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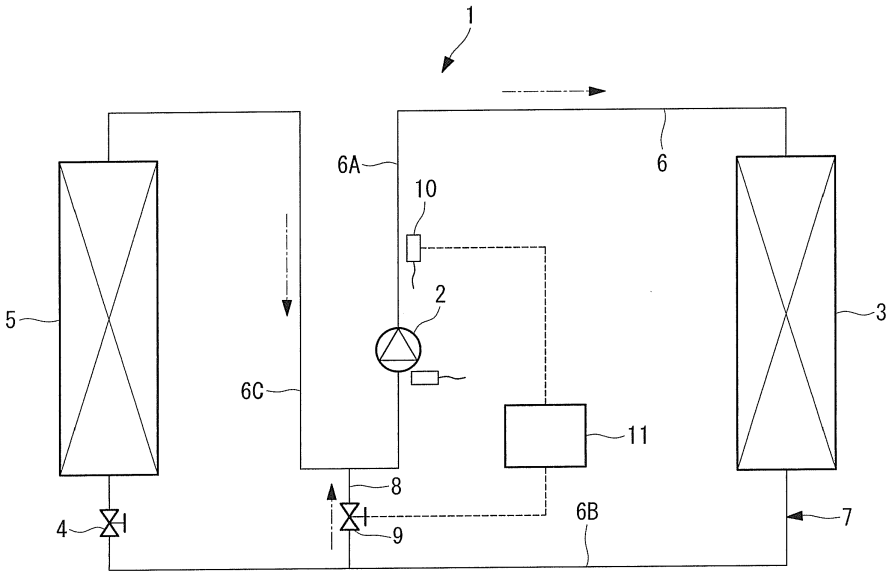
(54) Refrigeration/air-conditioning apparatus

(57) The invention provides a refrigeration/air-conditioning apparatus (1) which can bypass an appropriate amount of liquid refrigerant to suppress a rise in discharge temperature, while suppressing, as much as possible, the opening/closing frequency of an electromagnetic valve (9), and in which it is possible to form a liquid bypass circuit (8) with a low-cost and simple structure. The refrigeration/air-conditioning apparatus (1), which is equipped with a liquid bypass circuit (8) provided with an electromagnetic valve (9), between a high-pressure liquid line (6B) in a refrigeration cycle (7) and a suction line (6C) running to a compressor (2), includes a control means (11) for opening and closing the electromagnetic valve (9) on the basis of a detected temperature in a discharge temperature sensor (10) provided in a discharge line (6A) from the compressor (2), and for varying a set temperature at which the electromagnetic valve (9) is closed depending on the time since the last time the electromagnetic valve was opened or closed.

FIG. 1



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Description

{Technical Field}

[0001] The present invention relates to a refrigeration/air-conditioning apparatus in which a liquid bypass circuit is provided between a high-pressure liquid line of a refrigeration cycle and a suction line running to a compressor.

{Background Art}

[0002] In the related art, there are known systems in which, in a refrigeration cycle, a liquid bypass circuit is provided between a high-pressure liquid line of the refrigeration cycle and a suction line running to a compressor to prevent frequent protective shutdown due to an abnormal rise in the refrigerant discharge temperature from the compressor. When the discharge temperature detected by a discharge temperature sensor exceeds a set temperature, this liquid bypass circuit opens an electromagnetic valve to bypass part of the liquid refrigerant from the high-pressure liquid line to the suction line running to the compressor, thus cooling the compressor with this liquid refrigerant and preventing an abnormal rise in the discharge temperature.

[0003] Even if the above-mentioned liquid bypass circuit is provided, in the case where this circuit forms a single circuit, in refrigeration devices having a wide evaporation temperature range, if they are designed for a circuit in which the amount of circulating refrigerant is appropriate for operation at a high evaporation temperature, the amount of circulating refrigerant when operating at a low evaporation temperature becomes excessively large, and the electromagnetic valve repeatedly opens and closes in a short time. This causes some problems, such as the electromagnetic valve quickly exceeding its service life, a high risk of failure, and so forth. Thus, Patent Literature 1 discloses a system in which an appropriate amount of circulating refrigerant can be obtained by providing two liquid bypass circuits and opening a first-stage electromagnetic valve when the discharge temperature rises to a certain temperature, and then opening a second-stage electromagnetic valve when the discharge temperature rises even higher.

{Citation List}

{Patent Literature}

[0004]

{PTL 1}
Japanese Unexamined Patent Application, Publication No. HEI 5-172408

{Summary of Invention}

{Technical Problem}

[0005] In the above-described liquid bypass circuit, the electromagnetic valve is opened only when necessary, thus bypassing the liquid refrigerant. This is because there would be a high risk of damage to the compressor due to liquid compression if the liquid refrigerant were always bypassed, and the temperature at which the electromagnetic valve is opened and closed would be determined by the discharge temperature etc. at which use of the compressor is restricted from the viewpoint of compressor protection etc. However, depending on the operating state, there are cases where the refrigeration/air-conditioning apparatus operates close to the set temperature at which the electromagnetic valve is opened and closed, and in such cases, even if two separate liquid bypass circuits are provided, by operating the refrigeration/air-conditioning apparatus close to the set temperature of the second-stage electromagnetic valve, frequent opening and closing of the valve is unavoidable, and the problem of how this adversely affects the durability of the electromagnetic valve cannot be avoided.

[0006] Nevertheless, if the open/closed time of the electromagnetic valve is long, this will cause problems such as too much liquid refrigerant coming back, a higher risk of liquid compression by the compressor, and so forth. In addition, if the liquid bypass circuit is divided into two circuits, this causes problems in that the configuration becomes more complex, and the cost of providing the liquid bypass circuit becomes twice as high, based on a simple estimate.

[0007] The present invention has been conceived in light of these circumstances and provides a refrigeration/air-conditioning apparatus in which the frequency of opening/closing of an electromagnetic valve can be reduced as much as possible, a rise in discharge temperature can be suppressed by bypassing an appropriate amount of liquid refrigerant, and a liquid bypass circuit can be constructed with a simple construction and at low cost.

{Solution to Problem}

[0008] In order to solve the above problems, the refrigeration/air-conditioning apparatus of the present invention employs the following solutions.

A refrigeration/air-conditioning apparatus according to an aspect of the present invention is a refrigeration/air conditioning apparatus equipped with a liquid bypass circuit provided with an electromagnetic valve, between a high-pressure liquid line in a refrigeration cycle and a suction line running to a compressor, the refrigeration/air-conditioning apparatus including a control means for opening and closing the electromagnetic valve on the basis of a detected temperature in a discharge temperature sensor provided in a discharge line from the com-

pressor and for varying a set temperature at which the electromagnetic valve is closed depending on the time since the last time the electromagnetic valve was opened or closed.

[0009] The refrigeration/air-conditioning apparatus according to the above-described aspect of the present invention includes the control means that opens and closes the electromagnetic valve provided in the liquid bypass circuit on the basis of the detected temperature in the discharge temperature sensor and that varies the set temperature at which the electromagnetic valve is closed depending on the time since the last time the electromagnetic valve was opened or closed; therefore, even if there is a single liquid bypass circuit including the electromagnetic valve, by setting the set temperature at which the electromagnetic valve is opened to an appropriate temperature so as to bypass the liquid refrigerant, and varying the set temperature at which the electromagnetic valve is closed depending on the time since the last time the electromagnetic valve was opened or closed, it is possible to open the electromagnetic valve for an appropriate time and to bypass an appropriate amount of liquid refrigerant that is not excessive during that time. Therefore, it is possible to reduce the opening/closing frequency of the electromagnetic valve as much as possible, while at the same time reliably protecting the compressor by bypassing an appropriate amount of liquid refrigerant to suppress a rise in the discharge temperature. Moreover, it is possible to provide just a single liquid bypass circuit, thus enabling a low-cost, simple structure.

[0010] The refrigeration/air-conditioning apparatus according to the above-described aspect may have a configuration in which, when the time since the last opening/closing operation of the electromagnetic valve does not exceed a set time, control for reducing the set temperature at which the electromagnetic valve is closed by a predetermined temperature from an initial set temperature is repeated, and when the time since the last opening/closing operation exceeds the set time, control for raising the set temperature at which the electromagnetic valve is closed by the predetermined temperature is performed.

[0011] With this configuration, if the time since the last opening/closing operation of the electromagnetic valve has not exceeded the set time, the control means repeats control for reducing the set temperature at which the electromagnetic valve is closed by the predetermined temperature from the initial set temperature, and if the time since the last opening/closing operation has exceeded the set time, the control means performs control for raising the set temperature at which the electromagnetic valve is closed by the predetermined temperature; therefore, depending on whether or not the time since the last opening/closing operation of the electromagnetic valve has exceeded the set time, it is possible to raise or lower the set temperature at which the electromagnetic valve is closed by the predetermined temperature each time, thus enabling variable control of the set temperature within a temperature range below the initial set temperature. Therefore, it is possible to suppress the opening/closing frequency of the electromagnetic valve, while at the same time bypassing an appropriate amount of liquid refrigerant by opening the electromagnetic valve for an appropriate time so as to suppress a rise in discharge temperature, thus protecting the compressor.

[0012] The refrigeration/air-conditioning apparatus according to the above-described aspect may have a configuration in which a minimum value when decreasing the set temperature at which the electromagnetic valve is closed from the initial set temperature is defined.

[0013] With this configuration, since a minimum value when decreasing the set temperature at which the electromagnetic valve is closed from the initial set temperature is defined, it is possible to prevent a situation in which the amount of bypassed liquid refrigerant becomes excessive by excessively reducing the set temperature at which the electromagnetic valve is closed, which increases the risk of liquid compression in the compressor. Therefore, it is possible to always bypass an appropriate amount of liquid refrigerant, and it is possible to reduce the opening/closing frequency of the electromagnetic valve by increasing the open/closed time of the electromagnetic valve as much as possible.

[0014] The refrigeration/air-conditioning apparatus according to the above-described aspect may have a configuration in which a maximum value when increasing the set temperature at which the electromagnetic valve is closed from the decreased set temperature is defined as the initial set temperature.

[0015] With this configuration, since the maximum value when increasing the set temperature at which the electromagnetic valve is closed from the decreased set temperature is defined as the initial set temperature, even though the set temperature at which the electromagnetic valve is closed is varied by increasing or decreasing it, the set temperature is never raised beyond the initial set temperature, and it is possible to control the amount of bypassed liquid refrigerant by ensuring the minimum required open/closed time. Therefore, it is possible to reduce the opening/closing frequency of the electromagnetic valve as much as possible, while at the same time bypassing an appropriate amount of liquid refrigerant to suppress a rise in discharge temperature, thus protecting the compressor.

{Advantageous Effects of Invention}

[0016] According to the present invention, even with a single liquid bypass circuit provided with an electromagnetic valve, by setting the set temperature at which the electromagnetic valve is opened to an appropriate temperature so as to bypass liquid refrigerant and by varying the set temperature at which the electromagnetic valve is closed depending on the time since the last time the electromagnetic valve was opened or closed, the electromagnetic valve can be opened for an appropriate time,

and an appropriate amount of liquid refrigerant that is not excessive can be bypassed during that time. Therefore, by bypassing an appropriate amount of liquid refrigerant so as to suppress a rise in the discharge temperature, while reducing, as much as possible, the opening/closing frequency of the electromagnetic valve, it is possible to reliably protect the compressor. Moreover, it suffices to use only a single liquid bypass circuit, thus enabling a low-cost and simple structure.

{Brief Description of Drawings}

[0017]

{Fig. 1}
Fig. 1 is a diagram of a refrigeration cycle in a refrigeration/air-conditioning apparatus according to an embodiment of the present invention.
{Fig. 2}
Fig. 2 is a diagram of the opening/closing operation at a position close to an opening/closing set temperature of an electromagnetic valve provided in a liquid bypass circuit in the above refrigeration/air-conditioning apparatus.
{Fig. 3}
Fig. 3 is a diagram of the opening/closing operation at a position away from the opening/closing set temperature of the electromagnetic valve provided in the liquid bypass circuit in the above refrigeration/air-conditioning apparatus.
{Fig. 4}
Fig. 4 is an opening/closing control flowchart of the electromagnetic valve provided in the liquid bypass circuit in the above refrigeration/air-conditioning apparatus.
{Fig. 5}
Fig. 5 is a detailed control flowchart of part A in the control flowchart shown in Fig. 4.
{Fig. 6}
Fig. 6 is a diagram showing the relationship between a minimum required standard open/closed time of the electromagnetic valve and an open/closed time during which the set temperature at which the electromagnetic valve is closed is increased and an open/closed time during which the set temperature is decreased.

{Description of Embodiment}

[0018] An embodiment of the present invention will be described below with reference to Figs. 1 to 6.
Fig. 1 shows a diagram of a refrigeration cycle of a refrigeration/air-conditioning apparatus 1 according to an embodiment of the present invention, Figs. 2 and 3 are diagrams of an opening/closing operation of a liquid bypass electromagnetic valve provided in a liquid bypass circuit thereof, and Figs. 4 and 5 show opening/closing control flowcharts of the liquid bypass electromagnetic valve provided in this liquid bypass circuit.
The refrigeration/air-conditioning apparatus 1 includes a refrigeration cycle 7 in which a compressor 2, a condenser 3, an expansion valve 4, and an evaporator 5 are connected in this order by a refrigerant pipe 6, forming a closed-cycle circuit.

[0019] The refrigeration cycle 7 is provided with a liquid bypass circuit 8 that includes a liquid bypass electromagnetic valve (electromagnetic valve) 9 between a high-pressure liquid line 6B that connects the condenser 3 and the expansion valve 4 and a suction line 6C running to the compressor 2. This liquid bypass circuit 8 is configured so that, by opening the liquid bypass electromagnetic valve 9, part of the liquid refrigerant from the high-pressure liquid line 6B can be bypassed to the suction line 6C of the compressor 2.

[0020] The electromagnetic valve 9 is subjected to open/close control via a control means 11 on the basis of a refrigerant discharge temperature detected by a discharge temperature sensor 10 provided in a discharge line 6A from the compressor 2 so as to be opened when the discharge temperature exceeds a set temperature T_{open} and closed when the discharge temperature falls below a set temperature T_{close}. In addition, the control means 11 has a configuration including a function that can vary the set temperature T_{close} according to the time from the last opening/closing operation of the electromagnetic valve 9, at the same time as opening the electromagnetic valve 9 at the set temperature T_{open} and closing the electromagnetic valve 9 at the set temperature T_{close}.

[0021] In other words, when the refrigerant discharge temperature from the compressor 2 rises, the liquid refrigerant from the high-pressure liquid line 6B is bypassed to the suction line 6C, and the electromagnetic valve 9, which is provided in the liquid bypass circuit 8 for cooling and protecting the compressor 2, opens and closes depending on the temperature detected by the discharge temperature sensor 10; however, the set temperature T_{open} is set based on a temperature limit etc. at which the compressor 2 can be used. Therefore, in the case where the refrigeration/air-conditioning apparatus 1 operates in a state where the discharge temperature is close to the set temperature T_{open}, in an environment where the evaporation temperature is high, such as in summer, as shown in Fig. 2, the refrigeration/air-conditioning apparatus 1 repeats an operation in which the electromagnetic valve 9 is opened when the discharge temperature reaches the set temperature T_{open}, and the electromagnetic valve 9 is closed when the liquid refrigerant is bypassed to cool the compressor 2, causing the discharge temperature to drop to the set temperature T_{close}.

[0022] In cases like that described above, in order to avoid frequent opening/closing of the electromagnetic valve 9, depending on the time since the last opening/closing operation of the electromagnetic valve 9, the control means 11 is provided with a function for repeatedly performing control for reducing the set temperature

T_{close} at which the electromagnetic valve 9 is closed by a predetermined temperature X [deg] from an initial set temperature T_{close} if that time does not exceed a set time, and for performing control to raise the set temperature T_{close} at which the electromagnetic valve 9 is closed by the predetermined temperature X [deg] if the time since the last opening/closing operation exceeds the set time.

[0023] Accordingly, the electromagnetic valve 9 operates as shown, for example, in Fig. 2. Specifically, in the state where the electromagnetic valve 9 is closed, when the temperature detected by the discharge temperature sensor 10 reaches the set temperature T_{open}, the electromagnetic valve 9 opens, and the liquid refrigerant is bypassed to the suction line 6C via the liquid bypass circuit 8. As a result, since the compressor 2 is cooled, the discharge temperature drops, and once the discharge temperature reaches the set temperature T_{close}, the electromagnetic valve 9 is closed. In the case where the discharge temperature is on a rising inclination, when the electromagnetic valve 9 is closed, the discharge temperature starts to rise again, and when the discharge temperature reaches the set temperature T_{open}, the electromagnetic valve 9 is opened again.

[0024] In this case, the open time of the electromagnetic valve 9 is t_{o1}, and the closed time is t_{c1}. For these opening/closing operations of the electromagnetic valve 9, if the time since the last opening/closing operation of the electromagnetic valve 9 has not exceeded a set time, the control means 11 defines the set temperature T_{close} at which the electromagnetic valve 9 is closed as the set temperature T_{close} obtained by subtracting a predetermined temperature X [deg] from the initial set temperature T_{close}. Therefore, by reducing the set temperature T_{close} by the predetermined temperature X [deg], the electromagnetic valve 9 remains open longer by a corresponding amount, and during this time, an appropriate amount of liquid refrigerant is bypassed to cool the compressor 2. Then, once the discharge temperature drops to the decreased set temperature T_{close}, the electromagnetic valve 9 is closed.

[0025] In this case, the open time of the electromagnetic valve 9 is t_{o2}, and the closed time is t_{c2}, and if the time since the last opening/closing operation has not exceeded a set time, by repeating the operation described above, the open/closed times of the electromagnetic valve 9 become longer, namely, $t_{o3} < t_{o4}$ and $t_{c3} < t_{c4}$. During this process, although the set temperature T_{close} is decreased by the predetermined temperature X each time, this does not mean it is decreased indefinitely; as described below, because a minimum value $T_{c\text{-}min}$ is defined, the system is configured so that the set temperature T_{close} is never decreased beyond the minimum value $T_{c\text{-}min}$.

[0026] On the other hand, when the operating state changes and the time since the last opening/closing operation has exceeded the set time, conversely to the case described above, the set temperature T_{close} at which the electromagnetic valve 9 is closed is defined as a set temperature T_{close} obtained by increasing the last set temperature T_{close} by the predetermined temperature X [deg]. By repeating this operation, it is possible to avoid a situation where excessive liquid refrigerant is bypassed under conditions where it is not necessary to leave the electromagnetic valve 9 open for a long time, and it is thus possible to always bypass an appropriate amount of liquid refrigerant.

[0027] Accordingly, even in the case where the refrigeration/air-conditioning apparatus 1 is operated under conditions where the discharge temperature of the compressor 2 is close to the set temperature T_{open}, it is possible to bypass an appropriate amount of the liquid refrigerant by means of the liquid bypass circuit 8 to cool the compressor 2, while reducing the opening/closing frequency of the electromagnetic valve 9, and to protect the compressor 2 by preventing an abnormal rise in the discharge temperature.

When the refrigeration/air-conditioning apparatus 1 is operated under conditions where the discharge temperature of the compressor 2 is not very high and is lower than the set temperature T_{open} and the set temperature T_{close} at which the electromagnetic valve 9 is opened and closed, as shown in Fig. 3, the electromagnetic valve 9 is not frequently opened/closed, and only in cases where the discharge temperature rises momentarily, the electromagnetic valve 9 is opened for a short time, so that the liquid refrigerant is bypassed.

[0028] Next, a concrete control flow carried out by the control means 11 provided with the above-described function will be described in detail with reference to Figs. 4 and 5.

Upon starting-up the refrigeration/air-conditioning apparatus 1, the control means 11 starts to operate. First, in step S1, it is determined whether or not the discharge temperature (T_d) detected by the discharge temperature sensor 10 is above the set temperature T_{open} at which the electromagnetic valve (SV) 9 is opened. Here, if the discharge temperature (T_d) has risen and exceeded the set temperature T_{open}, the result of the determination is YES, and the processing shown by part A (the control from step S2 to step S9 shown in Fig. 5) is executed. On the other hand, if the result of the determination is NO, the process goes to step S12, where the electromagnetic valve (SV) 9 is kept closed, and the process then returns to step S1.

[0029] At step S2, it is determined whether or not the open/closed time t_c [sec] of the electromagnetic valve (SV) 9 at a certain time point is less than an open/closed time $t_{c\text{-}down}$ [sec] during which the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed is decreased (processing for extending t_c) ($t_c < t_{c\text{-}down}$). If the result of this determination is YES, the process proceeds to step S3, and if the result of the determination is NO, the process proceeds to step S4. In step S3, upon obtaining the result "$t_c < t_{c\text{-}down}$", in order to extend the open/closed time t_c [sec] of the electromagnetic valve (SV) 9, processing for decreasing the set temperature

T_{close} at which the electromagnetic valve (SV) 9 is closed by the predetermined temperature X [deg] is executed, and then the process proceeds to step S5.

[0030] In step S5, it is determined whether the set temperature T_{close} which has been decreased by the predetermined temperature X [deg] is less than the minimum set temperature $T_{c\text{-}min}$ after the decrease. If the result of the determination is NO, the set temperature T_{close} is set as the decreased set temperature T_{close}, and the process proceeds to the next step, step S10 (see Fig. 4). If the result of the determination is YES, the process proceeds to step S6, where the set temperature T_{close} is set to the minimum set temperature $T_{c\text{-}min}$, and the process proceeds to step S10. In step S10, processing for setting the electromagnetic valve (SV) 9 to "open" is executed, so that part of the liquid refrigerant from the high-pressure liquid line 6B is bypassed to the suction line 6C via the liquid bypass circuit 8.

[0031] Accordingly, since the compressor 2 is cooled, and the discharge temperature (Td) thereof drops, an abnormal rise in the discharge temperature (Td) is prevented, and thus the compressor 2 is protected. In step S11, the drop in the discharge temperature (Td) is monitored, and it is determined whether the discharge temperature (Td) has dropped below the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed ($Td < T_{close}$). If the result is NO, the operation continues in this way, but once the discharge temperature (Td) falls below the set temperature T_{close}, giving a YES result, the process proceeds to step S12. In step S12, processing for setting the electromagnetic valve (SV) 9 to "closed" is executed, and the process returns to step S1.

[0032] On the other hand, if the result of the determination at step S2 is NO and the process proceeds to step S4, it is determined whether the open/closed time t_c [sec] of the electromagnetic valve (SV) 9 at a certain time point exceeds an open/closed time $t_{c\text{-}up}$ during which the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed is increased ($t_c > t_{c\text{-}up}$). If the result of the determination is NO, the process proceeds to step S10, where the above-described operation is executed, and if the result of the determination is YES, the process proceeds to step S7. At step S7, upon obtaining the result "$t_c > t_{c\text{-}up}$", in order to shorten the open/closed time t_c [sec] of the electromagnetic valve (SV) 9, processing for increasing the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed by the predetermined temperature X [deg] is executed, and then the process proceeds to step S8.

[0033] At step S8, it is determined whether the set temperature T_{close} that has been increased by the predetermined temperature X [deg] exceeds a maximum set temperature $T_{c\text{-}max}$ after the increase (=initial set temperature T_{close}). If the result of the determination is NO, the set temperature T_{close} is set as the increased set temperature T_{close}, and the process proceeds to step S10 (see Fig. 4), where the above-described operation is executed. If the result of the determination is YES, the process proceeds to step S9, where the set temperature T_{close} is set to the maximum set temperature $T_{c\text{-}max}$ (=initial set temperature T_{close}), and the process then proceeds to step S10. In step S10, the processing for setting the electromagnetic valve (SV) 9 to "open", as described above, is executed.

[0034] As a result of the above, depending on the open/closed time t_c [sec] of the electromagnetic valve (SV) 9 at a certain time point, it is determined whether that time is less than the open/closed time $t_{c\text{-}down}$ [sec] during which the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed is decreased (processing for extending t_c), or whether that time exceeds the open/closed time $t_{c\text{-}up}$ [sec] during which the set temperature T_{close} is increased (processing for shortening t_c); if the open/closed time $t_{c\text{-}down}$ [sec] is not exceeded, control for reducing the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed by the predetermined temperature X [deg] from the initial set temperature T_{close} is repeated, and if the time since the last opening/closing operation exceeds the open/closed time $t_{c\text{-}up}$ [sec], control for raising the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed by the predetermined temperature X [deg] is performed; and by raising or lowering the set temperature T_{close} at which the electromagnetic valve (SV) 9 is closed by the predetermined temperature X each time, the set temperature T_{close} can be varied within a temperature range below the initial set temperature T_{close}.

[0035] As shown in Fig. 6, the open/closed time $t_{c\text{-}down}$ [sec] during which the set temperature T_{close} is decreased and the open/closed time $t_{c\text{-}up}$ [sec] during which the set temperature T_{close} is increased are determined with the minimum required standard opening/closing time $t_{c\text{-}std}$ [sec] of the electromagnetic valve (SV) 9 serving as a target value, so that the open/closed time $t_{c\text{-}down}$ [sec] during which the set temperature T_{close} is decreased (processing for extending t_c) or the open/closed time $t_{c\text{-}up}$ [sec] during which the set temperature T_{close} is increased (processing for shortening t_c) does not become too long or short.

[0036] According to this embodiment, the following advantageous effects are provided.

Even though a single liquid bypass circuit 8 provided with the electromagnetic valve 9 is provided, by setting the set temperature T_{open} at which the electromagnetic valve 9 is opened to an appropriate temperature so as to bypass the liquid refrigerant and by varying the set temperature T_{close} at which the electromagnetic valve 9 is closed depending on the time since the last time the electromagnetic valve was opened or closed, the electromagnetic valve 9 can be opened for an appropriate time, and an appropriate amount of liquid refrigerant that is not excessive can be bypassed during that time. Therefore, by bypassing an appropriate amount of liquid refrigerant via the liquid bypass circuit 8 so as to suppress a rise in the discharge temperature (Td), while reducing, as much as possible, the opening/closing frequency of the electro-

magnetic valve 9, it is possible to reliably protect the compressor 2. Moreover, it suffices to use only a single liquid bypass circuit 8, thus enabling a low-cost and simple structure.

[0037] In particular, when the time since the last opening/closing operation of the electromagnetic valve 9 has not exceeded the set time, control for reducing the set temperature T_{close} at which the electromagnetic valve 9 is closed by the predetermined temperature X [deg] from the initial set temperature T_{close} is repeated, and when the time since the last opening/closing operation has exceeded the set time, control for raising the set temperature T_{close} at which the electromagnetic valve 9 is closed by the predetermined temperature X [deg] is performed, so that the set temperature T_{close} at which the electromagnetic valve 9 is closed is raised or lowered by the predetermined temperature X each time, thus making it possible to variably control the set temperature T_{close} within a temperature range below the initial set temperature T_{close}. Accordingly, while reducing the opening/closing frequency of the electromagnetic valve 9, an appropriate amount of liquid refrigerant is bypassed by opening the electromagnetic valve 9 for an appropriate time, thus suppressing a rise in the discharge temperature (Td), which makes it possible to protect the compressor 2.

[0038] Furthermore, in this embodiment, a minimum value (minimum set temperature $T_{c\text{-}min}$) is defined when decreasing the set temperature T_{close} at which the electromagnetic valve 9 is closed from the initial set temperature T_{close}; therefore, it is possible to prevent a situation where the amount of bypassed liquid refrigerant becomes excessively large because the set temperature T_{close} at which the electromagnetic valve 9 is closed is reduced too much, and the risk of liquid compression in the compressor 2 becomes high. Therefore, it is possible to always bypass an appropriate amount of liquid refrigerant, and it is possible to reduce the opening/closing frequency of the electromagnetic valve by lengthening the open/closed time of the electromagnetic valve 9 as much as possible.

[0039] In addition, since the maximum value $T_{c\text{-}max}$ when increasing the set temperature T_{close} at which the electromagnetic valve 9 is closed from the decreased set temperature is set to the initial set temperature T_{close}, even when it is varied by increasing/decreasing the set temperature T_{close} at which the electromagnetic valve is closed, the set temperature T_{close} is never raised beyond the initial set temperature T_{close}, and it is possible to ensure a minimum required open/closed time, thus controlling the amount of bypassed liquid refrigerant. Accordingly, as well as reducing the opening/closing frequency of the electromagnetic valve 9 as much as possible, it is possible to suppress a rise in the discharge temperature (Td) by bypassing an appropriate amount of liquid refrigerant, thus protecting the compressor 2.

[0040] The present invention is not restricted to the above-described embodiment, and appropriate modifications are permitted so long as they do not depart from the scope of the invention. For example, the above embodiment has been explained using the refrigeration/air-conditioning apparatus 1 with a unidirectional cycle as an example; naturally, however, it can also be applied in a similar manner to a reversible-cycle refrigeration/air-conditioning apparatus provided with a four-way switching valve for switching the refrigerant circulation direction. Moreover, although the above embodiment has been explained using an example of a refrigeration cycle in which the single evaporator 5 is connected, it can also be applied in a similar manner to a multi-type refrigeration cycle in which a plurality of evaporators 5 are connected in parallel.

[0041] Although a refrigeration cycle that does not have an accumulator or receiver has been described in the above embodiment, various refrigeration cycle configurations can be considered; for example, as another possible embodiment, the present invention can also be applied in a similar manner to a refrigeration cycle in which such functional devices are additionally provided. Moreover, the present invention is very useful in cases where it is applied to refrigeration cycles using, for example, R32, R1234, and CO2 refrigerants, etc., which have the characteristic that the discharge temperature is high, which are limited to use at discharge temperatures (Td) of about 120 to 130 °C, and with which there is a high possibility of the liquid bypass electromagnetic valve 9 opening and closing at temperatures close to these temperatures.

{Reference Signs List}

[0042]

1 refrigeration/air-conditioning apparatus
2 compressor
6A discharge line
6B high-pressure liquid line
6C suction line
8 liquid bypass circuit
9 liquid bypass electromagnetic valve (electromagnetic valve)
10 discharge temperature sensor
11 control means
T_{open} discharge temperature setting for opening liquid bypass electromagnetic valve [°C]
T_{close} discharge temperature setting for closing liquid bypass electromagnetic valve [°C]
t_{o*} open time of liquid bypass electromagnetic valve [sec]
t_{c*} closed time of liquid bypass electromagnetic valve [sec]
$T_{c\text{-}min}$ minimum set temperature after decrease [°C]
$T_{c\text{-}max}$ maximum set temperature after increase [°C]
Td discharge temperature at certain time point [°C]
t_c open/closed time of liquid bypass electromagnetic valve at certain time point [sec]

$t_{c\text{-}up}$ open/closed time of liquid bypass electromagnetic valve during which T_{close} [sec] is increased
$t_{c\text{-}down}$ open/closed time of liquid bypass electromagnetic valve during which T_{close} [sec] is decreased
$t_{c\text{-}std}$ minimum required standard open/closed time of liquid bypass electromagnetic valve [sec]
X predetermined temperature for increasing/decreasing T_{close} [deg]

Claims

1. A refrigeration/air-conditioning apparatus equipped with a liquid bypass circuit (8) provided with an electromagnetic valve (9), between a high-pressure liquid line (6B) in a refrigeration cycle and a suction line (6C) running to a compressor (2), the refrigeration/air-conditioning apparatus (1) comprising:

   a control means (11) for opening and closing the electromagnetic valve (9) on the basis of a detected temperature in a discharge temperature sensor (10) provided in a discharge line (6A) from the compressor (2) and for varying a set temperature at which the electromagnetic valve (9) is closed depending on the time since the last time the electromagnetic valve was opened or closed.

2. A refrigeration/air-conditioning apparatus according to claim 1, wherein when the time since the last opening/closing operation of the electromagnetic valve (9) does not exceed a set time, control for reducing the set temperature at which the electromagnetic valve (9) is closed by a predetermined temperature from an initial set temperature is repeated, and when the time since the last opening/closing operation exceeds the set time, control for raising the set temperature at which the electromagnetic valve (9) is closed by the predetermined temperature is performed.

3. A refrigeration/air-conditioning apparatus according to claim 2, wherein a minimum value when decreasing the set temperature at which the electromagnetic valve (9) is closed from the initial set temperature is defined.

4. A refrigeration/air-conditioning apparatus according to claim 2 or 3, wherein a maximum value when increasing the set temperature at which the electromagnetic valve (9) is closed from the decreased set temperature is defined as the initial set temperature.

FIG. 1

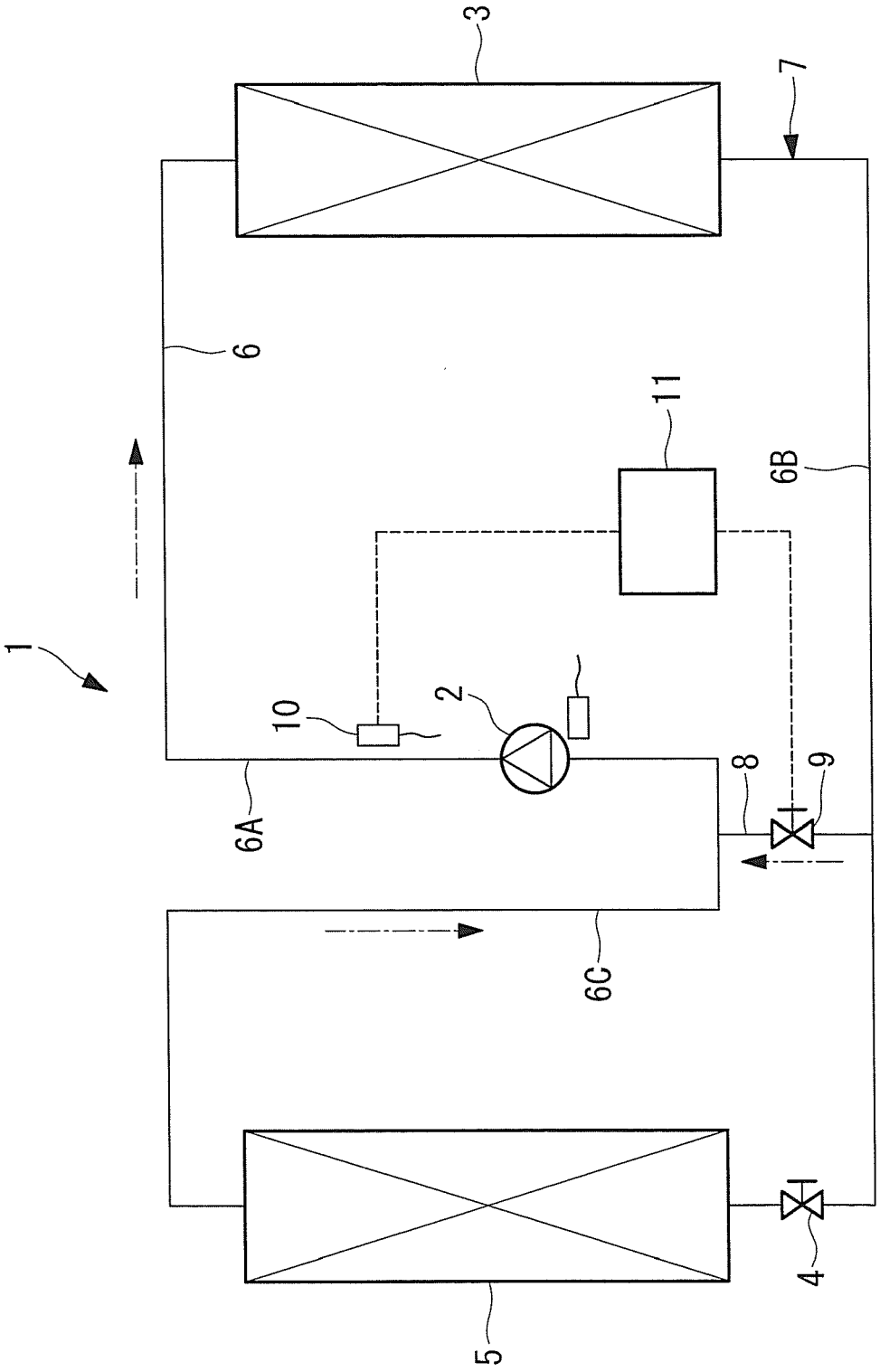
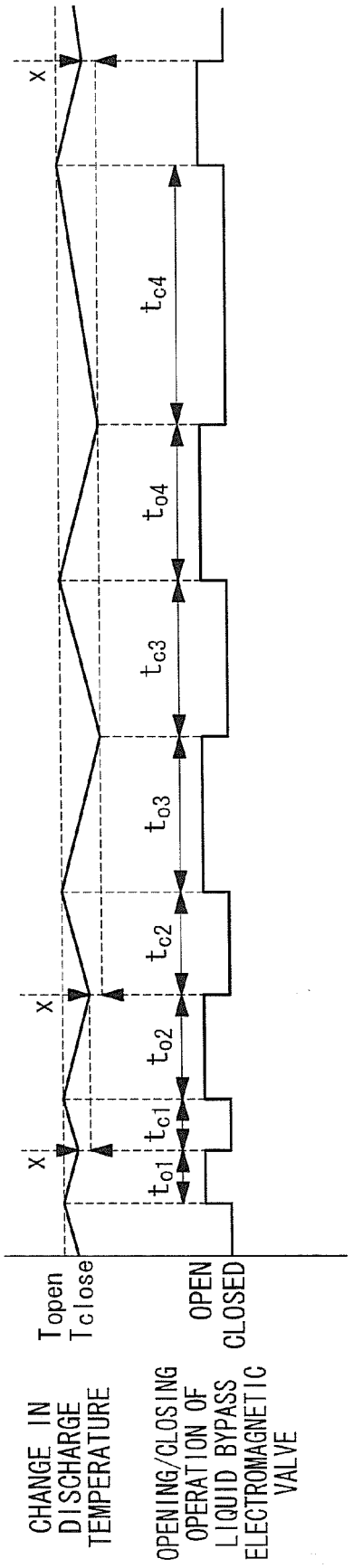


FIG. 2



Topen : DISCHARGE TEMPERATURE SETTING FOR OPENING LIQUID BYPASS ELECTROMAGNETIC VALVE[°C]
Tclose: DISCHARGE TEMPERATURE SETTING FOR CLOSING LIQUID BYPASS ELECTROMAGNETIC VALVE[°C]
to*: OPEN TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE[sec]
tc*: CLOSED TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE[sec]
X : PREDETERMINED TEMPERATURE FOR INCREASING/DECREASING T_{close}[deg]

FIG. 3

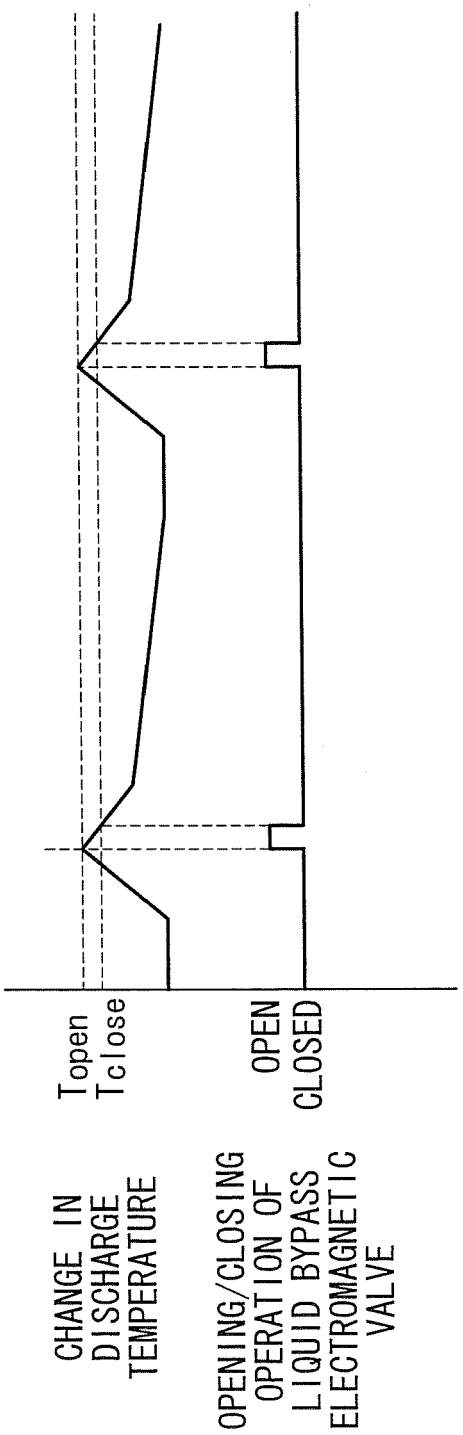
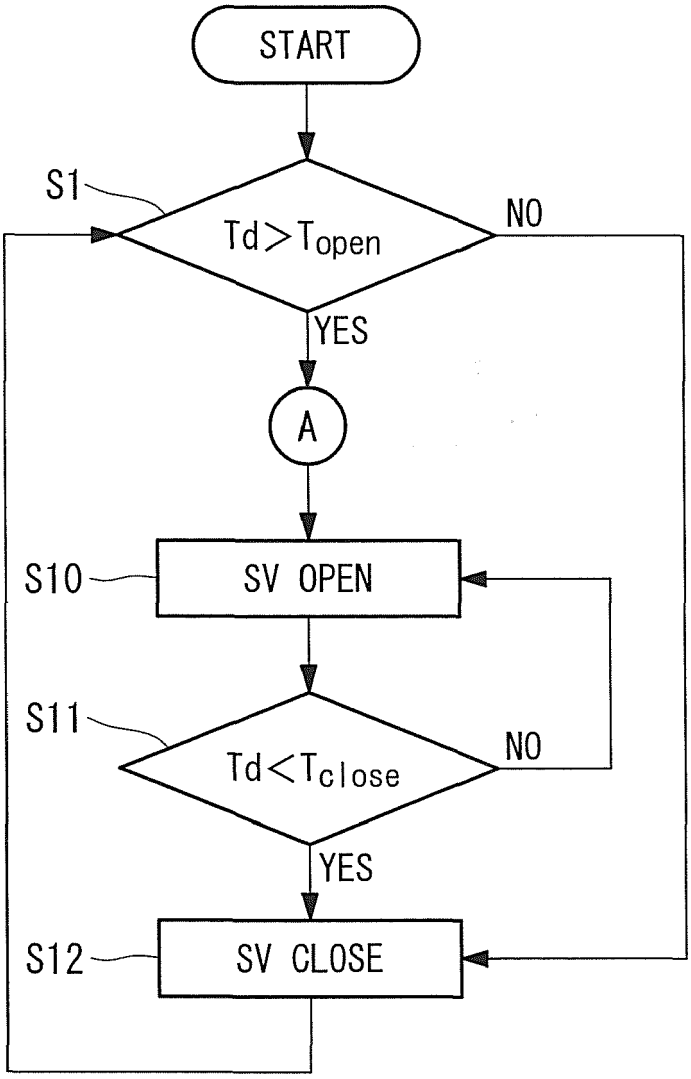
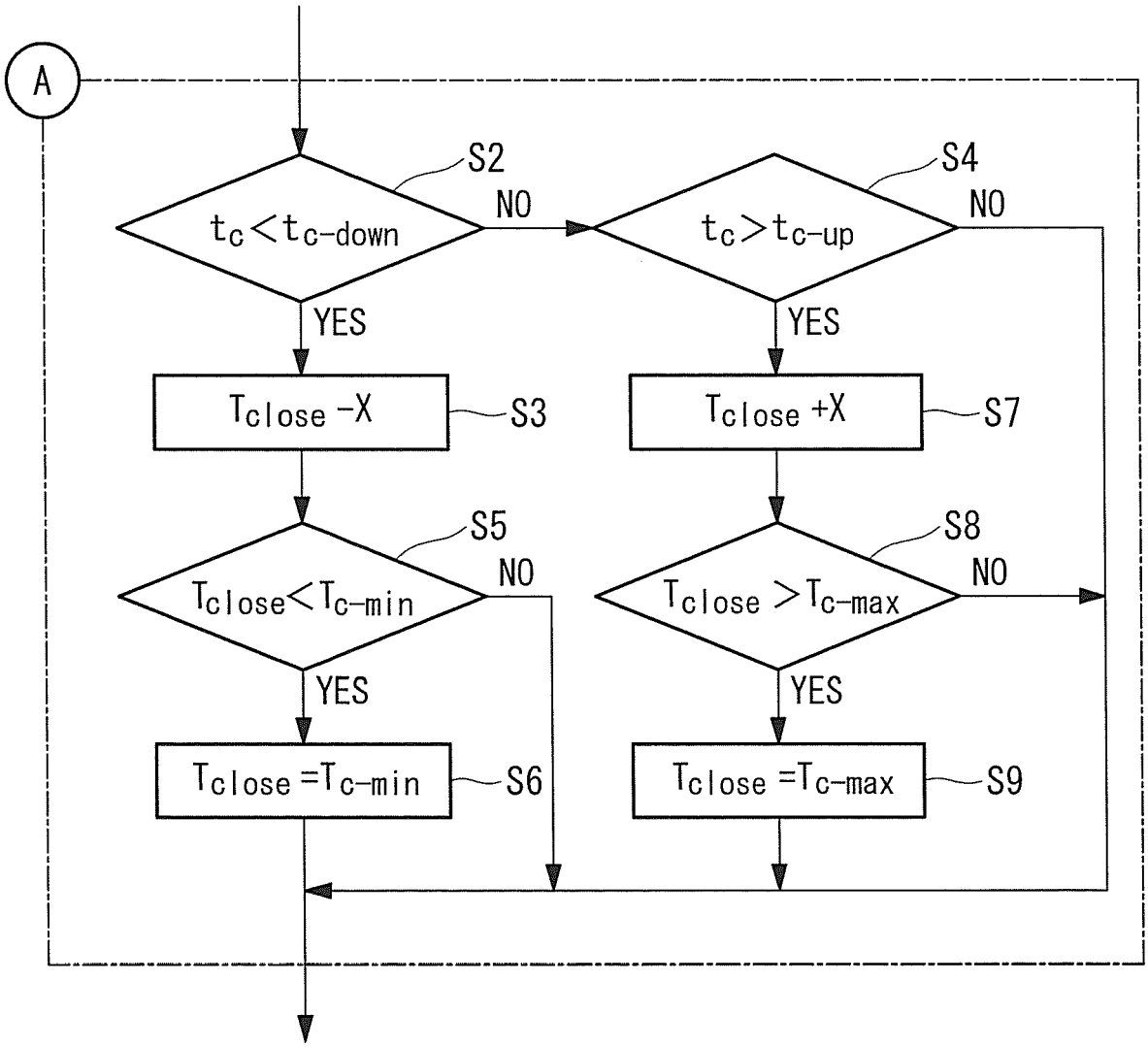

CHANGE IN DISCHARGE TEMPERATURE
Topen
Tclose
OPENING/CLOSING OPERATION OF LIQUID BYPASS ELECTROMAGNETIC VALVE
OPEN
CLOSED

FIG. 4



Td : DISCHARGE TEMPERATURE AT CERTAIN TIME POINT[°C]

FIG. 5



t_c : OPEN/CLOSED TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE AT CERTAIN TIME POINT[sec]

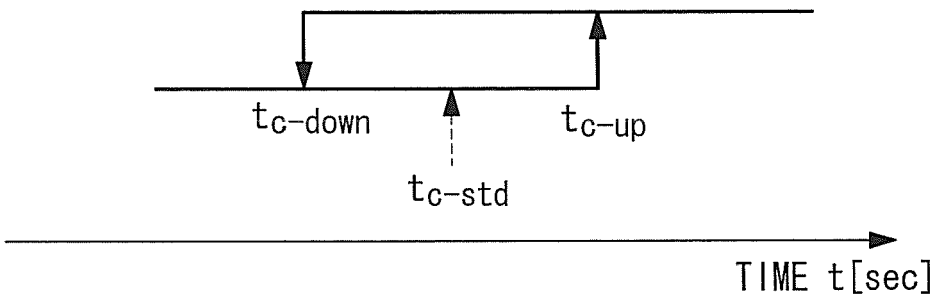
t_{c-up} : OPEN/CLOSED TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE DURING WHICH T_{close} IS INCREASED[sec]

t_{c-down} : OPEN/CLOSED TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE DURING WHICH T_{close} IS DECREASED[sec]

T_{c-min} : MINIMUM SET TEMPERATURE AFTER DECREASE[℃]

T_{c-max} : MAXIMUM SET TEMPERATURE AFTER INCREASE[℃]

FIG. 6



$t_{c\text{-}std}$: MINIMUM REQUIRED STANDARD OPEN/CLOSED TIME OF LIQUID BYPASS ELECTROMAGNETIC VALVE[sec]

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP HEI5172408 B **[0004]**