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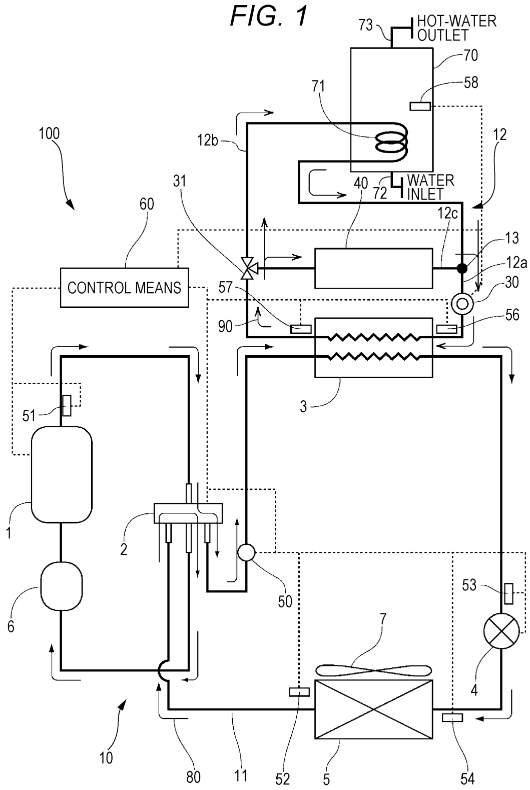
(54) Heat pump-type heating and hot-water supply apparatus

(57) A heat pump-type heating and hot-water supply apparatus includes a hot-water supply circuit, a compressor and control means. The control means when decreasing the speed of the compressor to decrease the going temperature, judges whether or not the going temperature is equal to or more than an upper limit temperature in the case that the speed of the compressor is at or below a lower limit speed, stops the compressor in the case that the going temperature is equal to or more than the upper limit temperature, and continues to operate the compressor at the lower limit speed in the case that the going temperature is not equal to or more than the upper limit temperature. Consequently, it is possible to suppress the degradation of the COP resulting from the degradation of the operating efficiency of the compressor.

FIG. 1



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Description

BACKGROUND

1. Technical Field

[0001] The present invention relates to a heat pump-type heating and hot-water supply apparatus that exchanges heat between refrigerant and water.

2. Description of the Related Art

[0002] A heat pump-type heating and hot-water supply apparatus has conventionally been known which uses hot water generated by heat exchange between refrigerant and water for heating and hot-water supply. The heat pump-type heating and hot-water supply apparatus includes a heat pump unit having a refrigerant circuit and a hot-water supply unit (see, for example, JP-A-2005-274021). The refrigerant circuit includes a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, an expansion valve, a heat source side heat exchanger, and a refrigerant pipe that connects them sequentially. The hot-water supply unit supplies hot water heated by the water/refrigerant heat exchanger to a heating unit (such as a floor heating panel or bathroom heating apparatus) or water storage tank by a circulation pump.

[0003] In the above-mentioned heat pump-type heating and hot-water supply apparatus, the speed of the compressor and the opening degree of the expansion valve are controlled so that the temperature of the hot water heated by the heat exchange with the refrigerant and flowing out of the water/refrigerant heat exchanger (hereinafter described as the going temperature) reaches a given target temperature. Here, the target temperature is determined depending on, for example, a room temperature requested by the heating unit, or a water heating temperature to heat the water stored in the water storage tank. In the following description, the above-mentioned room temperature requested by the heating unit, and water heating temperature may be described as the set temperature.

[0004] When the going temperature reaches the target temperature in the above-mentioned heat pump-type heating and hot-water supply apparatus, a control to maintain the temperature is performed. Specifically, the speed of the compressor is controlled so that the going temperature falls within a given range of the target temperature (for example, within $\pm$ 2°C of the target temperature). When the going temperature is within the given range, the room temperature of a room where the heating unit is installed, or a water temperature in the water storage tank becomes a temperature close to its set temperature. Hence, the amount of heat dissipation of the hot water flowing out of the water/refrigerant heat exchanger and flowing into the heating unit or water storage tank in the heating unit or water storage tank is reduced.

[0005] When the amount of heat dissipation of the hot water flowing out of the water/refrigerant heat exchanger is reduced, the going temperature is stabilized at (around) the target temperature. Hence, a condensation temperature in the water/refrigerant heat exchanger will hardly change. In other words, out of four processes (compression process/condensation process/expansion process/evaporation process) in the heat pump unit, three processes excluding the compression process hardly change in efficiency.

[0006] On the other hand, the operating efficiency of the compressor varies depending on the type of compressor and the outside temperature. However, in any case, the compressor is designed to have its maximum operating efficiency of the compressor when the speed of the compressor is a given speed. When the speed of the compressor increases or decreases as compared to the given speed, the operating efficiency of the compressor is degraded, in other words, the efficiency of the compression process out of the above-mentioned four processes in the heat pump unit, is degraded. This results from the property of a motor mounted in the compressor. Therefore, in the case that there is hardly any change in condensation temperature, the efficiency of the heat pump unit largely depends on the operating efficiency of the compressor. In other words, when the speed of the compressor is the given speed, the heat pump unit has the maximum efficiency. When the speed of the compressor increases or decreases as compared to this speed, the efficiency of the heat pump unit is degraded. When the above-mentioned going temperature is controlled so as to fall within the given range of the target temperature, in the case that the going temperature is equal to or more than an upper limit temperature within the given range, the going temperature is decreased to the target temperature by decreasing the speed of the compressor. At this point in time, the speed of the compressor is decreased as compared to a speed at which the compressor obtains the highest value of the operating efficiency, the efficiency of the heat pump unit is degraded. Accordingly, it may degrade the COP (Coefficient Of Performance) of the heat pump-type heating and hot-water supply apparatus.

[0007] The present invention has been made to solve the above problem. One object of the present invention is to provide a heat pump-type heating and hot-water supply apparatus that suppresses the degradation of the COP when controlling the compressor to decrease the going temperature.

SUMMARY

[0008] To solve the above problem, a heat pump-type heating and hot-water supply apparatus according to an embodiment of the present invention includes: a refrigerant circuit including a compressor, a water/refrigerant heat exchanger configured to exchange heat between refrigerant and water, and a heat source side heat exchanger; a hot-water supply circuit including a circulation pump and being configured to circulate hot water between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means configured to detect a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; and control means configured to control the compressor so that the going temperature approaches to a target temperature in accordance with a set temperature of the heating terminal. The control means when decreasing the speed of the compressor to decrease the going temperature, judges whether or not the going temperature is equal to or more than an upper limit temperature higher by a given temperature than the target temperature, in the case that the speed of the compressor is at or below a lower limit speed lower than an optimum speed corresponding to the highest value of a COP, stops the compressor in the case that the going temperature is equal to or more than the upper limit temperature, and continues to operate the compressor at the lower limit speed in the case that the going temperature is not equal to or more than the upper limit temperature.

[0009] In the heat pump-type heating and hot-water supply apparatus described above, the control means judges whether or not the speed of the compressor has decreased by a given speed or more as compared to the optimum speed corresponding to the highest value of the COP (whether or not at or below the lower limit speed) when decreasing the speed of the compressor. In the case that the speed of the compressor is at or below the lower limit speed, the control means judges whether or not the going temperature (water temperature) is equal to or more than the upper limit temperature that is higher by a given temperature than the target temperature. If the going temperature is equal to or more than the upper limit temperature, the control means stops the compressor. If the going temperature is not equal to or more than the upper limit temperature, the control means continues to operate the compressor at a speed that is lower by a given speed than the optimum speed corresponding to the highest value of the COP (the lower limit speed). Consequently, in the heat pump-type heating and hot-water supply apparatus, it is possible to maintain the going temperature at a temperature around the target temperature, and to suppress the degradation of the COP resulting from the degradation of the operating efficiency of the compressor.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a configuration diagram of a heat pump-type heating and hot-water supply apparatus in a first example of the present invention;

Fig. 2 is a drawing illustrating the relationship between the speed of a compressor and the COP in the first example of the present invention;

Fig. 3 is a compressor speed table in the first example of the present invention;

Fig. 4 is a flowchart illustrating a process to be performed by control means in the first example of the present invention;

Fig. 5 is a drawing illustrating the relationship between the speed of a compressor and the COP in a second example of the present invention;

Fig. 6 is a compressor speed table in the second example of the present invention;

Figs. 7A and 7B are time charts describing changes in the operating state of the compressor and the going temperature in a third example of the present invention;

Fig. 8 is a flowchart illustrating a process to be performed by control means in the third example of the present invention;

Fig. 9 is a time chart illustrating changes in the operating state of a compressor and the going temperature in a fourth example of the present invention;

Fig. 10 is a flowchart illustrating a process to be performed by control means in the fourth example of the present invention;

Fig. 11 is a time chart illustrating changes in the operating state of a compressor and the going temperature in a fifth example of the present invention; and

Fig. 12 is a flowchart illustrating a process to be performed by control means in the fifth example of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0011] In the following detailed description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

[0012] Hereinafter, embodiments of the present invention are described in detail with reference to the accompanying drawings. A description is given of the embodiments taking a heat pump-type heating and hot-water supply apparatus as an example. The heat pump-type heating and hot-water supply apparatus includes a water storage tank and an indoor unit, which are heating terminals of the present invention. In the heat pump-type heating and hot-water supply apparatus, upon heating, a water/refrigerant heat exchanger supplies hot water obtained by heat exchange between water and refrigerant to the indoor unit. Moreover, in the heat pump-type heating and hot-water supply apparatus, the water/refrigerant heat exchanger heats water stored in the water storage tank by the hot water obtained by the heat exchange between the water and the refrigerant. The present invention is not limited to the following embodiments (examples). Various modifications can be made to the embodiments of the present invention without departing from the gist of the present invention.

[First Example]

[0013] Fig. 1 illustrates the configuration of a heat pump-type heating and hot-water supply apparatus 100 according to a first example. The heat pump-type heating and hot-water supply apparatus 100 includes a refrigerant circuit 10. The refrigerant circuit 10 includes a variable capacity compressor 1, a four-way valve 2, a water/refrigerant heat exchanger 3 that exchanges heat between refrigerant and water, an expansion valve 4, a heat source side heat exchanger 5, an accumulator 6, and a refrigerant pipe 11 that connects them sequentially. In the heat pump-type heating and hot-water supply apparatus 100, the four-way valve 2 of the refrigerant circuit 10 is switched and accordingly a refrigerant circulation direction can be switched.

[0014] In the refrigerant circuit 10, the refrigerant pipe 11 in the vicinity of a refrigerant discharge opening of the compressor 1 is provided with a discharge temperature sensor 51 for detecting the temperature of the refrigerant discharged from the compressor 1. Moreover, the refrigerant pipe 11 between the water/refrigerant heat exchanger 3 and the expansion valve 4 is provided with a refrigerant temperature sensor 53. The refrigerant temperature sensor 53 detects the temperature of the refrigerant flowing out of the water/refrigerant heat exchanger 3 when the water/refrigerant heat exchanger 3 functions as a condenser. Furthermore, the refrigerant temperature sensor 53 detects the temperature of the refrigerant flowing into the water/refrigerant heat exchanger 3 when the water/refrigerant heat exchanger 3 functions as an evaporator. Moreover, the refrigerant pipe 11 between the expansion valve 4 and the heat source side heat exchanger 5 is provided with a heat exchanger temperature sensor 54. The heat exchanger temperature sensor 54 detects the temperature of the refrigerant flowing into the heat source side heat exchanger 5 when the heat source side heat exchanger 5 functions as an evaporator. The heat exchanger temperature sensor 54 detects the temperature of the refrigerant flowing out of the heat source side heat exchanger 5 when the heat source side heat exchanger 5 functions as a condenser. Furthermore, the refrigerant pipe 11 on the discharge side of the compressor 1 (between the four-way valve 2 and the water/refrigerant heat exchanger 3) is provided with a pressure sensor 50. Moreover, an outside temperature sensor (outside temperature detection means) 52 is provided in the vicinity of the heat source side heat exchanger 5.

[0015] A fan 7 is placed in the vicinity of the heat source side heat exchanger 5. The fan 7 takes in outside air into an unillustrated housing of the heat pump-type heating and hot-water supply apparatus 100 and accordingly supplies the outside air to the heat source side heat exchanger 5. The fan 7 is attached to an unillustrated output shaft (rotating shaft) of a motor whose speed is variable. The expansion valve 4 is configured to be capable of pulse control over the degree of opening of the expansion valve 4 using a stepping motor.

[0016] The water/refrigerant heat exchanger 3 is connected to the refrigerant pipe 11 and a hot-water supply pipe 12a. As illustrated in Fig. 1, an end of the hot-water supply pipe 12a is connected to a three-way valve 31. Both of an end of an indoor unit side pipe 12c and an end of a water storage tank side pipe 12b are connected to the three-way valve 31. Moreover, the other end of the hot-water supply pipe 12a is connected to the other end of the indoor unit side pipe 12c and the other end of the water storage tank side pipe 12b. In Fig. 1, a joint between the hot-water supply pipe 12a, the water storage tank side pipe 12b, and the indoor unit side pipe 12c is set as a connection point 13. The indoor unit side pipe 12c is provided with an indoor unit 40 such as a floor heating apparatus or radiator. Moreover, the water storage tank side pipe 12b is provided with a water storage tank 70.

[0017] A heat exchange unit 71 formed into a spiral shape is provided in a lower part of the water storage tank 70. Both ends of the heat exchange unit 71 are connected to the water storage tank side pipe 12b. Consequently, the hot water flowing through the water storage tank side pipe 12b flows into the heat exchange unit 71. A hot-water outlet 73 for supplying the hot water stored in the water storage tank 70 to a bathtub, a wash basin faucet, or the like is provided at the top of the water storage tank 70. Moreover, a water inlet 72 for supplying water into the water storage tank 70 is provided at the bottom of the water storage tank 70. The water inlet 72 is directly coupled to an unillustrated water pipe.

[0018] A variable capacity circulation pump 30 is provided between the connection point 13 and the water/refrigerant heat exchanger 3. The circulation pump 30 is driven to circulate the water that has exchanged heat with the refrigerant by the water/refrigerant heat exchanger 3 in a direction of an arrow 90 illustrated in Fig. 1. The water flowing out of the water/refrigerant heat exchanger 3 flows into the indoor unit 40 via the indoor unit side pipe 12c or into the water storage tank 70 via the water storage tank side pipe 12b, in accordance with the switched state of the three-way valve 31. The water flowing out of the indoor unit 40 or the water storage tank 70 flows into the water/refrigerant heat exchanger 3 via the connection point 13.

[0019] As described above, the water/refrigerant heat exchanger 3, the circulation pump 30, the indoor unit 40, and the water storage tank 70 are connected by the hot-water supply pipe 12a, the water storage tank side pipe 12b, and the indoor unit side pipe 12c to configure a hot-water supply circuit 12 of the heat pump-type heating and hot-water supply apparatus 100.

[0020] A water inlet side of the water/refrigerant heat exchanger 3 of the hot-water supply pipe 12a is provided with an inlet temperature sensor 56. The inlet temperature sensor 56 detects a return temperature that is the temperature of the water flowing into the water/refrigerant heat exchanger 3. A water outlet side of the water/refrigerant heat exchanger 3 of the hot-water supply pipe 12a is provided with an outlet temperature sensor 57. The outlet temperature sensor 57 is going temperature detection means that detects the going temperature that is the temperature of the water flowing out of the water/refrigerant heat exchanger 3. Moreover, a water storage tank temperature sensor 58 is provided at a substantially central portion in the vertical direction inside the water storage tank 70. The water storage tank temperature sensor 58 detects the temperature of the hot water built up inside the water storage tank 70.

[0021] In addition to the configuration described above, the heat pump-type heating and hot-water supply apparatus 100 includes control means 60. The control means 60 captures the temperature detected by each temperature sensor and the refrigerant pressure detected by the pressure sensor 50, or an operation request of a user by an unillustrated remote controller or the like, and performs various controls related to the operation of the heat pump-type heating and hot-water supply apparatus 100 depending on them. In other words, the control means 60 performs, for example, the drive control of the compressor 1, the fan 7, and the circulation pump 30, the switching control of the four-way valve 2, the control of the degree of opening of the expansion valve 4, and the switching control of the three-way valve 31. Furthermore, the control means 60 includes a timer unit that measures the time, and a storage unit (both are not illustrated). For example, values detected by various sensors, and a control program of the heat pump-type heating and hot-water supply apparatus 100 are stored in the storage unit.

[0022] As illustrated in Fig. 1, when the heat pump-type heating and hot-water supply apparatus 100 is operated setting the refrigerant circuit 10 as a heating cycle, the refrigerant discharged from the compressor 1 flows through the four-way valve 2, the water/refrigerant heat exchanger 3, the expansion valve 4, and the heat source side heat exchanger 5 sequentially, and flows back into the four-way valve 2, and is suctioned by the compressor 1 via the accumulator 6 (an arrow 80 illustrated in Fig. 1 indicates the flow of the refrigerant). On the other hand, when the heat pump-type heating and hot-water supply apparatus 100 is operated setting the refrigerant circuit 10 as a cooling cycle, the refrigerant discharged from the compressor 1 flows through the four-way valve 2, the heat source side heat exchanger 5, the expansion valve 4, and the water/refrigerant heat exchanger 3 sequentially, and flows back into the four-way valve 2, and is suctioned by the compressor 1 via the accumulator 6. In other words, in the cooling cycle, the refrigerant flows in the opposite direction to the refrigerant flow direction (direction of the arrow 80) in the heating cycle. In Fig. 1, the description of the refrigerant flow direction in the cooling cycle is omitted.

[0023] Next, a description is given of the operations of the refrigerant circuit 10 and the hot-water supply circuit 12 in the heat pump-type heating and hot-water supply apparatus 100 according to the example. In the following description, a description is given, as an example, of the operations of the refrigerant circuit 10 and the hot-water supply circuit 12 in a case of operating the heat pump-type heating and hot-water supply apparatus 100 setting the refrigerant circuit 10 as the heating cycle. Especially, a description is given taking, as examples, the operations of the refrigerant circuit 10 and the hot-water supply circuit 12 in a case of the heating operation with the drive of the indoor unit 40, and in a case of a water heating operation of heating the water stored in the water storage tank 70 to a given temperature.

[0024] Firstly, the case of the heating operation is described. When the user operates the remote controller or the like of the indoor unit 40, turns on the heat pump-type heating and hot-water supply apparatus 100, and instructs the start of the heating operation, the control means 60 starts the circulation pump 30 at a given speed. Furthermore, the control means 60 switches the three-way valve 31 so that hot water flows through the indoor unit side pipe 12c. Consequently, the hot water circulates between the water/refrigerant heat exchanger 3 and the indoor unit 40.

[0025] Moreover, the control means 60 switches the four-way valve 2 so as to set the refrigerant circuit 10 to the heating cycle. Specifically, the control means 60 switches the four-way valve 2 so as to connect the discharge side of the compressor 1 to the water/refrigerant heat exchanger 3, and connect an intake side of the compressor 1 to the heat source side heat exchanger 5. Consequently, the water/refrigerant heat exchanger 3 functions as a condenser as well as the heat source side heat exchanger 5 functions as an evaporator.

[0026] Next, the control means 60 starts the compressor 1 and the fan 7 to start the heating operation of the heat pump-type heating and hot-water supply apparatus 100. The control means 60 controls the compressor 1 so that the going temperature detected by the outlet temperature sensor 57, in other words, the temperature of the water heated by the water/refrigerant heat exchanger 3, reaches a water temperature corresponding to a set temperature of the heating operation, the set temperature having been set by the user (hereinafter described as the target temperature). The refrigerant discharged from the compressor 1 passes through the four-way valve 2, is condensed by heat exchange with water by the water/refrigerant heat exchanger 3, is further decompressed by the expansion valve 4, evaporates by heat exchange with the outside air by the heat source side heat exchanger 5, is suctioned into the compressor 1, and compressed again by the compressor 1. The processes of condensation, decompression (expansion), evaporation, and compression on the refrigerant are repeated.

[0027] On the other hand, the hot water heated by the water/refrigerant heat exchanger 3 flows out to the hot-water supply pipe 12a by the drive of the circulation pump

30. Furthermore, the hot water flows into the indoor unit 40 via the three-way valve 31 and the indoor unit side pipe 12c. A room where the indoor unit 40 is installed is heated by the heat dissipation of the hot water flowing through the indoor unit 40. The hot water flowing out of the indoor unit 40 flows into the water/refrigerant heat exchanger 3 via the connection point 13 and the circulation pump 30, and is reheated by heat exchange with the refrigerant.

[0028] Next, the case of the water heating operation is described. In the above heating operation, the control means 60 performs the drive control of the compressor 1 so that the going temperature detected by the outlet temperature sensor 57 reaches the target temperature corresponding to the set temperature of the heating operation set by the user. On the other hand, in the water heating operation, the control means 60 controls the compressor 1 so that the going temperature detected by the outlet temperature sensor 57 reaches the target temperature corresponding to a water heating temperature (described below). The water heating temperature is a target value of the temperature of the water stored in the water storage tank 70. The control of the refrigerant circuit 10 during the water heating operation is the same as the one during the above-mentioned heating operation. Accordingly, its detailed description is omitted.

[0029] The hot water stored in the water storage tank 70 decreases in amount by flowing out of the hot-water outlet 73. The water inlet 72 is directly coupled to the water pipe as described above. Hence, the pressure of the tap water causes water to be supplied by the decreased amount from the water inlet 72 to the water storage tank 70. Consequently, the temperature of the hot water stored in the water storage tank 70 decreases.

[0030] The control means 60 always monitors a water storage tank temperature detected by the water storage tank temperature sensor 58, which is the temperature of the hot water stored in the water storage tank 70. The control means 60 starts the water heating operation to bring the temperature of the hot water stored in the water storage tank 70 to the water heating temperature, when the detected water storage tank temperature increases to or above a temperature that is lower by a predetermined given temperature (for example, 5°C) than the water heating temperature (hereinafter described as the water heating start temperature).

[0031] The control means 60 starts the circulation pump 30 at a given speed and also switches the three-way valve 31 so as to flow water through the water storage tank side pipe 12b. Consequently, hot water circulates between the water/refrigerant heat exchanger 3 and the water storage tank 70. The hot water heated by the water/refrigerant heat exchanger 3 flows out from the water/refrigerant heat exchanger 3 to the hot-water supply pipe 12a by the operation of the circulation pump 30, flows through the water storage tank side pipe 12b via the three-way valve 31, and flows into the heat exchange unit 71 placed in the water storage tank 70. The water stored in the water storage tank 70 is heated by the hot water flowing through the heat exchange unit 71. The hot water flowing out of the heat exchange unit 71 flows into the water/refrigerant heat exchanger 3 via the connection point 13 and the circulation pump 30, and is reheated by heat exchange with the refrigerant.

[0032] As described above, when the heat pump-type heating and hot-water supply apparatus 100 performs the heating or water heating operation, the speed of the compressor 1 is controlled so that the going temperature detected by the outlet temperature sensor 57 (hereinafter described as the going temperature Tg) reaches the target temperature (hereinafter described as the target temperature Tt). The COP (the value of the COP) of the heat pump-type heating and hot-water supply apparatus 100 changes depending on the speed of the compressor 1. The relationship between the speed of the compressor 1 and the COP is described in detail with reference to Fig. 2.

[0033] Fig. 2 is a drawing illustrating the relationship between the speed of the compressor 1 (hereinafter described as the compressor speed R) and the COP. In Fig. 2, the vertical axis indicates the value of the COP. The horizontal axis indicates the compressor speed R (unit: rps). Fig. 2 depicts as an example, the relationship between the compressor speed R and the COP at different outside temperatures To1 and To2 (To1 > To2), where the outside temperature is To.

[0034] When the heat pump-type heating and hot-water supply apparatus 100 performs the heating or water heating operation, and the going temperature Tg reaches the target temperature Tt, the speed of the compressor 1 is controlled so that the going temperature Tg falls within a given range of the target temperature Tt. For example, when the target temperature Tt is 40°C, the speed of the compressor 1 is controlled so that the going temperature Tg is equal to or more than 38°C (hereinafter described as the lower limit temperature Tt2), and less than 42°C (hereinafter described as the upper limit temperature Tt1).

[0035] When the going temperature Tg reaches a temperature around the target temperature Tt, the temperature of the room where the indoor unit 40 is installed or the water temperature in the water storage tank 70 is close to each set temperature. Hence, the amount of the heat dissipation of the hot water flowing out of the water/refrigerant heat exchanger 3 and flowing into the indoor unit 40 or the water storage tank 70 decreases. When the amount of the heat dissipation of the hot water flowing out of the water/refrigerant heat exchanger 3 decreases, the going temperature Tg is stabilized at a temperature around the target temperature Tt. Hence, the condensation temperature in the water/refrigerant heat exchanger 3 will hardly change. In other words, out of the four processes (compression process/condensation process/expansion process/evaporation process) in the refrigerant circuit 10, the three processes excluding the compression process hardly changes in efficiency.

[0036] On the other hand, the operating efficiency of the compressor 1 varies depending on the type of compressor 1 and the outside temperature To. However, in any case, the compressor 1 is so designed as to have the maximum operating efficiency when the speed of the compressor 1 is an optimum speed Rm. When the speed of the compressor 1 increases or decreases as compared to the optimum speed Rm, the operating efficiency of the compressor 1 is degraded. In other words, the efficiency of the compression process out of the above-mentioned four processes (compression process/condensation process/expansion process/evaporation process) in the refrigerant circuit 10 is degraded. This results from the operating efficiency property of a motor mounted in the compressor 1. Therefore, the efficiency of the refrigerant circuit 10 of the heat pump-type heating and hot-water supply apparatus 100 depends largely on the operating efficiency of the compressor 1 in the case that the condensation temperature in the water/refrigerant heat exchanger 3 hardly changes. In other words, when the compressor speed R is the optimum speed Rm, the refrigerant circuit 10 has the maximum operating efficiency. On the other hand, In the case that the compressor speed R increases or decreases as compared to the optimum speed Rm, the operating efficiency of the refrigerant circuit 10 is degraded.

[0037] When the above-mentioned going temperature Tg is being controlled so as to be between the upper limit temperature Tt1 and the lower limit temperature Tt2, in the case that the going temperature Tg is equal to or more than the upper limit temperature Tt1, the compressor speed R is decreased to decrease the going temperature Tg to the target temperature Tt. At this point in time, if the compressor speed R is decreased to or below the optimum speed Rm, the efficiency of the refrigerant circuit 10 is degraded. Accordingly, the COP of the heat pump-type heating and hot-water supply apparatus 100 is degraded.

[0038] From the above descriptions, as illustrated in Fig. 2, the compressor speed R at which the COP has its highest value, in other words, the optimum speed Rm at which the compressor 1 has the maximum operating efficiency, is present at each of the outside temperatures To1 and To2. In the case that the compressor speed R is an optimum speed Rm1 at the outside temperature To1, the COP has a highest value C1. In the case that the compressor speed R is an optimum speed Rm2 at the outside temperature To2, the COP has a highest value C2. Here, Rm1 < Rm2 and C1 > C2. In other words, the lower the outside temperature To, the higher the COP at a lower compressor speed R. When the compressor speed R decreases as compared to the optimum speeds Rm1 and Rm2, respectively, at the outside temperatures To1 and To2, the COP is degraded.

[0039] In this example, in order to solve the above-mentioned problem, when the compressor speed R is being decreased to decrease the going temperature Tg, in the case that the compressor speed R reaches a compressor speed that is lower by a given rate than the optimum speed Rm (hereinafter described as the lower limit speed Rd), the control means 60 stops the compressor 1. For example, as illustrated in Fig. 2, in the case that the outside temperature is To1 or To2, the control means 60 decreases the compressor speed R and, when the compressor speed R reaches a lower limit speed Rd1 or Rd2 that is lower by 10% than the optimum speed Rm1 or Rm2 (see points P1 and P2 of Fig. 2), stops the compressor 1. Consequently, it is possible to decrease the going temperature Tg to reach a temperature between the upper limit temperature Tt1 and the lower limit temperature Tt2, and to suppress the degradation of the COP of the heat pump-type heating and hot-water supply apparatus 100, resulting from the decrease of the compressor speed R.

[0040] While the compressor 1 is at rest, the water is not heated by the water/refrigerant heat exchanger 3. However, the heat capacity of water is large. Accordingly, even if the compressor 1 stops for a short time, the water temperature is not suddenly decreased in the indoor unit 40 or the water storage tank 70. Hence, the control of the example is unlikely to provide discomfort to the user.

[0041] Next, with reference to Figs. 1 and 4, a detailed description is given of the control of the heat pump-type heating and hot-water supply apparatus 100 in which after the going temperature Tg reaches the target temperature Tt, the going temperature Tg is maintained between the upper limit temperature Tt1 and the lower limit temperature Tt2. Firstly, a compressor speed table 200 used upon the above control is described with reference to Fig. 3. Next, the flow of a process of when the control means 60 performs the above control is described with reference to Fig. 4.

[0042] The compressor speed table 200 illustrated in Fig. 3 is stored in the unillustrated storage unit of the control means 60. The compressor speed table 200 is created based on the result of an examination carried out in advance, and the like, and stored in the control means 60.

[0043] The optimum speed Rm and the lower limit speed Rd are defined in the compressor speed table 200, in accordance with the outside temperature To and the target temperature Tt. The optimum speed Rm is a compressor speed corresponding to the highest value of the COP (a compressor speed at which the COP has the highest value). The lower limit speed Rd is lower by a given rate (in the example, 10%) than the optimum speed Rm. As illustrated in Fig. 3, the outside temperature To is divided into three temperature ranges: less than 5°C, 5°C or more and less than 10°C, and 10°C or more. Moreover, the target temperature Tt is divided into three temperature ranges: less than 30°C, 30°C or more and less than 40°C, and 40°C or more, and assigned to each of the three temperature ranges of the outside temperature To.

[0044] For example, a description is given of a case where the outside temperature To is less than 5°C. In this case, when the target temperature Tt is less than 30°C, the optimum speed Rm is defined as 30 rps, and the lower limit speed Rd as 27 rps. Moreover, when the target temperature Tt is 30°C or more and less than 40°C, the optimum speed Rm is defined as 35 rps, and the lower limit speed Rd as 32 rps. Moreover, when the target temperature Tt is 40°C or more, the optimum speed Rm is defined as 40 rps, and the lower limit speed Rd as 36 rps. In other words, the optimum speed Rm and the lower limit speed Rd are defined so as to increase as the target temperature Tt increases.

[0045] Moreover, a description is given of the optimum speed Rm and the lower limit speed Rd in each temperature range of the outside temperature To in the case where the target temperature Tt is 40°C or more. In this case, when the outside temperature To is less than 5°C, the optimum speed Rm is 40 rps and the lower limit speed Rd is 36 rps, as described above. On the other hand, when the outside temperature To is 5°C or more and less than 10°C, the optimum speed Rm is 35 rps is defined as 35 rps, and the lower limit speed Rd as 32 rps. Furthermore, when the outside temperature To is 10°C or more, the optimum speed Rm is defined as 30 rps, and the lower limit speed Rd as 27 rps. In other words, the optimum speed Rm and the lower limit speed Rd are defined so as to decease as the outside temperature To increases.

[0046] Next, a description is given of the control of the compressor 1 using the above-mentioned compressor speed table 200, the control being performed by the control means 60 during the heating or water heating operation, with reference to a flowchart illustrated in Fig. 4. The flowchart illustrated in Fig. 4 illustrates the flow of a process of when the compressor 1 is controlled so that the going temperature Tg falls between the upper limit temperature Tt1 and the lower limit temperature Tt2 during the heating or water heating operation of the heat pump-type heating and hot-water supply apparatus 100. ST represents a step and the subsequent numeral represents a step number. In Fig. 4, the illustrations and descriptions of the controls of the heat pump-type heating and hot-water supply apparatus 100, other than the control related to the characteristic technology of the example, are omitted. The omitted controls include, for example, the control of the compressor 1 and the control of the degree of opening of the expansion valve 4 when the going temperature Tg is increased to the target temperature Tt.

[0047] When performing the heating or water heating operation, the control means 60 captures the going temperature Tg detected by the outlet temperature sensor 57, and judges whether or not the going temperature Tg is equal to or more than the target temperature Tt (ST1). The target temperature Tt is set by the user and stored in the storage unit at the start of the heating or water heating operation. If the going temperature Tg is not equal to or more than the target temperature Tt (ST1 - No), the control means 60 returns the processing to ST1, and maintains the current compressor speed R. After the start of the heating or water heating operation, the control means 60 continues to drive the compressor 1 setting the compressor speed R to a starting speed (for example, 60 rps) until the going temperature Tg reaches the target temperature Tt. Moreover, the control means 60 captures the going temperature Tg at given time intervals (for example, at intervals of 30 seconds).

[0048] If the going temperature Tg is equal to or more than the target temperature Tt in ST1 (ST1 - Yes), the control means 60 decreases the compressor speed R (ST2). The control means 60 decreases the compressor speed R in decrements of a given speed, for example, 2 rps/30 seconds.

[0049] When decreasing the compressor speed R, the control means 60 judges whether or not the compressor speed R is equal to or below the lower limit speed Rd (ST3). The control means 60 captures the outside temperature To detected by the outside temperature sensor 52 at given time intervals (for example, at intervals of 30 seconds). The control means 60 uses the outside temperature To and the stored target temperature Tt, refers to the compressor speed table 200, and extracts the lower limit speed Rd.

[0050] If the compressor speed R is not equal to or below the lower limit speed Rd (ST3 - No), the control means 60 returns the processing to ST2, and continues to decrease the compressor speed R. If the compressor speed R is equal to or below the lower limit speed Rd (ST3 - Yes), the control means 60 sets the compressor speed R to the lower limit speed Rd, and judges whether or not the going temperature Tg is less than the upper limit temperature Tt1 (ST4).

[0051] If the going temperature Tg is less than the upper limit temperature Tt1 (ST4 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST11), and returns the processing to ST4. If the going temperature Tg is not less than the upper limit temperature Tt1 (ST4 - No), the control means 60 stops the compressor 1 (ST5).

[0052] After stopping the compressor 1, the control means 60 judges whether or not the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST6). If the going temperature Tg is not equal to or less than the lower limit temperature Tt2 (ST6 - No), the control means 60 returns the processing to ST5, and continues to stop the compressor 1. If the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST6 - Yes), the control means 60 restarts the compressor 1 at the lower limit speed Rd (ST7).

[0053] After restarting the compressor 1, the control means 60 causes the timer to start measuring the time (ST8), and judges whether or not a given time has passed since the start of the time measurement (ST9). The given time here is, for example, 10 minutes. The given time is such a time as that the operating efficiency of the compressor 1 is degraded unless the compressor 1 continues to be driven over the given time or more.

[0054] If the given time has not passed (ST9 - No), the control means 60 returns the processing to ST9, and continues to drive the compressor 1 at the lower limit speed Rd. If the given time has passed (ST9 - Yes), the control means 60 resets the timer (ST10), and returns the processing to ST4.

[0055] As described above, in the heat pump-type heating and hot-water supply apparatus according to the example, the control means judges whether or not the speed of the compressor has decreased by a given speed or more as compared to the optimum speed corresponding to the highest value of the COP (whether or not at or below the lower limit speed) when decreasing the speed of the compressor. In the case that the speed of the compressor is at or below the lower limit speed, the control means judges whether or not the going temperature (water temperature) is equal to or more than the upper limit temperature that is higher by a given temperature than the target temperature. If the going temperature is equal to or more than the upper limit temperature, the control means stops the compressor. If the going temperature is not equal to or more than the upper limit temperature, the control means continues to operate the compressor at a speed (the lower limit speed) that is lower by a given speed than the optimum speed corresponding to the highest value of the COP. Consequently, in the heat pump-type heating and hot-water supply apparatus, it is possible to maintain the going temperature at a temperature around the target temperature, and to suppress the degradation of the COP resulting from the degradation of the operating efficiency of the compressor.

[0056] In the above-described example, the lower limit speed Rd is set to a speed that is lower by a given rate (for example, 10%) than the optimum speed Rm. Instead, the lower limit speed Rd may be set to, for example, a speed that is lower by 10 rps than the optimum speed Rm. In other words, in the example, a drop rate (for example, 10%), based on the optimum speed Rm, of the lower limit speed Rd may be set to be uniform, and the lower limit speed Rd may be set to a speed that is lower by a uniform speed (for example, 10 rps) than the optimum speed Rm.

[Second Example]

[0057] In the example, the heat pump-type heating and hot-water supply apparatus 100 operates as follows to maintain the going temperature at a temperature around the target temperature and suppress the degradation of the COP resulting from the degradation of the operating efficiency of the compressor.

[0058] In other words, when the compressor speed R is being decreased to decrease the going temperature Tg, in the case that the compressor speed R decreases to or below the lower limit speed Rd corresponding to a COP that is lower by a given rate (for example, -5%) than the highest value of the COP, the control means 60 stops the compressor 1. In this manner, in the example, the definition of the lower limit speed Rd is different from that of the first example.

[0059] For example, as illustrated in Fig. 5, in the case that the outside temperature is To1, the control means 60 decreases the compressor speed R and, when the compressor speed R reaches the lower limit speed Rd1 corresponding to C1' (see a point P1 of Fig. 5), stops the compressor 1. C1' is a COP value that is lower by 5% than C1 being the highest value of the COP. Moreover, in the case that the outside temperature is To2, the control means 60 decreases the compressor speed R and, when the compressor speed R reaches the lower limit speed Rd2 corresponding to C2' (see a point P2 of Fig. 5), stops the compressor 1. C2' is a COP value that is lower by 5% than C2 being the highest value of the COP. Consequently, it is possible to decrease the going temperature Tg to reach a temperature between the upper limit temperature Tt1 and the lower limit temperature Tt2, and to suppress the degradation of the COP of the heat pump-type heating and hot-water supply apparatus 100, resulting from the decrease of the compressor speed R.

[0060] While the compressor 1 is at rest, the water is not heated by the water/refrigerant heat exchanger 3. However, the heat capacity of water is large. Accordingly, even if the compressor 1 stops for a short time, the water temperature is not suddenly decreased in the indoor unit 40 or the water storage tank 70. Hence, the control of the example is unlikely to provide discomfort to the user.

[0061] Next, with reference to Figs. 1, 4 to 6, a detailed description is given of the control of the heat pump-type heating and hot-water supply apparatus 100 in which after the going temperature Tg reaches the target temperature Tt, the going temperature Tg is maintained between the upper limit temperature Tt1 and the lower limit temperature Tt2. Firstly, a compressor speed table 300 used upon the above control is described with reference to Fig. 6. Next, the flow of a process of when the control means 60 performs the above control is described with reference to Fig. 4.

[0062] The compressor speed table 300 illustrated in Fig. 6 is stored in the unillustrated storage unit of the control means 60. The compressor speed table 300 is created based on the result of an examination carried out in advance, and the like, and stored in the control means 60.

[0063] The optimum speed Rm and the lower limit speed Rd are predetermined in the compressor speed table 300, in accordance with the outside temperature To and the target temperature Tt. The optimum speed Rm is a compressor speed corresponding to the highest value of the COP (a compressor speed at which the COP has the highest value). The lower limit speed Rd, in the example, is a compressor speed corresponding to COP lower by a given rate (in the embodiment, -5%) than the highest value of the COP.

[0064] As illustrated in Fig. 6, the outside temperature To is divided into three temperature ranges: less than 5°C, 5°C or more and less than 10°C, and 10°C or more.

Moreover, the target temperature Tt is divided into three temperature ranges: less than 30°C, 30°C or more and less than 40°C, and 40°C or more, and assigned to each of the three temperature ranges of the outside temperature To.

[0065] For example, a description is given of a case where the outside temperature To is less than 5°C. In this case, when the target temperature Tt is less than 30°C, the optimum speed Rm is defined as 30 rps, and the lower limit speed Rd as 25 rps. Moreover, when the target temperature Tt is 30°C or more and less than 40°C, the optimum speed Rm is defined as 35 rps, and the lower limit speed Rd as 30 rps. Moreover, when the target temperature Tt is 40°C or more, the optimum speed Rm is defined as 40 rps, and the lower limit speed Rd as 35 rps. In other words, the optimum speed Rm and the lower limit speed Rd are defined so as to increase as the target temperature Tt increases.

[0066] Moreover, a description is given of the optimum speed Rm and the lower limit speed Rd in each temperature range of the outside temperature To in the case where the target temperature Tt is 40°C or more. In this case, when the outside temperature To is less than 5°C, the optimum speed Rm is 40 rps and the lower limit speed Rd is 35 rps, as described above. On the other hand, when the outside temperature To is 5°C or more and less than 10°C, the optimum speed Rm is defined as 35 rps, and the lower limit speed Rd as 30 rps. Furthermore, when the outside temperature To is 10°C or more, the optimum speed Rm is defined as 30 rps, and the lower limit speed Rd as 25 rps. In other words, the optimum speed Rm and the lower limit speed Rd are defined so as to decease as the outside temperature To increases.

[0067] The control of the compressor 1 using the above-mentioned compressor speed table 300, the control being performed by the control means 60 during the heating or water heating operation, according to the example, is substantially the same as the control of the compressor 1 using the compressor speed table 200 illustrated in the first example, excluding the difference of the compressor speed table. Hence, the details of the control of the compressor 1 using the compressor speed table 300 are omitted.

[0068] As described above, in the heat pump-type heating and hot-water supply apparatus according to the example, when the speed of the compressor is being decreased, in the case that the speed of the compressor decreases to or below the lower limit speed that is a speed corresponding to a COP that is lower by a given rate than the highest value of the COP, the control means judges whether or not the going temperature (water temperature) is equal to or more than the upper limit temperature that is higher by a given temperature than the target temperature. If the going temperature is equal to or more than the upper limit temperature, the control means stops the compressor. If the going temperature is not equal to or more than the upper limit temperature, the control means continues to operate the compressor at the lower limit speed. Consequently, in the heat pump-type heating and hot-water supply apparatus, it is possible to maintain the going temperature at the target temperature and to suppress the degradation of the COP resulting from the degradation of the operating efficiency of the compressor.

[0069] In the above-described example, the lower limit speed Rd is set to a speed corresponding to a COP that is lower by 5% than the highest value of the COP. In other words, a COP (first COP) corresponding to the lower limit speed Rd has a value that is lower by 5% than the highest value of the COP. Instead, for example, the first COP corresponding to the lower limit speed Rd may be a COP having a value that is lower by 0.5 than the highest value of the COP. In other words, in the example, the lower limit speed Rd may be set to a speed corresponding to the first COP that is lower by a given rate than the highest value of the COP, or may be set to a speed corresponding to the first COP that is lower by a given value than the highest value of the COP. In other words, the first COP may have a value that is lower by a given rate than the highest value of the COP, or may have a value that is lower by a given value than the highest value of the COP.

[Third Example]

[0070] In the example, a description is given of a problem arising when the compressor 1 is being controlled using the compressor speed table 200 or 300, and an operation to solve the problem, with reference to Figs. 7A and 7B. Fig. 7A is a timing chart illustrating the operation/stop of the compressor 1 and changes in the going temperature Tg in the case that the heat pump-type heating and hot-water supply apparatus 100 operates as illustrated in the first and second examples. Fig. 7B is a timing chart illustrating the operation/stop of the compressor 1 and changes in the going temperature Tg in the case that the heat pump-type heating and hot-water supply apparatus 100 operates as illustrated in this example.

[0071] In the first and second examples, as illustrated in Fig. 7A, when the compressor 1 stops, and the going temperature Tg decreases, and reaches the lower limit temperature Tt2 or below, the control means 60 restarts the compressor 1 at the lower limit speed Rd. At this point in time, the going temperature Tg may increase to the upper limit temperature Tt1 in a short time after the restart of the compressor 1 (a point Q of Fig. 7A). The reasons for this include, for example, that the outside temperature To is high, and that the temperature of the water returning from the indoor unit 40 or the water storage tank 70 to the water/refrigerant heat exchanger 3 (the return temperature) is high.

[0072] On the other hand, the operating efficiency of the compressor 1 varies depending also on the time during which the compressor 1 continues to be driven, in addition to the compressor speed R. Specifically, in the case that the operating time of the compressor 1 is shorter than a continuous operating time unique to the compressor 1 (for example, 10 minutes. Hereinafter described as the compressor minimum operating time tcm), the operating efficiency is degraded. On the other hand, in the case that the operating time of the compressor 1 is longer than the compressor minimum operating time tcm, the operating efficiency is improved.

[0073] From the above description, it is desired for the control means 60 to continue to operate the compressor 1 without a stop during a time from the restart of the compressor 1 at the lower limit speed Rd to the end of the passage of the compressor minimum operating time tcm. However, as illustrated in Fig. 7A, the going temperature Tg may be above the upper limit temperature Tt1 during the time from the restart of the compressor 1 to the end of the passage of the compressor minimum operating time tcm. In this case, the compressor 1 will continue to operate during a time from a point when the going temperature Tg is above the upper limit temperature Tt1 (at the time of the point Q) to the end of the passage of the compressor minimum operating time tcm. Consequently, the going temperature Tg may increase by ΔT°C (hereinafter described as the excessive temperature ΔT) from the upper limit temperature Tt1. In other words, water may be heated more than necessary. In this case, the compressor 1 may be unnecessarily operated, and the improvement of the COP of the heat pump-type heating and hot-water supply apparatus 100 may be suppressed.

[0074] Hence, in the heat pump-type heating and hot-water supply apparatus 100 according to the example, as illustrated in Fig. 7B, in the case that the excessive temperature ΔT occurs between the restart of the compressor 1 and the end of the passage of the compressor minimum operating time tcm, the following control is performed: The control means 60 stops the compressor 1 and decreases the going temperature Tg after the compressor minimum operating time tcm passes. When the going temperature Tg decreases to or below a temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2, the control means 60 restarts the compressor 1 at the lower limit speed Rd. Consequently, a time ti from the restart of the compressor 1 to when the going temperature Tg increases to the upper limit temperature Tt1 can be made longer than the compressor minimum operating time tcm. In other words, it is possible to continue to operate the compressor 1 during the compressor minimum operating time tcm, and to suppress the unnecessary operation of the compressor 1. Consequently, the COP of the heat pump-type heating and hot-water supply apparatus 100 improves.

[0075] Next, a description is given of the control of the compressor 1 using the above-mentioned compressor speed tables 200 or 300, the control being performed by the control means 60 during the heating or water heating operation, with reference to a flowchart illustrated in Fig. 8. The flowchart illustrated in Fig. 8 illustrates the flow of a process of when the compressor 1 is controlled so that the going temperature Tg falls between the upper limit temperature Tt1 and the lower limit temperature Tt2 during the heating or water heating operation of the heat pump-type heating and hot-water supply apparatus 100. ST represents a step and the subsequent numeral represents a step number. In Fig. 8, the illustrations and descriptions of the controls of the heat pump-type heating and hot-water supply apparatus 100, other than the control related to the characteristic technology of the example, are omitted. The omitted controls include, for example, the control of the compressor 1 and the control of the degree of opening of the expansion valve 4 when the going temperature Tg is increased to the target temperature Tt.

[0076] When performing the heating or water heating operation, the control means 60 captures the going temperature Tg detected by the outlet temperature sensor 57, and judges whether or not the going temperature Tg is equal to or more than the target temperature Tt (ST101). The target temperature Tt is defined corresponding to the set temperature of the heating or water heating operation and stored in the storage unit. If the going temperature Tg is not equal to or more than the target temperature Tt (ST101 - No), the control means 60 returns the processing to ST101, and maintains the current compressor speed R. After the start of the heating or water heating operation, the control means 60 continues to drive the compressor 1 setting the compressor speed R to a starting speed (for example, 60 rps) until the going temperature Tg reaches the target temperature Tt. Moreover, the control means 60 captures the going temperature Tg at given time intervals (for example, at intervals of 30 seconds).

[0077] If the going temperature Tg is equal to or more than the target temperature Tt in ST101 (ST101 - Yes), the control means 60 decreases the compressor speed R (ST102). The control means 60 decreases the compressor speed R in decrements of a given speed, for example, 2 rps/30 seconds.

[0078] When decreasing the compressor speed R, the control means 60 judges whether or not the compressor speed R is equal to or below the lower limit speed Rd (ST103). The control means 60 captures the outside temperature To detected by the outside temperature sensor 52 at given time intervals (for example, at intervals of 30 seconds). The control means 60 uses the outside temperature To and the stored target temperature Tt, refers to the compressor speed table 200 or 300, and extracts the lower limit speed Rd.

[0079] If the compressor speed R is not equal to or below the lower limit speed Rd (ST103 - No), the control means 60 returns the processing to ST102, and continues to decrease the compressor speed R. If the compressor speed R is equal to or below the lower limit speed Rd (ST103 - Yes), the control means 60 sets the compressor speed R to the lower limit speed Rd, and judges whether or not the going temperature Tg is less than the upper limit temperature Tt1 (ST104).

[0080] If the going temperature Tg is less than the upper limit temperature Tt1 (ST104 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST116), and returns the processing to ST104. If the going temperature Tg is not less than the upper limit temperature Tt1 (ST104 - No), the control means 60 stops the compressor 1 (ST105).

[0081] After stopping the compressor 1, the control means 60 judges whether or not the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST106). If the going temperature Tg is not equal to or less than the lower limit temperature Tt2 (ST106 - No), the control means 60 returns the processing to ST105, and continues to stop the compressor 1. If the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST106 - Yes), the control means 60 restarts the compressor 1 at the lower limit speed Rd (ST107).

[0082] After restarting the compressor 1, the control means 60 causes the timer to start measuring the time (ST108), and judges whether or not the compressor minimum operating time tcm has passed since the start of the time measurement (in other words, the restart of the compressor 1) (ST109). If the compressor minimum operating time tcm has not passed (ST109 - No), the control means 60 returns the processing to ST109, and continues to drive the compressor 1 at the lower limit speed Rd. If the compressor minimum operating time tcm has passed (ST109 - Yes), the control means 60 resets the timer (ST110).

[0083] After resetting the timer, the control means 60 judges again whether or not the going temperature Tg is less than the upper limit temperature Tt1 (ST111). If the going temperature Tg is less than the upper limit temperature Tt1 (ST111 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST117), and returns the processing to ST111. If the going temperature Tg is not less than the upper limit temperature Tt1 (ST111 - No), the control means 60 calculates the excessive temperature ΔT (ST112). Specifically, the control means 60 captures the going temperature Tg detected by the outlet temperature sensor 57 at the point when the compressor minimum operating time tcm has passed since the compressor 1 was restarted. The control means 60 calculates the excessive temperature ΔT by subtracting the upper limit temperature Tt1 from the captured going temperature Tg.

[0084] Next, the control means 60 stops the compressor 1 (ST113). The control means 60 then judges whether or not the going temperature Tg is equal to or less than a temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2 (ST114). If the going temperature Tg is not equal to or less than the temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2 (ST114 - No), the control means 60 returns the processing to ST113, and continues to stop the compressor 1. If the going temperature Tg is equal to or less than the temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2 (ST114 - Yes), the control means 60 restarts the compressor 1 at the lower limit speed Rd (ST115), and returns the processing to ST108.

[0085] After restarting the compressor 1 at the lower limit speed Rd (ST115), the control means 60 advances the processing to ST109 through ST108. Hence, the control means 60 continues to drive the compressor 1 for the compressor minimum operating time tcm or more, irrespective of the going temperature Tg.

[0086] As described above, in the heat pump-type heating and hot-water supply apparatus according to the example, the control means detects the going temperature during the operation of the compressor when the compressor minimum operating time has passed since the compressor was restarted. In the case that the going temperature is equal to or more than the upper limit temperature, the control means calculates the excessive temperature being a difference in temperature between the going temperature and the upper limit temperature, and stops the compressor. The control means then restarts the compressor when the going temperature reaches less than the temperature obtained by subtracting the excessive temperature from the lower limit temperature. Consequently, it is possible to prevent or suppress the going temperature from being equal to or above the upper limit temperature until the compressor minimum operating time passes after the restart of the compressor. As a result, it is possible to prevent or suppress the unnecessary operation of the compressor. Accordingly, the COP of the heat pump-type heating and hot-water supply apparatus can be improved.

[0087] Moreover, in the above-described embodiment, the excessive temperature ΔT, which is a difference between the going temperature Tg exceeding the upper limit temperature Tt1 and the upper limit temperature Tt1, is subtracted from the lower limit temperature Tt2. When the going temperature Tg reaches the temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2, the compressor 1 is restarted. The temperature to restart the compressor 1 may be set to a temperature obtained by subtracting an adjustment temperature from the lower limit temperature Tt2 instead. The adjustment temperature is a temperature that is higher or lower than the excessive temperature ΔT. As described above, in the example, when the going temperature Tg reaches the temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2, the compressor 1 is restarted. In the case that a second excessive temperature $\Delta T2$ that is smaller than ΔT occurs in the next cycle, when the going temperature Tg reaches a temperature obtained by subtracting the sum of the excessive temperature ΔT and the second excessive temperature $\Delta T2$ from the lower limit temperature (= $Tt2 - (\Delta T + \Delta T2)$, the control means 60 may restart the compressor.

[0088] In other words, the control means 60 may restart the compressor 1 at the lower limit speed Rd when the going temperature Tg decreases to or below a first temperature calculated based on the lower limit temperature Tt2 and the excessive temperature. The first temperature may be a temperature obtained by subtracting the excessive temperature ΔT from the lower limit temperature Tt2.

[0089] Moreover, in the example, if the going temperature Tg is less than the upper limit temperature Tt1 (ST104 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST116), and returns the processing to ST104. Instead, if the going temperature Tg is less than the upper limit temperature Tt1 (ST104 - Yes), the control means 60 may continue to operate the compressor 1 at the lower limit speed Rd (ST116), and advance the processing to ST108.

[0090] Moreover, in the example, the processing illustrated in ST108 to ST115 in Fig. 8 is performed after the compressor 1 is started, the going temperature Tg increases to or above the upper limit temperature Tt1, the compressor 1 is stopped, the going temperature Tg decreases to or below the lower limit temperature Tt2, and the compressor 1 is restarted. However, the processing is not limited to this. The control means 60 may not perform ST104 to ST107 and ST116 illustrated in Fig. 8, in the example. In this case, if the compressor speed R is equal to or less than the lower limit speed Rd (ST103 - Yes), the control means 60 sets the compressor speed R to the lower limit speed Rd. The control means 60 causes the timer to start measuring the time (ST108), and judges whether or not the compressor minimum operating time tcm has passed since the start of the time measurement (in other words, the restart of the compressor 1) (ST109). The processing of ST110 to ST115 and ST117 is subsequently performed. In this case, the control means 60 does not make a restart of the compressor 1 without considering the compressor minimum operating time tcm.

[Fourth Example]

[0091] In the example, a description is given of a problem arising when the compressor 1 is being controlled using the compressor speed table 200 or 300, and the operation of the example to solve the problem, with reference to Fig. 9. Fig. 9 is a timing chart illustrating the operation/stop of the compressor 1 and changes in the going temperature Tg. Fig. 9 illustrates the above-mentioned going temperature Tg, target temperature Tt, upper limit temperature Tt1, and lower limit temperature Tt2. Furthermore, in Fig. 9, a threshold temperature is set as Ts, a threshold temperature excessive time as ti, and a first excessive time limitation as te1.

[0092] Here, the threshold temperature Ts is a temperature equal to or more than the predetermined target temperature Tt and less than the upper limit temperature Tt1. For example, when the target temperature Tt is 40°C and the upper limit temperature Tt1 is 42°C, the threshold temperature Ts is 41.5°C. Moreover, the threshold temperature excessive time ti is the duration during which the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1. Moreover, the first excessive time limitation te1 is a time limitation on the predetermined threshold temperature excessive time ti. The first excessive time limitation te1 is preferred to be longer than the compressor minimum operating time tcm.

[0093] As described above, in the heat pump-type heating and hot-water supply apparatus 100 of the first and second examples, if the compressor speed R reaches the lower limit speed Rd, the control means 60 judges whether or not the going temperature Tg is equal to or more than the upper limit temperature Tt1. If the going temperature Tg is equal to or more than the upper limit temperature Tt1, the control means 60 stops the compressor 1. If the going temperature Tg decreases to or below the lower limit temperature Tt2 while the compressor 1 is at rest, the control means 60 restarts the compressor 1 at the lower limit speed Rd. If the compressor 1 is restarted at the lower limit speed Rd, and then the going temperature Tg increases to or above the upper limit temperature Tt1 again, the control means 60 stops the compressor 1.

[0094] For example, when the compressor 1 was restarted at the lower limit speed Rd and the going temperature Tg is increasing, the going temperature Tg may be equal to or above the upper limit temperature Tt1 while the lapse of a threshold temperature excessive time Ti1 is still short which is a time that has passed since a point when the going temperature Tg exceeds the threshold temperature Ts (a point Q1 of Fig. 9). In this case, the time is short during which the compressor 1 is being operated in a state where the going temperature Tg is higher than the target temperature Tt. Hence, an unnecessary operating time of the heat pump-type heating and hot-water supply apparatus 100 becomes short. Accordingly, the COP is not degraded much.

[0095] On the other hand, depending on the heating load (for example, the solar radiation state of the room where the indoor unit 40 is installed) of the indoor unit 40 or the outside temperature To, even if a threshold temperature excessive time Ti2 is long which is a time that has passed since a point when the going temperature Tg exceeds the threshold temperature Ts (a point Q2 of Fig. 9), the going temperature Tg may not reach the upper limit temperature Tt1 as illustrated in Fig. 9. In such a case, the water temperature in the indoor unit 40 or the water storage tank 70 may be equal to or more than the set temperature. Furthermore, the compressor 1 continues to be operated at the lower limit speed Rd since the going temperature Tg is not equal to or more than the upper limit temperature Tt1. In other words, the heat pump-type heating and hot-water supply apparatus 100 will be unnecessarily operated. If this state continues for a long time (in the above example, the threshold temperature excessive time Ti2), the improvement of the COP of the heat pump-type heating and hot-water supply apparatus 100 is prevented.

[0096] Hence, in the heat pump-type heating and hot-water supply apparatus 100 of the example, the control means 60 starts measuring the time when the going temperature Tg reaches the threshold temperature Ts after the restart of the compressor 1. In other words, the control means 60 starts measuring a time during which the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (in other words, a threshold temperature excessive time Ti). When the threshold temperature excessive time Ti reaches the first excessive time limitation te1 or above as in the threshold temperature excessive time Ti2 illustrated in Fig. 9, even if the going temperature Tg is not equal to or more than the upper limit temperature Tt1, the control means 60 stops the compressor 1. Consequently, it is possible to prevent or suppress the compressor 1 from continuing to be operated when the going temperature Tg is equal to or more than the target temperature Tt. As a result, the COP of the heat pump-type heating and hot-water supply apparatus 100 can be improved.

[0097] Next, a description is given of the control of the compressor 1 using the above-mentioned compressor speed tables 200 or 300, the control being performed by the control means 60 during the heating or water heating operation, with reference to a flowchart illustrated in Fig. 10. The flowchart illustrated in Fig. 10 illustrates the flow of a process of when the compressor 1 is controlled so that the going temperature Tg falls between the upper limit temperature Tt1 and the lower limit temperature Tt2 during the heating or water heating operation of the heat pump-type heating and hot-water supply apparatus 100. ST represents a step and the subsequent numeral represents a step number. In Fig. 10, the illustrations and descriptions of the controls of the heat pump-type heating and hot-water supply apparatus 100, other than the control related to the characteristic technology of the example, are omitted. The omitted controls include, for example, the control of the compressor 1 and the control of the degree of opening of the expansion valve 4 when the going temperature Tg is increased to the target temperature Tt.

[0098] When performing the heating or water heating operation, the control means 60 captures the going temperature Tg detected by the outlet temperature sensor 57, and judges whether or not the going temperature Tg is equal to or more than the target temperature Tt (ST201). The target temperature Tt is defined corresponding to the set temperature of the heating or water heating operation and stored in the storage unit. If the going temperature Tg is not equal to or more than the target temperature Tt (ST201 - No), the control means 60 returns the processing to ST201, and maintains the current compressor speed R. After the start of the heating or water heating operation, the control means 60 continues to drive the compressor 1 setting the compressor speed R to a starting speed (for example, 60 rps) until the going temperature Tg reaches the target temperature Tt. Moreover, the control means 60 captures the going temperature Tg at given time intervals (for example, at intervals of 30 seconds). If the going temperature Tg is equal to or more than the target temperature Tt in ST201 (ST201 - Yes), the control means 60 decreases the compressor speed R (ST202). The control means 60 decreases the compressor speed R in decrements of a given speed, for example, 2 rps/30 seconds.

[0099] When decreasing the compressor speed R, the control means 60 judges whether or not the compressor speed R is equal to or below the lower limit speed Rd (ST203). The control means 60 captures the outside temperature To detected by the outside temperature sensor 52 at given time intervals (for example, at intervals of 30 seconds). The control means 60 uses the outside temperature To and the stored target temperature Tt, refers to the compressor speed table 200 or 300, and extracts the lower limit speed Rd.

[0100] If the compressor speed R is not equal to or below the lower limit speed Rd (ST203 - No), the control means 60 returns the processing to ST202, and continues to decrease the compressor speed R. If the compressor speed R is equal to or below the lower limit speed Rd (ST203 - Yes), the control means 60 sets the compressor speed R to the lower limit speed Rd, and judges whether or not the going temperature Tg is less than the upper limit temperature Tt1 (ST204).

[0101] If the going temperature Tg is less than the upper limit temperature Tt1 (ST204 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST211). The control means 60 then judges whether or not the going temperature Tg is equal to or more than the threshold temperature Ts (ST212).

[0102] If the going temperature Tg is not equal to or more than the threshold temperature Ts (ST212 - No), the control means 60 returns the processing to ST204. If the going temperature Tg is equal to or more than the threshold temperature Ts (ST212 - Yes), the control means 60 starts measuring the threshold temperature excessive time ti (ST213). After the start of the measurement of the threshold temperature excessive time ti, the control means 60 judges whether or not the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST214). If the going temperature Tg is not equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST214 - No), the control means 60 returns the processing to ST204. If the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST214-Yes), the control means 60 judges whether or not the threshold temperature excessive time ti is equal to or more than the first excessive time limitation te1 (ST215).

[0103] If the threshold temperature excessive time ti is not equal to or more than the first excessive time limitation te1 (ST215 - No), the control means 60 returns the processing to ST214. If the threshold temperature excessive time ti is equal to or more than the first excessive time limitation te1 (ST215 - Yes), the control means 60 resets the timer (ST216), and advances the processing to ST205.

[0104] If the going temperature Tg is not less than the upper limit temperature Tt1 in ST204 (ST204 - No), the control means 60 stops the compressor 1 (ST205). After stopping the compressor 1, the control means 60 judges whether or not the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST206). If the going temperature Tg is not equal to or less than the lower limit temperature Tt2 (ST206 - No), the control means 60 returns the processing to ST205, and continues to stop the compressor 1. If the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST206 - Yes), the control means 60 restarts the compressor 1 at the lower limit speed Rd (ST207).

[0105] After restarting the compressor 1, the control means 60 causes the timer to start measuring the time (ST208), and judges whether or not the given time has passed since the start of the time measurement (in other words, the restart of the compressor 1) (ST209). If the given time has not passed (ST209 - No), the control means 60 returns the processing to ST209, and continues to drive the compressor 1 at the lower limit speed Rd. If the given time has passed (ST209 - Yes), the control means 60 resets the timer (ST210), and returns the processing to ST204. Here, the given time in ST209 is the above-mentioned compressor minimum operating time tcm. In other words, the given time is such a time as that while the operating efficiency is degraded in the case that the operating time of the compressor 1 is shorter than the given time, the operating efficiency of the compressor 1 improves in the case that the operating time of the compressor 1 is longer than the given time. The control means 60 stops the compressor 1 regardless of the threshold temperature excessive time ti when the going temperature Tg reaches the upper limit temperature Tt1 or above.

[0106] As described above, in the heat pump-type heating and hot-water supply apparatus of the example, the control means operates the compressor at the lower limit speed and puts the going temperature within a temperature range defined by the upper limit temperature and the lower limit temperature, and also stops the compressor when the threshold temperature excessive time reaches the given excessive time limitation or above. The threshold temperature excessive time is a time during which the going temperature is equal to or more than the threshold temperature being a temperature that is higher by a given temperature than the target temperature, and less than the upper limit temperature. Consequently, it is possible to prevent or suppress the compressor from being operated for a long time when the going temperature is stable at a temperature that is higher than the target temperature. As a result, the COP of the heat pump-type heating and hot-water supply apparatus can be improved.

[Fifth Example]

[0107] In the example, a description is given of a problem arising when the compressor 1 is being controlled using the compressor speed table 200 or 300, and the operation of the example to solve the problem, with reference to Fig. 11. Fig. 11 is a timing chart illustrating the operation/stop of the compressor 1 and changes in the going temperature Tg. Fig. 11 illustrates the above-mentioned going temperature Tg, target temperature Tt, upper limit temperature Tt1, and lower limit temperature Tt2. Furthermore, in Fig. 11, a threshold temperature is set as Ts, a threshold temperature excessive time as ti, and a second excessive time limitation as te2.

[0108] The relationship between the second excessive time limitation te2 and the first excessive time limitation te1 illustrated in the fourth example is te1 > te2. Moreover, in the example, operating the compressor 1 at the lower limit speed Rd is defined to as an operation 1, and operating the compressor 1 at the optimum speed Rm as an operation 2.

[0109] Here, the threshold temperature Ts is a temperature equal to or more than the predetermined target temperature Tt and less than the upper limit temperature Tt1. For example, when the target temperature Tt is 40°C and the upper limit temperature Tt1 is 42°C, the threshold temperature Ts is 41.5°C. Moreover, the threshold temperature excessive time ti is the duration during which the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1. Moreover, the second excessive time limitation te2 is a time limitation on the predetermined threshold temperature excessive time ti. The second excessive time limitation te2 is preferred to be longer than the compressor minimum operating time tcm.

[0110] As described above, depending on the heating load (for example, the solar radiation state of the room where the indoor unit 40 is installed) of the indoor unit 40 or the outside temperature To, even if a threshold temperature excessive time Ti2 is long which is a time that has passed since a point when the going temperature Tg exceeds the threshold temperature Ts (a point Q2 of Fig. 11), the going temperature Tg may not reach the upper limit temperature Tt1 as illustrated in Fig. 11. In such a case, the water temperature in the indoor unit 40 or the water storage tank 70 may be equal to or more than the set temperature. Furthermore, the compressor 1 continues to be operated at the lower limit speed Rd since the going temperature Tg is not equal to or more than the upper limit temperature Tt1. In other words, the heat pump-type heating and hot-water supply apparatus 100 will be unnecessarily operated. If this state continues for a long time (in the above example, the threshold temperature excessive time Ti2), the improvement of the COP of the heat pump-type heating and hot-water supply apparatus 100 is prevented.

[0111] Hence, in the heat pump-type heating and hot-water supply apparatus 100 of the example, the control means 60 starts measuring the time when the going temperature Tg reaches the threshold temperature Ts after the compressor 1 is restarted. In other words, the control means 60 starts measuring a time during which the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (in other words, the threshold temperature excessive time Ti). When the threshold temperature excessive time Ti reaches the second excessive time limitation te2 (a point X of Fig. 11) or above as in the threshold temperature excessive time Ti2 illustrated in Fig. 11, the control means 60 increases the speed of the compressor 1 from the lower limit speed Rd to the optimum speed Rm (switches from the operation 1 to the operation 2). The control means 60 stops the compressor 1 when the going temperature Tg increases to or above the upper limit temperature Tt1 during the operation of the compressor 1 at the optimum speed Rm.

[0112] In this manner, in the example, the control means 60 accelerates the increase of the going temperature Tg by increasing the speed of the compressor 1 to the optimum speed Rm corresponding to the highest value of the COP. In other words, the control means 60 causes the going temperature Tg to reach the upper limit temperature Tt1 quickly and stops the compressor 1 quickly. Consequently, it is possible to prevent or suppress the compressor 1 from continuing to be operated when the going temperature Tg is equal to or more than the target temperature Tt. As a result, the COP of the heat pump-type heating and hot-water supply apparatus 100 can be improved.

[0113] Next, a description is given of the control of the compressor 1 using the above-mentioned compressor speed tables 200 or 300, the control being performed by the control means 60 during the heating or water heating operation, with reference to a flowchart illustrated in Fig. 12. The flowchart illustrated in Fig. 12 illustrates the flow of a process of when the compressor 1 is controlled so that the going temperature Tg falls between the upper limit temperature Tt1 and the lower limit temperature Tt2 during the heating or water heating operation of the heat pump-type heating and hot-water supply apparatus 100. ST represents a step and the subsequent numeral represents a step number. In Fig. 12, the illustrations and descriptions of the controls of the heat pump-type heating and hot-water supply apparatus 100, other than the control related to the characteristic technology of the example, are omitted. The omitted controls include, for example, the control of the compressor 1 and the control of the degree of opening of the expansion valve 4 when the going temperature Tg is increased to the target temperature Tt.

[0114] When performing the heating or water heating operation, the control means 60 captures the going temperature Tg detected by the outlet temperature sensor 57, and judges whether or not the going temperature Tg is equal to or more than the target temperature Tt (ST301). The target temperature Tt is defined corresponding to the set temperature of the heating or water heating operation and stored in the storage unit. If the going temperature Tg is not equal to or more than the target temperature Tt (ST301 - No), the control means 60 returns the processing to ST301, and maintains the current compressor speed R. After the start of the heating or water heating operation, the control means 60 continues to drive the compressor 1 setting the compressor speed R to a starting speed (for example, 60 rps) until the going temperature Tg reaches the target temperature Tt. Moreover, the control means 60 captures the going temperature Tg at given time intervals (for example, at intervals of 30 seconds).

[0115] If the going temperature Tg is equal to or more than the target temperature Tt in ST301 (ST301 - Yes), the control means 60 decreases the compressor speed R (ST302). The control means 60 decreases the compressor speed R in decrements of a given speed, for example, 2 rps/30 seconds.

[0116] When decreasing the compressor speed R, the control means 60 judges whether or not the compressor speed R is equal to or below the lower limit speed Rd (ST303). The control means 60 captures the outside temperature To detected by the outside temperature sensor 52 at given time intervals (for example, at intervals of 30 seconds). The control means 60 uses the outside temperature To and the stored target temperature Tt, refers to the compressor speed table 200 or 300, and extracts the lower limit speed Rd.

[0117] If the compressor speed R is not equal to or below the lower limit speed Rd (ST303 - No), the control means 60 returns the processing to ST302, and continues to decrease the compressor speed R. If the compressor speed R is equal to or below the lower limit speed Rd (ST303 - Yes), the control means 60 sets the compressor speed R to the lower limit speed Rd, and judges whether or not the going temperature Tg is less than the upper limit temperature Tt1 (ST304).

[0118] If the going temperature Tg is less than the upper limit temperature Tt1 (ST304 - Yes), the control means 60 continues to operate the compressor 1 at the lower limit speed Rd (ST311). The control means 60 then judges whether or not the going temperature Tg is equal to or more than the threshold temperature Ts (ST312).

[0119] If the going temperature Tg is not equal to or more than the threshold temperature Ts (ST312 - No), the control means 60 returns the processing to ST304. If the going temperature Tg is equal to or more than the threshold temperature Ts (ST312 - Yes), the control means 60 starts measuring the threshold temperature excessive time ti (ST313).

[0120] After the start of the measurement of the threshold temperature excessive time ti, the control means 60 judges whether or not the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST314). If the going temperature Tg is not equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST314 - No), the control means 60 returns the processing to ST304. If the going temperature Tg is equal to or more than the threshold temperature Ts and less than the upper limit temperature Tt1 (ST314 - Yes), the control means 60 judges whether or not the threshold temperature excessive time ti is equal to or more than the second excessive time limitation te2 (ST315).

[0121] If the threshold temperature excessive time ti is not equal to or more than the second excessive time limitation te2 (ST315 - No), the control means 60 returns the processing to ST314. If the threshold temperature excessive time ti is equal to or more than the second excessive time limitation te2 (ST315 - Yes), the control means 60 resets the timer (ST316), and sets the compressor speed R to the optimum speed Rm to operate the compressor 1 (ST317). The control means 60 captures the outside temperature To detected by the outside temperature sensor 52 at given time intervals (for example, at intervals of 30 seconds). The control means 60 uses the outside temperature To and the stored target temperature Tt, refers to the compressor speed table 200 or 300, and extracts the optimum speed Rm.

[0122] Next, the control means 60 judges whether or not the going temperature Tg of when the compressor 1 is being operated at the optimum speed Rm is less than the upper limit temperature Tt1 (ST318). If the going temperature Tg is less than the upper limit temperature Tt1 (ST318-Yes), the control means 60 returns the processing to ST317, and continues to operate the compressor 1 at the optimum speed Rm. If the going temperature Tg is not less than the upper limit temperature Tt1 (ST318 - No), the control means 60 advances the processing to ST305.

[0123] If the going temperature Tg is not less than the upper limit temperature Tt1 in ST304 (ST304 - No), the control means 60 stops the compressor 1 (ST305). After stopping the compressor 1, the control means 60 judges whether or not the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST306). If the going temperature Tg is not equal to or less than the lower limit temperature Tt2 (ST306 - No), the control means 60 returns the processing to ST305, and continues to stop the compressor 1. If the going temperature Tg is equal to or less than the lower limit temperature Tt2 (ST306 - Yes), the control means 60 restarts the compressor 1 at the lower limit speed Rd (ST307).

[0124] After restarting the compressor 1, the control means 60 causes the timer to start measuring the time (ST308), and judges whether or not the given time has passed since the start of the time measurement (in other words, the restart of the compressor 1) (ST309). If the given time has not passed (ST309 - No), the control means 60 returns the processing to ST309, and continues to drive the compressor 1 at the lower limit speed Rd. If the given time has passed (ST309 - Yes), the control means 60 resets the timer (ST310), and returns the processing to ST304. Here, the given time in ST309 is the above-mentioned compressor minimum operating time tcm. In other words, the given time is such a time as that while the operating efficiency is degraded in the case that the operating time of the compressor 1 is shorter than the given time, the operating efficiency of the compressor 1 improves in the case that the operating time of the compressor 1 is longer than the given time. The control means 60 stops the compressor 1 regardless of the threshold temperature excessive time ti when the going temperature Tg reaches the upper limit temperature Tt1 or above.

[0125] As described above, in the heat pump-type heating and hot-water supply apparatus according to the example, the control means increases the speed of the compressor to the optimum speed when the threshold temperature excessive time reaches a given excessive time limitation or more, and stops the compressor when the going temperature increases to or above the upper limit temperature. The threshold temperature excessive time is a time during which the going temperature is equal to or more than the threshold temperature and less than the upper limit temperature. The threshold temperature is a temperature that is higher by a given temperature than the target temperature.

[0126] In this manner, in the example, the control means increases the speed of the compressor to the optimum speed corresponding to the highest value of the COP, and accordingly accelerates the increase of the going temperature. In other words, the control means causes the going temperature to reach the upper limit temperature quickly and stops the compressor quickly. Consequently, it is possible to prevent or suppress the compressor from continuing to be operated when the going temperature is equal to or more than the target temperature. As a result, the COP of the heat pump-type heating and hot-water supply apparatus can be improved.

[0127] Moreover, in the third to fifth examples, the lower limit speed Rd may be a speed that is lower by a given rate (for example, 10%) than the optimum speed Rm, or may be a speed that is lower by a uniform speed (for example, 10 rps) than the optimum speed Rm. Furthermore, the lower limit speed may be a speed corresponding to the first COP that is lower by a fixed rate than the highest value of the COP, or may be a speed corresponding to the first COP that is lower by a fixed value than the highest value of the COP. In other words, in this case, the first COP may have a value that is lower by a given rate than the highest value of the COP, or may have a value that is lower by a given value than the highest value of the COP.

[0128] The heat pump-type heating and hot-water supply apparatus according to the embodiments of the present invention may be the following first to thirteenth heat pump-type heating and hot-water supply apparatuses.

[0129] The first heat pump-type heating and hot-water supply apparatus is a heat pump-type heating and hot-water supply apparatus including: a refrigerant circuit configured by sequentially connecting a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, flow rate adjustment means, and a heat source side heat exchanger; a hot-water supply circuit that circulates hot water by the operation of a circulation pump between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means the detects a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; and control means that controls the compressor, where the control means judges whether or not the water temperature is equal to or more than an upper limit temperature that is higher by a given temperature than the target temperature if the speed of the compressor decreases by a given speed or more from an optimum speed at which a COP has its highest value when the control means is decreasing the speed of the compressor to decrease the going temperature upon controlling the compressor so that the going temperature approaches to a target temperature in accordance with capacity required by the heating terminal, stops the compressor if the water temperature is equal to or more than the upper limit temperature, and continues to operate the compressor at a speed that is lower by a given speed than the optimum speed at which the COP has the highest value if the water temperature is not equal to or more than the upper limit temperature.

[0130] In the second heat pump-type heating and hot-water supply apparatus according to the first heat pump-type heating and hot-water supply apparatus, the control means restarts the compressor at a speed at which the compressor was stopped, if the water temperature reaches less than a lower limit temperature that is lower by a given temperature than the target temperature while the compressor is at rest.

[0131] The third heat pump-type heating and hot-water supply apparatus is a heat pump-type heating and hot-water supply apparatus including: a refrigerant circuit configured by sequentially connecting a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, flow rate adjustment means, a heat source side heat exchanger; a hot-water supply circuit that circulates hot water by the operation of a circulation pump between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means that detects a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; outside temperature detection means that detects the outside temperature; and control means that controls the compressor, where the control means judges whether or not the water temperature is equal to or more than an upper limit temperature that is higher by a given temperature than the target temperature if the speed of the compressor decreases to or below a lower limit speed being a speed of the compressor corresponding to the value of a COP that is lower by a given rate than the highest value of the COP predetermined in accordance with the outside temperature and the target temperature when the control means is decreasing the speed of the compressor to decrease the going temperature upon controlling the compressor so that the going temperature approaches to a target temperature in accordance with capacity required by the heating terminal, stops the compressor if the water temperature is equal to or more than the upper limit temperature, and continues to operate the compressor at the lower limit speed if the water temperature is not equal to or more than the upper limit temperature.

[0132] The fourth heat pump-type heating and hot-water supply apparatus according to the third heat pump-type heating and hot-water supply apparatus, where the control means restarts the compressor at a speed at which the compressor was stopped if the water temperature reaches less than a lower limit temperature that is lower by a given temperature than the target temperature while the compressor is at rest.

[0133] The fifth heat pump-type heating and hot-water supply apparatus is a heat pump-type heating and hot-water supply apparatus including: a refrigerant circuit configured by sequentially connecting a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, flow rate adjustment means, and a heat source side heat exchanger; a hot-water supply circuit that circulates hot water by the operation of a circulation pump between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means that detects a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; and control means that controls the compressor, where when operating the compressor at a lower limit speed that is lower by a given speed than a speed of the compressor at which a COP has its highest value in order to put the going temperature within a temperature range including a target temperature in accordance with capacity required by the heating terminal and defined by an upper limit temperature and a lower limit temperature, the control means judges whether or not a compressor minimum operating time being a given time has passed since the start of the compressor, judges whether or not the going temperature of when the compressor minimum operating time passed is equal to or more than the upper limit temperature if the compressor minimum operating time has passed, stops the compressor if the going temperature is equal to or more than the upper limit temperature, and also calculates an excessive temperature being a difference in temperature between the going temperature and the upper limit temperature, and restarts the compressor at the lower limit speed if the going temperature reaches less than a temperature obtained by subtracting the excessive temperature or an adjustment temperature corresponding to the excessive temperature from the lower limit temperature while the compressor is at rest.

[0134] In the sixth heat pump-type heating and hot-water supply apparatus according to the fifth heat pump-type heating and hot-water supply apparatus, the control means continues to drive the compressor for the compressor minimum operating time or more, irrespective of the going temperature, after restarting the compressor at the lower limit speed.

[0135] In the seventh heat pump-type heating and hot-water supply apparatus according to the fifth or sixth heat pump-type heating and hot-water supply apparatus, the lower limit speed is a speed of the compressor corresponding to a COP value that is lower by a given rate than the highest value of the COP.

[0136] The eighth heat pump-type heating and hot-water supply apparatus is a heat pump-type heating and hot-water supply apparatus including: a refrigerant circuit configured by sequentially connecting a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, flow rate adjustment means, and a heat source side heat exchanger; a hot-water supply circuit that circulates hot water by the operation of a circulation pump between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means that detects a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; and control means that controls the compressor, where when operating the compressor at a lower limit speed that is lower by a given speed than a speed of the compressor at which a COP has its highest value in order to put the going temperature within a temperature range including a target temperature in accordance with capacity required by the heating terminal and defined by an upper limit temperature and a lower limit temperature, the control means judges whether or not the going temperature is equal to or above a threshold temperature being a given temperature between the target temperature and the upper limit temperature, measures a threshold temperature excessive time being a time after the going temperature reaches the threshold temperature, during which the going temperature is equal to or more than the threshold temperature and less than the upper limit temperature, if the going temperature is equal to or more than the threshold temperature, and stops the compressor if the threshold temperature excessive time reaches a predetermined excessive time limitation or above.

[0137] In the ninth heat pump-type heating and hot-water supply apparatus according to the eighth heat pump-type heating and hot-water supply apparatus, the control means continues to drive the compressor at the lower limit speed until the threshold temperature excessive time reaches the excessive time limitation, and stops the compressor if the going temperature is equal to or above the upper limit temperature.

[0138] In the tenth heat pump-type heating and hot-water supply apparatus according to the eighth or ninth heat pump-type heating and hot-water supply apparatus, the lower limit speed is a speed of the compressor corresponding to a COP value that is lower by a given rate than the highest value of the COP.

[0139] The eleventh heat pump-type heating and hot-water supply apparatus is a heat pump-type heating and hot-water supply apparatus including: a refrigerant circuit configured by sequentially connecting a compressor, a water/refrigerant heat exchanger that exchanges heat between refrigerant and water, flow rate adjustment means, and a heat source side heat exchanger; a hot-water supply circuit that circulates hot water by the operation of a circulation pump between a heating terminal and the water/refrigerant heat exchanger; going temperature detection means that detects a going temperature being the temperature of water flowing out of the water/refrigerant heat exchanger; and control means that controls the compressor, where when operating the compressor at a lower limit speed that is lower by a given speed than an optimum speed being a speed of the compressor at which a COP has its highest value in order to put the going temperature within a temperature range including a target temperature in accordance with capacity required by the heating terminal and defined by an upper limit temperature and a lower limit temperature, the control means judges whether or not the going temperature is equal to or above a threshold temperature being a given temperature between the target temperature and the upper limit temperature, measures a threshold temperature excessive time being a time after the going temperature reaches the threshold temperature, during which the going temperature is equal to or more than the threshold temperature and less than the upper limit temperature, if the going temperature is equal to or more than the threshold temperature, sets the speed of the compressor to the optimum speed if the threshold temperature excessive time reaches a predetermined excessive time limitation or above, and stops the compressor if the going temperature increases to or above the upper limit temperature during the operation of the compressor at the optimum speed.

[0140] In the twelfth heat pump-type heating and hot-water supply apparatus according to the eleventh heat pump-type heating and hot-water supply apparatus, the control means continues to drive the compressor at the lower limit speed until the threshold temperature excessive time reaches the excessive time limitation, and stops the compressor if the going temperature increases to or above the upper limit temperature during the operation of the compressor at the lower limit speed.

[0141] In the thirteenth heat pump-type heating and hot-water supply apparatus according to the eleventh or twelfth heat pump-type heating and hot-water supply apparatus, the lower limit speed is a speed of the compressor corresponding to a COP value that is lower by a given rate than the highest value of the COP.

[0142] The foregoing detailed description has been presented for the purposes of illustration and description. Many modifications and variations are possible in light of the above teaching. It is not intended to be exhaustive or to limit the subject matter described herein to the precise form disclosed. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims appended hereto.

Claims

1. A heat pump-type heating and hot-water supply apparatus (100) comprising:

    a refrigerant circuit (10) including
    a compressor (1),
    a water/refrigerant heat exchanger (3) configured to exchange heat between refrigerant and water, and
    a heat source side heat exchanger (5);
    a hot-water supply circuit (12) including a circulation pump (30) and being configured to circulate hot water between a heating terminal (40, 70) and the water/refrigerant heat exchanger (3);
    going temperature detection means (57) configured to detect a going temperature (Tg) being the temperature of water flowing out of the water/refrigerant heat exchanger (3); and
    control means (60) configured to control the compressor (1) so that the going temperature (Tg) approaches to a target temperature (Tt) in accordance with a set temperature of the heating terminal (40, 70), wherein
    the control means (60)
    when decreasing the speed of the compressor (1) to decrease the going temperature (Tg), judges whether or not the going temperature (Tg) is equal to or more than an upper limit temperature (Tt1) higher by a given temperature than the target temperature (Tt), in the case that the speed of the compressor (1) is at or below a lower limit speed (Rd) lower than an optimum speed (Rm) corresponding to the highest value of a COP,
    stops the compressor (1) in the case that the going temperature (Tg) is equal to or more than the upper limit temperature (Tt1), and
    continues to operate the compressor (1) at the lower limit speed (Rd) in the case that the going temperature (Tg) is not equal to or more than the upper limit temperature (Tt1).

2. The heat pump-type heating and hot-water supply apparatus (100) according to claim 1, wherein during the operation of the compressor (1) at the lower limit speed (Rd),
    the control means (60)
    judges whether or not a compressor minimum operating time (tcm) being a given time has passed since the start of the compressor (1),
    judges whether or not the going temperature (Tg) is equal to or more than the upper limit temperature (Tt1) in the case that the compressor minimum operating time (tcm) has passed,
    stops the compressor (1) and calculates an excessive temperature (ΔT) being a difference in temperature between the going temperature (Tg) and the upper limit temperature (Tt1) in the case that the going temperature (Tg) is equal to or more than the upper limit temperature (Tt1), and
    restarts the compressor (1) at the lower limit speed (Rd) when the going temperature (Tg) decrease to or below a first temperature calculated based on a lower limit temperature (Tt2) lower by a given temperature than the target temperature (Tt), and the excessive temperature (ΔT) during the stop of the compressor (1).

3. The heat pump-type heating and hot-water supply apparatus (100) according to claim 2, wherein the first temperature is a temperature obtained by subtracting the excessive temperature (ΔT) from the lower limit temperature (Tt2).

4. The heat pump-type heating and hot-water supply apparatus (100) according to claim 2 or 3, wherein the control means (60) continues to drive the compressor (1) for the compressor minimum operating time (tcm) or more, irrespective of the going temperature (Tg), after restarting the compressor (1) at the lower limit speed (Rd).

5. The heat pump-type heating and hot-water supply apparatus (100) according to claim 1, wherein
    during the operation of the compressor (1) at the lower limit speed (Rd), the control means (60)
    judges whether or not the going temperature (Tg) has increased to or above a threshold temperature (Ts) being a given temperature between the target temperature (Tt) and the upper limit temperature (Tt1),
    measures a threshold temperature excessive time (ti) being a time after the going temperature (Tg) reaches the threshold temperature (Ts), during which the going temperature (Tg) is equal to or more than the threshold temperature (Ts) and less than the upper limit temperature (Tt1), in the case that the going temperature (Tg) is equal to or above the threshold temperature (Ts), and
    stops the compressor (1) in the case that the threshold temperature excessive time (ti) reaches a predetermined first excessive time limitation (te1) or above.

6. The heat pump-type heating and hot-water supply apparatus (100) according to claim 1, wherein during the operation of the compressor (1) at the lower limit speed (Rd),
the control means (60)
judges whether or not the going temperature (Tg) has increased to or above a threshold temperature (Ts) being a given temperature between the target temperature (Tt) and the upper limit temperature (Tt1),
measures a threshold temperature excessive time (ti) being a time after the going temperature (Tg) reaches the threshold temperature (Ts), during which the going temperature (Tg) is equal to or more than the threshold temperature (Ts) and less than the upper limit temperature (Tt1), in the case that the going temperature (Tg) is equal to or more than the threshold temperature (Ts),
sets the speed of the compressor (1) at the optimum speed (Rm) when the threshold temperature excessive time (ti) reaches a predetermined second excessive time limitation (te2) or above, and
stops the compressor (1) when the going temperature (Tg) reaches the upper limit temperature (Tt1) or above during the operation of the compressor (1) at the optimum speed (Rm).

7. The heat pump-type heating and hot-water supply apparatus (100) according to claim 5 or 6, wherein the control means (60) stops the compressor (1), irrespective of the threshold temperature excessive time (ti), in the case that the going temperature (Tg) increases to or above the upper limit temperature (Tt1) during the operation of the compressor (1) at the lower limit speed (Rd).

8. The heat pump-type heating and hot-water supply apparatus according to any one of claims 1 to 7, wherein the lower limit speed (Rd) is lower by a given speed than the optimum speed (Rm).

9. The heat pump-type heating and hot-water supply apparatus according to any one of claims 1 to 7, wherein the lower limit speed (Rd) is lower by a given rate than the optimum speed (Rm).

10. The heat pump-type heating and hot-water supply apparatus according to any one of claims 1 to 7, further comprising outside temperature detection means (52) configured to detect an outside temperature (To), wherein the lower limit speed (Rd) is a speed corresponding to a first COP lower than the highest value of the COP predetermined in accordance with the outside temperature (To) and the target temperature (Tt).

11. The heat pump-type heating and hot-water supply apparatus according to claim 10, wherein the first COP has a value lower by a given rate than the highest value of the COP.

12. The heat pump-type heating and hot-water supply apparatus according to claim 10, wherein the first COP has a value lower by a given value than the highest value of the COP.

13. The heat pump-type heating and hot-water supply apparatus according to claim 1, wherein the control means (60) restarts the compressor (1) at the lower limit speed (Rd) in the case that the going temperature (Tg) reaches less than a lower limit temperature (Tt2) lower by a given temperature than the target temperature (Tt) during the stop of the compressor (1).

14. The heat pump-type heating and hot-water supply apparatus according to claim 1, further comprising outside temperature detection means (52) configured to detect an outside temperature (To), wherein the lower limit speed (Rd) is a speed corresponding to a first COP lower than the highest value of the COP predetermined in accordance with the outside temperature (To) and the target temperature (Tt), and
the control means (60) restarts the compressor (1) at the lower limit speed (Rd) in the case that the going temperature (Tg) reaches less than a lower limit temperature (Tt2) lower by a given temperature than the target temperature (Tt) during the stop of the compressor (1).

FIG. 1

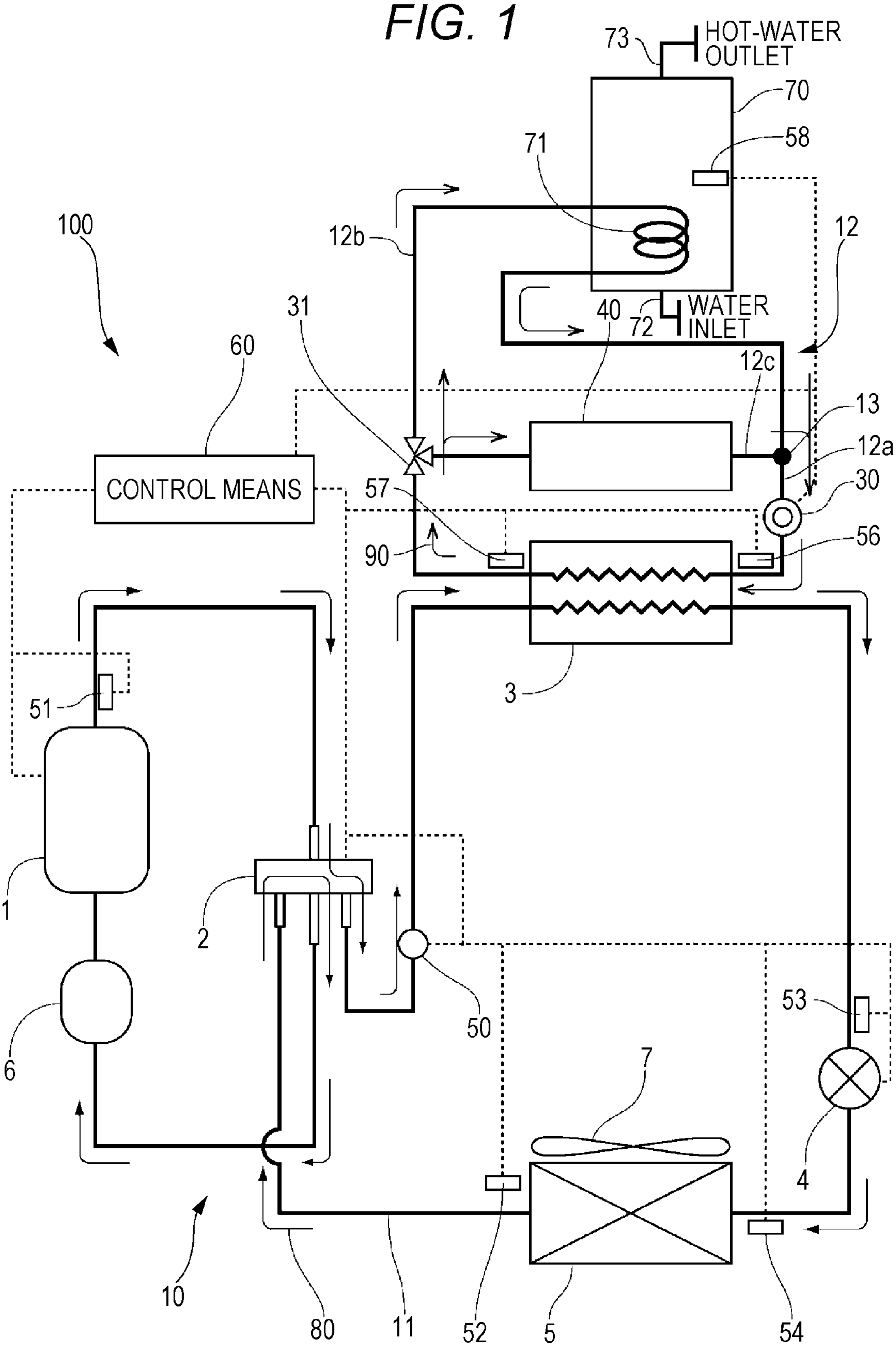
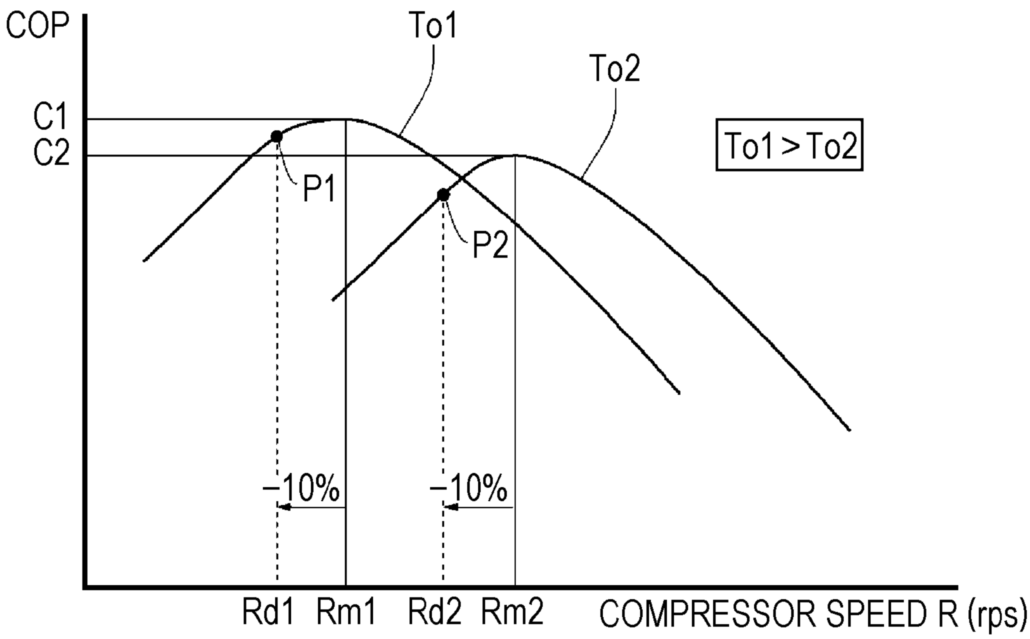

73
HOT-WATER OUTLET
70
71
58
100
12b
12
31
40
72
WATER INLET
60
12c
13
12a
CONTROL MEANS
30
57
56
90
51
3
1
2
50
53
6
7
4
10
80
11
52
5
54

FIG. 2



To1, To2: OUTSIDE TEMPERATURE (°C)
P1, P2: CONTINUOUS OPERATION START POINT

FIG. 3

200

OUTSIDE TEMPERATURE To (°C)	TARGET TEMPERATURE Tt (°C)	OPTIMUM SPEED Rm (rps)	LOWER LIMIT SPEED Rd (rps)
To<5	Tt<30	30	27
	30≤Tt<40	35	32
	40≤Tt	40	36
5≤To<10	Tt<30	30	27
	30≤Tt<40	35	32
	40≤Tt	35	32
10≤To	Tt<30	25	23
	30≤Tt<40	25	23
	40≤Tt	30	27

FIG. 4

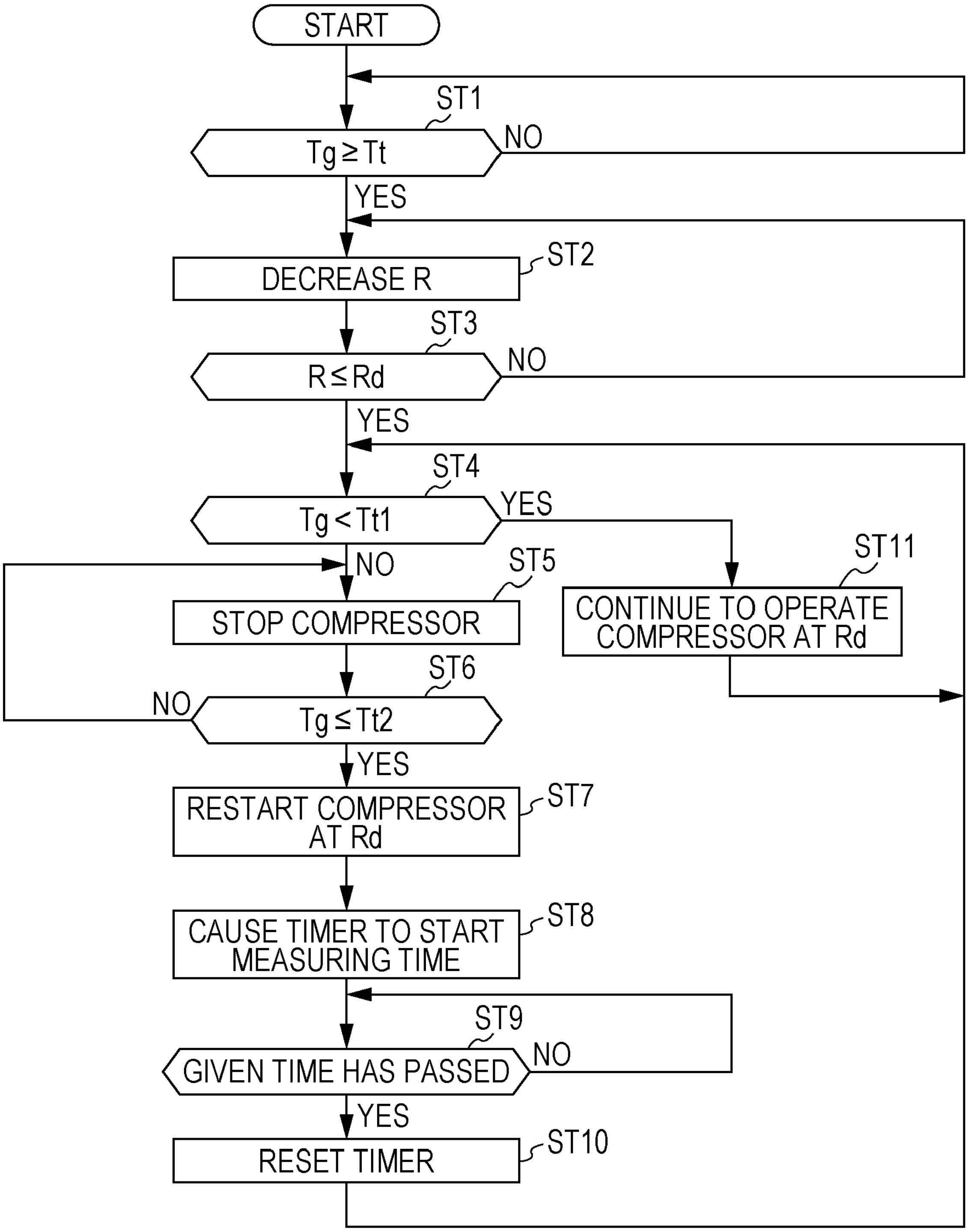
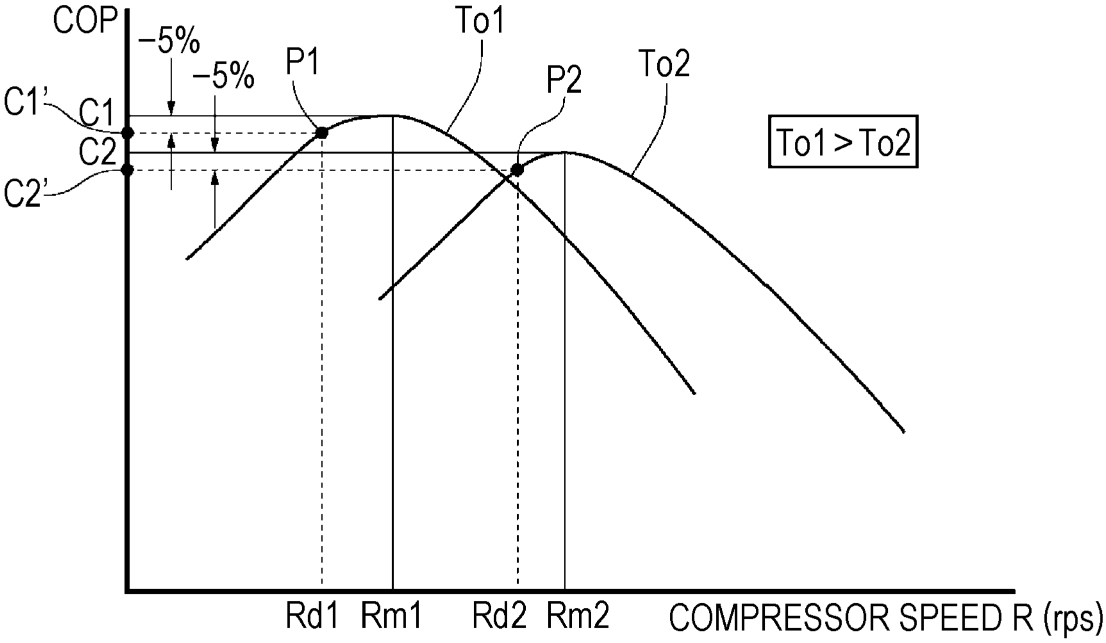

START
ST1
Tg ≥ Tt
NO
YES
DECREASE R
ST2
ST3
R ≤ Rd
NO
YES
ST4
Tg < Tt1
YES
ST11
NO
ST5
STOP COMPRESSOR
CONTINUE TO OPERATE COMPRESSOR AT Rd
ST6
NO
Tg ≤ Tt2
YES
RESTART COMPRESSOR AT Rd
ST7
CAUSE TIMER TO START MEASURING TIME
ST8
ST9
NO
GIVEN TIME HAS PASSED
YES
RESET TIMER
ST10

FIG. 5



To1, To2: OUTSIDE TEMPERATURE (°C)
P1, P2: CONTINUOUS OPERATION START POINT

FIG. 6

300

OUTSIDE TEMPERATURE To (°C)	TARGET TEMPERATURE Tt (°C)	OPTIMUM SPEED Rm (rps)	LOWER LIMIT SPEED Rd (rps)
To<5	Tt<30	30	25
	30≤Tt<40	35	30
	40≤Tt	40	35
5≤To<10	Tt<30	30	20
	30≤Tt<40	35	25
	40≤Tt	35	30
10≤To	Tt<30	25	20
	30≤Tt<40	25	20
	40≤Tt	30	25

FIG. 7A

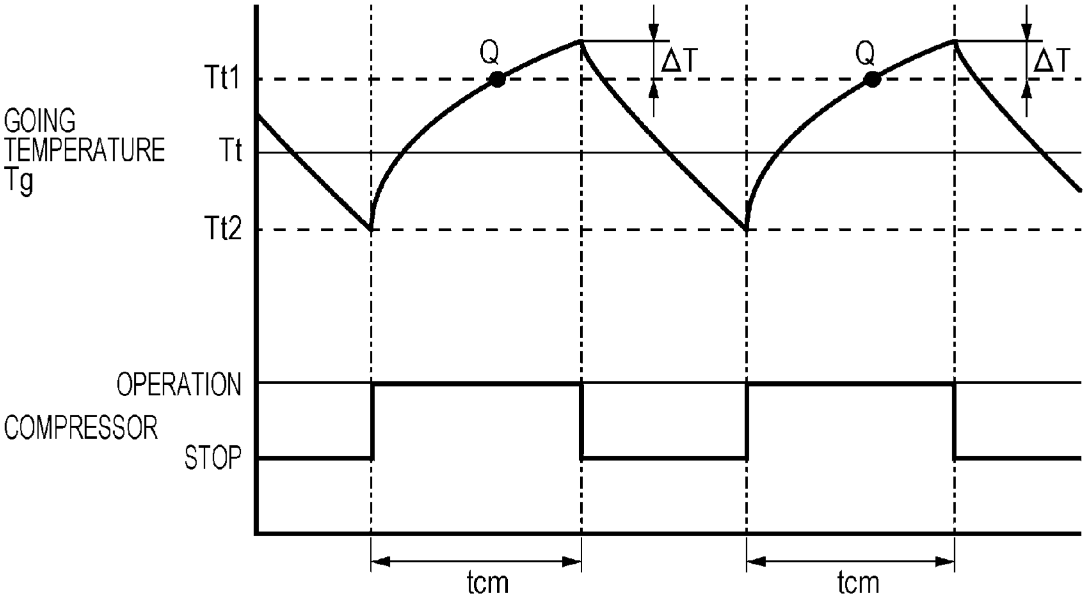

Tt1
GOING TEMPERATURE Tg
Tt
Tt2
Q
Q
ΔT
ΔT
OPERATION
COMPRESSOR
STOP
tcm
tcm

FIG. 7B

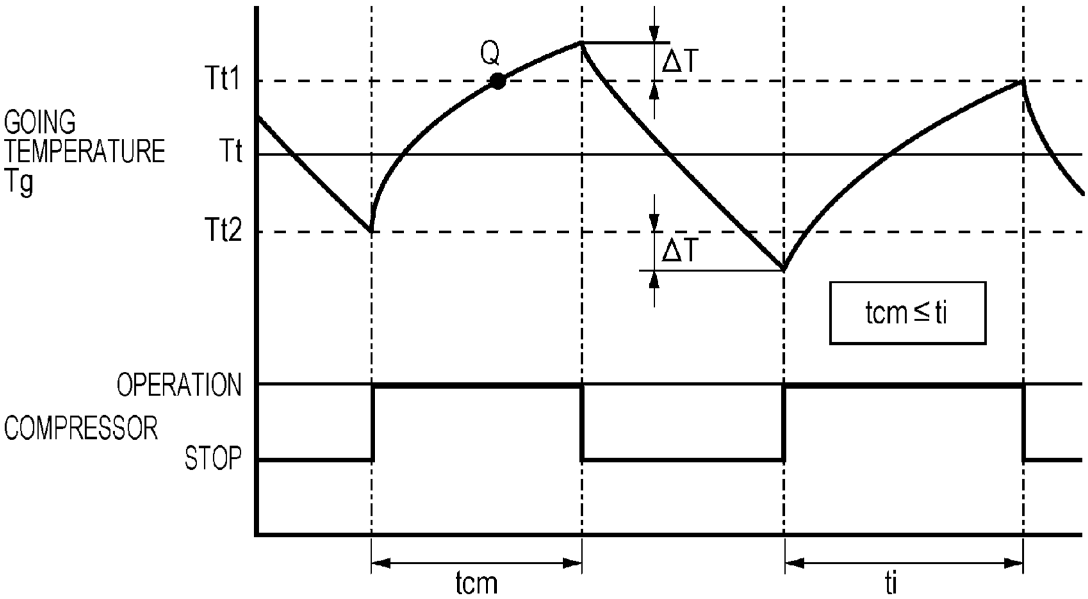

Tt1
GOING TEMPERATURE Tg
Tt
Tt2
Q
ΔT
ΔT
tcm≤ti
OPERATION
COMPRESSOR
STOP
tcm
ti

FIG. 8

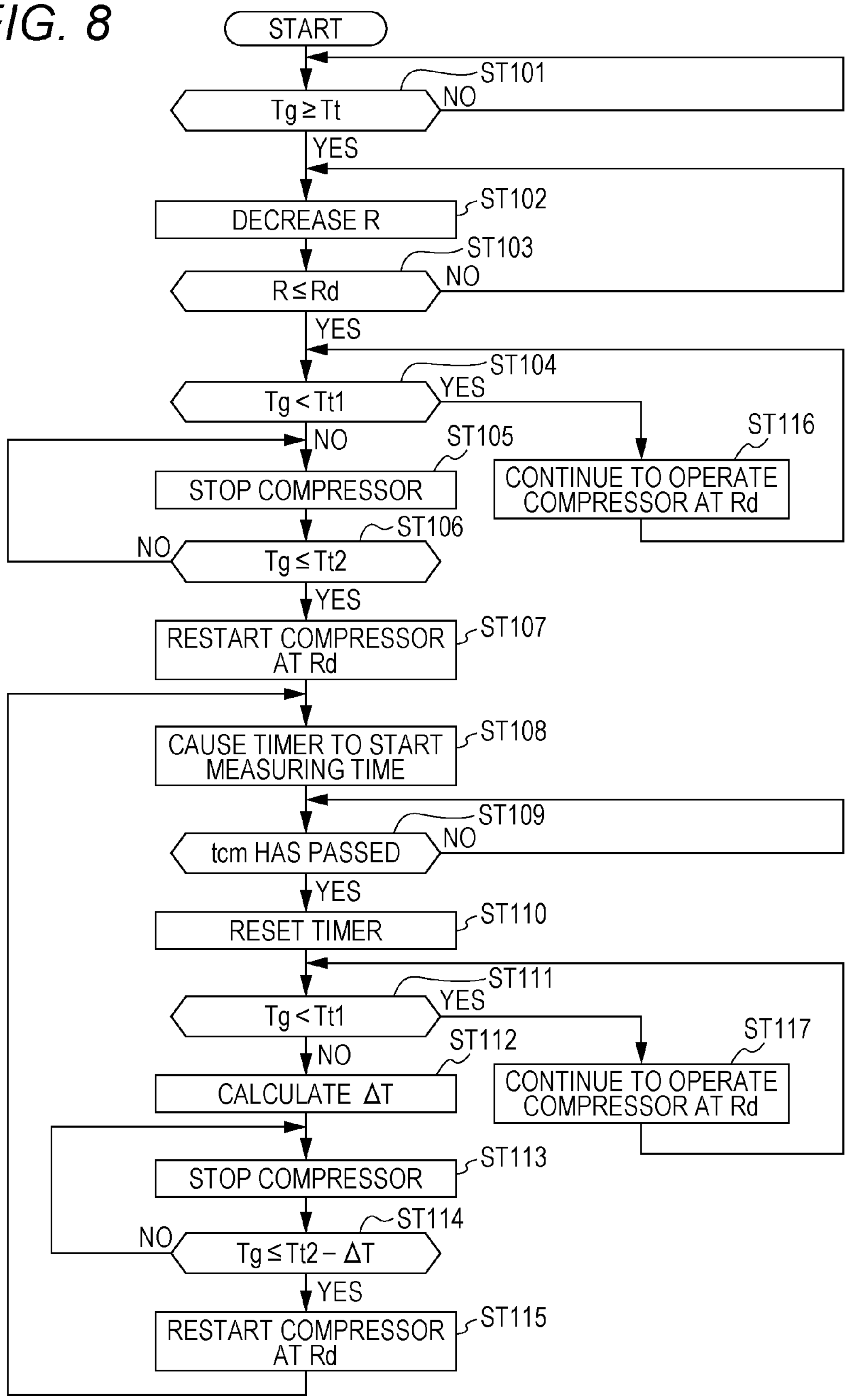
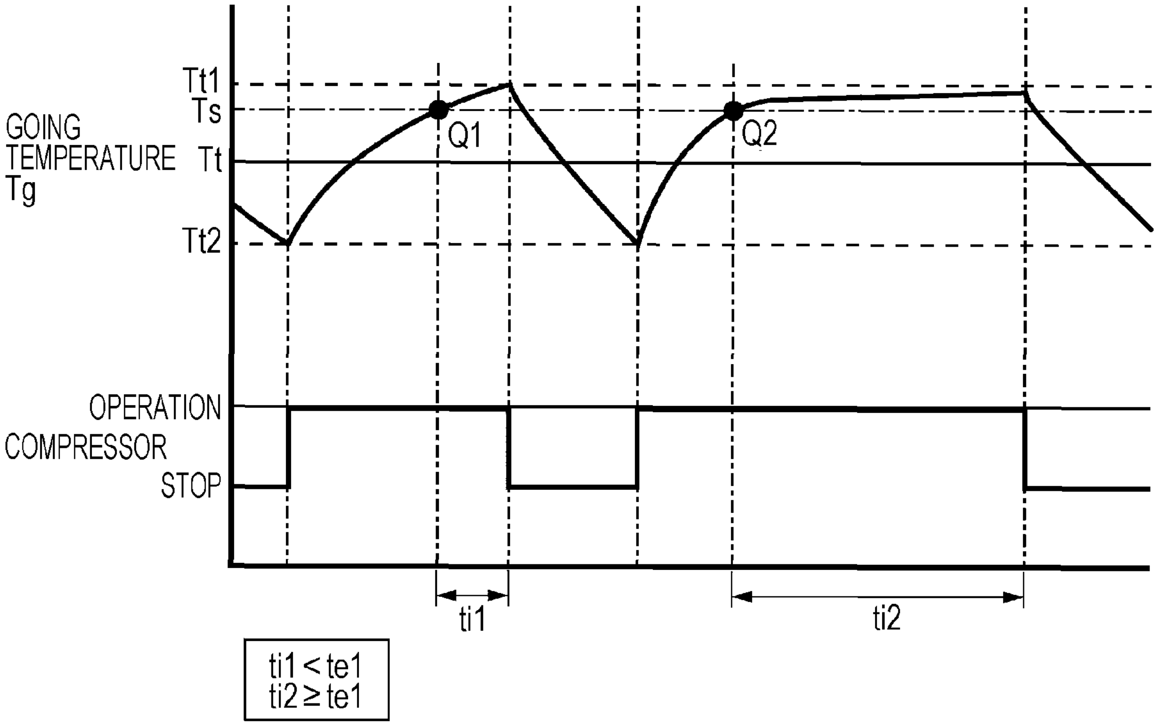

START
ST101
Tg ≥ Tt
NO
YES
DECREASE R
ST102
ST103
R ≤ Rd
NO
YES
ST104
Tg < Tt1
YES
NO
ST105
STOP COMPRESSOR
ST116
CONTINUE TO OPERATE COMPRESSOR AT Rd
ST106
NO
Tg ≤ Tt2
YES
RESTART COMPRESSOR AT Rd
ST107
CAUSE TIMER TO START MEASURING TIME
ST108
ST109
tcm HAS PASSED
NO
YES
RESET TIMER
ST110
ST111
Tg < Tt1
YES
NO
ST112
CALCULATE ΔT
ST117
CONTINUE TO OPERATE COMPRESSOR AT Rd
STOP COMPRESSOR
ST113
ST114
NO
Tg ≤ Tt2 − ΔT
YES
RESTART COMPRESSOR AT Rd
ST115

FIG. 9



Tt1
Ts
GOING TEMPERATURE Tg
Tt
Tt2
Q1
Q2
OPERATION
COMPRESSOR
STOP
ti1
ti2
ti1 < te1
ti2 ≥ te1

FIG. 10

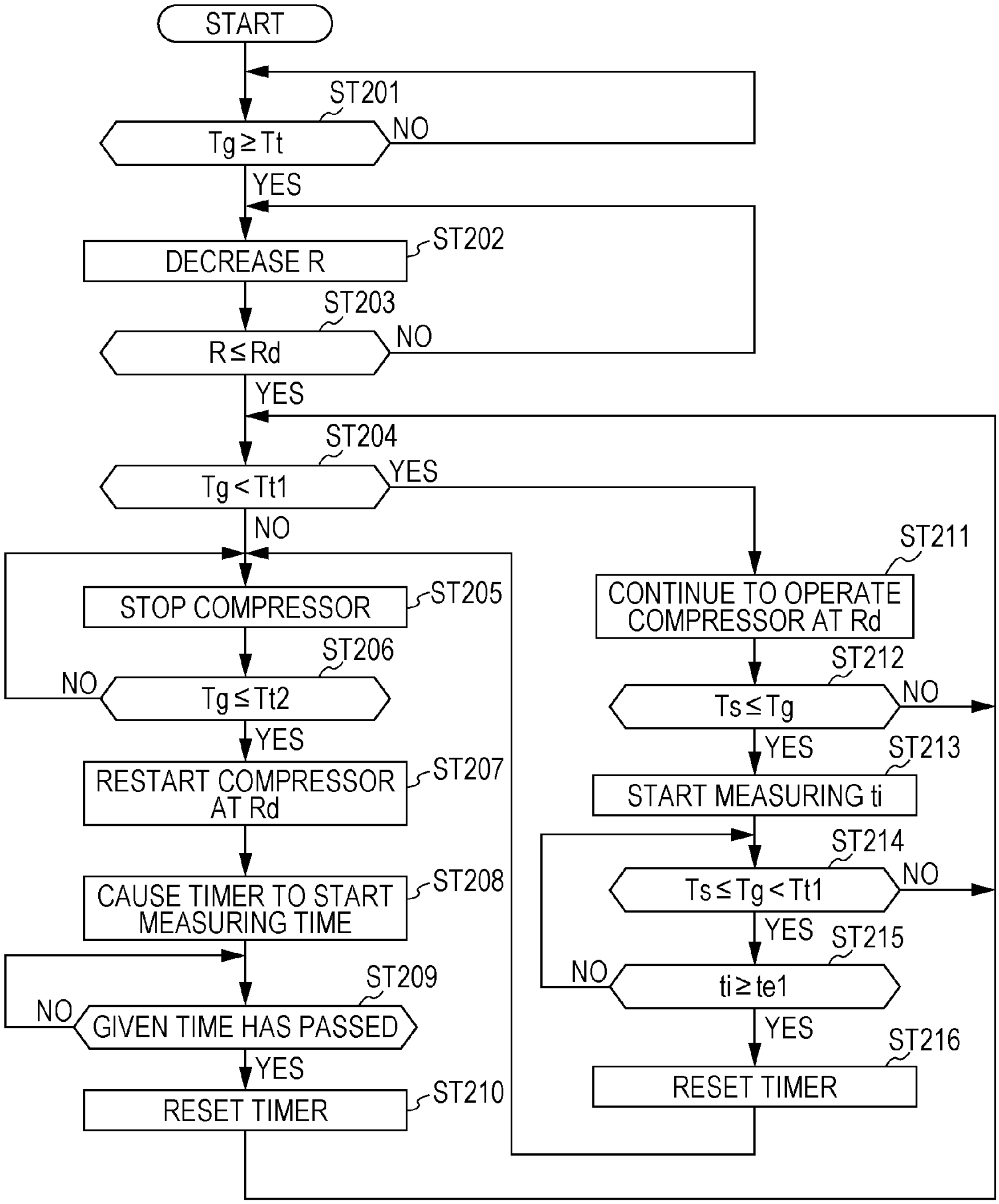

START
ST201
Tg≥Tt
NO
YES
DECREASE R
ST202
ST203
R≤Rd
NO
YES
ST204
Tg<Tt1
YES
NO
STOP COMPRESSOR
ST205
ST206
NO
Tg≤Tt2
YES
RESTART COMPRESSOR AT Rd
ST207
CAUSE TIMER TO START MEASURING TIME
ST208
ST209
NO
GIVEN TIME HAS PASSED
YES
RESET TIMER
ST210
ST211
CONTINUE TO OPERATE COMPRESSOR AT Rd
ST212
Ts≤Tg
NO
YES
ST213
START MEASURING ti
ST214
Ts≤Tg<Tt1
NO
YES
ST215
NO
ti≥te1
YES
ST216
RESET TIMER

FIG. 11

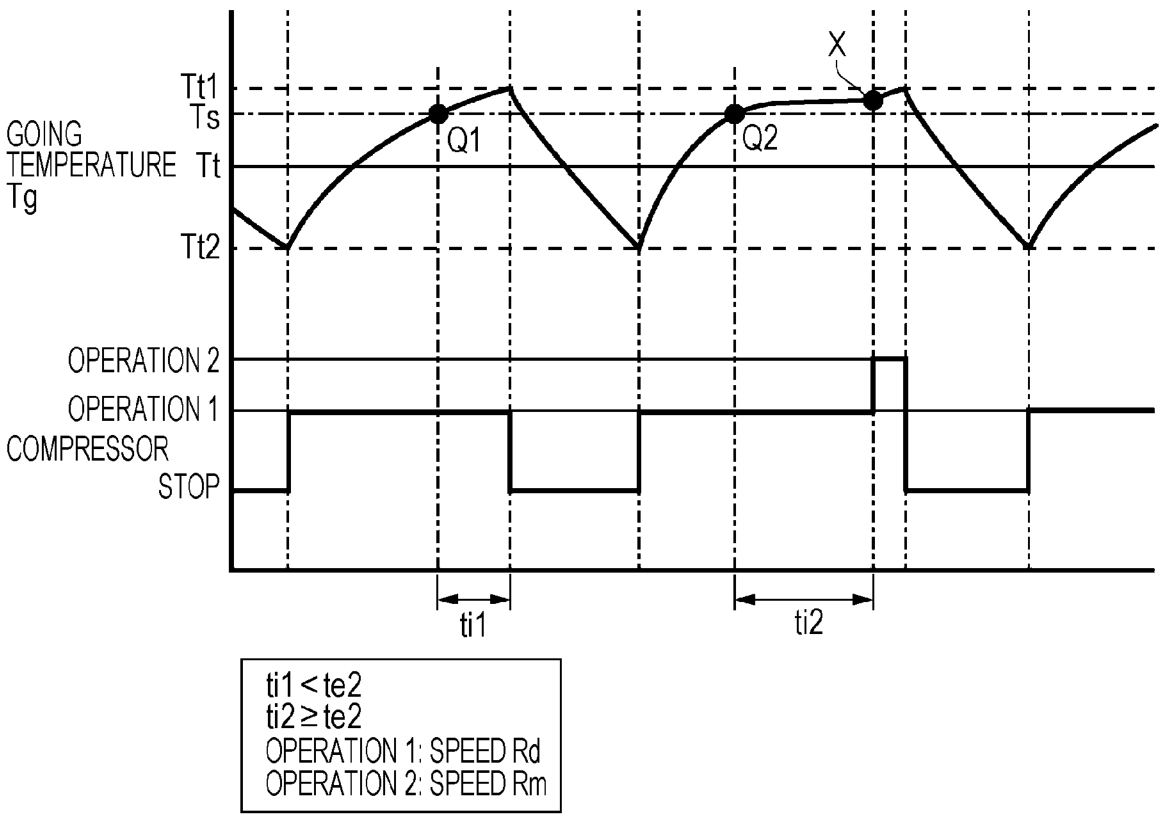
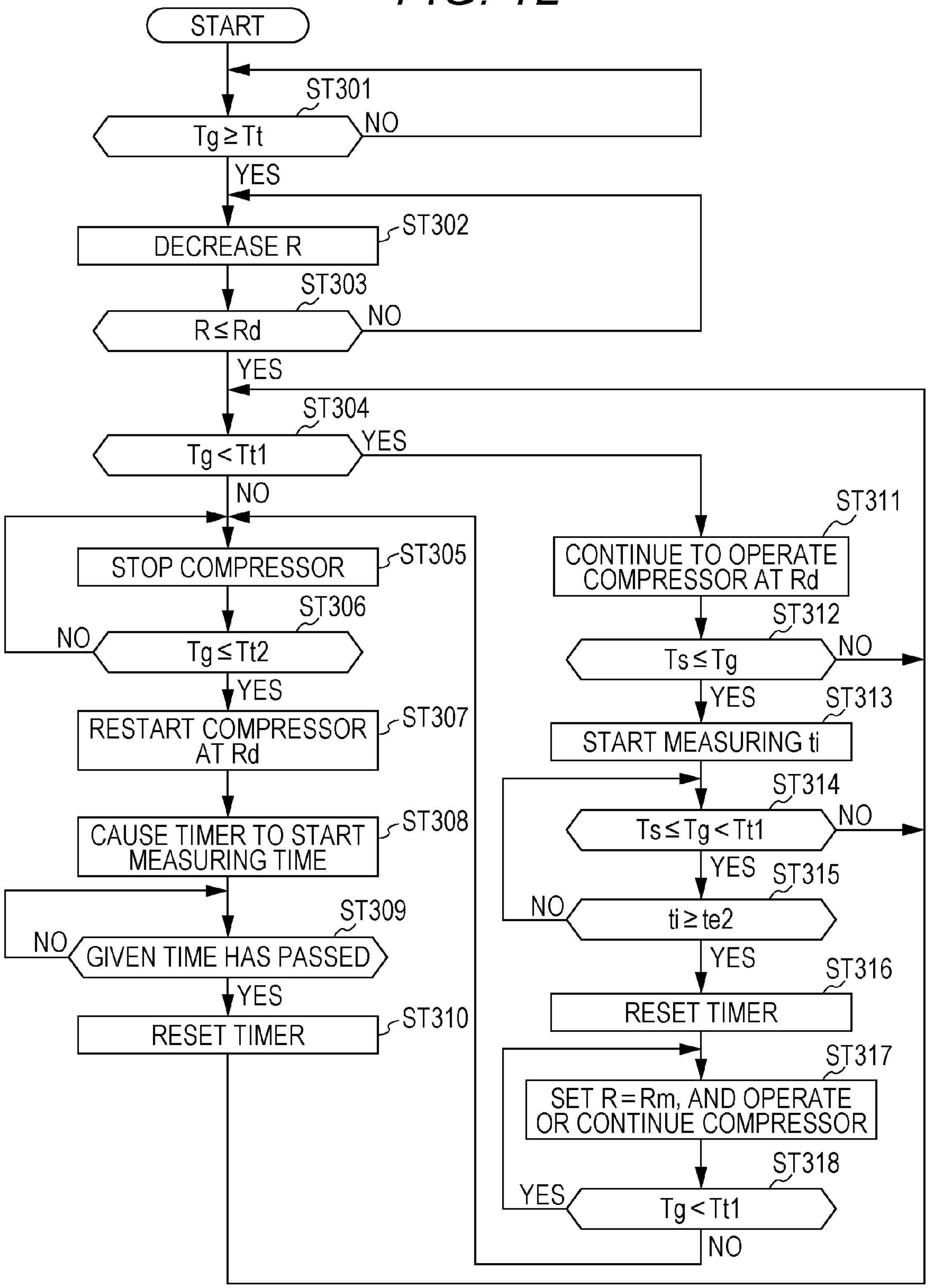

Tt1
Ts
GOING TEMPERATURE Tg
Tt
Tt2
Q1
Q2
X
OPERATION 2
OPERATION 1
COMPRESSOR
STOP
ti1
ti2
ti1 < te2
ti2 ≥ te2
OPERATION 1: SPEED Rd
OPERATION 2: SPEED Rm

FIG. 12


START
ST301
Tg ≥ Tt
NO
YES
DECREASE R
ST302
ST303
R ≤ Rd
NO
YES
ST304
Tg < Tt1
YES
NO
STOP COMPRESSOR
ST305
ST306
Tg ≤ Tt2
NO
YES
RESTART COMPRESSOR AT Rd
ST307
CAUSE TIMER TO START MEASURING TIME
ST308
ST309
GIVEN TIME HAS PASSED
NO
YES
RESET TIMER
ST310
ST311
CONTINUE TO OPERATE COMPRESSOR AT Rd
ST312
Ts ≤ Tg
NO
YES
ST313
START MEASURING ti
ST314
Ts ≤ Tg < Tt1
NO
YES
ST315
ti ≥ te2
NO
YES
ST316
RESET TIMER
ST317
SET R = Rm, AND OPERATE OR CONTINUE COMPRESSOR
ST318
Tg < Tt1
YES
NO

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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 2741

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 312 226 A2 (FUJITSU GENERAL LTD [JP]) 20 April 2011 (2011-04-20) * paragraph [0011] - paragraph [0019]; figure 1 *	1-14	INV. F25B49/02 F25B13/00
A	EP 1 793 182 A2 (MATSUSHITA ELECTRIC IND CO LTD [JP] PANASONIC CORP [JP]) 6 June 2007 (2007-06-06) * the whole document *	1-14	
A	EP 2 589 901 A2 (PANASONIC CORP [JP]) 8 May 2013 (2013-05-08) * & corresponding description; figures 1-5 *	1-14	
A	US 2008/229770 A1 (LIU JIN MING [FR]) 25 September 2008 (2008-09-25) * paragraph [0098] - paragraph [0102] *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)
F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 June 2015	Gasper, Ralf

CATEGORY OF CITED DOCUMENTS

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2312226 A2	20-04-2011	AU 2010224454 A1	14-04-2011
		CN 102032714 A	27-04-2011
		EP 2312226 A2	20-04-2011
		JP 2011094810 A	12-05-2011
		US 2011072840 A1	31-03-2011
EP 1793182 A2	06-06-2007	EP 1793182 A2	06-06-2007
		JP 4665736 B2	06-04-2011
		JP 2007147211 A	14-06-2007
EP 2589901 A2	08-05-2013	CN 103090603 A	08-05-2013
		EP 2589901 A2	08-05-2013
		JP 2013096670 A	20-05-2013
US 2008229770 A1	25-09-2008	EP 1965156 A1	03-09-2008
		FR 2913102 A1	29-08-2008
		JP 5543689 B2	09-07-2014
		JP 2008213830 A	18-09-2008
		US 2008229770 A1	25-09-2008

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Patent documents cited in the description

- JP 2005274021 A **[0002]**