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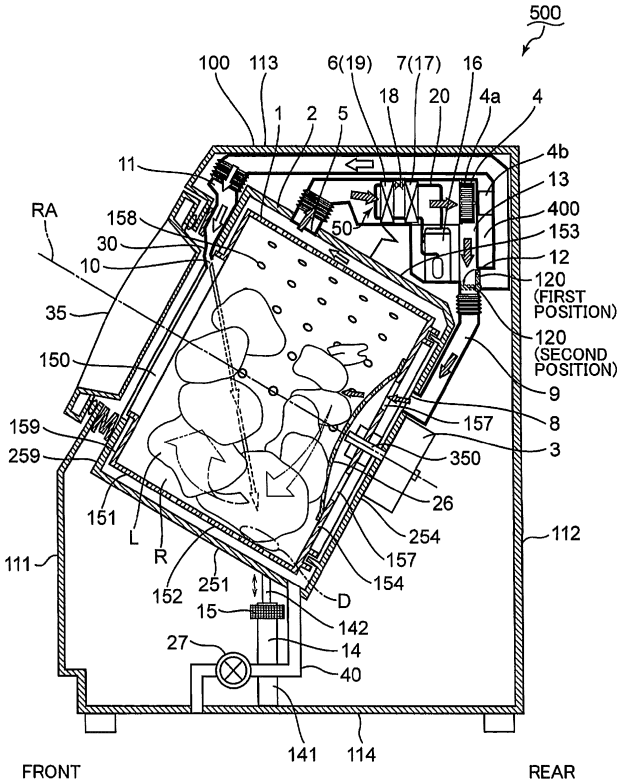
(54) Laundry dryer and washing and drying machine

(57) A laundry dryer and a washing and drying machine include a drum (1) for storing laundry, a drive motor (3) for rotating the drum (1), and a nozzle (30) from which dry air is blown out to dry the laundry. The drum (1) rotated by the drive motor (3) vertically moves the laundry, and the nozzle (30) directs the dry air to faces a moving direction of the laundry.

FIG.1



EP 2 444 539 A1

Description

BACK GROUND 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] The drum-type drying machine dries the laundry in a relatively narrow interior space of the drum. Accordingly, the dried laundry becomes severely wrinkled. Various methods have been proposed to reduce the wrinkles of the dried laundry (c.f. JP 2009-112841 A, JP 2009-50338 A, JP 2009-72495 A).

[0004] The aforementioned Patent Documents disclose technologies which utilize dry air to effectively eliminate the wrinkles of laundry. According to the aforementioned Patent Documents, the dry air is directed closely to the laundry which rotates and moves in the drum. It should be noted that the direction of the spouted dry air substantially coincident with a moving direction of the laundry.

[0005] Fig. 9 is a schematic view of a vertical cross section of a conventional drum-type drying machine (washing and drying machine). The conventional drum-type drying machine is described with reference to Fig. 9.

[0006] The drum-type drying machine 900 shown in Fig. 9 comprises a nozzle 320, and a drum 300 which defines a storage room R for storing laundry L. The dry air is blown out from the nozzle 320.

[0007] As shown in Fig. 9, while the drum 300 rotates, the laundry L vertically moves in the drum 300. When the laundry L reaches an upper portion of the storage room R (position where the laundry L bounced up by the rotation of the drum 300 starts to fall), the dry air blown out from the nozzle 320 at a high velocity comes in direct contact with the laundry L. Since the moving direction of the laundry L and the flow direction of the dry air are both downward, the relative velocity between the laundry L and the dry air becomes small. Accordingly, it becomes likely that a dry air force applied to the laundry L becomes insufficient to eliminate the wrinkles of the laundry L (i.e. insufficient to stretch the laundry).

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide a laundry dryer and a washing and drying machine which effectively eliminate the wrinkles of laundry.

[0009] The laundry dryer according to one aspect of the present invention includes a drum configured to store laundry; a drive motor configured to rotate the drum; and a nozzle from which dry air is blown out to dry the laundry, wherein the drum rotated by the drive motor vertically moves the laundry, and the nozzle directs the dry air to face a moving direction of the laundry.

[0010] 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 drum and stores wash water.

[0011] The aforementioned laundry dryer and washing and drying machine may apply a force great enough to eliminate the wrinkles of the laundry. Accordingly, the laundry dryer and the washing and drying machine may effectively eliminate the wrinkles of the laundry.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a schematic view of a vertical cross section of the washing and drying machine according to one embodiment;
Fig. 2 is a schematic front view of a nozzle mounted on a front wall portion of a water tub of the washing drying machine according to one embodiment;
Fig. 3 is a schematic block diagram of the washing and drying machine shown in Fig. 1;
Fig. 4 is a schematic timing chart showing duct switching operation of the washing and drying machine shown in Fig. 1;
Fig. 5 is a schematic timing chart showing other duct switching operation of the washing and drying machine shown

in Fig. 1;
Fig. 6 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1;
Fig. 7 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1;
Fig. 8 is a schematic timing chart showing yet other duct switching operation of the washing and drying machine shown in Fig. 1; and
Fig. 9 is a schematic side view of a cross section of a conventional drum-type washing and drying machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] 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>

[0014] 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.

[0015] 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 which is attached to the front wall 111. A user may open the door 35 to access the laundry L in the housing 100.

[0016] The washing and drying machine 500 further comprises a drum 1 configured to store the laundry L. The drum 1 includes a substantially cylindrical peripheral wall 151. The peripheral wall 151 defines a storage room R to store the laundry L. The peripheral wall 151 includes a front wall portion 159 facing the door 35. The front wall portion 159 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.

[0017] 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.

[0018] 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.

[0019] 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 in the water tub 2 is rotated by the drive motor 3. 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 becomes higher than the rotation center of the bottom wall 154 of the drum 1.

[0020] 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 configured to blow the dry air into the drum 1. The dry air blown into the drum 1 removes moisture from the laundry L, which consequently increases a humidity of the dry air.

[0021] 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.

[0022] 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.

[0023] The air supplier 400 comprises a heater 7 after the dehumidifier 6. The heater 7 heats the dry air dehumidified by the dehumidifier 6.

[0024] 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.

[0025] 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 further comprises a nozzle 30 which defines the second outlet 10. The dry guided by the second duct 11 is blown out from the second outlet 10, which is formed by the nozzle 30.

[0026] 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 into the drum 1 through the first outlet 8 becomes lower than that 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 that 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, the larger bore of the first outlet 8 preferably facilitates to supply a large flow volume of the dry air into the drum 1.

[0027] 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.

[0028] Fig. 2 is a schematic front view (view from the front side) of the nozzle 30 mounted on the front wall portion 259 of the water tub 2. The nozzle 30 is described with reference to Figs. 1 and 2.

[0029] The nozzle 30 is mounted on an upper right portion of the front wall portion 259 (i.e., upper right with respect to the rotation axis RA of the drum 1).

[0030] In Fig. 2, the drum 1 is represented with the dotted line. In the present embodiment, the drive motor 3 rotates the drum 1 clockwise. Fig. 2 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 P1 sequentially faces the points P2 to P4. Meanwhile, the dry air is blown out from the nozzle 30.

[0031] Fig. 1 shows movement of the laundry L associated with the rotation of the drum 1. As shown by the two-dot chain line in Fig. 1, the laundry L is bounced up and subsequently falls down during the rotation of the drum 1. The vertical movement of the laundry L is repeated during the rotation of the drum 1.

[0032] In the present embodiment, the nozzle 30 is mounted on the front wall portion 259 of the water tub 2 so that the dry air becomes directed (i.e. downward) to the laundry L, which vertically moves.

[0033] In the description hereinafter, a part of the peripheral wall 151 of the drum 1, which defines the lower half of the storage room R is referred to as the "first portion 152". A part of the peripheral wall 151 of the drum 1 which defines the upper half of the storage room R is referred to as the "second portion 153". Fig. 1 shows the lowest area D (below the rotation axis RA of the drum 1) of the first portion 152 near the bottom wall 154 of the drum 1. Most of the laundry L, which vertically moves in association with the rotation of the drum 1, falls to the lowest area D. The rapid dry air blown out from the nozzle 30 at high-pressure is directed toward the lowest area D. It should be noted that the nozzle 30 may be directed to a left side than the lowest area D (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 of the drum 1 such as rotation velocity and drum shape. Thus, the rapid dry air at high-pressure is directed to face the laundry L, which vertically moves in the drum 1.

[0034] The laundry L dropped to the lowest area D is bounced up once again, so that the laundry L moves upward. Meanwhile, the rapid dry air at high-pressure is blown downward from the nozzle 30. Accordingly, the laundry L, which moves upward, strongly collides with the dry air blown downward. The washing and drying machine 500 according to the present embodiment is characterized in the nozzle 30 which defines the blowing direction of the dry air to face the moving direction of the laundry L in the drum 1.

[0035] In general, a drum-type washing and drying machine dries laundry in a narrow storage room. If the laundry is dried by a conventional washing and drying machine, it is difficult to reduce wrinkles of the laundry. Approaches which require an increase in a flow volume of the dry air to reduce the wrinkles of the laundry make the washing and drying machine consume a lot of power. The unique arrangement of the aforementioned nozzle 30 contributes to resolving the problems of the conventional washing and drying machine (i.e. wrinkles and great power consumption).

[0036] The nozzle 30 of the present embodiment directs the dry air toward the lowest area D. The laundry L dropped to the lowest area D is once again bounced up in association with the rotation of the drum 1. Since the dry air blown out from the nozzle 30 faces the moving direction of the bounced laundry, a relative velocity between the dry air and the laundry L goes up. Thus, the laundry L is subjected to a strong force from the dry air. The relative velocity between the laundry L and the dry air applies a force strong enough to stretch the laundry L to decrease the wrinkles of the laundry L. Accordingly, the wrinkles of the laundry L may be effectively reduced even in the narrow storage room R defined by

the drum 1.

[0037] In the present embodiment, the drum 1 is rotated clockwise. Alternatively, the drum may be rotated counterclockwise. If the drum is rotated counterclockwise, the nozzle is preferably mounted on an upper left portion of the front wall portion of the water tub. Thus, even if the drum is rotated counterclockwise, the aforementioned advantageous effects may be obtained.

[0038] 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 moves in association with the rotation of the drum.

[0039] In the present embodiment, the nozzle 30 which forms the second outlet 10 with 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 another nozzle which forms an outlet with a large bore to cause little pressure loss. Thus, the rapid dry air at high-pressure is appropriately blown to the lowest area D to appropriately reduce the wrinkles of the laundry by means of the relative velocity between the laundry L and the dry air.

[0040] 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 small holes 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 a sufficiently high aperture ratio so as to facilitate to dry the laundry L.

[0041] 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 becomes higher than the rotation center of the bottom wall 154 of the drum 1. Accordingly, short laundry L such as socks, handkerchiefs and briefs is likely to converge around the lowest area D whereas long laundry L such as long-sleeved underwear, long pants, long-sleeved dress shirts and long-sleeved pajamas is likely to converge nearby the front wall portion 159 of the drum 1 rather than the lowest area D. 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 lowest area D. The dry air then 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.

[0042] The long laundry L has portions which are easily twisted, such as the sleeve. Accordingly, the long laundry L is likely to wrinkle. 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 nozzle 30 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 blown out from the second outlet 10 is more rapid and has a higher pressure than the dry air blown out from the first outlet 8. Thus, the long laundry L which directly collides (come in contact) with the dry air blown out from the second outlet 10 is facilitated to spread out. The dry air blown out from the second outlet 10 moves the long laundry L a lot to effectively reduce the wrinkles of the long laundry L.

[0043] 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 mounted 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.

[0044] The blower 4 and the switching valve 120 are situated in the circulatory duct 13. The dry air exhausted 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.

[0045] 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 approximately 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 blown out from the first outlet 8.

[0046] 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.

[0047] 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.

[0048] 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 an arbitrary 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.

[0049] The second outlet 10 formed by the nozzle 30, which is mounted on the front wall portion 259 of the water tub 2, directs the dry air toward the lowest area D from an upper portion of the storage room R defined by the drum 1, so that the flow direction of the dry air, which is blown out from the second outlet 10, faces the moving direction of the laundry L bounced up by the rotation of the drum 1. The dry air, which is rapidly blown out at high-pressure from the second outlet 10, causes a force strong enough to effectively stretch the laundry L to remove the wrinkles of the laundry L in the narrow storage room R defined by the drum 1.

[0050] The washing and drying machine 500 comprises a damper 14 situated below the water tub 2. The damper 14 configured to support the water tub 2 damps vibration of the water tub 2. For example, if the laundry L converges to a specific portion in the drum 1 in spin-drying processes, the drum 1 and the water tub 2 become unbalanced. Meanwhile, it becomes likely that the rotation of the drum 1 causes the vibration of the drum 1 and the water tub 2. The damper 14 appropriately damps the vibration, which is transmitted from the drum 1 and the water tub 2 to the housing 100.

[0051] 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).

[0052] 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.

[0053] The heat pump device 50 comprises a choke 18 configured to reduce 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 sequentially guides the refrigerant to the compressor 16, the radiator 17, the choke 18 and the heat sink 19. 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.

[0054] As described above, in the present embodiment, the washing and drying machine 500 dries the laundry L by means of the heat pump device 54. 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.

[0055] Fig. 3 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 3.

[0056] As shown in Fig. 3, 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 the operation 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 working 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.

[0057] 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, temperature and humidity 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.

[0058] 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.

[0059] In the present embodiment, the first duct 9 comprises a single first outlet 8. Alternatively, the first duct may comprise several first outlets.

[0060] 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>

[0061] 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)

[0062] The principles of wrinkling while the laundry is dried are described.

[0063] 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 wrinkles on the laundry.

[0064] A lot of moisture intervening among the fibers facilitates to move the fibers. If agitation force associated with the rotation of the drum works to stretch the folded laundry, it becomes likely that the wrinkles of the folded laundry are removed.

[0065] 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 a resultant force from the agitation associated with 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.

[0066] 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 deterioration in finish of the laundry after the drying process.

[0067] 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 maintain their stretched state,

the high bonding strength between the fibers with little moisture prevents new wrinkles even if a force is thereafter applied to bend the fibers.

[0068] 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 approximately 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 approximately 90% and 100%, the laundry is more likely to wrinkle. The following equation represents the dryness factor (%).

[Equation 1]

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

[0069] 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%.

[0070] 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).

[0071] In the following descriptions, the drying process is separated 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 approximately 90%. The term "middle drying phase" means a period while the dryness factor falls in a range between approximately 90% and 100%. The term "late drying phase" means a period while the dryness factor exists in a range over approximately 100%. It should be noted that the laundry is less likely to wrinkle in the "early drying phase" because there are 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.

[0072] 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 approximately 90% (refer to Figs. 1 and 2). The controller 70 causes the switcher 12 to select the second duct 11 if the dryness factor of the laundry is no less than approximately 90%. In the present embodiment, the value of approximately 90% is exemplified as the predetermined value which becomes 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.

[0073] As a result of the aforementioned control of the controller 70, in the middle drying phase, the dry air is blown out from the nozzle 30, which forms the second outlet 10 of the second duct 11, toward the lowest area D (refer to Fig. 1). Since the rapid dry air at high-pressure blown out from the nozzle 30 is directed to the laundry bounced up from the lowest area D by the rotation of the drum 1, the laundry are significantly stretched to effectively decrease the wrinkles of the laundry.

[0074] In the middle drying phase (while the dryness factor is from approximately 90% to 100%), as described above, it becomes likely that the wrinkles are fixed. The laundry is lighter in the middle drying phase than in the early drying phase, so that the laundry in the middle drying phase moves a lot during the rotation of the drum 1. In the middle drying phase (while the dryness factor is from approximately 90% to 100%), since the rapid dry air at high-pressure is blown out from the second outlet 10 formed by the nozzle 30, the relative velocity between the laundry and the dry air goes up and causes a force strong enough to stretch the laundry and preferably reduce the wrinkles of the laundry.

[0075] 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.

[0076] 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 executes the switching operation of the switcher 12 in response to the resultant estimation about the early, middle and late drying phases.

[0077] In the present embodiment, the controller 70 determines a period from when the drying process starts to when

the aforementioned first period passes as the early drying phase. The aforementioned 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.

[0078] 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.

[0079] Unlike the conventional washing and drying machine, the switcher 12 of the washing and drying machine 500 according to 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. Accordingly, the wrinkles may be effectively reduced by means of the single blower 4. Thus, in comparison to the conventional washing and drying machine, the washing and drying machine 500 according to 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.

[0080] As described above, the exhaust port 5 is formed near the second outlet 10 formed by the nozzle 30, which is 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, the distance between the first outlet 8 and the exhaust port 5 become lengthened. Consequently, the dry air blown out from the first outlet 8 formed on the bottom wall 254 of the water tub 2 is likely to spread throughout the storage room R in the drum 1. Accordingly, the dry air efficiently comes in contact with the laundry in the drum 1 to efficiently dry the laundry with less power consumption.

[0081] 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)

[0082] Fig. 4 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, 3 and 4.

[0083] 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.

[0084] The controller 70 activates the timer 71 at the same time as the start of the drying process 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 decrease a rotational speed of 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 and reduce the power consumption.

[0085] 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 is started, the controller 70 causes the switcher 12 to select the second duct 11. The controller 70 maintains the second position of the switcher 12 until the late drying phase is complete. The controller 70 increases the rotational speed of the fan motor 4b.

[0086] 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 immediately after the spin-drying process. Thus, the initial dryness factor becomes high (for example, about 90 % of the dryness factor). The laundry with a 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.

[0087] 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. Since the rotational speed of the fan motor 4b is increased during these periods, the dry air from the second outlet 10 becomes high-velocity and high-pressure.

[0088] 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. Simultaneously, the controller 70 controls the blower 4 to increase the rotational speed of the fan motor 4b. Subsequently, the controller 70 continues to open the second duct 11 until the drying process is complete. Thus, the dry air appropriately stretches the laundry in the middle and late drying phases to reduce the wrinkles of the laundry.

[0089] 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.

[0090] Unlike the conventional washing and drying machine, the washing and drying machine 500 according to 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 according to 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.

[0091] Fig. 5 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, 3 and 5.

[0092] 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.

[0093] 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 second duct 11 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. Accordingly, the dry air may apply a force strong enough to stretch the laundry, which contributes to an effective reduction in wrinkles of the laundry.

[0094] 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.

[0095] 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.

[0096] As described above, in the late drying phase, the circulation path of the dry air is switched to the first duct 9, which has 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.

[0097] 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 simultaneously controls the blower 4 to reduce the rotational speed of the fan motor 4b. Subsequently, the controller 70 continues to open the first duct 9 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. Therefore 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).

[0098] Fig. 6 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, 3 and 6.

[0099] 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.

[0100] The controller 70 activates the timer 71 once the drying process starts 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.

[0101] 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.

[0102] 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 continues to open the second duct 11 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.

[0103] 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.

[0104] 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.

[0105] As described above, in the late drying phase, the circulation path of the dry air is switched to the first duct 9, which has 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.

[0106] 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 continues to open the first duct 9 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). Consequently, 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).

[0107] Figs. 7 and 8 are schematic timing charts showing other duct switching operations of the washing and drying machine 500. Fig. 7 shows the operation of the washing and drying machine 500 under a small amount of the laundry in the drum 1. Fig. 8 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, 3, 7 and 8.

[0108] 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.

[0109] 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.

[0110] 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.

[0111] The controller 70 sets the first and second periods on the basis of the detection results of the detector 15. As shown in Fig. 7, 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. 8, 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".

[0112] 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.

[Equation 2]

$$A1 < B1$$

[Equation 3]

$$A2 < B2$$

[0113] The controller 70 may extend the first and second periods in response to an increase in amount of the laundry.

[0114] 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).

[0115] 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. 4 to 6.

[0116] In the present embodiment, the detector 15 detects a 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 rotational speed, drive current and torque of the drive motor 3 during the rotation of the drum 1.

[0117] 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.

[0118] 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.

[0119] 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.

[0120] The aforementioned embodiment above mainly includes the laundry dryer and washing and drying machine with the following configurations. The laundry dryer and the washing and drying machine, which have the following configurations, may effectively decrease wrinkles of the laundry.

[0121] The laundry dryer according to one aspect of the aforementioned embodiment includes a drum configured to store laundry; a drive motor configured to rotate the drum; and a nozzle from which dry air is blown out to dry the laundry, wherein the drum rotated by the drive motor vertically moves the laundry, and the nozzle directs the dry air to face a moving direction of the laundry.

[0122] According to the aforementioned configuration, the laundry is stored in the drum. While the drive motor rotates the drum, the laundry vertically moves. The nozzle from which the dry air is blown out to dry the laundry is situated so that the dry air is directed to face the moving direction of the laundry. Since a relative velocity between the laundry and the dry air goes up, a large force may be applied to the laundry. Consequently, it becomes less likely that the laundry wrinkles.

[0123] In the aforementioned configuration, preferably, the drum includes a feed opening through which the laundry is fed and a peripheral wall defining a storage room where the laundry is vertically moved, 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 nozzle directs the dry air toward the first portion.

[0124] According to the aforementioned configuration, the drum includes a feed opening through which the laundry is fed, and a peripheral wall defining a storage room where the laundry is vertically moved. The peripheral wall includes the first portion which defines the lower portion of the storage room, and the second portion which defines the upper portion of the storage room. The laundry falls to the first portion and thereafter bounces upward due to the rotation of the drum. Since the dry air from the nozzle is directed toward the first portion, the relative velocity between the laundry and the dry air goes up. Accordingly, it becomes likely that a force which is great enough to reduce wrinkles of the laundry is applied to the laundry.

[0125] In the aforementioned configuration, preferably, the laundry dryer further comprises an air supplier configured

to supply the dry air to the drum, wherein the drum includes a bottom opposite to the feed opening, the air supplier includes: a first duct with a first outlet which is used to blow the dry air from the bottom; a second duct which includes a second outlet formed in 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.

[0126] According to the aforementioned configuration, the laundry dryer further comprises the air supplier which supplies the dry air to the drum. The drum includes the bottom opposite to the feed opening. The air supplier includes the first duct with the first outlet which is used to blow the dry air from the bottom, the second duct which includes the second outlet formed in the feed opening, the switcher which selectively guides the dry air to the first or second duct, and the 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, the characteristics of the dry air are adjusted in response to the drying progress for the laundry.

[0127] In the aforementioned configuration, preferably, the first duct has a larger bore than the second duct.

[0128] According to the aforementioned configuration, it becomes less likely that the first duct, which has the larger bore than the second duct, causes pressure loss of the dry air blown out from the first outlet. Accordingly, it becomes likely that the dry air with a large flow volume may be blown out from the first outlet. Consequently, the laundry is efficiently dried while the dry air is blown out from the first outlet.

[0129] In the aforementioned configuration, preferably, the nozzle defines the second outlet.

[0130] According to the aforementioned configuration, since the pressure and velocity of the dry air blown out from the second outlet, which the nozzle forms, are greater than the pressure and velocity of the dry air blown out from the first outlet, it becomes likely that a force applied to the laundry becomes great enough to reduce wrinkles of the laundry.

[0131] 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.

[0132] 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. The controller causes the switcher to select the second duct unless the dryness factor of the laundry is less than the predetermined value. Since dry air with a large flow volume 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 the predetermined value, the laundry become lighter due to a decrease in moisture in the laundry. Accordingly, the laundry is 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, it becomes likely that a force applied to the laundry becomes great enough to reduce wrinkles of the laundry.

[0133] 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.

[0134] 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%, it becomes likely that wrinkles of the laundry become fixed.

[0135] 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 drum and stores wash water.

[0136] In the aforementioned configuration, since the washing and drying machine comprises the aforementioned laundry dryer, and the water tub which encloses the drum and stores wash water, the wrinkles of laundry may be effectively reduced.

Industrial Applicability

[0137] The principles according to the embodiment may be applied to various devices used for drying laundry.

Claims

1. A laundry dryer comprising:

   a drum (1) configured to store laundry;
   a drive motor (3) configured to rotate the drum (1); and
   a nozzle (30) from which dry air is blown out to dry the laundry, wherein
   the drum (1) rotated by the drive motor (3) vertically moves the laundry, and
   the nozzle (30) directs the dry air to face a moving direction of the laundry.

2. The laundry dryer according to claim 1, wherein
   the drum (1) includes a feed opening (150) through which the laundry is fed, and a peripheral wall (151) defining a storage room (R) where the laundry is vertically moved,
   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 nozzle (30) directs the dry air toward the first portion (152).

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

   an air supplier (400) configured to supply the dry air to the drum (1), wherein
   the drum (1) includes a bottom (154) opposite to the feed opening (150),
   the air supplier (400) includes:

      a first duct (9) with a first outlet (8) which is used to blow the dry air from the bottom (154);
      a second duct (11) which includes a second outlet (10) formed in 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).

4. The laundry dryer according to claim 3, wherein
   the first duct (9) has a larger bore than the second duct (10).

5. The laundry dryer according to claim 4, wherein
   the nozzle (30) defines the second outlet (10).

6. The laundry dryer according to claim 5, 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.

7. The laundry dryer according to claim 6, 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).

8. A washing and drying machine, comprising:

   the laundry dryer according to claim 1; and
   a water tub (2) which encloses the drum (1) and stores wash water.

FIG.1

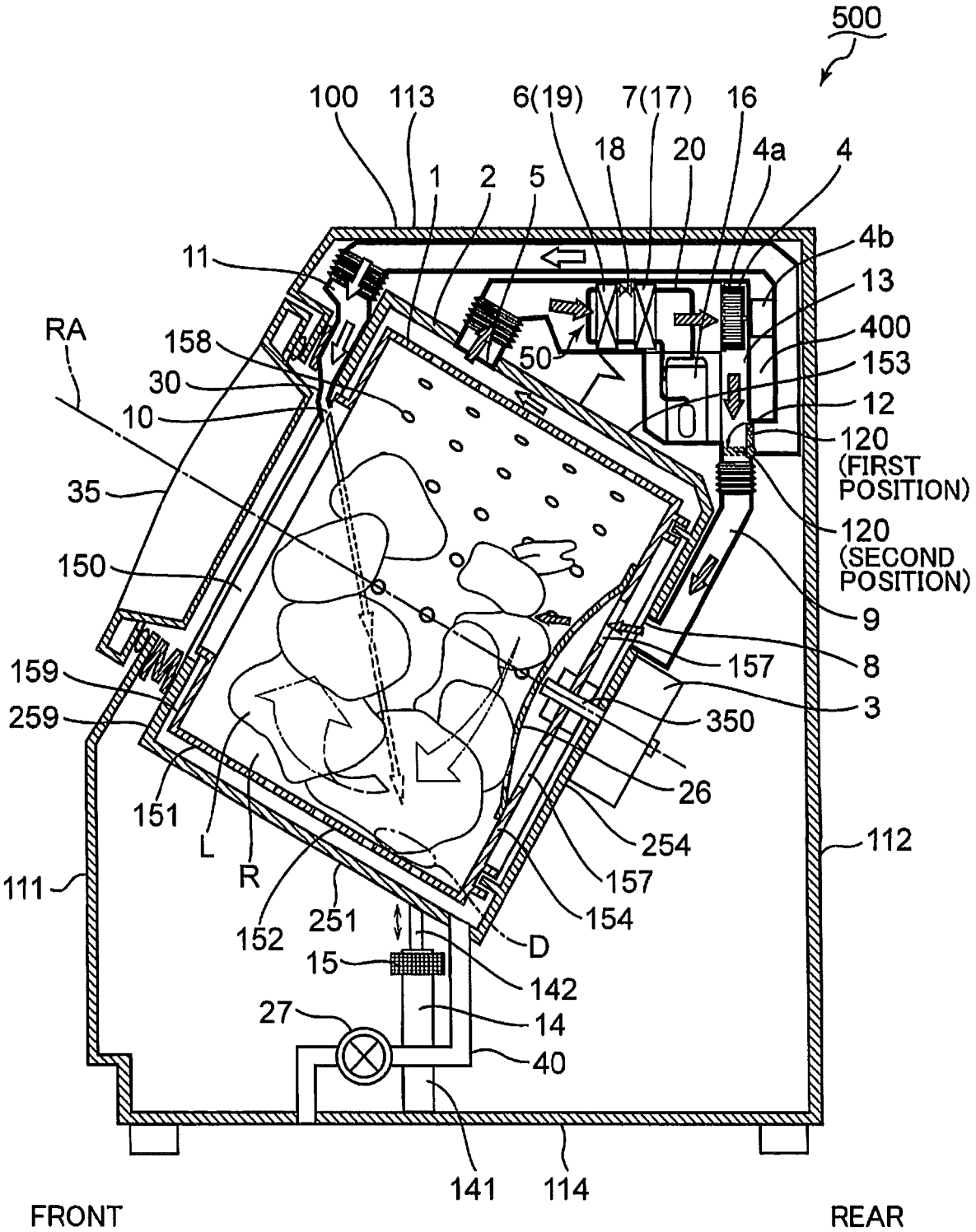

500
100
113
6(19)
7(17)
16
18
20
4a
4
1
2
5
11
4b
13
400
153
12
120
(FIRST
POSITION)
120
(SECOND
POSITION)
9
8
3
RA
158
30
10
35
150
159
259
151
L
R
111
152
251
15
27
50
157
350
26
254
157
154
D
142
14
40
112
141
114
FRONT
REAR

FIG.2

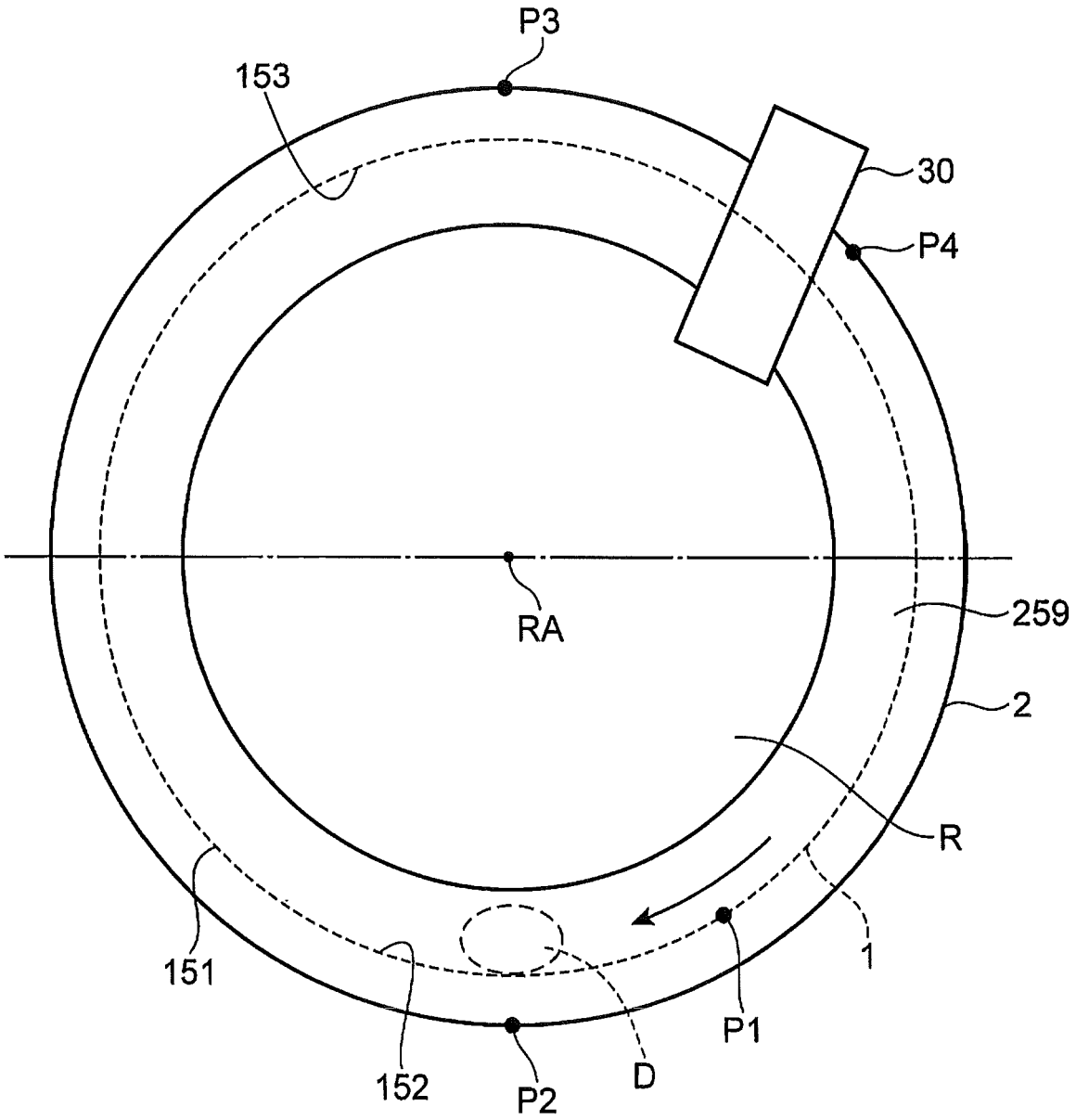


FIG.3

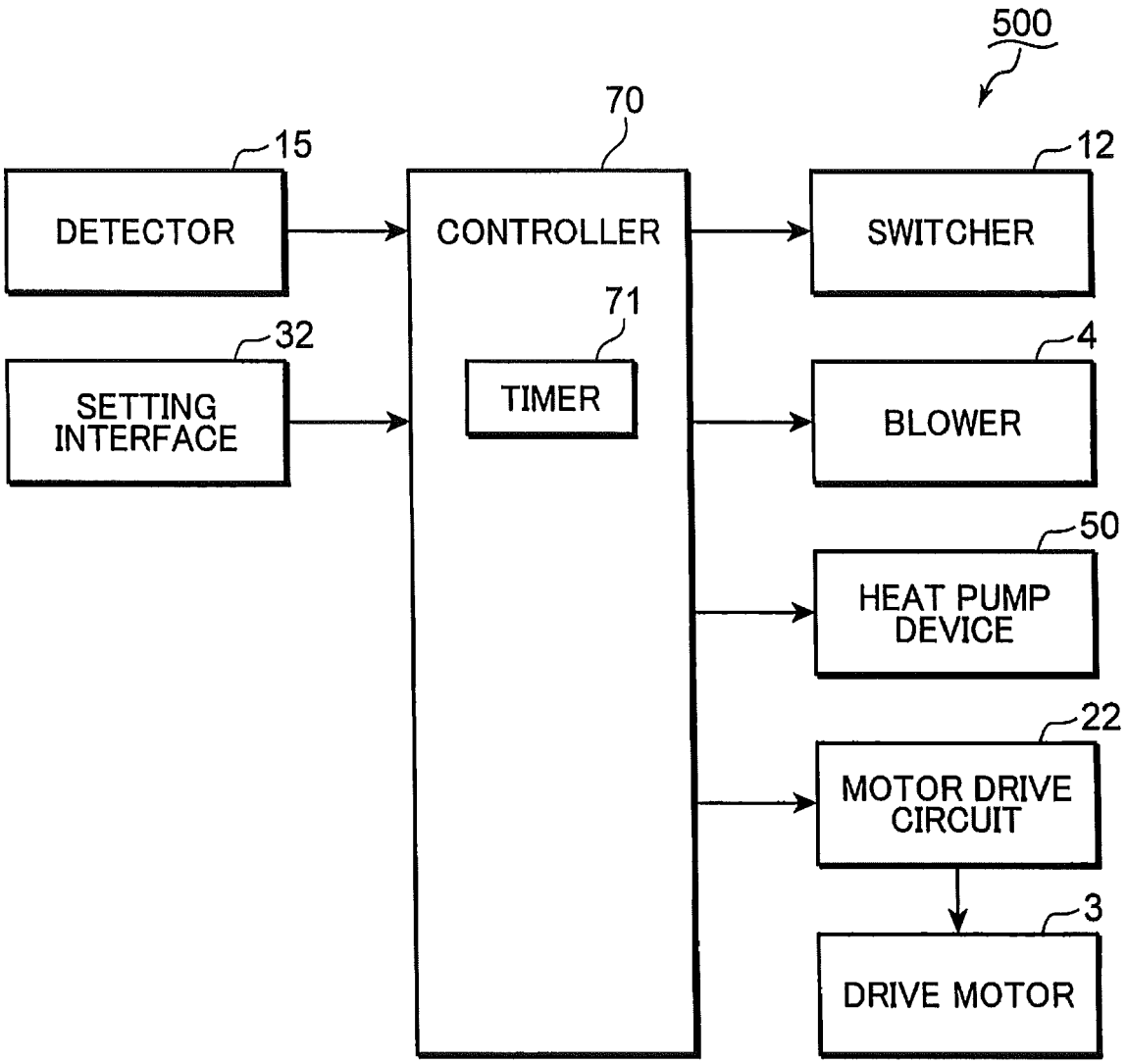

500
70
15
12
DETECTOR
CONTROLLER
SWITCHER
71
32
4
SETTING INTERFACE
TIMER
BLOWER
50
HEAT PUMP DEVICE
22
MOTOR DRIVE CIRCUIT
3
DRIVE MOTOR

FIG.4

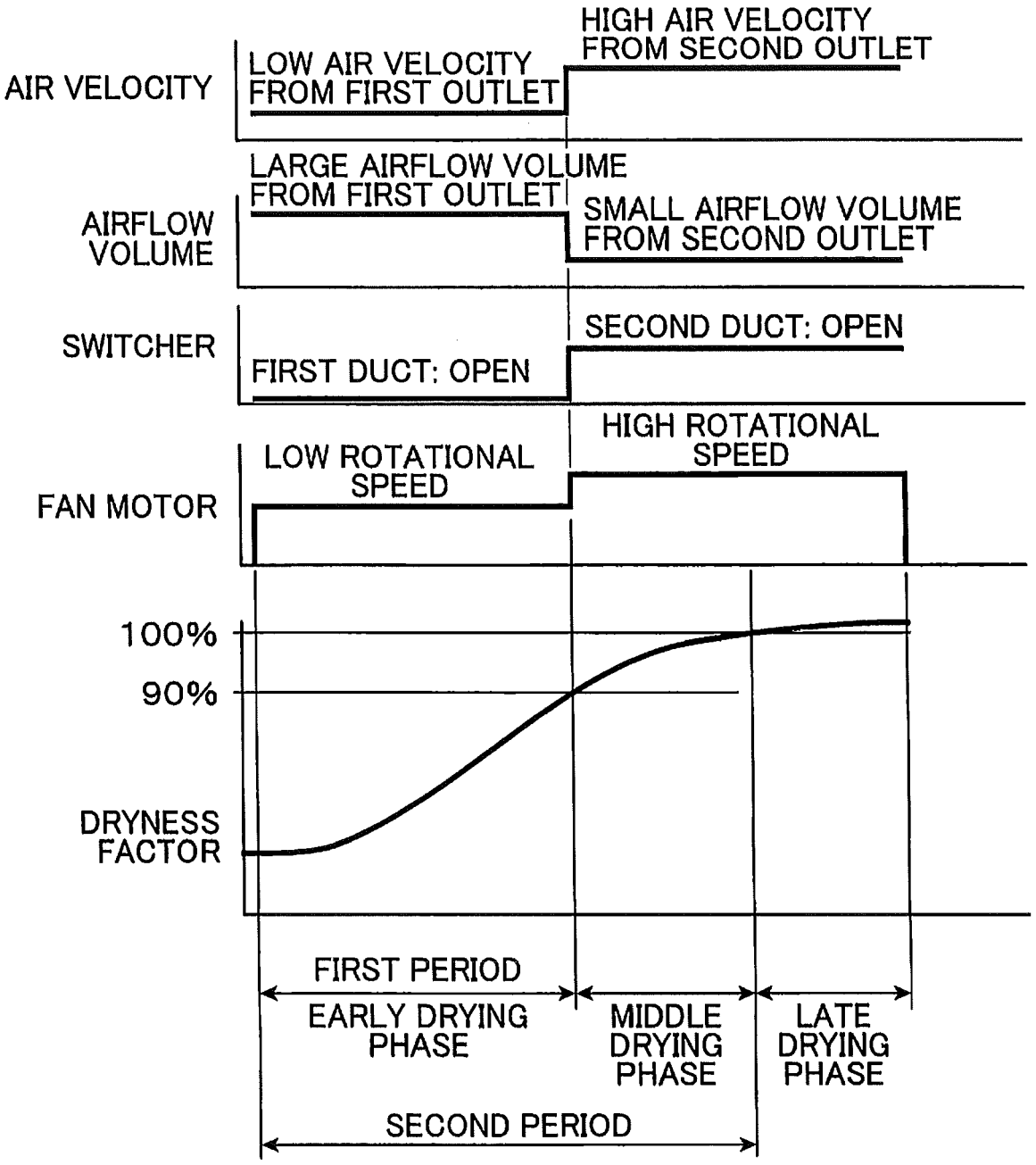

AIR VELOCITY
LOW AIR VELOCITY FROM FIRST OUTLET
HIGH AIR VELOCITY FROM SECOND OUTLET
AIRFLOW VOLUME
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
SMALL AIRFLOW VOLUME FROM SECOND OUTLET
SWITCHER
FIRST DUCT: OPEN
SECOND DUCT: OPEN
FAN MOTOR
LOW ROTATIONAL SPEED
HIGH ROTATIONAL SPEED
100%
90%
DRYNESS FACTOR
FIRST PERIOD
EARLY DRYING PHASE
MIDDLE DRYING PHASE
LATE DRYING PHASE
SECOND PERIOD

FIG.5

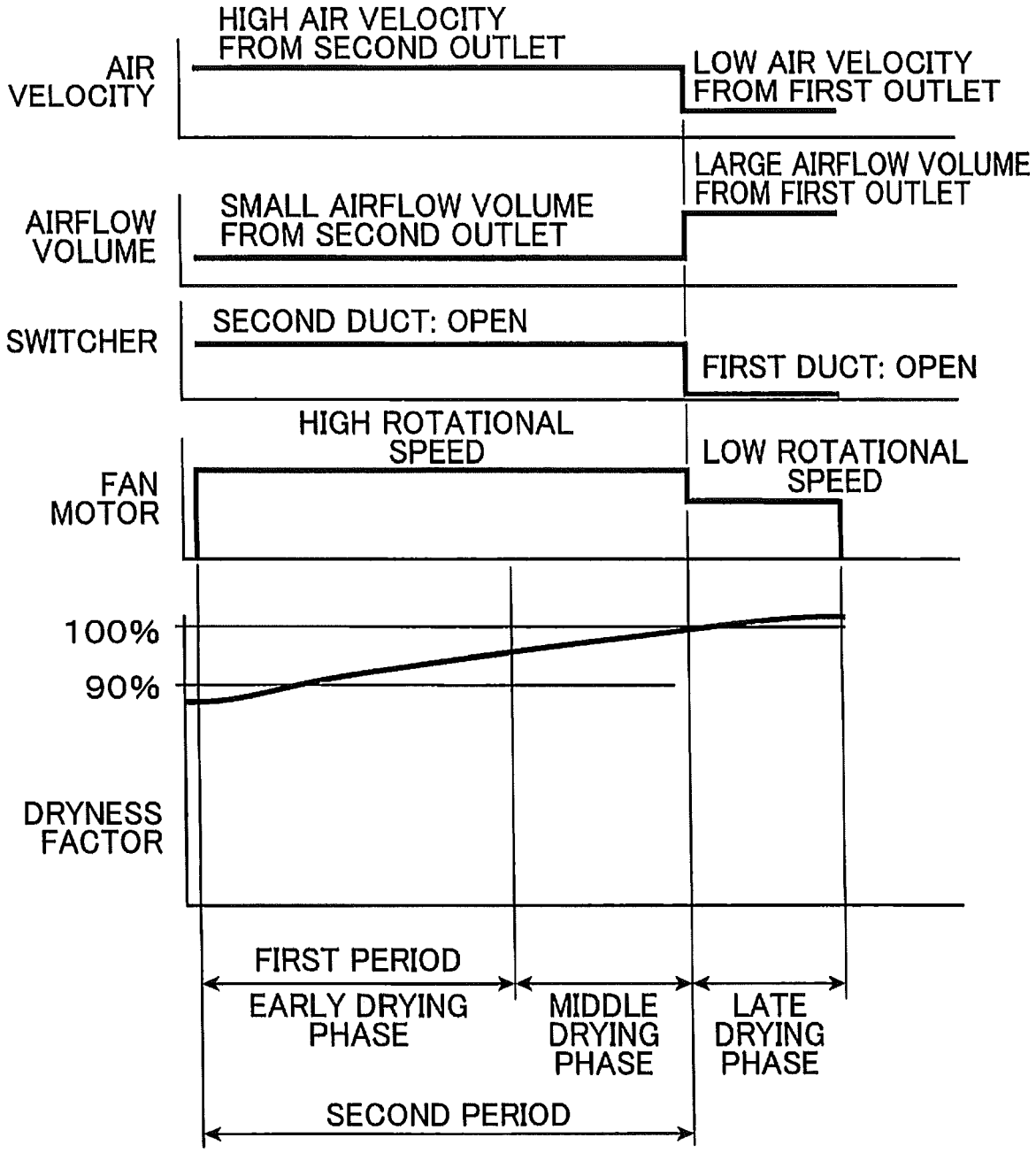

AIR VELOCITY
HIGH AIR VELOCITY FROM SECOND OUTLET
LOW AIR VELOCITY FROM FIRST OUTLET
AIRFLOW VOLUME
SMALL AIRFLOW VOLUME FROM SECOND OUTLET
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
SWITCHER
SECOND DUCT: OPEN
FIRST DUCT: OPEN
FAN MOTOR
HIGH ROTATIONAL SPEED
LOW ROTATIONAL SPEED
100%
90%
DRYNESS FACTOR
FIRST PERIOD
EARLY DRYING PHASE
MIDDLE DRYING PHASE
LATE DRYING PHASE
SECOND PERIOD

FIG.6

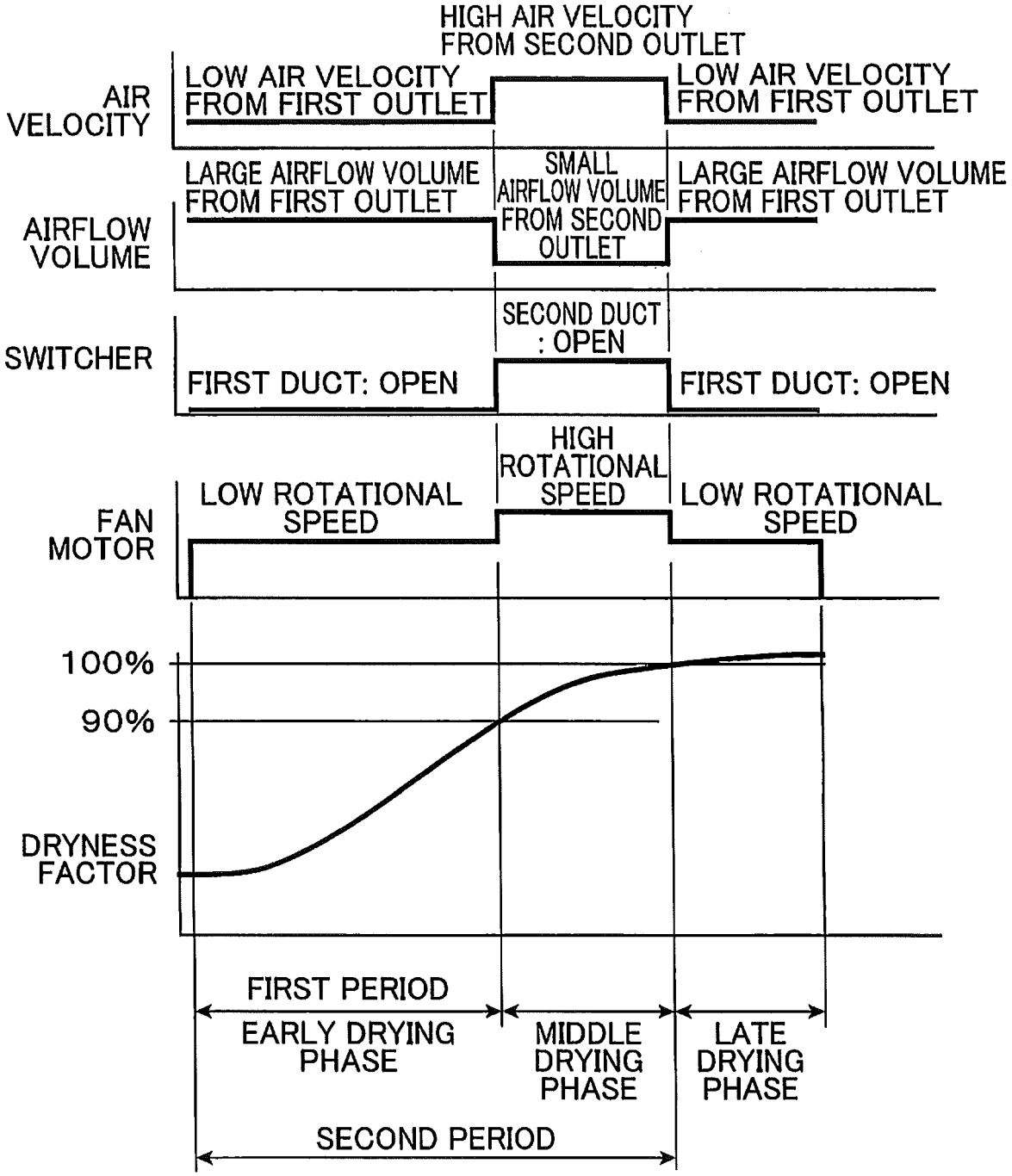

HIGH AIR VELOCITY
FROM SECOND OUTLET
AIR VELOCITY
LOW AIR VELOCITY FROM FIRST OUTLET
LOW AIR VELOCITY FROM FIRST OUTLET
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
SMALL AIRFLOW VOLUME FROM SECOND OUTLET
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
AIRFLOW VOLUME
SECOND DUCT : OPEN
SWITCHER
FIRST DUCT: OPEN
FIRST DUCT: OPEN
HIGH ROTATIONAL SPEED
LOW ROTATIONAL SPEED
LOW ROTATIONAL SPEED
FAN MOTOR
100%
90%
DRYNESS FACTOR
FIRST PERIOD
EARLY DRYING PHASE
MIDDLE DRYING PHASE
LATE DRYING PHASE
SECOND PERIOD

FIG.7

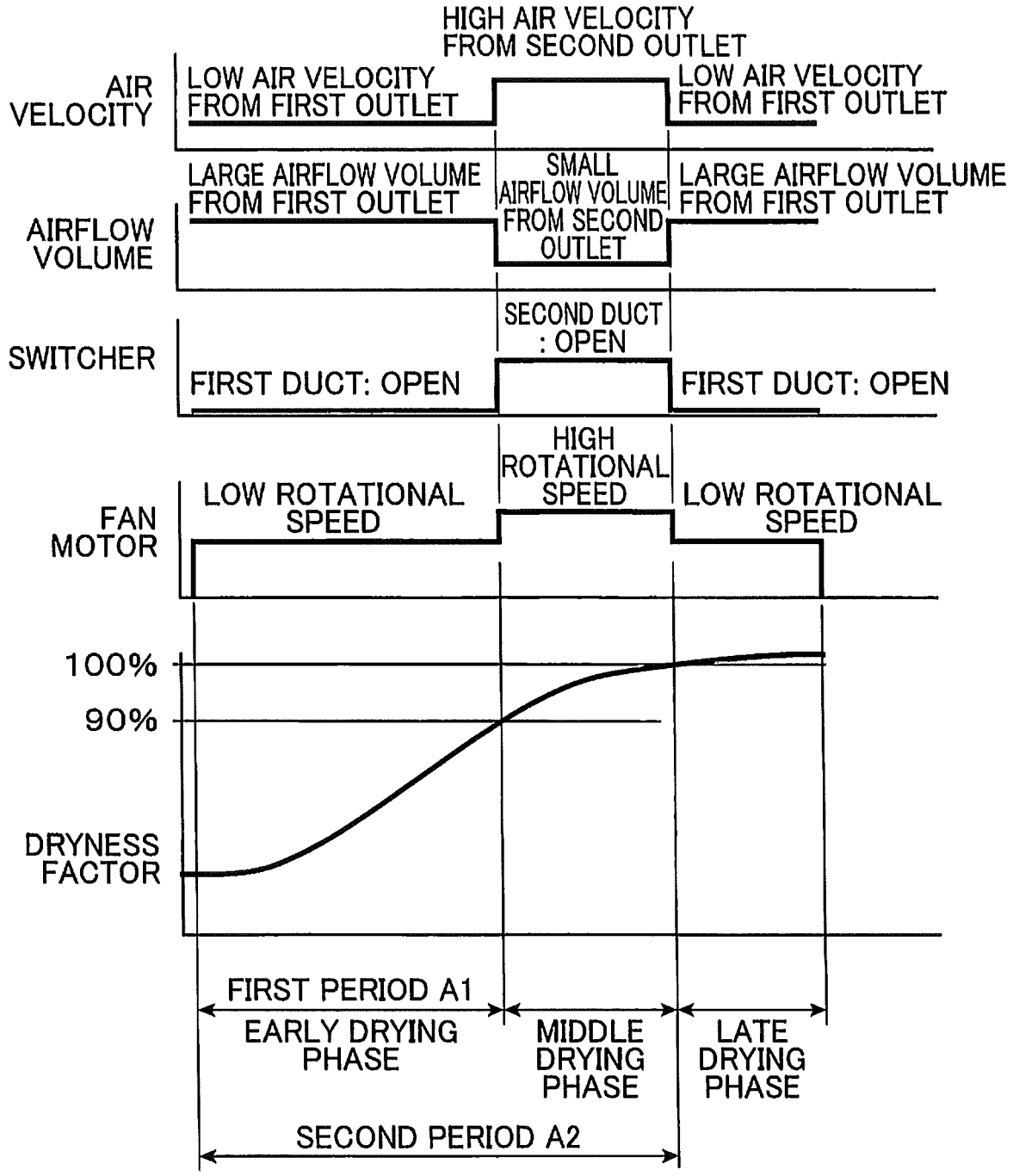

HIGH AIR VELOCITY FROM SECOND OUTLET
AIR VELOCITY
LOW AIR VELOCITY FROM FIRST OUTLET
LOW AIR VELOCITY FROM FIRST OUTLET
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
SMALL AIRFLOW VOLUME FROM SECOND OUTLET
LARGE AIRFLOW VOLUME FROM FIRST OUTLET
AIRFLOW VOLUME
SECOND DUCT : OPEN
SWITCHER
FIRST DUCT: OPEN
FIRST DUCT: OPEN
HIGH ROTATIONAL SPEED
LOW ROTATIONAL SPEED
LOW ROTATIONAL SPEED
FAN MOTOR
100%
90%
DRYNESS FACTOR
FIRST PERIOD A1
EARLY DRYING PHASE
MIDDLE DRYING PHASE
LATE DRYING PHASE
SECOND PERIOD A2

FIG.8

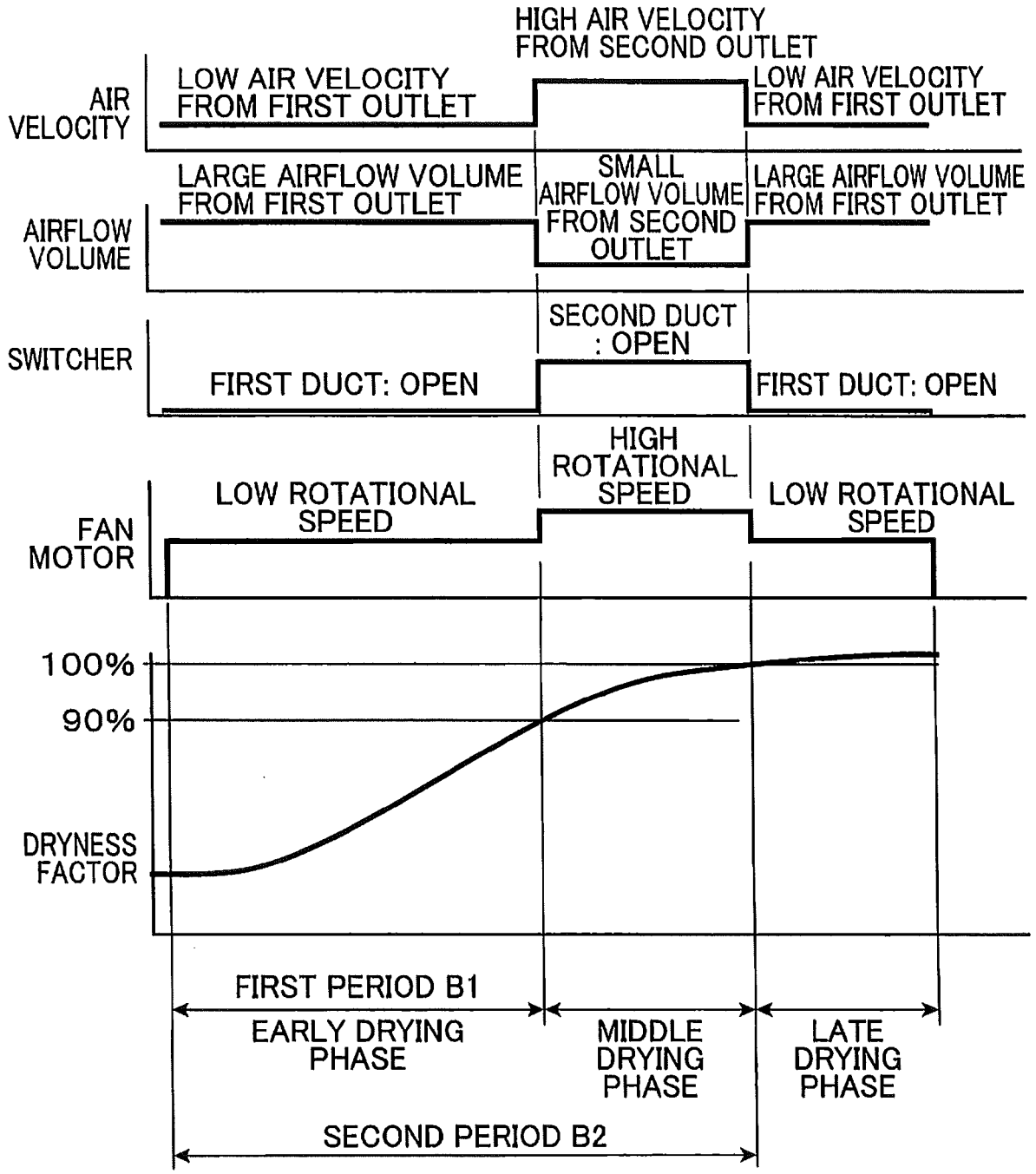
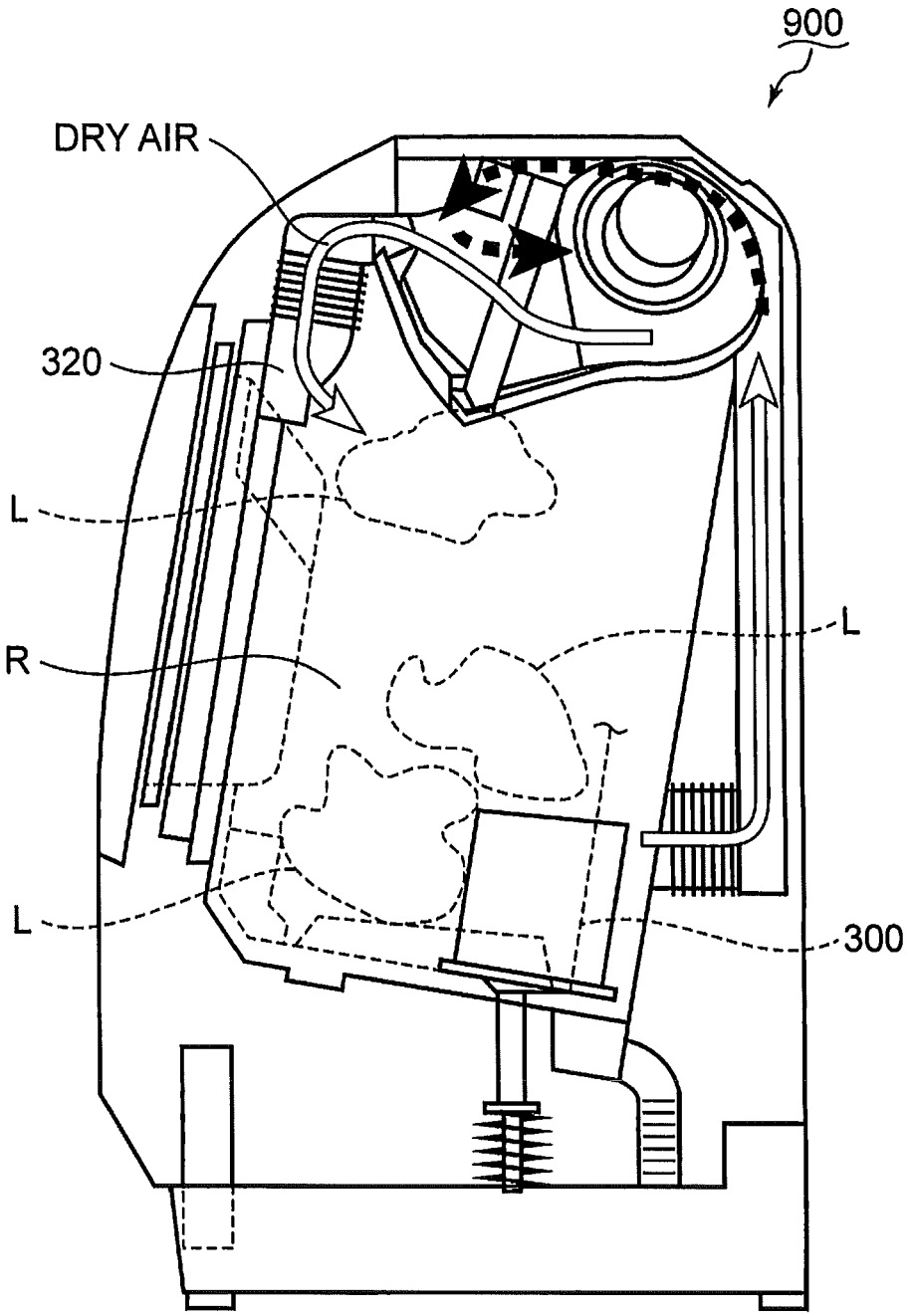

HIGH AIR VELOCITY
FROM SECOND OUTLET
AIR VELOCITY
LOW AIR VELOCITY
FROM FIRST OUTLET
LOW AIR VELOCITY
FROM FIRST OUTLET
AIRFLOW VOLUME
LARGE AIRFLOW VOLUME
FROM FIRST OUTLET
SMALL
AIRFLOW VOLUME
FROM SECOND
OUTLET
LARGE AIRFLOW VOLUME
FROM FIRST OUTLET
SWITCHER
SECOND DUCT
: OPEN
FIRST DUCT: OPEN
FIRST DUCT: OPEN
FAN MOTOR
LOW ROTATIONAL
SPEED
HIGH
ROTATIONAL
SPEED
LOW ROTATIONAL
SPEED
100%
90%
DRYNESS
FACTOR
FIRST PERIOD B1
EARLY DRYING
PHASE
MIDDLE
DRYING
PHASE
LATE
DRYING
PHASE
SECOND PERIOD B2

FIG.9



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EUROPEAN SEARCH REPORT

Application Number
EP 11 18 5773

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2009 072501 A (HITACHI APPLIANCES INC) 9 April 2009 (2009-04-09)	1,2,8	INV. D06F25/00 D06F58/04 D06F58/20 D06F58/28
A	* the whole document *	3-7	

X	JP 2006 197963 A (TOSHIBA CORP; TOSHIBA CONSUMER MARKETING; TOSHIBA KADEN SEIZO KK) 3 August 2006 (2006-08-03)	1,2,8	
A	* paragraphs [0043], [0047] *	3-7	

TECHNICAL FIELDS SEARCHED (IPC)

D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 January 2012	Jezierski, Krzysztof

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16-01-2012

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