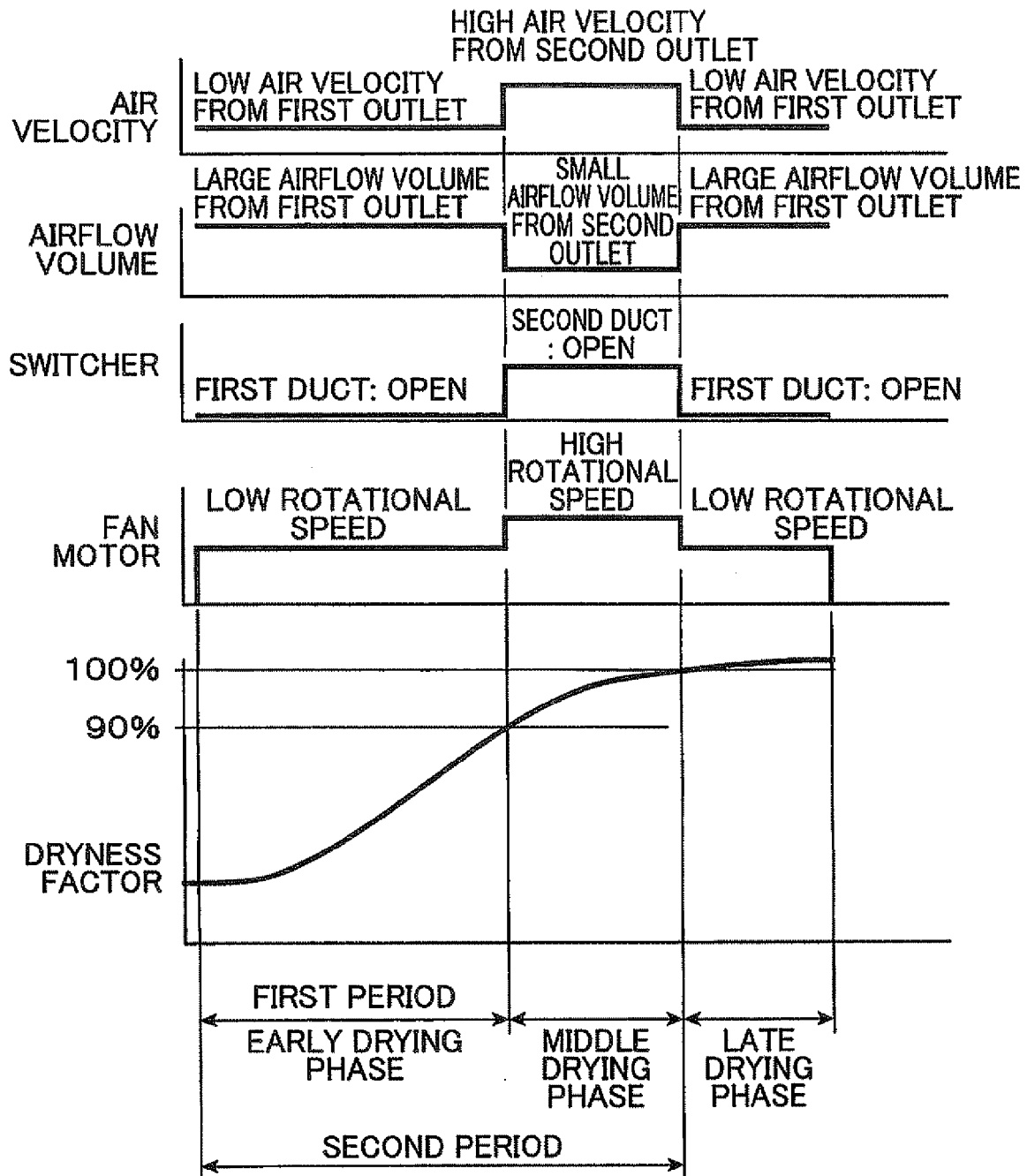


FIG.10

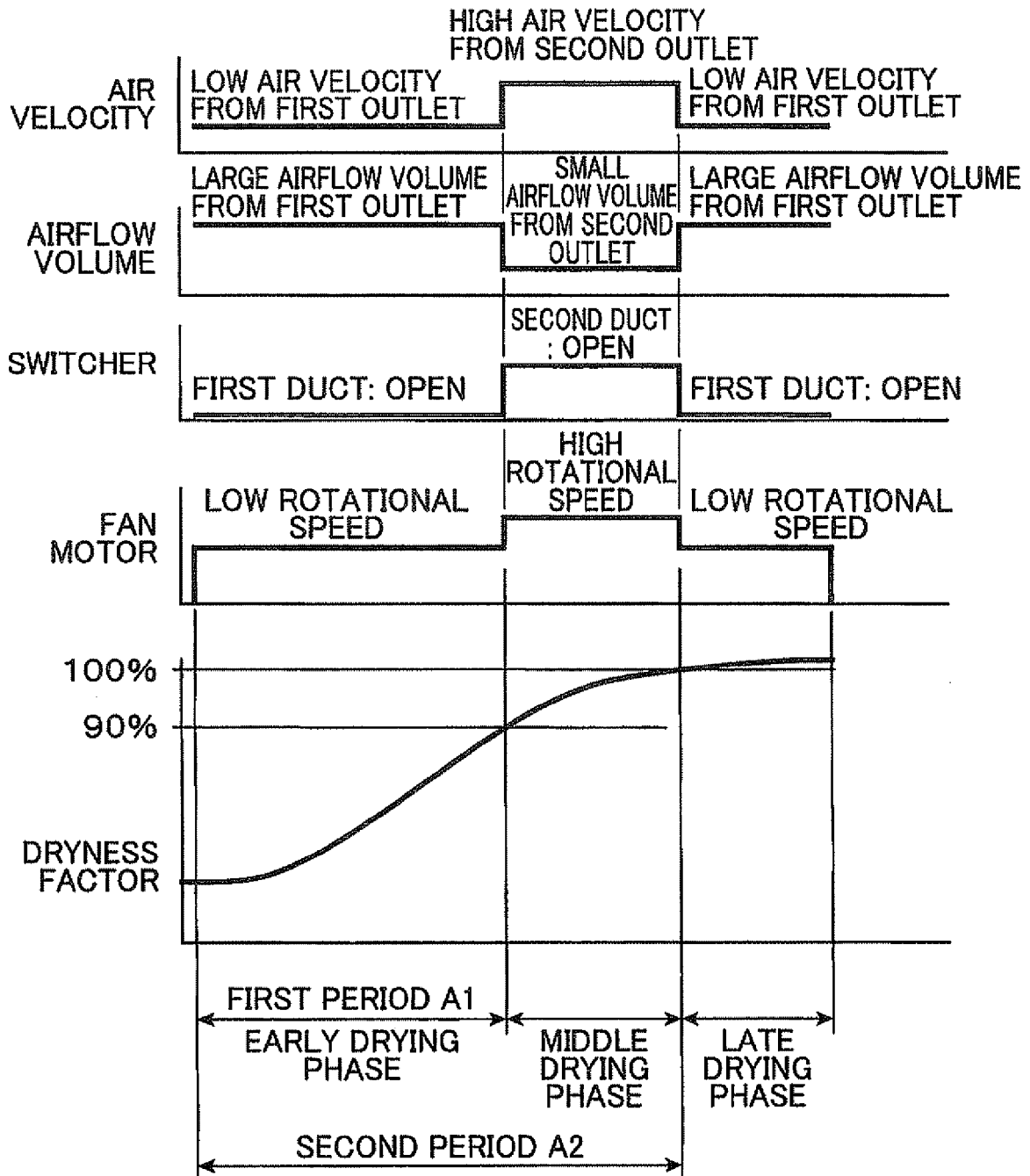


FIG.11

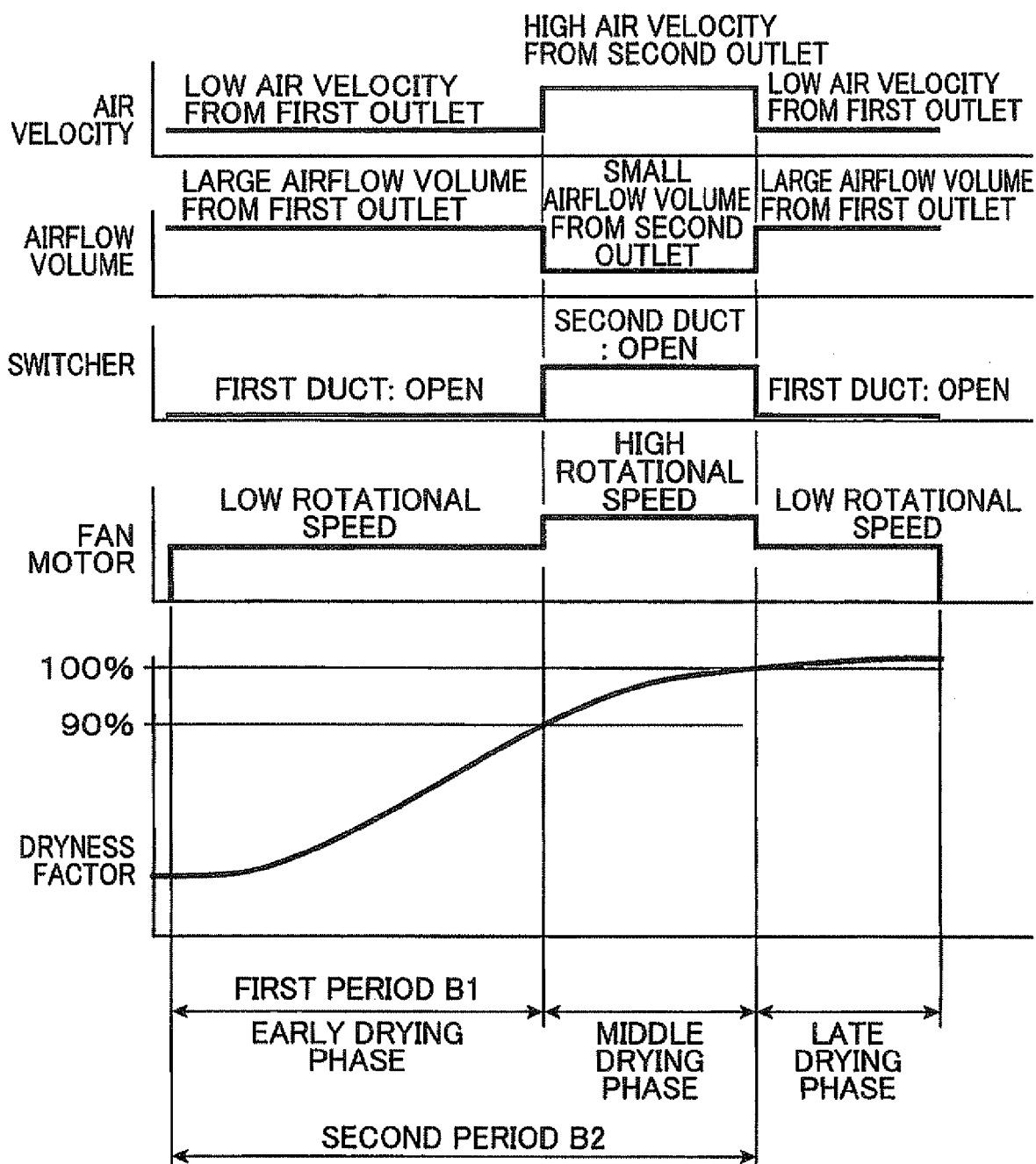


FIG.12

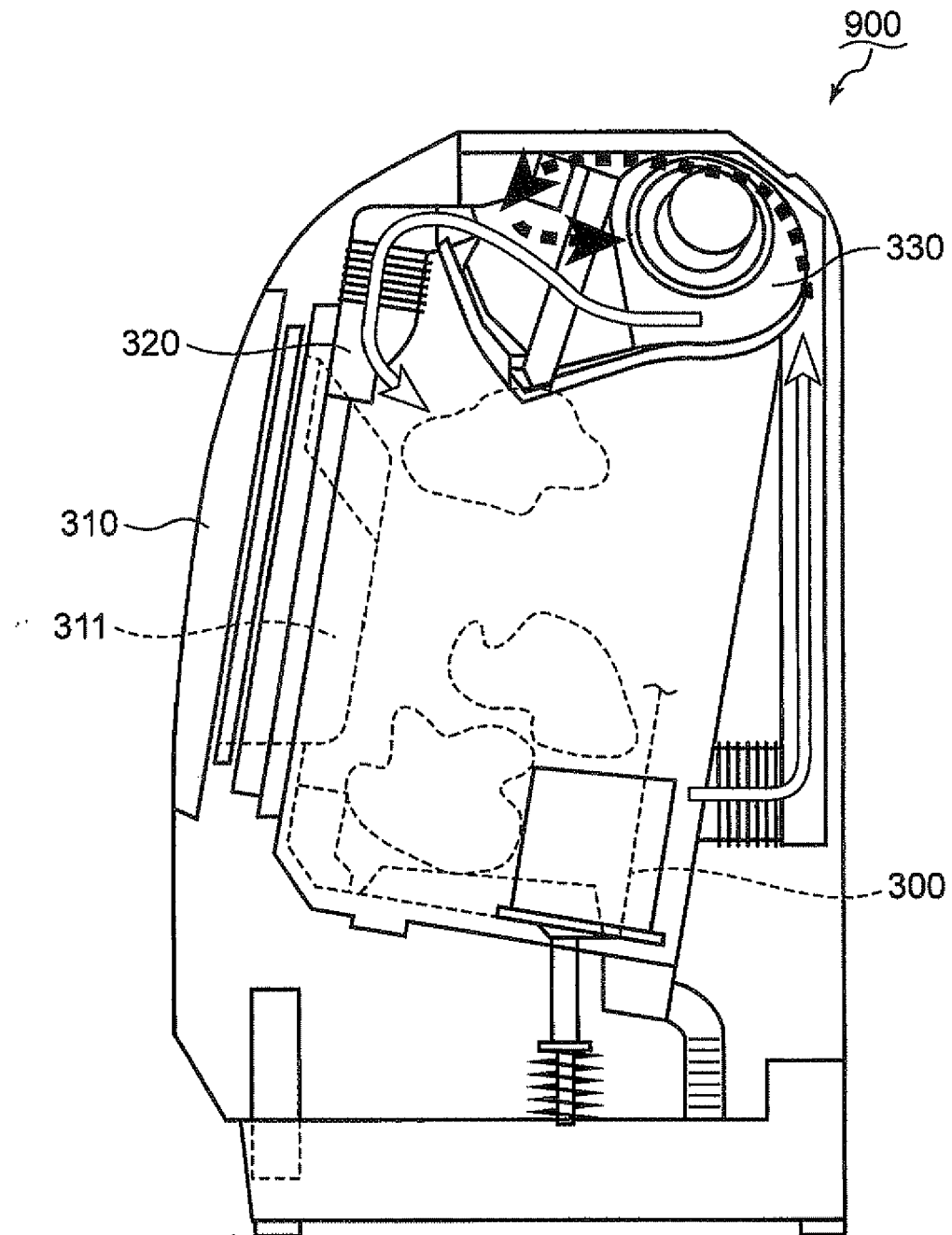
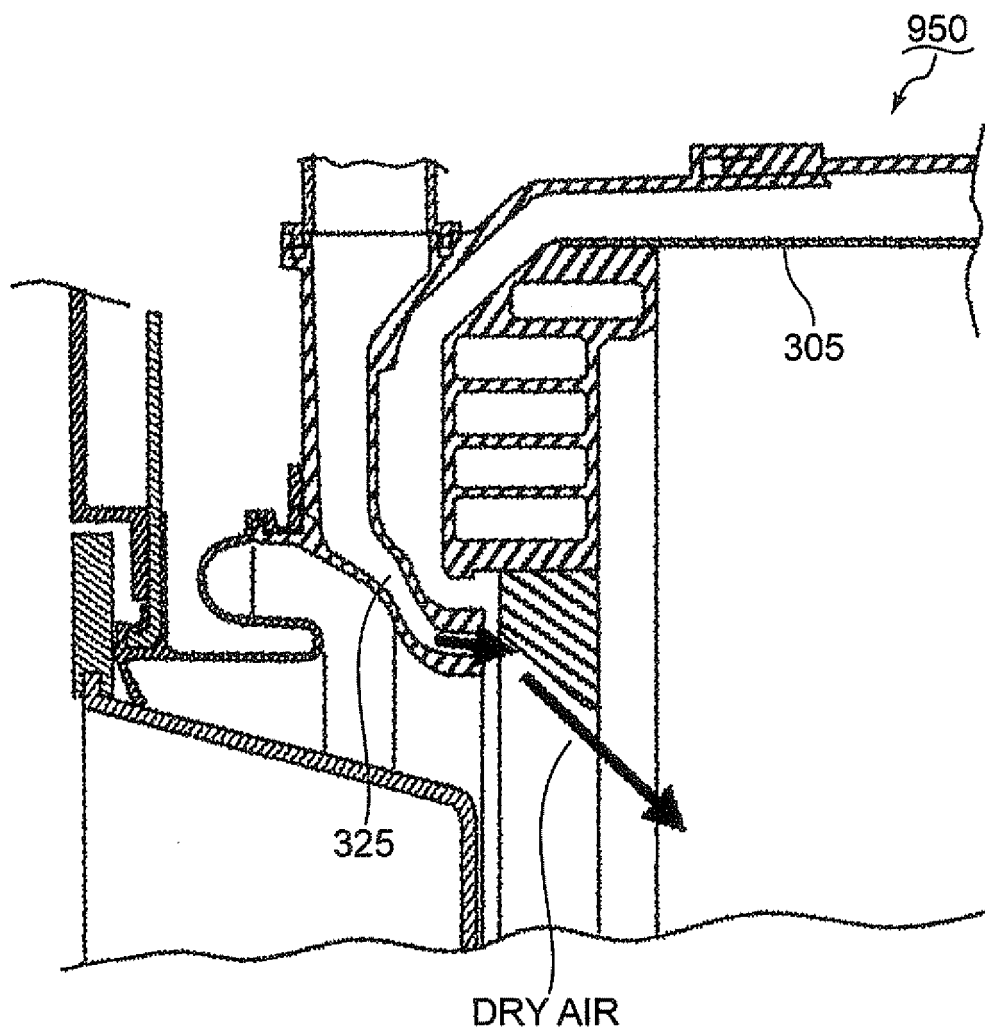


FIG.13



REFERENCES CITED IN THE DESCRIPTION

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