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(54) **Hot water system**

Heißwassersystem

Système de fourniture d'eau chaude

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Description

[0001] The present invention relates to a heat-pump hot water system equipped with a plate heat exchanger.

[0002] A general air conditioner controls a room temperature in such a manner as to calculate the difference between a temperature set by a remote control or the like and an actual room temperature, wherein when the difference is large, the speed of operation of a compressor is increased to enhance the performance of the air conditioner so that the actual room temperature reaches the set temperature as fast as possible.

[0003] When the temperature difference is small, the speed of operation of the compressor is decreased to reduce the performance of the air conditioner to save power and prevent the conditioner from being stopped because of overshooting of the room temperature relative to the set temperature..

[0004] In a hot water system, a compressor can be controlled by controlling a condensing temperature so as to reach a target condensing temperature in the same manner as the above because the condensing temperature depend on a target hot water temperature.

[0005] An example of the conventional air conditioner is disclosed in which the compressor is controlled according to the deviation between the condensing temperature of the refrigerant based on the pressure of the high-pressure refrigerant detected by a high-pressure sensor and a target condensing temperature (refer to Japanese Unexamined Patent Application Publication No. 2002-327949 (p. 4, Fig. 1)).

[0006] Although the conventional air conditioner discloses a technique for controlling a compressor using a high-pressure sensor, it does not refer to application of this technique to a hot water system equipped with a plate heat exchanger.

[0007] In a hot water system equipped with a plate heat exchanger, the refrigerant flows in the plate heat exchanger acting as a condenser. Therefore, it is impossible to detect the condensing temperature by temperature detection means mounted on the surface, thus posing the problem that the compressor cannot be controlled according to the condensing temperature of the refrigerant.

[0008] UK Patent Application GB 2 414 289 discloses a heat pump installation containing an outdoor unit containing an evaporator. The outdoor unit may also include a compressor and an electronically controlled expansion valve. A first condenser is also disclosed.

[0009] European Patent Application EP 0 750 166 A2 discloses a refrigerant circulating system containing a four-way valve.

[0010] The present invention is made to solve the above problems. Accordingly, it is an object of the invention to provide a hot water system equipped with a plate heat exchanger capable of controlling a compressor so that the condensing temperature calculated from the pressure detected by pressure detection means reaches a target condensing temperature and performing subcooling control and superheat control using the calculated condensing temperature.

[0011] According to the present invention there is provided a hot water system as specified in the claims.

[0012] The invention will now be described by way of non-limiting examples with reference to the accompanying drawings, in which:

Fig. 1 is a refrigerant circuit diagram of a hot water system according to an example;
Fig. 2 is a graph showing the relationship between the condensing pressure and the condensing temperature of the refrigerating cycle; and
Fig. 3 is a refrigerant circuit diagram of a hot water system according to a first embodiment of the invention.

[0013] Fig. 1 is a refrigerant circuit diagram of a hot water system according to an example. Fig. 2 is a graph showing the relationship between condensing pressure and condensing temperature of a refrigerating cycle.

[0014] As shown in Fig. 1, the heat-pump hot water system according to the example includes a compressor 1, a four-way valve 2 for switching a refrigerant circuit, a plate heat exchanger 10 for exchanging heat between water and a refrigerant, a first electronic expansion valve 6 for controlling the flow rate of the refrigerant to decrease the pressure, a receiver 7 for holding an excess refrigerant, a second electronic expansion valve 8 for controlling the flow rate of the refrigerant to decrease the pressure, and a heat exchanger 9 for exchanging heat between air and the refrigerant, which are connected in order by a pipeline 3 and housed in a hot water system outdoor unit 40.

[0015] A pipe connecting the outlet of the compressor 1 and the four-way valve 2 for switching the refrigerating circuit has pressure detection means Pd for detecting the pressure of the discharged refrigerant. The circuit has a structure in which the heat exchanger of the indoor unit of a so-called air conditioner is replaced with the plate heat exchanger 10 for exchanging heat between water and the refrigerant. The plate heat exchanger 10 is, however, housed in the hot water system outdoor unit 40, as shown in Fig. 1. The pipeline for connection is therefore very short.

[0016] The operation of the hot water system according to the example will be described.

[0017] The refrigerant converted to high-pressure high-temperature gas in the compressor 1 is discharged from the compressor 1 and fed to the four-way valve 2 for switching the circuit.

[0018] During heating the water, the four-way valve 2 is fixed so as to feed the refrigerant discharged from the compressor 1 to the plate heat exchanger 10.

[0019] The refrigerant discharged from the four-way valve 2 is fed to the plate heat exchanger 10. The refrigerant fed to the plate heat exchanger 10 exchanges heat

with the water passing through a water pipe 50, and is condensed and in the plate heat exchanger 10 to radiate heat. The refrigerant is condensed into a high-pressure normal-temperature liquid refrigerant in the plate heat exchanger 10. The water obtains heat from the refrigerant to increase its temperature, and is discharged. The condensed liquid refrigerant is decreased in pressure by the first electronic expansion valve 6.

[0020] The first electronic expansion valve 6 controls the refrigerant that is condensed by the plate heat exchanger 10 acting as a condenser according to the degree of subcooling.

[0021] However, the plate heat exchanger 10 has a structure in which the refrigerant and water flow between plates alternately to exchange heat. Therefore, it is impossible to dispose a temperature sensor for sensing the condensing temperature in the middle of the plate heat exchanger 10.

[0022] Therefore, the pressure detection means Pd is used to detect the pressure of the refrigerant discharged from the compressor 1. That is, the pipe from the compressor 1 to the plate heat exchanger 10 is so short that pressure loss is low, so that the pressure detected by the pressure detection means Pd is substantially equal to the condensing pressure of the refrigerant in the plate heat exchanger 10. As shown in the graph of Fig. 2 of the relationship between the condensing pressure and the condensing temperature of the refrigerating cycle, there is a certain correlation between the condensing pressure and the condensing temperature (saturation temperature). Therefore, if the condensing pressure is known, the condensing temperature (saturation temperature) can be found. For example, in the case where the refrigerant is R410A, the condensing temperature (saturation temperature) at a condensing pressure of 2.7 MPa is 46°C, as shown in Fig. 2.

[0023] Accordingly, the saturation temperature T10 of the refrigerant can be calculated from the condensing pressure of the refrigerant in the plate heat exchanger 10.

[0024] The degree of subcooling can be calculated as the difference between the saturation temperature T10 of the refrigerant and the actual condensing temperature of the liquid refrigerant detected by a temperature sensor Tix installed at the outlet of the plate heat exchanger 10.

[0025] When the degree of subcooling is low, the degree of opening of the first electronic expansion valve 6 is decreased so that the liquid of the refrigerant condensed by the plate heat exchanger 10 is increased to thereby increase the degree of subcooling. In contrast, when the degree of subcooling is high, the degree of opening of the first electronic expansion valve 6 is increased so that the liquid of the refrigerant condensed by the plate heat exchanger 10 is decreased to thereby decrease the degree of subcooling.

[0026] Thus the degree of opening of the first electronic expansion valve 6 is controlled according to the calculated degree of subcooling to control the degree of subcooling.

[0027] The decompressed refrigerant becomes a low-presser low-temperature liquid refrigerant and enters the receiver 7 connected ahead thereof. The receiver 7 holds an excess refrigerant.

[0028] The refrigerant discharged from the receiver 7 is again reduced in pressure by the second electronic expansion valve 8.. The decompressed refrigerant flows into the heat exchanger 9 that exchanges heat between air and the refrigerant.

[0029] Since the refrigerant flowing into the heat exchanger 9 is low in temperature, it receives heat from the air to evaporate into a low-pressure low-temperature gas refrigerant. In contrast, the air is cooled to low temperature and blows out. The heat exchanger 9 thus acts as an evaporator of the refrigerating cycle.

[0030] The low-pressure low-temperature gas refrigerant discharged from the heat exchanger 9 again flows into the four-way valve 2 for switching the circuit, from which the gas refrigerant is fed to a pipe to the inlet of the compressor 1. The low-pressure low-temperature gas refrigerant fed to the inlet of the compressor 1 is compressed in the compressor 1 into a high-pressure high-temperature gas refrigerant, and is discharged from the outlet.

[0031] The second electronic expansion valve 8 is located downstream of the receiver 12. The second electronic expansion valve 8 controls the refrigerant to be evaporated in the heat exchanger 9 according to the degree of superheat (degree of discharge superheat).

[0032] The degree of discharge superheat for control is calculated from the difference between the temperature of the refrigerant discharged from the compressor 1 which is detected by temperature detection means Td and the saturation temperature T10 calculated from the condensing pressure of the refrigerant in the plate heat exchanger 10 detected by the pressure detection means Pd.

[0033] When the degree of discharge superheat is low, the degree of opening of the second electronic expansion valve 8 is decreased to thereby decrease the amount of the refrigerant evaporated by the heat exchanger 9 to increase the degree of dryness of the refrigerant due to evaporation, thereby increasing the degree of discharge superheat. In contrast, when the degree of discharge superheat is high, the degree of opening of the second electronic expansion valve. 8 is increased to thereby increase the amount of the refrigerant evaporated by the heat exchanger 9 to decrease the degree of dryness of the refrigerant due to evaporation, thereby decreasing the degree of discharge superheat.

[0034] Thus, the degree of discharge superheat can be controlled by adjusting the degree of opening of the second electronic expansion valve 8 according to the calculated degree of discharge superheat.

[0035] During heating water, the foregoing cycle is repeated to thereby increase the temperature of the water by heat pump action of transferring the heat obtained from outside air to the water flowing in the water pipe 50.

[0036] A method for controlling the variable-capacity compressor 1 of the hot water system according to the example will be described.

[0037] The water flowing through the water pipe 50 gradually increases in temperature while circulating. A target condensing temperature depends on a set water temperature because the condensing temperature depends on the temperature of the circulating water.

[0038] The target condensing temperature determined from the set water temperature corresponds to the set temperature of air conditioners.

[0039] The present condensing temperature corresponds to the temperature of the air flowing into the heat exchanger in the indoor unit of air conditioners. Thus, the compressor 1 is controlled according to the difference between the present condensing temperature and the target condensing temperature determined from the set water temperature.

[0040] The present condensing temperature is calculated as the saturation temperature at the condensing pressure detected by the pressure detection means Pd.

[0041] When the present condensing temperature is lower than the target condensing temperature determined from the set water temperature and the difference therebetween is large, the speed of operation of the compressor 1 is increased to increase the amount of the refrigerant circulating in the refrigerating cycle so that the actual condensing temperature reaches the target condensing temperature fast, thereby enhancing the performance.

[0042] In contrast, when the present condensing temperature is lower than the target condensing temperature determined from the set water temperature and the difference therebetween is small, or when the present condensing temperature is higher than the target condensing temperature, the speed of operation of the compressor 1 is decreased to reduce the amount of the refrigerant circulating in the refrigerating cycle, thereby reducing the performance.

[0043] As described above, the hot water system of the example includes the pressure detection means Pd disposed between the outlet of the compressor 1 and the four-way valve 2, for detecting the pressure of the refrigerant discharged from the compressor 1, wherein the operation speed of the compressor 1 is controlled according to the difference between the condensing temperature calculated from the pressure detected by the pressure detection means Pd and a target condensing temperature. The hot water system further includes the temperature sensor Tix disposed at the outlet of the plate heat exchanger 10 for detecting the temperature of the liquid refrigerant, wherein the degree of opening of the first electronic expansion valve 6 is adjusted according to the difference between the condensing temperature calculated from the pressure detected by the pressure detection means Pd and the temperature of the liquid refrigerant detected by the temperature sensor Tix. Therefore, even with the plate heat exchanger 10, the first electronic expansion valve 6 and the variable-capacity compressor 1 can be controlled by a control method similar to that for heating by an air conditioner, ensuring reliability similar to that established by the air conditioner. The application of the control established for the air conditioner can reduce the period to develop a control program.

[0044] Moreover, the use of a refrigerant such as R410A used in the air conditioner allows a control constant for use in driving the actuators to be also applied, providing further reliability and reducing the period for development.

First Embodiment

[0045] Fig. 3 is a refrigerant circuit diagram of a hot water system according to a first embodiment of the invention.

[0046] As shown in Fig. 3, the heat-pump hot water system according to the first embodiment of the invention includes the compressor 1, the four-way valve 2 for switching the refrigerant circuit, the plate heat exchanger 10 for exchanging heat between water and the refrigerant, the first electronic expansion valve 6 for controlling the flow rate of the refrigerant to decrease the pressure, the receiver 7 for holding an excess refrigerant, the second electronic expansion valve 8 for controlling the flow rate of the refrigerant to decrease the pressure, and the heat exchanger 9 for exchanging heat between air and the refrigerant, which are connected in sequence by a pipeline and housed in the hot water system outdoor unit 40.

[0047] The first embodiment further includes pressure detection means Pc disposed at the pipe connecting the four-way valve 2 and the plate heat exchanger 10, for detecting the condensing pressure of the refrigerant.

[0048] In the case where the pressure detection means Pc for detecting the condensing pressure of the refrigerant is disposed at the pipe connecting the four-way valve 2 and the plate heat exchanger 10, the distance between the pressure detection means Pc and the plate heat exchanger 10 is short, so that the pressure loss of the pipe can be minimized. Accordingly, the condensing temperature can be measured more accurately than the previous example.

[0049] Descriptions of the operations of the other components are omitted here because they are the same as those of the previous example.

[Explanation of Numerals]

[0050]

1: COMPRESSOR
2: FOUR-WAY VALVE
3: PIPELINE
6: FIRST ELECTRONIC EXPANSION VALVE
7: RECEIVER
8: SECOND ELECTRONIC EXPANSION VALVE

9: HEAT EXCHANGER
10: PLATE HEAT EXCHANGER
40: HOT WATER SYSTEM OUTDOOR UNIT
50: WATER PIPE
Td: TEMPERATURE SENSOR FOR DETECTING DISCHARGED REFRIGERANT TEMPERATURE
Tix: TEMPERATURE SENSOR FOR DETECTING LIQUID REFRIGERANT TEMPERATURE
Pd: PRESSURE DETECTION MEANS FOR DETECTING DISCHARGED REFRIGERANT PRESSURE

Claims

1. A hot water system comprising:

a compressor (1) with variable operation capacity;
a four-way valve (2) for switching the direction of the refrigerating cycle;
a plate heat exchanger (10) for exchanging heat between water and the refrigerant;
a first expansion valve (6) for controlling the flow rate of the refrigerant to reduce the pressure; and
a heat exchanger (9) for exchanging heat between air and the refrigerant, which are connected in that order by a pipeline to form a refrigerating cycle for circulating the refrigerant, thereby heating water;

characterised by a pressure detection means (Pc) disposed between the four-way valve (2) and the plate heat exchanger (10), for detecting the condensing pressure of the refrigerant, wherein
the speed of operation of the compressor (1) is controlled according to the difference between the condensing temperature calculated from the pressure detected by the pressure detection means (Pc) and a target condensing temperature.

2. The hot water system according to Claim 1, further comprising:

temperature detection means (Tix) for detecting the temperature of a liquid refrigerant disposed at the outlet of the plate heat exchanger (10), wherein
the degree of opening of the first expansion valve (6) is controlled according to the difference between the condensing temperature calculated from the pressure detected by the pressure detection means (Pc) and the temperature of the liquid refrigerant detected by the temperature detection means (Tix).

3. The hot water system according to Claim 1, further comprising:

a receiver (7) disposed between the first expansion valve (6) and the heat exchanger (9);
a second expansion valve (8) disposed between the receiver (7) and the heat exchanger (9); and
temperature detection means (Td) for detecting the temperature of the discharged refrigerant, disposed at the outlet of the compressor (1), wherein

the degree of opening of the second expansion valve (8) is controlled according to the difference between the condensing temperature calculated from the pressure detected by the pressure detection means (Pc) and the temperature of the liquid refrigerant detected by the temperature detection means (Td).

4. The hot water system according to any of Claims 1 to 3, wherein the refrigerant used in the refrigerating cycle is R410A.

Patentansprüche

1. Warmwassersystem, umfassend:

einen Kompressor (1) mit variabler Betriebskapazität;
ein Vierwegeventil (2) zum Wechseln der Richtung des Kühlkreislaufs;
eine Plattenwärmeaustauschvorrichtung (10) zum Austauschen von Wärme zwischen Wasser und dem Kältemittel;
ein erstes Expansionsventil (6) zum Steuern der Flussrate des Kältemittels, um den Druck zu verringern; und
eine Wärmeaustauschvorrichtung (9) zum Austauschen von Wärme zwischen der Luft und dem Kältemittel, die in dieser Reihenfolge durch eine Rohrleitung verbunden sind, um einen Kühlkreislauf zum Zirkulieren des Kältemittels zu bilden und dadurch Wasser zu erwärmen;

gekennzeichnet durch ein Druckerfassungsmittel (Pc), das zwischen dem Vierwegeventil (2) und der Plattenwärmeaustauschvorrichtung (10) angeordnet ist, zum Erfassen des Kondensierungsdrucks des Kältemittels, wobei
die Betriebsgeschwindigkeit des Kompressors (1) gemäß dem Unterschied zwischen der anhand des **durch** das Druckerfassungsmittel (Pc) erfassten Drucks berechneten Kondensiertemperatur und einer Zielkondensiertemperatur gesteuert wird.

2. Warmwassersystem nach Anspruch 1, ferner umfassend:

Temperaturerfassungsmittel (Tix) zum Erfassen der Temperatur eines flüssigen Kältemittels, das am Auslass der Plattenwärmeaustauschvorrichtung (10) angeordnet ist, wobei der Öffnungsgrad des ersten Expansionsventils (6) gemäß dem Unterschied zwischen der anhand des durch das Druckerfassungsmittel (Pc) erfassten Drucks berechneten Kondensiertemperatur und der durch das Temperaturerfassungsmittel (Tix) erkannten Temperatur des flüssigen Kältemittels gesteuert wird.

3. Warmwassersystem nach Anspruch 1, ferner umfassend:

eine Empfangsvorrichtung (7), die zwischen dem ersten Expansionsventil (6) und der Wärmeaustauschvorrichtung (9) angeordnet ist;
ein zweites Expansionsventil (8), das zwischen der Empfangsvorrichtung (7) und der Wärmeaustauschvorrichtung (9) angeordnet ist; und
Temperaturerfassungsmittel (Td) zum Erfassen der Temperatur des abgegebenen Kältemittels, das am Auslass des Kompressors (1) angeordnet ist, wobei

der Öffnungsgrad des zweiten Expansionsventils (8) gemäß dem Unterschied zwischen der anhand des durch das Druckerfassungsmittel (Pc) erfassten Drucks berechneten Kondensiertemperatur und der durch das Temperaturerfassungsmittel (Td) erkannten Temperatur des flüssigen Kältemittels gesteuert wird.

4. Warmwassersystem nach einem der Ansprüche 1 bis 3, wobei das im Kühlkreislauf benutzte Kältemittel R410A ist.

Revendications

1. Système d'eau chaude comprenant :

un compresseur (1) à capacité opératoire variable ;
une soupape à quatre voies (2) pour modifier la direction du cycle de réfrigération ;
un échangeur de chaleur à plaques (10) pour l'échange thermique entre l'eau et le fluide frigorigène
une première soupape de détente (6) pour commander le débit du fluide frigorigène afin de réduire la pression ; et
un échangeur de chaleur (9) pour l'échange thermique entre l'air et le fluide frigorigène, qui sont raccordés dans cet ordre par une conduite pour former un cycle de réfrigération destiné à faire circuler le fluide frigorigène, chauffant ainsi l'eau ;

caractérisé par des moyens de détection de pression (Pc) placé entre la soupape à quatre voies (2) et l'échangeur de chaleur à plaques (10), afin de détecter la pression de condensation du fluide frigorigène,
la vitesse de fonctionnement du compresseur (1) étant commandée en fonction de la différence entre la température de condensation calculée d'après la pression détectée par les moyens de détection de pression (Pc) et une température de condensation cible.

2. Système d'eau chaude selon la revendication 1, comprenant en outre :

des moyens de détection de température (Tix) pour détecter la température d'un fluide frigorigène liquide situé au niveau de l'orifice de sortie de l'échangeur de chaleur à plaques (10),
le degré d'ouverture de la première soupape de détente (6) étant commandé en fonction de la différence entre la température de condensation calculée à partir de la pression détectée par les moyens de détection de pression (Pc) et la température du fluide frigorigène liquide détectée par les moyens de détection de température (Tix).

3. Système d'eau chaude selon la revendication 1, comprenant en outre :

un récepteur (7) placé entre la première soupape de détente (6) et l'échangeur de chaleur (9) ;
une deuxième soupape de détente (8) placée entre le récepteur (7) et l'échangeur de chaleur (9) ; et
des moyens de détection de température (Td) pour détecter la température du fluide frigorigène évacué, placés au niveau de l'orifice de sortie du compresseur (1),

le degré d'ouverture de la deuxième soupape de détente (8) étant commandé en fonction de la différence entre la température de condensation calculée à partir de la pression détectée par les moyens de détection de pression (Pc) et la température du fluide frigorigène liquide détectée par les moyens de détection de température (Td).

4. Système d'eau chaude selon l'une quelconque des revendications 1 à 3, dans lequel le fluide frigorigène utilisé dans le cycle de réfrigération est le R410A.

FIG. 1

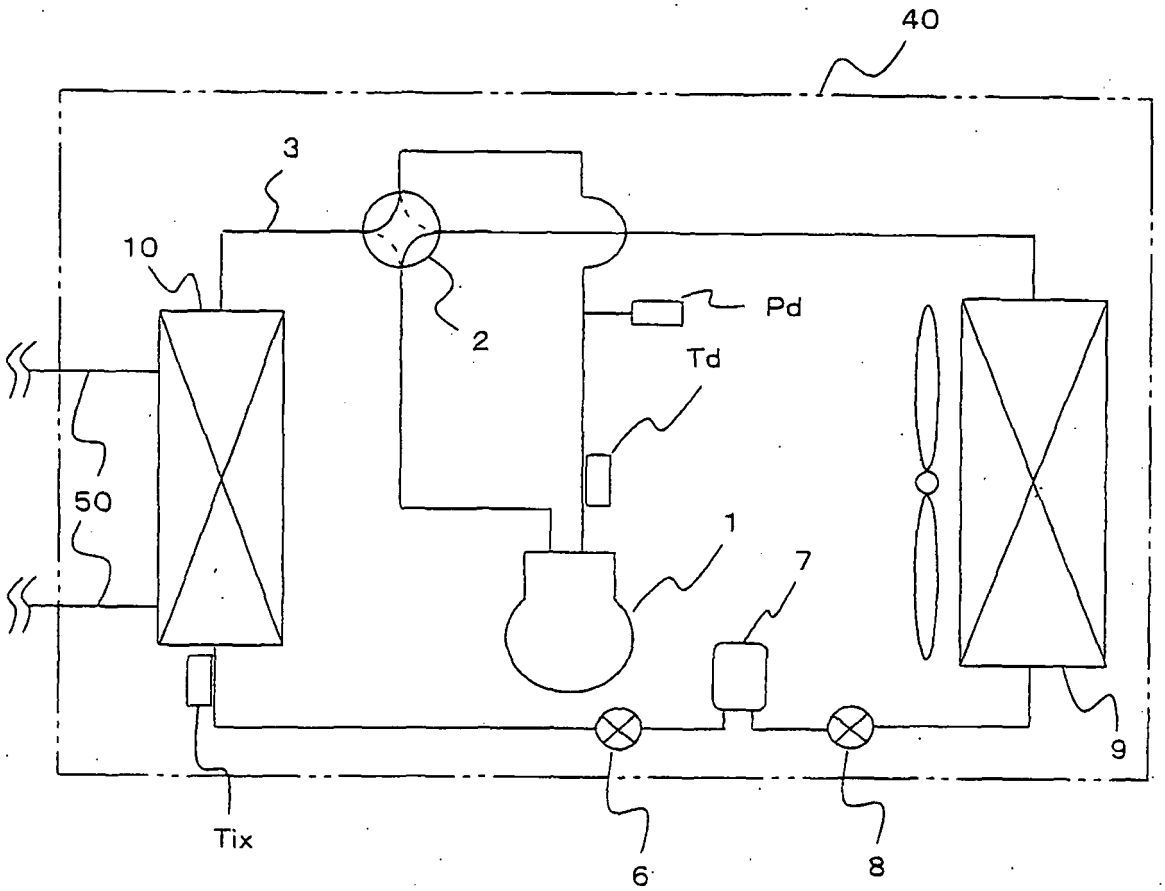


FIG. 2

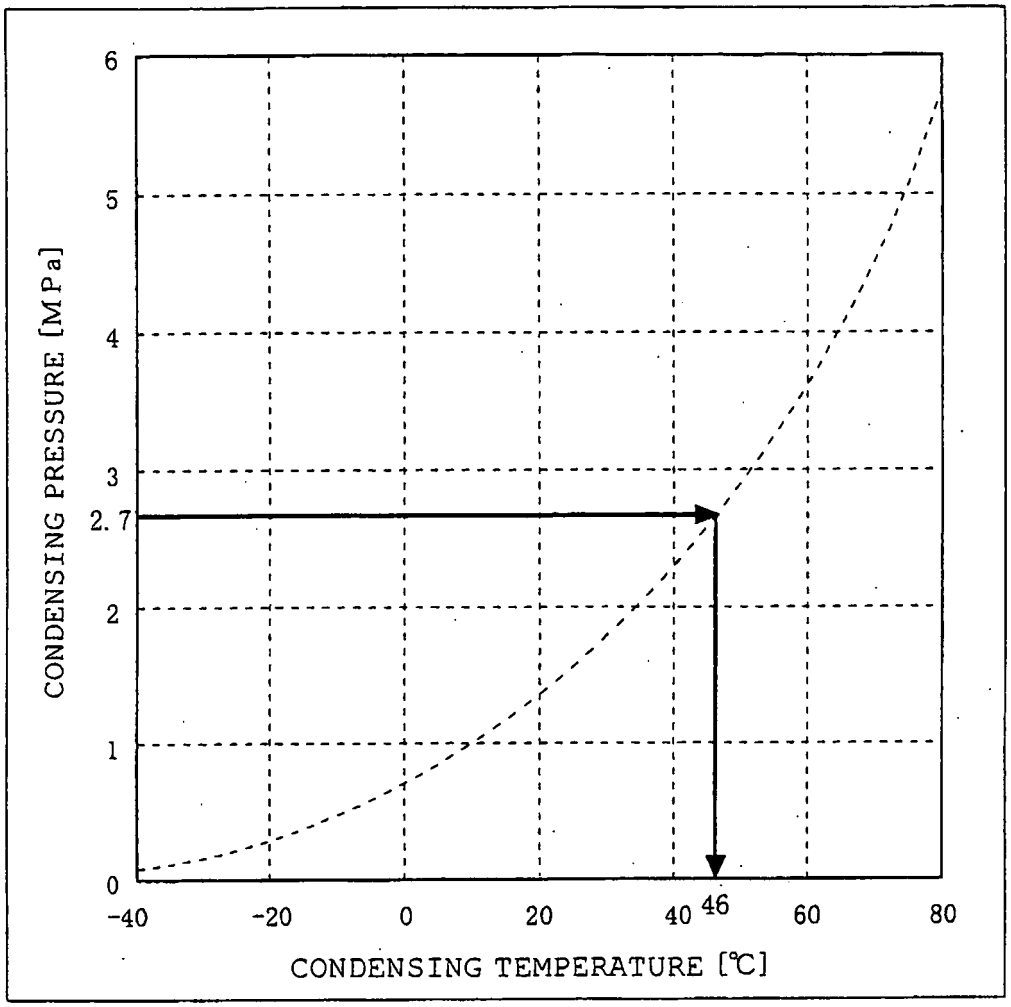
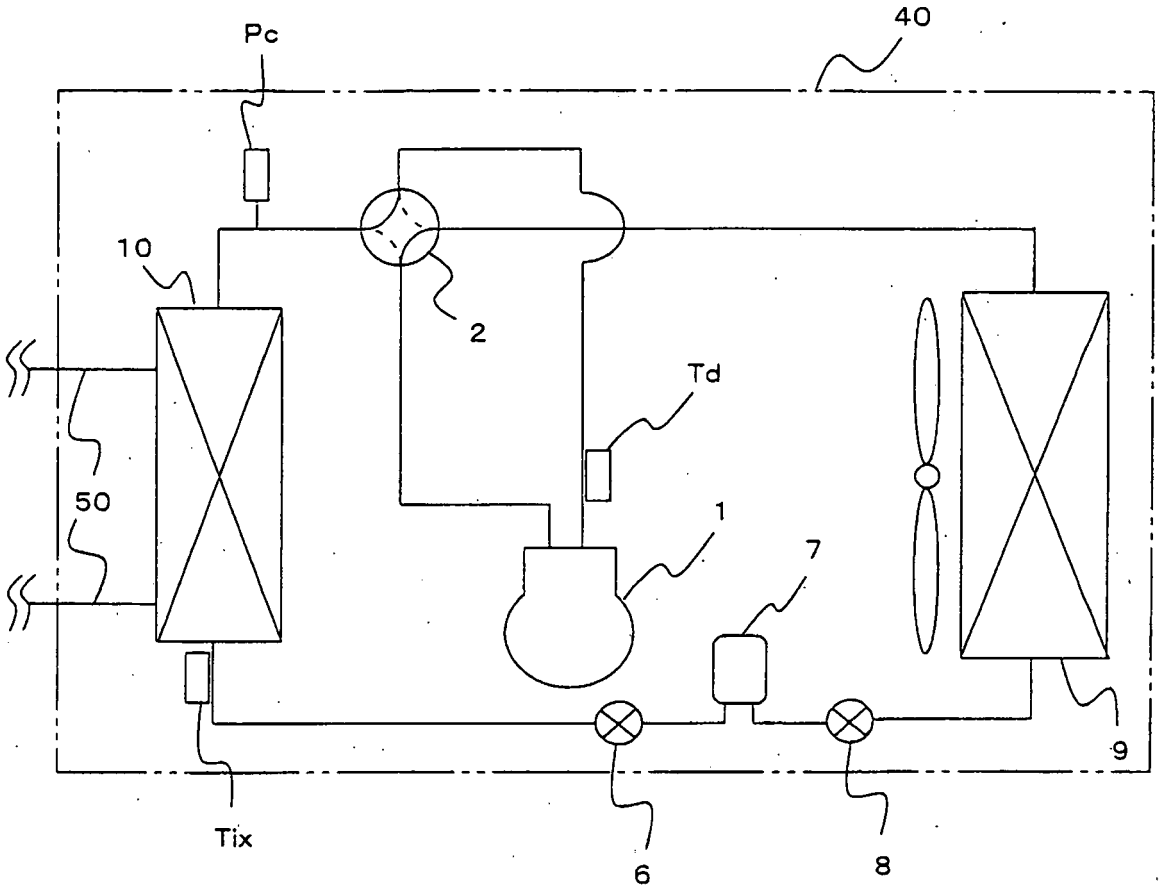

CONDENSING PRESSURE [MPa]
6
5
4
3
2.7
2
1
0
-40
-20
0
20
40
46
60
80
CONDENSING TEMPERATURE [℃]

FIG. 3



PC: PRESSURE DETECTION MEANS FOR DETECTING THE CONDENSING PRESSURE OF REFRIGERANT

REFERENCES CITED IN THE DESCRIPTION

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- GB 2414289 A **[0008]**
- EP 0750166 A2 **[0009]**