DESCRIPTION

Subcooling Apparatus

Technical Field

[0001] The present invention relates to a refrigerating apparatus and particularly relates to measures for increasing power of a refrigerating apparatus including a refrigerant circuit that performs a two-stage compression refrigerating cycle and for enhancing reliability.

Background Art

[0002] Conventionally, as disclosed in Japanese Patent Application Laid Open Publication No. 10-185333A, a subcooling apparatuses is known which is incorporated to a refrigerating apparatus for the purpose of increasing cooling power and which cools refrigerant sent from a heat source unit to a utility unit in the refrigerating apparatus.

[0003] This subcooling apparatus is incorporated to an air conditioner including an outdoor unit and an indoor unit. Specifically, the subcooling apparatus, which includes a subcooling refrigerant circuit, is provided in the middle of a liquid side communication pipe that connects the outdoor unit and the indoor unit. The subcooling unit performs a refrigeration cycle by circulating the refrigerant of the subcooling refrigerant circuit to cool by an evaporator of the subcooling refrigerant circuit the refrigerant of the air conditioner sent from the liquid side communication pipe. The subcooling apparatus cools the liquid refrigerant sent from the outdoor unit to the indoor unit of the air conditioner, thereby lowering the enthalpy of the liquid refrigerant sent to the indoor unit to increase the cooling capacity.

[0004] In the above subcooling apparatus, a control section of the subcooling apparatus is connected to a control section of the air conditioner to form one control system. The control section of the subcooling apparatus receives a singal indicating a load state of the air conditioner from the control section of the air conditioner. Then, the subcooling apparatus performs driving operation on the basis of the singal input from the control section of the air conditioner. For example, when it is judged from the input signal that

the cooling load is large, the subcooling apparatus starts operating to increase the cooling power of the air conditioner. In reverse, when it is judged small, the subcooling apparatus stops its operation. Namely, the subcooling apparatus adjusts the cooling power appropriately by sending and receiving a signal to and from the air conditioner.

[0005] **- Problems that the Invention is to Solve -**

In the aforementioned conventional subcooling apparatus, however, in order to incorporate the subcooling apparatus to the refrigerating apparatus, wiring for transmitting a singal therebetween is necessary, thereby complicating installation of the subcooling apparatus. Further, mis-wiring may be involved in its wiring works, resulting in invitation of troubles caused due to human errors.

[0006] The present invention has been made in view of the foregoing and has its objectives of enabling operation control of a subcooling apparatus without sending and receiving a signal to and from a refrigerating apparatus to which the subcooling apparatus is incorporated, of simplifying installation of the subcooling apparatus, and of obviating troubles caused due to human errors at installation.

Means for Solving the Problems

[0007] The means for solving the problem provided in the present invention is as follows.

[0008] Specifically, the first problem solving means directs to a subcooling apparatus which is incorporated to a refrigerating apparatus (**10**) that performs a vapor compression refrigeration cycle by circulating refrigerant between a heat source unit (**11**) and a utility unit (**12**, **13**, **14**) connected to each other by means of communication pipes and which cools the refrigerant of the refrigerating apparatus (**10**) sent from the heat source unit (**11**) to the utility unit (**12**, **13**, **14**). The subcooling apparatus includes: a refrigerant passage (**205**) connected to liquid side communication pipes of the refrigerating apparatus (**10**); a cooling fluid circuit (**220**) including a subcooling heat exchanger (**210**) that cools the refrigerant of the refrigerant passage (**205**) by heat exchange with cooling fluid; and control means (**240**) for adjusting cooling temperature of the refrigerant of the refrigerant

passage (**205**) in the subcooling heat exchanger (**210**) on the basis of an ambient condition of the subcooling heat exchanger (**210**).

[0009] In the above problem solving means, the refrigerant passes to and fro between the heat source unit (**11**) and the utility unit (**12, 13, 14**) through communication pipes in the refrigerating apparatus (**10**) to which the subcooling apparatus is incorporated. The refrigerant passage (**205**) of the subcooling apparatus is connected to the liquid side communication pipes (**21, 22**) of the refrigerating apparatus (**10**) so that the refrigerant of the refrigerating apparatus (**10**) flows therethrough. The cooling fluid such as refrigerant, water, air, or the like flows in the cooling fluid circuit (**220**) of the subcooling apparatus. In the subcooling heat exchanger (**210**), the refrigerant of the refrigerating apparatus (**10**) flowing in the refrigerant passage (**205**) is heat-exchanged with the cooling fluid. In the subcooling heat exchanger (**210**), the cooling fluid absorbs heat from the refrigerant of the refrigerating apparatus (**10**) to be evaporated, thereby cooling the refrigerant of the refrigerating apparatus (**10**).

[0010] In the subcooling apparatus of this problem solving means, the control means (**240**) adjusts the cooling temperature of the refrigerant of the refrigerating apparatus (**10**) flowing in the refrigerant passage (**205**) on the basis of the ambient condition of the subcooling heat exchanger (**210**), such as outside air temperature, the refrigerant flow rate, or the like. For example, in the case where the outside air temperature is used as the ambient condition of the subcooling heat exchanger (**210**), the cooling temperature of the refrigerant is adjusted to be low when outside air temperature is high or to be high when outside air temperature is low. In detail, the load state of the refrigerating apparatus (**10**) can be known from the ambient condition of the subcooling heat exchanger (**210**), and therefore, adjustment according to the ambient condition attains driving operation appropriate to the load state. Thus, the cooling power of the subcooling apparatus can be adjusted without receiving a signal relating to the load state or the like from the refrigerating apparatus (**10**).

[0011] Referring to the second problem solving means, in the first problem solving means, the control means (**240**) includes a control section (**242**) for adjusting a flow rate of the cooling fluid flowing in the subcooling heat exchanger (**210**) on the basis of a target cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) which is set in advance according to the ambient condition of the subcooling heat exchanger (**210**).

[0012] The above problem solving means sets in advance the target cooling temperature of the refrigerant of the refrigerating apparatus (**10**) according to the ambient condition of the subcooling heat exchanger (**210**), such as outside air temperature, that is, a load state. For example, the target cooling temperature is set comparatively low when outside air temperature is high or is set comparatively high when outside air temperature is low. When the target cooling temperature is set low, the control section (**242**) increases the flow rate of the cooling fluid such as refrigerant, water, or the like in the subcooling heat exchanger (**210**). This increases an amount of heat exchange between the refrigerant of the refrigerating apparatus (**10**) and the cooling fluid in the subcooling heat exchanger (**210**), thereby attaining further cooling of the refrigerant of the refrigerating apparatus (**10**). In reverse, when the target cooling temperature is set high, the control section (**242**) reduces the flow rate of the cooling fluid such as refrigerant, water, or the like in the subcooling heat exchanger (**210**). This reduces the heat exchange amount in the subcooling heat exchanger (**210**), so that the refrigerant of the refrigerating apparatus (**10**) is not so cooled.

[0013] Referring to the third problem solving means, in the second problem solving means, the cooling fluid circuit serves as a subcooling refrigerant circuit (**220**) which includes a capacity variable subcooling compressor (**221**) and a heat source side heat exchanger (**222**) and which performs the vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and the control section (**242**) of the control means (**240**) adjusts a flow rate of the subcooling refrigerant flowing in the

subcooling heat exchanger (**210**) by controlling operation frequency of the subcooling compressor (**221**) on the basis of the target cooling temperature.

[0014] In the above problem solving means, the cooling fluid circuit serves as the subcooling refrigerant circuit (**220**). Further, in the subcooling refrigerant circuit (**220**), the refrigerant discharged from the subcooling compressor (**221**) is heat-exchanged with, for example, air in the heat source side heat exchanger (**222**), is heat-exchanged with the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**), and then, returns to the subcooling compressor (**221**), which is circulation repeated. In addition, the control section (**242**) increases, when the target cooling temperature is set low, the flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by increasing the operation frequency of the subcooling compressor (**221**). In reverse, the control section (**242**) reduces, when the target cooling temperature is set high, the flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by reducing the operation frequency of the subcooling compressor (**221**).

[0015] Referring to the fourth problem solving means, in the second problem solving means, the cooling fluid circuit serves as a subcooling refrigerant circuit (**220**) which includes a capacity variable subcooling compressor (**221**) and a heat source side heat exchanger (**222**) and which performs the vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and the control section (**242**) of the control means (**240**) adjusts a flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by controlling operation frequency of a fan (**230**) of the heat source side heat exchanger (**222**) on the basis of the target cooling temperature.

[0016] In the above problem solving means, in the subcooling refrigerant circuit (**220**), the refrigerant discharged from the subcooling compressor (**221**) is heat-exchanged with air taken in by the fan (**230**) in the heat source side heat exchanger (**222**), is heat-exchanged with the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**), and then, returns to the subcooling compressor (**221**), which is circulation repeated.

Further, the control section (**242**) increases, when the target cooling temperature is set low, the flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by reducing the operation frequency of the fan (**230**) of the heat source side heat exchanger (**222**). In reverse, the control section (**242**) reduces, when the target cooling temperature is set high, the flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by increasing the operation frequency of the fan (**230**) of the heat source side heat exchanger (**222**).

[0017] Referring to the fifth problem solving means, in the third problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the subcooling compressor (**221**) on the basis of difference between the target cooling temperature and temperature of the refrigerant of the refrigerant passage (**205**) which is cooled in the subcooling heat exchanger (**210**).

[0018] In the above problem solving means, when the temperature of the refrigerant of the refrigerant passage (**205**) after cooled is higher than the target cooling temperature, the cooling temperature of the refrigerant in the subcooling heat exchanger (**210**) is lowered by increasing the operation frequency of the subcooling compressor (**221**). In reverse, when the temperature of the refrigerant of the refrigerant passage (**205**) after cooled is lower than the target cooling temperature, the cooling temperature of the refrigerant in the subcooling heat exchanger (**210**) is raised by reducing the operation frequency of the subcooling compressor (**221**). Thus, acquisition of the actual temperature of the cooled refrigerant as information attains reliable adjustment of the cooling power. The temperature of the refrigerant after cooled is information obtainable from the temperature sensor or the like within the subcooling apparatus. Accordingly, also in this invention, the cooling power of the subcooling apparatus can be adjusted reliably without receiving any signal relating to the load state from the refrigerating apparatus (**10**).

[0019] Referring to the sixth problem solving means, in the third problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the

subcooling compressor (**221**) on the basis of difference between the target cooling temperature and set temperature set from saturation temperature corresponding to low pressure of the subcooling refrigerant of the subcooling refrigerant circuit (**220**).

[0020] In the above problem solving means, the set temperature regarded as the temperature of the refrigerant after cooled in the subcooling heat exchanger (**210**) is set from the saturation temperature corresponding to low pressure of the subcooling refrigerant. Hence, substantially the same information as the actual temperature of the cooled refrigerant can be obtained without receiving any singal relating to the load state or the like from the refrigerating apparatus (**10**), thereby attaining reliable adjustment of the cooling power.

[0021] Referring to the seventh problem solving means, in the third problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the subcooling compressor (**221**) on the basis of difference between the target cooling temperature and set temperature set from suction temperature of the subcooling compressor (**221**).

[0022] In the above problem solving means, the set temperature regarded as the temperature of the refrigerant after cooled in the subcooling heat exchanger (**210**) is set from the suction temperature of the subcooling compressor (**221**). Hence, substantially the same information as the actual temperature of the cooled refrigerant can be obtained without receiving any singal relating to the load state or the like from the refrigerating apparatus (**10**), thereby attaining reliable adjustment of the cooling power.

[0023] Referring to the eighth problem solving means, in the fourth problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and temperature of the refrigerant of the refrigerant passage (**205**) which is cooled in the subcooling heat exchanger (**210**).

[0024] In the above problem solving means, when the temperature of the refrigerant of the

refrigerant passage (**205**) after cooled is higher than the target cooling temperature, the operation frequency of the fan (**230**) is reduced to lower the cooling temperature of the refrigerant in the subcooling heat exchanger (**210**). In reverse, when the temperature of the refrigerant of the refrigerant passage (**205**) after cooled is lower than the target cooling temperature, the driving frequency of the fan (**230**) is increased to raise the cooling temperature of the refrigerant in the subcooling heat exchanger (**210**). Thus, acquisition of the actual temperature of the cooled refrigerant as information attains reliable adjustment of the cooling power. The temperature of the refrigerant after cooled is information obtainable from the temperature sensor or the like within the subcooling apparatus. Accordingly, also in this invention, the cooling power of the subcooling apparatus can be adjusted reliably without receiving any signal relating to the load state or the like from the refrigerating apparatus (**10**).

[0025] Referring to the ninth problem solving means, in the fourth problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and set temperature set from saturation temperature corresponding to low pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**).

[0026] In the above problem solving means, the set temperature regarded as the temperature of the refrigerant after cooled in the subcooling heat exchanger (**210**) is set from the saturation temperature corresponding to low pressure of the subcooling refrigerant. Hence, substantially the same information as the actual temperature of the cooled refrigerant can be obtained without receiving any singal relating to the load state or the like from the refrigerating apparatus (**10**), thereby attaining reliable adjustment of the cooling power.

[0027] Referring to the tenth problem solving means, in the fourth problem solving means, the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and set

temperature set from suction temperature of the subcooling compressor (**221**).

[0028] In the above problem solving means, the set temperature regarded as the temperature of the refrigerant after cooled in the subcooling heat exchanger (**210**) is set from the suction temperature of the subcooling compressor (**221**). Hence, substantially the same information as the actual temperature of the cooled refrigerant can be obtained without receiving any singal relating to the load state or the like from the refrigerating apparatus (**10**), thereby attaining reliable adjustment of the cooling power.

[0029] Referring to the eleventh problem solving means, in the first problem solving means, the ambient condition of the subcooling heat exchanger (**210**) is outside air temperature.

[0030] In the above problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) is adjusted on the basis of outside air temperature. For example, the cooling temperature of the refrigerant is adjusted to be low when outside air temperature is high or is adjusted to be high when outside air temperature is low. In short, the control means (**240**) judges the load state of the refrigerating apparatus (**10**) on the basis of outside air temperature.

[0031] Referring to the twelfth problem solving means, in the first problem solving means, the ambient condition of the subcooling heat exchanger (**210**) is a flow rate of the refrigerant of the refrigerant passage (**205**).

[0032] In the above problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) is adjusted on the basis of the actual flow rate of the refrigerant of the refrigerant passage (**205**). For example, the cooling temperature of the refrigerant is adjusted to be low when the refrigerant flow rate is large or is adjusted to be high when the refrigerant flow rate is small. In short, the control means (**240**) judges the load state of the refrigerating apparatus (**10**) on the basis of the refrigerant flow rate.

[0033] Referring to the thirteenth problem solving means, in the first problem solving

means, the ambient condition of the subcooling heat exchanger (**210**) is temperature of the refrigerant of the refrigerant passage (**205**) before cooled in the subcooling heat exchanger (**210**) or temperature of the refrigerant of the refrigerant passage (**205**) after cooled in the subcooling heat exchanger (**210**).

[0034] In the above problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) is adjusted on the basis of the actual temperature of the refrigerant before or after cooled. For example, the cooling temperature of the refrigerant is adjusted to be low when the refrigerant temperature is high or is adjusted to be high when the refrigerant temperature is low. In short, the control means (**240**) judges the load state of the refrigerating apparatus (**10**) on the basis of the refrigerant temperature.

[0035] Referring to the fourteenth problem solving means, in the first problem sovling means, the cooling fluid circuit is a subcooling refrigerant circuit (**220**) that performs a vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and the ambient condition of the subcooling heat exchanger (**210**) is low pressure or high pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**).

[0036] In the above problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) is adjusted on the basis of the actual low pressure or high pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**). Wherein, the low pressure of the subcooling refrigerant is regarded as suction pressure of the compressor of the subcooling refrigerant circuit (**220**) while the high pressure of the subcooling refrigerant is regarded as discharge pressure of the compressor of the subcooling refrigerant circuit (**220**). For example, the cooling temperature of the refrigerant is adjusted to be low when the low pressure or high pressure is high or is adjusted to be high when the low pressure or high pressure is low. In short, the control means (**240**) judges the load state of the refrigerating apparatus (**10**) on the basis of the low pressure or the high pressure in the vapor compression refrigeration

cycle of the subcooling refrigerant circuit (**220**).

[0037] Referring to the fifteenth problem solving means, in the first problem solving means, the cooling fluid circuit is a subcooling refrigerant circuit (**220**) that performs a vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and the ambient condition of the subcooling heat exchanger (**210**) is temperature of the subcooling refrigerant after cooled, in the subcooling heat exchange (**210**), the refrigerant of the refrigerant passage (**205**).

[0038] In the above problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) is adjusted on the basis of the actual temperature of the subcooling refrigerant after cooled. Wherein, the temperature of the subcooling refrigerant may be regarded as the suction temperature of the compressor of the subcooling refrigerant circuit (**220**). For example, the cooling temperature of the refrigerant is adjusted to be low when the temperature of the subcooling refrigerant is high or is adjusted to be high when the temperature of the subcooling refrigerant is low. In short, the control means (**240**) judges the load state of the refrigerating apparatus (**10**) on the basis of the temperature of the subcooling refrigerant after cooled in the subcooling refrigerant circuit (**220**).

[0039] - Effects -

As described above, in the first problem solving means, the cooling temperature of the refrigerant of the refrigerant passage (**205**) is adjusted on the basis of the ambient condition of the subcooling heat exchanger (**210**) which can be detected within the apparatus. Hence, appropriate operation can be performed according to the load state of the utility unit (**12, 13, 14**) without sending and receiving any signal between the heat source unit (**11**) and the utility unit (**12, 13, 14**). As a result, for incorporating the subcooling apparatus to the refrigerating apparatus (**10**), only connection of the refrigerant passage (**205**) of the subcooling apparatus to the communication pipes of the refrigerating apparatus (**10**) is required. This eliminates the need to wire any communication wirings

for sending and receiving a signal between the refrigerating apparatus (**10**) and the subcooling apparatus. Accordingly, the number of operation steps for incorporating the subcooling apparatus to the refrigerating apparatus (**10**) can be reduced, and in turn, troubles caused due to human errors in installation, such as mis-wiring and the like, can be obviated.

[0040] Further, in the second problem solving means, the flow rate of the cooling fluid flowing in the subcooling heat exchanger (**210**) is adjusted on the basis of the target cooling temperature of the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**), which is set according to the ambient condition of the subcooling heat exchanger (**210**). Hence, appropriate adjustment of the cooling power can be attained with information obtainable within the subcooling apparatus, as well.

[0041] Furthermore, in the third or fourth problem solving means, the subcooling refrigerant circuit (**220**) serves as the cooling fluid circuit and the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**) is adjusted by controlling the operation of the subcooling compressor (**221**) or the fan (**230**) of the heat source side heat exchanger (**222**). Hence, the cooling temperature of the refrigerant of the refrigerating apparatus (**10**) can be adjusted reliably.

[0042] Moreover, the operation of the subcooling compressor (**221**) or the fan (**230**) is controlled on the basis of the difference between the actual temperature of the refrigerant cooled in the subcooling heat exchanger (**210**) and the target cooling temperature in the fifth or eighth problem solving means, on the basis of the difference between the set temperature set from the saturation temperature corresponding to the low pressure of the subcooling refrigerant and the target cooling temperature in the sixth or ninth problem solving means, or on the basis of the difference between the set temperature set from the suction temperature of the subcooling compressor (**221**) and the target cooling temperature in the seventh or tenth problem solving means. In each case, the cooling power can be adjusted to be further appropriate to the load state only with information obtainable within

the subcooling apparatus.

[0043] In the eleventh to fifteenth problem solving means, the outside air temperature, the flow rate or the temperature of the refrigerant as a state quantity of the refrigerant of the refrigerating apparatus (**10**), or pressure or temperature of the refrigerant as a state quantity of the refrigerant of the subcooling refrigerant circuit (**220**) is used as the ambient condition of the subcooling heat exchanger (**210**). Thus, such values can be obtained as the information obtainable within the subcooling apparatus reliably and readily. As a result, highly reliable apparatus can be provided.

Brief Description of the Drawings

[0044] [FIG. **1**] FIG. **1** is a piped system diagram showing a construction of a refrigeration system including a subcooling unit.

[FIG. **2**] FIG. **2** is a piped system diagram showing operation in cooling operation of the refrigeration system.

[FIG. **3**] FIG. **3** is a piped system diagram showing operation in first heating operation of the refrigeration system.

[FIG .**4**] FIG. **4** is a piped system diagram showing another operation in the first heating operation of the refrigeration system.

[FIG. **5**] FIG. **5** is a piped system diagram showing operation of second heating operation of the refrigeration system.

[FIG. **6**] FIG. **6** is a flowchart showing control operation by a controller in the subcooling unit.

[FIG. **7**] FIG. **7** is graph presenting the relationship between outside air temperature and target cooling temperature.

Best mode for Carrying out the Invention

[0045] Embodiments of the present invention will be described in detail with reference to the drawings.

[0046] A refrigeration system in the present embodiment is installed in a convenience

store or the like for conditioning air in the store and cooling showcases. The refrigeration system includes a subcooling unit (**200**) as a subcooling apparatus according to the present invention and a refrigerating apparatus (**10**) to which the subcooling unit (**200**) is incorporated.

[0047] As shown in FIG. **1**, the refrigeration system includes an outdoor unit (**11**), an air conditioning unit (**12**), a cooling showcase (**13**), a refrigeration showcase (**14**), a booster unit (**15**), and the subcooling unit (**200**). The refrigerating apparatus (**10**) is composed of the outdoor unit (**11**), the air conditioning unit (**12**), the cooling showcase (**13**), the refrigeration showcase (**14**), and the booster unit (**15**). In the refrigeration system, the outdoor unit (**11**) and the subcooling unit (**200**) are installed outdoors while the other units such as the air conditioning unit (**12**) and the like are installed in a store such as a convenience store.

[0048] The outdoor unit (**11**) includes an outdoor circuit (**40**), the air conditioning unit (**12**) includes an air conditioning circuit (**100**), the cooling showcase (**13**) includes a cooling circuit (**110**), the refrigeration showcase (**14**) includes a refrigeration circuit (**130**), and the booster unit (**15**) includes a booster circuit (**140**). Further, the subcooling unit (**20**) includes a refrigerant passage (**205**). In the refrigeration system, the aforementioned circuits (**40**, **100**, ...) and the refrigerant passage (**205**) of the subcooling unit (**200**) are connected by means of pipes to form a refrigerant circuit (**20**).

[0049] A first liquid side communication pipe (**21**), a second liquid side communication pipe (**22**), a first gas side communication pipe (**23**), and a second gas side communication pipe (**24**) are provided in the refrigerant circuit (**20**).

[0050] The first liquid side communication pipe (**21**) connects one end of the refrigerant passage (**205**) of the subcooling unit (**200**) and the outdoor circuit (**40**). One end of the second liquid side communication pipe (**22**) is connected to the other end of the refrigerant passage (**205**). The other end of the second liquid side communication pipe (**22**) branches into three ends to be connected to the air conditioning circuit (**100**), the cooling circuit

(**100**), and the refrigeration circuit (**130**). A liquid side closing valve (**25**) is provided in one of branch pipes of the second liquid side communication pipe (**22**) which is connected to the refrigeration circuit (**130**).

[0051] One end of the first gas side communication pipe (**23**) branches into two ends connected to the cooling circuit (**110**) and the booster circuit (**140**). A gas side closing valve (**26**) is provided in one of the branch pipes of the first gas side communication pipe (**23**) which is connected to the booster circuit (**140**). The other end of the first gas side communication pipe (**23**) is connected to the outdoor circuit (**40**). The second gas side communication pipe (**24**) connects the air conditioning circuit (**100**) and the outdoor circuit (**40**).

[0052] <Outdoor Unit>

The outdoor unit (**11**) serves as a heat source unit of the refrigerating apparatus (**10**). The outdoor circuit (**40**) of the outdoor unit (**11**) includes a variable capacity compressor (**41**), a first fixed capacity compressor (**42**), a second fixed capacity compressor (**43**), an outdoor heat exchanger (**44**), a receiver (**45**), and an outdoor expansion valve (**46**). The outdoor circuit (**40**) also includes three intake pipes (**61**, **62**, **63**), two discharge pipes (**64**, **65**), four liquid pipes (**81**, **82**, **83**, **84**), and one high-pressure gas pipe (**66**). The outdoor circuit (**40**) further includes three four-way switching valves (**51**, **52**, **53**), one liquid side closing valve (**54**), and two gas side closing valves (**55**, **56**).

[0053] In the outdoor circuit (**40**), the first liquid side communication pipe (**21**), the first gas side communication pipe (**23**), and the second gas side communication pipe (**24**) are connected to the liquid side closing valve (**54**), the first gas side closing valve (**55**), and the second gas side closing valve (**56**), respectively.

[0054] Each of the variable capacity compressor (**41**), the first fixed capacity compressor (**42**), and the second fixed capacity compressor (**43**) is a hermetic scroll compressor of high-pressure dome type. Electric power is supplied to the variable capacity compressor (**41**) through an inverter. The variable capacity compressor (**41**) is variable in capacity by

changing the rotation speed of its compressor motor by changing the output frequency of the inverter. In contrast, the first and second fixed capacity compressors (**42**, **43**) are operated by driving their compressor motors always at a given rotation speed, so that the capacities thereof are invariable.

[0055] The first suction pipe (**61**) is connected at one end thereof to the first gas closing valve (**55**). The first suction pipe (**61**) branches at the other end thereof into a first branch pipe (**61a**) and a second branch pipe (**61b**), wherein the first branch pipe (**61a**) is connected to the intake side of the variable capacity compressor (**41**) while the second branch pipe (**61b**) is connected to the third four-way switching valve (**53**). A check valve (**CV-1**) for allowing the refrigerant to flow from the first gas side closing valve (**55**) towards the third four-way switching valve (**53**) is provided in the second branch pipe (**64b**) of the first suction pipe (**61**).

[0056] The second suction pipe (**62**) is connected at one end thereof to the third four-way switching valve (**53**) and at the other end thereof to the suction side of the first fixed capacity compressor (**42**).

[0057] The third suction pipe (**63**) is connected at one end thereof to the second four-way switching valve (**52**). The third suction pipe (**63**) branches at the other end thereof into a first branch pipe (**63a**) and a second branch pipe (**63b**), wherein the first branch pipe (**63a**) is connected to the suction side of the second fixed capacity compressor (**43**) while the second brand pipe (**63b**) is connected to the third four-way switching valve (**53**). A check valve (**CV-2**) for allowing the refrigerant to flow from the second four-way switching valve (**52**) towards the third four-way switching valve (**53**) is provided in the second branch pipe (**63b**) of the third suction pipe (**63**).

[0058] The first discharge pipe (**64**) branches at one end thereof into a first branch pipe (**64a**) and a second branch pipe (**64b**), wherein the first branch pipe (**64a**) is connected to the discharge side of the variable capacity compressor (**41**) while the second branch pipe (**64b**) is connected to the discharge side of the first fixed capacity compressor (**42**). The

other end of the first discharge pipe (**64**) is connected to the first four-way switching valve (**51**). A check valve (**CV-3**) for allowing the refrigerant to flow from the first fixed capacity compressor (**42**) towards the first four-way switching valve (**51**) is provided in the second branch pipe (**64b**) of the first discharge pipe (**64**).

[0059] The second discharge pipe (**65**) is connected at one end thereof to the suction side of the second fixed capacity compressor (**43**) and at the other end thereof to a part of the discharge pipe (**64**) immediately before the first four-way switching valve (**51**). A check valve (**CV-4**) for allowing the refrigerant to flow from the second fixed capacity compressor (**43**) towards the first four-way switching valve (**51**) is provided in the second discharge pipe (**65**).

[0060] The outdoor heat exchanger (**44**) is a fin and tube heat exchanger of cross fin type. The outdoor heat exchanger (**44**) performs heat exchange between the refrigerant and outdoor air. One end of the outdoor heat exchanger (**44**) is connected to the first four-way switching valve (**51**) via a closing valve (**57**). The other end of the outdoor heat exchanger (**44**) is connected to the head of the receiver (**45**) through the first liquid pipe (**81**). A check valve (**CV-5**) for allowing the refrigerant to flow from the outdoor heat exchanger (**44**) towards the receiver (**45**) is provided in the first liquid pipe (**81**).

[0061] To the bottom of the receiver (**45**), one end of the second liquid pipe (**82**) is connected via a closing valve (**58**). The other end of the second liquid pipe (**82**) is connected to the liquid side closing valve (**54**). A check valve (**CV-6**) for allowing the refrigerant to flow from the receiver (**45**) towards the liquid side closing valve (**54**) is provided in the second liquid pipe (**82**).

[0062] One end of the third liquid pipe (**83**) is connected between the check valve (**CV-6**) and the liquid side closing valve (**54**) in the second liquid pipe (**82**). The other end of the third liquid pipe (**83**) is connected to the head of the receiver through the first liquid pipe (**81**). A check valve (**CV-7**) for allowing the refrigerant to flow from the one end towards the other end is provided in the third liquid pipe (**83**).

[0063] One end of the fourth liquid pipe (**84**) is connected between the closing valve (**58**) and the check valve (**CV-6**) in the second liquid pipe (**82**). The other end of the fourth liquid pipe (**84**) is connected between the outdoor heat exchanger (**44**) and the check valve (**CV-5**) in the first liquid pipe (**81**). A check valve (**CV-8**) and the outdoor expansion valve (**46**) are provided in this order from the one end towards the other end of the fourth liquid pipe (**84**). The check valve (**CV-8**) is provided for allowing the refrigerant to flow from the one end towards the other end of the fourth liquid pipe (**84**). The outdoor expansion valve (**46**) is an electronic expansion valve.

[0064] The high-pressure gas pipe (**66**) is connected at one end thereof to a part of the first discharge pipe (**64**) immediately before the first four-way switching valve (**51**). The other end of the high-pressure gas pipe (**66**) branches into a first branch pipe (**66a**) and a second branch pipe (**66b**), wherein the first branch pipe (**66a**) is connected to the downstream side of the check valve (**CV-5**) in the first liquid pipe (**81**) while the second branch pipe (**66b**) is connected to the third four-way switching valve (**53**). A solenoid valve (**SV-7**) and a check valve (**CV-9**) are provided in the first branch pipe (**66a**) of the high-pressure gas pipe (**66**). The check valve (**CV-9**) is arranged downstream of the solenoid valve (**SV-7**) for allowing the refrigerant to flow from the solenoid valve (**SV-7**) towards the first liquid pipe (**81**).

[0065] In the first four-way switching valve (**51**), the first port, the second port, the third port, and the fourth port are connected to the terminal end of the first discharge pipe (**64**), the second four-way switching valve (**52**), the outdoor heat exchanger (**44**), and the second gas side closing valve (**56**), respectively. The first four-way switching valve (**51**) is exchangeable between the first state that the first port and the third port communicate with each other while the second port and the fourth port communicate with each other and the second state that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0066] In the second four-way switching valve (**52**), the first port, the second port, and the

fourth port are connected to the downstream side of the check valve (**CV-4**) in the second discharge pipe (**65**), the start end of the second suction pipe (**62**), and the second port of the first four-way switching valve (**51**), respectively. The third port of the second four-way switching valve (**52**) is closed. The second four-way switching valve (**52**) is exchangeable between the first state that the first port and the third port communicate with each other while the second port and the fourth port communicate with each other and the second state that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0067] In the third four-way switching valve (**53**), the first port, the second port, the third port, and the fourth port are connected to the terminal end of the second branch pipe (**66b**) of the high-pressure gas pipe (**66**), the start end of the second suction pipe (**62**), the terminal end of the second branch pipe (**61b**) of the first suction pipe (**61**), and the terminal end of the second branch pipe (**63b**) of the third intake pipe (**63**), respectively. The third four-way switching valve (**53**) is exchangeable between the first state that the first port and the third port communicate with each other while the second port and the fourth port communicate with each other and the second state that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0068] The outdoor circuit (**40**) further includes an injection pipe (**85**), a communication pipe (**87**), an oil separator (**75**), and an oil return pipe (**76**). The outdoor circuit (**40**) also includes four oil level equalizing pipes (**71**, **72**, **73**, **74**).

[0069] The injection pipe (**85**) is provided for liquid injection. The injection pipe (**85**) is connected at one end thereof between the check valve (**CV-8**) and the outdoor expansion valve (**46**) in the fourth liquid pipe (**84**) and at the other end thereof to the first suction pipe (**61**). A closing valve (**59**) and a flow rate adjusting valve (**86**) are provided in this order from the one end towards the other end of the injection pipe (**85**). The flow rate adjusting valve (**86**) is an electronic expansion valve.

[0070] The communication pipe (**87**) is connected at one end thereof between the closing valve (**59**) and the flow rate adjusting valve (**86**) in the injection pipe (**85**) and at the other end thereof to the upstream side of the solenoid valve (**SV-7**) in the first branch pipe (**66a**) of the high-pressure gas pipe (**66**). In the communication pipe (**87**), a check valve (**CV-10**) is provided for allowing the refrigerant to flow from the one end towards the other end thereof.

[0071] The oil separator (**75**) is provided upstream of the connection point of the first discharge pipe (**64**) where the second discharge pipe (**65**) and the high-pressure gas pipe (**66**) are connected to each other. The oil separator (**75**) is provided for separating the refrigerator oil from the discharged gas in the compressors (**41**, **42**).

[0072] The oil return pipe (**76**) is connected at one end thereof to the oil separator (**75**). The oil return pipe (**76**) branches at the other end thereof into a first branch pipe (**76a**) and a second branch pipe (**76b**), wherein the first branch pipe (**76a**) is connected to the downstream side of the flow rate adjusting valve (**86**) in the injection pipe (**85**) while the second branch pipe (**76b**) is connected to the second suction pipe (**62**). Further, solenoid valves (**SV-5**, **SV-6**) are provided at the first branch pipe (**76a**) and the second branch pipe (**76b**) of the oil return pipe (**76**), respectively. When the solenoid valve (**SV-5**) of the first branch pipe (**76a**) opens, the refrigerator oil separated in the oil separator (**75**) returns to the first suction pipe (**61**) through the injection pipe (**85**). On the other hand, when the solenoid valve (**SV-6**) of the second branch pipe (**76b**) opens, the refrigerator oil separated in the oil separator (**75**) returns to the second suction pipe (**62**).

[0073] The first oil level equalizing pipe (**71**) is connected at one end thereof to the variable capacity compressor (**41**) and at the other end thereof to the second suction pipe (**62**). A solenoid valve (**SV-1**) is provided in the first oil level equalizing pipe (**71**). The second oil level equalizing pipe (**72**) is connected at one end thereof to the first fixed capacity compressor (**42**) and at the other end thereof to the first branch pipe (**63a**) of the third suction pipe (**63**). A solenoid valve (**SV-2**) is provided in the second oil level

equalizing pipe (**72**). The third oil level equalizing pipe (**73**) is connected at one end thereof to the second fixed capacity compressor (**43**) and at the other end thereof to the first branch pipe (**61a**) of the first suction pipe (**61**). A solenoid valve (**SV-3**) is provided in the third oil level equalizing pipe (**73**). The fourth oil level equalizing pipe (**74**) is connected at one end thereof to the upstream side of the solenoid valve (**SV-2**) in the second oil level equalizing pipe (**72**) and at the other end thereof to the first branch pipe (**61a**) of the first suction pipe (**61**). A solenoid valve (**SV-4**) is provided in the fourth oil level equalizing pipe (**74**). Appropriate opening/closing of the solenoid valves (**SV-1** to **SV-4**) of the oil level equalizing pipes (**71** to **74**) equalizes each amount of the refrigerator oil reserved in the compressors (**42, 42, 43**).

[0074] A variety of sensors and pressure switches are provided in the outdoor circuit (**40**). Specifically, a first suction temperature sensor (**91**) and a first suction pressure sensor (**92**) are provided in the first suction pipe (**61**). A second suction pressure sensor (**93**) is provided in the second suction pipe (**62**). A third suction temperature sensor (**94**) and a third suction pressure sensor (**95**) are provided in the third suction pipe (**63**). A first discharge temperature sensor (**97**) and a first discharge pressure sensor (**98**) are provided in the first discharge pipe (**64**). A high-pressure switch (**69**) is provided at each of the branch pipes (**64a, 64b**) of the first discharge pipe (**64**). A second discharge temperate sensor (**99**) and a high pressure switch (**96**) are provided in the second discharge pipe (**65**).

[0075] The outdoor unit (**11**) further includes an outdoor air temperature sensor (**90**) and an outdoor fan (**48**). The outdoor fan (**48**) sends outdoor air to the outdoor heat exchanger (**44**).

[0076] <Air Conditioning Unit>

The air conditioning unit (**12**) composes a utility unit. The air conditioning circuit (**100**) of the air conditioning unit (**12**) is connected at the liquid side end thereof to the second liquid side communication pipe (**22**) and at the gas side end thereof to the second gas side communication pipe (**24**).

[0077] The air conditioning circuit (**100**) includes an air conditioning expansion valve (**102**) and an air conditioning heat exchanger (**101**) in this order form the liquid side end towards the gas side end. The air conditioning heat exchanger (**101**) is a fin and tube heat exchanger of cross fin type. The air conditioning heat exchanger (**101**) performs heat exchange between the refrigerant and room air. The air conditioning expansion valve (**102**) is an electronic expansion valve.

[0078] The air conditioning unit (**12**) includes a heat exchanger temperature sensor (**103**) and a refrigerant temperature sensor (**104**). The heat exchanger temperature sensor (**103**) is incorporated at the heat transfer tube of the air conditioning heat exchanger (**101**). The refrigerant temperature sensor (**104**) is incorporated in the vicinity of the gas side end of the air conditioning circuit (**100**). The air conditioning unit (**12**) also includes an indoor air temperature sensor (**106**) and an air conditioning fan (**105**). The air conditioning fan (**105**) sends room air in the store to the air conditioning heat exchanger (**101**).

[0079] <Cooling Showcase>

The Cooling showcase (**13**) composes the utility unit. The cooling circuit (**110**) of the cooling showcase (**13**) is connected at the liquid side end thereof to the second liquid side communication pipe (**22**) and at the gas side end thereof to the first gas side communication pipe (**23**).

[0080] The cooling circuit (**110**) includes a cooling solenoid valve (**114**), a cooling expansion valve (**112**), and a cooling heat exchanger (**111**) in this order from the liquid side end towards the gas side end. The cooling heat exchanger (**111**) is a fin and tube heat exchanger of cross fin type. The cooling heat exchanger (**111**) performs heat exchange between the refrigerant and the inside air of the cooling showcase (**13**). The cooling expansion valve (**112**) is a thermostatic expansion valve. The cooling expansion valve (**112**) has a temperature sensing bulb (**113**) incorporated at the pipe on the outlet side of the cooling heat exchanger (**111**).

[0081] The cooling showcase (**13**) includes a cooler temperature sensor (**116**) and a cooler

fan (**115**). The cooler fan (**115**) sends the inside air of the cooling showcase (**13**) to the cooling heat exchanger (**111**).

[0082] <Refrigeration Showcase>

The refrigeration showcase (**14**) composes the utility unit. The refrigeration circuit (**130**) of the refrigeration showcase (**14**) is connected at the liquid side end thereof to the second liquid side communication pipe (**22**) and at the gas side end thereof to the booster unit (**15**) through a pipe.

[0083] The refrigeration circuit (**130**) includes a refrigeration solenoid valve (**134**), a refrigeration expansion valve (**132**), and a refrigeration heat exchanger (**131**) in this order from the liquid side end towards the gas side end. The refrigeration heat exchanger (**131**) is a fin and tube heat exchanger of cross fin type. The refrigeration heat exchanger (**131**) performs heat exchange between the refrigerant and the inside air of the refrigeration showcase (**14**). The refrigeration expansion valve (**132**) is a thermostatic expansion valve. The refrigeration expansion valve (**132**) has a temperature sensing bulb (**133**) incorporated at the pipe on the outlet side of the refrigeration heat exchanger (**131**).

[0084] The refrigeration showcase (**14**) includes a refrigerator temperature sensor (**136**) and a refrigerator fan (**135**). The refrigerator fan (**135**) sends the inside air of the refrigeration showcase (**14**) to the refrigeration heat exchanger (**131**).

[0085] <Booster Unit>

The booster circuit (**140**) of the booster unit (**15**) includes a booster compressor (**141**), a suction pipe (**143**), a discharge pipe (**144**), and a bypass pipe (**150**).

[0086] The booster compressor (**141**) is a hermetic scroll compressor of high pressure dome type. Electric power is supplied to the booster compressor (**141**) through an inverter. The booster compressor (**141**) is variable in capacity by changing the rotation speed of its compressor motor by changing the output frequency of the inverter.

[0087] The suction pipe (**143**) is connected at the terminal end thereof to the suction side of the booster compressor (**141**) and at the start end thereof to the gas side end of the

refrigeration circuit (**130**) through a pipe.

[0088] The discharge pipe (**144**) is connected at the start end thereof to the discharge side of the booster compressor (**141**) and at the terminal end thereof to the first gas side communication pipe (**23**). The discharge pipe (**144**) includes a high-pressure switch (**148**), an oil separator (**145**), and a discharge side check valve (**149**) in this order from the start end towards the terminal end thereof. The discharge side check valve (**149**) allows the refrigerant to flow from the start end towards the terminal end of the discharge pipe (**144**).

[0089] The oil separator (**145**) is provided for separating the refrigerator oil from the discharge gas of the booster compressor (**141**). One end of an oil return pipe (**146**) is connected to the oil separator (**145**). The other end of the oil return pipe (**146**) is connected to the suction pipe (**143**). The oil return pipe (**146**) includes a capillary tube (**147**). The refrigerator oil separated in the oil separator (**145**) is sent back to the suction side of the booster compressor (**141**) through the oil return pipe (**146**).

[0090] The bypass pipe (**150**) is connected at the start end thereof to the suction pipe (**143**) and at the terminal end thereof to a part of the discharge pipe (**64**) between the oil separator (**145**) and the discharge side check valve (**149**). The bypass pipe (**150**) includes a bypass check valve (**151**) for allowing the refrigerant to flow from the start end towards the terminal end thereof.

[0091] <Subcooling Unit>

The subcooling unit (**200**) includes the refrigerant passage (**205**), a subcooling refrigerant circuit (**220**), and a controller (**240**).

[0092] The refrigerant passage (**205**) is connected at one end thereof to the first liquid side communication pipe (**21**) and at the other end thereof to the second liquid side communication pipe (**22**).

[0093] The subcooling refrigerant circuit (**220**) is a closed circuit formed in such a fashion that the subcooling compressor (**221**), a subcooling outdoor heat exchanger (**222**), a

subcooling expansion valve (**223**), and a subcooling heat exchanger (**210**) are connected in this order by means of pipes. The subcooling refrigerant circuit (**220**) serves as a cooling fluid circuit for performing a vapor compression refrigeration cycle by circulating the subcooling refrigerant as the cooling fluid filled therein.

[0094] The subcooling compressor (**221**) is a hermetic scroll compressor of high pressure dome type. Electric power is supplied to the subcooling compressor (**221**) through an inverter. The subcooling compressor (**221**) is variable in capacity by changing the rotation speed of its compressor motor by changing the output frequency of the inverter.

[0095] The subcooling outdoor heat exchanger (**222**) is a fin and tube heat exchanger of cross fin type and serves as a heat source side heat exchanger. The subcooling outdoor heat exchanger (**222**) performs heat exchange between the subcooling refrigerant and outdoor air. The subcooling expansion valve (**223**) is an electronic expansion valve.

[0096] The subcooling heat exchanger (**210**) is a generally-called a plate type heat exchanger and serves as a utility side heat exchanger. A plurality of first flow paths (**211**) and a plurality of second flow paths (**212**) are formed in the subcooling heat exchanger (**210**). The first flow paths (**211**) and the second flow paths (**211**) are connected to the subcooling refrigerant circuit (**220**) and the refrigerant passage (**205**), respectively. The subcooling heat exchanger (**210**) performs heat exchange between the subcooling refrigerant flowing in the first flow paths (**211**) and the refrigerant of the refrigerating apparatus (**10**) flowing in the second flow paths (**212**).

[0097] The subcooling unit (**200**) also includes a variety of sensors and pressure switches. Specifically, in the subcooling refrigerant circuit (**220**), a suction temperature sensor (**235**) and a suction pressure sensor (**234**) are provided on the suction side of the subcooling compressor (**221**) and a discharge temperature sensor (**233**) and a high pressure switch (**232**) are provided on the discharge side of the subcooling compressor (**221**). A refrigerant temperature sensor (**236**) is provided at a part of the refrigerant passage (**205**) nearer the other end than the subcooling heat exchanger (**210**), that is, a part thereof near

the end connected to the second liquid side communication pipe (**22**). The refrigerant temperature sensor (**236**) serves as refrigerant temperature detection means.

[0098] The subcooling unit (**200**) also includes an outside air temperature sensor (**231**) and an outdoor fan (**230**). The outdoor fan (**230**) sends outdoor air to the subcooling outdoor heat exchanger (**222**).

[0099] The controller (**240**) serves as control means. The controller (**240**) includes a setting section (**241**) and a control section (**242**).

[0100] The setting section (**241**) receives outside air temperature as detection temperature of the outside air temperature sensor (**231**). The setting section (**241**) sets a target cooling temperature (Eom) of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) which is set in advance on the basis of the input outside air temperature. For example, when outside air temperature is high, the cooling load in the store becomes large, and therefore, the target cooling temperature (Eom) of the refrigerant is set low. In reverse, when outside air temperature is low, the cooling load in the store becomes small, and therefore, the target cooling temperature (Eom) of the refrigerant is set high. In short, the setting section (**241**) in the present embodiment uses the outside air temperature as an ambient condition of the subcooling heat exchanger (**210**).

[0101] The control section (**242**) receives the detection temperature (Tout) of the refrigerant temperature sensor (**236**) and the detection pressure (LP) of the suction pressure sensor (**234**). As far as the refrigerant temperature sensor (**236**) can perform the detection normally, the control section (**242**) controls the operation frequency of the subcooling compressor (**221**) on the basis of the difference between the detection temperature (Tout) of the refrigerant temperature sensor (**246**) and the target cooling temperature (Eom) of the setting section (**241**).

[0102] In the case where the refrigerant temperature sensor (**236**) becomes abnormal and cannot perform the detection, the control section (**242**) controls the operation frequency of the subcooling compressor (**221**) on the basis of the difference between set temperature

(Tout) set from the saturation temperature (TG) of the subcooling refrigerant which corresponds to the detection pressure (LP) of the suction pressure sensor (**234**) and the target cooling temperature (Eom). In other words, in the control section (**242**), the set temperature (Tout) set from the saturation temperature (TG) corresponding to the low pressure of the subcooling refrigerant of the subcooling refrigerant circuit (**220**) is regarded as the detection temperature of the refrigerant temperature sensor (**236**). In the present embodiment, for example, the set temperature (Tout) is set at a temperature obtained by adding α °C to the saturation temperature (TG) (TG + α °C). Wherein, α can be set arbitrarily.

[0103] It is noted that in the present embodiment, the control section (**242**) regards the set temperature set from the detection pressure (LP) of the suction pressure sensor (**234**) as the detection temperature (Tout) of the refrigerant but may regard set temperature (Tout) set from the suction temperature, which is the detection temperature (Ti) of the suction temperature sensor (**235**), as the detection temperature (Tout) of the refrigerant. In this case, the control section (**242**) receives the detection temperature (Tout) of the refrigerant temperature sensor (**236**) and the detection temperature (Ti) of the suction temperature sensor (**235**). In the case where the refrigerant temperature sensor (**236**) becomes abnormal and cannot perform the detection, the control section (**242**) controls the operation frequency of the subcooling compressor (**221**) on the basis of the difference between the set temperature (Tout) set from the detection temperature (Ti) of the suction temperature sensor (**235**) and the target cooling temperature (Eom). In this case, the set temperature (Tout) is set at, for example, a temperature obtained by adding β °C to the detection temperature (Ti) (Ti + β °C). Wherein, β can be set arbitrarily.

[0104] When the operation frequency of the subcooling compressor (**21**) is increased, the circulation amount of the subcooling refrigerant of the subcooling refrigerant circuit (**220**) increases to increase the amount of heat exchange between the subcooling refrigerant and the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**).

This lowers the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), increasing the cooling power and the like of the air conditioning unit (**12**). In reverse, when the operation frequency of the subcooling compressor (**221**) is reduced, the circulation amount of the subcooling refrigerant of the subcooling refrigerant circuit (**220**) reduces to reduce the amount of heat exchange between the subcooling refrigerant and the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**), raising the cooling temperature of the refrigerant of the refrigerating apparatus (**10**) and lowering the cooling power and the like of the air conditioning unit (**12**). In sum, the controller (**240**) adjusts the cooling temperature of the refrigerant of the refrigerating apparatus (**10**) in such a manner that the capacity of the subcooling compressor (**221**) is controlled on the basis of the outside air temperature to adjust the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**).

[0105] As described above, the controller (**240**) receives none of signals from the refrigerating apparatus (**10**) composed of the outdoor unit (**11**), the air conditioning unit (**12**), and the like. In other words, the controller (**240**) controls the operation of the subcooling compressor (**221**) on the basis of only information obtained within the subcooling unit (**200**), such as the detection values of the sensors provided in the subcooling unit (**200**). This eliminates the need of works of wiring for transmitting signals between the subcooling unit (**200**) and the refrigerating apparatus (**10**).

[0106] It is noted that the setting section (**241**) in the present embodiment sets the target cooling temperature (Eom) of the refrigerant on the basis of the outside air temperature as the ambient condition of the subcooling heat exchanger (**210**) but may use the followings (parameters) rather than the outside air temperature.

[0107] For example, the setting section (**241**) may use as the ambient condition of the subcooling heat exchanger (**210**) the refrigerant flow rate of the refrigerant passage (**205**), that is, the flow rate of the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**). In this case, refrigerant flow rate detection means is provided

upstream of the subcooling heat exchanger (**210**) in the refrigerant passage (**205**) so that the detection flow rate of the flow rate detection mean is input into the setting section (**241**) of the controller (**240**). The setting section (**241**) judges that the cooling load in the store is large when the input detection flow rate is large to set the target cooling temperature (Eom) of the refrigerant to be low or sets the target cooling temperature (Eom) of the refrigerant to be high when the detection flow rate is small, with the cooling load in the store judged small.

[0108] Alternatively, the setting section (**241**) may use as the ambient condition of the subcooling heat exchanger (**210**) the temperature of the refrigerant of the refrigerant passage (**205**) before cooled in the subcooling heat exchanger (**210**) or the temperature of the refrigerant of the refrigerant passage (**205**) after cooled in the subcooling heat exchanger (**210**). In this case, refrigerant temperature detection means is provided upstream of the subcooling heat exchanger (**210**) in the refrigerant passage (**205**) so that the detection temperature of the flow rate detection means is input as the temperature of the refrigerant before cooled into the setting section (**241**) of the controller (**240**). Or, the detection temperature of the refrigerant temperature sensor (**236**) provided downstream of the subcooling heat exchanger (**210**) is input into the setting section (**241**) of the controller (**240**). Then, the setting section (**241**) judges that the cooling load in the store is large when the input detection temperature is high to set the target cooling temperature (Eom) of the refrigerant to be low or sets the target cooling temperature (Eom) of the refrigerant to be high when the detection temperature is low, with the cooling load in the store judged small.

[0109] Further, the setting section (**241**) may use as the ambient condition of the subcooling heat exchanger (**210**) low pressure or high pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**). In this case, the detection pressure of the intake pressure sensor (**234**) provided on the suction side of the subcooling compressor (**221**) is input as the low pressure into the setting section (**241**). Or,

refrigerant pressure detection means is provided on the discharge side of the subcooling compressor (**221**) so that the detection pressure of the pressure detection means is input as the high pressure into the setting section (**241**). Then, the setting section (**241**) judges that the cooling load in the store is large when the input detection pressure is high to set the target cooling temperature (Eom) of the refrigerant to be low or sets the target cooling temperature (Eom) of the refrigerant to be high when the detection pressure is low, with the cooling load in the store judged small.

[0110] Moreover, the setting section (**241**) may use as the ambient condition of the subcooling heat exchanger (**210**) the temperature of the subcooling refrigerant after cooled in the subcooling heat exchanger (**210**). In this case, the detection temperature of the suction temperature sensor (**235**) of the subcooling compressor (**221**) is input into the setting section (**241**). Or, refrigerant temperature detection means is provided immediately downstream of the subcooling heat exchanger (**210**) in the subcooling refrigerant circuit (**220**) so that the detection temperature of the temperature detection means is input into the setting section (**241**) in lieu to the detection temperature of the aforementioned suction temperature sensor (**235**). Then, setting section (**241**) judges that the cooling load in the store is large when the input detection temperature is high to set the target cooling temperature (Eom) of the refrigerant to be low or sets the target cooling temperature (Eom) of the refrigerant to be high when the detection temperature is low, with the cooling load in the store judged small.

[0111] As described above, any of the above parameters are information obtainable within the subcooling unit (**200**), and therefore, eliminates the need for signal transmission to and from the refrigerating apparatus (**10**).

[0112] - Driving Operation of Refrigeration System -

Main operations of driving operation that the refrigeration system performs will be described.

[0113] <Cooling Operation>

Cooling operation is operation for cooling the inside air of the cooling showcase (**13**) and of the refrigeration showcase (**14**) and for cooling room air by the air conditioning unit (**12**) to cool the store.

[0114] As shown in FIG. **2**, during the cooling operation, the first four-way switching valve (**51**), the second four-way switching valve (**52**), and the third four-way switching valve (**53**) are set to the first state. The outdoor expansion valve (**46**) is closed fully while each opening of the air conditioning expansion valve (**102**), the cooling expansion valve (**112**), and the refrigeration expansion valve (**132**) is adjusted appropriately. In this condition, the variable capacity compressor (**41**), the first fixed capacity compressor (**42**), the second fixed capacity compressor (**43**), and the booster compressor (**141**) are operated. During the cooling operation, the subcooling unit (**200**) is operated. Driving operation of the subcooling unit (**200**) will be described later.

[0115] The refrigerant discharged from the variable capacity compressor (**41**), the first fixed capacity compressor (**42**), and the second fixed capacity compressor (**43**) is sent to the outdoor heat exchanger (**44**) via the first four-way switching valve (**51**). In the outdoor heat exchanger (**44**), the refrigerant radiates heat to outdoor air to be condensed. The refrigerant condensed in the outdoor heat exchanger (**44**) passes through the first liquid pipe (**81**), the receiver (**45**), and the second liquid pipe (**82**) in this order, and then, flows into the first liquid side communication pipe (**21**).

[0116] The refrigerant flowing in the first liquid side communication pipe (**21**) flows into the refrigerant passage (**205**) of the subcooling unit (**200**). The refrigerant flowing in the refrigerant passage (**205**) is cooled when passing through the second flow paths (**212**) of the subcooling heat exchanger (**210**). The subcooled liquid refrigerant cooled in the subcooling heat exchanger (**210**) passes through the second liquid side communication pipe (**22**), and then, is divided to flow into the air conditioning circuit (**100**), the cooling circuit (**110**), and the refrigeration circuit (**130**).

[0117] The refrigerant flowing in the air conditioning circuit (**100**) is pressure-reduced

when passing through the air conditioning expansion valve (**102**), and then, is introduced into the air conditioning heat exchanger (**101**). In the air conditioning heat exchanger (**101**), the refrigerant absorbs heat from room air to be evaporated. For the evaporation, the air conditioning heat exchanger (**101**) is so set that the evaporation temperature of the refrigerant is 5 °C, for example. The air conditioning unit (**12**) supplies the room air cooled in the air conditioning heat exchanger (**101**) to the store.

[0118] The refrigerant evaporated in the air conditioning heat exchanger (**101**) passes through the second gas side communication pipe (**24**), flows into the outdoor circuit (**40**), passes through the first four-way switching valve (**51**) and the second four-way switching valve (**52**) in this order, and then, flows into the third suction pipe (**63**). Part of the refrigerant flowing in the third suction pipe (**63**) passes through the first branch pipe (**63a**), and then, is sucked into the second fixed capacity compressor (**43**) while the other part thereof passes through the third four-way switching valve (**53**) and the second suction pipe (**62**) in this order, and then, is sucked into the first fixed capacity compressor (**42**).

[0119] The refrigerant flowing in the cooling circuit (**100**) is pressure-reduced when passing through the cooling expansion valve (**112**), and then, is introduced into the cooling heat exchanger (**111**). In the cooling heat exchanger (**111**), the refrigerant absorbs heat from the inside air to be evaporated. For the evaporation, the cooling heat exchanger (**111**) is so set that the evaporation temperature of the refrigerant is -5 °C, for example. The refrigerant evaporated in the cooling heat exchanger (**111**) flows into the first gas side communication pipe (**23**). In the cooing showcase (**13**), the inside air cooled in the cooling heat exchanger (**111**) is supplied thereto so that the inside temperature is kept at 5 °C, for example.

[0120] The refrigerant flowing in the refrigeration circuit (**130**) is pressure-reduced when passing through the refrigeration expansion valve (**132**), and then, is introduced into the refrigeration heat exchanger (**131**). In the refrigeration heat exchanger (**131**), the refrigerant absorbs heat from the inside air to be evaporated. For the evaporation, the

refrigeration heat exchanger (**131**) is so set that the evaporation temperature of the refrigerant is -30 °C, for example. In the refrigeration showcase (**14**), the inside air cooled in the refrigeration heat exchanger (**131**) is supplied to the inside thereof so that the inside temperature is kept at -20 °C, for example.

[0121] The refrigerant evaporated in the refrigeration heat exchanger (**131**) flows into the booster circuit (**140**) to be sucked into the booster compressor (**141**). The refrigerant compressed in the booster compressor (**141**) passes through the discharge pipe (**144**) and flows into the first gas side communication pipe (**23**).

[0122] In the first gas side communication pipe (**23**), the refrigerant sent from the cooling circuit (**110**) and the refrigerant sent from the booster circuit (**140**) are combined together. Then, the combined refrigerant passes through the first gas side communication pipe (**23**) and flows into the first suction pipe (**61**) of the outdoor circuit (**40**). The refrigerant flowing in the first suction pipe (**61**) passes through the first branch pipe (**61a**) thereof to be sucked into the variable capacity compressor (**41**).

[0123] <First Heating Operation>

First heating operation is operation for cooling the inside air of the cooling showcase (**13**) and of the refrigeration showcase (**14**) and for heating room air by the air conditioning unit (**12**) to heat the store.

[0124] As shown in FIG. **3**, in the outdoor circuit (**40**), the first four-way switching valve (**51**), the second four-way switching valve (**52**), and the third four-way switching valve (**53**) are set to the second state, the first state, and the first state, respectively. The outdoor expansion valve (**46**) is closed fully while each opening of the air conditioning expansion valve (**102**), the cooling expansion valve (**112**), and the refrigeration expansion valve (**132**) is adjusted appropriately. In this condition, the variable capacity compressor (**41**) and the booster compressor (**14**) are operated while the first fixed capacity compressor (**42**) and the second fixed capacity compressor (**43**) are stopped. The outdoor heat exchanger (**44**) is stopped with no refrigerant sent thereto. During this first heating

operation, the subcooling unit (**200**) is stopped.

[0125] The refrigerant discharged from the variable capacity compressor (**41**) passes through the first four-way switching valve (**51**) and the second gas side communication pipe (**24**) in this order, is introduced into the air conditioning heat exchanger (**101**) of the air conditioning circuit (**100**), and then, radiates heat to room air to be condensed. The air conditioning unit (**12**) supplies the room air heated in the air conditioning heat exchanger (**101**) to the store. The refrigerant condensed in the air conditioning heat exchanger (**101**) passes through the second liquid side communication pipe (**22**) to be divided to flow into the cooling circuit (**110**) and the refrigeration circuit (**130**).

[0126] In the cooling showcase (**13**) and the refrigeration showcase (**14**), the inside air is cooled, like in the cooling operation. The refrigerant flowing in the cooling circuit (**110**) is evaporated in the cooling heat exchanger (**111**), and then, flows into the first gas side communication pipe (**23**). On the other hand, the refrigerant flowing in the refrigeration circuit (**130**) is evaporated in the refrigeration heat exchanger (**131**), is compressed in the booster compressor (**141**), and then, flows into the first gas side communication pipe (**23**). The refrigerant flowing in the first gas side communication pipe (**23**) passes through the first suction pipe (**61**), and then, is sucked into the variable capacitor compressor (**41**) to be compressed.

[0127] As described above, in the first heating operation, the refrigerant absorbs heat in the cooling heat exchanger (**111**) and in the refrigeration heat exchanger (**131**) while radiating heat in the air conditioning heat exchanger (**101**). Then, the store is heated by utilizing the heat that the refrigerant absorbs from the inside air of the cooling heat exchanger (**111**) and of the refrigeration heat exchanger (**131**).

[0128] It is noted that the first fixed capacity compressor (**42**) may be operated as shown in FIG. **4** during the first heating operation. The operation of the first fixed capacity compressor (**42**) depends on cooling loads in the cooling showcase (**13**) and the refrigeration showcase (**14**). In this case, the third four-way switching valve (**53**) is set to

the second state. Further, part of the refrigerant flowing in the first suction pipe (**61**) passes through the first branch pipe (**61a**) thereof to be sucked into the variable capacity compressor (**42**) while the other part thereof passes through the second branch pipe (**61b**) thereof, the third four-way switching valve (**53**), and the second suction pipe (**62**) in this order to be sucked into the first fixed capacity compressor (**42**).

[0129] <Second Heating Operation>

Second heating operation is operation for heating the store, similarly to the first heating operation. The second heating operation is performed in the case where the heating power in the first heating operation only is insufficient.

[0130] As shown in FIG. **5**, in the outdoor circuit (**40**), the first four-way switching valve (**51**), the second four-way switching valve (**52**), and the third four-way switching valve (**53**) are set to the second state, the first state, and the first state, respectively. Each opening of the outdoor expansion valve (**46**), the air conditioning expansion valve (**102**), the cooling expansion valve (**112**), and the refrigeration expansion valve (**132**) is adjusted appropriately. In this condition, the variable capacity compressor (**41**), the second fixed capacity compressor (**43**), and the booster compressor (**14**) are operated while the first fixed capacity compressor (**42**) is stopped. During this first heating operation, the subcooling unit (**200**) is stopped.

[0131] The refrigerant discharged from the variable capacity compressor (**41**) and the second fixed capacity compressor (**43**) passes through the first four-way switching valve and the second gas side communication pipe (**24**) in this order, is introduced into the air conditioning heat exchanger (**101**) of the air conditioning circuit (**100**), and then, radiates heat to room air to be condensed. The air conditioning unit (**12**) supplies the room air heated in the air conditioning heat exchanger (**101**) to the store. The refrigerant condensed in the air conditioning heat exchanger (**101**) flows into the second liquid side communication pipe (**22**). Part of the refrigerant flowing in the second liquid side communication pipe (**22**) is divided to flow into the cooling circuit (**110**) and the

refrigeration circuit (**130**) while the other part thereof is introduced into the refrigerant passage (**205**) of the subcooling unit (**200**).

[0132] In the cooling showcase (**13**) and the refrigeration showcase (**14**), the inside air is cooled, like in the cooling operation. The refrigerant flowing in the cooling circuit (**110**) is evaporated in the cooling heat exchanger (**111**), and then, flows into the first gas side communication pipe (**23**). On the other hand, the refrigerant flowing in the refrigeration circuit (**130**) is evaporated in the refrigeration heat exchanger (**131**), is compressed in the booster compressor (**141**), and then, flows into the first gas side communication pipe (**23**). The refrigerant flowing in the first gas side communication pipe (**23**) passes through the first suction pipe (**61**), and then, is sucked into the variable capacitor compressor (**41**) to be compressed.

[0133] The refrigerant flowing in the refrigerant passage (**205**) of the subcooling unit (**200**) passes through the first liquid side communication pipe (**21**) and the third liquid pipe (**83**) in this order, flows into the receiver (**45**), passes through the second liquid pipe (**82**), and then, flows into the fourth liquid pipe (**84**). The refrigerant flowing in the fourth liquid pipe (**84**) passes through the outdoor expansion valve (**46**) to be pressure-reduced, is introduced into the outdoor heat exchanger (**44**), and then, absorbs heat from outdoor air to be evaporated. The refrigerant evaporated in the outdoor heat exchanger (**44**) passes through the first four-way switching valve (**51**), the second four-way switching valve (**52**) in this order, flows into the second suction pipe (**62**), and then, is sucked into the second fixed capacity compressor (**43**) to be compressed.

[0134] As described above, in the second heating operation, the refrigerant absorbs heat in the cooling heat exchanger (**111**), the refrigeration heat exchanger (**131**), and the outdoor heat exchanger (**44**) while radiating heat in the air conditioning heat exchanger (**101**). Then, the store is heated by utilizing the heat that the refrigerant absorbs from the inside air in the cooling heat exchanger (**111**) and the refrigerant heat exchanger (**131**) and the heat that the refrigerant absorbs from outdoor air in the outdoor heat exchanger (**44**).

[0135] - Driving Operation of Subcooling Unit-

Driving operation of the subcooling unit (**200**) will be described. In the condition that the subcooling unit (**200**) is operated, the subcooling compressor (**211**) is operated and the opening of the subcooling expansion valve (**223**) is adjusted appropriately.

[0136] As shown in FIG. **1**, the subcooling refrigerant discharged from the subcooling compressor (**221**) radiates heat to outdoor air in the subcooling outdoor heat exchanger (**222**) to be condensed. The subcooling refrigerant condensed in the subcooling outdoor heat exchanger (**222**) passes through the subcooling expansion valve (**223**) to be pressure-reduced, and then, flows into the first flow paths (**211**) of the subcooling heat exchanger (**210**). In the first flow paths (**211**) of the subcooling heat exchanger (**210**), the subcooling refrigerant absorbs heat from the refrigerant in the second flow paths (**212**) to be evaporated. The subcooling refrigerant evaporated in the subcooling heat exchanger (**210**) is sucked into the subcooling compressor (**221**) to be compressed.

[0137] As described above, the controller (**240**) controls the capacity of the subcooling compressor (**221**) on the basis of the input outside air temperature. Herein, the control operation by the controller (**240**) will be described with reference to FIG. **6**. The control operation of the controller (**240**) is repeated every given time period (30 seconds, for example).

[0138] First, when the control starts, a value is calculated in a step ST1 by subtracting the target cooling temperature (Eom) set in the setting section (**241**) of the controller (**240**) from the detection temperature (Tout) of the refrigerant temperature sensor (**236**). In the present embodiment, the target cooling temperature (Eom) is set as shown in FIG. 7. Specifically, when the outside air temperature is not exceeding 25 °C, comparatively low, the target cooling temperature (Eom) is set to be 25 °C. Or, when the outside air temperature is exceeding 40 °C, the target cooling temperature (Eom) is set to be 0 °C. When the outside air temperature is within the range between 25 °C and 40 °C, the target cooling temperature (Eom) is set so as to be lowered from 25 °C to 0 °C in proportion. It

is noted that the target refrigerant temperature (Eom) is not limited to the above set values.

[0139] In the step ST1, when the difference between the detection value (Tout) and the target cooling temperature (Eom) is less than "-1.0," the routine proceeds to a step ST2. When the difference is larger than "+1.0," the routine proceeds to a step ST3. When the difference is within the range between "-1.0 and +1.0," the routine returns so that the control terminates. Specifically, the routine proceeds to the step ST2 when the cooling power and the like are excessive because of excessive cooling of the refrigerant of the refrigerating apparatus (**10**). The routine proceeds to the step ST3 when the cooling power and the like is insufficient because of insufficient cooling of the refrigerant of the refrigerating apparatus (**10**). The difference within the range between "-1.0 and +1.0" falls in a no change necessitating range that necessitates no change in operation frequency of the subcooling compressor (**221**), wherein the set width thereof is exchangeable to, for example, between "-1.5 and +1.5" and between "-2.0 and +2.0." In this case, the above set values, "less than -1.0" and larger than "+1.0" are exchanged accordingly.

[0140] In the step ST2, whether or not the operation frequency of the subcooling compressor (**221**) is the lowest frequency is judged. When it is judged as the lowest frequency, the routine returns so that the control terminates. When it is judged as not the lowest frequency, the routine proceeds to a step ST4. In the step ST4, the control section (**242**) of the controller (**240**) reduces one level the operation frequency of the subcooling compressor (**221**). This raises the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), lowering the cooling power and the like, which have been excessive, to appropriate power according to the load.

[0141] In the step ST3, whether or not the operation frequency of the subcooling compressor (**221**) is the highest frequency is judged. When it is judged as the highest frequency, the routine returns so that the control terminates. When it is judged as not the highest frequency, the routine proceeds to a step ST5. In the step ST5, the control section (**242**) of the controller (**240**) increases one level the operation frequency of the subcooling

compressor (**221**). This lowers the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), increasing the cooling power and the like, which have been insufficient, to appropriate power according to the load. It is noted that in the present embodiment, the operation frequency of the subcooling compressor (**221**) is changeable among 20 levels.

[0142] In the case where the temperature of the subcooling refrigerant cannot be detected correctly due to disorder or the like of the refrigerant temperature sensor (**236**), in the step ST1, a value is calculated by subtracting the target cooling temperature (Eom) of the setting section (**241**) from the set temperature (Tout) set with the use of the detection pressure of the suction pressure sensor (**234**). The following control subsequent thereto is the same as the control as described above.

[0143] - Effects of Embodiment -

As described above, according to the present embodiment, in the subcooling unit (**200**), the operation of the subcooling compressor (**221**) is controlled on the basis of the outside air temperature as the detection value of the sensor provided in the subcooling unit (**200**), that is, information obtainable within the subcooling unit (**200**) to adjust the cooling temperature of the refrigerant of the refrigerating apparatus (**10**). Hence, appropriate operation can be performed according to the load state of the air conditioning unit (**12**) or the like without sending and receiving any signal to and from the outdoor unit (**11**) or the air conditioning unit (**12**) of the refrigerating apparatus (**10**). As a result, for incorporating the subcooling unit (**200**) to the refrigerating apparatus (**10**), only connection of the refrigerant passage (**205**) of the subcooling unit (**200**) to the first and second liquid side communication pipes (**21**, **22**) of the refrigerating apparatus (**10**) is required. This eliminates the need to wire any communication wirings for sending and receiving a signal between the refrigerating apparatus (**10**) and the subcooling unit (**200**).

[0144] Hence, according to the present embodiment, the number of operation steps for incorporating the subcooling unit (**200**) to the refrigerating apparatus (**10**) can be reduced

and troubles caused due to human errors in installation, such as mis-wiring, can be obviated.

[0145] Moreover, the controller (**240**) controls the driving operation of the subcooling compressor (**221**) on the basis of the difference between the detection temperature (Tout) of the refrigerant and the target cooling temperature (Eom) set according to the outside air temperature, thereby enabling reliable adjustment of the cooling power with only information obtainable within the subcooling unit (**200**), as well.

[0146] Furthermore, even in the case where the refrigerant temperature sensor (**236**) becomes abnormal and cannot perform the detection, the set temperature set from the saturation temperature (TG) of the subcooling refrigerant in the detection pressure (LP) of the suction pressure sensor (**234**) provided within the subcooling unit (**200**) is regarded as the detection temperature of the refrigerant, thereby attaining further reliable adjustment of the cooling power.

[0147] In order to send and receive a signal between the subcooling unit (**200**) and the refrigerating apparatus (**10**), a communication interface is needed at the refrigerating apparatus (**10**) as well as at the subcooling unit (**200**). For this reason, in the case where operation control of a subcooling unit (**200**) requires signal input from a refrigerating apparatus (**10**), an applicable type of the refrigerating apparatus (**10**) is limited, resulting in poor usability of the subcooling unit (**200**).

[0148] In contrast, the subcooling unit (**200**) in the present embodiment eliminates the need to send and receive any signal to and from the refrigerating apparatus (**10**) and no limitation is imposed on the type of the refrigerating apparatus (**10**) as an object to which the subcooling unit (**200**) is to be incorporated. Hence, the usability of the subcooling unit (**200**) is enhanced remarkably.

[0149] - Modified Example 1 of Embodiment –

In Modified Example 1, the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**) is adjusted by controlling the operation frequency of the

outdoor fan (**230**) of the subcooling outdoor heat exchanger (**222**), rather than the control of the subcooling compressor (**221**). The outdoor fan (**230**) of the present modified example is changeable in capacity by changing the operation frequency of its fan motor.

[0150] Specifically, when the operation frequency of the outdoor fan (**230**) is reduced, the high pressure in the subcooling refrigerant circuit (**220**) increases to increase the circulation amount of the subcooling refrigerant. Accordingly, the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**) increases. This increases the amount of heat exchange between the subcooling refrigerant and the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**) to lower the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), increasing the cooling power and the like of the air conditioning unit (**12**). In reverse, when the operation frequency of the outdoor fan (**230**) is increased, the high pressure in the subcooling refrigerant circuit (**220**) reduces to reduce the circulation amount of the subcooling refrigerant. Accordingly, the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**) reduces. This reduces the amount of heat exchange between the subcooling refrigerant and the refrigerant of the refrigerating apparatus (**10**) in the subcooling heat exchanger (**210**) to raise the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), lowering the cooling power and the like of the air conditioning unit (**12**).

[0151] In the present modified example, the control operation by the controller (**240**) is as follows. In the step ST2 in FIG. **6**, whether or not the operation frequency of the outdoor fan (**230**) is the highest frequency is judged. When it is judged as the highest frequency, the routine returns so that the control terminates. When it is judged as not the highest frequency, the routine proceeds to the step ST4. In the step ST4, the control section (**242**) of the controller (**240**) increases one level the operation frequency of the outdoor fan (**230**). This raises the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), enabling lowering of the cooling power and the like, which have been excessive, to

appropriate power according to the load.

[0152] In the step ST3, whether or not the operation frequency of the outdoor fan (**230**) is the lowest frequency is judged. When it is judged as the lowest frequency, the routine returns so that the control terminates. When it is judged as not the lowest frequency, the routine proceeds to the step ST5. In the step ST5, the control section (**242**) of the controller (**240**) reduces one level the operation frequency of the outdoor fan (**230**). This lowers the cooling temperature of the refrigerant of the refrigerating apparatus (**10**), enabling increase in cooling power and the like, which have been insufficient, to appropriate power according to the load.

[0153] It is noted that in the present invention, the flow rate of the subcooling refrigerant in the subcooling heat exchanger (**210**) may be adjusted by controlling both the subcooling compressor (**221**) and the outdoor fan (**230**). In this case, the controllability of the cooling temperature of the refrigerant is enhanced.

[0154] -Modified Example 2 of Embodiment –

In Modified Example 2, the cooling fluid circuit in the above embodiment is modified, though not shown. While the refrigerant circuit serves as the cooling fluid circuit in the above embodiment, a cold water circuit in which cold water flows serves as the cooling fluid circuit in this modified example. Specifically, the cold water circuit includes the subcooling heat exchanger (**210**) and a pump so that the pump circulates the cold water between a cooling tower and the subcooling heat exchanger (**210**). In the subcooling heat exchanger (**210**), the cold water is heat-exchanged with the refrigerant of the refrigerant passage (**205**) to cool the refrigerant thereof. In short, the cold water flows as the cooling fluid in the cooling fluid circuit in the present modified example.

[0155] In this modified example, for example, when the outside air temperature is high, the operation frequency of the pump is increased for increasing the flow rate of the cold water in the subcooling heat exchanger (**210**) to lower the cooling temperature of the refrigerant, thereby increasing the cooling power and the like of the air conditioning unit

(**12**). In reverse, when the outside air temperature is low, the operation frequency of the pump is reduced for reducing the flow rate of the cold water in the subcooling heat exchanger (**210**) to raise the cooling temperature of the refrigerant, thereby lowering the cooling power and the like of the air conditioning unit (**12**). The other composition, operation and effects thereof are the same as those in the embodiment.

[0156] It is noted that in the present modified example, the setting section (**241**) of the controller (**240**) may use as the ambient condition of the subcooling heat exchanger (**210**) the temperature of the cold water after cooled in the subcooling heat exchanger (**210**), rather than the outside air temperature.

[0157] <Other Embodiments>

In the above embodiment, either the detection pressure (LP) of the suction pressure sensor (**234**) or the detection temperature (Ti) of the suction temperature sensor (**235**) is input into the control section (**242**) of the controller (**240**) when the refrigerant temperature sensor (**236**) is abnormal, but both of them may be input. In this case, the detection pressure (LP) of the suction pressure sensor (**234**) is used first when the refrigerant temperature sensor (**236**) is abnormal. Then, the detection temperature (Ti) of the suction temperature sensor (**235**) is used in the case where both the refrigerant temperature sensor (**236**) and the suction pressure sensor (**234**) are abnormal.

[0158] Further, in the above embodiment and the modified examples thereof, only the detection pressure (LP) of the suction pressure sensor (**234**) or the detection temperature (Ti) of the suction temperature sensor (**235**) may be input into the control section (**242**) without inputting the detection temperature (Tout) of the refrigerant temperature sensor (**236**). In this case, the difference between the set temperature (Tout) set from the detection pressure (LP) or the detection temperature (Ti) and the target cooling temperature (Eom) is used as a reference value for controlling the subcooling compressor (**221**) or the outdoor fan (**230**), irrespective of normal or abnormal operation of the refrigerant temperature sensor (**236**).

[0159] Moreover, if a four-way switching valve or the like is provided in the subcooling refrigerant circuit (**220**) of the above embodiment so that the refrigerant circulating direction is exchangeable and the refrigerant passage (**205**) is connected to the gas side communication pipes such as the first gas side communication pipe (**23**) and the second gas side communication pipe (**24**), the refrigerant of the refrigerating apparatus (**10**) can be heated. This prevents generally-called wet vapor suction to the respective compressors (**41**, ...) of the outdoor unit (**11**). Hence, with the subcooling refrigerant circuit (**220**) exchangeable in direction of the refrigerant circulation, the subcooling unit (**200**) in the present invention can be exchangeable between the subcooling apparatus and a heating apparatus for the refrigerant as needed.

[0160] It should be noted that the above embodiments are substantially preferred examples and do not intend to limit the scopes of the present invention, applicable objects, and use thereof.

Industrial Applicability

[0161] As described above, the present invention is useful in subcooling apparatuses for cooling refrigerant sent from a heat source unit to a utility unit in a refrigerating apparatus.

CLAIMS

[1] A subcooling apparatus which is incorporated to a refrigerating apparatus (**10**) that performs a vapor compression refrigeration cycle by circulating refrigerant between a heat source unit (**11**) and a utility unit (**12, 13, 14**) connected to each other by means of communication pipes and which cools the refrigerant of the refrigerating apparatus (**10**) sent from the heat source unit (**11**) to the utility unit (**12, 13, 14**), the subcooling apparatus, comprising:

a refrigerant passage (**205**) connected to liquid side communication pipes of the refrigerating apparatus (**10**);

a cooling fluid circuit (**220**) including a subcooling heat exchanger (**210**) that cools the refrigerant of the refrigerant passage (**205**) by heat exchange with cooling fluid; and

control means (**240**) for adjusting cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) on the basis of an ambient condition of the subcooling heat exchanger (**210**).

[2] The subcooling apparatus of Claim 1,

wherein the control means (**240**) includes a control section (**242**) for adjusting a flow rate of the cooling fluid flowing in the subcooling heat exchanger (**210**) on the basis of a target cooling temperature of the refrigerant of the refrigerant passage (**205**) in the subcooling heat exchanger (**210**) which is set in advance according to the ambient condition of the subcooling heat exchanger (**210**).

[3] The subcooling apparatus of Claim 2,

wherein the cooling fluid circuit serves as a subcooling refrigerant circuit (**220**) which includes a capacity variable subcooling compressor (**221**) and a heat source side heat exchanger (**222**) and which performs the vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and

the control section (**242**) of the control means (**240**) adjusts a flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by controlling operation frequency of the subcooling compressor (**221**) on the basis of the target cooling temperature.

[4] The subcooling apparatus of Claim 2,

wherein the cooling fluid circuit serves as a subcooling refrigerant circuit (**220**) which includes a capacity variable subcooling compressor (**221**) and a heat source side heat exchanger (**222**) and which performs the vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and

the control section (**242**) of the control means (**240**) adjusts a flow rate of the subcooling refrigerant flowing in the subcooling heat exchanger (**210**) by controlling operation frequency of a fan (**230**) of the heat source side heat exchanger (**222**) on the basis of the target cooling temperature.

[5] The subcooling apparatus of Claim 3,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the subcooling compressor (**221**) on the basis of difference between the target cooling temperature and temperature of the refrigerant of the refrigerant passage (**205**) which is cooled in the subcooling heat exchanger (**210**).

[6] The subcooling apparatus of Claim 3,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the subcooling compressor (**221**) on the basis of difference between the target cooling temperature and set temperature set from saturation temperature corresponding to low pressure of the subcooling refrigerant of the subcooling refrigerant circuit (**220**).

[7] The subcooling apparatus of Claim 3,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the subcooling compressor (**221**) on the basis of difference between the target cooling temperature and set temperature set from suction temperature of the subcooling compressor (**221**).

[8] The subcooling apparatus of Claim 4,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and temperature of the refrigerant of the refrigerant passage (**205**) which is cooled in the subcooling heat exchanger (**210**).

[9] The subcooling apparatus of Claim 4,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and set temperature set from saturation temperature corresponding to low pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**).

[10] The subcooling apparatus of Claim 4,

wherein the control section (**242**) of the control means (**240**) controls the operation frequency of the fan (**230**) on the basis of difference between the target cooling temperature and set temperature set from suction temperature of the subcooling compressor (**221**).

[11] The subcooling apparatus of Claim 1,

wherein the ambient condition of the subcooling heat exchanger (**210**) is outside air temperature.

[12] The subcooling apparatus of Claim 1,

wherein the ambient condition of the subcooling heat exchanger (**210**) is a flow rate of the refrigerant of the refrigerant passage (**205**).

[13] The subcooling apparatus of Claim 1,

wherein the ambient condition of the subcooling heat exchanger (**210**) is temperature of the refrigerant of the refrigerant passage (**205**) before cooled in the subcooling heat exchanger (**210**) or temperature of the refrigerant of the refrigerant passage (**205**) after cooled in the subcooling heat exchanger (**210**).

[14] The subcooling apparatus of Claim 1,

wherein the cooling fluid circuit is a subcooling refrigerant circuit (**220**) that performs a vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and

the ambient condition of the subcooling heat exchanger (**210**) is low pressure or high pressure of the subcooling refrigerant in the subcooling refrigerant circuit (**220**).

[15] The subcooling apparatus of Claim 1,

wherein the cooling fluid circuit is a subcooling refrigerant circuit (**220**) that performs a vapor compression refrigeration cycle by circulating subcooling refrigerant as the cooling fluid, and

the ambient condition of the subcooling heat exchanger (**210**) is temperature of the subcooling refrigerant after cooled, in the subcooling heat exchange (**210**), the refrigerant of the refrigerant passage (**205**).