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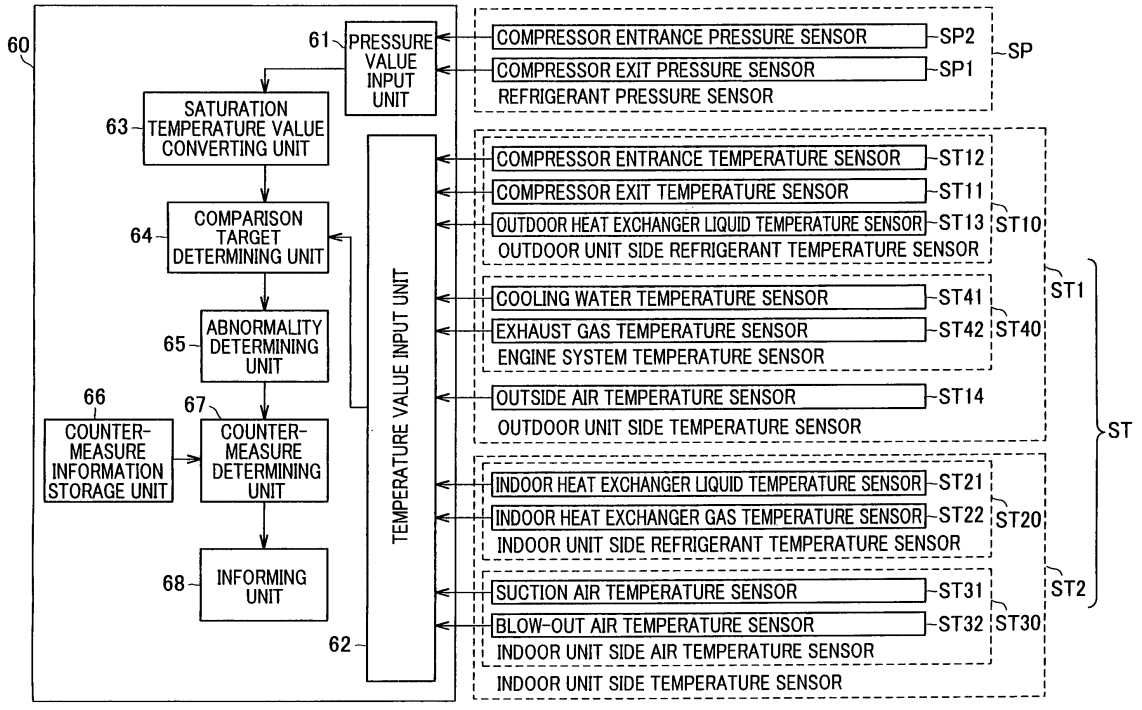
(54) Air conditioner and energy equipment

(57) An air conditioner (100) comprising a refrigerant circuit (1) including a compressor (15), a four-way valve (18), an outdoor heat exchanger (19) and an indoor heat exchanger (26) which are successively connected to one another, plural sensors (SP, ST) containing refrigerant state detecting sensors (SP, ST11, ST12, ST13, ST21, ST22) for detecting a state of refrigerant in the refrigerant circuit, the compressor being driven on the basis of detection values of the respective sensors to perform an air conditioning operation, and an abnormality determining unit (65) for mutually comparing the detection values of mutual comparison target sensors of the plural sensors to determine presence or absence of abnormality of each of the sensors when the refrigerant returns to a stationary state after the air conditioning operation is stopped.

FIG. 2



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an air conditioner and energy equipment in which energy is applied to prescribed liquid such as refrigerant or the like to make the liquid perform a predetermined work such as an air conditioning work or the like, and particularly to an air conditioner and energy equipment having a plurality of sensors.

2. Description of the Related Art

[0002] There is known an air conditioner having a refrigerant circuit including a compressor, a four-way valve, an outdoor heat exchanger and an indoor heat exchanger which are successively connected to one another, and plural sensors for detecting temperature and pressure of refrigerant circulating in the refrigerant circuit. According to this air conditioner, the compressor is driven on the basis of detection values of the respective sensors to perform an air conditioning operation corresponding to an air conditioning load (for example, JP-A-08-159567).

[0003] With respect to various sensors such as a temperature sensor, etc., variation occurs in sensor characteristic due to aged deterioration or the like in some cases. When some variation occurs in the sensor characteristic, it would be impossible to accurately detect temperature and pressure of a detection target such as refrigerant or the like. In this case, the air conditioning operation is executed on the basis of a pressure value and a temperature value which are different from actual values, and thus the air conditioning performance required to the air conditioner cannot be exerted. Furthermore, there occurs a problem that an energy consumption amount is increased due to an excessive operation. However, according to conventional air conditioners, in such a case that the variation of the sensor characteristic of a sensor is small or the like, it has been impossible to determine whether a detection value of the sensor is abnormal or not, and thus it has been difficult to detect abnormality of the sensor before the sensor breaks down completely.

SUMMARY OF THE INVENTION

[0004] Therefore, the present invention has been implemented in view of the foregoing problem, and has an object to provide an air conditioner and energy equipment that can detect more early abnormality of each sensor provided to the air conditioner or the energy equipment.

[0005] In order to attain the above object, according to a first aspect of the present invention, an air conditioner (100) comprising a refrigerant circuit (1) including a compressor (15), a four-way valve (18), an outdoor heat exchanger (19) and an indoor heat exchanger (26) which are successively connected to one another, and plural sensors (SP, ST) containing refrigerant state detecting sensors (SP, ST11, ST12, ST13, ST21, ST22) for detecting a state of refrigerant in the refrigerant circuit, the compressor being driven on the basis of detection values of the respective sensors to perform an air conditioning operation, is characterized by further comprising an abnormality determining unit (65) for mutually comparing the detection values of mutual comparison target sensors of the plural sensors to determine presence or absence of abnormality of each of the sensors when the refrigerant returns to a stationary state after the air conditioning operation is stopped.

[0006] According to the air conditioner of the first aspect, the abnormality determining unit mutually compares the detection values of the respective sensors to determine the presence or absence of abnormality of each sensor when the refrigerant returns to the stationary state after the air conditioning operation is stopped. Here, when application of energy (for example, compression) to the refrigerant by the compressor is stopped after the air conditioning operation is stopped, the refrigerant state such as the refrigerant temperature or the like is substantially equal to the ambient state such as ambient temperature or the like, and thus the refrigerant is set to a stationary state. Accordingly, when the refrigerant returns to the stationary state, the detection value of each sensor is equal to the value corresponding to the ambient state.

[0007] Accordingly, the detection values of the respective sensors are mutually compared with one another, and when some sensor outputs a detection value indicating a state different from the ambient state indicated by the detection values of the other sensors, the sensor concerned can be determined as an abnormal sensor. A sensor whose sensor characteristic is varied (deviated) can be also determined as an abnormal sensor. Accordingly, the abnormality of each sensor can be detected at an early stage and thus breakdown of the sensor can be predicted before the sensor falls into a complete breakdown state like a wire breaking trouble or a short-circuiting trouble.

[0008] In the first aspect of the air conditioner, the refrigerant state detecting sensors may contain a refrigerant temperature sensor (ST11, ST12, ST13, ST21, ST22) for detecting the temperature of the refrigerant and a refrigerant pressure sensor (SP1, SP2) for detecting the pressure of the refrigerant, and the abnormality determining unit may determine a saturation temperature value from the detection value of the refrigerant pressure sensor, and mutually compares the detection values of the respective sensors in terms of temperature values.

[0009] According to the above construction, the saturation temperature value is converted from the detection value of the refrigerant pressure sensor, and the detection values of the respective sensors are mutually compared with one another in terms of temperature values. Therefore, even when the number of the refrigerant pressure sensors provided to the air conditioner is small, the

detection values (converted values) of the refrigerant pressure sensors can be compared with the detection values of the temperature sensors to determine the presence or absence of abnormality of the refrigerant pressure sensors.

[0010] In the air conditioner of the first aspect, the plural sensors may contain plural temperature sensors (ST) for detecting the temperature of a detection target and plural pressure sensors (SP) for detecting the pressure of a detection target, and the abnormality determining unit may mutually compare the respective detection values of the temperature sensors with excluding the detection values of the pressure sensors from comparison targets to determine the presence or absence of abnormality when the presence or absence of abnormality of the temperature sensors is determined, and mutually compare the respective detection values of the pressure sensors with excluding the detection values of the temperature sensors from comparison targets to determine the presence or absence of abnormality when the presence or absence of abnormality of the pressure sensors is determined.

[0011] According to the above construction, when the presence or absence of abnormality of the temperature sensors is determined, the abnormality determining unit excludes the detection values of the pressure sensors for mutual comparison targets (i.e., does not select these detection values for mutual comparison). Therefore, a step of converting the detection values of the pressure sensors to temperature values, etc. can be omitted, and thus the processing of determining the presence or absence of abnormality can be readily performed. Likewise, when the presence or absence of abnormality of the pressure sensors is determined, the detection values of the temperature sensors are excluded from mutual comparison targets, and the pressure values of the pressure sensors are mutually compared with one another to readily determine the presence or absence of abnormality.

[0012] In the air conditioner of the first aspect, the plural sensors may contain air temperature sensors (ST14, ST31, ST32) for detecting the temperature of ambient air around the refrigerant circuit.

[0013] According to the above construction, the plural sensors contain the air temperature sensors for detecting the temperature of air around the refrigerant circuit, and thus the abnormality determining unit can determine the presence or absence of abnormality of the air temperature sensors. Furthermore, the presence or absence of abnormality of the other sensors containing the refrigerant state detecting sensors can be also determined by using the detection values of the air temperature sensors.

[0014] The air conditioner of the first aspect may further comprise an engine for driving the compressor, wherein the plural sensors contain an exhaust gas temperature sensor (ST42) for detecting the temperature of exhaust gas of the engine.

[0015] According to the above construction, the plural sensors contain the temperature sensor for detecting the exhaust gas temperature of the engine for driving the compressor, and thus the abnormality determining unit can determine the presence or absence of abnormality of the exhaust gas temperature sensor. Furthermore, the presence or absence of abnormality of the other sensors containing the refrigerant state detecting sensors can be also determined by using the detection value of the exhaust gas temperature sensor.

[0016] The air conditioner of the first aspect further may comprise a cooling water circuit for circulating cooling water for cooling an engine for driving the compressor, wherein the plural sensors contain a coolingwater temperature sensor (ST41) for detecting the temperature of the cooling water.

[0017] According to the above construction, the plural sensors contain the cooling water temperature sensor for detecting the temperature of the cooling water for cooling the engine for driving the compressor, and thus the abnormality determining unit can determine the presence or absence of abnormality of the cooling water temperature sensor. Furthermore, the presence or absence of abnormality of the other sensors containing the refrigerant state detecting sensors can be also determined by using the detection value of the cooling water temperature sensor.

[0018] The air conditioner of the first aspect may further comprise a comparison target determining unit for determining on the basis of at least one of a sensor characteristic, a detection target and a detection position for each of the sensors whether the sensor is selected as a mutual comparison target sensor when the presence or absence of abnormality is determined in the abnormality determining unit.

[0019] According to the above construction, on the basis of at least one of the sensor characteristic, the detection target and the detection position, the comparison target determining unit determines for each sensor whether the sensor is selected as a mutual comparison target sensor when the presence or absence of abnormality is determined in the abnormality determining unit. Therefore, sensors which are not preferable as mutual comparison target sensors can be excluded from the mutual comparison target sensors on the basis of the sensor characteristic, the detection target and the detection position of the sensor, so that erroneous determination can be prevented.

[0020] For example, the plural sensors provided to the air conditioner may contain a temperature sensor having such a temperature characteristic that the detection precision thereof is lower than the other sensors in a prescribed temperature area due to the difference of detection targets. Therefore, a detection value range in which the detection value can be mutually compared with the detection values of the other sensors, that is, a detection value range in which a high-reliability detection value can be output is set for each sensor as an abnormality presence or absence determinable range on the basis of the sensor characteristic of each sensor, and when the de-

tection value of the temperature sensor indicates a value out of the abnormality presence or absence determinable range, the sensor concerned is excluded from the comparison targets, whereby erroneous determination of the presence or absence of abnormality of each sensor in the abnormality presence or absence determining unit can be prevented.

[0021] Furthermore, when the plural sensors contain temperature sensors for detecting the temperatures of different detection targets like refrigerant and cooling water, there is a case where the time required until each detection target returns to the stationary state after the air conditioning operation is stopped is different between these different detection targets. Therefore, the detection values of the respective sensors maybe different from each other due to the difference in detection target in accordance with the timing at which the presence or absence of abnormality is determined. Accordingly, in a case where the presence or absence of abnormality is determined by the abnormality determining unit, when the refrigerant returns to the stationary state, however, the other detection target does not return to the stationary state, a sensor which detects the state of the other detection target which does not return so the stationary state is excluded from mutual comparison target sensors, whereby the erroneous determination of the presence or absence of abnormality can be prevented.

[0022] Still furthermore, the ambient temperature or the like is greatly different between the indoor unit side and the outdoor unit side in some seasons. Accordingly, in a case where the presence or absence of abnormality of each sensor is determined by the abnormality determining unit, the sensors whose detection positions are located at the outdoor unit side are excluded from mutual comparison sensors when the presence or absence of abnormality is determined for sensors whose detection positions are located at the indoor unit side, whereby the erroneous determination of the presence or absence of abnormality can be prevented. Likewise, the sensors whose detection positions are located at the indoor unit side are excluded frommutual comparison sensors when the presence or absence of abnormality is determined for sensors whose detection positions are located at the outdoor unit side, whereby the erroneous determination of the presence or absence of abnormality can be prevented.

[0023] In the air conditioner of the first aspect, in a case where it is determined whether a sensor is selected as a mutual comparison target sensor, the comparison target determining unit may not select the senor concerned as a mutual comparison target sensor when the detection value of the sensor concerned is out of a predetermined abnormality presence or absence determinable range set on the basis of the sensor characteristic of the sensor concerned.

[0024] According to this construction, for example, even when a temperature sensor has a sensor characteristic having low detection precision in a prescribed temperature area, the detection value range in which the detection values can be mutually compared with the those of the other sensors, that is, the detection value range in which the high-reliability detection values can be output are preset as the abnormality presence or absence determinable range on the basis of the sensor characteristic of the sensor concerned, and when the detection value of the sensor concerned is equal to a value out of the abnormality presence or absence determinable range, the sensor concerned is excluded from the mutual comparison targets, whereby the erroneous determination of the presence or absence of abnormality of each sensor in the abnormality presence or absence determining unit can be prevented. An exhaust gas temperature sensor for detecting the exhaust gas of the engine for driving the compressor is a sensor as described above. The exhaust gas temperature sensor targets the exhaust gas of the engine for driving the compressor. The exhaust gas temperature increases to higher temperature as compared with the temperature of the refrigerant, the temperature of ambient air around the refrigerant circuit, etc., and thus a temperature sensor having high detection precision in a high temperature area is used as the exhaust gas temperature sensor. When a temperature sensor having high detection precision in a high-temperature area is used, the detection precision thereof in a low-temperature area (for example, 20°C or less, or the like) maybe lowered. Accordingly, if the detection value range in which a high-reliability detection value can be output is set as the abnormality presence or absence determinable range on the basis of the sensor characteristic, when the detection value of the exhaust gas temperature sensor concerned is within this abnormality presence or absence determinable range, the presence or absence of abnormality in the abnormality determining unit can be accurately determined. On the other hand, when the detection value of the exhaust gas temperature sensor is out of the abnormality presence or absence determinable range, the presence or absence of abnormality is determined by the abnormality determining unit without selecting the exhaust gas temperature sensor as a mutual comparison target sensor, so that the erroneous determination can be prevented when the presence or absence of abnormality of the other sensors is determined.

[0025] In the air conditioner of the first aspect, in a case where it is determined whether a sensor is selected as a mutual comparison target sensor, the comparison target determining unit may not select the senor concerned as a mutual comparison target sensor when the sensor concerned detects the state of a detection target which does not return to a stationary state.

[0026] According to the above construction, for example when there are temperature sensors for detecting the temperatures of different detection targets like refrigerant and coolingwater, the time required to return to the stationary state after the air conditioning operation is longer for cooling water than that for refrigerant. Therefore, the

detection value of the cooling water temperature sensor for detecting the temperature of the cooling water is higher than the detection value of the refrigerant temperature sensor for detecting the temperature of the refrigerant at some timing at which the presence or absence of abnormality is determined. Accordingly, when the presence or absence of abnormality of each sensor is determined by the abnormality determining unit, the sensor for detecting the state of a detection target which does not return to the stationary state is excluded frommutual comparison target sensors (i.e., is not selected as a mutual comparison target sensor), whereby the erroneous determination when the presence or absence of abnormality of the other sensors can be prevented.

[0027] The air conditioner of the first aspect may further comprise: a countermeasure information storage unit (66) for storing countermeasure information obtained by associating countermeasures with each sensor when the sensor is determined to be abnormal by the abnormality determining unit while classing the countermeasures into a case where the sensor indicates a detection value higher than the detection values of the group of the mutual comparison target sensors and a case where the sensor indicates a detection value lower than the detection values of the group of the mutual comparison target sensors; and an informing unit (68) for informing a corresponding countermeasure on the basis of the detection value of an abnormality determination target sensor when the sensor concerned is determined to be abnormal by the abnormality determining unit.

[0028] According to the above construction, when it is determined that a sensor as an abnormality determination target sensor is determined to have abnormality, in accordance with whether the detection value of the sensor concerned is higher or lower than the detection values (or a statistical value thereof) of the group of the mutual comparison target sensors, the corresponding countermeasure is informed by the informing unit.

[0029] According to a second aspect of the present invention, energy equipment including a fluid circulating passage for circulating fluid to which prescribed energy is applied, and plural sensors containing fluid state detecting sensors for detecting the state of the fluid, a predetermined work being executed by discharging the energy of the fluid in a circulation process of the fluid, is characterized by an abnormality determining unit (65) for mutually comparing the detection values of mutual comparison target sensors of the plural sensors to determine presence or absence of abnormality of each of the sensors when the fluid returns to a stationary state after the application of the energy to the fluid is stopped.

[0030] According to the energy equipment of the second aspect, the abnormality determining unit mutually compares the detection values of the respective sensors to determine the presence or absence of abnormality of each sensor when the fluid returns to the stationary state after the application of the energy to the fluid is stopped. When the application of the energy to the fluid is stopped, the fluid state such as the fluid temperature or the like is substantially equal to the ambient state such as ambient temperature or the like, and thus the detection value of each sensor is equal to the value corresponding to the ambient state. Therefore, a sensor which outputs a detection value indicating an ambient state different from that of the other sensors can be determined as an abnormal sensor. A sensor having a deviated (varied) sensor characteristic can be determined as an abnormal sensor. Accordingly, before a sensor perfectly falls into a trouble like a wire breaking trouble or a short-circuiting trouble, the abnormality of the sensor can be detected at an early stage, and the trouble of the sensor can be predicted.

[0031] According to the present invention, the presence or absence of abnormality of each sensor can be detected at an early stage by mutually comparing the detection values of the plural sensors provided to the air conditioner or the energy equipment. Furthermore, according to the present invention, the presence or absence of abnormality of a sensor is determined even when the variation (deviation) of the sensor characteristic of a sensor is small. Therefore, the sensor can be repaired or exchanged at a stage that no trouble occurs even when the air conditioning operation is stopped, for example, in the nighttime or at an intermediate stage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

Fig. 1 is a diagram showing an example of a refrigerant circuit and a cooling water circuit of an air conditioner according to the present invention;
Fig. 2 is a block diagram showing a functional construction of a controller;
Fig. 3 is a diagram showing variation of a detection value of each sensor with respect to time lapse;
Fig. 4 is a diagram showing countermeasure information;
Fig. 5 is a flowchart showing comparison target determining processing; and
Fig. 6 is a flowchart showing abnormality determining processing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0033] A preferred embodiment according to the present invention will be described with reference to the accompanying drawings.

[0034] Fig. 1 is a diagram showing the construction of a gas heat pump (GHP) type air conditioner 100 according to an embodiment of the present invention. First, the construction of a refrigerant circuit 100 of the air conditioner 100 will be described. In Fig. 1, the refrigerant circuit 10 is represented by a heavy line.

[0035] The air conditioner 100 shown in Fig. 1 has an

outdoor unit 11 disposed outdoors, and an indoor unit 12 disposed indoors, and an outdoor refrigerant pipe 13 of the outdoor unit 11 is connected to an indoor refrigerant pipe 14 of the indoor unit 12.

[0036] As shown in Fig. 1, a compressor 15 is disposed in the outdoor refrigerant pipe 13. The compressor 15 is connected to a gas engine 40 (engine) through a V belt 40A, and driven by the gas engine 40. An accumulator 16 is disposed at the suction side of the compressor 15 of the outdoor refrigerant pipe 13, and a four-way valve 18, an outdoor heat exchanger 19 and an outdoor expansion valve 20 are successively disposed through an oil separator 17 at the discharge side of the compressor 15. An outdoor fan 21 for blowing air to the outdoor heat exchanger 19 is disposed in proximity to the outdoor heat exchanger 19. Furthermore, a radiator 54 described later is disposed in proximity to the outdoor heat exchanger 19.

[0037] An oil return pipe 22 and a bypass valve 23 are connected between the refrigerant high-pressure side of the outdoor refrigerant pipe 13 (the discharge side of the compressor 15) and the refrigerant low-pressure side of the outdoor refrigerant pipe 13 (in front of the accumulator 16 in Fig. 1), and a liquid valve 24 is connected to the entrance side of the accumulator 16 and the exit side of the outdoor expansion valve 20. A pressure switch SW, a compressor exit pressure sensor SP1 for detecting the pressure of refrigerant at the exit side of the compressor 15, and a compressor exit temperature sensor ST11 for detecting the temperature of refrigerant at the exist side of the compressor 15 are provided at the refrigerant high-pressure side of the outdoor refrigerant pipe 13. Furthermore, a compressor entrance pressure ST12 for detecting the pressure of refrigerant at the entrance side of the compressor 15 and a compressor entrance temperature sensor ST12 for detecting the temperature of refrigerant at the entrance side of the compressor 15 are provided at the refrigerant low-pressure side of the outdoor refrigerant pipe 13. An outdoor heat exchanger liquid temperature sensor ST13 for detecting the temperature of liquid refrigerant is provided to the outdoor refrigerant pipe 13 which connects one end of the outdoor heat exchanger 19 and the outdoor expansion 20. The outdoor unit 11 is further provided with an outside air temperature sensor ST14. The compressor exit pressure sensor SP1 and the compressor entrance pressure sensor SP2 may be generically named as refrigerant pressure sensor SP (see Fig. 2) . Furthermore, the compressor exit temperature sensor ST11, the compressor entrance temperature sensor ST12 and the outdoor heat exchanger liquid temperature sensor ST13 may be generically named as outdoor unit side refrigerant temperature sensor ST10. The outdoor unit side refrigerant temperature ST10, the outside air temperature sensor ST14 and a cooling water temperature sensor ST41 and an exhaust gas temperature sensor ST42 described later may be generically named as outdoor unit side temperature sensor ST1.

[0038] As shown in Fig. 1, the indoor unit 12 has an indoor heat exchanger 26 disposed in the indoor refrigerant pipe 14. An indoor expansion valve 27 is disposed in the indoor refrigerant pipe 14 in the neighborhood of the indoor heat exchanger 26. An indoor fan 28 is disposed in proximity to the indoor heat exchanger 26, and the indoor fan 28 for blowing air to the indoor heat exchanger 26. An indoor heat exchanger liquid temperature sensor ST21 for detecting the temperature of liquid refrigerant is provided between one end side of the indoor heat exchanger 26 of the indoor refrigerant pipe 14 and the indoor expansion valve 27, and an indoor heat exchanger gas temperature sensor ST22 for detecting the temperature of gas refrigerant is provided to the other end side of the indoor heat exchanger 26. Furthermore, the indoor unit 12 is provided with a suction port for sucking indoor air (not shown), and a suction air temperature sensor ST31 for detecting the temperature of air sucked into the indoor unit 12 is provided in the neighborhood of the suction port. The indoor unit 12 is further provided with an air blow-out port (not shown) for blowing out air-conditioned air, and a blow-out air temperature sensor ST32 for detecting the temperature of air-conditioned air to be blown out into a room is provided in the neighborhood of the air blow-out port.

[0039] As shown in Fig. 2, the indoor heat exchanger liquid temperature sensor ST21 and the indoor heat exchanger gas temperature sensor ST22 may be generically named as indoor unit side refrigerant temperature sensor ST20, and the suction air temperature sensor ST31 and the blow-out air temperature sensor ST32 may be generically named as indoor unit side air temperature sensor ST30. The indoor unit side refrigerant temperature sensor ST20 and the indoor unit side air temperature sensor ST30 may be generically named as indoor unit side temperature sensor ST2. The indoor unit side temperature sensor ST1 and the indoor unit side temperature sensor ST2 may be generically named as temperature sensor ST.

[0040] In the air conditioner 100, the cooling operation and the heating operation are switched to each other by switching the four-way valve 18. When the four-way valve 18 is switched to the cooling side, refrigerant flows along a solid-line arrow shown in Fig. 1, the outdoor heat exchanger 19 serves as a condenser, the indoor heat exchanger 26 serves as an evaporator, and the indoor heat exchanger 26 is set to a cooling operation state under which the room is cooled.

[0041] Furthermore, when the four-way valve 18 is switched to the heating side, refrigerant flows along a broken-line arrow shown in Fig. 1, the indoor heat exchanger 26 serves as a condenser, the outdoor heat exchanger 19 serves as an evaporator and the indoor heat exchanger 26 is set to a heating operation state under which the room is heated. Under cooling operation under heating operation, the compressor 15, the gas engine 40, etc. are controlled by a controller 60 (see Fig. 2) described later on the basis of the state of the refrigerant detected by the refrigerant pressure sensors SP and the various kinds of temperature sensors ST, the tempera-

ture of ambient air of the refrigerant circuit, etc., thereby performing air-conditioning operation corresponding to an air-conditioning load. Furthermore, when the detection values of the refrigerant pressure sensors SP and the temperature sensors ST represent abnormal increase of refrigerant temperature, abnormal increase of refrigerant pressure or the like, the controller 60 stops the driving of the compressor 15 and the gas engine 40 so as to stop the air-conditioning operation for the sake of safety.

[0042] Next, the constituent elements associated with the gas engine 40 will be described.

[0043] The air conditioner 100 according to this embodiment has a cooling water circuit 50 for cooling the gas engine 40. The cooling water circuit 50 is provided with an exhaust gas heat exchanger 52, a plate heat exchanger 53 and a radiator 54 in the cooling water pipe 51 in order to withdraw waste heat of the gas engine 40. In Fig. 1, the cooling water circuit 50 is represented by a thin line. The exhaust gas route of the gas engine 40 is represented by a double line.

[0044] Here, the exhaust gas heat exchanger 52 is a heat exchanger for performing heat exchange between exhaust gas of the gas engine 40 and cooling water, and an exhaust muffler 53A, a drain filter 52B and an exhaust top 52C are connected to the exhaust gas heat exchanger 52. Furthermore, a plate heat exchanger is a cooling-water/refrigerant heat exchanger for performing heat exchange between refrigerant in the refrigerant circuit 10 and cooling water in the cooling water circuit 50. The plate heat exchanger 53 is disposed between the four-way valve 18 of the outdoor refrigerant pipe 13 and the compressor 15, and the plate heat exchanger 53 made to function as a sub evaporator during heating operation, whereby the heating performance can be kept and enhanced. The radiator 54 cools cooling water which withdraws wasted heat of the gas engine 40.

[0045] The cooling water circuit 50 has a first cooling water passage 50A in which cooing water is circulated between the exhaust gas heat exchanger 52 and the gas engine 40, a second cooling water passage 50B in which cooling water is circulated between the plate heat exchanger 53 and the gas engine 40, and a third cooling water passage 50C in which cooling water is circulated between the radiator 54 and the gas engine 40

[0046] The first cooling water passage 50A, the second cooling water passage 50B and the third cooling passage 50C are branched by a first three-way valve 55 and a second three-way valve 56 provided to the cooling water pipe 51.

[0047] A cooling water exit 50B of the gas engine 40 is connected through the cooling water pipe 51 at the entrance 55A of the first three-way valve 55, and an electrically-operated circulating pump 57 for circulating cooling water and an exhaust gas heat exchanger 52 are successively connected to one exist 55B of the first three-way valve 55. As indicated by an arrow A, the first cooling water passage 50A is formed by a pipe passage for connecting the first three-way valve 55, the circulating pump 57 and the exhaust gas heat exchanger 52.

[0048] A second three-wayvalve 56 is a flowrate adjusting type three-way valve, and it leads high-temperature cooling water flowing through the first three-way valve 55 to one of the plate heat exchanger 53 and the radiator 54, or both the plate heat exchanger 53 and the radiator 54 while changing the flow distributing ratio. The other exit 55C of the first three-way valve 55 is connected to the entrance 56A of the second three-way valve 56 through the cooling water pipe 51. Furthermore, the plate heat exchanger 53 is connected to one exit 56B of the second three-way valve 56 through the cooling water pipe 51. Furthermore, the radiator 54 is connected to the other exit 56C of the second three-way valve 56 through the cooling water pipe 51. as indicated by an arrow B, the second cooling water passage 50B is formed by a pipe passage for connecting the first three-way valve 55, one exit 56B of the second three-way valve 56 and the plate heat exchanger 53, and it is connected to the first cooling water passage 50A. As indicated by an arrow C, the third cooling water passage 50C is formed by a pipe passage for connecting the first three-way valve 55, the other exit 56C of the second three-way valve and the radiator 54, and it is connected to the first cooling water passage 50A. In the cooling water circuit 50, the cooling water pipe 51 for connecting the cooling water exit 40B of the gas engine 40 and the entrance 55A of the first three-way valve 55 is provided with a cooling water temperature sensor ST41 for detecting the temperature of the cooling water at the exit side of the gas engine 40. The controller 60 controls the switching operation of the first three-way valve 55 and the second three-way valve 56 in accordance with the temperature of cooling water detected by the cooling water temperature sensor ST41, the state of the air-conditioning operation of the air conditioner 100, etc. so that the cooling water is circulated in a predetermined cooling water passage.

[0049] An exhaust muffler 52A provided to the exhaust gas heat exchanger 52 is provided with an exhaust gas temperature sensor ST42 for detecting the temperature of exhaust gas of the gas engine 40. The controller 60 monitors the state of the gas engine 40 on the basis of the temperature of the exhaust gas detected by the exhaust gas temperature sensor ST42, the temperature of the cooling water detected by the cooling water temperature sensor ST41, the air conditioning state, etc., and when abnormality of the gas engine 40 is detected, the controller 60 controls to stop the operation of the gas engine for the sake of safety. The cooling water temperature sensor ST41 and the exhaust gas temperature sensor ST42 may be generically named as engine system temperature sensor ST40.

[0050] Next, the controller 60 for controlling the respective constituent elements of the air conditioner 100 will be described with reference to Fig. 2. The controller 60 controls the respective constituent elements by a computer system having CPU, RAM, EEPROM, etc. (not

shown). As described above, the controller 60 detects the state of the refrigerant circulating in the refrigerant circuit 10 by the refrigerant pressure sensors SP, the outdoor unit side refrigerant temperature sensor ST10 and the indoor unit side refrigerant temperature sensor ST20, detects the temperature of the ambient air of the refrigerant circuit 10 by the outside air temperature sensor ST14 and the indoor unit side air temperature sensor ST30, detects the state of the gas engine 40 by the engine system temperature sensor ST40, and controls the respective constituent elements so as to perform the air conditioning operation corresponding to the air conditioning load. In addition, when abnormality is detected in the state of the refrigerant or the state of the gas engine 40, the controller 60 controls to stops the air conditioning operation.

[0051] Not only when breakdown such as breaking, short-circuit or the like occurs in these refrigerant pressure sensors SP or the various kinds of temperature sensors ST, but also when variation occurs in the detection value due to variation of sensor characteristic or the like, the air conditioning performance required to the air conditioner 100 cannot be exerted, and the state of the refrigerant or abnormality of the gas engine 40 may be detected with delay. Therefore, according to the air conditioner 10 of this embodiment, after the air conditioning operation is stopped, when a predetermined time elapses and the refrigerant state is returned to a stationary state, the detection values of the respective sensors SP and ST are mutually compared with one another to determined the presence or absence of abnormality of each sensor SP, ST, whereby the abnormality of each sensor SP, ST containing variation of the sensor characteristic is detected at an early stage.

[0052] Fig. 2 shows a functional construction of the controller 60 associated with the abnormality determining processing. As shown in Fig. 2, the controller 60 has a pressure value input unit 61, a temperature value input unit 62, a saturation temperature value converter 63, a comparison target determining unit 64, an abnormality determining unit 65, a countermeasure information storage unit 66, a countermeasure determining unit 67 and an informing unit 68. EEPROM (non-volatile memory) stores various kinds of control programs containing a sensor abnormality determining program, etc. and various other kinds of information. The functional construction of the controller 60 shown in Fig. 2 is implemented by the cooperation of a computer system as a hardware system and various kinds of programs as software resources.

[0053] The detection values as pressure values detected by the refrigerant pressure sensors SP are input from the compressor entrance pressure sensor SP2 and the compressor exit pressure sensor SP1 to the pressure value input unit 61. Furthermore, the detection values as temperature values detected by the temperature sensors ST are input to the temperature value input unit 62 from the compressor entrance temperature sensor sT12, the compressor exit temperature sensor sT11, the outdoor heat exchanger liquid temperature sensor ST13, the cooling water temperature sensor ST41, the exhaust gas temperature sensor ST42, the outside air temperature sensor ST14 , the indoor heat exchanger liquid temperature sensor ST21, the indoor heat exchanger gas temperature sensor ST22, the suction air temperature sensor ST31 and the blow-out air temperature sensor ST32.

[0054] The saturation temperature value converter 63 has a function of determining the saturation temperature value of the refrigerant at the detection value of each refrigerant pressure sensor SP on the basis of the detection values of the refrigerant pressure sensors SP which are input to the pressure value input unit 61. The saturation temperature value determined in the saturation temperature value converter 63 is output to the comparison target determining unit 64 as the detection value of each refrigerant pressure sensor SP. In the abnormality determining unit 65, the saturation temperature values are mutually compared with the temperature values as the detection values of the respective temperature sensors ST when the presence or absence of abnormality of each sensor SP, ST is determined.

[0055] The comparison target determining unit 64 has a function of determining on the basis of at least one of the sensor characteristic, the detection target and the detection position whether each sensor SP, ST provided to the air conditioner 100 should be set as a target sensor to be mutually compared when the presence or absence of abnormality is determined in the abnormality determining unit 65. A sensor which is not favorable as a target sensor to be mutually compared can be excluded from mutual comparison target sensors by the comparison target determining unit 64, and thus erroneous determination can be prevented. The comparison target determining processing executed in the comparison target determining unit 64 will be described later.

[0056] When the refrigerant is returned to a stationary state after the air conditioning operation is stopped, the abnormality determining unit 65 has a function of mutually comparing the detection values of the respective sensors SP, ST, and determining the presence or absence of each sensor SP, ST. Here, the detection values of the respective sensors SP, ST are mutually compared in temperature value. Furthermore, when the presence or absence of abnormality is determined, the average value of the detection values of the group of the target sensors which are permitted as the mutual comparison target sensors by the comparison target determining unit 64 is determined. A normal temperature range (normal value range) which would contain the detection value of each SP, ST if the sensor SP, ST is normal is set on the basis of the above average value, and the presence or absence of abnormality of each sensor SP, ST is determined according to whether the detection value of the sensor SP, ST is contained in the normal temperature range. For example, the normal temperature range may be set like the average value of the detection values ± a% (for ex-

ample, a = 5) or the like. Here, with respect to (the average value ± a%), for the average value of 10°C and a = 5, the normal temperature range is set to a range from 0.5°C to 10.5°C, and for the average value of 20°C and a=5, the normal temperature range is set to a range from 19°C to 21°C.

[0057] Here, the principle of the abnormality determining processing according to this embodiment will be described with reference to Fig. 3.

[0058] In Fig. 3, (a) represents temperature variation of the outside air temperature detected by the outside air temperature sensor ST14 during air conditioning operation and after the air conditioning operation is stopped, (b) represents refrigerant temperature variation detected by the outdoor heat exchanger liquid temperature sensor ST13, (c) represents cooling-water temperature variation detected by the cooling water temperature sensor ST41, and (d) represents exhaust-gas temperature variation detected by the exhaust gas temperature sensor sT42. The abscissa axis represents time lapse, and the ordinate axis represents temperature. The air conditioning operation is executed for the time period between T0 and T1 in the air conditioner 100, and the air conditioning operation is stopped at the time point of T_1.

[0059] As shown in Fig. 3, during the period for which the air conditioning operation is executed, the driving of the compressor d15 and the gas engine 40 is controlled in accordance with the air conditioning load based on variation of the set temperature, variation of the outside air temperature, etc. during air conditioning operation, and the temperature of the refrigerant in the refrigerant circuit 10, the temperature of the cooling water in the cooling water circuit 50 and the temperature of the exhaust gas in the gas engine 40 vary in connection with the above control.

[0060] Furthermore, when the air conditioning operation is stopped at the time point indicated by T1, the detection values of outdoor heat exchanger liquid temperature sensor ST13, the cooling water temperature sensor ST41 and the exhaust gas temperature sensor ST42 gradually decrease as indicated by (b), (c) and (d) of Fig. 3. When application of energy as compression to the refrigerant is stopped in connection with stop of the air conditioning operation, the temperature and pressure of the refrigerant have values corresponding to the state of atmosphere around the refrigerant circuit 10. Therefore, when the apparatus is left for a sufficient time until the state of the refrigerant is returned to the stationary state, the detection values of the outdoor heat exchanger liquid temperature sensor ST13, the cooling water temperature sensor ST41 and the exhaust gas temperature sensor ST42 indicated by (b), (c), (d) of Fig. 3 are substantially equal to the detection value of the outside air temperature sensor sT14 indicated by (a) of fig. 3, and thus it can be determined that some abnormality occurs in a sensor whose value is deviated from the detection values of the other sensors SP, ST by a predetermined value or not. The abnormality determining unit 65 determines the presence or absence of abnormality of the sensors SP, ST containing the variation (deviation) of the sensor characteristic by using the above principle.

[0061] When the presence or absence of abnormality is determined on the basis of the difference in sensor characteristic, the difference in detection target and the difference in detection position among the respective sensors SP, ST, some sensors may be contained (selected) as mutual comparison target sensors, and some sensors induce erroneous determination when they are contained (selected) as mutual comparison target sensors.

[0062] For example, the exhaust gas temperature sensor ST42 targets exhaust gas of the gas engine 40 as a detection target. The temperature of the exhaust gas increases to a value higher than the temperature of the refrigerant and the temperature of air around the refrigerant circuit 10. The exhaust gas temperature sensor ST42 is constructed by using a temperature sensor having high detection precision in a high-temperature area. When the temperature sensor having the high detection precision in the high temperature area is used, the detection precision in the low temperature area may be lowered. For example, in the exhaust gas temperature sensor ST42 according to this embodiment, the detection precision in the low-temperature area above 2 0°C is lower that those of the other sensors ST41, ST13 and ST14 shown in (a), (b), (c) of Fig. 3. Therefore, in this embodiment, for example when the outside air temperature is not more than 20°C, the detection values of the other sensors ST41, ST13, ST14 indicate 20°C or less, however, the detection value of the exhaust gas temperature sensor ST42 is set to indicate 20°C at all times irrespective of the actual temperature of the outside air temperature. Accordingly, when the outside temperature is not more than 20°C, it would be impossible to accurately determine the presence or absence of abnormality of each sensor SP, ST if the exhaust gas temperature sensor ST42 is contained (selected) as a mutual comparison target sensor. Therefore, according to this embodiment, with respect to each sensor SP, ST, a detection value range in which detection values can be mutually compared with another sensor SP, STwhen the presence or absence of abnormality is determined, that is, a range which can output a high-reliability detection value is preset as an abnormality presence or absence determinable range which enables determination as to the presence or absence of abnormality on the basis of the each sensor characteristic, and on the basis of whether the detection value of each sensor SP, ST is within this abnormality presence or absence determinable range, it is determined whether this sensor SP, ST shouldbe contained (selected) as a comparison target or not (i.e., the sensor should be excluded from comparison targets).

[0063] As indicated by (b) and (c) of Fig. 3, the time required to return to the stationary state is different between the refrigerant as the detection target of the outdoorheat exchanger liquid temperature sensor ST13 and

the cooling water as the detection target of the cooling water temperature sensor ST41, and the cooling water requires more time to return to the stationary state as compared with the refrigerant. Therefore, after the air conditioning operation is stopped, the detection value of the cooling water temperature sensor ST41 is higher than the detection value of the outdoor heat exchanger liquid temperature sensor ST13 before the state of the cooling water returns to the stationary state. Therefore, sensors for detecting the states of detection targets which do not return to the stationary state even at a timing at which the presence or absence of abnormality of each sensor SP, ST is determined by the abnormality determining unit 65 are excluded from the mutual comparison target sensors, whereby the presence or absence of abnormality of the other sensors can be accurately determined.

[0064] Furthermore, there is a season under which the ambient temperature or the like is greatly different between the outdoor unit 11 side and the indoor unit 12 side. In a case where the presence or absence of the abnormality of each sensor SP, ST is determined by the abnormality determining unit 65 in the above case, when the presence or absence of abnormality is determined for the sensor ST2 whose detection position is at the outdoor unit 11 side, the sensor ST1 whose detection position is out of the indoor unit 12 side is excluded from the comparison target, whereby the erroneous determination of the presence or absence of abnormality canbe prevented. Likewise, when the presence or absence of abnormality is determined for the sensors SP, ST1 whose detection position is located at the outdoor unit side, the sensor ST2 whose detection position is located at the indoor unit side is excluded from the comparison targets, whereby the erroneous determination of the presence or absence of abnormality can be prevented.

[0065] A countermeasure information storage unit 66 defines and stores a countermeasure when the presence of abnormality it is determined by the abnormality determining unit 65.

[0066] Fig. 4 shows the countermeasure information. As shown in Fig. 4, countermeasures are defined every each sensor SP, ST while classified into a case where the detection value indicates a value higher than the normal temperature range and a case where the detection value indicates a value lower than the normal temperature range, and the thus-defined countermeasures are stored in association with the respective sensors SP, ST.

[0067] For example, when the detection value of the outdoor heat exchanger liquid temperature sensor ST13 indicates a higher value than the normal temperature range described above, temperature higher than the actual refrigerant temperature is detected. Therefore, it affects the air conditioning performance, however, it is hardly necessary to immediately stop the air conditioning operation. Accordingly, with respect to the outdoor heat exchanger liquid temperature sensor ST13, "breakdown prediction" informing a user of a risk of breakdown is associated as a countermeasure when the detection value is higher than the normal temperature range.

[0068] Furthermore, when the detection value of the exhaust gas temperature sensor ST42 indicates a value lower than the normal temperature range, temperature lower than the actual exhaust gas temperature is output as the detection value. Therefore, when the exhaust gas temperature increases abnormally, it may be detected with delay. Therefore, when the detection value of the exhaust gas temperature sensor ST42 is lower than the normal temperature range, "prohibition of air conditioning operation" as well as "informing abnormality" of the exhaust gas temperature sensor ST42 is associated as a countermeasure. Furthermore, each countermeasure may be further minutely defined in accordance with informing targets such as a user side and a maintenance side of the air conditioner 100, that is, a maintenance worker side, a managing company side or the like.

[0069] The informing unit 68 is constructed by LED which is provided to a control board or the like and switched to turn-on/turn-out/blinking in accordance with an informing content, a liquid crystal display panel for displaying an informing result with characters, symbols or the like, a display unit provided to a remote controller for remotely operating the air conditioner 100 or the like. Furthermore, it may be configured to output countermeasure information to external equipment such as a remote monitoring device for remotely monitoring the air conditioner 100, a central control device or the like and inform the informing content through an informing unit such as a liquid crystal display panel provided to the external equipment.

[0070] With respect to a sensor which is determined to have abnormality by the abnormality determining unit 65, the informing unit 68 informs the corresponding countermeasure on the basis of the countermeasure information stored in the countermeasure information storage unit 66 according to the situation that the detection value is higher or lower than the normal temperature range.

[0071] Next, the comparison target determining processing will be described with reference to Fig. 5.

[0072] In the comparison target determining processing, the comparison target determining unit 64 first determines whether the present time is an execution timing of the abnormality determining processing in the abnormality determining unit 65 (step S1). When the present time is determined as the execution timing of the abnormality determining processing step S1; Y), the sensor number of a determination target sensor (i) of the comparison target determination is first set to "1" (i=1) (step S2). Here, inherent sensor numbers beginning from "1" are successively allocated to the respective sensors SP, ST described above in a predetermined order, and the controller 60 identifies the respective sensors SP, ST on the basis of the sensor numbers.

[0073] Subsequently, with respect to the determination target sensor (i) of the comparison target determination to which the sensor number (i) is allocated, it is determined on the basis of the sensor characteristic of the

determination target sensor concerned whether the present detection value of the determination target sensor (i) concerned is contained in the abnormality presence or absence determinable rangewhich is preset as a range inwhich a high-reliability detection value can be output (step S39. Here, in this embodiment, the abnormality presence or absence determinable range is set so as to be equal to or lower than the upper limit value of the detectable temperature range of each sensor SP, ST by predetermined temperature (for example, 5°C) and also equal to or higher than the lower limit value of the detectable temperature range by predetermined temperature (for example, 5°C).

[0074] When it is determined in S2 that the present detection value of the determination target sensor (i) of the comparison target determination is within the preset abnormality presence or absence determinable range (step S3:Y), it is then determined whether the detection value output from the determination target sensor (i) is stable or not (step S4). Here, the stable detection value means that the variation of the detection value within a predetermined time falls into a predetermined range, the detection target of the determination target sensor (i) of the comparison target determination returns to the stationary state and the detection value corresponding to the state around the refrigerant circuit 10 is output. The processing of the step S2 may be set so that a time required until the detection value is stabilized after the air conditioning operation is stopped is preset every sensor SP, ST by an experiment or the like, and it is determined on the basis of the lapse of this preset time whether the detection value of each sensor SP, ST is stable or not.

[0075] When it is determined in step S4 that the detection value of the determination target sensor (i) is stable (step S4; Y), the comparison target determining unit 64 permits that this sensor (i) is contained as a mutual comparison target sensor (step S5). On the other hand, when it is determined in step S3 that the detection value of the determination target sensor is not contained in the abnormality presence or absence determinable range (step S3; N) and also it is determined in step S4 that the detection value is not stable (step S4; N), the processing goes to step S6, and the comparison target determining unit 64 prohibits this determination target sensor (i) from being contained as a mutual comparison target sensor (step S6).

[0076] In step S7, the sensor number of the determination target sensor (i) is incremented by one (i=i+1), and it is determined whether the comparison target determination for all the sensors SP, ST is completed or not (step S8). The above processing repetitively executed until the comparison target determination is executed on all the sensors SP, ST (step S8; Y).

[0077] In the flowchart of the comparison target determination processing shown in Fig. 5, it is not determined on the basis of the detection position of each sensor SP, ST whether a determination target sensor is contained as a mutual comparison target sensor or not. In this embodiment, with respect to the refrigerant pressure sensors SP and the outdoor unit side temperature sensor ST1 provided to the outdoor unit 11 side and the indoor unit side temperature sensor ST2 provided to the indoor unit side, the presence or absence of abnormality is individually determined for each sensor.

[0078] That is, when the presence or absence of abnormality is determined for the indoor unit side temperature sensor ST2 whose detectionposition is located at the indoor unit 12 side, the refrigerant pressure sensors SP and the outdoor unit side temperature sensor ST1 whose detection positions are located at the outdoor unit 11 side are excluded from the mutual comparison target sensors, whereby the erroneous determination of the presence or absence of abnormality canbe prevented. Likewise, when the presence or absence of abnormality is determined for the refrigerant pressure sensors SP and the outdoor unit side temperature sensor ST1 whose detection values are located at the outdoor unit 11 side, the indoor unit side temperature sensor ST2 whose detection position is located at the indoor unit 12 side is excluded from the mutual comparison target sensors, whereby the erroneous determination of the presence or absence of abnormality can be prevented. This is because the ambient temperature, etc. are greatly different between the outdoor unit 11 side and the indoor unit 12 side in some seasons.

[0079] Next, the abnormality determining processing will be described with reference to Fig. 6.

[0080] When the abnormality determining processing is executed, the abnormality determining unit 65 first determines whether the air conditioning operation is stopped or not (step S11). When it is determined that the air conditioning operation is stopped (step S11; Y), it is determined whether a predetermined time elapses or not (step S12). Here, the predetermined time is a time which is preset on the basis of a time required until the refrigerant returns to the stationary state after the air conditioning operation is stopped, and this time is used to settle the timing for executing the abnormality presence or absence determining processing.

[0081] When it is determined in step S12 that the predetermined time elapses (step S12; Y), the abnormality determining unit 65 sets a temperature range (for example, the average value $\pm$ 5% in this embodiment) as the normal temperature range on the basis of the average value of the detection values of the group of sensors which are permitted as mutual comparison target sensors by the comparison target determining unit 64. When it is determined in step S12 that the predetermined time does not elapse step S12; N), the processing returns to step S11 to wait until the predetermined time elapses.

[0082] Subsequently, the sensor number of the determination target sensor (j) for which the presence or absence of abnormality is determined is first set to "1" (j = 1) (step S14). It is determined whether the abnormality presence or absence determining target sensor (j) is permitted as a mutual comparison target sensor by the com-

parison target determining unit 64 (step S15). When it is determined in step S15 that the abnormality presence or absence determining target sensor (j) is permitted as the mutual comparison target sensor (step S15; Y), the processing goes to the processing of step S16. In step S16, it is determined whether the detection value of the determination target sensor (j) is contained in the normal temperature range set in step S13 (step S16). When the detection value of the determining target sensor (j) is contained in the normal temperature range, it is determined that this sensor (j) has no abnormality (step S17). When the detection value of the determining target sensor (j) is not contained in the normal temperature range, it is determined that the sensor (j) has abnormality (step S18).

[0083] Subsequently, in step S19, the abnormality determining unit 65 increments the sensor number of the determining target sensor (j) by one (j=j+1), and determines whether the determination is executed on all the sensors SP and ST (step S20). The above processing is repetitively executed until the determination is executed on all the sensors SP, ST (step S20; Y) . However, when in step S15 the comparison target determining unit 64 determines the determining target sensor (j)as a sensor which is prohibited from being contained as a mutual comparison target sensor (step S15; N), the determination as to the presence or absence of abnormality is not executed on this determining target sensor (j).

[0084] In step S18, with respect to a sensor which is determined to have abnormality, the corresponding countermeasure information is read out from the countermeasure information storage unit 66 by the countermeasure determining unit 67 on the basis of whether the detection value indicates a value higher or lower than the normal temperature range, and output to the informing unit 68. In the informing unit 68, "abnormality informing" or "breakdown prediction" is informed to the user or the maintenance worker on the basis of the detection value of the sensor which is determined to have abnormality. When the prohibition of the air conditioning operation is associated as the countermeasure for the sensor determined as having abnormality by the countermeasure determining unit 67, the controller 60 controls the respective constituent elements to stop the air conditioner 100.

[0085] As described above, according to this embodiment, when the predetermined time elapses after the air conditioning operation is stopped and thus the refrigerant returns to the stationary state, the detection values of the respective sensors SP, ST are mutually compared with one another to determine the presence or absence of abnormality of each sensor SP, ST. Here, when energy as compression is applied to the refrigerant by the compressor 15 after the air conditioning operation is stopped, the refrigerant state such as refrigerant temperature or the like is substantially equal to the ambient state such as the ambient temperature or the like around the refrigerant circuit 10, and thus the refrigerant is set to the stationary state. Accordingly, when the refrigerant returns to the stationary state, the detection value of each sensor SP, ST is equal to the value corresponding to the ambient state. Therefore, the detection values of the respective sensors SP, ST are compared with one another, and a sensor which outputs a detection value indicating a state different from the ambient state around the refrigerant circuit 10 which is indicated by the detection values of the other sensors SP, ST can be determined to be abnormal, and a sensor whose sensor characteristic is varied (deviated) can be also determined to be abnormal. Accordingly, the abnormality of each sensor SP, ST can be detected at an early stage before each sensor SP, ST falls into a complete breakdown state as in the case of a wire breaking trouble or a short-circuit trouble, and the trouble of the sensor SP, ST can be predicted. Furthermore, the abnormality of each sensor SP, ST can be detected while the variation of the sensor characteristic is still small, so that the sensor can be repaired or exchanged at a stage that a user's business or the like is not disturbed even when the air conditioning operation is stopped, for example, in the night or at an intermediary stage.

[0086] Furthermore, according to this embodiment, in the saturation temperature value converter 63, the saturation temperature value is determined from the detection values of the refrigerant pressure sensors SP, and the detection values of the respective sensors SP, ST are mutually compared with one another in terms of temperature values to determine the presence or absence of abnormality of each sensor SP, ST. Therefore, even in a case where the number of refrigerant pressure sensors SP provided to the air conditioner 100 is equal to two as in the case of this embodiment, when any one of the refrigerant pressure sensors SP has abnormality, it can be determined through the comparison with the detection values of the other temperature sensors ST which one of the refrigerant pressure sensors SP has abnormality. Furthermore, even when the number of the refrigerant pressure sensors SP provided to the air conditioner 100 is small, the presence or absence of abnormality can be accurately determined by mutually comparison with the detection values of the other temperature sensors ST.

[0087] According to the above embodiment, with respect to each sensor SP, ST, it is determined on the basis of at least one of the sensor characteristic, the detection target and the detection position by the comparison target determining unit 64 whether each sensor should be contained as a mutual comparison target sensor. Therefore, when the presence or absence of abnormality is determined, a sensor which would cause erroneous determination if it is contained as a mutual comparison target sensor can be excluded, and thus the presence or absence of abnormality of each sensor SP, ST can be accurately determined.

[0088] Furthermore, when it is determined that the determining target sensor (j) has abnormality, the countermeasure corresponding to the content of the abnormality is determined by the countermeasure determining unit

67 in accordance with whether the detection value of the sensor (j) which is determined to have the abnormality concerned is higher or lower than the normal temperature range set on the basis of the average value of the detection values of the mutual comparison target sensors, and the informing unit 68 is made to inform the determination result to the user or the maintenance worker of the air conditioner 100, the management company or the like.

[0089] The present invention is not limited to the above embodiment, and various kinds of modifications may be made. For example, the constituent parts and the pipe arrangement of the present invention are not limited to those of the above embodiment, and they may be properly modified without departing from the subject matter of the present invention.

[0090] For example, in the above embodiment, the saturation temperature value is determined form the detection values of the refrigerant pressure sensors SP, and the detection values of the respective sensors SP, ST are compared with one another in terms of temperature values to determine the presence or absence of abnormality of each sensor SP, ST. However, when the number of the refrigerant pressure sensors SP provided to the air conditioner 100 is equal to three or more, the presence or absence of abnormality of each refrigerant pressure sensor SP may be determined without containing the temperature sensors ST as the mutual comparison target sensors. In this case, the detection value of each refrigerant pressure sensor SP is not converted to a temperature value, and the pressure values of these refrigerant pressure sensors SP are directly mutually compared with one another to determine the presence or absence of abnormality of the respective refrigerant pressure sensors SP. Accordingly, the presence or absence of abnormality can be easily determined. Likewise, the presence or absence of abnormality of each temperature sensor ST may be determined without containing the refrigerant pressure sensors SP as the mutual comparison target sensors.

[0091] Furthermore, according to the above embodiment, in the controller 60 provided to the air conditioner 100, the comparison target determining processing and the abnormality determining processing are executed. However, it is needless to say that external equipment such as a remote monitoring device for remotely monitoring the air conditioner 100, a central managing device or the like may be designed so as to executed the comparison target determining processing and the abnormality determining processing.

[0092] Still furthermore, the above embodiment is applied to the gas heat pump type air conditioner 100 in which the compressor 15 is driven by the gas engine 40. However, this invention is not limited to the gas heat pump type air conditioner 100, and it may be applied to various kinds of air conditioners. In short, the present invention may be applied to any air conditioner insofar as the air conditioner has plural sensors containing a refrigerant state detecting sensor for detecting the state of the refrigerant in the refrigerant circuit and drives the compressor on the basis of the detection value of each sensor to perform the air conditioning operation. Furthermore, in this embodiment, then air conditioner is configured so that one indoor unit is connected to one outdoor unit, however, the present invention may be applied to an air conditioner having plural indoor units.

[0093] According to the present invention, with respect to plural sensors provided to energy equipment such as a steam boiler or the like, the presence or absence of abnormality of each sensor provided to the energy equipment can be determined according to the same method as the above embodiment. That is, the present invention may be applied to energy equipment which has a fluid circulation passage for circulating fluid to which prescribed energy such as compression, heat or the like is applied and plural sensors containing a fluid state detecting sensor for detecting the state of the fluid, and in which energy accumulated in the fluid is discharged to perform a predetermined work in a fluid circulating process. The energy equipment is provided with an abnormality determining unit for mutually comparing the detection values of the respective sensors when application of energy to the fluid is stopped and then the fluid is returned to the stationary state, and the presence or absence of abnormality containing variation (deviation) of the sensor characteristic of each sensor can be detected at an early stage. That is, when the application of energy to fluid such as refrigerant, steam or the like is stopped, the state of the fluid such as temperature or the like is substantially equal to the state around the fluid, and the detection value of each sensor is equal to the value corresponding to the ambient state around the sensor. Therefore, a sensor which outputs a detection value representing an ambient state different from those of the other sensors can be determined as an abnormal sensor. Accordingly, a sensor whose sensor characteristic is varied (deviated from a normal sensor characteristic) can be determined to be abnormal. Accordingly, abnormality of a sensor can be detected at an early stage and the breakdown of the sensor can be predicted before the sensor completely reaches the breakdown as in the case of the breaking trouble or the short-circuit trouble.

Claims

1. An air conditioner (100) comprising a refrigerant circuit (1) including a compressor (15), a four-way valve (18), an outdoor heat exchanger (19) and an indoor heat exchanger (26) which are successively connected to one another, and plural sensors (SP, ST) containing refrigerant state detecting sensors (SP, ST11, ST12, ST13, ST21, ST22) for detecting a state of refrigerant in the refrigerant circuit, the compressor being driven on the basis of detection values of the respective sensors to perform an air conditioning operation, **characterized by** further comprising an

abnormality determining unit (65) for mutually comparing the detection values of mutual comparison target sensors of the plural sensors to determine presence or absence of abnormality of each of the sensors when the refrigerant returns to a stationary state after the air conditioning operation is stopped.

2. The air conditioner according to claim 1, wherein the refrigerant state detecting sensors contain a refrigerant temperature sensor (ST11, ST12, ST13, ST21, ST22) for detecting the temperature of the refrigerant and a refrigerant pressure sensor (SP1, SP2) for detecting the pressure of the refrigerant, and the abnormality determining unit determines a saturation temperature value from the detection value of the refrigerant pressure sensor, and mutually compares the detection values of the respective sensors in terms of temperature values.

3. The air conditioner according to claim 1, wherein the plural sensors contain plural temperature sensors (ST) for detecting the temperature of a detection target and plural pressure sensors (SP) for detecting the pressure of a detection target, and the abnormality determining unit mutually compares the respective detection values of the temperature sensors with excluding the detection values of the pressure sensors from comparison targets to determine the presence or absence of abnormality when the presence or absence of abnormality of the temperature sensors is determined, and mutually compares the respective detection values of the pressure sensors with excluding the detection values of the temperature sensors from compari son targets to determine the presence or absence of abnormality when the presence or absence of abnormality of the pressure sensors is determined.

4. The air conditioner according to claim 1, wherein the plural sensors contain air temperature sensors (ST14, ST31, ST32) for detecting the temperature of ambient air around the refrigerant circuit.

5. The air conditioner according to claim 1, further comprising an engine for driving the compressor, wherein the plural sensors contain an exhaust gas temperature sensor (ST42) for detecting the temperature of exhaust gas of the engine.

6. The air conditioner according to claim 1, further comprising a cooling water circuit for circulating cooling water for cooling an engine for driving the compressor, wherein the plural sensors contain a coolingwater temperature sensor (ST41) for detecting the temperature of the cooling water.

7. The air conditioner according to claim 1, further comprising a comparison target determining unit for determining on the basis of at least one of a sensor characteristic, a detection target and a detectionposition for each of the sensors whether the sensor is selected as a mutual comparison target sensor when the presence or absence of abnormality is determined in the abnormality determining unit.

8. The air conditioner according to claim 5, wherein in a case where it is determined whether a sensor is selected as a mutual comparison target sensor, the comparison target determining unit does not select the senor concerned as a mutual comparison target sensor when the detection value of the sensor concerned is out of a predetermined abnormality presence or absence determinable range set on the basis of the sensor characteristic of the sensor concerned.

9. The air conditioner according to claim 6, wherein in a case where it is determined whether a sensor is selected as a mutual comparison target sensor, the comparison target determining unit does not select the senor concerned as a mutual comparison target sensor when the sensor concerned detects the state of a detection target which does not return to a stationary state.

10. The air conditioner according to claim 1, further comprising:

a countermeasure information storage unit (66) for storing countermeasure information obtained by associating countermeasures with each sensor when the sensor is determined to be abnormal by the abnormality determining unit while classing the countermeasures into a case where the sensor indicates a detection value higher than the detection values of the group of the mutual comparison target sensors and a case where the sensor indicates a detection value lower than the detection values of the group of the mutual comparison target sensors; and
an informing unit (68) for informing a corresponding countermeasure on the basis of the detection value of an abnormality determination target sensor when the sensor concerned is determined to be abnormal by the abnormality determining unit.

11. Energy equipment including a fluid circulating passage for circulating fluid to which prescribed energy is applied, and plural sensors containing fluid state detecting sensors for detecting the state of the fluid, a predetermined work being executed by discharging the energy of the fluid in a circulation process of the fluid, **characterized by** an abnormality determining unit (65) for mutually comparing the detection values of mutual comparison target sensors of the plural sensors to determine presence or absence of

abnormality of each of the sensors when the fluid returns to a stationary state after the application of the energy to the fluid is stopped.

FIG. 1

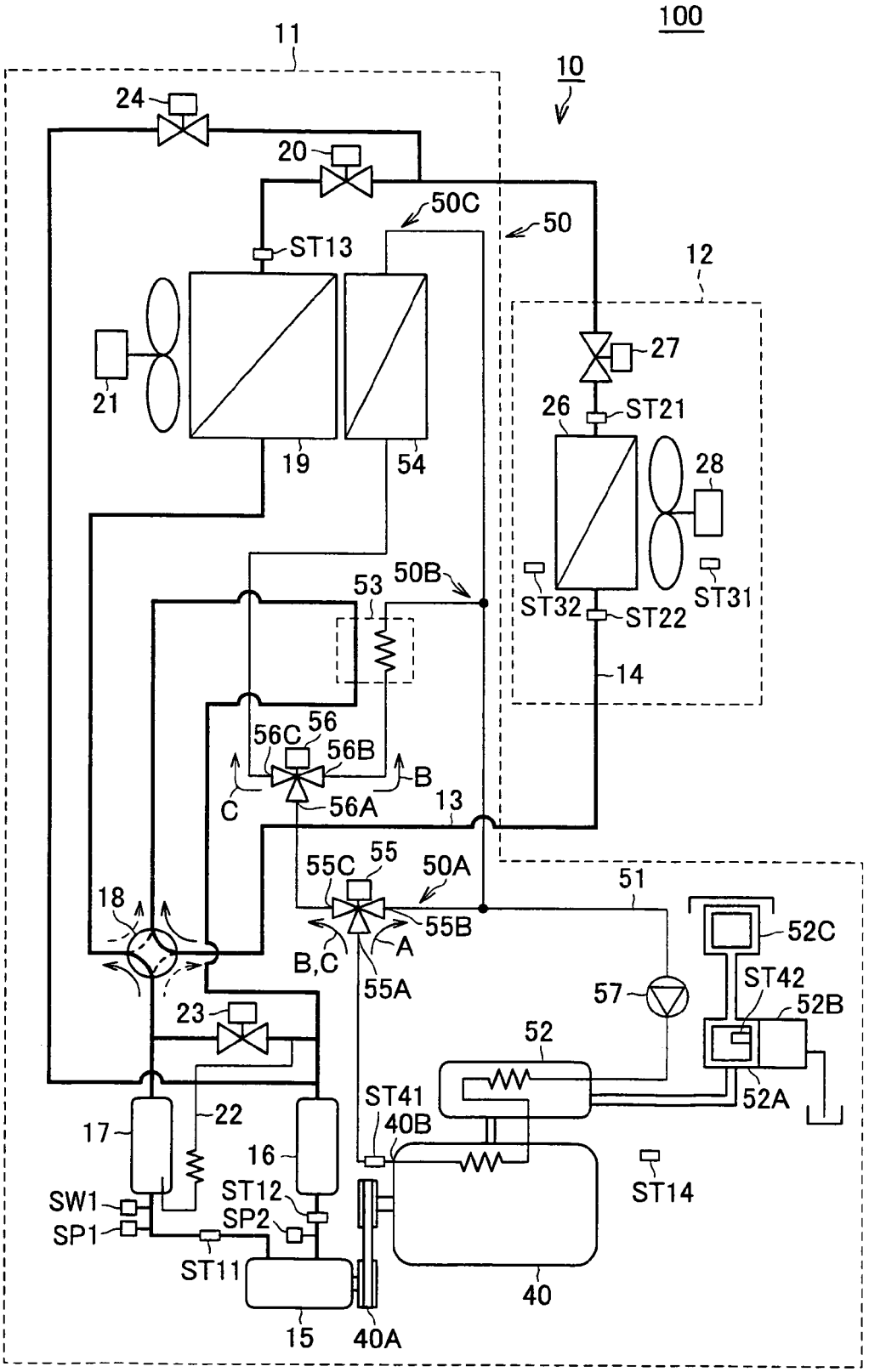

100
11
10
24
20
50C
50
ST13
12
27
21
26
ST21
28
19
54
ST32
ST22
ST31
14
53
50B
56
56C
56B
B
C
56A
13
55C
55
50A
51
18
55B
52C
A
B,C
55A
57
ST42
52B
23
52
ST41
52A
17
22
40B
16
ST14
SW1
ST12
SP1
SP2
ST11
40
15
40A

FIG. 2

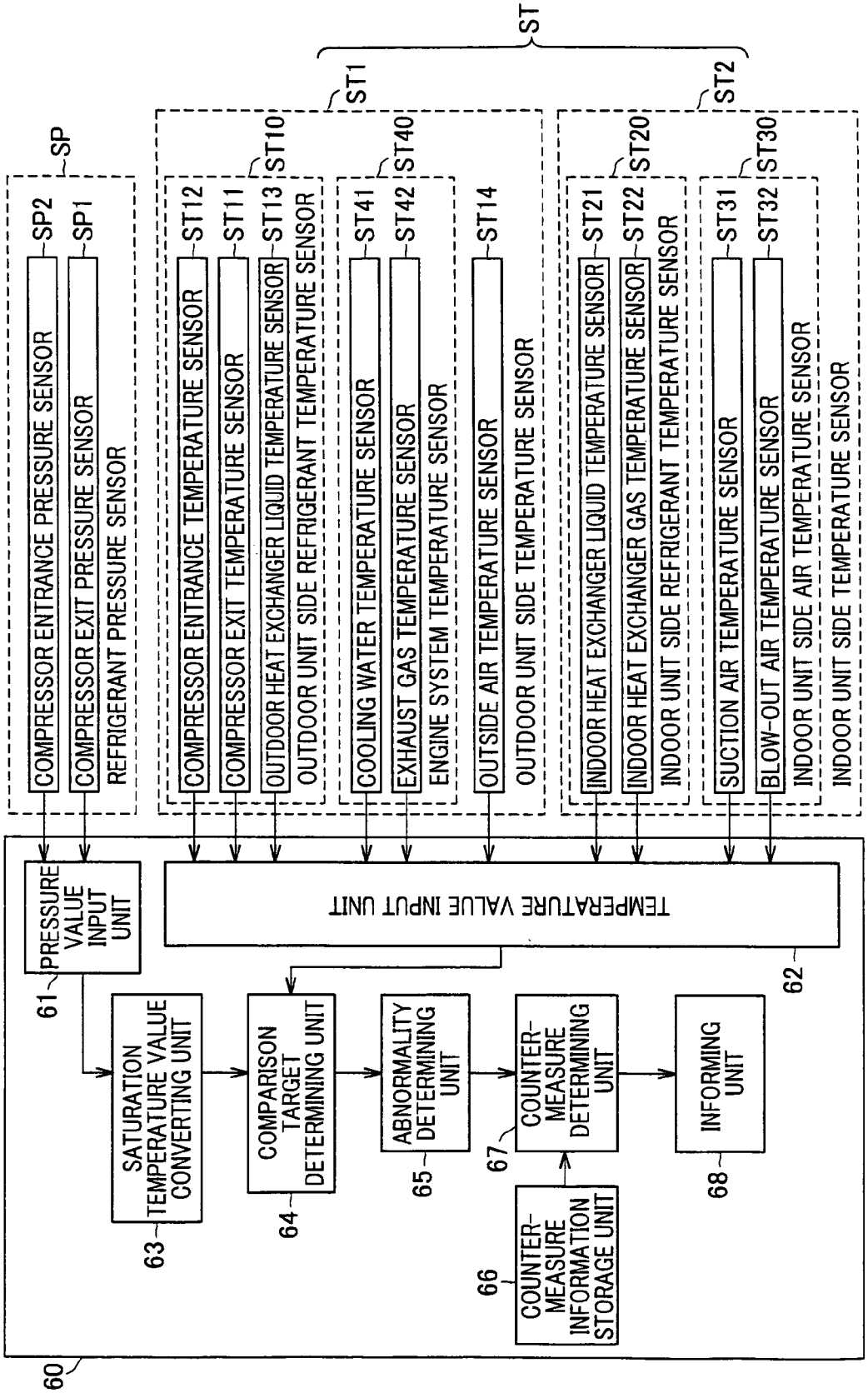

ST
ST1
ST2
SP
SP2
SP1
COMPRESSOR ENTRANCE PRESSURE SENSOR
COMPRESSOR EXIT PRESSURE SENSOR
REFRIGERANT PRESSURE SENSOR
ST10
ST12
ST11
ST13
COMPRESSOR ENTRANCE TEMPERATURE SENSOR
COMPRESSOR EXIT TEMPERATURE SENSOR
OUTDOOR HEAT EXCHANGER LIQUID TEMPERATURE SENSOR
OUTDOOR UNIT SIDE REFRIGERANT TEMPERATURE SENSOR
ST40
ST41
ST42
COOLING WATER TEMPERATURE SENSOR
EXHAUST GAS TEMPERATURE SENSOR
ENGINE SYSTEM TEMPERATURE SENSOR
ST14
OUTSIDE AIR TEMPERATURE SENSOR
OUTDOOR UNIT SIDE TEMPERATURE SENSOR
ST20
ST21
ST22
INDOOR HEAT EXCHANGER LIQUID TEMPERATURE SENSOR
INDOOR HEAT EXCHANGER GAS TEMPERATURE SENSOR
INDOOR UNIT SIDE REFRIGERANT TEMPERATURE SENSOR
ST30
ST31
ST32
SUCTION AIR TEMPERATURE SENSOR
BLOW-OUT AIR TEMPERATURE SENSOR
INDOOR UNIT SIDE AIR TEMPERATURE SENSOR
INDOOR UNIT SIDE TEMPERATURE SENSOR
60
PRESSURE VALUE INPUT UNIT
61
TEMPERATURE VALUE INPUT UNIT
62
SATURATION TEMPERATURE VALUE CONVERTING UNIT
63
COMPARISON TARGET DETERMINING UNIT
64
ABNORMALITY DETERMINING UNIT
65
COUNTER-MEASURE DETERMINING UNIT
67
INFORMING UNIT
68
COUNTER-MEASURE INFORMATION STORAGE UNIT
66

FIG. 3

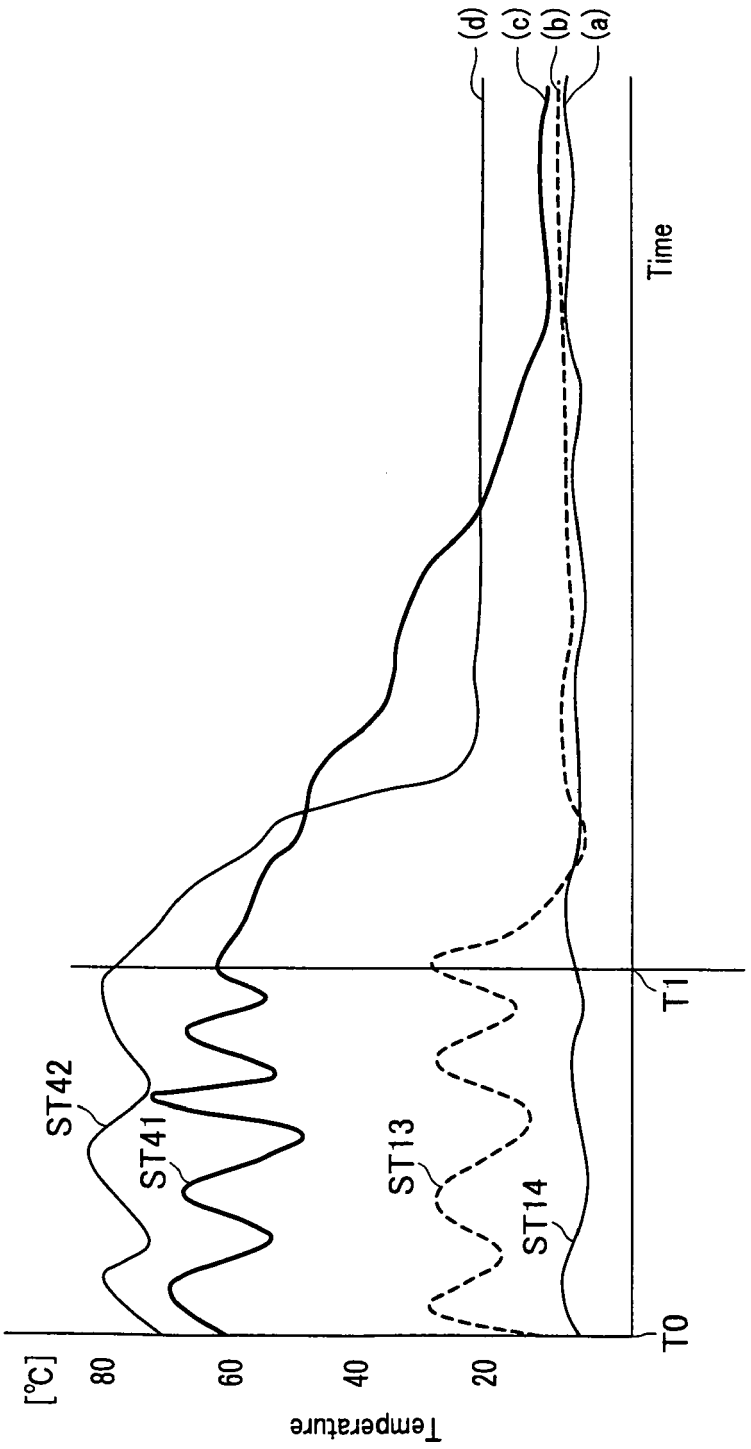


FIG. 4

			COUNTERMEASURE FOR HIGHER DETECTION VALUE	COUNTERMEASURE FOR LOWER DETECTION VALUE
OUTDOOR UNIT SIDE	REFRIGERANT PRESSURE	COMPRESSOR ENTRANCE PRESSURE SENSOR	INFORM ABNORMALITY (PROHIBIT OPERATION)	PREDICT BREAKDOWN
		COMPRESSOR EXIT PRESSURE SENSOR	PREDICT BREAKDOWN	INFORM ABNORMALITY (PROHIBIT OPERATION)
	REFRIGERANT TEMPERATURE	COMPRESSOR ENTRANCE TEMPERATURE SENSOR	PREDICT BREAKDOWN	INFORM ABNORMALITY (PROHIBIT OPERATION)
		COMPRESSOR EXIT TEMPERATURE SENSOR	PREDICT BREAKDOWN	INFORM ABNORMALITY (PROHIBIT OPERATION)
		OUTDOOR HEAT EXCHANGER LIQUID TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN
	ENGINE	COOLING WATER TEMPERATURE SENSOR	PREDICT BREAKDOWN	INFORM ABNORMALITY (PROHIBIT OPERATION)
		EXHAUST GAS TEMPERATURE SENSOR	PREDICT BREAKDOWN	INFORM ABNORMALITY (PROHIBIT OPERATION)
	AIR	OUTSIDE AIR TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN
INDOOR UNIT SIDE	REFRIGERANT TEMPERATURE	INDOOR HEAT EXCHANGER LIQUID TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN
		INDOOR HEAT EXCHANGER GAS TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN
	AIR	SUCTION AIR TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN
		BLOW-OUT AIR TEMPERATURE SENSOR	PREDICT BREAKDOWN	PREDICT BREAKDOWN

FIG. 5

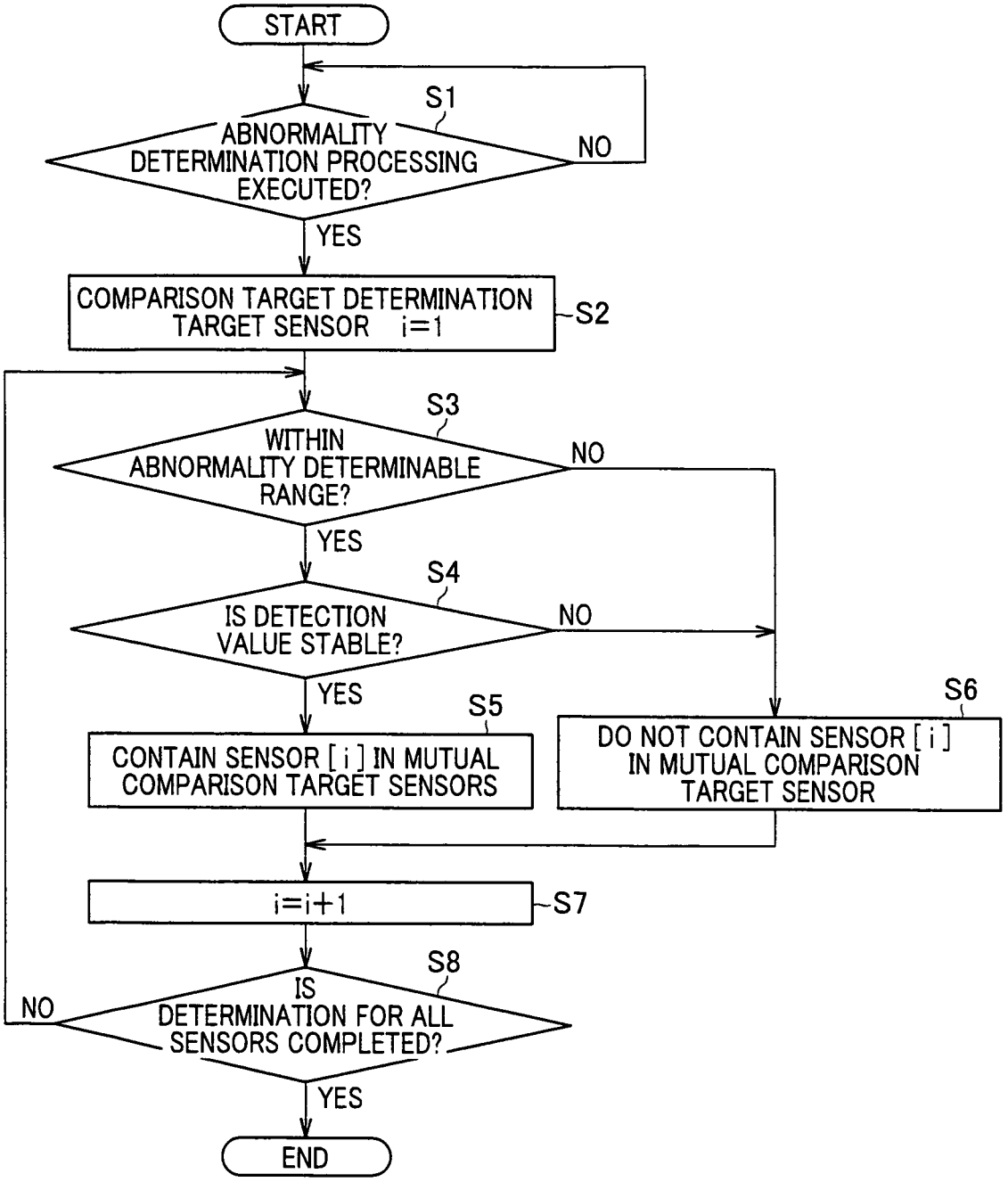
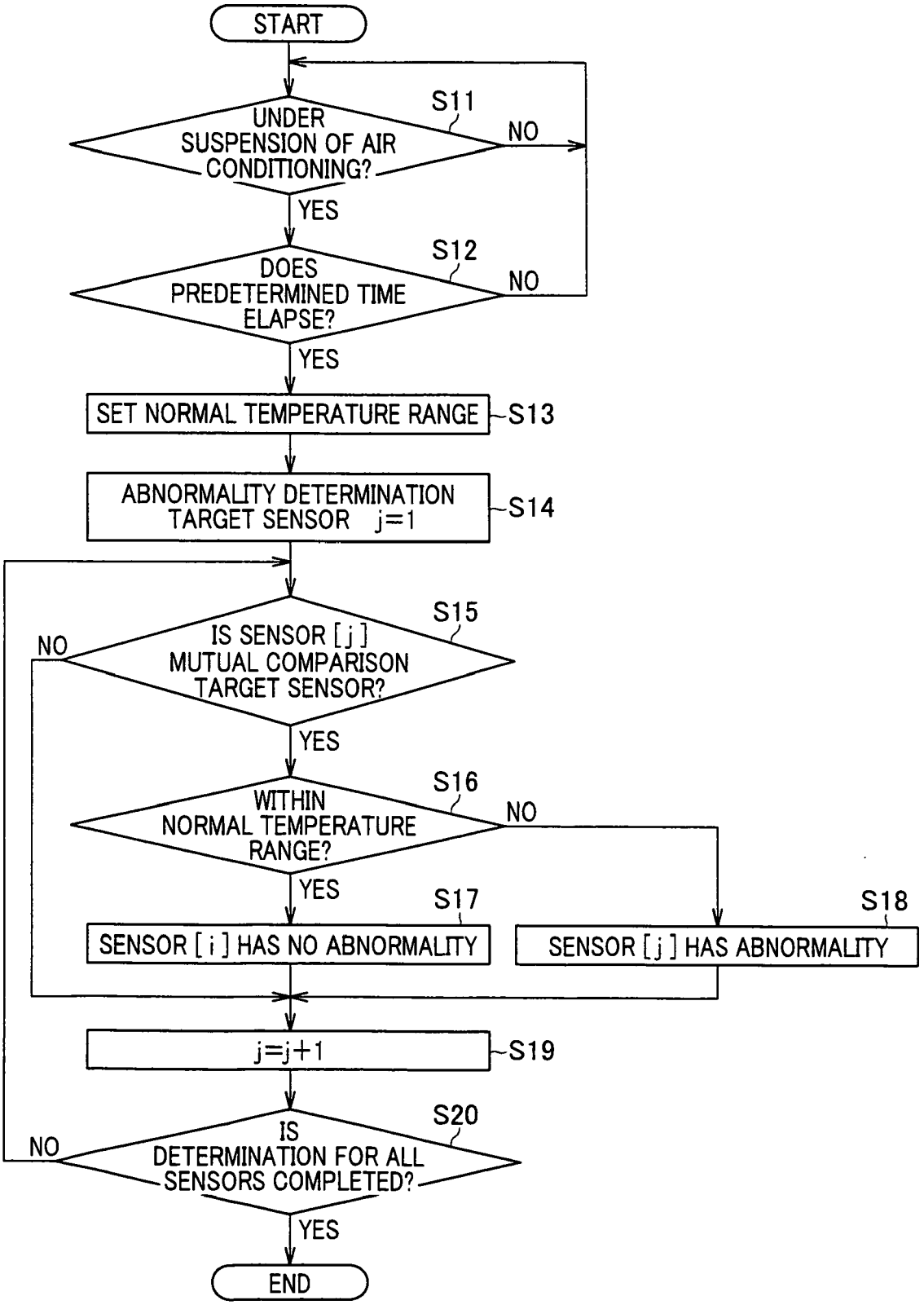

START
S1
ABNORMALITY DETERMINATION PROCESSING EXECUTED?
NO
YES
COMPARISON TARGET DETERMINATION TARGET SENSOR i=1
S2
S3
WITHIN ABNORMALITY DETERMINABLE RANGE?
NO
YES
S4
IS DETECTION VALUE STABLE?
NO
YES
S5
CONTAIN SENSOR [i] IN MUTUAL COMPARISON TARGET SENSORS
S6
DO NOT CONTAIN SENSOR [i] IN MUTUAL COMPARISON TARGET SENSOR
i=i+1
S7
S8
IS DETERMINATION FOR ALL SENSORS COMPLETED?
NO
YES
END

FIG. 6


START
S11
UNDER SUSPENSION OF AIR CONDITIONING?
NO
YES
S12
DOES PREDETERMINED TIME ELAPSE?
NO
YES
SET NORMAL TEMPERATURE RANGE
S13
ABNORMALITY DETERMINATION TARGET SENSOR j=1
S14
S15
IS SENSOR [j] MUTUAL COMPARISON TARGET SENSOR?
NO
YES
S16
WITHIN NORMAL TEMPERATURE RANGE?
NO
YES
S17
SENSOR [i] HAS NO ABNORMALITY
S18
SENSOR [j] HAS ABNORMALITY
j=j+1
S19
S20
IS DETERMINATION FOR ALL SENSORS COMPLETED?
NO
YES
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8159567 A **[0002]**