

DESCRIPTION

Subcooling Apparatus

Technical Field

[0001] The present invention relates to a subcooling apparatus, which is incorporated to a refrigerating apparatus including a heat source unit and a utility unit, for cooling refrigerant sent through liquid side communication pipes from the heat source unit to the utility unit.

Background Art

[0002] Subcooling apparatuses are known which are incorporated to refrigerating apparatuses for the purpose of increasing cooling power so as to cool refrigerant sent from a heat source unit to a utility unit of the refrigerating apparatuses.

[0003] A subcooling apparatus disclosed in, for example, Patent Document 1 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 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] As described above, the subcooling apparatus is provided for increasing the cooling power by assisting the refrigerating apparatus of an air conditioner or the like. Accordingly, operation of only the subcooling apparatus in non-operation of the refrigerating apparatus is nonsense. The operation of the subcooling apparatus in the condition that the refrigerating apparatus operates as a heat pump for heating operation of the air conditioner is also nonsense. In this way, it is necessary for determining whether or not the subcooling apparatus should be operated to know the operation state of the

refrigerating apparatus to which the subcooling apparatus is incorporated.

[0005] Under the circumstances, in the conventional subcooling apparatus disclosed in Patent Document 1, 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 signal indicating an operation state of the air conditioner from the control section of the air conditioner. Then, the subcooling apparatus performs operation control on the basis of the signal input from the control section of the air conditioner.

Patent Document 1: Japanese Patent Application Laid Open Publication No. 10-185333A

10 **Summary of the Invention**

Problems that the Invention is to Solve

[0006] As described above, the conventional subcooling apparatus sends and receives a signal to and from the refrigerating apparatus to which the subcooling apparatus is incorporated. For this reason, in order to incorporate the subcooling apparatus to the refrigerating apparatus, wiring for transmitting a signal therebetween is necessary, thereby complicating installation of the subcooling apparatus. Further, mis-wiring may be involved in installation of the subcooling apparatus, resulting in invitation of troubles caused due to such miss-installation.

[0007] 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

[0008] The first invention directs to a subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10); a
5 cooling fluid circuit (220) in which cooling fluid flows; a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the cooling fluid; and control means (240) for controlling a flowing state of the cooling fluid in the cooling fluid circuit (220) according to a flowing state of the heat source side refrigerant in the refrigerant passage (205).

10 [0009] In the first invention, 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 (200) is incorporated. The refrigerant passage (205) of the subcooling apparatus (200) is connected to the liquid side communication pipes (21, 22) of the refrigerating apparatus (10) so that the heat source
15 side refrigerant of the refrigerating apparatus (10) flows therethrough. The cooling fluid flows in the cooling fluid circuit (220) of the subcooling apparatus (200). In the subcooling heat exchanger (210), the heat source side refrigerant flowing in the refrigerant passage (205) is cooled by heat exchange with the cooling fluid.

[0010] The subcooling apparatus (200) in this invention assists the operation of the
20 refrigerating apparatus (10). Accordingly, operation of the subcooling apparatus (200) is required only during operation of the refrigerating apparatus (10), and therefore, the operation of only the subcooling apparatus (200) in non-operation of the refrigerating apparatus (10) is nonsense. Also, the subcooling apparatus (200) of this invention is provided for increasing the cooling power at the utility unit (12, 13, 14). Therefore, in the
25 condition, for example, that the refrigerating apparatus (10) serves as a heat pump, no or less effect is expected through the operation of the subcooling apparatus (200). Thus, the state that the subcooling apparatus (200) should be operated or should not be operated

depends on the operation of the refrigerating apparatus (10).

[0011] In contrast, in the subcooling apparatus (200) of this invention, the control means (240) controls the flowing state of the cooling fluid in the cooling fluid circuit (220). The control means (240) performs control of the flowing state of the cooling fluid according to the flowing state of the heat source side refrigerant in the refrigerant circuit (205). In the refrigerant passage (205), the heat source side refrigerant passing to and fro between the heat source unit (11) and the utility unit (12, 13, 14) through the liquid side communication pipes (21, 22) flows. Accordingly, the operation state of the refrigerating apparatus (10) can be judged on the basis of the flowing state of the refrigerant in the refrigerant passage (205). Therefore, the control means (240) of the subcooling apparatus (200) controls the flowing state of the cooling fluid in the cooling fluid circuit (220) according to the flowing state of the heat source side refrigerant in the refrigerant passage (205) without receiving a signal relating to the operation state of the refrigerating apparatus (10) from the refrigerating apparatus (10).

[0012] Referring to the second invention, in the subcooling apparatus of the first invention, the cooling fluid circuit is composed of a subcooling refrigerant circuit (220), and the subcooling refrigerant circuit (220) includes a subcooling compressor (221) and performs a refrigeration cycle by circulating subcooling refrigerant as the cooling fluid.

[0013] In the second invention, the refrigeration cycle is performed by circulating the subcooling refrigerant in the subcooling refrigerant circuit (220) of the subcooling apparatus (200). The subcooling heat exchanger (210) performs heat exchange between the heat source side refrigerant flowing in the refrigerant passage (205) and the subcooling refrigerant. In the subcooling heat exchanger (210), the subcooling refrigerant absorbs heat from the heat source side refrigerant to be evaporated, thereby cooling the heat source side refrigerant.

[0014] Referring to the third invention, in the subcooling apparatus of the second invention, the control means (240) controls a circulation state of the subcooling refrigerant

in the subcooling refrigerant circuit (220) by controlling operation of the subcooling compressor (221).

[0015] In the third invention, when the control means (240) adjusts operation capacity of the subcooling compressor (221), the circulation amount of the subcooling refrigerant in the subcooling refrigerant circuit (220) varies. Therefore, control of the operation of the subcooling compressor (221) attains control of the circulation state of the subcooling refrigerant in the subcooling refrigerant circuit (220).

[0016] Referring to the fourth invention, in the subcooling apparatus of the third invention, the control means (240) detects a direction in which the heat source side refrigerant flows in the refrigerant passage (205) and a state in which the heat source side refrigerant flows or does not flow in refrigerant passage (205) in operation of the subcooling compressor (221) as the flowing state of the heat source side refrigerant, and the control means (240) allows the subcooling compressor (221) to continue operating in a state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205) or stops the operation of the subcooling compressor (221) in a state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or in a state that the heat source side refrigerant does not flow in the refrigerant passage (205).

[0017] In the fourth invention, the control means (240) detects the flowing state of the refrigerant in operation of the subcooling compressor (221). Specifically, the control means (240) detects, as the flowing state of the refrigerant, the flowing direction of the refrigerant in the refrigerant passage (205) and flow of the refrigerant in the refrigerant passage (205).

[0018] The control means (240) of this invention performs operation control of the subcooling compressor (221) on the basis of the detected flowing state of the refrigerant. The state that the refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205) can be judged as the state that the refrigerating

apparatus (10) performs operation for cooling an object in the utility unit (12, 13, 14). Therefore, in this state, the control means (240) allows the subcooling compressor (221) to continue operating so that the subcooling apparatus (200) cools the refrigerant flowing from the heat source unit (11) to the utility unit (12, 13, 14). In contrast, the state that the refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) and the state that the refrigerant does not flow in the refrigerant passage (205) can be judged as the state that the refrigerating apparatus (10) does not perform the operation for cooling an object in the utility unit (12, 13, 14). Therefore, in these states, the control means (240) stops the operation of the subcooling compressor (221) to avoid unnecessary operation of the subcooling apparatus (200).

[0019] Referring to the fifth invention, in the subcooling apparatus of fourth invention, the control means (240) activates the subcooling compressor (221) after a predetermined time period elapses from a time point when the subcooling compressor (221) is stopped.

[0020] In the fifth invention, the control means (240) times elapsed time from the time point when the subcooling compressor (221) is stopped. The control means (240) activates the subcooling compressor (21) upon elapse of the predetermined time period from the time point when the subcooling compressor (221) is stopped. The control means (240) detects the flowing state of the refrigerant in the refrigerant passage (205) after activation of the subcooling compressor (221) to judge whether the subcooling compressor (221) should be kept operating or should be stopped.

[0021] Referring to the sixth invention, the subcooling apparatus of any one of the third, fourth, and fifth inventions further includes refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210), wherein the control means (240) judges the flowing state of the heat source side refrigerant on the basis of variation in detection value of the refrigerant temperature detection means (236) from a time point when the subcooling compressor (221) is activated.

[0022] In the sixth invention, the subcooling apparatus (200) includes the refrigerant temperature detection means (236). The refrigerant temperature detection means (236) detects refrigerant temperature at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210).

[0023] The control means (240) of this invention judges the flowing state of the refrigerant in the refrigerant passage (205) on the basis of variation in detection value of the refrigerant temperature detection means (236) from the time point when the subcooling compressor (221) is activated. For example, the state that the detection value of the refrigerant temperature detection means (236) decreases as the time elapses from activation of the subcooling compressor (221) can be judged as the state that the temperature of the refrigerant cooled in the subcooling heat exchanger (210) is detected by the refrigerant temperature detection means (236), and in turn, can be judged as the state that the refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). Also, the state that the detection value of the refrigerant temperature detection means (236) does not vary even after a predetermined time period elapses from activation of the subcooling compressor (221) can be judged as the state that the temperature of the refrigerant before flowing into the subcooling heat exchanger (210) is detected by the refrigerant temperature detection means (236) or as the state that the refrigerant does not flow in the refrigerant passage (205).

[0024] Referring to the seventh invention, the subcooling apparatus of any one of the third, fourth, and fifth inventions further includes: refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210); and evaporation temperature detection means (234) for detecting evaporation temperature of the subcooling refrigerant in the subcooling heat exchanger (210), wherein the control means (240) judges the flowing state of the heat source side refrigerant on the basis of a

detection value of the refrigerant temperature detection means (236) and a detection value of the evaporation temperature detection means (234).

[0025] In the seventh invention, the subcooling apparatus (200) includes the refrigerant temperature detection means (236) and the evaporation temperature detection means (234).

5 The refrigerant temperature detection means (236) detects refrigerant temperature at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210). The evaporation temperature detection means (234) detects evaporation temperature of the subcooling refrigerant in the subcooling heat exchanger (210).

[0026] The control means (240) of this invention judges the flowing state of the
10 refrigerant in the refrigerant passage (205) on the basis of the detection value of the refrigerant temperature detection means (236) and the detection value of the evaporation temperature detection means (234). For example, the state that the detection value of the refrigerant temperature detection means (236) is slightly greater than the detection value of the evaporation temperature detection means (234) can be judged as the state that the
15 temperature of the refrigerant cooled in the subcooling heat exchanger (210) is detected by the refrigerant temperature detection means (236), and in turn, can be judged as the state that the refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). In contrast, the state that the detection value of the refrigerant temperature detection means (236) is largely greater than the detection value of
20 the evaporation temperature detection means (234) can be judged as the state that the temperature of the refrigerant before flowing into the subcooling heat exchanger (210) is detected by the refrigerant temperature detection means (236) or as the state that the refrigerant does not flow in the refrigerant passage (205).

[0027] Referring to the eighth invention, the subcooling apparatus of any one of the third,
25 fourth, and fifth inventions further includes: first refrigerant temperature detection means (237) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat

exchanger (210); and second refrigerant temperature detection means (238) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the heat source unit (11) than the subcooling heat exchanger (210), wherein the control means (240) judges the flowing state of the heat source side refrigerant on the basis of a detection value of the first refrigerant temperature detection means (237) and a
5 detection value of the second refrigerant temperature detection means (238).

[0028] In the eighth invention, the subcooling apparatus (200) includes the first refrigerant temperature detection means (237) and the second refrigerant temperature detection means (238). The first refrigerant temperature detection means (237) detects the refrigerant
10 temperature at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210). The second refrigerant temperature detection means (238) detects refrigerant temperature at a part of the refrigerant passage (205) nearer the heat source unit (11) than the subcooling heat exchanger (210).

[0029] The control means (240) of this invention judges the flowing state of the
15 refrigerant in the refrigerant passage (205) on the basis of the detection value of the first refrigerant temperature detection means (237) and the detection value of the second refrigerant temperature detection means (238). For example, the state that the detection value of the first refrigerant temperature detection means (237) is sufficiently smaller than the detection value of the second refrigerant temperature detection means (238) can be
20 judged as the state that the refrigerant flowing from the heat source unit (11) towards the utility unit (12, 13, 14) is cooled in the subcooling heat exchanger (210). In reverse, the state that the detection value of the first refrigerant temperature detection means (237) is greater than the detection value of the second refrigerant temperature detection means (238) can be judged as the state that the refrigerant flowing from the utility unit (12, 13,
25 14) towards the heat source unit (11) is cooled in the subcooling heat exchanger (210). As well, the state that the detection value of the first refrigerant temperature detection means (237) is almost equal to the detection value of the second refrigerant temperature

detection means (238) can be judged as the state that the refrigerant does not flow in the refrigerant passage (205).

[0030] Referring to the ninth invention, in the subcooling apparatus of any one of the first, second, and third invention, a flow meter (251) is provided at the refrigerant passage (205) for detecting a flow rate of the heat source side refrigerant, and the control means (240) uses a detection value of the flow meter (251) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220).

[0031] In the ninth invention, the detection value of the flow meter (251) is input to the control means (240). The flowing state of the heat source side refrigerant in the refrigerant passage (205) can be judged from the detection value of the flow meter (251). Therefore, the control means (240) uses the detection value of the flow meter (251) as a flowing state indication value to control the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication value.

[0032] Referring to the tenth invention, the subcooling apparatus of any one of the first, second, and third inventions, further includes: first refrigerant temperature detection means (237) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210); and second refrigerant temperature detection means (238) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the heat source unit (11) than the subcooling heat exchanger (210), wherein the control means (240) uses a difference between a detection value of the first refrigerant temperature detection means (237) and a detection value of the second refrigerant temperature detection means (238) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines,

on the basis of the flowing state indication value, whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220).

[0033] In the tenth invention, the detection values of the first refrigerant temperature
5 detection means (237) and the second refrigerant temperature detection means (238) are
input to the control means (240). Comparison between the detection value of the first
refrigerant temperature detection means (237) and the detection value of the second
refrigerant temperature detection means (238) attains judgment of the flowing state of the
10 heat source side refrigerant in the refrigerant passage (205). For example, the state that
the detection value of the first refrigerant temperature detection means (237) is smaller
than the detection value of the second refrigerant temperature detection means (238) can be
judged as the state that the heat source side refrigerant flows from the heat source unit (11)
towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can
15 be judged as the state that the heat source side refrigerant flows from the utility unit (12, 13,
14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the
heat source side refrigerant does not flow therein. Therefore, the control means (240)
uses the difference between the detection value of the first refrigerant temperature
detection means (237) and the detection value of the second refrigerant temperature
20 detection means (238) as a flowing state indication value to control the flowing state of the
cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication
value.

[0034] Referring to the eleventh invention, the subcooling apparatus of any one of the first,
second, and third inventions further includes refrigerant temperature detection means (236)
for detecting temperature of the heat source side refrigerant at a part of the refrigerant
25 passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210),
wherein the control means (240) uses variation in detection value of the refrigerant
temperature detection means (236) as a flowing state indication value that indicates the

flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220).

5 [0035] In the eleventh invention, the detection value of the refrigerant temperature detection means (236) is input to the control means (240). Monitoring variation in detection value of the refrigerant temperature detection means (236) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the detection value of the refrigerant temperature detection means
10 (236) decreases in the state that the cooling fluid flows is judged as the state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can be judges as the state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the heat source side refrigerant
15 does not flow therein. Therefore, the control means (240) uses the detection value of the refrigerant temperature detection means (236) as a flowing state indication value to control the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication value.

[0036] Referring to the twelfth invention, in the subcooling apparatus of any one of the
20 first, second, and third inventions, the cooling fluid circuit (220) includes inlet side fluid temperature detection means (252) for detecting temperature of the cooling fluid at an inlet of the subcooling heat exchanger (210) and outlet side fluid temperature detection means (253) for detecting temperature of the cooling fluid at an outlet of the subcooling heat exchanger (210), and the control means (240) uses a difference between a detection value
25 of the inlet side fluid temperature detection means (252) and a detection value of the outlet side fluid temperature detection means (253) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240)

determines, on the basis of the flowing state indication value, whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220).

[0037] In the twelfth invention, the detection values of the inlet side fluid temperature detection means (252) and the outlet side fluid temperature detection means (253) are input to the control means (240). Comparison between the detection value of the inlet side fluid temperature detection means (252) and the detection value of the inlet side fluid temperature detection means (252) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the detection value of the inlet side fluid temperature detection means (252) is greater than the detection value of the inlet side fluid temperature detection means (252) is judged as the state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can be judges as the state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the heat source side refrigerant does not flow therein. Therefore, the control means (240) uses the difference between the detection value of the inlet side fluid temperature detection means (252) and the detection value of the outlet side fluid temperature detection means (253) as a flowing state indication value to control the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication value.

[0038] Referring to the thirteenth invention, in the subcooling apparatus of the second or third invention, the subcooling refrigerant circuit (220) includes evaporation pressure detection means (234) for detecting evaporation pressure of the subcooling refrigerant in the subcooling heat exchanger (210), and the control means (240) uses a detection value of the evaporation pressure detection means (234) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether circulation of the

subcooling fluid should be continued or stopped in a state that the subcooling fluid circulates in the cooling fluid circuit (220).

- [0039] In the thirteenth invention, the detection value of the evaporation pressure detection means (234) is input to the control means (240). Monitoring variation in
- 5 detection value of the evaporation pressure detection means (234) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the detection value of the evaporation pressure detection means (234) is greater to some extent than a predetermined value in the state that the subcooling refrigerant circulates is judged as the state that the heat source side refrigerant flows in the
- 10 refrigerant passage (205). The other states can be judged as the state that the heat source side refrigerant does not flow in the refrigerant passage (205). Therefore, the control means (240) uses the detection value of the evaporation pressure detection means (234) as a flowing state indication value to control the flowing state of the subcooling refrigerant in the subcooling refrigerant circuit (220) on the basis of the flowing state indication value.
- 15 [0040] Referring to the fourteenth invention, the subcooling apparatus of the second or third invention further includes: refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210); and evaporation temperature detection means (234) for detecting evaporation temperature of
- 20 the subcooling refrigerant in the subcooling heat exchanger (210), wherein the control means (240) uses a difference between a detection value of the refrigerant temperature detection means (236) and a detection value of the evaporation temperature detection means (234) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing
- 25 state indication value, whether circulation of the subcooling refrigerant should be continued or stopped in a state that the subcooling refrigerant circulates in the subcooling refrigerant circuit (220).

[0041] In the fourteenth invention, the detection values of the refrigerant temperature detection means (236) and the evaporation temperature detection means (234) are input to the control means (240). Comparison between the detection value of the refrigerant temperature detection means (236) and the detection value of the evaporation temperature detection means (234) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the difference between the detection value of the refrigerant temperature detection means (236) and the detection value of the evaporation temperature detection means (234) is equal to or smaller than a predetermined value (10 °C, for example) can be judged as the state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can be judged as the state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the heat source side refrigerant does not flow therein. Therefore, the control means (240) uses the difference between the detection value of the refrigerant temperature detection means (236) and the detection value of the evaporation temperature detection means (234) as a flowing state indication value to control the flowing state of the subcooling refrigerant in the subcooling refrigerant circuit (220) on the basis of the flowing state indication value.

[0042] Referring to the fifteenth invention, the subcooling apparatus of any one of the first, second, and third inventions, further includes refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210), wherein the control means (240) uses a detection value of the refrigerant temperature detection means (236) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether the flow of the cooling fluid should be started or kept stopping in a state that the cooling fluid stops flowing in the

cooling fluid circuit (220).

[0043] In the fifteenth invention, the detection value of the refrigerant temperature detection means (236) is input to the control means (240). Monitoring the detection value of the refrigerant temperature detection means (236) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the detection value of the refrigerant temperature detection means (236) is greater to some extent than a predetermined value in the state that the cooling fluid stops flowing can be judged as the state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can be judged as the state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the heat source side refrigerant does not flow therein. Therefore, the control means (240) uses the detection value of the refrigerant temperature detection means (236) as a flowing state indication value to control the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication value.

[0044] Referring to the sixteenth invention, the subcooling apparatus of any one of the first, second, and third inventions further includes refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210), wherein the control means (240) uses variation in detection value of the refrigerant temperature detection means (236) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether the flow of the cooling fluid should be started or kept stopping in a state that the cooling fluid stops flowing in the cooling fluid circuit (220).

[0045] In the sixteenth invention, the detection value of the refrigerant temperature detection means (236) is input to the control means (240). Monitoring variation in

detection value of the refrigerant temperature detection means (236) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the detection value of the refrigerant temperature detection means (236) increases in the state that the cooling fluid stops flowing can be judged as the state that the heat source side refrigerant flows from the heat source unit (11) towards the utility unit (12, 13, 14) in the refrigerant passage (205). The other states can be judged as the state that the heat source side refrigerant flows from the utility unit (12, 13, 14) towards the heat source unit (11) in the refrigerant passage (205) or as the state that the heat source side refrigerant does not flow therein. Therefore, the control means (240) uses the variation in detection value of the refrigerant temperature detection means (236) as a flowing state indication value to control the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the flowing state indication value.

[0046] Referring to the seventeenth invention, the subcooling apparatus of the second or third invention further includes: outside air temperature detection means (231) for detecting temperature of outside air; and refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210), wherein the control means (240) uses a difference between a detection value of the refrigerant temperature detection means (236) and a detection value of the outside air temperature detection means (231) as a flowing state indication value that indicates the flowing state of the heat source side refrigerant, and the control means (240) determines, on the basis of the flowing state indication value, whether the flow of the subcooling refrigerant should be started or kept stopping in a state that the subcooling refrigerant stops flowing in the subcooling refrigerant circuit (220).

[0047] In the seventeenth invention, the detection values of the outside air temperature detection means (231) and the refrigerant temperature detection means (236) are input to the control means (240). Comparison between the detection value of the refrigerant

temperature detection means (236) and the detection value of the outside air temperature detection means (231) attains judgment of the flowing state of the heat source side refrigerant in the refrigerant passage (205). For example, the state that the difference between the detection value of the refrigerant temperature detection means (236) and the
 5 detection value of the outside air temperature detection means (231) is equal to or greater than a predetermined value in the state that the cooling fluid stops flowing can be judged as the state that the heat source side refrigerant flows in the refrigerant passage (205). The reverse state can be judged as the state that the heat source side refrigerant does not flow therein. Therefore, the control means (240) uses the difference between the detection
 10 value of the refrigerant temperature detection means (236) and the detection value of the outside air temperature detection means (231) as a flowing state indication value to control the flowing state of the subcooling refrigerant in the subcooling refrigerant circuit (220) on the basis of the flowing state indication value.

[0048] The eighteenth invention directs to a subcooling apparatus which is incorporated to
 15 a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in the refrigerating apparatus (10) sent from the heat source unit (11) to the utility unit (12, 13, 14). Wherein the heat source unit (11) of the refrigerating apparatus
 20 (10) performs heat exchange between the heat source side refrigerant and outdoor air, and the subcooling apparatus includes: a refrigerant passage (205) connected to liquid side communication pipes (21, 22) of the refrigerating apparatus (10); a cooling fluid circuit (220) in which cooling fluid flows; a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the cooling
 25 fluid; outside air temperature detection means (231) for detecting temperature of outside air; and control means (240) for controlling a flowing state of the cooling fluid in the cooling fluid circuit (220) according to a detection value of the outside air temperature

detection means (231).

[0049] In the eighteenth invention, similar to the first invention, the cooling fluid cools the heat source side refrigerant in the refrigerant passage (205). The detection value of the outside air temperature detection means (231) is input to the control means (240) of this invention. Monitoring the detection value of the outside air temperature detection means (231) attains estimation of the magnitude of cooling load in the utility unit (12, 13, 14), leading to judgment as to whether or not the heat source side refrigerant in the refrigerant passage (205) should be cooled. Therefore, the control means (240) controls the flowing state of the cooling fluid in the cooling fluid circuit (220) on the basis of the detection value of the outside air temperature detection means (231).

[0050] Referring to the nineteenth invention, in the subcooling apparatus of the eighteenth invention, the cooling fluid circuit is composed of a subcooling refrigerant circuit (220), and the subcooling refrigerant circuit (220) includes a subcooling compressor (221) and performs a refrigeration cycle by circulating the subcooling refrigerant as the cooling fluid.

[0051] In the nineteenth invention, the subcooling refrigerant circuit (220) of the subcooling apparatus (200) performs the refrigeration cycle by circulating the subcooling refrigerant. The subcooling heat exchanger (210) performs heat exchange between the heat source side refrigerant flowing in the refrigerant passage (205) and the subcooling refrigerant. In the subcooling heat exchanger (210), the subcooling refrigerant absorbs heat from the heat source side refrigerant to be evaporated, thereby cooling the heat source side refrigerant.

[0052] Referring to the twentieth invention, in the subcooling apparatus of the eighteenth or nineteenth invention, the control means (240) determines, on the basis of a detection value of the outside air temperature detection means (231), whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220).

[0053] Referring to the twenty-first invention, in the subcooling apparatus of the

eighteenth or nineteenth invention, the control means (240) determines, on the basis of a detection value of the outside air temperature detection means (231), whether the flow of the cooling fluid should be started or kept stopping in a state that the cooling fluid does not flow in the cooling fluid circuit (220).

5 [0054] In the twentieth and twenty-first inventions, the control means (240) monitors the detection value of the outside air temperature detection means (231). The detection value of the outside air temperature detection means (231) exceeding a predetermined reference value (25 °C, for example) leads to estimation of the state that the cooling load in the utility unit (12, 13, 14) increases and the heat source side refrigerant in the refrigerant passage
10 (205) should be cooled. The reverse state leads to estimation of the state that the cooling load in the utility unit (12, 13, 14) is not so high and cooling of the heat source side refrigerant in the refrigerant passage (205) is not so necessary. Therefore, the control means (240) judges on the basis of the detection value of the outside air temperature detection means (231) whether or not the cooling fluid should be allowed to flow in the
15 cooling fluid circuit (220).

[0055] Referring to the twenty-second invention, the subcooling apparatus of the second or nineteenth invention further includes: heat radiation heat exchanger (222) connected to the subcooling refrigerant circuit (220) for performing heat exchange between the subcooling refrigerant and outdoor air; and outdoor fan (230) for supplying outdoor air to
20 the heat radiation heat exchanger (222), wherein the subcooling refrigerant circuit (220) is capable of performing natural circulation operation that allows the subcooling refrigerant to naturally circulate by operating the outdoor fan (230) in non-operation of the subcooling compressor (221), and the control means (240) allows the subcooling refrigerant circuit (220) to perform the natural circulation operation by activating the outdoor fan (230) in
25 order to start circulation of the subcooling refrigerant, and the control means (240) determines whether the subcooling compressor (221) should be activated or kept stopping according to the flowing state of the heat source side refrigerant in the refrigerant passage

(205) in natural circulation operation.

[0056] In the twenty-second invention, even during the time when the subcooling compressor (221) is stopped, the subcooling refrigerant circulates in the subcooling refrigerant circuit (220) by operating the outdoor fan (230). Namely, in the subcooling
5 refrigerant circuit (220), the operation of the outdoor fan (230) only can cool the heat source side refrigerant in the subcooling heat exchanger (210). For starting the circulation of the subcooling refrigerant, the control means (240) of this invention first activates only the outdoor fan (230) to cause natural circulation of the subcooling refrigerant in the subcooling refrigerant circuit (220) for cooling the heat source side
10 refrigerant through the naturally circulating subcooling refrigerant. Then, the control means (240) judges whether or not the heat source side refrigerant is sufficiently cooled in this condition and determines whether the subcooling compressor (221) should be activated according to the judgment. In detail, the control means (240) keeps the subcooling compressor (221) being stopped when the heat source side refrigerant is
15 sufficiently cooled while activating the subcooling compressor (221) when the heat source side refrigerant is insufficiently cooled for starting the refrigeration cycle in the subcooling refrigerant circuit (220).

Effects of the Invention

[0057] In the subcooling apparatus (200) of the present invention, the control means (240)
20 controls the operation of the subcooling compressor (221) according to the flowing state of the refrigerant in the refrigerant passage (205). Accordingly, in the subcooling apparatus (200), the operation of the subcooling compressor (221) can be controlled according to the operation state of the refrigerating apparatus (10) without sending and receiving a signal to and from the refrigerating apparatus (10). As a result, for incorporating the subcooling
25 apparatus (200) to the refrigerating apparatus (10), only connection of the refrigerant passage (205) of the subcooling apparatus (220) to the 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 apparatus (200).

[0058] Hence, according to the present invention, the number of operation steps for incorporating the subcooling apparatus (200) to the refrigerating apparatus (10) can be reduced and troubles caused due to human errors in installation, such as mis-wiring and the like, can be obviated.

Brief Description of the Drawings

[0059] [FIG. 1] FIG. 1 is a piped system diagram showing a construction of a refrigeration system including a subcooling unit.

10 [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.

20 [FIG. 7] FIG. 7 is a piped system diagram showing a construction of a refrigeration system in Modified Example 1 of Embodiment.

[FIG. 8] FIG. 8 is a piped system diagram showing a construction of a refrigeration system in Modified Example 2 of Embodiment.

[FIG. 9] FIG. 9 is a piped system diagram showing a construction of a refrigeration system in Modified Example 5 of Embodiment.

25 [FIG. 10] FIG. 10 a piped system diagram showing a construction of a refrigeration system in Modified Example 10 of Embodiment.

Explanation of Reference Numerals

[0060]	10	refrigerating apparatus
	11	outdoor unit (heat source unit)
	12	air conditioning unit (utility unit)
5	13	cooling showcase (utility unit)
	14	refrigeration showcase (utility unit)
	21	first liquid side communication pipe (liquid side communication pipe)
	22	second liquid side communication pipe (liquid side communication pipe)
	205	refrigerant passage
10	210	subcooling heat exchanger
	220	subcooling refrigerant circuit (cooling fluid circuit)
	221	subcooling compressor
	200	subcooling unit (subcooling apparatus)
	230	outdoor fan
15	234	suction pressure sensor (evaporation temperature detection means, evaporation pressure detection means)
	236	refrigerant temperature sensor (refrigerant temperature detection means)
	237	first refrigerant temperature sensor (first refrigerant temperature detection means)
20	238	second refrigerant temperature sensor (second refrigerant temperature detection means)
	240	controller (control means)
	251	flow meter
25	252	first subcooling refrigerant temperature sensor (inlet side fluid temperature detection means)
	253	second subcooling refrigerant temperature sensor (outlet side fluid temperature detection means)

Best mode for Carrying out the Invention

[0061] Embodiments of the present invention will be described in detail with reference to the drawings.

[0062] 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.

[0063] 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.

[0064] 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 (200) includes a refrigerant passage (205). In the refrigeration system, these circuits (40, 100, ...) are connected to the refrigerant passage (205) of the subcooling unit (200) by means of pipes to form a refrigerant circuit (20). Heat source side refrigerant is filled in the refrigerant circuit (20).

[0065] 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).

[0066] 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
 5 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).

[0067] One end of the first gas side communication pipe (23) branches into two ends
 10 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
 15 (40).

[0068] <Outdoor Unit>

The outdoor unit (11) serves as a heat source unit of the refrigerating apparatus (10). The outdoor unit (11) includes the outdoor circuit (40).

[0069] The outdoor circuit (40) includes a variable capacity compressor (41), a first fixed
 20 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
 25 (54), and two gas side closing valves (55, 56).

[0070] 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.

[0071] 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.

[0072] 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 (61b) of the first suction pipe (61).

[0073] 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).

[0074] 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 branch 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).

[0075] 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).

[0076] 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).

[0077] 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).

[0078] 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).

[0079] 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).

[0080] 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.

[0081] 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 on the downstream side of the solenoid valve (SV-7) for allowing the refrigerant to flow from the solenoid valve (SV-7) towards the first liquid pipe (81).

[0082] 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 (shown by the solid lines in FIG. 1) 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 (shown by the broken lines in FIG. 1) that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0083] 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 (shown by the solid lines in FIG. 1) 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 (shown by the broken lines in FIG. 1) that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0084] 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 (shown by the solid lines in FIG. 1) 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 (shown by the broken lines in FIG. 1) that the first port and the fourth port communicate with each other while the second port and the third port communicate with each other.

[0085] 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).

[0086] 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.

[0087] 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.

[0088] The oil separator (75) is provided on the upstream side 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).

[0089] 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).

[0090] 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).

[0091] 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 temperature sensor (99) and a high pressure switch (96) are provided in the second discharge pipe (65).

[0092] 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).

[0093] <Air Conditioning Unit>

5 The air conditioning unit (12) composes a utility unit. The air conditioning unit (12) includes the air conditioning circuit (100). The air conditioning circuit (100) 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).

10 [0094] The air conditioning circuit (100) includes an air conditioning expansion valve (102) and an air conditioning heat exchanger (101) in this order from 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.

15 [0095] 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
20 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).

[0096] <Cooling Showcase>

 The Cooling showcase (13) composes the utility unit. The cooling showcase (13) includes the cooling circuit (110). The cooling circuit (110) is connected at the liquid
25 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).

[0097] 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).

[0098] 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).

[0099] <Refrigeration Showcase>

The refrigeration showcase (14) composes the utility unit. The refrigeration showcase (143) includes the refrigeration circuit (130). The refrigeration circuit (130) 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.

[0100] 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).

[0101] 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).

[0102] <Booster Unit>

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

[0103] 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.

[0104] 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.

[0105] 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).

[0106] 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).

[0107] 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.

[0108] <Subcooling Unit>

The subcooling unit (200) as a subcooling apparatus includes the refrigerant passage (205), a subcooling refrigerant circuit (220), a subcooling heat exchanger (210),
5 and a controller (240).

[0109] 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).

[0110] The subcooling refrigerant circuit (220) is a closed circuit formed in such a fashion
10 that the subcooling compressor (221), the subcooling outdoor heat exchanger (222), a subcooling expansion valve (223), and the subcooling heat exchanger (210) are connected by means of pipes in this order. The subcooling refrigerant circuit (220) serves as a cooling fluid circuit. Subcooling refrigerant serving as cooling fluid is filled in the subcooling refrigerant circuit (220). As the subcooling refrigerant, there may be used not
15 only generally-called fluorocarbon refrigerants such as R704 and the like but also various refrigerants such as carbon dioxide (CO₂), ammonium, and the like. The subcooling refrigerant circuit (220) performs a refrigeration cycle by circulating the subcooling refrigerant filled therein.

[0111] The subcooling compressor (221) is a hermetic scroll compressor of high pressure
20 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. The subcooling outdoor heat exchanger (222) is a fin and tube heat exchanger of cross fin type. The subcooling outdoor heat exchanger (222) performs heat exchange between the
25 subcooling refrigerant and outdoor air. The subcooling expansion valve (223) is an electronic expansion valve.

[0112] The subcooling heat exchanger (210) is a generally-called a plate type 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

5 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).

[0113] 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

10 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

15 temperature sensor (236) serves as refrigerant temperature detection means.

[0114] The subcooling unit (200) also includes an outside air temperature sensor (231) and an outdoor fan (230). The outdoor fan (230) sends outside air to the subcooling outdoor heat exchanger (222).

[0115] The controller (240) serves as control means. The controller (240) receives the

20 detection value of the refrigerant temperature sensor (236), the detection value of the suction pressure sensor (236), and the detection value of the outside air temperature sensor (231). The controller (240) controls activation and stop of the subcooling compressor (221) on the basis of the input detection values of the sensors. The controller (240) receives none of signals from the refrigerating apparatus (10) composed of the outdoor unit

25 (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 inside the subcooling unit (200), such as detection values of the sensors provided

in the subcooling unit (200).

[0116] - Driving Operation of Refrigeration System -

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

5 [0117] <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.

[0018] As shown in FIG. 2, during the cooling operation, the first four-way switching
10 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),
15 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.

[0119] 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
20 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).

25 [0120] 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).

5 [0121] 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
10 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.

[0122] 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
15 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).

20 [0123] 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.

25 The refrigerant evaporated in the cooling heat exchanger (111) flows into the first gas side communication pipe (23). In the cooling 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.

[0124] 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.

[0125] 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).

[0126] 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).

[0127] <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.

[0128] 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.

[0129] 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).

[0130] 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.

[0131] 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).

[0132] 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).

[0133] <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.

[0134] 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.

[0135] The refrigerant discharged from the variable capacity compressor (41) and the second fixed capacity compressor (43) 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) 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).

[0136] 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.

[0137] 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.

[0138] 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
 5 that the refrigerant absorbs from outdoor air in the outdoor heat exchanger (44).

[0139] - 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.

10 [0140] As shown in FIG. 1, the subcooling refrigerant discharged from the subcooling compressor (221) radiates heat to outside 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
 15 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.

[0141] As described above, the controller (240) controls activation and stop of the
 20 subcooling compressor (221) on the basis of the detection values input from the sensors. 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 (10 seconds, for example).

[0142] First, in a step ST10, whether the subcooling compressor (221) is operated or
 25 stopped is checked.

[0143] If it is judged in the step ST10 that the subcooling compressor (221) is operated, the routine proceeds to a step ST11. In the step ST11, judgment is performed as to

whether or not a predetermined time period (two minutes, for example) has elapsed from the time point when the subcooling compressor (221) is activated. If the predetermined time period has elapsed from the time point when the subcooling compressor (221) is activated, the routine proceeds to a step ST12. On the other hand, if the predetermined time period has not elapsed yet, the routine proceeds to a step ST14 so that the control operation is once terminated for allowing the subcooling compressor (221) to continue operating.

[0144] In the step ST12, judgment is performed as to whether or not the subcooling compressor (221) should be stopped. In the step ST12, judgment is performed as to whether or not the following four conditions are fulfilled. If at least one of the four conditions is fulfilled, the routine proceeds to a step ST13 for stopping the subcooling compressor (221). On the other hand, if none of the four conditions are fulfilled, the routine proceeds to the step ST14 so that the control operation is once terminated for allowing the subcooling compressor (221) to continue operating.

[0145] The first condition in the step ST12 will be described. The first condition is a condition for judging whether the detection value of the refrigerant temperature sensor (236) decreases favorably after activation of the subcooling compressor (221).

[0146] In order to fulfill the first condition in the step ST12, the following six requirements must be satisfied. The first requirement requires a detection value T_a of the outdoor temperature sensor (231) to be below 20 °C ($T_a < 20$). The second requirement requires a difference between a detection value $T_{out\#0}$ of the refrigerant temperature sensor (236) at the time point when the subcooling compressor (221) is activated and a detection value $T_{out\#1}$ of the refrigerant temperature sensor (236) after one minute elapses from the activation of the subcooling compressor (221) to be equal to or smaller than 3 °C ($T_{out\#0} - T_{out\#1} \leq 3$). The third requirement requires a difference between the detection value $T_{out\#0}$ of the refrigerant temperature sensor (236) at the time point when the subcooling compressor (221) is activated and a detection value $T_{out\#2}$ of the refrigerant

temperature sensor (236) after two minutes elapse from the activation of the subcooling compressor (221) to be equal to or smaller than 5 °C ($T_{out\#0} - T_{out\#2} \leq 5$). The fourth requirement requires a difference between the detection value $T_{out\#0}$ of the refrigerant temperature sensor (236) at the time point when the subcooling compressor (221) is activated and a detection value $T_{out\#3}$ of the refrigerant temperature sensor (236) after three minutes elapse from the activation of the subcooling compressor (221) to be equal to or smaller than 7 °C ($T_{out\#0} - T_{out\#3} \leq 7$). The fifth requirement requires three minutes to elapse after the time point when the subcooling compressor (221) is activated. The sixth requirement requires the refrigerant temperature sensor (236) to operate normally.

10 [0147] When all of the first to sixth requirements are satisfied, the detection value T_{out} of the refrigerant temperature sensor (236) less decreases even though the temperature of outside air is not so high and the cooling power is exerted sufficiently in the subcooling heat exchanger (210). From this aspect, the state that the first condition in the step ST12 is fulfilled is judged as the state that the refrigerant does not flow in the refrigerant passage
15 (205) as in the first heating operation or as the state that the refrigerant flows towards the outdoor unit (11) in the refrigerant passage (205) as in the second heating operation. Therefore, when the first condition is fulfilled, the controller (240) judges that the refrigerating apparatus (10) is in a driving condition that necessitates no operation of the subcooling unit (200) to stop the subcooling compressor (221).

20 [0148] The second condition in the step ST12 will be described. The second condition is a condition for judging whether the detection value of the refrigerant temperature sensor (236) is an appropriate value corresponding to the evaporation temperature of the subcooling refrigerant in operation of the subcooling compressor (221).

[0149] In order to fulfill the second condition in the step ST12, the following four
25 requirements must be satisfied. The first requirement requires that five minutes has already elapsed after the time point when the subcooling compressor (221) is activated. The second requirement requires the detection value T_{out} of the refrigerant temperature

sensor (236) to be greater than a value obtained by adding 15 to an evaporation temperature T_g of the subcooling refrigerant in the subcooling heat exchanger (210) ($T_{out} > T_g + 15$). The third requirement requires the refrigerant temperature sensor (236) to operate normally. The fourth requirement requires the suction pressure sensor (234) to
 5 operate normally.

[0150] Wherein, in the controller (240), the saturation temperature of the subcooling refrigerant in the detection value LP of the suction pressure sensor (234) is regarded as the evaporation temperature T_g of the subcooling refrigerant. Namely, in the present embodiment, the suction pressure sensor (234) serves as evaporation temperature detection
 10 means for detecting the evaporation temperature of the subcooling refrigerant.

[0151] When all of the first to fourth requirements are satisfied, the difference between the detection value T_{out} of the refrigerant temperature sensor (236) and the evaporation temperature T_g of the subcooling refrigerant is greater than 15 °C even though the subcooling refrigerant circuit (220) is performing the refrigeration cycle. From this
 15 aspect, the state that the second condition in the step ST12 is fulfilled is judged also as the state that the refrigerant does not flow in the refrigerant passage (205) as in the first heating operation or as the state that the refrigerant flows towards the outdoor unit (11) in the refrigerant passage (205) as in the second heating operation. Therefore, when the second condition is fulfilled, the controller (240) judges that the refrigerating apparatus (10) is in a
 20 driving condition that necessitates no operation of the subcooling unit (200) to stop the subcooling compressor (221).

[0152] The third condition in the step ST12 will be described. The third condition is satisfied when the detection value LP of the suction pressure sensor (234) is below 0.2 MPa and the suction pressure sensor operates abnormally. If satisfied, the detection value
 25 of the suction pressure sensor (234) would be abnormal, and therefore, the operation of the subcooling compressor (221) could not be controlled properly with the abnormal detection value. Accordingly, when the third condition is satisfied, the controller (240) stops the

operation of the subcooling compressor (221).

[0153] The fourth condition in the step ST12 will be described. The fourth condition is satisfied when the detection value LP of the suction pressure sensor (234) is below 0.15 MPa. When satisfied, the detection value of the suction pressure sensor (234) is small to
 5 such an extent that the pressure never reaches the value in the normal operation. Therefore, when the fourth condition is satisfied, the controller (240) judges that some trouble occurs to stop the subcooling compressor (221).

[0154] If it is judged in the step ST10 that the subcooling compressor (221) is stopped, the routine proceeds to a step ST15. In the step ST15, whether a predetermined time period
 10 has elapsed from the time point when the subcooling compressor (221) is stopped is judged. In order to avoid repetition of activation and stop of the subcooling compressor (221) within a short period of time, after the subcooling compressor (221) is stopped once, re-activation of the subcooling compressor (221) is restrained until a given period of time elapses from the stop. In the step ST15, if the predetermined time period has not elapsed
 15 from the time point when the subcooling compressor (221) is stopped, the routine proceeds to the step ST14 so that the control operation is once terminated for keeping the subcooling compressor (221) stopping. On the other hand, if the predetermined time period has elapsed from the time point when the subcooling compressor (221) is stopped, the routine proceeds to a step ST16.

20 [0155] In the step ST16, whether or not the subcooling compressor (221) should be activated is judged. In the step ST16, judgment is performed as to whether or not the following three conditions are fulfilled. When at least one of the three conditions is fulfilled, the routine proceeds to a step ST17 so that the subcooling compressor (221) is activated. On the other hand, if none of the three conditions are fulfilled, the routine
 25 proceeds to the step ST14 so that the control operation is once terminated for keeping the subcooling compressor (221) stopping.

[0156] The first condition in the step ST16 will be described. The first condition is

fulfilled when the detection value Ta of the outside air temperature sensor (231) is equal to or greater than 25 °C and one minute has elapsed from the time point when the subcooling compressor (221) is stopped. In this state, the subcooling compressor (221) is stopped for one or more minutes even though the temperature of outside air is rather high. Therefore,
 5 when the first condition is fulfilled, the controller (240) activates the subcooling compressor (221) for cooling the refrigerant in the refrigerant passage (205).

[0157] The second condition in the step ST16 will be described. The second condition is fulfilled when the detection value Ta of the outside air temperature sensor (231) is equal to or greater than 20 °C and three minutes have elapsed from the time point when the
 10 subcooling compressor (221) is stopped. In this state, the subcooling compressor (221) is stopped for three or more minutes even though the temperature of outside air is comparatively high. Therefore, when the second condition is fulfilled, the controller (240) activates the subcooling compressor (221) for cooling the refrigerant in the refrigerant passage (205).

15 [0158] The third condition in the step ST16 will be described. The third condition is fulfilled when ten minutes have already elapsed from the time point when the subcooling compressor (221) is stopped. In this state, the subcooling compressor (221) is stopped for a comparatively long period of time. Therefore, when the third condition is fulfilled, the controller (240) activates the subcooling compressor (221) for cooling the refrigerant in the
 20 refrigerant passage (205). In this way, the controller (240) never fails to activate the subcooling compressor (221) upon a lapse of ten minutes after the time point when the subcooling compressor (221) is stopped.

[0159] - Effects of Embodiment -

In the subcooling unit (200), the controller (240) controls the operation of the
 25 subcooling compressor (221) on the basis of only information obtained within the subcooling unit (200), such as the detection value of a sensor provided in the subcooling unit (200). In other words, in the subcooling unit (200), the operation of the subcooling

compressor (221) can be controlled according to the operation state of the refrigerating apparatus (10) without sending and receiving a signal to and from 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).

[0160] 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.

[0161] 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).

[0162] 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, in the present embodiment, the limitation on the type of the refrigerating apparatus (10) as an object to which the subcooling unit (200) is to be incorporated is eliminated, thereby enhancing the usability of the subcooling unit (200) remarkably.

[0163] - Modified Example 1 of Embodiment -

The subcooling unit (200) of the present embodiment may include temperature

sensors (237, 238) on the respective sides of the subcooling heat exchanger (210) in the refrigerant passage (205) in order to control the operation of the subcooling compressor (221) on the basis of the detection values of the temperature sensors (237, 238).

[0164] As shown in FIG. 7, in the refrigerant passage (205), the first refrigerant temperature sensor (237) is provided at a part nearer the other end than the subcooling heat exchanger (210), that is, a part near the end portion connected to the second liquid side communication pipe (22). Also, in the refrigerant passage (205), the second refrigerant temperature sensor (238) is provided at a part nearer the one end than the subcooling heat exchanger (210), that is, a part near the end portion connected to the first liquid side communication pipe (21). In this subcooling unit (200), the first refrigerant temperature sensor (237) and the second refrigerant temperature sensor (238) serve as first refrigerant temperature detection means and second refrigerant temperature detection means, respectively.

[0165] The controller (240) of the present modified example receives the detection value of the first refrigerant temperature sensor (237) and the detection value of the second refrigerant temperature sensor (238). The controller (240) compares the detection values of the refrigerant temperature sensors (237, 238) during operation of the subcooling compressor (221) to determine whether the operation of the subcooling compressor (221) should be continued or stopped according to the comparison result.

[0166] Control operation by the controller (240) will be described.

[0167] First, the state that the detection value of the first refrigerant temperature sensor (237) is smaller than the detection value of the second refrigerant temperature sensor (238) in operation of the subcooling compressor (221) means that the temperature of the refrigerant cooled in the subcooling heat exchanger (210) is detected by the first refrigerant temperature sensor (237). From this aspect, this state can be judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205) as in the cooling

operation, and therefore, the controller (240) allows the subcooling compressor (221) to continue operating.

[0168] In reverse, the state that the detection value of the second refrigerant temperature sensor (238) is smaller than the detection value of the first refrigerant temperature sensor (237) in operation of the subcooling compressor (221) means that the temperature of the refrigerant cooled in the subcooling heat exchanger (210) is detected by the second refrigerant temperature sensor (238). From this aspect, this state can be judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) as in the second heating operation, and therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0169] Further, the state that the detection value of the first refrigerant temperature sensor (237) and the detection value of the second refrigerant temperature sensor (238) are almost equal to each other in operation of the subcooling compressor (221) can be judged as the state that the refrigerant does not flows in the refrigerant passage (205) as in the first heating operation, and therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0170] It is noted that in the controller (240) of the present modified example, the difference between the detection value of the first refrigerant temperature sensor (237) and the detection value of the second refrigerant temperature sensor (238) may be used as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205). Specifically, the state that a value obtained by subtracting the detection value of the second refrigerant temperature sensor (238) from the detection value of the first refrigerant temperature sensor (237) is negative can be judged as the state that the detection value of the first refrigerant temperature sensor (237) is smaller than the detection value of the second refrigerant temperature sensor (238). Therefore, the controller (240) allows the subcooling compressor (221) to continue operating. Further,

the state that a value obtained by subtracting the detection value of the second refrigerant temperature sensor (238) from the detection value of the first refrigerant temperature sensor (237) is equal to or greater than 0 can be judged as the state that the detection value of the first refrigerant temperature sensor (237) is equal to or greater than the detection value of the second refrigerant temperature sensor (238). Therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0171] - Modified Example 2 of Embodiment -

In the subcooling unit (200) of the present embodiment, a flow meter (251) may be provided at the refrigerant passage (205) in order to control the operation of the subcooling compressor (221) on the basis of the detection value of the flow meter (251).

[0172] In this subcooling unit (200), the controller (240) receives the detection value of the flow meter (251). The controller (240) judges, on the basis of the detection value of the flow meter (251), the flowing direction of the refrigerant in the refrigerant passage (205) and whether or not the refrigerant flows in the refrigerant passage (205). In other words, the controller (240) uses the detection value of the flow meter (251) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205).

[0173] When it is judged that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205) in operation of the subcooling compressor (221), the controller (240) allows the subcooling compressor (221) to continue operating. When it is judged that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) in operation of the subcooling compressor (221) or that the refrigerant does not flow in the refrigerant passage (205) in operation of the subcooling compressor (221), the controller (240) stops the operation of the subcooling compressor (221).

[0174] - Modified Example 3 of Embodiment-

The controller (24) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of only the detection value of the outside air temperature sensor (231).

[0175] Operation of this controller (240) will be described. The state that the detection value of the outside air temperature sensor (231) is greater than a predetermined upper limit value (30 °C, for example) can be estimated as the state that the cooling load in the cooling showcase (13) or the refrigeration showcase (14) or the cooling load in the air conditioning unit (12) is high. Therefore, in this state, the controller (240) activates the subcooling compressor (221) if the subcooling compressor (221) is stopped or allows the subcooling compressor (221) to continue operating if the subcooling compressor (221) is operated. The refrigerant flowing from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205) is supplied to the cooling showcase (13) and the like after cooled in the subcooling heat exchanger (210).

[0176] In reverse, the state that the detection value of the outside air temperature sensor (231) is smaller than a predetermined lower limit value (20 °C, for example) can be estimated as the state that the cooling load in the cooling showcase (13) or the refrigeration showcase (14) or the cooling load in the air conditioning unit (12) is low. From this aspect, this state can be judged as the state that the operation of the subcooling compressor (221) is unnecessary. Therefore, in this state, the controller (240) keeps the subcooling compressor (221) being stopped if the subcooling compressor (221) is stopped or stops the operation of the subcooling compressor (221) if the subcooling compressor (221) is operated.

[0177] - Modified Example 4 of Embodiment-

The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of only variation in detection value of the refrigerant temperature detection means (236). The controller (240) in the present

modified example uses variation in detection value of the refrigerant temperature detection means (236) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205).

[0178] Operation of this controller (240) will be described. The state that the detection value of the refrigerant temperature detection means (236) gradually decreases from the time point when the subcooling compressor (221) is activated can be judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205). In this state, therefore, the controller (240) allows the subcooling compressor (221) to continue operating.

[0179] In reverse, the state that the detection value of the refrigerant temperature detection means (236) does not decrease after activation of the subcooling compressor (221) can be judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) or as the state that the refrigerant does not flow in the refrigerant passage (205). In this state, therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0180] Further, the state that the detection value of the refrigerant temperature detection means (236) gradually increases from the time point when the subcooling compressor (221) is stopped can be judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205). In this state, therefore, the controller (240) activates the subcooling compressor (221) again.

[0181] In reverse, the state that the detection value of the refrigerant temperature detection means (236) does not increase even in the time when the subcooling compressor (221) is stopped can be judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the

refrigerant passage (205) or as the state that the refrigerant does not flow in the refrigerant passage (205). In this state, therefore, the controller (240) keeps the subcooling compressor (221) being stopped.

[0182] - Modified Example 5 of Embodiment-

5 The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of difference in temperature of the subcooling refrigerant between at the inlet and at the outlet of the first flow paths (221) of the subcooling heat exchanger (210).

[0183] As shown in FIG. 9, the subcooling unit (200) of the present modified example
10 includes a first subcooling refrigerant temperature sensor (252) and a second subcooling refrigerant temperature sensor (253). In the subcooling refrigerant circuit (220), the first subcooling refrigerant temperature sensor (252) is provided immediately before the first flow paths (211) of the subcooling heat exchanger (210) for detecting the temperature of the subcooling refrigerant that is to flow into the first flow paths (211). On the other hand,
15 the second subcooling refrigerant temperature sensor (253) is provided immediately after the first flow paths (211) of the subcooling heat exchanger (210) for detecting the temperature of the subcooling refrigerant immediately after flowing out from the first flow paths (211). The controller (240) of the present modified example uses the difference between the detection value of the first subcooling refrigerant temperature sensor (252) and
20 the detection value of the second subcooling refrigerant temperature sensor (253) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205)

[0184] Operation of this controller (240) will be described. The state that the detection value of the second subcooling refrigerant temperature sensor (253) is greater than the
25 detection value of the first subcooling refrigerant temperature sensor (252) (that is, the state that a value obtained by subtracting the detection value of the first subcooling refrigerant temperature sensor (252) from the detection value of the second subcooling

refrigerant temperature sensor (253) is positive (+)) in operation of the subcooling compressor (221) can be judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205). In this state, therefore, the controller (240) allows the
 5 subcooling compressor (221) to continue operating.

[0185] In reverse, the state that the detection value of the second subcooling refrigerant temperature sensor (253) is smaller than the detection value of the first subcooling refrigerant temperature sensor (252) or the state that there is no difference therebetween (that is, the state that a value obtained by subtracting the detection value of the first
 10 subcooling refrigerant temperature sensor (252) from the detection value of the second subcooling refrigerant temperature sensor (253) is equal to or smaller than 0) in operation of the subcooling compressor (221) can be judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) or as the state that the refrigerant
 15 does not flow in the refrigerant passage (205). In this state, therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0186] - Modified Example 6 of Embodiment-

The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of only the detection value of the suction
 20 pressure sensor (234). The detection value of the suction pressure sensor (234) is substantially equal to the refrigerant pressure in the first flow paths (211) of the subcooling heat exchanger (210), that is, the evaporation pressure of the subcooling refrigerant. Thus, the suction pressure sensor (234) in the present modified example serves as evaporation pressure detection means. The controller (240) of the present modified example uses the
 25 detection value of the suction pressure sensor (234) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205).

[0187] Operation of this controller (240) will be described. The detection value of the

suction pressure sensor (234) being greater than a predetermined reference value (0.2 MPa, for example) in operation of the subcooling compressor (210) means evaporation of the subcooling refrigerant in the first flow paths (211) of the subcooling heat exchanger (210), and in turn, can be judged as the state that the refrigerant flows in the refrigerant passage (205). Therefore, in this state, the controller (240) allows the subcooling compressor (221) to continue operating.

[0188] In reverse, the detection value of the suction pressure sensor (234) being equal to or smaller than the predetermined reference value in operation of the subcooling compressor (210) means no or less evaporation of the subcooling refrigerant in the first flow paths (211) of the subcooling heat exchanger (210), and in turn, can be judged as the state that the refrigerant does not flow in the refrigerant passage (205). Therefore, in this state, the controller (240) stops the operation of the subcooling compressor (221).

[0189] - Modified Example 7 of Embodiment-

The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of only the difference between the detection value T_{out} of the refrigerant temperature sensor (236) and the evaporation temperature T_g of the subcooling refrigerant. The controller (240) of the present modified example uses the difference between the detection value T_{out} of the refrigerant temperature sensor (236) and the evaporation temperature T_g of the subcooling refrigerant as a flowing state indication value that indicate the flowing state of the refrigerant in the refrigerant passage (205).

[0190] Operation of this controller (240) will be described. The state that a value obtained by subtracting the evaporation temperature T_g of the subcooling refrigerant from the detection value T_{out} of the refrigerant temperature sensor (236) is equal to or smaller than a predetermined reference value (15 °C, for example) in operation of the subcooling compressor (221) is judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the

refrigerant passage (205). In this state, therefore, the controller (240) allows the subcooling compressor (221) to continue operating.

[0191] In reverse, the state that a value obtained by subtracting the evaporation temperature T_g of the subcooling refrigerant from the detection value T_{out} of the refrigerant temperature sensor (236) is equal to or smaller than the predetermined reference value in operation of the subcooling compressor (221) is judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) or as the state that the refrigerant does not flow in the refrigerant passage (205). In this state, therefore, the controller (240) stops the operation of the subcooling compressor (221).

[0192] - Modified Example 8 of Embodiment -

The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of only the detection value of the refrigerant temperature detection means (236). The controller (240) of the present modified example uses the detection value of the refrigerant temperature detection means (236) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205).

[0193] Operation of this controller (240) will be described. The state that the detection value of the refrigerant temperature detection means (236) is greater than a predetermined reference value in non-operation of the subcooling compressor (221) can be estimated as the state that the cooling power in the cooling showcase (13) or the like is insufficient to some extent because of high temperature of the refrigerant sent from the outdoor unit (11) to the utility side such as the cooling showcase (13) or the like. Therefore, in this state, the controller (240) activates the subcooling compressor (221).

[0194] In reverse, the state that the detection value of the refrigerant temperature detection means (236) is equal to or smaller than the predetermined reference value in non-operation of the subcooling compressor (221) can be estimated as the state that the cooling power in

the cooling showcase (13) or the like is secured sufficiently because of not-so-high temperature of the refrigerant sent from the outdoor unit (11) to the utility side such as the cooling showcase (13) or the like. Therefore, in this state, the controller (240) keeps the subcooling compressor (221) being stopped.

5 [0195] - Modified Example 9 of Embodiment -

The controller (240) of the present embodiment may control the operation of the subcooling compressor (221) on the basis of the difference between the detection value of the refrigerant temperature detection means (236) and the detection value of the outside air temperature sensor (231). The controller (240) of the present modified example uses the
10 difference between the detection value of the refrigerant temperature detection means (236) and the detection value of the outside air temperature sensor (231) as a flowing state indication value that indicates the flowing state of the refrigerant in the refrigerant passage (205).

[0196] Operation of this controller (240) will be described. When the refrigerant flows
15 from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage (205), the refrigerant condensed by radiating heat to outdoor air in the outdoor heat exchanger (44) flows into the refrigerant passage (205), wherein the temperature of this refrigerant never becomes smaller than the temperature of the outdoor air. From this aspect, the state that a value obtained by
20 subtracting the detection value of the outside air temperature sensor (231) from the detection value of the refrigerant temperature detection means (236) is greater than a predetermined reference value in non-operation of the subcooling compressor (221) can be judged as the state that the refrigerant flows from the first liquid side communication pipe (21) towards the second liquid side communication pipe (22) in the refrigerant passage
25 (205). Therefore, in this state, the controller (240) activates the subcooling compressor (221).

[0197] In reverse, the state that a value obtained by subtracting the detection value of the

outside air temperature sensor (231) from the detection value of the refrigerant temperature detection means (236) is equal to or smaller than the predetermined reference value in non-operation of the subcooling compressor (221) can be judged as the state that the refrigerant flows from the second liquid side communication pipe (22) towards the first liquid side communication pipe (21) in the refrigerant passage (205) or as the state that the refrigerant does not flow in the refrigerant passage (205). Therefore, in this state, the controller (240) keeps the subcooling compressor (221) being stopped.

[0198] - Modified Example 10 of Embodiment-

In the subcooling unit (200) of the present embodiment, the subcooling refrigerant circuit (220) may be so composed that the refrigerant naturally circulates.

[0199] As shown in FIG. 10, in the subcooling refrigerant circuit (220) of the present modified example, the subcooling outdoor heat exchanger (222) is arranged upper than the subcooling heat exchanger (210). Further, the subcooling refrigerant circuit (222) includes a bypass pipe (224). The bypass pipe (224) is connected at one end thereof to the suction side of the subcooling compressor (221) and at the other end thereof to the discharge side of the subcooling compressor (221). In addition, the bypass pipe (224) includes a check valve (225) for allowing the refrigerant to flow from the one end towards the other end thereof.

[0200] In the subcooling refrigerant circuit (220), the subcooling refrigerant circulates by operating the outdoor fan (230) even in non-operation of the subcooling compressor (221). Specifically, when the outdoor fan (230) is operated, the refrigerant 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) falls down by gravitation to pass through the subcooling expansion valve (223) set to be opened fully, 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 of the second passages (212) to be evaporated.

The subcooling refrigerant evaporated in the subcooling heat exchanger (210) passes through the bypass pipe (224) to return to the subcooling outdoor heat exchanger (222), thereby being condensed again by heat exchange with outdoor air.

[0201] For activating the subcooling unit (200), the controller (240) of the present modified example activates the outdoor fan (230) first and judges whether or not the subcooling compressor (221) should be activated in the condition that the outdoor fan (230) is operated. Specifically, upon judgment that the refrigerant flowing in the refrigerant passage (205) should be cooled, the controller (240) activates only the outdoor fan (230) with the subcooling compressor (221) stopped. When the outdoor fan (230) is activated, the subcooling refrigerant naturally circulates in the refrigerant passage (205) while the refrigerant in the second flow paths (212) is cooled by the subcooling refrigerant in the subcooling heat exchanger (210). The controller (240) allows only the outdoor fan (230) to continue operating for a predetermined time period (five minutes, for example), and then, judges whether or not the refrigerant flowing in the refrigerant passage (205) is cooled sufficiently. When the refrigerant flowing in the refrigerant passage (205) is cooled insufficiently, the controller (240) activates the subcooling compressor (221). When the subcooling compressor (221) is activated, the subcooling refrigerant circuit (220) performs the refrigeration cycle. In reverse, when the refrigerant is sufficiently cooled, the controller (240) allows only the outdoor fan (230) to continue operating with the subcooling compressor (221) kept stopping.

[0202] In the present modified example, the subcooling compressor (221) is activated only when only the natural circulation of the subcooling refrigerant by the operation of the outdoor fan (230) is insufficient for cooling the heat source side refrigerant. Accordingly, the situation that the subcooling compressor (221) is activated even when the activation of the subcooling compressor (221) is unnecessary can be avoided, reducing the number of times of activation of the subcooling compressor (221). As a result, the time period when the subcooling compressor (221) falls in an unstable transient state in its operation can be

shortened, increasing the reliability of the subcooling compressor (221).

[0203] - Modified Example 11 of Embodiment -

5 The subcooling unit (200) of the present embodiment may include, as the cooling fluid circuit, a cold water circuit in which cold water flows rather than the subcooling refrigerant circuit (220). In this cold water circuit, water at comparatively low temperature, for example, at a temperature of approximately 5 °C flows. In the subcooling heat exchanger (210) of the present modified example, the cold water circuit is connected to the first flow paths (211) so that the cold water flowing in the first flow paths (211) is heat-exchanged with the refrigerant flowing in the second flow paths (212).

10 [0204] 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

15 [0205] 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 refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

10 a subcooling refrigerant circuit (220) for performing a refrigeration cycle by circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210); and

control means (240) for stopping the subcooling compressor (221) when an amount of reduction in a detection value detected by the refrigerant temperature detection means (236) in a predetermined period of time from an activation of the subcooling compressor (221) is at or less than a reference value, without receiving a signal from the refrigerating apparatus (10).

[2] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

5 a subcooling refrigerant circuit (220) for performing a refrigeration cycle by circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

10 refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210);

evaporation temperature detection means (234) for detecting evaporation temperature of the subcooling refrigerant in the subcooling heat exchanger (210); and

15 control means (240) for stopping the subcooling compressor (221) when a detection value detected by the refrigerant temperature detection means (236) is higher than a detection value detected by the evaporation temperature detection means (234) by a predetermined value or more during an operation of the subcooling compressor (221), without receiving a signal from the refrigerating apparatus (10).

[3] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that
20 performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in the refrigerating apparatus (10) sent from the heat source unit (11) to the utility unit (12, 13, 14), the subcooling apparatus, comprising:

25 a refrigerant passage (205) connected to liquid side communication pipes (21, 22) of the refrigerating apparatus (10);

a subcooling refrigerant circuit (220) for performing a refrigeration cycle by

circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

first refrigerant temperature detection means (237) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210);

second refrigerant temperature detection means (238) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the heat source unit (11) than the subcooling heat exchanger (210); and

control means (240) for stopping the subcooling compressor (221) when a detection value detected by the second refrigerant temperature detection means (238) is at or less than a detection value detected by the first refrigerant temperature detection means (237) during an operation of the subcooling compressor (221), without receiving a signal from the refrigerating apparatus (10).

15

[4] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

a cooling fluid circuit (220) in which cooling fluid flows;

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the cooling fluid;

a flow meter (251) provided at the refrigerant passage (205) for detecting a flow

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rate of the heat source side refrigerant, and

control means (240) for determining whether a flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid circuit (220) based on a detection value detected by the flow meter (251) without receiving a signal
5 from the refrigerating apparatus (10).

[5] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side refrigerant between a heat source unit (11) and a utility unit (12, 13, 14) connected to each other by means of
10 communication pipes and which cools the heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

15 a subcooling refrigerant circuit (220) for performing a refrigeration cycle by circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

inlet side fluid temperature detection means (252) for detecting temperature of the
20 subcooling refrigerant at an inlet of the subcooling heat exchanger (210);

outlet side fluid temperature detection means (253) for detecting temperature of the subcooling refrigerant at an outlet of the subcooling heat exchanger (210), and

control means (240) for stopping the subcooling compressor (221) when a detection value detected by the outlet side fluid temperature detection means (253) is at or
25 less than a detection value detected by the inlet side fluid temperature detection means (252) during an operation of the subcooling compressor (221), without receiving a signal from the refrigerating apparatus (10).

[6] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

a subcooling refrigerant circuit (220) for performing a refrigeration cycle by circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

evaporation pressure detection means (234) for detecting evaporation pressure of the subcooling refrigerant in the subcooling heat exchanger (210), and

control means (240) for stopping the subcooling compressor (221) when a detection value detected by the evaporation pressure detection means (234) is at or less than a reference value during an operation of the subcooling compressor (221), without receiving a signal from the refrigerating apparatus (10).

[7] A subcooling apparatus which is incorporated to a refrigerating apparatus (10) that performs a refrigeration cycle by circulating heat source side 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 heat source side refrigerant in 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 (21, 22) of the refrigerating apparatus (10);

a subcooling refrigerant circuit (220) for performing a refrigeration cycle by circulating subcooling refrigerant using a subcooling compressor (221);

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the subcooling refrigerant;

5 outside air temperature detection means (231) for detecting temperature of outside air;

refrigerant temperature detection means (236) for detecting temperature of the heat source side refrigerant at a part of the refrigerant passage (205) nearer the utility unit (12, 13, 14) than the subcooling heat exchanger (210), and

10 control means (240) for determining whether a flow of the subcooling refrigerant should be started or kept stopping in a state that the subcooling refrigerant stops flowing in the subcooling refrigerant circuit (220) based on a difference between a detection value of the refrigerant temperature detection means (236) and a detection value of the outside air temperature detection means (231), without receiving a signal from the refrigerating
15 apparatus (10).

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

wherein the heat source unit (11) of the refrigerating apparatus (10) performs heat exchange between the heat source side refrigerant and outdoor air,

the subcooling apparatus comprising:

25 a refrigerant passage (205) connected to liquid side communication pipes (21, 22) of the refrigerating apparatus (10);

a cooling fluid circuit (220) in which cooling fluid flows;

a subcooling heat exchanger (210) for cooling the heat source side refrigerant in the refrigerant passage (205) by heat exchange with the cooling fluid;

outside air temperature detection means (231) for detecting temperature of outside air; and

5 control means (240) for controlling a flowing state of the cooling fluid in the cooling fluid circuit (220) according to a detection value of the outside air temperature detection means (231), without receiving a signal from the refrigerating apparatus (10).

[9] The subcooling apparatus of Claim 8,

10 wherein the cooling fluid circuit is composed of a subcooling refrigerant circuit (220), and

the subcooling refrigerant circuit (220) includes a subcooling compressor (221) and performs a refrigeration cycle by circulating the subcooling refrigerant as the cooling fluid.

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[10] The subcooling apparatus of Claim 8 or 9,

wherein the control means (240) determines, on the basis of a detection value of the outside air temperature detection means (231), whether the flow of the cooling fluid should be continued or stopped in a state that the cooling fluid flows in the cooling fluid
20 circuit (220).

[11] The subcooling apparatus of Claim 8 or 9,

wherein the control means (240) determines, on the basis of a detection value of the outside air temperature detection means (231), whether the flow of the cooling fluid should be started or kept stopping in a state that the cooling fluid does not flow in the
25 cooling fluid circuit (220).

[12] The subcooling apparatus of any one of Claims 1, 2, 3, 5, 6, 7 and 9, further comprising:

heat radiation heat exchanger (222) connected to the subcooling refrigerant circuit (220) for performing heat exchange between the subcooling refrigerant and outside air; and

5 outdoor fan (230) for supplying outdoor air to the heat radiation heat exchanger (222),

wherein the subcooling refrigerant circuit (220) is capable of performing natural circulation operation that allows the subcooling refrigerant to naturally circulate by operating the outdoor fan (230) in non-operation of the subcooling compressor (221), and

10 the control means (240) allows the subcooling refrigerant circuit (220) to perform the natural circulation operation by activating the outdoor fan (230) in order to start circulation of the subcooling refrigerant, and the control means (240) determines whether the subcooling compressor (221) should be activated or kept stopping according to the flowing state of the heat source side refrigerant in the refrigerant passage (205) in natural
15 circulation operation.

[13] The subcooling apparatus of any one of Claims 1, 2, 3, 5, 6, 7 and 9,

wherein the control means (240) activates the subcooling compressor (221) after a predetermined time period elapses from a time point when the subcooling compressor
20 (221) is stopped.