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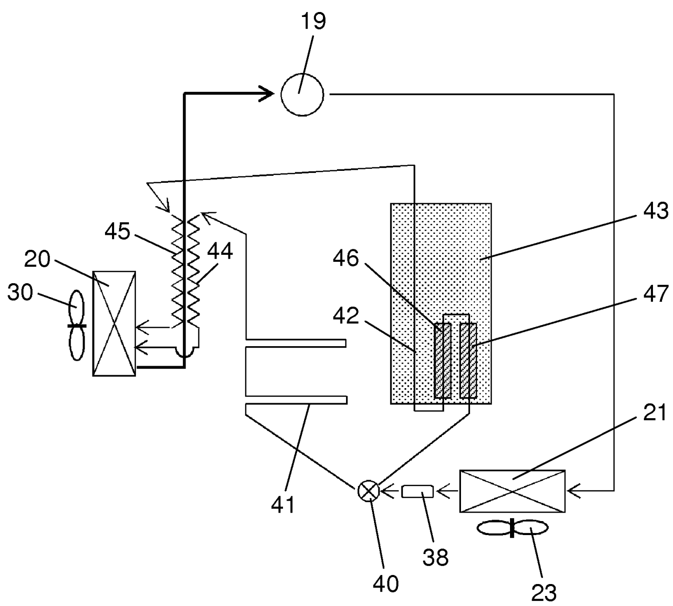
(54) **REFRIGERATOR**

(57) A refrigerator includes an anti-condensation pipe that partly serves as a bypass passage. The refrigerator further includes a heat storage material disposed near the bypass passage. The heat storage material is thermally in contact with both an outer shell surface of the refrigerator and the bypass passage.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigerator configured to reduce an amount of a thermal load owing to an anti-condensation pipe.

BACKGROUND ART

[0002] In view of energy saving, a household refrigerator has a switching valve for switching between anti-condensation pipes for use and reduces an amount of a thermal load owing to the anti-condensation pipes by letting a refrigeration cycle run without using some of the anti-condensation pipes. The refrigerator of this type puts some of the anti-condensation pipes into temporary non-use under light load conditions in which both temperature and humidity around the refrigerator are relatively low, and thus lowers temperature in and around the anti-condensation pipes to a degree that no condensation occurs on the surface of a housing for the refrigerator. Accordingly, the refrigerator decreases an amount of inflow heat transferred to an interior of the housing and consequently reduces the amount of the thermal load on the refrigerator to achieve energy saving. In a configuration presented for the refrigerator of this type, a plurality of the anti-condensation pipes put into temporary non-use are connected to an evaporator via respective capillary tubes (for example, refer to PTL 1). In the refrigerator of this type, pressure inside the anti-condensation pipes in temporary non-use is kept low. This allows a refrigerant retained in the anti-condensation pipes to be collected while the anti-condensation pipes are in use. This in turn enables the refrigerator to avoid a decrease in the amount of the refrigerant in circulation and suppresses the efficiency of the refrigeration cycle from lowering.

[0003] With reference to the drawings, a conventional refrigerator will be described below.

[0004] FIG. 5 is a longitudinal cross-sectional view of a conventional refrigerator. FIG. 6 is a diagram illustrating a refrigeration cycle in the conventional refrigerator. FIG. 7 is a diagram illustrating actions performed by a passage switching valve in the conventional refrigerator.

[0005] With reference to FIG. 5, conventional refrigerator 111 includes housing 112, doors 113, legs 114 supporting housing 112, lower machine chamber 115 disposed below housing 112, refrigerating compartment 117 disposed in an upper part of housing 112, and freezing compartment 118 disposed in a lower part of housing 112. With reference to FIG. 6, refrigerator 111 includes compressor 156 contained in lower machine chamber 115, evaporator 120 contained in a rear side of freezing compartment 118, and primary condenser 121 contained in lower machine chamber 115. These components constitute a part of a refrigeration cycle. With reference to FIG. 5, refrigerator 111 includes partition wall 122 to divide lower machine chamber 115, fan 123 installed in partition wall 122 to cool primary condenser 121 by air, evaporation pan 157 disposed above compressor 156, and bottom plate 125 for lower machine chamber 115. Refrigerator 111 has a plurality of suction ports 126 that are provided in bottom plate 125, discharge ports 127 that are provided on a rear side of lower machine chamber 115, and communicating duct 128 that connects discharge ports 127 of lower machine chamber 115 to the upper part of housing 112. Lower machine chamber 115 is divided by partition wall 122 into two rooms. Primary condenser 121 is contained in the room on a windward side of fan 123, whereas compressor 156 and evaporation pan 157 are contained in the room on a leeward side of fan 123.

[0006] With reference to FIG. 6, refrigerator 111 includes anti-condensation pipe 160 that is positioned downstream of primary condenser 121 and thermally coupled to an outer surface of housing 112 around an opening of freezing compartment 118, dryer 137 that is positioned downstream of anti-condensation pipe 160 and designed to dry a circulating refrigerant, and throttle 144 that joins dryer 137 to evaporator 120 and reduces pressure of the circulating refrigerant. These components constitute a part of the refrigeration cycle. Refrigerator 111 further includes passage switching valve 140 that lets the path upstream of anti-condensation pipe 160 to branch, and bypass passage 161, dryer 139, and throttle 145 that connect between passage switching valve 140 and evaporator 120 in parallel with anti-condensation pipe 160 in order to put anti-condensation pipe 160 into temporary non-use.

[0007] With reference to FIG. 5, refrigerator 111 has evaporator fan 150 to supply cool air generated from evaporator 120 to refrigerating compartment 117 and freezing compartment 118, freezing compartment damper 151 to cut off the supply of cool air to freezing compartment 118, and refrigerating compartment damper 152 to cut off the supply of cool air to refrigerating compartment 117. Refrigerator 111 further includes duct 153 to supply cool air to refrigerating compartment 117, FCC temperature sensor 154 to detect temperature in freezing compartment 118, PCC temperature sensor 155 to detect temperature in refrigerating compartment 117, and DEF temperature sensor 158 to detect temperature in evaporator 120.

[0008] Operation of conventional refrigerator 111 configured as described above will now be described.

[0009] In a cooling stop state in which all of fan 123, compressor 156, and evaporator fan 150 stop working (this working is hereinafter referred to as an "OFF mode"), refrigerator 111 gets freezing compartment damper 151 to be closed and refrigerating compartment damper 152 to be opened when temperature detected by FCC temperature sensor 154 rises to a predetermined temperature level of FCC_ON or when temperature detected by PCC temperature sensor 155 rises to a predetermined temperature level of PCC_ON. Refrigerator 111 then operates compressor 156, fan 123, and evaporator fan 150 (this working is hereinafter referred to as a "PC cooling mode").

[0010] In the PC cooling mode, because of fan 123 in operation, the room for primary condenser 121 in lower machine chamber 115 divided by partition wall 122 is put under negative pressure such that outside air is drawn in through the plurality of suction ports 126. At the same time, the room for compressor 156 and evaporation pan 157 are put under positive pressure such that air in lower machine chamber 115 is discharged to the outside through a plurality of discharge ports 127.

[0011] In the meantime, primary condenser 121 exchanges heat between a refrigerant discharged from compressor 156 and outside air. While a part of the gaseous refrigerant is left behind, the refrigerant is condensed and then is fed to anti-condensation pipe 160. The refrigerant passing through anti-condensation pipe 160 radiates heat to the outside via housing 112 and condenses while warming the opening of freezing compartment 118. Dryer 137 removes moisture from the liquid refrigerant passing through anti-condensation pipe 160, and throttle 144 reduces pressure of the refrigerant. The refrigerant evaporates by evaporator 120 and exchanges heat with air inside refrigerating compartment 117 so as to cool refrigerating compartment 117. The liquid refrigerant that has cooled refrigerating compartment 117 turns into the gaseous refrigerant to flow back into compressor 156.

[0012] Operation of passage switching valve 140 will now be described.

[0013] In FIG. 7, intervals p1, p2, p3 each show a period during which the refrigeration cycle runs, whereas intervals h1, h2 each show a period during which the refrigeration cycle stops. During each of interval p1, interval p2, and interval p3, refrigerator 111 gets compressor 156 to operate and passage switching valve 140 to switch between actions such that anti-condensation pipe 160 is intermittently in use. FIG. 7 also shows housing surface temperature that represents temperature at the opening of freezing compartment 118 warmed by anti-condensation pipe 160. Through an "open-close" action performed by passage switching valve 140, as shown in FIG. 7, refrigerator 111 opens a flow path for anti-condensation pipe 160 and closes a flow path for bypass 161 and thereby gets the refrigerant to flow from primary condenser 121 to anti-condensation pipe 160. Similarly, through a "close-open" action performed by passage switching valve 140, refrigerator 111 closes the flow path for anti-condensation pipe 160 and opens the flow path for bypass 161 and thereby gets the refrigerant to flow from primary condenser 121 to bypass 161 and allows the retained refrigerant in anti-condensation pipe 160 to be collected into evaporator 120. Through a "close-close" action performed by passage switching valve 140, refrigerator 111 closes the flow path for anti-condensation pipe 160 and closes the flow path for bypass 161 and thereby prevents the refrigerant from flowing from primary condenser 121 into evaporator 120 due to a pressure difference for interval q1 and interval q2 during which compressor 156 stops.

[0014] While the refrigeration cycle in conventional refrigerator 111 is running, passage switching valve 140 performs the "close-open" action as described above such that anti-condensation pipe 160 and bypass 161 are alternately in use. This configuration provides a decrease in the surface temperature of the housing warmed by anti-condensation pipe 160 and lowers quantity of inflow heat. Meanwhile, time r for which anti-condensation pipe 160 is in use and time s for which anti-condensation pipe 160 is in non-use are fixed, and passage switching valve 140 switches between the actions more than once during each of the intervals. Thus, refrigerator 111 controls a ratio of non-use of anti-condensation pipe 160 (a ratio of time for which anti-condensation pipe 160 is in non-use to a total length of time for one interval) so as to adjust a mean value of the surface temperature of the housing warmed by anti-condensation pipe 160 to a predetermined level. Refrigerator 111 adjusts the ratio between time r for use of anti-condensation pipe 160 and time s for non-use of anti-condensation pipe 160 described above in accordance with humidity around refrigerator 111 detected with a humidity sensor (not shown), for example. When the humidity around refrigerator 111 is high, refrigerator 111 increases time r for use of anti-condensation pipe 160 and thereby increases the surface temperature of the housing. When the humidity around refrigerator 111 is low, refrigerator 111 decreases time r for use of anti-condensation pipe 160 and thereby lowers the surface temperature of the housing. This configuration enables refrigerator 111 to achieve a balance between dew condensation prevention and energy saving.

[0015] In the PC cooling mode, refrigerator 111 makes a transition to the OFF mode described above when temperature detected by FCC temperature sensor 154 falls to a predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 155 falls to a predetermined temperature level of PCC_OFF.

[0016] In the PC cooling mode, when temperature detected by FCC temperature sensor 154 is higher than the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 155 falls to the predetermined temperature level of PCC_OFF, refrigerator 111 gets freezing compartment damper 151 to be opened and refrigerating compartment damper 152 to be closed, and then operates compressor 156, fan 123, and evaporator fan 150. In common with PC cooling, refrigerator 111 subsequently runs the refrigeration cycle and thereby exchanges heat between air inside freezing compartment 118 and evaporator 120 to cool freezing compartment 118 (this working is hereinafter referred to as an "FC cooling mode").

[0017] In the FC cooling mode, refrigerator 111 makes a transition to the PC cooling mode when temperature detected by FCC temperature sensor 154 falls to the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 155 is higher than or equal to the predetermined temperature level of PCC_ON.

[0018] In the FC cooling mode, refrigerator 111 makes a transition to the OFF mode when temperature detected by FCC temperature sensor 154 falls to the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 155 is lower than the predetermined temperature level of PCC_ON.

[0019] While the refrigeration cycle is running, conventional refrigerator 111 performs the operation described above such that anti-condensation pipe 160 and bypass 161 are alternately in use. This configuration provides a decrease in the surface temperature of the housing warmed by anti-condensation pipe 160 and lowers quantity of inflow heat. Accordingly, refrigerator 111 can achieve energy saving while maintaining dew condensation prevention performance.

[0020] However, in a configuration of conventional refrigerator 111 as described above, bypass passage 161 is substantially shorter than anti-condensation pipe 160 and thus heat radiation capacity of bypass passage 161 is small. This leads to a rise in condensation temperature and decreases efficiency of the refrigeration cycle. This results in an increase in the quantity of electricity consumed by the refrigerator.

Citation List

Patent Literature

[0021] PTL 1: Unexamined Japanese Patent Publication No. H8-189753

SUMMARY OF THE INVENTION

[0022] The present disclosure, accomplished to solve the above-described problems in the conventional technology, provides a refrigerator including a bypass passage that serves as a radiator and a heat storage material that radiates heat during non-use of the bypass passage. This configuration enables the bypass passage to possess increased heat radiation capacity and allows the refrigerator to achieve energy saving.

[0023] Specifically, a refrigerator according to an exemplary embodiment of the present disclosure includes a bypass passage thermally in contact with an outer shell surface of the refrigerator and a heat storage material disposed near the bypass passage. The heat storage material is thermally in contact with both the outer shell surface of the refrigerator and the bypass passage.

[0024] This configuration allows waste heat absorbed by the heat storage material during use of the bypass passage to be radiated during non-use of the bypass passage. This in turn enables the refrigerator to increase an amount of heat radiated from the bypass passage and achieve energy saving.

BRIEF DESCRIPTION OF DRAWINGS

[0025]

FIG. 1 is a longitudinal cross-sectional view of a refrigerator according to an exemplary embodiment of the present disclosure.

FIG. 2 is a diagram illustrating a refrigeration cycle in a refrigerator according to an exemplary embodiment of the present disclosure.

FIG. 3 is a transverse cross-sectional view of a back wall of a refrigerator according to an exemplary embodiment of the present disclosure.

FIG. 4 is a diagram illustrating actions performed by a passage switching valve in a refrigerator according to an exemplary embodiment of the present disclosure.

FIG. 5 is a longitudinal cross-sectional view of a conventional refrigerator.

FIG. 6 is a diagram illustrating a refrigeration cycle in the conventional refrigerator.

FIG. 7 is a diagram illustrating actions performed by a passage switching valve in the conventional refrigerator.

DESCRIPTION OF EMBODIMENT

[0026] A refrigerator according to an exemplary embodiment of the present disclosure includes a housing. The refrigerator also includes a compressor, an evaporator, a primary condenser, an anti-condensation pipe, and a throttle, each of which is provided inside the housing and configures a refrigeration cycle. The refrigerator according to the exemplary embodiment of the present disclosure further includes a passage switching valve connected to a downstream side of the primary condenser in the refrigeration cycle, the anti-condensation pipe connected to a downstream side of the passage switching valve, and a bypass passage connected in parallel with the anti-condensation pipe. The bypass passage radiates heat via an outer shell surface of the housing. The refrigerator according to the exemplary embodiment of the present disclosure further includes a heat storage material disposed near the bypass passage. The heat storage material is thermally coupled to both the bypass passage and the outer shell surface of the housing.

[0027] This configuration allows waste heat absorbed by the heat storage material during use of the bypass passage to be radiated during non-use of the bypass passage. This in turn enables the refrigerator to increase an amount of heat radiated from the bypass passage and achieve energy saving while maintaining dew condensation prevention capacity.

[0028] In the refrigerator according to an aspect of the exemplary embodiment of the present disclosure, the heat storage material is preferably provided in a container having thermal conductivity. Preferably, the heat storage material includes a paraffinic latent heat storage material which stores heat at a temperature ranging from 20°C to 40°C inclusive and has a melting point of 80°C or higher.

[0029] This configuration ensures form stability for the heat storage material especially in an outside temperature range of 20°C and higher in which the amount of heat radiation can be effectively increased. As a result, the heat storage material can be contained in a laminated aluminum film container or any similar thin container with relatively high thermal conductivity. This can suppress heat transmission resistance owing to the container for the heat storage material and improve efficiency in absorbing heat from the bypass passage and the outer shell surface of the refrigerator, as well as efficiency in radiating heat to the outer shell surface of the refrigerator.

[0030] In the refrigerator according to an aspect of the exemplary embodiment of the present disclosure, the heat storage material preferably includes a plurality of heat storage materials with different heat storage temperatures. This configuration enables the heat storage material to produce effects in a wide range of outside air temperatures.

[0031] Preferably, the refrigerator according to an aspect of the exemplary embodiment of the present disclosure further includes a heat insulating wall. In this case, the heat insulating wall preferably includes an inner wall surface, a urethane foam insulating material, and a vacuum heat insulating material. In this case, a space is preferably provided between the vacuum heat insulating material and the outer shell surface, and the heat storage material and the bypass passage are preferably contained in the space. This configuration, in a production process in which urethane foams after injection of the urethane between the inner wall surface and the outer shell surface of the refrigerator, allows the vacuum heat insulating material to reduce heat and pressure caused by the foaming urethane. Consequently, neither excessive heat nor pressure is exerted on the heat storage material, and this configuration prevents the occurrence of a burst in the container for the heat storage material. This allows the heat storage material to be contained in a thin container with relatively low strength and thus can suppress resistance to heat transmitted to a bypass and the outer shell surface of the refrigerator. This can improve efficiency in heat absorption and radiation.

[0032] An exemplary embodiment of the present disclosure will be described below with reference to the drawings. The following exemplary embodiment should not be construed to limit the scope of the present disclosure.

(Exemplary embodiment)

[0033] FIG. 1 is a longitudinal cross-sectional view of a refrigerator according to an exemplary embodiment of the present disclosure. FIG. 2 is a diagram illustrating a refrigeration cycle in a refrigerator according to an exemplary embodiment of the present disclosure. FIG. 3 is a transverse cross-sectional view of a back wall of a refrigerator according to an exemplary embodiment of the present disclosure. FIG. 4 is a diagram illustrating actions performed by a passage switching valve in a refrigerator according to an exemplary embodiment of the present disclosure.

[0034] With reference to FIGS. 1 to 3, refrigerator 11 according to an exemplary embodiment of the present disclosure includes housing 12, doors 13, legs 14 supporting housing 12, lower machine chamber 15 disposed below housing 12, upper machine chamber 16 disposed above housing 12, refrigerating compartment 17 disposed in an upper part of housing 12, and freezing compartment 18 disposed in a lower part of housing 12. Refrigerator 11 includes compressor 19 contained in upper machine chamber 16, evaporator 20 contained in a rear side of freezing compartment 18, and primary condenser 21 contained in lower machine chamber 15. These components constitute a part of a refrigeration cycle. Refrigerator 11 includes partition wall 22 to divide lower machine chamber 15, fan 23 installed in partition wall 22 to cool primary condenser 21 by air, evaporation pan 24 disposed on a leeward side of partition wall 22, and bottom plate 25 for lower machine chamber 15.

[0035] Compressor 19 is a variable-speed compressor that operates at six levels of rotation rates arbitrarily selected from a range of 20 rps to 80 rps inclusive, for example. Since compressor 19 operates at several levels of rotation rates between low speed and high speed, refrigerator 11 can adjust refrigerating performance by switching the rotation rate of compressor 19 among different levels between low speed and high speed while avoiding resonance of parts such as a pipe.

[0036] Compressor 19 operates at a low speed on startup and accelerates along with an increase in operating time taken for cooling refrigerating compartment 17 or freezing compartment 18. This is because compressor 19 is controlled so as to primarily operate at low speeds, the most highly efficient speed range, and suitably shift to a relatively high rotation rate in response to an increase in the load on refrigerating compartment 17 or freezing compartment 18 due to factors such as high outside temperature and door opening or closing. The rotation rate of compressor 19 is controlled independently of refrigerator 11 cooling mode.

[0037] At startup of a PC cooling mode that entails high evaporation temperature and relatively high refrigerating performance, the rotation rate of the compressor may be lower than a rotation rate specified for operation in an FC cooling mode. Refrigerator 11 may adjust refrigerating performance by decreasing the rotation rate of compressor 19 in response to a drop in the temperature in refrigerating compartment 17 or freezing compartment 18.

[0038] Refrigerator 11 according to the exemplary embodiment further includes a plurality of suction ports 26 that are provided in bottom plate 25, discharge ports 27 that are provided on a rear side of lower machine chamber 15, and communicating duct 28 that connects discharge ports 27 of lower machine chamber 15 to upper machine chamber 16. Lower machine chamber 15 is divided by partition wall 22 into two rooms. Primary condenser 21 is contained in the room on a windward side of fan 23, whereas evaporation pan 24 is contained in the room on a leeward side of fan 23.

[0039] Refrigerator 11 according to the exemplary embodiment further includes dryer 38 that is positioned downstream of primary condenser 21 and designed to dry a circulating refrigerant and passage switching valve 40 that is positioned downstream of dryer 38 and designed to control flow of the refrigerant. These components constitute a part of the refrigeration cycle (see FIG. 2).

[0040] Refrigerator 11 according to the exemplary embodiment further includes anti-condensation pipe 41 positioned downstream of passage switching valve 40 and anti-condensation pipe 42 that is positioned downstream of passage switching valve 40 and in parallel with anti-condensation pipe 41. Anti-condensation pipe 41 is thermally coupled to an outer surface of housing 12 around an opening of freezing compartment 18. Anti-condensation pipe 42 serves as a bypass passage bypassing anti-condensation pipe 41 and is in contact with a back surface of housing 12 to radiate heat. Anti-condensation pipe 41 and anti-condensation pipe 42 are connected to evaporator 20 via respective throttle 44 and throttle 45. Passage switching valve 40 performs opening and closing to control respective separate flows of the refrigerant to anti-condensation pipe 41 and anti-condensation pipe 42.

[0041] With reference to FIGS. 2 and 3, refrigerator 11 according to the exemplary embodiment includes spacers 48, heat storage material 46, and heat storage material 47 provided between vacuum heat insulating material 43 and anti-condensation pipe 42. Heat storage material 46 is a latent heat storage material contained in a laminated film container that includes aluminum foil, for example. The latent heat storage material is primarily composed of C19 paraffin. Heat storage material 46 is thermally coupled to anti-condensation pipe 42 and outer shell surface 51 on a rear side of refrigerator 11. Heat storage material 47 is a latent heat storage material contained in a laminated film container that includes aluminum foil, for example. The latent heat storage material is primarily composed of C18 paraffin. Heat storage material 47 is thermally coupled to anti-condensation pipe 42 and outer shell surface 51 on the rear side of refrigerator 11.

[0042] A framework of heat storage material 46 is made of an olefinic block copolymer and includes paraffin C19 with a melting point of approximately 32°C, for example. A framework of heat storage material 47 is made of an olefinic block copolymer and includes a latent heat storage material impregnated with paraffin C18 with a melting point of 29°C, for example. Accordingly, these heat storage materials store heat owing to latent heat of fusion of the principal ingredient paraffin. The olefinic block copolymers, which form the frameworks of the latent heat storage materials, each have a melting point of 80°C or higher and thus are solid matter at temperatures below the melting point. Because of excellent form stability, these olefinic block copolymers can be contained in the laminated film containers of relatively low strength.

[0043] Heat storage material 46 and heat storage material 47 are contained in spaces formed between vacuum heat insulating material 43 and outer shell surface 51 on the rear side of refrigerator 11. This allows vacuum heat insulating material 43 to suppress temperature and pressure in urethane foam insulating material 54 that reach a range of 100°C to 120°C inclusive and a range of 1.3 atm to 1.4 atm inclusive, respectively at the time of producing heat insulating wall 53, a component of housing 12. Urethane foam insulating material 54 is injected between inner wall surface 52 of heat insulating wall 53 and outer shell surface 51. This configuration prevents the occurrence of a burst in the containers for heat storage material 46 and heat storage material 47 owing to high temperature and high pressure that are entailed in production of heat insulating wall 53, a component of housing 12.

[0044] Spacers 48 are used to reduce the volume of spaces formed between vacuum heat insulating material 43 and outer shell surface 51 on the rear side of refrigerator 11. Spacers 48 are also used to assist adhesion of anti-condensation pipe 42 as well as heat storage material 46 and heat storage material 47 to outer shell surface 51 on the rear side of refrigerator 11.

[0045] Passage switching valve 40 is contained in lower machine chamber 15 and suppresses resonance of piping due to vibration from compressor 19 in upper machine chamber 16. Passage switching valve 40 is disposed below housing 12, and compressor 19 is disposed above housing 12. At the same time, flow paths inside anti-condensation pipe 41 and anti-condensation pipe 42 are configured so as to have virtually no trap structure and produce a substantially upwelling current. This configuration contributes to a reduction in an amount of the refrigerant retained inside the pipes in use. Inflow heat produced by anti-condensation pipe 41 is larger in quantity than inflow heat produced by anti-condensation pipe 42, and thus anti-condensation pipe 41 causes an increase in thermal load on housing 12. Nevertheless, anti-condensation pipe 41 is designed to radiate an amount of heat necessary for preventing dew condensation around the opening of freezing compartment 18 in response to a situation in which humidity around refrigerator 11 is high.

[0046] With reference to FIG. 1, refrigerator 11 according to the exemplary embodiment has evaporator fan 30 to supply cool air generated from evaporator 20 to refrigerating compartment 17 and freezing compartment 18, freezing compartment damper 31 to cut off the supply of cool air to freezing compartment 18, and refrigerating compartment damper 32 to cut off the supply of cool air to refrigerating compartment 17. Refrigerator 11 according to the exemplary embodiment includes duct 33 to supply cool air to refrigerating compartment 17, FCC temperature sensor 34 to detect temperature in freezing compartment 18, PCC temperature sensor 35 to detect temperature in refrigerating compartment 17, and DEF temperature sensor 36 to detect temperature in evaporator 20. Duct 33 is formed along a wall surface adjacent to refrigerating compartment 17 and upper machine chamber 16. A part of cool air passing through duct 33 is discharged from around a middle of refrigerating compartment 17, and a majority of cool air passing through duct 33 is discharged from an upper part of refrigerating compartment 17. The majority of cool air passing through duct 33 is discharged from the upper part of refrigerating compartment 17 after cooling the wall surface adjacent to upper machine chamber 16 and passing through duct 33.

[0047] Operation of refrigerator 11 having the above-described configuration according to the exemplary embodiment will now be described. The operation of refrigerator 11 described below is performed by a controller provided inside housing 12.

[0048] In a cooling stop state in which all of fan 23, compressor 19, and evaporator fan 30 stop working (this working is hereinafter referred to as an "OFF mode"), refrigerator 11 gets freezing compartment damper 31 to be closed and refrigerating compartment damper 32 to be opened when temperature detected by FCC temperature sensor 34 rises to a predetermined temperature level of FCC_ON or when temperature detected by PCC temperature sensor 35 rises to a predetermined temperature level of PCC_ON. Refrigerator 11 then operates compressor 19, fan 23, and evaporator fan 30 (this working is hereinafter referred to as a "PC cooling mode").

[0049] In the PC cooling mode, because of fan 23 in operation, the room for primary condenser 21 in lower machine chamber 15 divided by partition wall 22 is put under negative pressure such that outside air is drawn in through the plurality of suction ports 26. At the same time, the room for evaporation pan 24 is put under positive pressure such that air in lower machine chamber 15 is discharged to the outside through a plurality of discharge ports 27.

[0050] In the meantime, primary condenser 21 exchanges heat between a refrigerant discharged from compressor 19 and outside air. While a part of the gaseous refrigerant is left behind, the refrigerant is condensed. After that, moisture is removed from the refrigerant by dryer 38, and the refrigerant is fed to anti-condensation pipe 41 or anti-condensation pipe 42 through passage switching valve 40. The refrigerant passing through anti-condensation pipe 41 radiates heat to the outside via housing 12 and condenses while warming the opening of freezing compartment 18. After that, throttle 44 reduces pressure of the refrigerant passing through anti-condensation pipe 41. The refrigerant evaporates by evaporator 20 and exchanges heat with air inside refrigerating compartment 17 so as to cool refrigerating compartment 17. The refrigerant then turns into the gaseous refrigerant to flow back into compressor 19. On the other hand, the refrigerant passing through anti-condensation pipe 42 radiates heat to the outside via the back surface of housing 12 and condenses. After that, throttle 45 reduces pressure of the refrigerant passing through anti-condensation pipe 42. The refrigerant evaporates by evaporator 20 and exchanges heat with air inside refrigerating compartment 17 so as to cool refrigerating compartment 17. The refrigerant then turns into the gaseous refrigerant to flow back into compressor 19.

[0051] In the PC cooling mode, refrigerator 11 makes a transition to the OFF mode described above when temperature detected by FCC temperature sensor 34 falls to a predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 35 falls to a predetermined temperature level of PCC_OFF.

[0052] In the PC cooling mode, when temperature detected by FCC temperature sensor 34 is higher than the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 35 falls to the predetermined temperature level of PCC_OFF, refrigerator 11 gets freezing compartment damper 31 to be opened and refrigerating compartment damper 32 to be closed, and then operates compressor 19, fan 23, and evaporator fan 30. In common with PC cooling, refrigerator 11 subsequently runs the refrigeration cycle while letting passage switching valve 40 switch between actions, and thereby exchanges heat between air inside freezing compartment 18 and evaporator 20 to cool freezing compartment 18 (this working is hereinafter referred to as an "FC cooling mode").

[0053] In the FC cooling mode, refrigerator 11 makes a transition to the PC cooling mode when temperature detected by FCC temperature sensor 34 falls to the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 35 is higher than or equal to the predetermined temperature level of PCC_ON.

[0054] In the FC cooling mode, refrigerator 11 makes a transition to the OFF mode described above when temperature detected by FCC temperature sensor 34 falls to the predetermined temperature level of FCC_OFF and when temperature detected by PCC temperature sensor 35 is lower than the predetermined temperature level of PCC_ON.

[0055] Switching operation of passage switching valve 40 will now be described.

[0056] In FIG. 4, intervals g1, g2, g3 each show a period during which the refrigeration cycle runs, whereas intervals h1, h2 each show a period during which the refrigeration cycle stops. During each of interval g1, interval g2, and interval g3, refrigerator 11 gets compressor 19 to operate and passage switching valve 40 to switch between actions such that anti-condensation pipe 41 or anti-condensation pipe 42 is alternately in use. In FIG. 4, through an "open-close" action performed by passage switching valve 40, refrigerator 11 opens a flow path for anti-condensation pipe 41 and closes a flow path for anti-condensation pipe 42 and thereby gets the refrigerant to flow from primary condenser 21 to anti-condensation pipe 41 and allows the retained refrigerant in anti-condensation pipe 42 to be collected into evaporator 20. Similarly, through a "close-open" action performed by passage switching valve 40, refrigerator 11 closes the flow path for anti-condensation pipe 41 and opens the flow path for anti-condensation pipe 42 and thereby gets the refrigerant to flow from primary condenser 21 to anti-condensation pipe 42 and allows the retained refrigerant in anti-condensation pipe 41 to be collected into evaporator 20. Through a "close-close" action performed by passage switching valve 40, refrigerator 11 closes the flow path for anti-condensation pipe 41 and closes the flow path for anti-condensation pipe 42 and thereby prevents the refrigerant from flowing from primary condenser 21 into evaporator 20 due to a pressure difference for interval q1 and interval q2 during which compressor 19 stops.

[0057] FIG. 4 also shows housing surface temperature that represents temperature at the opening of freezing compartment 18 warmed by anti-condensation pipe 41. In the intervals during which the refrigeration cycle runs, the anti-condensation pipes are first operative by turns. Specifically, as shown in FIG. 4, anti-condensation pipe 41 is first operative (for time K) in interval g1, and anti-condensation pipe 42 is first operative for time L in interval g2, for example.

[0058] Refrigerator 11 controls time K for which anti-condensation pipe 41 is in use and time L for which anti-condensation pipe 42 is in use so as to adjust a mean value of the surface temperature of the housing warmed by anti-condensation pipe 41 to a predetermined level. Refrigerator 11 adjusts a ratio between time K for use of anti-condensation pipe 41 and time L for use of anti-condensation pipe 42 in accordance with humidity around refrigerator 11 detected with a humidity sensor (not shown), for example. When the humidity is high, refrigerator 11 increases time K for use of anti-condensation pipe 41 and thereby increases the surface temperature of housing 12. When the humidity is low, refrigerator 11 increases time L for use of anti-condensation pipe 42 and thereby lowers the surface temperature of housing 12. This configuration enables refrigerator 11 to achieve a balance between dew condensation prevention and energy saving.

[0059] As described above, in the intervals during which the refrigeration cycle runs, the anti-condensation pipes are first operative by turns. Thus, time K and time L can be set to an amount on a par with each of the intervals during which the refrigeration cycle runs. This allows a number of the actions switched by the passage switching valve during the refrigeration cycle running interval to be decreased to approximately once. Preferably, refrigerator 11 adjusts a sum of time K and time L to an amount on a par with or greater than the refrigeration cycle running interval in order to decrease the number of the switched actions during the refrigeration cycle running interval. At startup of compressor 19, refrigerator 11 determines time K and time L based on the running interval and the stopping interval for the refrigeration cycle immediately before the startup. This enables refrigerator 11 to minimize the number of the actions for switching between the anti-condensation pipes in response to a change in ratio of operation of the refrigeration cycle while maintaining dew condensation prevention performance.

[0060] During time L, heat of condensation of the refrigerant passing through anti-condensation pipe 42 is radiated to the outside via outer shell surface 51 of refrigerator 11 and stored in at least one of heat storage material 46 and heat storage material 47. While anti-condensation pipe 42 is in non-use, such as interval h1 or time K subsequent to time L, heat of condensation of the refrigerant stored in heat storage material 46 and heat storage material 47 is radiated to the outside via outer shell surface 51 of refrigerator 11. This configuration can increase the amount of radiated heat compared to an amount of heat radiated directly from anti-condensation pipe 42 to the outside only via outer shell surface 51 of refrigerator 11.

[0061] To ensure that heat of condensation of the refrigerant stored in at least one of heat storage material 46 and heat storage material 47 is efficiently radiated to the outside, a temperature at which at least one of heat storage material 46 and heat storage material 47 stores heat is preferably specified to a midway point between condensation temperature of the refrigerant and outside air temperature. However, the condensation temperature of the refrigerant and the outside air temperature are variable. Thus, a refrigerator can be effectively used in a wider range of outside air temperatures when the refrigerator includes a combination of a plurality of heat storage materials with different heat storage temperatures such as heat storage material 46 and heat storage material 47 included in refrigerator 11 of the exemplary embodiment. In terms of modest effect in heat radiation capacity improvement in the case of outside air temperatures lower than 20°C and prevention of dew condensation at an opening of refrigerator 11 in the case of outside air temperatures higher than 40°C, anti-condensation pipe 41 is mostly used in these temperature ranges. Consequently, it is preferable that heat storage temperatures for heat storage material 46 and heat storage material 47 are specified to points in a range of 20°C to 40°C inclusive.

[0062] In refrigerator 11 according to the exemplary embodiment of the present disclosure, anti-condensation pipe 42 is a circular pipe in common with anti-condensation pipe 41 and fixed to outer shell surface 51 of housing 12 for refrigerator 11 by thermal coupling using an aluminum foil tape (not shown), for example. However, anti-condensation pipe 42 may be a refrigerant pipe made of a multipath flat pipe to widen an area of contact with outer shell surface 51 of refrigerator 11.

[0063] Refrigerator 11 according to the exemplary embodiment of the present disclosure may include a thermal-conductive material, such as a silicone sealer, formed between anti-condensation pipe 42 and outer shell surface 51 of refrigerator 11. This configuration allows a tiny gap between anti-condensation pipe 42 and outer shell surface 51 of refrigerator 11 to be filled with the silicone sealer or other thermal-conductive material and thus can widen an area of real contact between anti-condensation pipe 42 and outer shell surface 51 of refrigerator 11. This in turn suppresses resistance to heat transmitted from anti-condensation pipe 42 to outer shell surface 51 of refrigerator 11 and contributes to an improvement in heat storage efficiency.

[0064] Refrigerator 11 according to the exemplary embodiment of the present disclosure gets heat to be radiated from outer shell surface 51 to the outside and gets heat to be transmitted from anti-condensation pipe 42 and outer shell surface 51 to at least one of heat storage material 46 and heat storage material 47 concurrently with transmission of heat from anti-condensation pipe 42 to outer shell surface 51 of refrigerator 11. Consequently, the amount of heat transmitted from anti-condensation pipe 42 to outer shell surface 51 in refrigerator 11 is two to three times larger than an amount of heat transmission in a conventional refrigerator without having heat storage material disposed. In cases in which the amount of heat transmitted from anti-condensation pipe 42 to outer shell surface 51 of refrigerator 11 is large, a thermal-conductive material, such as a silicone sealer, that is formed between anti-condensation pipe 42 and outer shell surface 51 of refrigerator 11 suppresses resistance to heat transmitted from anti-condensation pipe 42 to outer shell surface 51 of refrigerator 11 and contributes to an improvement in heat storage efficiency.

[0065] As described above, refrigerator 11 according to an exemplary embodiment of the present disclosure includes heat storage material 46 and heat storage material 47 that are disposed near anti-condensation pipe 42 and thermally in contact with both anti-condensation pipe 42 and outer shell surface 51 of refrigerator 11. This configuration allows waste heat absorbed by at least one of heat storage material 46 and heat storage material 47 during use of anti-condensation pipe 42 to be radiated during non-use of anti-condensation pipe 42. This in turn enables refrigerator 11 to increase the amount of heat radiated from anti-condensation pipe 42 and achieve further energy saving.

INDUSTRIAL APPLICABILITY

[0066] As described above, the present disclosure provides a refrigerator including a bypass passage that serves as a radiator and a heat storage material that radiates heat during non-use of the bypass passage. This configuration enables the bypass passage to possess increased heat radiation capacity and allows the refrigerator to achieve further energy saving while maintaining dew condensation prevention performance of an anti-condensation pipe in line with conditions such as an installation environment for the refrigerator and an operating state of the refrigerator. Accordingly, the present disclosure is applicable to household and commercial refrigerators and other products incorporating freezing and refrigerating technology.

REFERENCE MARKS IN THE DRAWINGS

[0067]

11: refrigerator
12: housing
13: door
14: leg
15: lower machine chamber
16: upper machine chamber
17: refrigerating compartment
18: freezing compartment
19: compressor
20: evaporator
21: primary condenser
22: partition wall
23: fan
24: evaporation pan
25: bottom plate
26: suction port
27: discharge port
28: communicating duct
30: evaporator fan
31: freezing compartment damper
32: refrigerating compartment damper
33: duct
34: FCC temperature sensor
35: PCC temperature sensor
36: DEF temperature sensor
38: dryer
40: passage switching valve
41: anti-condensation pipe
42: anti-condensation pipe (bypass passage)
43: vacuum heat insulating material
44: throttle
45: throttle
46: heat storage material
47: heat storage material
48: spacer
51: outer shell surface
52: inner wall surface
53: heat insulating wall
54: urethane foam insulating material

Claims

1. A refrigerator comprising:

a housing;
including a compressor, an evaporator, a primary condenser, an anti-condensation pipe, and a throttle each of which is provided inside the

housing and configures a refrigerating cycle;
a passage switching valve connected to a downstream of the primary condenser in the refrigeration cycle;
an anti-condensation pipe connected to a downstream of the passage switching valve;
a bypass passage connected in parallel with the anti-condensation pipe, the bypass passage being configured to radiate heat via an outer shell surface of the housing; and
a heat storage material disposed near the bypass passage, the heat storage material being thermally coupled to both the bypass passage and the outer shell surface of the housing.

2. The refrigerator according to claim 1, wherein the heat storage material is disposed in a container having thermal conductivity, and includes a paraffinic latent heat storage material which stores heat at a temperature ranging from 20°C to 40°C inclusive and has a melting point of 80°C or higher.

3. The refrigerator according to either claim 1 or 2, wherein the heat storage material includes a plurality of heat storage materials with different heat storage temperatures.

4. The refrigerator according to any one of claims 1 to 3, further comprising a heat insulating wall that includes an inner wall surface, an urethane foam insulating material, and a vacuum heat insulating material, wherein a space is provided between the vacuum heat insulating material and the outer shell surface, and wherein the heat storage material and the bypass passage are contained in the space.

FIG. 1

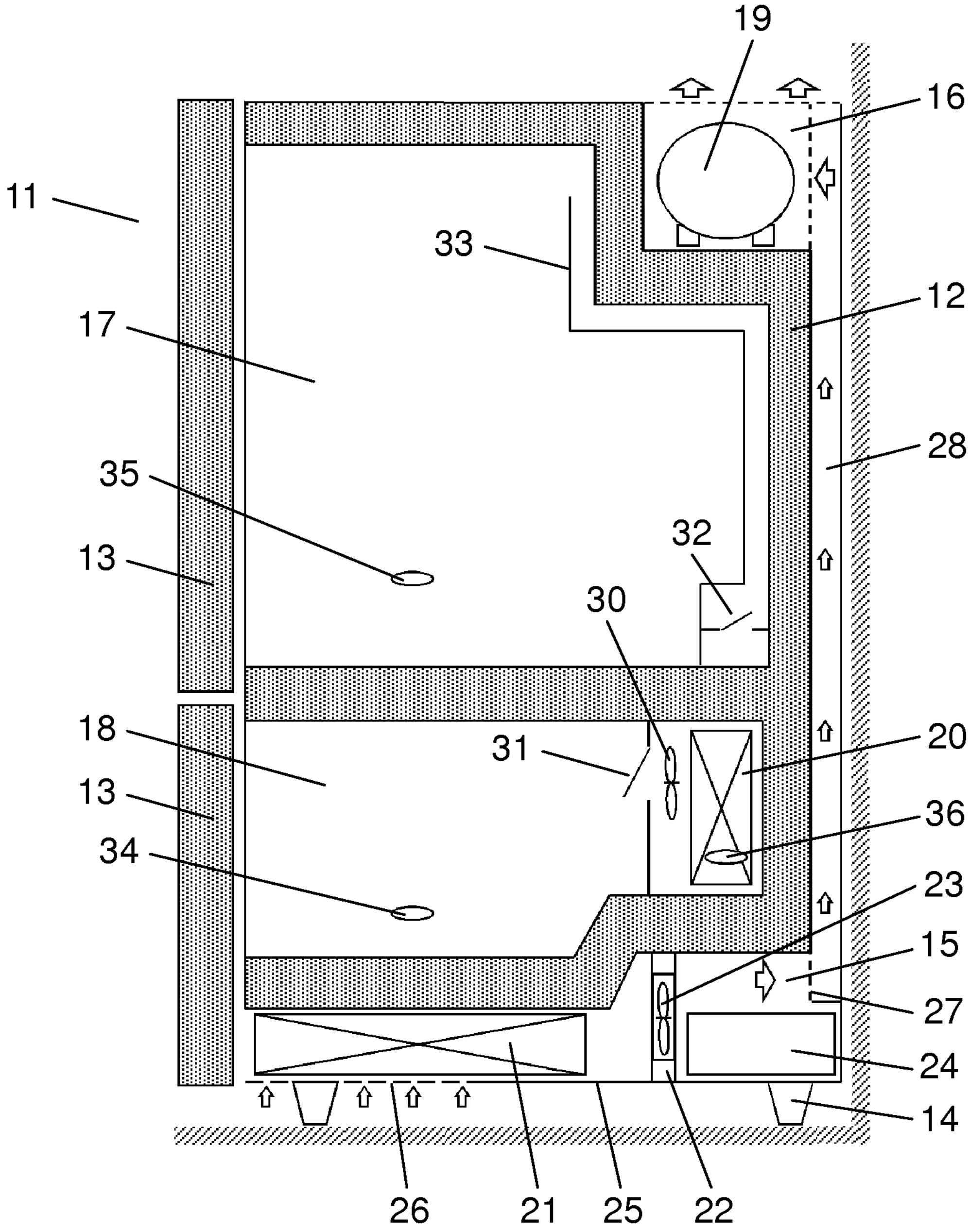
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FIG. 2

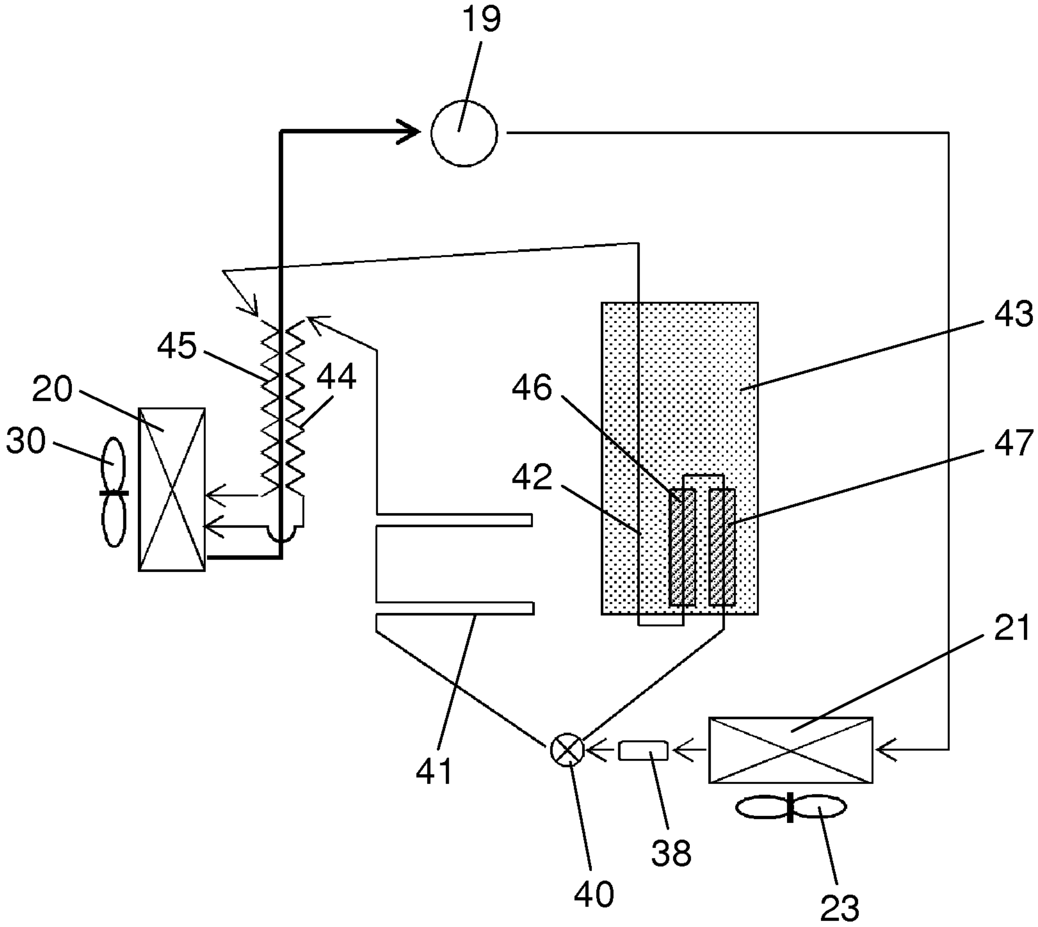

FIG. 3

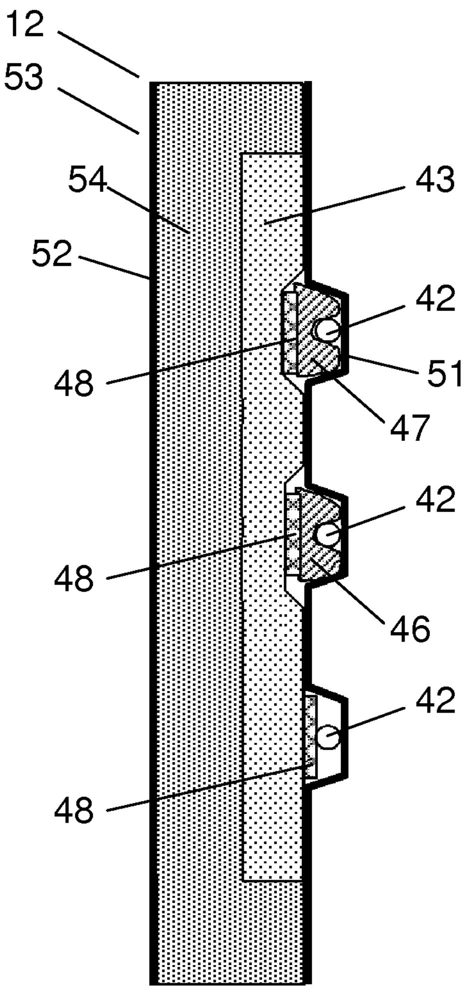

FIG. 4

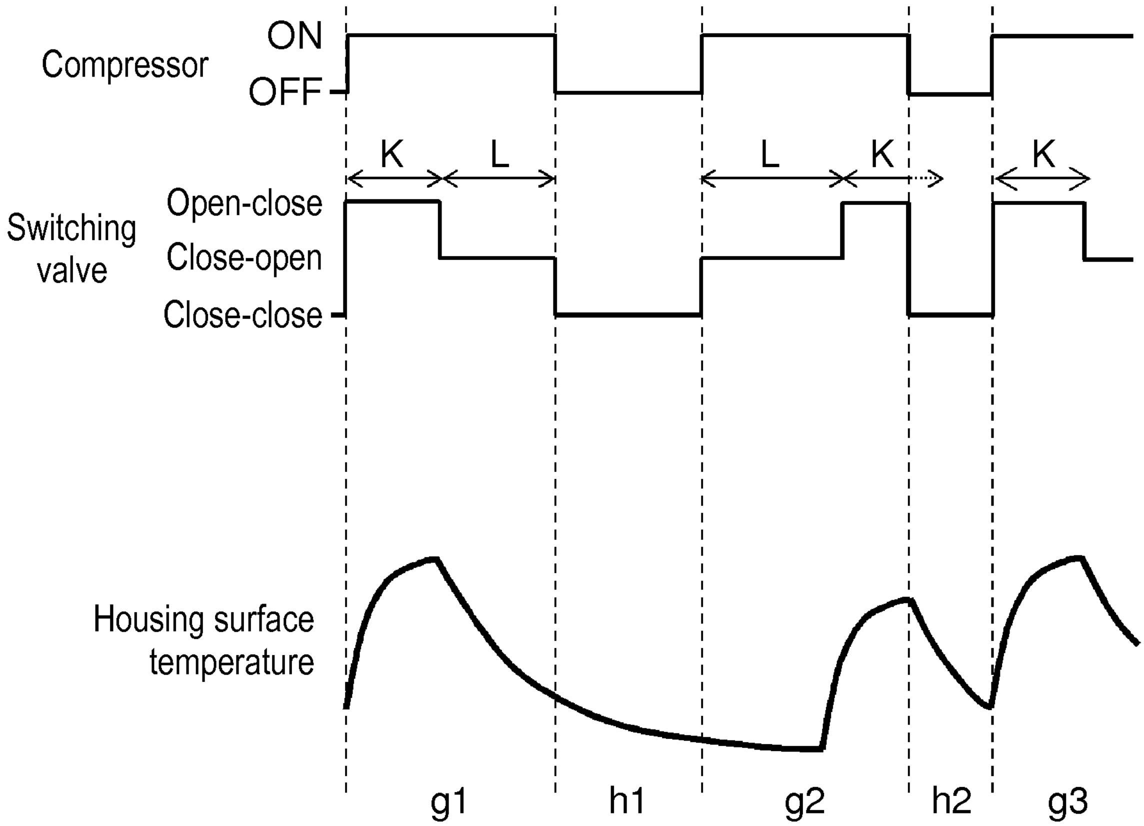
Compressor
ON
OFF
K
L
L
K
K
Switching valve
Open-close
Close-open
Close-close
Housing surface temperature
g1
h1
g2
h2
g3

FIG. 5

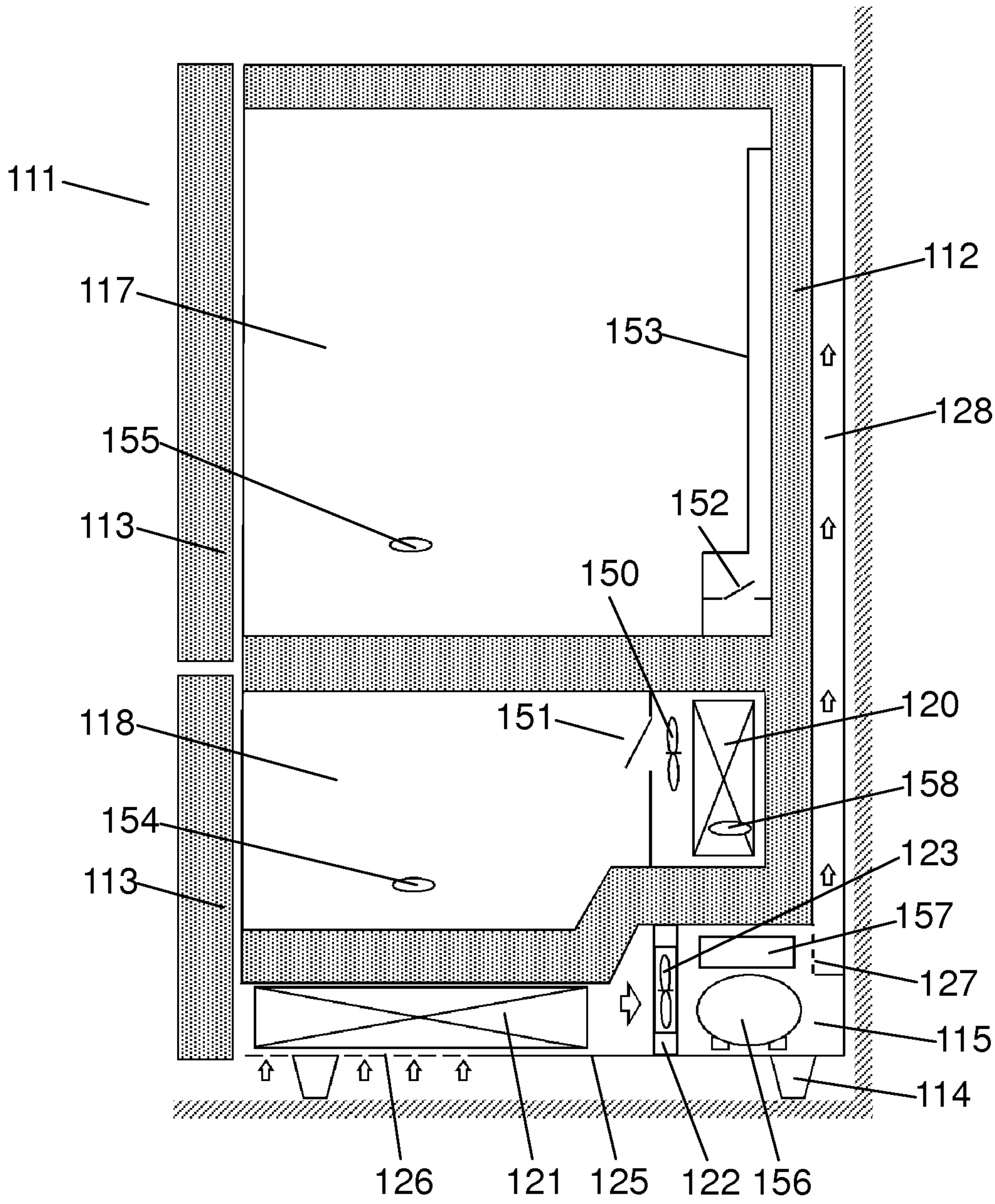
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FIG. 6

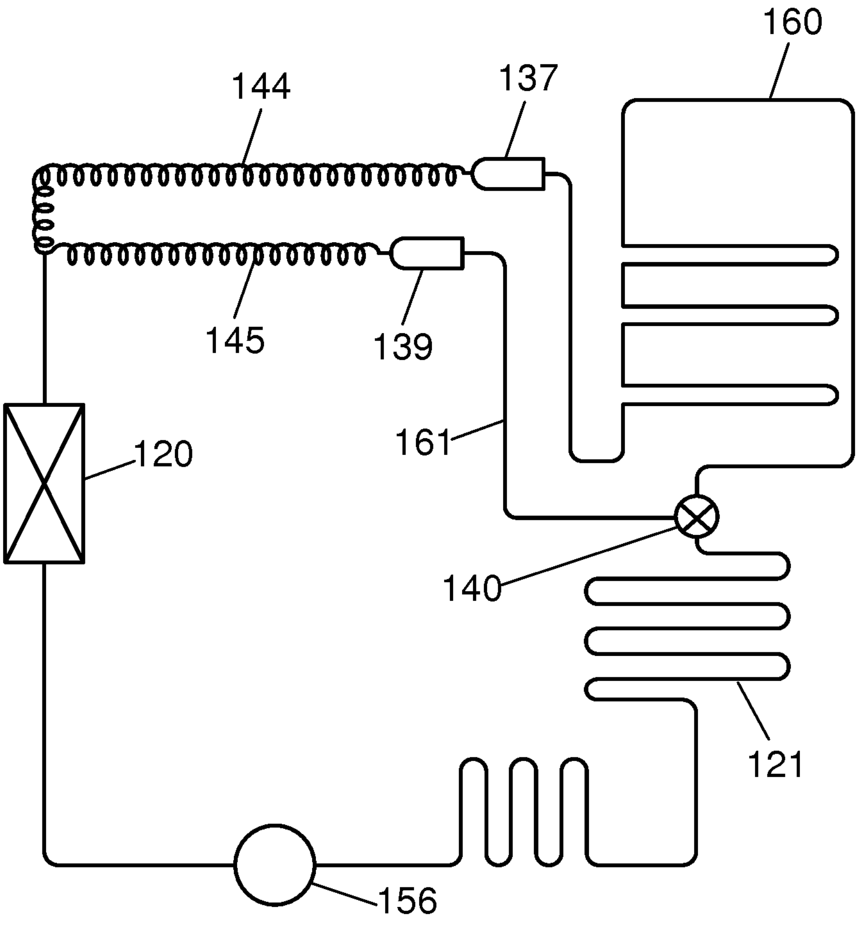
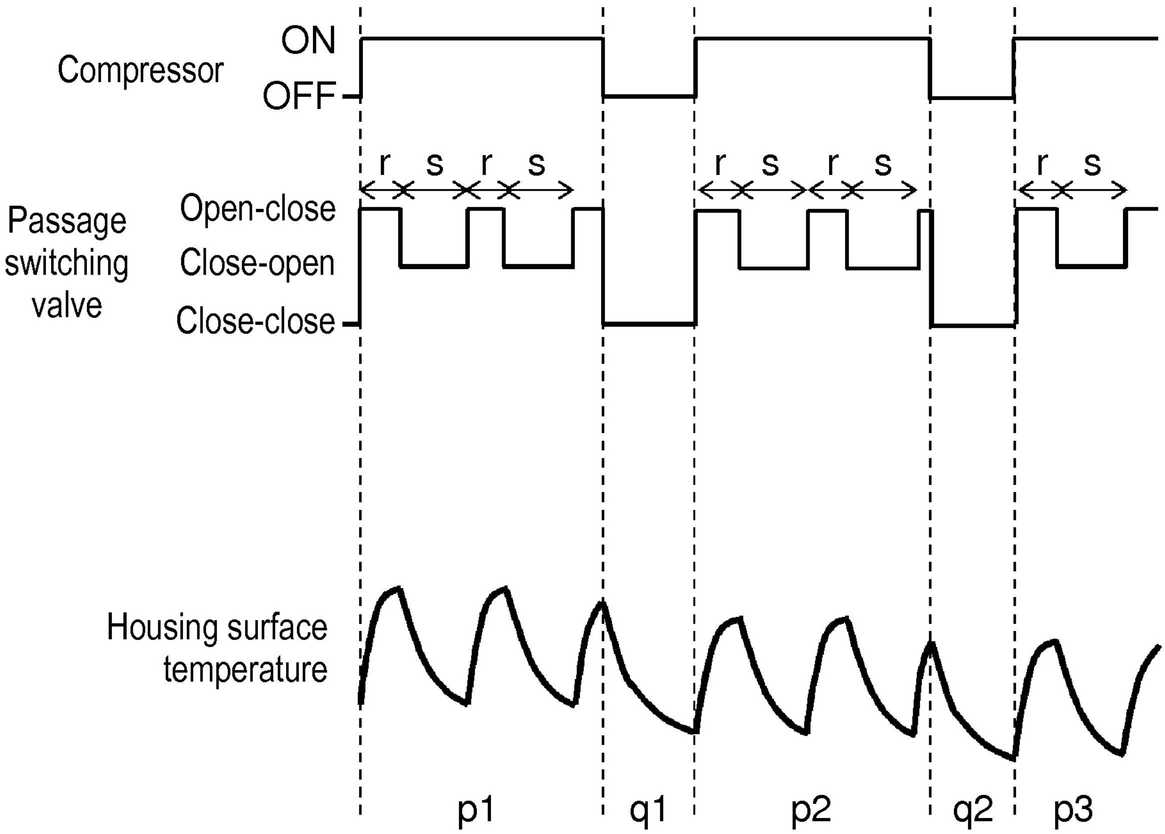


FIG. 7


Compressor
ON
OFF
Passage switching valve
Open-close
Close-open
Close-close
r
s
Housing surface temperature
p1
q1
p2
q2
p3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/001884

A. CLASSIFICATION OF SUBJECT MATTER
F25D21/04(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25D21/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2015-1358 A (Panasonic Corp.), 05 January 2015 (05.01.2015), paragraphs [0045] to [0066]; fig. 2 to 3 (Family: none)	1-2,4 3
Y A	JP 2004-309090 A (Sanden Corp.), 04 November 2004 (04.11.2004), paragraphs [0005], [0015] to [0018]; fig. 2 (Family: none)	1-2,4 3
Y A	JP 2000-213853 A (Mitsubishi Electric Corp.), 02 August 2000 (02.08.2000), paragraphs [0012] to [0015]; fig. 2 (Family: none)	1-2,4 3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 March 2017 (24.03.17)	11 April 2017 (11.04.17)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/001884

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 74935/1988(Laid-open No. 178575/1989) (NEC Home Electronics Ltd.), 21 December 1989 (21.12.1989), specification, page 4, line 1 to page 5, line 10; fig. 1 to 2 (Family: none)	1-2,4 3
Y A	US 5638694 A (BANICEVIC), 17 June 1997 (17.06.1997), column 3, lines 7 to 36; fig. 4 & CA 2123029 A1	1-2,4 3
Y	JP 2012-87992 A (Mitsubishi Electric Corp.), 10 May 2012 (10.05.2012), paragraphs [0018] to [0019]; fig. 3 (Family: none)	4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H8189753 B **[0021]**