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(54) **LAUNDRY PROCESSING APPARATUS**

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(57) **ABSTRACT**

The present application discloses a laundry processing apparatus including: a storage tub which stores laundry; a steam supply mechanism which supplies steam to the storage tub; and a water supply valve which supplies water from an external water source to the steam supply mechanism. The steam supply mechanism includes: a water storage tank storing the water, which is supplied from the water supply value; a steam generator which generates the steam; and a pump which supplies the water in the water storage tank to the steam generator.

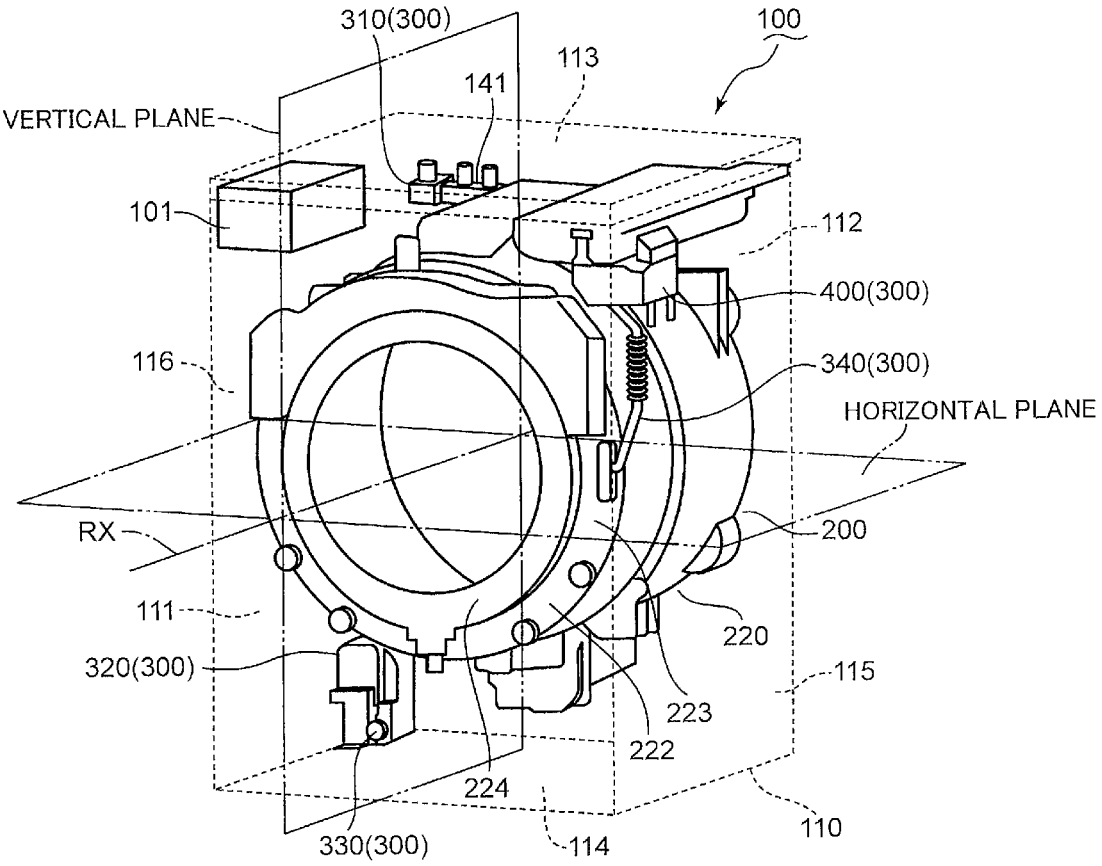


FIG.1

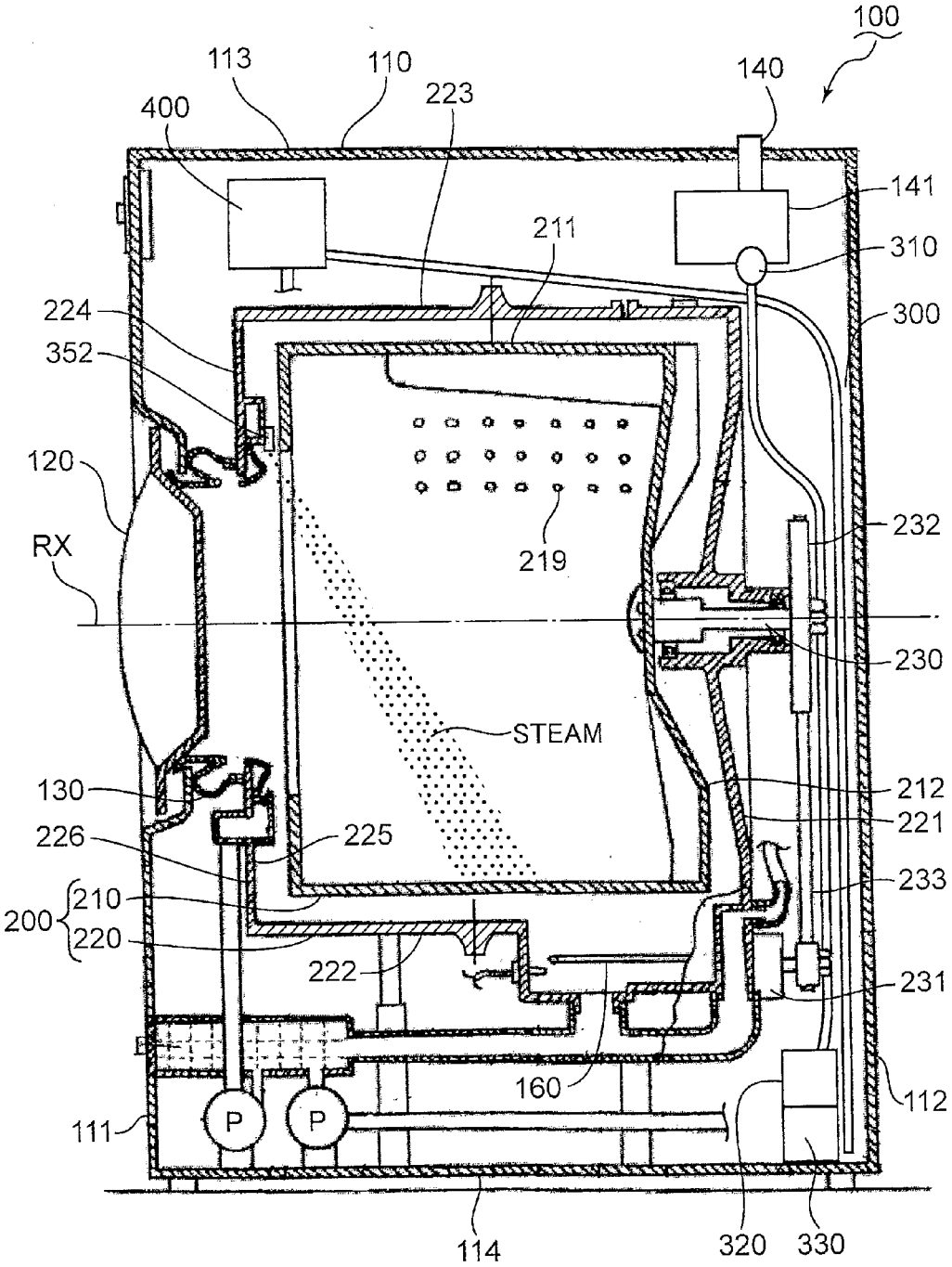

100
113
110
223
140
400
141
211
310
224
300
352
120
219
232
RX
230
STEAM
130
212
221
226
225
233
210
200
220
222
231
160
112
111
P
P
114
320
330

FIG.2

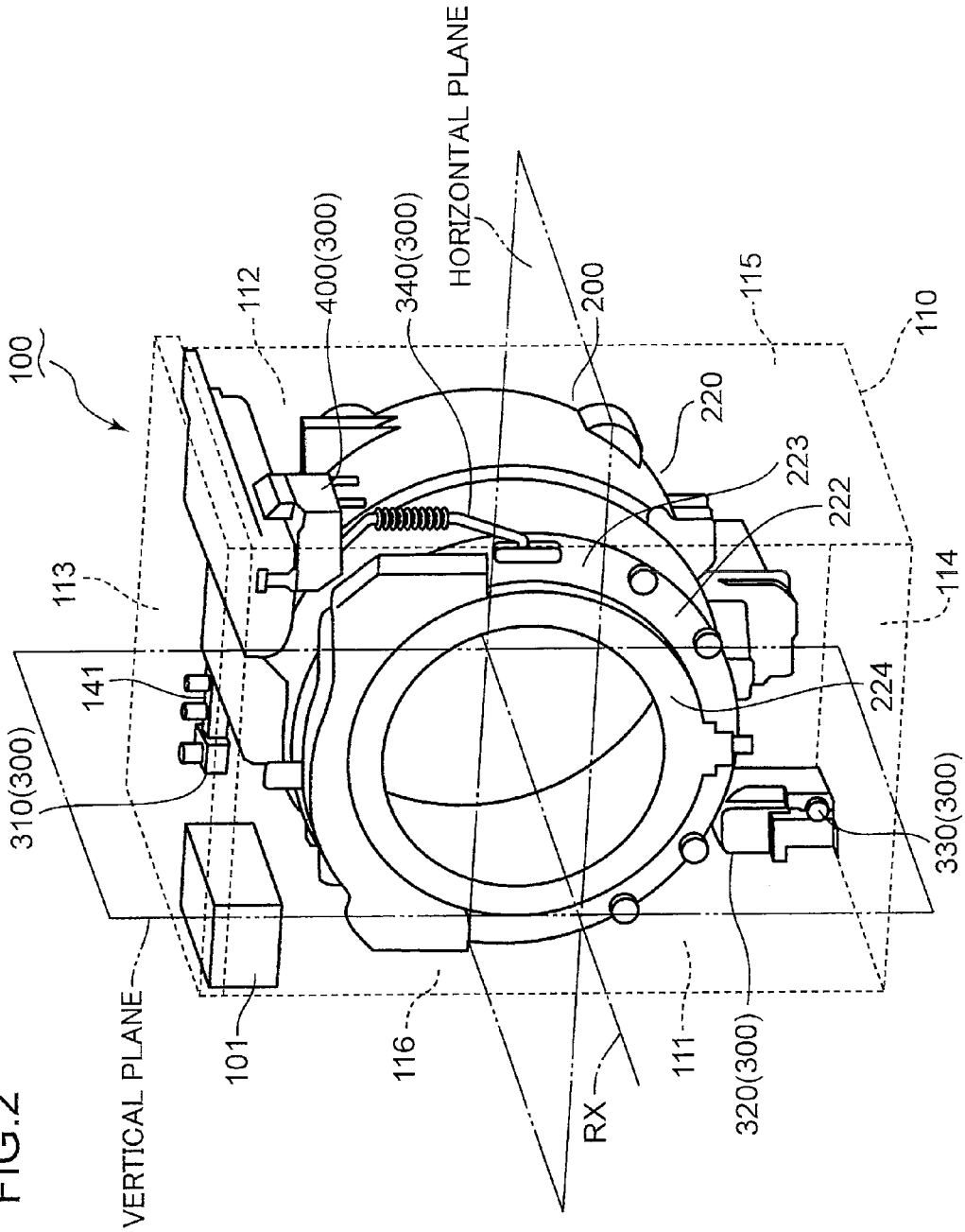

100
112
400(300)
340(300)
HORIZONTAL PLANE
200
115
110
220
223
222
114
113
141
224
310(300)
330(300)
VERTICAL PLANE
101
116
111
320(300)
RX

FIG.3

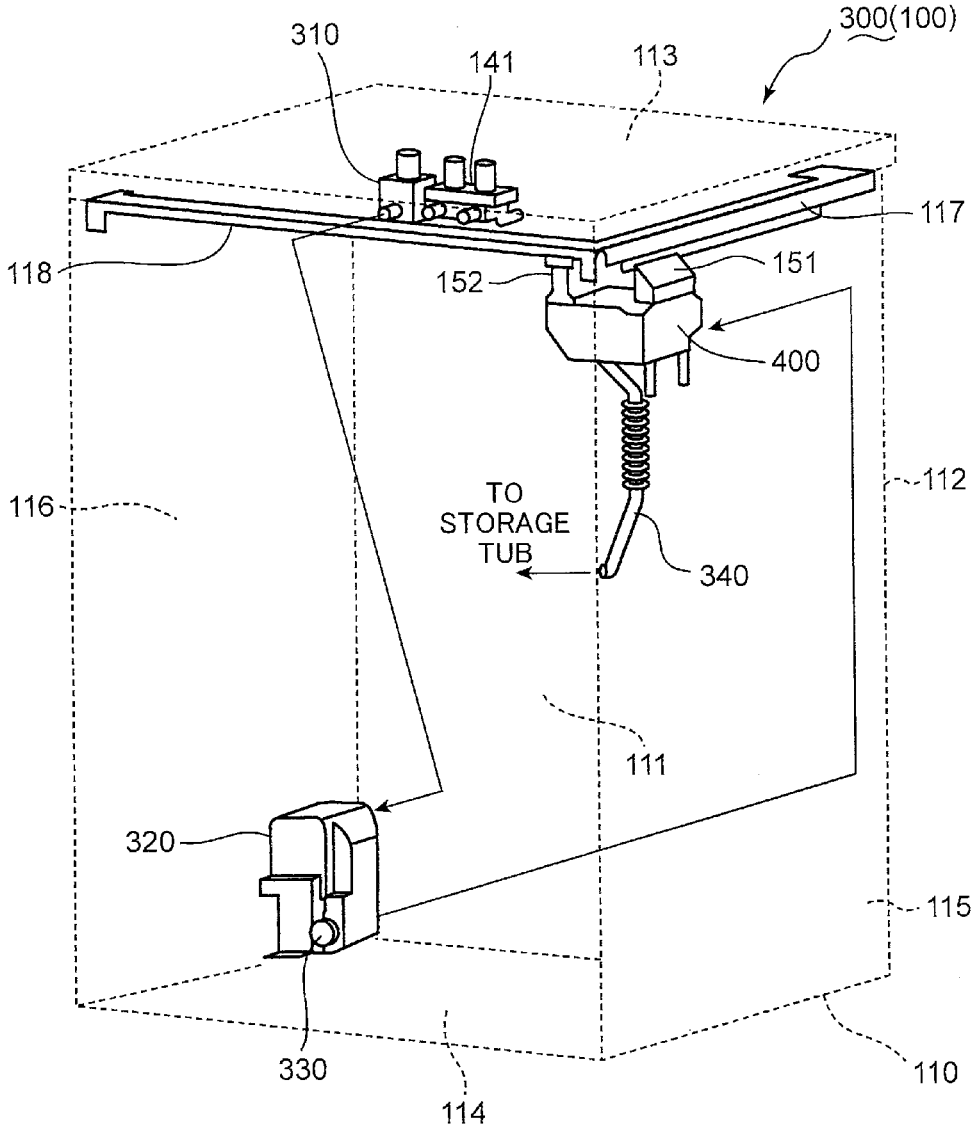

300(100)
310
141
113
117
118
152
151
400
112
116
TO
STORAGE
TUB
340
111
320
115
330
110
114

FIG.4A

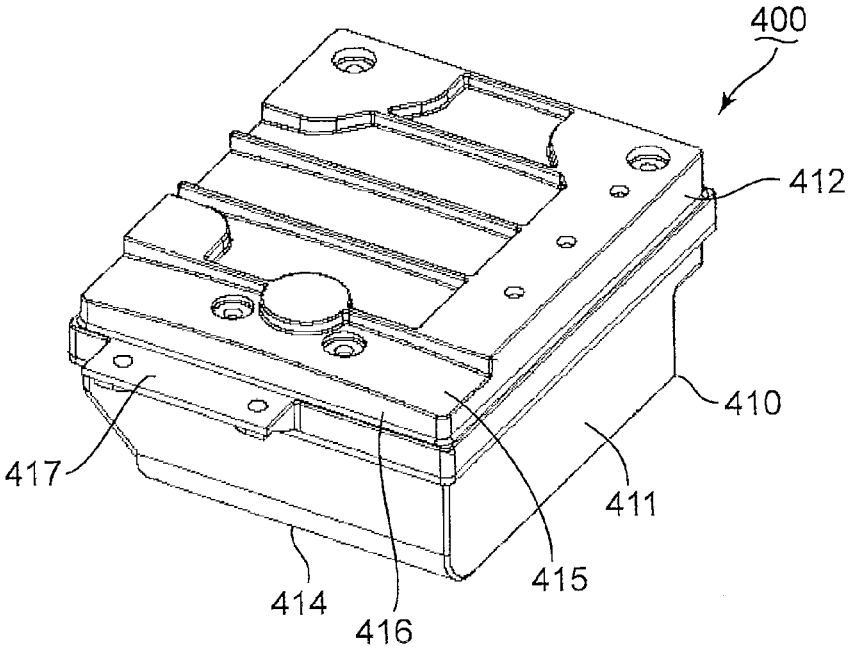

400
412
410
417
411
415
414
416

FIG.4B

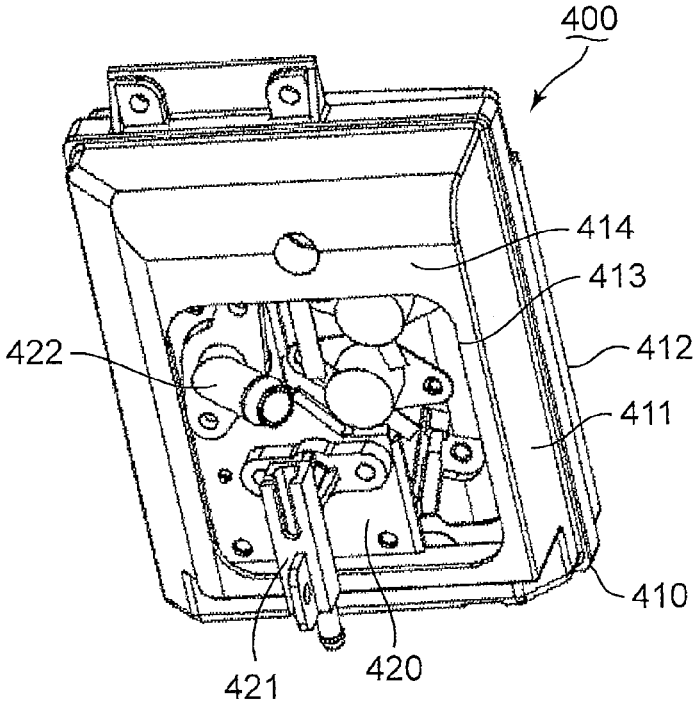

400
414
413
422
412
411
410
421
420

FIG.5

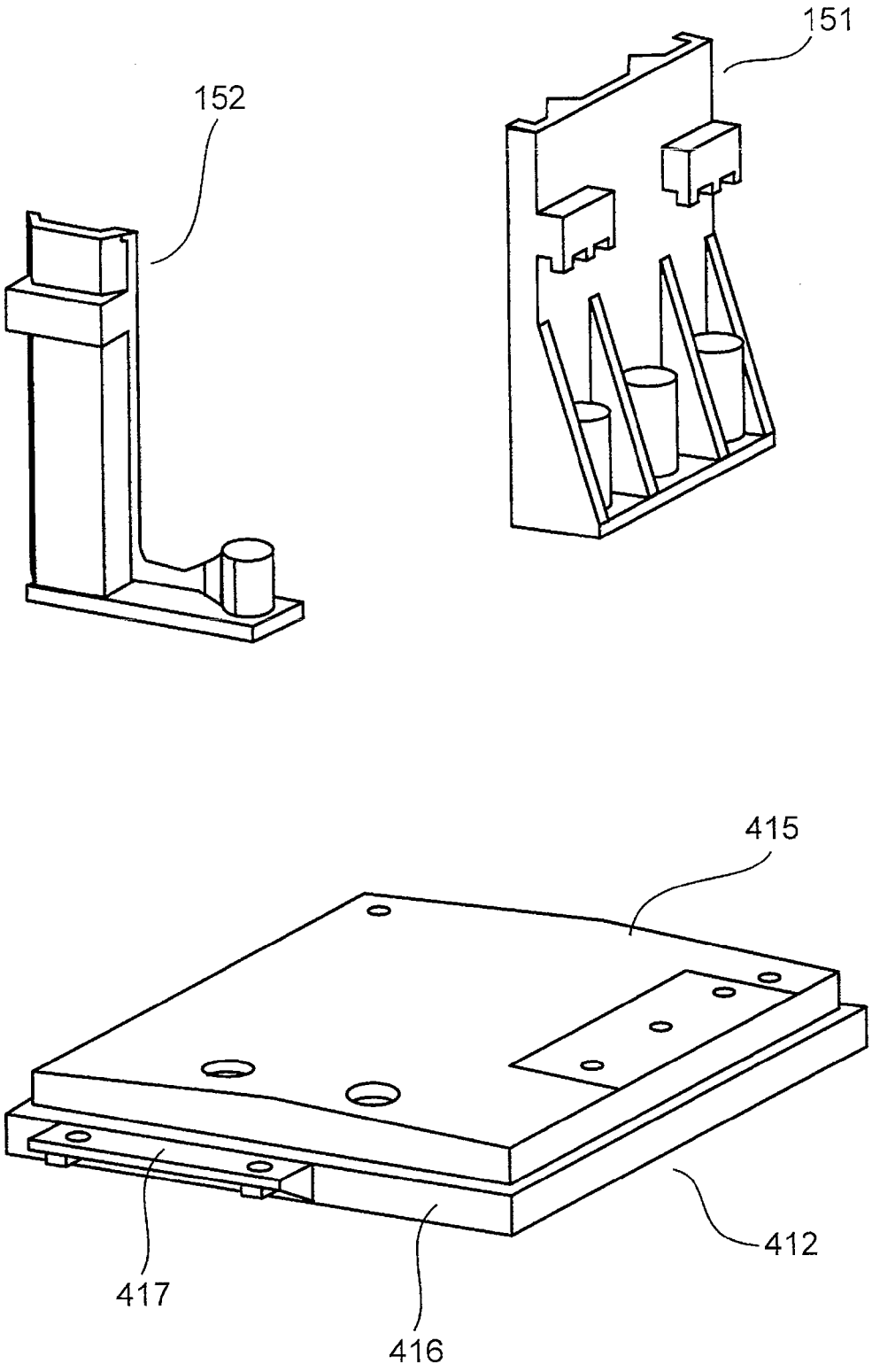


FIG.6A

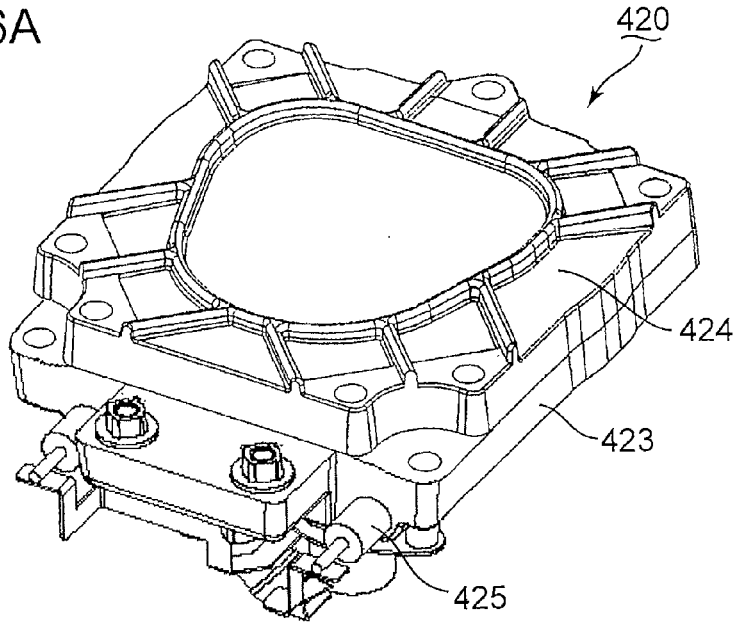


FIG.6B

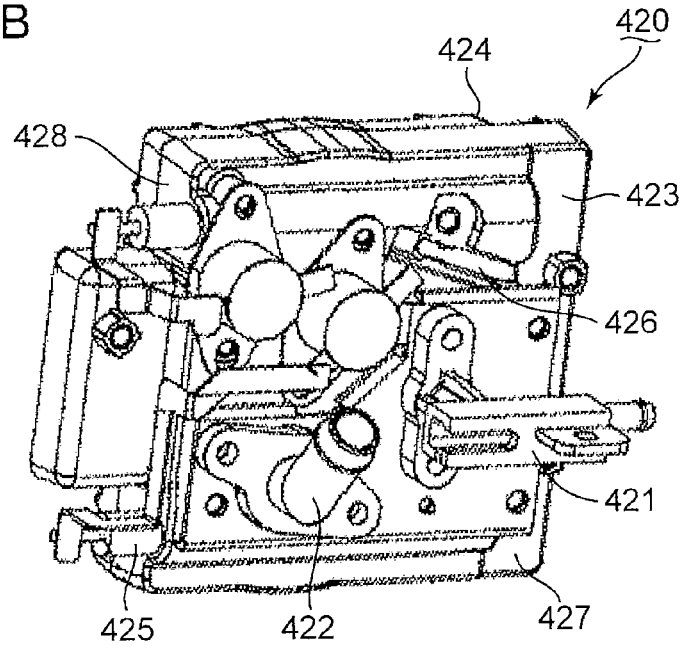


FIG.7

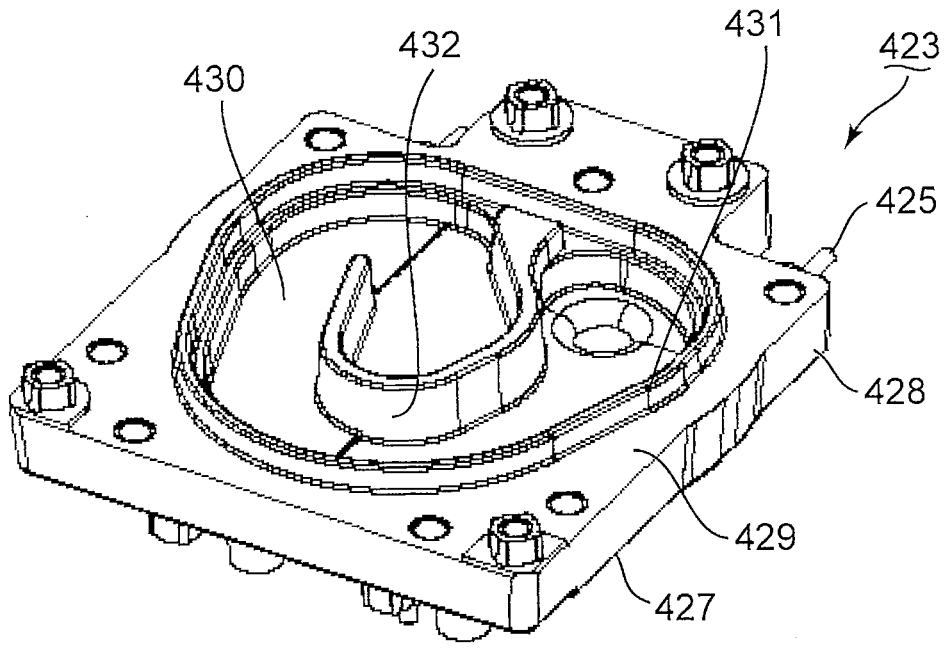


FIG.8

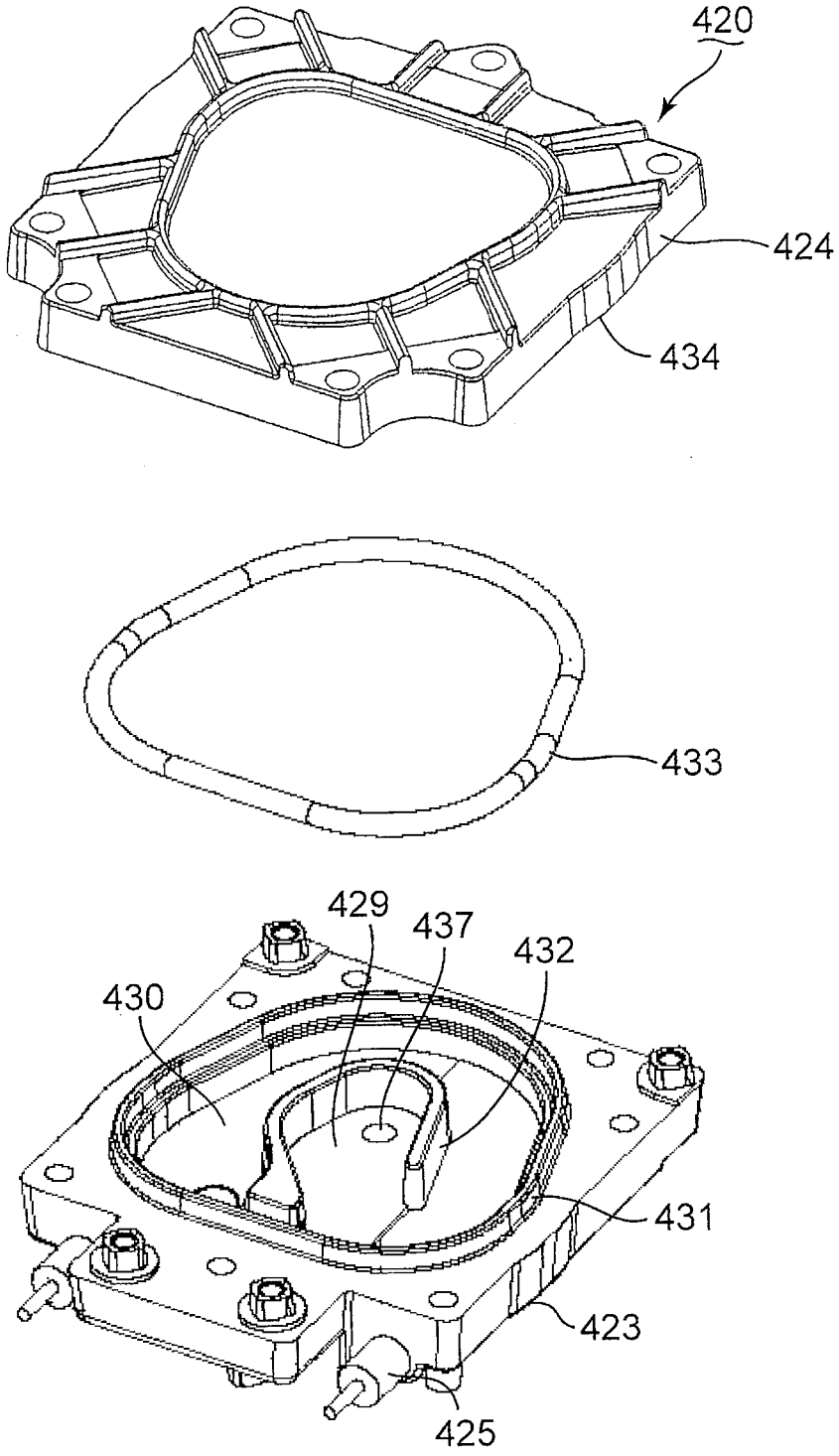


FIG.9

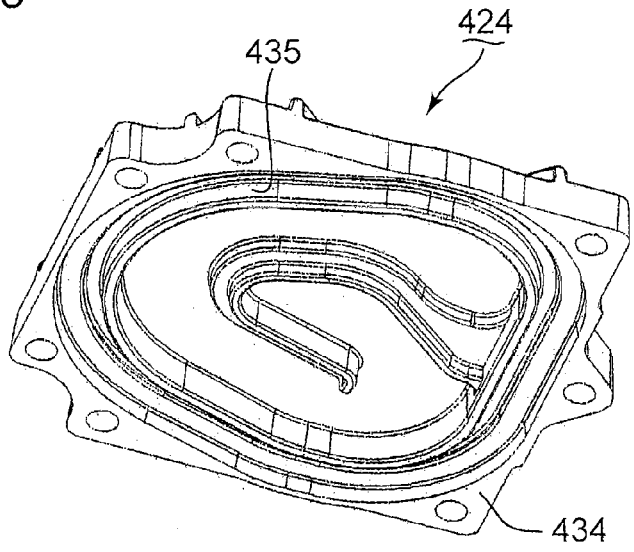


FIG.10

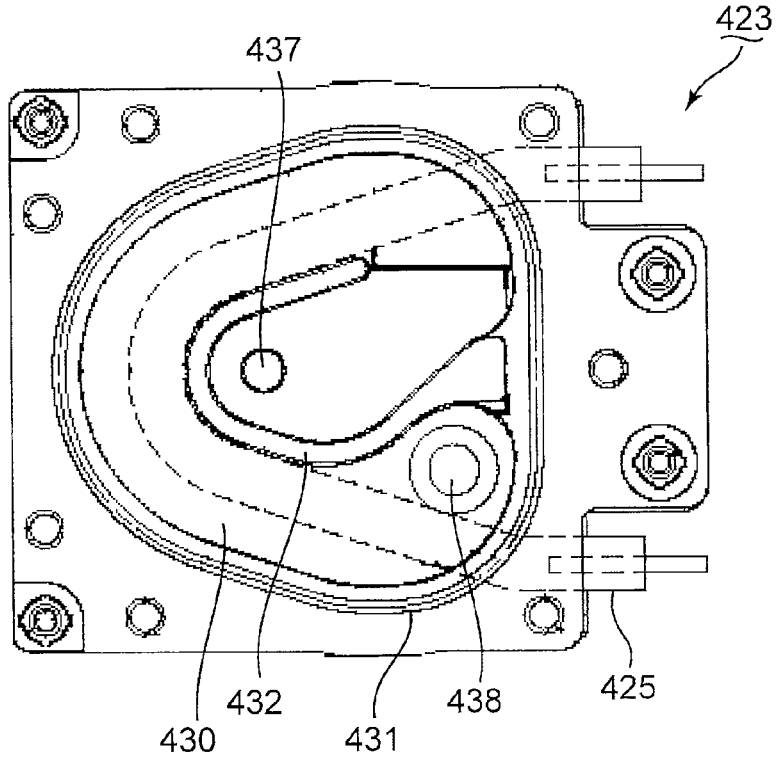


FIG.11

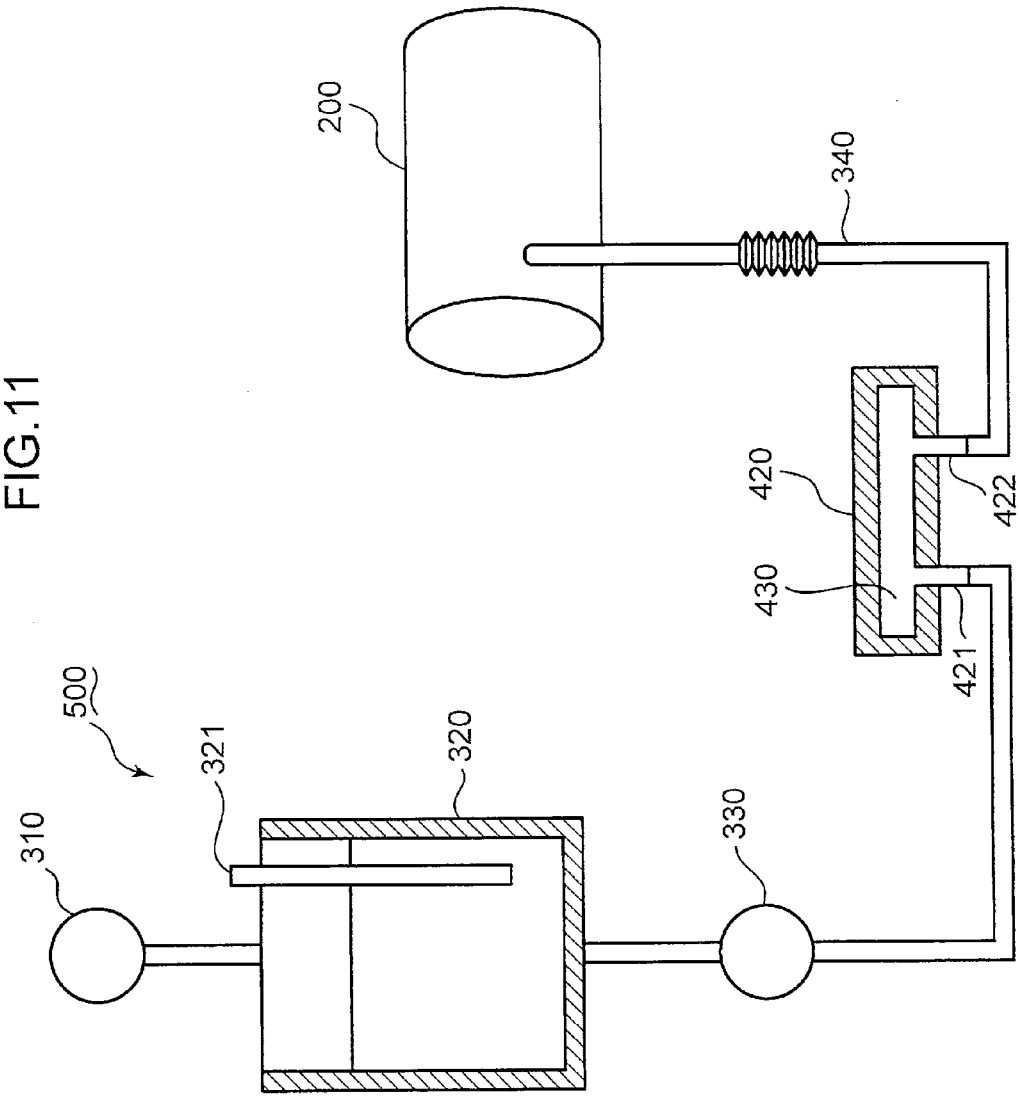


FIG.12

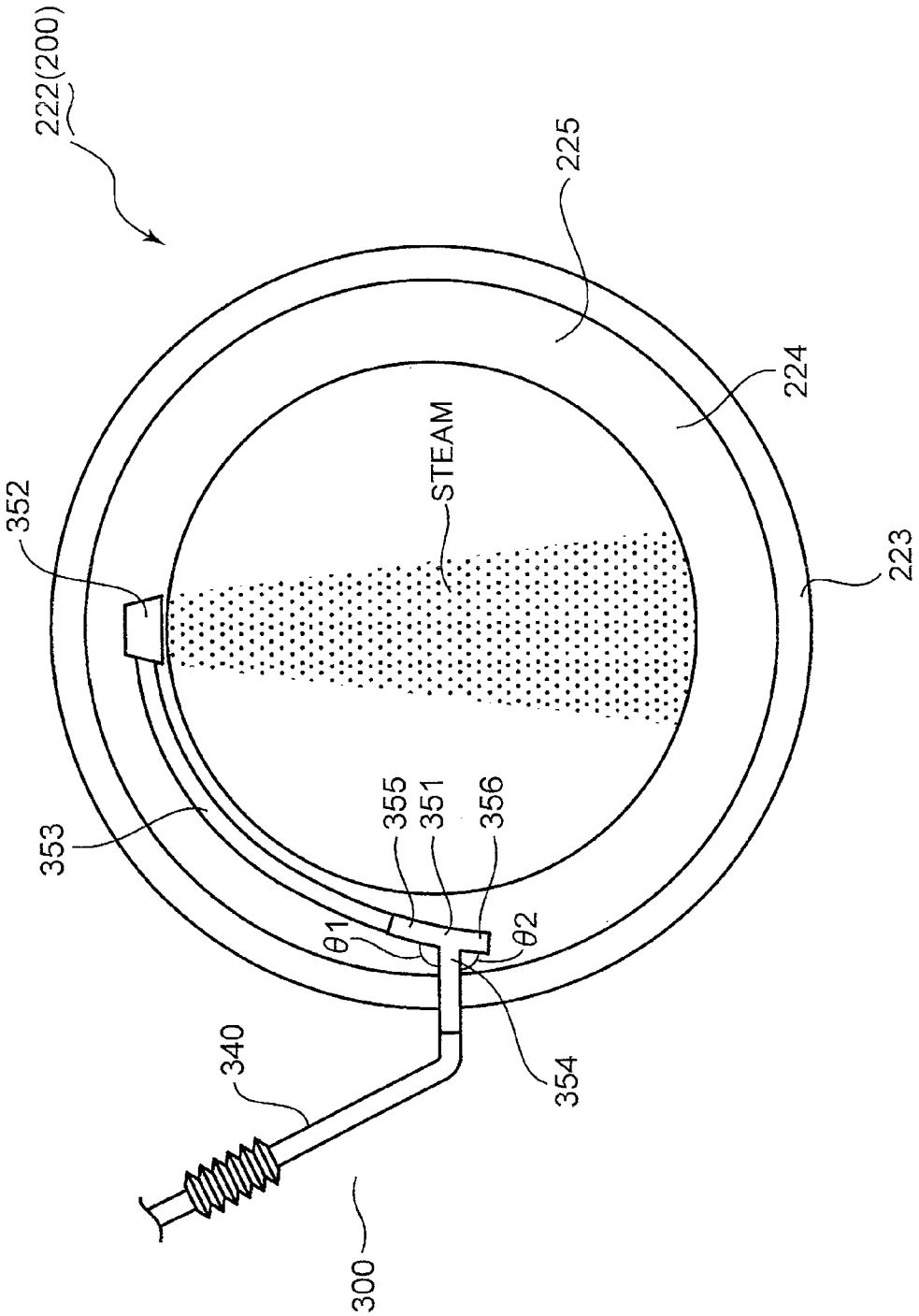


FIG.13

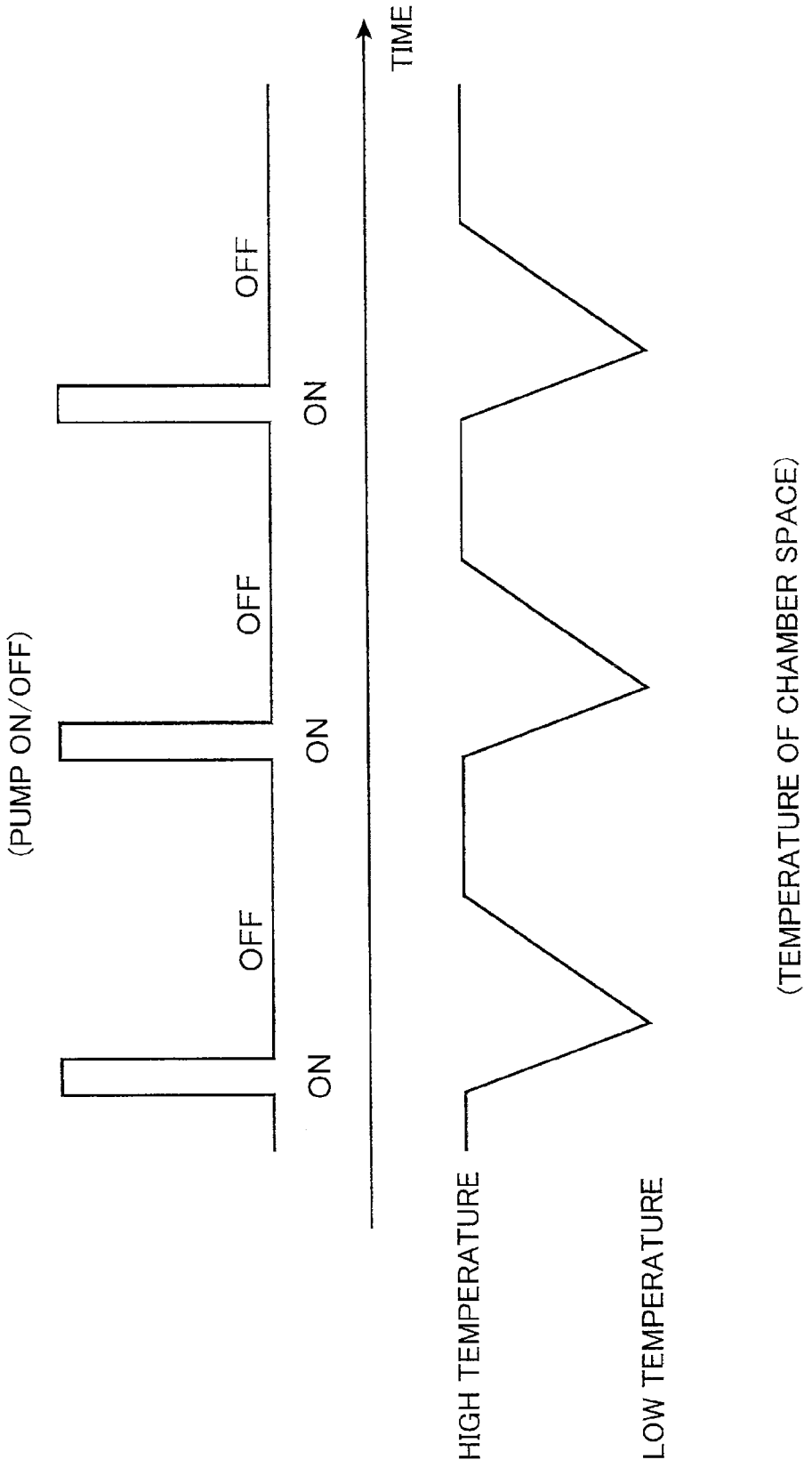

(PUMP ON/OFF)
ON
OFF
ON
OFF
ON
OFF
TIME
HIGH TEMPERATURE
LOW TEMPERATURE
(TEMPERATURE OF CHAMBER SPACE)

FIG.14

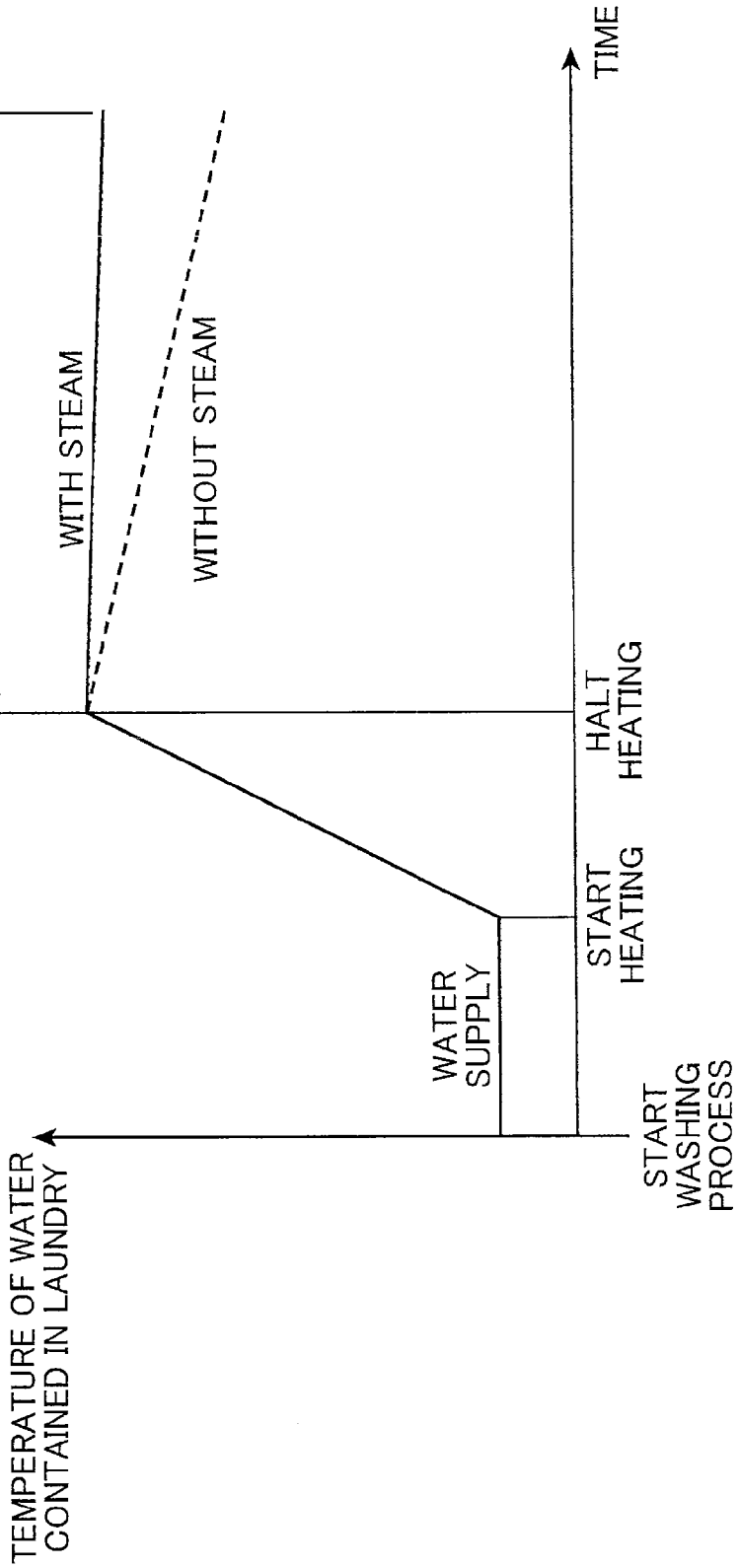

TEMPERATURE OF WATER CONTAINED IN LAUNDRY
TIME
STEAM SUPPLY PERIOD
WITH STEAM
WITHOUT STEAM
WATER SUPPLY
START HEATING
HALT HEATING
START WASHING PROCESS

FIG.15A

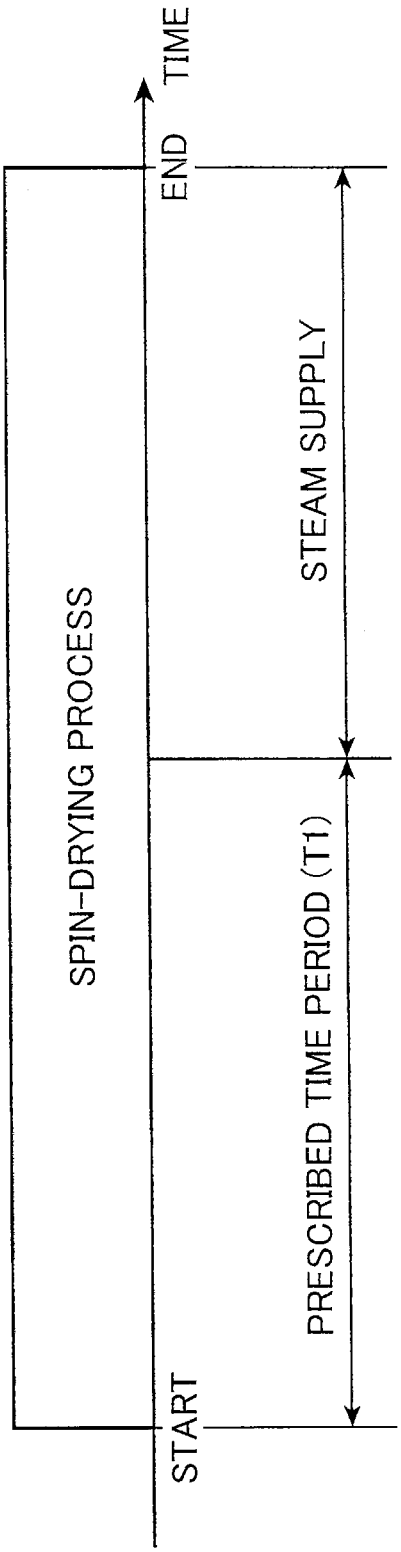

TIME
END
STEAM SUPPLY
SPIN-DRYING PROCESS
PRESCRIBED TIME PERIOD (T1)
START

FIG.15B

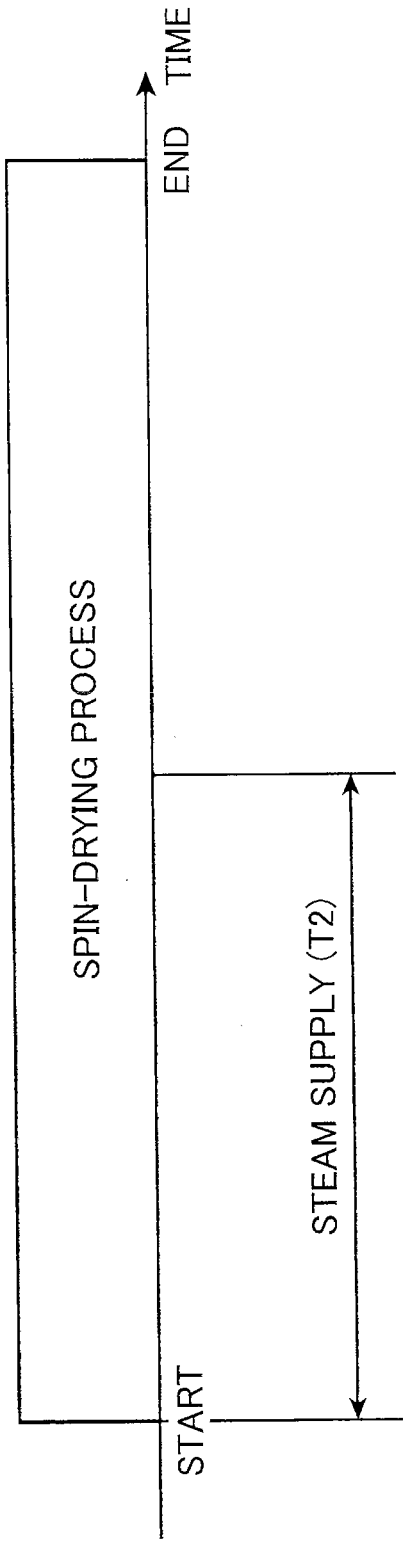


FIG.15C

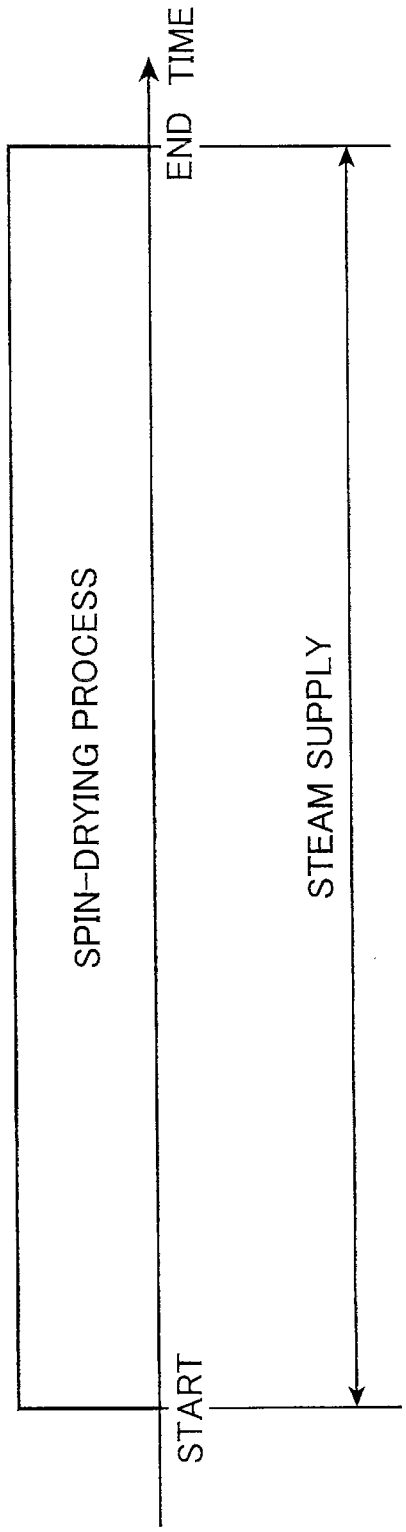


FIG.16

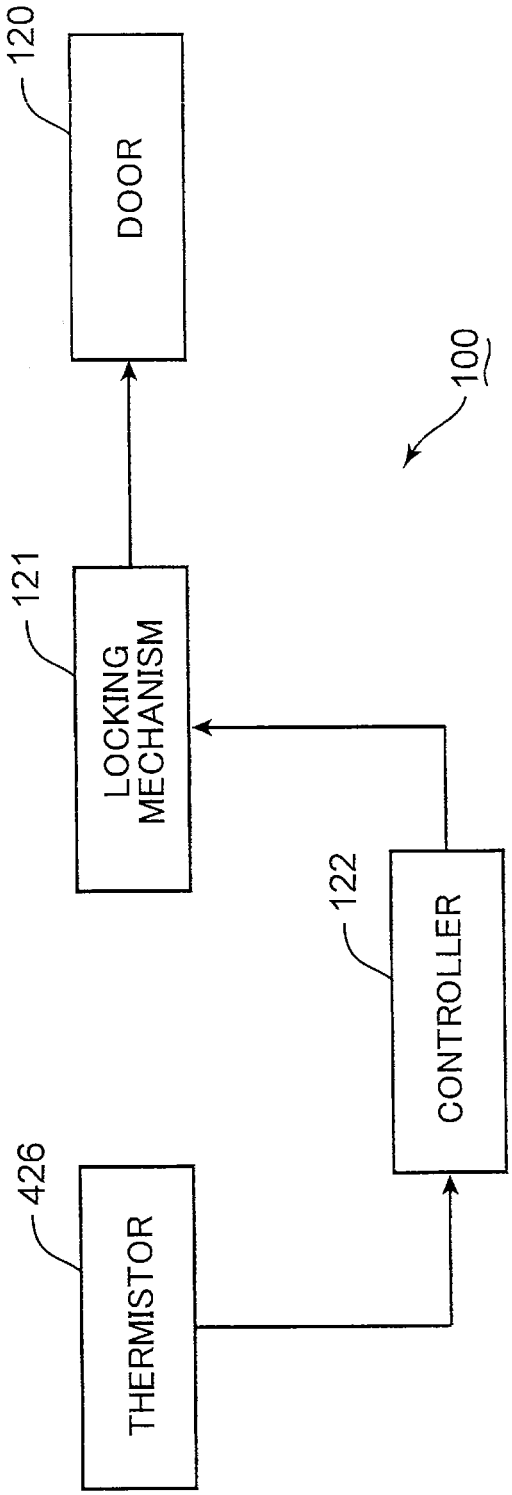

120
DOOR
100
121
LOCKING MECHANISM
122
CONTROLLER
426
THERMISTOR

FIG.17

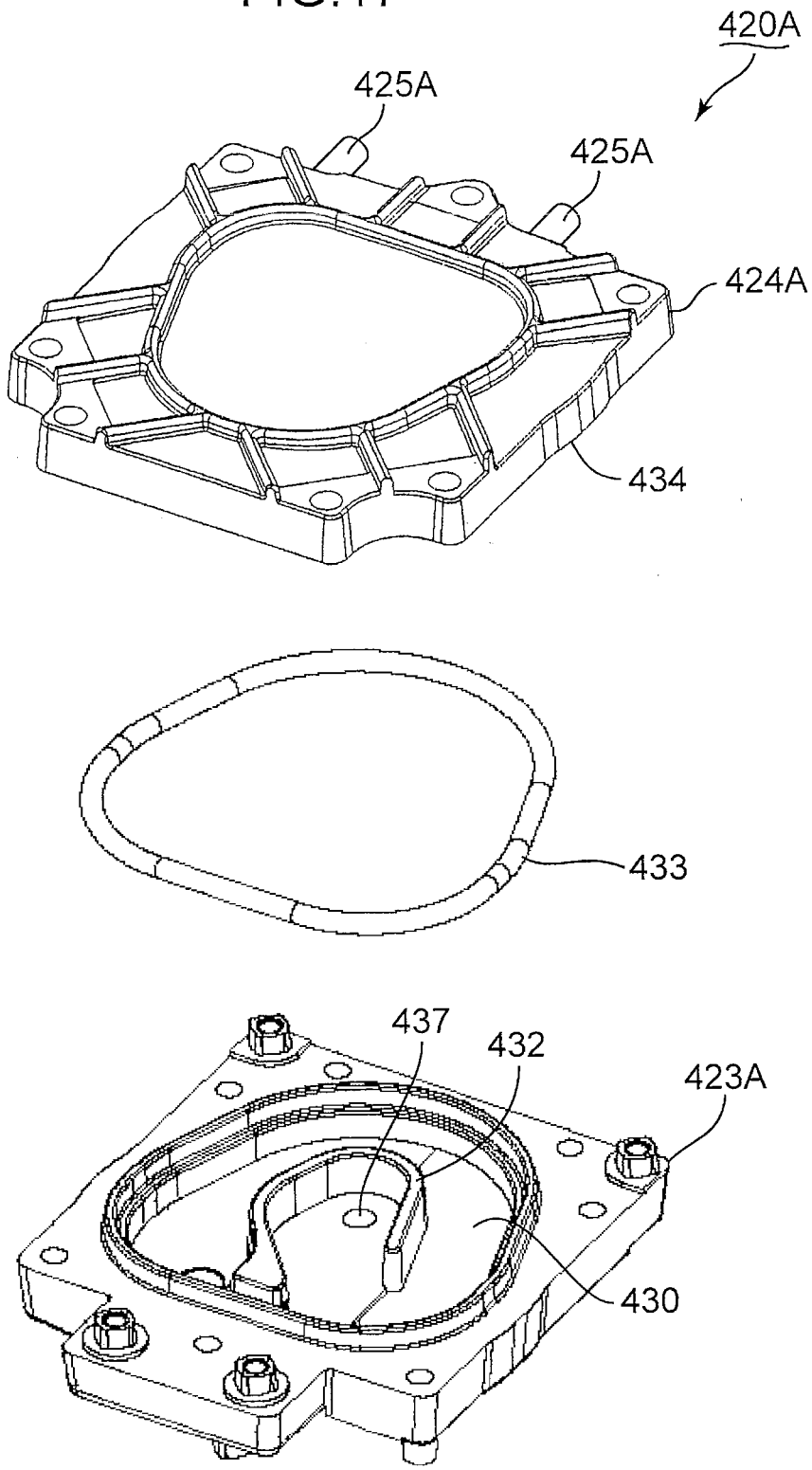
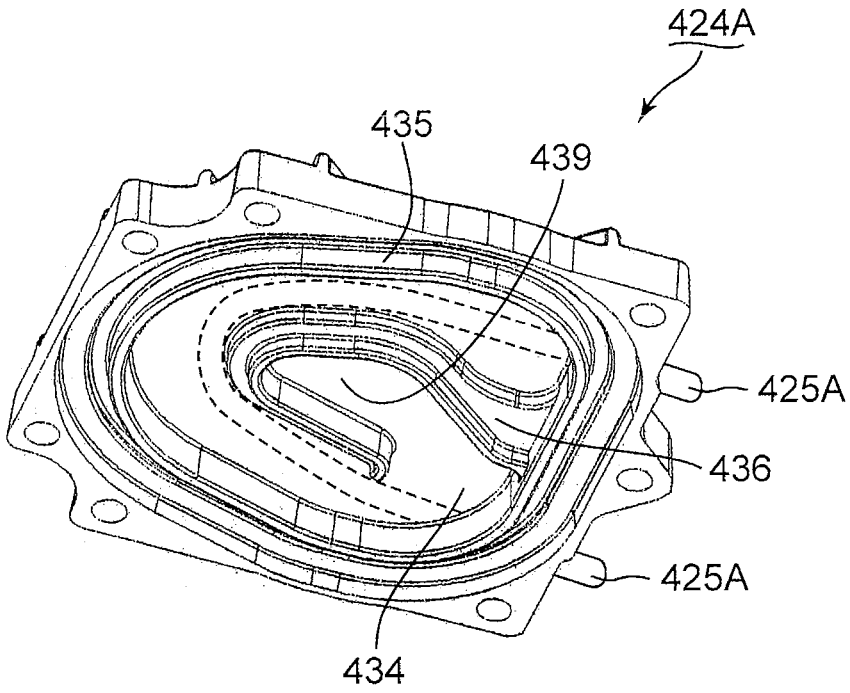


FIG.18



LAUNDRY PROCESSING APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a laundry processing apparatus for washing, spin-drying and/or drying laundry.

BACKGROUND ART

[0002] Washing machines which supply steam to laundry for sterilization have been developed (Patent Documents 1 and 2). The washing machine according to Patent Document 1 generates steam by using a heater immersed in water.

[0003] The washing machines according to Patent Documents 1 and 2 supply steam to a drum in which laundry is stored. However, because of a low pressure of steam supplied to the drum, a space inside the drum has to be filled with the steam. Consequently, the washing machines according to Patent Documents 1 and 2 consume a large amount of power in order to generate steam.

[0004] Patent Document 1: EP2039823

[0005] Patent Document 2: EP2044255

SUMMARY OF THE INVENTION

[0006] It is an object of the present invention to provide a laundry processing apparatus with a structure to efficiently supply steam to laundry.

[0007] The laundry processing apparatus according to one aspect of the present invention includes: a storage tub which stores laundry; a steam supply mechanism which supplies steam to the storage tub; and a water supply valve for supplying water from an external water source to the steam supply mechanism. The steam supply mechanism includes: a water storage tank which stores the water which is supplied from the water supply value; a steam generator which generates the steam; and a pump which supplies the water in the water storage tank to the steam generator.

[0008] The laundry processing apparatus according to the present invention may supply steam to laundry efficiently.

[0009] The objects, features and advantages of the present invention will become more apparent from the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic vertical cross-sectional view of a washing machine exemplified as the laundry processing apparatus according to the first embodiment.

[0011] FIG. **2** is a schematic perspective view of the washing machine shown in FIG. **1**.

[0012] FIG. **3** is a schematic perspective view of a steam supply mechanism stored in a housing of the washing machine shown in FIG. **1**.

[0013] FIG. **4**A is a schematic perspective view of a steam generating portion of the steam supply mechanism shown in FIG. **3**.

[0014] FIG. **4**B is a schematic perspective view of the steam generating portion of the steam supply mechanism shown in FIG. **3**.

[0015] FIG. **5** is a schematic perspective view of an attachment structure which connects a lid portion of the steam generating portion shown in FIGS. **4**A and **4**B to the housing.

[0016] FIG. **6**A is a schematic perspective view of a steam generator of the steam generating portion shown in FIGS. **4**A and **4**B.

[0017] FIG. **6**B is a schematic perspective view of the steam generator of the steam generating portion shown in FIGS. **4**A and **4**B.

[0018] FIG. **7** is a schematic perspective view of a main piece of the steam generator shown in FIGS. **6**A and **6**B.

[0019] FIG. **8** is a schematic exploded perspective view of the steam generator shown in FIGS. **6**A and **6**B.

[0020] FIG. **9** is a schematic perspective view of a lid piece of the steam generator shown in FIG. **8**.

[0021] FIG. **10** is a schematic plan view of the main piece shown in FIG. **7**.

[0022] FIG. **11** is a schematic view of a water supply mechanism in the steam supply mechanism shown in FIG. **3**.

[0023] FIG. **12** is a schematic back view of a front portion of a storage tub of the washing machine shown in FIG. **1**.

[0024] FIG. **13** is a graph schematically showing a relationship between intermittent operation of a pump of the water supply mechanism shown in FIG. **11** and an internal temperature in a chamber space.

[0025] FIG. **14** is a graph schematically showing a change in a temperature of the water supplied to a water tank of the washing machine shown in FIG. **1**.

[0026] FIG. **15**A is a schematic timing chart showing steam supply timings during a spin-drying process.

[0027] FIG. **15**B is a schematic timing chart showing steam supply timings during the spin-drying process.

[0028] FIG. **15**C is a schematic timing chart showing steam supply timings during the spin-drying process.

[0029] FIG. **16** is a block diagram schematically showing control of a door, in response to a temperature of the steam generator shown in FIG. **6**B.

[0030] FIG. **17** is a schematic expanded perspective view of a steam generator which is used in a washing machine exemplified as the laundry processing apparatus according to the second embodiment.

[0031] FIG. **18** is a schematic perspective view of the steam generator shown in FIG. **17**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] A laundry machine exemplified as the laundry processing apparatus is described hereinafter with reference to the drawings. Following directional terms such as "up", "down", "left" and "right" are simply intended to clarify the description. Therefore, these terms do not limit principles of the laundry processing apparatus in any way. The principles of the laundry processing apparatus may be applied to an apparatus having a washing function and drying function for laundry (washing and drying machine), an apparatus having only a function for drying laundry (drying machine) and an apparatus having only a function for washing laundry (washing machine).

First Embodiment

Washing Machine

[0033] FIG. **1** is a schematic vertical cross-sectional view of the washing machine **100** according to the first embodiment. The washing machine **100** is described with reference to FIG. **1**.

[0034] The washing machine **100** includes a housing **110** and a storage tub **200** which stores laundry in the housing **110**. The storage tub **200** includes a rotary drum **210**, which has a

substantially cylindrical peripheral wall **211** surrounding a rotational axis RX, and a water tank **220**, which stores the rotary drum **210**.

[0035] The housing **110** includes a front wall **111** provided with a loading opening to load laundry into the storage tub **200**, and a rear wall **112** opposite to the front wall **111**. The rotary drum **210** and the water tank **220** open towards the front wall **111**.

[0036] The washing machine **100** further includes a door **120** which is attached to the front wall **111**. The door **120** rotates between a closed position, at which the door closes the loading opening formed in the front wall **111**, and an open position, at which the door opens the loading opening. A user may rotate the door **120** to the open position and load laundry into the storage tub **200** through the loading opening in the front wall **111**. The user may then move the door **120** to the closed position and make the washing machine **100** wash the laundry. The door **120** shown in FIG. **1** is in the closed position.

[0037] The rotary drum **210** rotates about the rotational axis RX which extends between the front and rear walls **111**, **112**. The laundry loaded into the storage tub **200** moves in the rotary drum **210** with rotation of the rotary drum **210**, and is subjected to various processes such as washing, rinsing and/or spin-drying.

[0038] The rotary drum **210** includes a bottom wall **212** which faces the door **120** at the closed position. The water tank **220** includes a bottom portion **221**, which surrounds the bottom wall **212** and a part of the peripheral wall **211** of the rotary drum **210**, and a front portion **222**, which surrounds the other part of the peripheral wall **211** of the rotary drum **210** between the bottom portion **221** and the door **120**.

[0039] The storage tub **200** includes a rotary shaft **230** which is mounted on the bottom wall **212** of the rotary drum **210**. The rotary shaft **230** extends towards the rear wall **112** along the rotational axis RX. The rotary shaft **230** passes through the bottom portion **221** of the water tank **220** and appears between the water tank **220** and the rear wall **112**.

[0040] The washing machine **100** further includes a motor **231**, which is mounted below the water tank **220**, a pulley **232**, which is mounted on the rotary shaft **230** exposed outside the water tank **220**, and a belt **233** for transmitting a drive force of the motor **231** to the pulley **232**. When the motor **231** operates, the drive force of the motor **231** is transmitted to the belt **233**, the pulley **232** and the rotary shaft **230**. Consequently, the rotary drum **210** rotates in the water tank **220**.

[0041] The washing machine **100** further includes a packing structure **130** which is situated between the front portion **222** of the water tank **220** and the door **120**. The door **120** rotated to the closed position compresses the packing structure **130**. Consequently, the packing structure **130** forms a watertight sealing structure between the door **120** and the front portion **222**.

[0042] The housing **110** includes a housing top wall **113**, which extends substantially horizontally between the front and rear walls **111**, **112**, and a housing bottom wall **114** opposite to the housing top wall **113**. The washing machine **100** further includes a water supply port **140**, which is connected to a faucet (not shown), and a distributing portion **141**, which distributes water supplied through the water supply port **140**. The water supply port **140** appears above the housing top wall **113**. The distributing portion **141** is situated between the housing top wall **113** and the storage tub **200**. In the present embodiment, the faucet is exemplified as the external water source.

[0043] The washing machine **100** further includes a detergent storage portion (described hereinafter), in which detergent is stored, and a steam supply mechanism **300** (described hereinafter) which injects steam towards the storage tub **200**. The distributing portion **141** includes a few water supply valves for supplying water selectively to the storage tub **200**, the detergent storage portion and the steam supply mechanism **300**. In FIG. **1**, the water supply path to the storage tub **200** and the detergent storage portion are not shown. Technologies used in commonly known washing machines are suitable for supplying water to the storage tub **200** and the detergent storage portion.

<Steam Supply Mechanism>

[0044] FIG. **2** is a schematic perspective view of the washing machine **100**. FIG. **3** is a schematic perspective view of the steam supply mechanism **300** which is stored in the housing **110**. In FIGS. **2** and **3**, the housing **110** is indicated by dotted lines. In FIG. **3**, the storage tub **200** is not shown. The arrow in FIG. **3** schematically represents the water supply path. The steam supply mechanism **300** is described with reference to FIGS. **1** to **3**.

[0045] The steam supply mechanism **300** includes a water supply valve **310**, which is used as a part of the distributing portion **141**, and a water storage tank **320**, which is situated below the storage tub **200**. The water supply valve **310** is used in order to control water supply to the water storage tank **320**. When the water supply valve **310** is open, water is supplied from the water supply port **140** to the water storage tank **320**. When the water supply valve **310** is closed, the water supply to the water storage tank **320** is halted.

[0046] The steam supply mechanism **300** further includes a pump **330**, which is installed in the water storage tank **320**, and a steam generating portion **400** which receives the water discharged from the pump **330**. The pump **330** performs water supply operation intermittently or continuously to the steam generating portion **400**. During the intermittent water supply operation, the pump **330** adjusts a water amount so as to cause instantaneous steam generation, and then a suitable water amount is supplied to the steam generating portion **400**. If the pump **330** supplies water continuously to the steam generating portion **400**, impurities (scale) contained in the water used for the steam generation is flushed from the steam generating portion **400**. The steam generating portion **400** is described hereinafter.

[0047] As shown in FIG. **2**, the steam supply mechanism **300** further includes a steam conduit **340** which extends downwards from the steam generating portion **400**. As shown in FIG. **1**, the front portion **222** of the water tank **220** includes a peripheral wall portion **223**, which surrounds the peripheral wall **211** of the rotary drum **210**, and a ring portion **224** which forms a water-tight sealing structure in conjunction with the packing structure **130**. The steam conduit **340** is connected to the peripheral wall portion **223**. Steam generated by the steam generating portion **400** is supplied to the storage tub **200** through the steam conduit **340**. The steam conduit **340** may include a bellows pipe. The bellows pipe may decrease vibration which is caused by rotation of the storage tub **200** and transmitted to the steam generating portion **400**.

[0048] FIGS. **4**A and **4**B are schematic perspective views of the steam generating portion **400**. A structure and arrangement of the steam generating portion **400** are described with reference to FIGS. **2** to **4**B.

[0049] The steam generating portion **400** includes a substantially rectangular box-shaped case **410**, and a steam generator **420** which is stored in the case **410**. The case **410** includes a container portion **411**, which stores the steam generator **420**, and a lid portion **412**, which covers the container portion **411**.

[0050] The steam generator **420** is connected to the pump **330** by a connecting pipe **421** and a tube (not shown). The steam generator **420** is also connected to the steam conduit **340** by an exhaust pipe **422**. The container portion **411** includes a bottom wall portion **414** provided with an opening **413**. The connecting pipe **421** and the exhaust pipe **422** project downwards through the opening **413**.

[0051] Since the pump **330** forcibly supplies water from the water storage tank **320** to the steam generator **420** in the steam generating portion **400**, the steam generator **420** may be situated above the water storage tank **320**. If water is supplied from the water storage tank to the water generator without a pump, the water in the water storage tank may be sent to the steam generator by the action of gravity. In this case, the steam generator has to be situated below the water storage tank. In the present embodiment, the pump **330** is used to supply water to the steam generator **420**. The water is supplied from the water storage tank **320** to the steam generator **420** forcibly by a pressure of the pump **330**. Consequently, in a design of the washing machine **100** according to the present embodiment, there are few restrictions on a positional relationship in the vertical direction between the steam generator **420** and the water storage tank **320**. Since there is a high degree of design freedom about the arrangement of the steam generator **420** and the water storage tank **320**, the internal space of the housing **110** may be used efficiently.

[0052] As shown in FIG. **2**, the steam generator **420** is situated above the water storage tank **320**. The pump **330** may supply water appropriately from the water storage tank **320** to the steam generator **420**.

[0053] If the steam generator is situated below the water storage tank, water may flow accidentally into the steam generator because of failures in a water supply path to the stream generator. Consequently, steam may be generated unnecessarily.

[0054] In the present embodiment, since the pump **330** is used to supply water to the steam generator **420**, the water storage tank **320** may be situated below the steam generator **420**. Even after an accidental stop of water supply to the steam generator **420** because of failures in the pump **330**, stagnant water in hoses, which are connected to the water storage tank **320**, the pump **330** and the steam generator **420**, is less likely to flow into the steam generator **420**.

[0055] As described above, if the water supply path from the water storage tank to the steam generator is designed without a pump, the steam generator has to be situated below the water storage tank. For example, if there are failures in control components such as an opening/closing valve for controlling water supply from the water storage tank to the steam generator, the water supply to the steam generator may become out of control. Consequently, water flows unnecessarily into the steam generator from the water storage tank because of the action of gravity. In the present embodiment, the pump **330** is used to supply water from the water storage tank **320** to the steam generator **420**, so that unnecessary water supply from the water storage tank **320** to the steam generator **420** is less likely to happen.

[0056] As shown in FIG. **2**, the housing **110** includes a right wall **115**, which stands between the front and rear walls **111**, **112**, and a left wall **116** opposite to the right wall **115**. The water storage tank **320** is situated at the corner defined by the housing bottom wall **114**, the rear wall **112** and the left wall **116**. The steam generator **420** is situated in the corner defined by the right wall **115**, the housing top wall **113** and the front wall **111**. Thus, the steam generator **420** and the water storage tank **320** are arranged in substantially symmetrical positions with respect to the central axis of the storage tub **200** (rotational axis RX).

[0057] As shown in FIG. **2**, the detergent storage portion **101** is situated in the corner defined by the front wall **111**, the housing top wall **113** and the left wall **116**. Other corners of the housing **110** are used efficiently for arrangement of the water storage tank **320** and the steam generator **420**. As shown in FIG. **2**, the water storage tank **320** is situated at the corner defined by the housing bottom wall **114**, the rear wall **112** and the left wall **116**. The steam generator **420** is situated in the corner defined by the right wall **115**, the housing top wall **113** and the front wall **111**. Since the housing **110** has a substantially rectangular-box shape and the storage tub **200** is cylindrical, wide spaces are formed in the corners of the housing **110**. As described above, the wide spaces in the corners are used efficiently for the arrangement of the detergent storage portion **101**, the water storage tank **320** and the steam generator **420**, respectively. The water storage tank **320** and the steam generator **420** may be designed to a large size in accordance with the corners of the housing **110**.

[0058] The detergent storage portion may be situated at the corner defined by the front wall, the housing top wall and the right wall. In this case, the steam generator may be situated at the corner defined by the left wall, the housing top wall and the front wall. The water storage tank may be situated at one of the corners defined by the bottom wall of the housing in accordance with a piping design for the steam generator.

[0059] For example, the water storage tank may be situated at a substantially rotationally symmetrical position with respect to the detergent storage portion about the rotational axis of the storage tub. The steam generator may be situated symmetrically with the water storage tank with respect to the horizontal plane including the rotational axis of the storage tub. With such a layout design, the internal space of the housing is used effectively as well, like the layout design shown in FIG. **2**.

[0060] The water storage tank may be situated below the detergent storage portion, which is placed at the corner defined by the front wall, the housing top wall and the left or right wall. In this case, the steam generator may be situated in a substantially rotationally symmetrical position with respect to the water storage tank about the rotational axis of the storage tub. With such a layout design, the internal space of the housing is used effectively as well, like the layout design shown in FIG. **2**.

[0061] In the present embodiment, the rotational axis RX of the storage tub **200** is substantially horizontal. Alternatively, the storage tub may rotate about an inclined rotational axis. For example, the rotational axis may be inclined upwards from the rear wall towards the front wall. The water storage tank may be situated below a plane including the inclined rotational axis whereas the steam generator may be situated

above this plane. If the water storage tank is arranged to the left or right with respect to the vertical plane including the inclined rotational axis, the steam generator may be arranged to the right or left with respect to the vertical plane. With such a layout design, the space between the housing and the storage tub is used efficiently.

[0062] FIG. **5** is a schematic perspective view of an attachment structure for connecting the lid portion **412** to the housing **110**. The attachment structure between the lid portion **412** and the housing **110** is described with reference to FIGS. **3**, **4**A and **5**.

[0063] The housing **110** further includes a first reinforcing frame **117**, which is arranged along the upper edge of the right wall **115**, and a second reinforcing frame **118**, which is arranged along the upper edge of the front wall **111**.

[0064] The lid portion **412** includes a substantially rectangular upper wall **415**, a lid peripheral wall **416**, which projects downwards from the edges of the upper wall **415**, and a projecting piece **417**, which projects forwards from the lid peripheral wall **416**. The washing machine **100** further includes a first attachment piece **151**, which is connected to the first reinforcing frame **117** and the upper wall **415**, and a second attachment piece **152**, which is connected to the second reinforcing frame **118** and the projecting piece **417**. The first and second attachment pieces **151**, **152** protrude upwards from the lid portion **412** to make the housing top wall **113** distant from the steam generating portion **400**, which results in little thermal transmission from the steam generating portion **400** to the housing **110**. In the present embodiment, the first and second attachment pieces **151**, **152** are exemplified as the holder.

[0065] FIGS. **6**A and **6**B are schematic perspective views of the steam generator **420**. The steam generator **420** is described with reference to FIGS. **6**A and **6**B.

[0066] The steam generator **420** includes a substantially rectangular main piece **423**, a lid piece **424**, which is situated above the main piece **423**, and a line heater **425** which is situated in the main piece **423**. In the present embodiment, the main piece **423** and the lid piece **424** are made from aluminum. Therefore, the main piece **423** and the lid piece **424** are heated appropriately by the heater **425**.

[0067] The steam generator **420** further includes a thermistor **426**. The thermistor **426** is also installed on the main piece **423**, in addition to the connecting pipe **421**, the exhaust pipe **422** and the heater **425**. The heater **425** is controlled in response to thermal information obtained by the thermistor **426**. Therefore, a temperature of the main piece **423** and the lid piece **424** is kept substantially uniform. Similar advantageous effects are also obtained if a thermostat configured to control switching on and off of the heater **425** at a prescribed temperature is used instead of the thermistor **426**.

[0068] FIG. **7** is a schematic perspective view showing the main piece **423**. The main piece **423** is described with reference to FIGS. **6**B and **7**.

[0069] The main piece **423** includes a main piece lower surface **427** to which the connecting pipe **421**, the exhaust pipe **422** and the thermistor **426** are attached, a peripheral surface **428** in which the heater **425** is situated, and an upper surface **429** opposite to the main piece lower surface **427**. The main piece **423** further includes an outer chamber wall **431**, which stands towards the lid piece **424** from the upper surface **429** and defines a substantially triangular chamber space **430**, and a substantially J-shaped inner chamber wall **432**, which defines a flow path of steam in the chamber space **430**.

[0070] FIG. **8** is a schematic exploded perspective view of the steam generator **420**. FIG. **9** is a schematic perspective view of the lid piece **424**. The steam generator **420** is described with reference to FIGS. **3**, **6**B to **9**.

[0071] The steam generator **420** includes a packing ring **433**, which is mounted on the main piece **423** so as to surround the outer chamber wall **431**. The packing ring **433** is made of heat-resistant rubber.

[0072] The lid piece **424** includes a lower surface **434**, which faces the main piece **423**, and an outer shield wall **435** of which shape is substantially the same as the outer chamber wall **431**. The lid piece **424** is pressed against the main piece **423**. Consequently, the outer shield wall **435** compresses the packing ring **433** to keep the chamber space **430** hermetically sealed.

[0073] The main piece **423** is provided with an inflow port **437** which allows water supplied through the connecting pipe **421** to flow into the chamber space **430**. The inflow port **437** is formed at substantially the center of the chamber space **430** and surrounded by the internal chamber wall **432**. When the pump **330** supplies a prescribed amount of water to the steam generator **420**, the water is spouted upwards through the connecting pipe **421** and the inflow port **437**. Accordingly, the water hits the inner chamber wall **432**, the upper surface **429** of the main piece **423**, which is surrounded by the inner chamber wall **432**, and/or the lower surface **434** of the lid piece **424** above the inflow port **437**. The steam generator **420** is heated by the heater **425** (e.g. to approximately 200° C.), and has a high thermal energy. The pump **330** which performs intermittent water supply operation supplies a suitable amount of water in accordance with the thermal energy of the steam generator **420** (e.g. approximately 2 cc per supply action). Accordingly, the water which is spouted upwards from the inflow port **437** evaporates instantaneously. In the present embodiment, the chamber space **430** used for steam generation is exemplified as the chamber. The inner chamber wall **432**, which is hit by the water supplied through the inflow port **437**, and the upper surface **429** of the main piece **423**, which is surrounded by the internal chamber wall **432**, and/or the lower surface **434** of the lid piece **424** above the inflow port **437** are exemplified as the wall surface. The inflow port **437**, to which the connecting pipe **421** is attached, is exemplified as the attachment portion.

[0074] The water supplied by the pump **330** may contain impurities. When the water is vaporized, the impurities in the water may adhere or be precipitated onto the wall surfaces which form the chamber space **430**. As a result of the instantaneous vaporization of the water, ane internal pressure of the chamber space **430** increases rapidly. As a result of the rapid increase in the internal pressure of the chamber space **430**, the impurities adhering or precipitated onto the wall surfaces, which form the chamber space **430**, are subjected to a strong pressure and separated from the wall surfaces. Accordingly, the impurities are easily discharged outside the chamber space **430**.

[0075] FIG. **10** is a schematic plan view showing the main piece **423**. The main piece **423** is described with reference to FIGS. **2**, **6**B and **10**.

[0076] The heater **425** extends along a substantially U-shaped path inside the main piece **423**. Consequently, the heater **425** surrounds the inflow port **437** to which the connection pipe **421** is attached. Accordingly, the inner chamber wall **432** and a region surrounded by the inner chamber wall

432 become the hottest in the chamber space **430**. Consequently, the water spouted through the inflow port **437** evaporates instantaneously.

[0077] Since the substantially J-shaped inner chamber wall **432** projects inside the chamber space **430** which is defined by the outer chamber wall **431**, the chamber space **430** forms a whorl flow path. The main piece **423** is provided with an exhaust port **438** at the end of the flow path. Steam generated in the space surrounded by the inner chamber wall **432** is guided to the exhaust port **438** as the internal pressure in the chamber space **430** increases. An exhaust pipe **422** is attached to the exhaust port **438**. The steam arriving at the exhaust port **438** is exhausted downwards through the exhaust pipe **422**.

[0078] The heater **425** extends in a U-shape along the outer path of the whorl flow path. Consequently, steam generated in the space surrounded by the inner chamber wall **432** is heated while the steam moves to the exhaust pipe **422**. Therefore, the steam at high temperature is exhausted.

[0079] When water is spouted onto the heated wall surfaces, the steam generator **420** generates steam instantaneously with less power consumption than prior art technologies, in which steam is generated by a heater immersed in water, if the steam generator **420** is required to generate the same amount of steam.

[0080] As shown in FIG. **2**, the steam generator **420** is situated above the storage tub **200**. When the water vaporizes in the chamber space **430**, impurities contained in the water supplied to the steam generator **420** adhere or are precipitated onto the wall surfaces which form the chamber space **430** (i.e. the outer chamber wall **431**, the inner chamber wall **432** and the upper surface **429** of the main piece **423**, and the lower surface **434** of the lid piece **424**). If the impurities accumulate on the wall surfaces which form the chamber space **430**, thermal transmission efficiency between the wall surfaces and the water supplied to the chamber space **430** declines. Accordingly, water becomes less likely to evaporate in the chamber space **430**. However, in the present embodiment, the steam generator **420** is situated above the storage tub **200**, so that the adhering or precipitated impurities are discharged or dropped off below the steam generator **420** due to the internal pressure generated by the vaporization of water or the action of gravity. Therefore, the impurities are easily discharged from the interior of the chamber space **430** into the storage tub **200**. Accordingly, there may be little accumulation of the adhering or precipitated impurities in the chamber of the steam generator **420**, which results in little decline in vaporization capability because of impurity accumulation.

<Water Supply Mechanism>

[0081] FIG. **11** is a schematic view of a water supply mechanism **500**. The water supply mechanism **500** is described with reference to FIG. **11**.

[0082] The water supply mechanism **500** which pumps water into the chamber space **430** of the steam generator **420** includes the water supply valve **310**, the water storage tank **320**, the pump **330** and the connecting pipe **421** which are described above. The water supply mechanism **500** further includes a level sensor **321** configured to detect a water level in the water storage tank **320**. The water supply valve **310** may allow or stop water supply to the water storage tank **320** in response to the water level detected by the level sensor **321**. In the present embodiment, the level sensor **321** is exemplified as the first detection element.

[0083] The water supply valve **310** may be controlled on the basis of an operating time and/or an operating pattern of the pump **330** (i.e. intermittent and/or continuous water supply operation). For example, a water supply amount from the water supply valve **310** may be adjusted so that the water storage tank **320** becomes empty at the end of operation of the pump **330**. Consequently, the water is less likely to freeze in the water storage tank **320**.

[0084] The pump **330** supplies the water stored in the water storage tank **320** to the chamber space **430** through the connecting pipe **421**. The intermittent water supply operation of the pump **330** is adjusted so that the water pumped into the chamber space **430** evaporates instantaneously.

[0085] As a result of the water evaporation in the chamber space **430**, impurities contained in the water accumulate in the chamber space **430**. The continuous water supply operation of the pump **330** is adjusted so that water flows into the chamber space **430** at a sufficient flow rate to push out the accumulated impurities.

[0086] The exhaust pipe **422** is connected to the steam conduit **340**. Steam generated in the chamber space **430** during the intermittent water supply operation of the pump **330** and water flowed into the chamber space **430** during the continuous water supply operation of the pump **330** flow into the storage tub **200** through the exhaust pipe **422** and the steam conduit **340**.

<Supply of Steam and Water to Storage Tub>

[0087] FIG. **12** is a schematic back view of the front portion **222** of the storage tub **200**. The supply of steam and water to the storage tub **200** is described with reference to FIGS. **1**, **11** and **12**.

[0088] As shown in FIG. **1**, the ring portion **224** of the front portion **222** includes an inner surface **225**, which faces the rotary drum **210**, and an outer surface **226**, which faces the front wall **111** of the housing **110**. FIG. **12** principally shows the inner surface **225**.

[0089] The steam supply mechanism **300** includes a branching pipe **351** and a nozzle **352**, which are attached to the inner surface **225**. The steam supply mechanism **300** further includes a steam tube **353** which connects the branching pipe **351** to the nozzle **352**. The steam conduit **340** is connected to the branching pipe **351** through the peripheral wall portion **223**.

[0090] Steam generated in the chamber space **430** flows into the steam conduit **340** through the exhaust pipe **422** in accordance with a pressure rise in the chamber space **430**. The steam is then guided from the steam conduit **340** to the branching pipe **351**. The nozzle **352** is situated above the branching pipe **351**. The hot steam arriving at the branching pipe **351** is guided to the steam tube **353** and arrives at the nozzle **352**. Eventually, the steam is injected downwards from the nozzle **352**. In the present embodiment, the exhaust pipe **422**, the steam conduit **340**, the branching pipe **351** and the steam tube **353** lead the steam generated in the chamber space **430** to the nozzle **352**. Consequently, the exhaust pipe **422**, the steam conduit **340**, the branching pipe **351** and the steam tube **353** are exemplified as the guide pipe.

[0091] As described above, the pump **330** which performs intermittent water supply operation supplies a suitable amount of water into the hot chamber space **430**, so that the water evaporates instantaneously. Accordingly, the internal pressure in the chamber space **430** increases rapidly. Consequently, the steam is injected at high pressure from the nozzle

352 and traverses the internal space of the storage tub **200** in the vertical direction. Due to the gravity, laundry is likely to gather near a lower end of the rotary drum **210**. The steam injected from the nozzle **352**, which is attached to an upper portion of the storage tub **200**, arrives at the vicinity of the lower end of the rotary drum **210**. Therefore, the steam is supplied efficiently to the laundry.

[0092] The branching pipe **351** includes a parent tube **354**, which is connected to the steam conduit **340**, an upper child tube **355**, which bends upwards from the parent tube **354**, and a lower child tube **356**, which bends downwards from the parent tube **354**. Steam or water flows into the parent tube **354** through the steam conduit **340**. The upper child tube **355** is connected to the steam tube **353** and defines an upward path of the steam towards the nozzle **352**. In the present embodiment, the upward path defined by the upper child tube **355** and the steam tube **353** is exemplified as the first path. The parent tube **354** is exemplified as the inflow pipe. The upper child tube **355** is exemplified as the first pipe.

[0093] Unlike the upper chilled tube **355**, the lower child tube **356** defines a downward path. While the pump **330** carries out continuous water supply operation, the water flowing into the branching pipe **351** through the steam conduit **340** flows down through the lower child tube **356** due to the action of gravity. In the present embodiment, the downward path defined by the lower child tube **356** is exemplified as the second path. The lower child tube **356** is exemplified as the second pipe.

[0094] In FIG. **12**, an intersection angle θ**1** is shown between the parent tube **354** and the upper child tube **355**. FIG. **12** shows an intersection angle θ**2** between the parent tube **354** and the lower child tube **356**. The intersection angle θ**1** is an obtuse angle whereas the intersection angle θ**2** is an acute angle. Since the intersection angle θ**2** is an acute angle, flow loss from the parent tube **354** to the lower child tube **356** is relatively large. Consequently, there is little steam flowing from the parent tube **354** to the lower child tube **356** whereas most of the steam flows into the upper child tube **355**. On the other hand, since the upper child tube **355** defines the upward flow path, there is little water flowing from the parent tube **354** to the upper child tube **355** whereas the water flows mainly into the lower child tube **356** due to the action of gravity. Consequently, the flow path of the steam and the flow path of the water are appropriately distinguished.

<Intermittent Operation of Pump>

[0095] FIG. **13** is a graph schematically showing a relationship between the intermittent operation of the pump **330** and a temperature in the chamber space **430**. The intermittent operation of the pump **330** is described with reference to FIGS. **8**, **11** and **13**.

[0096] As shown in FIG. **13**, a time period during which the pump **330** operates (ON period) is set to be shorter than a time period during which the pump **330** is halted (OFF period). Accordingly, a suitable amount of water is pumped into the chamber space **430**.

[0097] During the ON period, a prescribed amount of water is supplied to the chamber space **430**. Consequently, the water evaporates and becomes steam. Due to the resultant heat of vaporization from phase change from water to steam, a temperature of the chamber space **430** declines temporarily. Since the OFF period is set to be relatively long as described above, the heater **425** may heat the chamber space **430** sufficiently during the OFF period. Therefore, high-pressure steam continues to be supplied to the storage tub **200** while the pump **330** performs the intermittent operation. In particular, since the chamber space **430** is heated sufficiently during the OFF period and a suitable amount of water, which evaporates instantaneously due to the thermal energy of the steam generator **420** including the chamber space **430**, is supplied (e.g. approximately 2 cc per supply action) during the ON period, high-pressure steam continues to be appropriately supplied to the storage tub **200**.

<Usage of Steam During Washing Process>

[0098] FIG. **14** is a graph schematically showing a change in a temperature of the water supplied to the water tank **220** in the washing process. Effects of steam used in the washing process are described with reference to FIGS. **1**, **8**, **11** and **14**.

[0099] As shown in FIG. **1**, a water heater **160** is situated below the water tank **220**. The water heater **160** is used for heating water supplied to the interior of the water tank **220**. In the present embodiment, the water heater **160** is exemplified as the second heater.

[0100] As shown in FIG. **14**, when the washing process is started, water is supplied to the water tank **220**. Meanwhile, a temperature of the water contained in the laundry inside the water tank **220** is substantially uniform. Subsequently, the water inside the water tank **220** is heated by the water heater **160**. The water heater **160** generates a large amount of heat. Therefore, the temperature of the water contained in the laundry inside the water tank **220** rises rapidly. When the water then reaches a prescribed temperature, the heating of the water inside the water tank **220** is halted.

[0101] In FIG. **14**, the dotted line after halting heating indicates a change in the temperature of the water contained in the laundry when the heating performed by the water heater **160** is halted without steam supply. The solid line after halting heating indicates a change in the temperature of the water contained in the laundry when the heating performed by the water heater **160** is halted and steam is supplied to the storage tub **200**.

[0102] As described above, since the steam supplied to the storage tub **200** is high temperature and supplied directly to the laundry, a fall in the temperature of the water contained in the laundry in the water tank **220** is diminished. The heater **425** used in the steam generator **420** consumes a smaller amount of power than the water heater **160** which is installed in the water tank **220**. Therefore, temperature maintenance by supplying steam may be achieved with smaller power consumption than temperature maintenance of the water in the water tank **220** using the water heater **160**. Consequently, it is preferable that the pump **330** carries out intermittent water supply operation after halting the water heater **160**.

<Usage of Steam in Spin-Drying Process>

[0103] Effects of steam used in the spin-drying process are described with reference to FIGS. **1**, **11** and **12**.

[0104] In the spin-drying process, the rotary drum **210** rotates at high speed. As shown in FIG. **1**, many small holes **219** are formed in the peripheral wall **211** of the rotary drum **210**. The laundry stored in the rotary drum **210** is pressed against the peripheral wall **211** by the centrifugal force, which is caused by the rotation of the rotary drum **210**. Accordingly, water contained in the laundry is discharged outside the rotary drum **210** through the small holes **219**. Therefore, the water is squeezed out suitably from the laundry.

[0105] Hydrogen bonds are likely to occur between fibers of the laundry subjected to the spin-drying. The hydrogen bonds between the fibers result in wrinkles in the laundry. If steam is supplied to the interior of the rotary drum **210**, the steam breaks the hydrogen bonds between the fibers to decrease the wrinkles in the laundry. Therefore, it is preferable that the pump **330** carries out intermittent water supply operation while the laundry is subjected to the spin-drying process. As a result of the intermittent water supply operation, the steam is injected into the rotary drum **210** at high pressure from the nozzle **352**. As described above, the steam injected from the nozzle **352** traverses the storage tub **200**, so that the steam is sprayed evenly onto the rotating laundry sticking to the peripheral wall **211**. Consequently, wrinkles are less likely to occur over the laundry in the rotary drum **210**.

[0106] FIGS. **15**A to **15**C are schematic timing charts which represent steam supply timings during the spin-drying process. The steam supply timings are described with reference to FIGS. **1** and **15**A to **15**C.

[0107] As shown in FIG. **15**A, the steam supply mechanism **300** may start steam supply a prescribed time period (T**1**) after the start of the spin-drying process. In this case, since the laundry contains only a small amount of water, the laundry is humidified efficiently in accordance with a heat amount of the steam and a water amount. As shown in FIGS. **15**B and **15**C, the steam supply mechanism **300** may start the steam supply in synchronism with the start of the spin-drying process. In this case, since the laundry is heated at the beginning of the spin-drying process, the laundry is humidified at a relatively high temperature. As shown in FIGS. **15**A and **15**B, the steam supply mechanism **300** may supply steam during a part of the time period of the spin-drying process. As shown in FIG. **15**C, the time period during which the steam supply mechanism **300** supplies steam may match the time period from the start to the end of the spin-drying process.

<Cooling of Steam Generator>

[0108] A cooling process of the steam generator **420** is described with reference to FIGS. **8** and **11**.

[0109] It is preferable that the steam generator **420** is cooled at the end of processing the laundry with steam. If the steam generator **420** is cooled, unnecessary injection of hot steam into the storage tub **200** is prevented.

[0110] Power supply to the heater **425** is halted in order to cool the steam generator **420**. The pump **330** then starts continuous water supply operation. Consequently, the water flows continuously from the water storage tank **320** into the chamber space **430**. The water flowed into the chamber space **430** draws heat from the heat generator **420** and flows into the storage tub **200**. Consequently, the steam generator **420** is cooled rapidly.

[0111] FIG. **16** is a block diagram schematically showing control of the door **120** in response to a temperature of the steam generator **420**. The control of the door **120** is described with reference to FIGS. **1**, **6**B and **16**.

[0112] The washing machine **100** includes a locking mechanism **121**, which locks the door **120** at the closed position, and a controller **122**, which controls locking and unlocking of the locking mechanism **121**. The mechanical and electrical mechanisms of the locking mechanism **121** may employ structures used in commonly known washing machines.

[0113] As shown in FIG. **6**B, the steam generator **420** is equipped with the thermistor **426**. The thermistor **426** detects a temperature of the main piece **423** and outputs to the controller **122** signals corresponding to the detected temperature. In the present embodiment, the thermistor **426** is exemplified as the second detection element.

[0114] The controller **122** keeps the door **120** locked by the locking mechanism until the signals output from the thermistor **426** indicate a temperature no more than a prescribed value. Accordingly, the internal space of the storage tub **200** is isolated from the exterior until the steam generator **420** becomes the prescribed temperature or lower. Consequently, the washing machine **100** is very safe.

Second Embodiment

[0115] FIG. **17** is a schematic exploded perspective view of a steam generator **420**A which is used in a washing machine exemplified as the laundry processing apparatus according to the second embodiment. The washing machine according to the second embodiment has similar structures to the washing machine **100** according to the first embodiment, except for structures of the steam generator **420**A. Therefore, differences from the first embodiment are described below. The description of the first embodiment may be applied to the washing machine of the second embodiment, except for the differences described below. The same reference numerals are assigned to the same elements as the first embodiment. Consequently, the description of the first embodiment may be applied to the elements to which the same reference numerals are assigned.

[0116] The steam generator **420**A includes a main piece **423**A, a lid piece **424**A, and a packing ring **433** which is sandwiched between the main piece **423**A and the lid piece **424**A. Unlike the main piece **423** described in the context of the first embodiment, a heater is not installed in the main piece **423**A. On the other hand, a heater **425**A is installed in the lid piece **424**A.

[0117] FIG. **18** is a schematic perspective view of the lid piece **424**A. An attachment structure of the heater **425**A is described with reference to FIGS. **17** and **18**.

[0118] The lid piece **424**A includes an inner shield wall **436** which is surrounded by the outer shield wall **435**. The inner shield wall **436** has substantially the same shape as the internal chamber wall **432** of the main piece **423**A. The inner shield wall **436** overlaps with the inner chamber wall **432**. Accordingly, a whorl flow path is formed in the chamber space **430**. A region of the lower surface **434** surrounded by the inner shield wall **436** faces the inflow port **437** which is formed in the main piece **423**A. Therefore, this region is called the "facing region **439**" in the following description. The heater **425**A is installed inside the lid piece **424**A so as to surround the facing region **439**. If a water flow rate is adjusted so that the water flowed from the inflow port **437** reaches the lid piece **424**A, the facing region **439** achieves instantaneous evaporation because of a particularly high temperature of the facing region **439**.

[0119] In the various embodiments described above, water is spouted upwards and converted into steam in the chamber space. Alternatively, the water may be dripped downwards and converted into steam in the chamber space. The water may be applied from the side in accordance to requirements. The supply direction of the water does not in any way limit the principles of the disclosed embodiments.

[0120] The aforementioned embodiments mainly include the following features.

[0121] The laundry processing apparatus according to one aspect of the aforementioned embodiments includes: a storage tub which stores laundry; a steam supply mechanism which supplies steam to the storage tub; and a water supply valve for supplying water from an external water source to the steam supply mechanism. The steam supply mechanism includes: a water storage tank which stores the water supplied from the water supply value; a steam generator which generates the steam; and a pump which supplies the water in the water storage tank to the steam generator.

[0122] According to the aforementioned configuration, the pump supplies water stored in the water storage tank to the steam generator. Since a suitably adjusted amount of water is supplied to the steam generator, the water which hits the steam generator evaporates. Pressure inside the steam generator increases rapidly due to the resultant vaporization pressure from the evaporation of the water, so that steam is injected at high pressure into the storage tub in which the laundry is stored. Consequently, the laundry processing apparatus may supply the steam to the laundry efficiently.

[0123] Due to arrangement of the pump, there are few restrictions on a vertical arrangement of the steam generator and the water storage tank. Since there is increased freedom in a design of the arrangement of the water storage tank and the steam generator, a space inside the housing is utilized efficiently.

[0124] In the aforementioned configuration, the steam generator may be situated above the storage tub.

[0125] According to the aforementioned configuration, if impurities contained in the water supplied to the steam generator are precipitated during vaporization inside the steam generator, the precipitated substances are easily discharged from the steam generator into the storage tub due to the pressure during vaporization and the action of gravity. Consequently, there is little decline in the vaporization capability caused by accumulation of precipitated impurities inside the steam generator.

[0126] In the aforementioned configuration, the steam generator may be situated above the water storage tank.

[0127] According to the aforementioned configuration, stagnant water between the water storage tank or the pump and steam generator is prevented from flowing inadvertently into the steam generator. Therefore, even if there is an accident in the pump or other failures, accidental steam injection is less likely to happen.

[0128] In the aforementioned configuration, the laundry processing apparatus may further include a rectangular box-shaped housing which stores the storage tub and the steam supply mechanism. The housing may include a front wall provided with a loading opening to load the laundry into the storage tub, and a rear wall opposite to the front wall. The storage tub may have a cylindrical shape having a central axis extending from the front wall towards the rear wall. The steam generator and the water storage tank may be arranged symmetrically with respect to the central axis or a plane including the central axis.

[0129] According to the aforementioned configuration, the laundry processing apparatus further includes a rectangular box-shaped housing which stores the storage tub and the steam supply mechanism. The housing includes a front wall provided with a loading opening to load the laundry into the storage tub, and a rear wall opposite to the front wall. The storage tub has a cylindrical shape with a central axis extending from the front wall towards the rear wall. Since the steam generator and the water storage tank are arranged symmetrically with respect to the central axis or a plane including the central axis, the space inside the housing is used efficiently.

[0130] In the aforementioned configuration, the steam generator may include a wall surface which defines a chamber for generating the steam and a heater which heats the wall surface. The pump may supply the water towards the wall surface which is heated by the heater.

[0131] According to the aforementioned configuration, the steam generator has a wall surface which defines a chamber for generating steam. The pump supplies water towards the wall surface heated by the first heater. The supplied water hits the wall surface heated by the first heater and turns into steam. An internal pressure in the chamber increases rapidly due to the vaporization pressure of the steam, so that the steam is injected into the storage tub in which the laundry is stored. Unlike prior art technologies to subject laundry to a steam atmosphere by seeping of steam, the steam is injected at high pressure so that the steam is supplied directly to the laundry. Consequently, the laundry processing apparatus may supply the steam to the laundry very efficiently.

[0132] In the aforementioned configuration, the pump may adjust an amount of the water so that the water hitting the wall surface evaporates instantaneously.

[0133] According to the aforementioned configuration, since the pump makes a water amount suitable for a heat amount in the chamber, the water hitting the wall surface vaporizes instantaneously, which results in an instantaneous pressure rise in the chamber. Therefore, the steam supply mechanism may inject the steam into the storage tub in which the laundry is stored. Unlike prior art technologies to subject laundry to a steam atmosphere by seeping of steam, the steam is injected at high pressure so that the steam is supplied directly to the laundry. Consequently, the laundry processing apparatus may supply the steam to the laundry very efficiently. For example, even if a heat amount in the chamber is small, since the pump adjusts a water amount so that the water evaporates instantaneously, the steam supply mechanism may inject and supply the steam at high pressure directly to the laundry.

INDUSTRIAL APPLICABILITY

[0134] The principles of the various embodiments described above are applicable to apparatuses configured to process laundry by using steam.

1. A laundry processing apparatus, comprising:

a storage tub configured to store laundry;

a steam supply mechanism configured to supply steam to the storage tub; and

a water supply valve for supplying water from an external water source to the steam supply mechanism,

wherein the steam supply mechanism includes: a water storage tank configured to store the water, which is supplied from the water supply value; a steam generator configured to generate the steam; and a pump configured to supply the water in the water storage tank to the steam generator.

2. The laundry processing apparatus according to claim **1**, wherein the steam generator is situated above the storage tub.

3. The laundry processing apparatus according to claim **1**, wherein the steam generator is situated above the water storage tank.

4. The laundry processing apparatus according to claim **2**, further comprising a rectangular box-shaped housing which stores the storage tub and the steam supply mechanism,

wherein the housing includes a front wall provided with a loading opening to load the laundry into the storage tub, and a rear wall opposite to the front wall,

the storage tub has a cylindrical shape having a central axis extending from the front wall towards the rear wall, and

the steam generator and the water storage tank are arranged symmetrically with respect to the central axis or a plane including the central axis.

5. The laundry processing apparatus according to claim **1**, wherein the steam generator includes a wall surface which defines a chamber for generating the steam and a heater which heats the wall surface, and

the pump supplies the water towards the wall surface which is heated by the heater.

6. The laundry processing apparatus according to claim **1**, wherein the pump adjusts an amount of the water so that the water hitting the wall surface evaporates instantaneously.

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