



(11) **EP 1 835 241 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
19.09.2007 Bulletin 2007/38

(51) Int Cl.:
F25B 5/02 (2006.01) F25B 1/00 (2006.01)

(21) Application number: **05819439.0**

(86) International application number:
PCT/JP2005/023585

(22) Date of filing: **22.12.2005**

(87) International publication number:
WO 2006/070684 (06.07.2006 Gazette 2006/27)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **28.12.2004 JP 2004381015**
18.10.2005 JP 2005303502

(71) Applicant: **DAIKIN INDUSTRIES, LTD.**
Osaka-shi, Osaka 530-8323 (JP)

(72) Inventors:
• **Takegami, Masaaki**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)
• **Sakae, Satoru**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)

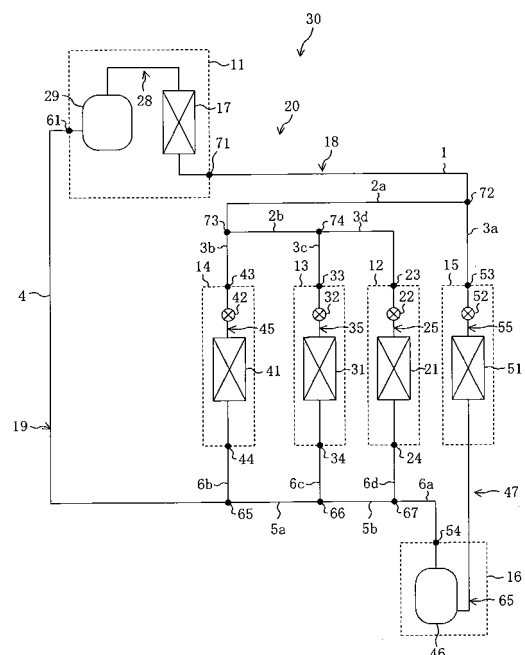
• **Tanimoto, Kenji**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)
• **Nomura, Kazuyoshi**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)
• **Oda, Yoshinari**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)
• **Kondo, Azuma**
c/o Kanaoka Factory, Sakai Plant
Sakai-shi, Osaka 5918511 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) **REFRIGERATING APPARATUS**

(57) The loss of refrigerant pressure which is caused in a return-side interconnecting piping line (19) comprising return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of single-stage side utilization units (12, 13, 14) to an inlet port (61) of a heat source unit (11) is set such that the lowest valued refrigerant pressure loss is caused by a said return-side interconnecting piping line of the return-side interconnecting piping line (19) that is connected to the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature.

FIG. 1



EP 1 835 241 A1

Description

TECHNICAL FIELD

[0001] This invention relates to a refrigerating apparatus in which a plurality of utilization units are connected in parallel with a heat source unit.

BACKGROUND ART

[0002] For many years, a refrigerating apparatus of the type, in which a plurality of utilization units are connected in parallel with a single heat source unit, has been known in the art. For example, such a type of refrigerating apparatus is installed in a convenience store and provides cold storage and freeze storage in showcases in the store. In this refrigerating apparatus, the heat source unit is equipped with a compressor and a heat source-side heat exchanger while on the other hand each of the utilization units is provided with a cooling heat exchanger and an expansion valve. The utilization units are connected to the heat source unit by interconnecting piping lines. In each of the utilization units, the temperature at which refrigerant becomes evaporated in the cooling heat exchanger is set depending on the compartment preset temperature of the showcases.

[0003] JP-A-2003-314909 discloses a refrigerating apparatus which is of the above-described type. In this patent document, Figure 1 thereof shows a refrigerating apparatus in which three indoor units (utilization units) are connected in parallel with a single outdoor unit (heat source unit). Two of the three indoor units are cold storage units and the rest is a freeze storage unit, and a booster unit provided with a compressor is connected in series with the freeze storage unit.

DISCLOSURE OF THE INVENTION

PROBLEMS WHICH THE INVENTION SEEKS TO OVERCOME

[0004] Incidentally, in the case where such a refrigerating apparatus is installed in a commercial facility such as a convenience store, the decision on where to place a heat source unit and utilization units is made mainly by the layout of the facility as well as by the style of service. And the length of interconnecting piping lines from the outlet ports of the utilization units to the inlet port of the heat source unit is determined by the layout of the heat source unit as well as by the layout of the utilization units.

[0005] Accordingly, in some cases, the length of an interconnecting piping line extending from the outlet port of one utilization unit of lower compartment preset temperature to the inlet port of the heat source unit may become longer than the other utilization unit of higher compartment preset temperature. In such a case, there is the possibility that the loss of refrigerant pressure which is caused in the return-side interconnecting piping lines re-

spectively extending from the outlet ports of the utilization units to the inlet port of the heat source unit becomes higher in one utilization unit of lower compartment preset temperature than in the other utilization unit of higher compartment preset temperature.

[0006] At this time, both the refrigerant pressure at the outlet ports of the utilization units and the refrigerant evaporative pressure in the utilization units become higher in the one utilization unit of lower compartment preset temperature than in the other utilization unit of higher compartment preset temperature. Consequently, the refrigerant evaporative temperature in the one utilization unit (at lower compartment preset temperature) becomes higher than in the other utilization unit (at higher compartment preset temperature). This therefore gives rise the possibility that in a conventional refrigerating apparatus the refrigerant evaporative temperature in a certain utilization unit does not correspond to the compartment preset temperature.

[0007] With the above-described problems with the conventional techniques in mind, the present invention was devised. Accordingly, a general object of the present invention is to make the refrigerant evaporative temperature in a utilization unit in a refrigerating apparatus appropriate with respect to the compartment preset temperature of the utilization unit to thereby aim at accomplishing improvement in the efficiency of the refrigerant apparatus.

MEANS FOR OVERCOMING THE PROBLEMS

[0008] The present invention provides, as first to fourth aspects, refrigerating apparatuses (30) each of which comprises: (a) a plurality of single-stage side utilization units (12, 13, 14) having cooling heat exchangers (21, 31, 41) respectively, each of the cooling heat exchangers (21, 31, 41) being configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature, and (b) a single heat source unit (11) having a compressor (29), wherein in a refrigerant circuit (20) in which the single-stage side utilization units (12, 13, 14) are connected in parallel with the heat source unit (11) by interconnecting piping lines (18, 19) refrigerant is circulated between each of the single-stage side utilization units (12, 13, 14) and the heat source unit (11) whereby single-stage compression refrigeration cycles are performed.

[0009] In the refrigerating apparatus (30) of the first aspect, the loss of pressure of the refrigerant which is caused in the return-side interconnecting piping line (19) comprising return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to an inlet port (61) of the heat source unit (11) is set such that the lowest valued refrigerant pressure loss is caused by a said return-side interconnecting piping line that is connected to the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature.

[0010] In the refrigerating apparatus (30) of the second aspect, the loss of pressure of the refrigerant which is caused in the return-side interconnecting piping line (19) comprising return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to an inlet port (61) of the heat source unit (11) is set such that the aforesaid refrigerant pressure loss becomes smaller as the compartment preset temperature in the single-stage side utilization units (12, 13, 14) connected respectively by the aforesaid return-side interconnecting piping lines to the inlet port (61) of the heat source unit (11) becomes lower.

[0011] In the refrigerating apparatus (30) of the third aspect, the length of return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to an inlet port (61) of the heat source unit (11) is set such that a said return-side interconnecting piping line that is connected to the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature is the shortest return-side interconnecting piping line.

[0012] In the refrigerating apparatus (30) of the fourth aspect, the length of return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to an inlet port (61) of the heat source unit (11) is set such that the aforesaid length becomes shorter as the compartment preset temperature in the single-stage side utilization units (12, 13, 14) connected respectively by the return-side interconnecting piping lines to the inlet port (61) of the heat source unit (11) becomes lower.

[0013] The present invention provides, as a fifth aspect according to any one of the first to fourth aspects, a refrigerating apparatus in which in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines establishing respective connections between the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) and the inlet port (61) of the heat source unit (11) the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature is connected at the most downstream side.

[0014] The present invention provides, as a sixth aspect according to the fifth aspect, a refrigerating apparatus in which in the supply-side interconnecting piping line (18) composed of supply-side interconnecting piping lines establishing respective connections between an outlet port (71) of the heat source unit (11) and inlet ports (23, 33, 43) of the single-stage side utilization units (12, 13, 14) the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature is connected at the most upstream side.

[0015] The present invention provides, as a seventh aspect according to any one of the first to sixth aspects, a refrigerating apparatus in which the refrigerating apparatus further includes a two-stage side circuit (47) in which a two-stage side utilization unit (15) having a cool-

ing heat exchanger (51) configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature and a booster compressor (46) are connected in series, and in the refrigerant circuit (20) the two-stage side circuit (47) is, together with the single-stage side utilization units (12, 13, 14), connected in parallel with the heat source unit (11) by the interconnecting piping lines (18, 19) and the refrigerant is circulated between the two-stage side utilization unit (15) and the heat source unit (11) whereby two-stage compression refrigeration cycles are performed.

[0016] The present invention provides, as an eighth aspect according to the seventh aspect, a refrigerating apparatus in which the two-stage side circuit (47) is connected at the most upstream side in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines establishing respective connections between (i) the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) and an outlet port (54) of the two-stage side circuit (47) and (ii) the inlet port (61) of the heat source unit (11).

[0017] The present invention provides, as a ninth aspect according to the eighth aspect, a refrigerating apparatus in which the two-stage side circuit (47) is connected at the most upstream side in the supply-side interconnecting piping line (18) composed of the supply-side interconnecting piping lines establishing respective connections between (i) the outlet port (71) of the heat source unit (11) and (ii) the inlet ports (23, 33, 43) of the single-stage side utilization units (12, 13, 14) and an inlet port (53) of the two-stage side circuit (47).

OPERATION OF THE INVENTION

[0018] In the first aspect of the present invention, the pressure of refrigerant at the outlet port (44) of the single-stage side utilization unit (14) which is the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature is the lowest. The evaporative pressure of refrigerant in the single-stage side utilization units (12, 13, 14) is approximately equal to the pressure of refrigerant at the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14). Stated another way, both the refrigerant evaporative pressure and the refrigerant evaporative temperature in the single-stage side utilization units (12, 13, 14) decrease as the refrigerant pressure at the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) decreases. Consequently, the refrigerant evaporative temperature in the single-stage side utilization unit (14) of lowest compartment preset temperature is the lowest among the refrigerant evaporative temperatures of the single-stage side utilization units (12, 13, 14).

[0019] In the second aspect of the present invention, the pressure of refrigerant at the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) becomes lower in ascending order of the compartment pre-

set temperature. Consequently, both the refrigerant evaporative pressure and the refrigerant evaporative temperature in the single-stage side utilization units (12, 13, 14) also decrease in ascending order of the compartment preset temperature.

[0020] The loss of refrigerant pressure caused by an interconnecting piping line is approximately proportional to the length of the interconnecting piping line. Accordingly, in the third aspect of the present invention, the loss of refrigerant pressure which is caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) is easily minimized in one of the return-side interconnecting piping lines that is connected to the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature.

[0021] In the fourth aspect of the present invention, the loss of refrigerant pressure which is caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) tends to decrease as the compartment preset temperature in the single-stage side utilization units (12, 13, 14) connected by the return-side interconnecting piping lines to the inlet port (61) of the heat source unit (11) decreases.

[0022] In the fifth aspect of the present invention, the single-stage side utilization unit (14) of lowest compartment preset temperature is connected at the most downstream side in the return-side interconnecting piping line (19), in other words the single-stage side utilization unit (14) is connected on the near side from the heat source unit (11).

[0023] In the sixth aspect of the present invention, the single-stage side utilization unit (14) of lowest compartment preset temperature which is connected at the most downstream side in the return-side interconnecting piping line (19) (i.e., on the near side from the heat source unit (11)) is connected at the most upstream side in the supply-side interconnecting piping line (18) (i.e., on the near side from the heat source unit (11)). In other words, the single-stage side utilization unit (14) of lowest compartment preset temperature, which is connected in the return-side interconnecting piping line (19) such that refrigerant is easily returned to the heat source unit (11) from the single-stage side utilization unit (14), is connected in the supply-side interconnecting piping line (18) such that refrigerant easily flows into the single-stage side utilization unit (14) from the heat source unit (11). Consequently, when compared to the single-stage side utilization units (12, 13), more liquid refrigerant tends to flow into the single-stage side utilization unit (14) of lowest compartment preset temperature which requires higher cooling capability than the single-stage side utilization units (12, 13).

[0024] In the seventh aspect of the present invention, one part of refrigerant exiting the heat source unit (11) flows into the single-stage side utilization units (12, 13, 14), becomes evaporated in the cooling heat exchangers (21, 31, 41), is thereafter returned back to the heat source unit (11), while on the other hand the other refrigerant part flows into the two-stage side utilization unit (15), becomes evaporated in the cooling heat exchanger (51), is compressed in the booster compressor (46), and is thereafter returned back to the heat source unit (11). Accordingly, the refrigerant from the two-stage side utilization unit (15) is increased in pressure by the booster compressor (46) by the time that it reaches the outlet port of the two-stage side circuit (47), thereby making it possible for both the refrigerant evaporative pressure and the refrigerant evaporative temperature in the two-stage side utilization unit (15) to be set at lower values than the single-stage side utilization units (12, 13, 14).

[0025] In the eighth aspect of the present invention, the two-stage side circuit (47) to which is connected the booster compressor (46) is connected at the most upstream side in the return-side interconnecting piping line (19). The refrigerant pressure loss caused by the return-side interconnecting piping line (19) between the two-stage side circuit (47) and the heat source unit (11) exceeds the refrigerant pressure loss caused by the return-side interconnecting piping line (19) between each of the single-stage side utilization units (12, 13, 14) and the heat source unit (11). However, in the two-stage side circuit (47), refrigerant evaporated in the two-stage side utilization unit (15) is fed out after being compressed in the booster compressor (46). Consequently, the refrigerant evaporative temperature in the two-stage side utilization unit (15) becomes lower than the refrigerant evaporative temperature in the single-stage side utilization units (12, 13, 14).

[0026] In the ninth aspect of the present invention, the two-stage side circuit (47) to which the two-stage side utilization unit (15) is connected is connected at the most upstream side in the supply-side interconnecting piping line (18) so that refrigerant easily flows into the two-stage side utilization unit (15). This arrangement therefore enables liquid refrigerant to easily flow into the two-stage side utilization unit (15) capable of being set at lower values in refrigerant evaporative pressure as well as in refrigerant evaporative temperature than the single-stage side utilization units (12, 13, 14).

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0027] In accordance with the first aspect of the present invention, it is arranged such that the refrigerant evaporative temperature in the single-stage side utilization unit (14) of lowest compartment preset temperature is the lowest among the single-stage side utilization units (12, 13, 14). Consequently, the refrigerant evaporative temperature in the cooling heat exchanger (41) of the single-stage side utilization unit (14) of lowest compart-

ment preset temperature can be set to be the lowest so that it becomes appropriate with respect to the compartment preset temperature, whereby compartment cooling by the single-stage side utilization unit (14) is efficiently performed.

[0028] In accordance with the second aspect of the present invention, it is arranged such that the refrigerant evaporative temperature in the single-stage side utilization units (12, 13, 14) decreases in ascending order of the compartment preset temperature. This arrangement therefore makes it possible to set the refrigerant evaporative temperature in the cooling heat exchangers (21, 31, 41) of the single-stage side utilization units (12, 13, 14) to decrease in ascending order of the compartment preset temperature so that it becomes appropriate with respect to the compartment preset temperature, whereby compartment cooling by the single-stage side utilization units (12, 13, 14) is efficiently performed.

[0029] In accordance with the third aspect of the present invention, the length of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) is specified, whereby the refrigerant pressure loss which is caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) is easily minimized in one of the return-side interconnecting piping lines that is connected to the lowest of the single-stage side utilization units (12, 13, 14) in compartment preset temperature. This is therefore advantageous for the single-stage side utilization unit (14) of lowest compartment preset temperature to efficiently perform its compartment cooling.

[0030] In accordance with the fourth aspect of the present invention, the length of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) is specified, whereby the refrigerant pressure loss which is caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the heat source unit (11) is easily made to become smaller as the compartment preset temperature in the single-stage side utilization units (12, 13, 14) connected by the return-side interconnecting piping lines to the inlet port (61) of the heat source unit (11) decreases. This is therefore advantageous for the single-stage side utilization units (12, 13, 14) to efficiently perform their compartment cooling.

[0031] In accordance with the sixth aspect of the present invention, the single-stage side utilization unit (14) of lowest compartment preset temperature which requires higher cooling capability than the single-stage

side utilization units (12, 13) is connected in the return-side interconnecting piping line (19) such that refrigerant is easily returned to the heat source unit (11) while the single-stage side utilization unit (14) is connected in the supply-side interconnecting piping line (18) such that refrigerant easily flows into the single-stage side utilization unit (14) from the heat source unit (11), whereby more liquid refrigerant tends to flow into the single-stage side utilization unit (14) as compared to the single-stage side utilization units (12, 13). This therefore makes it possible for the single-stage side utilization unit (14) of lowest compartment temperature to exert cooling capability sufficient enough to keep the compartment at a predetermined preset temperature.

[0032] In accordance with the seventh aspect of the present invention, even when both the refrigerant evaporative pressure and the refrigerant evaporative temperature in the two-stage side utilization unit (15) are set at lower values than the single-stage side utilization units (12, 13, 14), the refrigerant from the two-stage side utilization unit (15) is compressed by the booster compressor (46) to a higher pressure before reaching the outlet port of the two-stage side circuit (47). Therefore, without affecting the refrigerant evaporative temperature/pressure in the single-stage side utilization units (12, 13, 14), the two-stage side utilization unit (15) is able to exert higher cooling capability as compared to the single-stage side utilization units (12, 13, 14).

[0033] In accordance with the ninth aspect of the present invention, the two-stage side utilization unit (15) capable of being set at lower values in refrigerant evaporative pressure as well as in refrigerant evaporative temperature than the single-stage side utilization units (12, 13, 14) is connected in the supply-side interconnecting piping line (18) such that refrigerant easily flows therein to. Accordingly, more liquid refrigerant tends to flow into the two-stage side utilization unit (15), so that even when its compartment preset temperature is set at a lower value than that of the single-stage side utilization units (12, 13, 14) the two-stage side utilization unit (15) is able to exert cooling capability sufficient enough to keep the compartment at a predetermined preset temperature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] In the accompanying drawings:

Figure 1 is a schematic block diagram of a refrigerating apparatus according to a first embodiment of the present invention;

Figure 2 is a schematic block diagram of a refrigerating apparatus according to a second variation of the first embodiment of the present invention; and

Figure 3 is a schematic block diagram of a refrigerating apparatus according to a second embodiment of the present invention.

REFERENCE NUMERALS IN THE DRAWINGS

[0035]

11: OUTDOOR UNIT (HEAT SOURCE UNIT)
12: FIRST COLD STORAGE SHOWCASE (SINGLE-STAGE SIDE UTILIZATION UNIT)
13: SECOND COLD STORAGE SHOWCASE (SINGLE-STAGE SIDE UTILIZATION UNIT)
14: THIRD COLD STORAGE SHOWCASE (SINGLE-STAGE SIDE UTILIZATION UNIT OF LOWEST COMPARTMENT PRESET TEMPERATURE)
15: FREEZE STORAGE SHOWCASE (TWO-STAGE SIDE UTILIZATION UNIT)
18: LIQUID-SIDE INTERCONNECTING PIPING LINE (SUPPLY-SIDE INTERCONNECTING PIPING LINE)
19: GAS-SIDE INTERCONNECTING PIPING LINE (RETURN-SIDE INTERCONNECTING PIPING LINE)
20: REFRIGERANT CIRCUIT
21: COLD STORAGE HEAT EXCHANGER (COOLING HEAT EXCHANGER) OF FIRST COLD STORAGE SHOWCASE
23: INLET PORT OF FIRST COLD STORAGE SHOWCASE (INLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
24: OUTLET PORT OF FIRST COLD STORAGE SHOWCASE (OUTLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
29: COMPRESSOR
30: REFRIGERATING APPARATUS
31: COLD STORAGE HEAT EXCHANGER (COOLING HEAT EXCHANGER) OF SECOND COLD STORAGE SHOWCASE
33: INLET PORT OF SECOND COLD STORAGE SHOWCASE (INLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
34: OUTLET PORT OF SECOND COLD STORAGE SHOWCASE (OUTLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
41: COLD STORAGE HEAT EXCHANGER (COOLING HEAT EXCHANGER) OF THIRD COLD STORAGE SHOWCASE
43: INLET PORT OF THIRD COLD STORAGE SHOWCASE (INLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
44: OUTLET PORT OF THIRD COLD STORAGE SHOWCASE (OUTLET PORT OF SINGLE-STAGE SIDE UTILIZATION UNIT)
46: BOOSTER COMPRESSOR
47: TWO-STAGE SIDE CIRCUIT
51: FREEZE STORAGE HEAT EXCHANGER (COOLING HEAT EXCHANGER)
53: INLET PORT OF TWO-STAGE SIDE CIRCUIT
54: OUTLET PORT OF TWO-STAGE SIDE CIRCUIT
61: INLET PORT OF OUTDOOR UNIT (INLET

PORT OF HEAT SOURCE UNIT)

71: OUTLET PORT OF OUTDOOR UNIT (OUTLET PORT OF HEAT SOURCE UNIT)

BEST EMBODIMENT MODE FOR CARRYING OUT THE INVENTION

[0036] In the following, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

FIRST EMBODIMENT OF THE INVENTION

[0037] The present embodiment provides a refrigerating apparatus (**30**). The refrigerating apparatus (**30**) is installed in, for example, a convenience store and provides cooling of showcases.

[0038] As shown in Figure 1, the refrigerating apparatus (**30**) of the present embodiment has an outdoor unit (**11**) serving as a heat source unit, four showcases (**12**, **13**, **14**, **15**), and a booster unit (**16**). Of these four showcases (**12**, **13**, **14**, **15**), the showcases (**12**, **13**, **14**) are, respectively, first to third cold storage showcases (**12**, **13**, **14**) and the showcase (**15**) is a freeze storage showcase (**15**). The outdoor unit (**11**) is installed outdoors. On the other hand, the four showcases (**12**, **13**, **14**, **15**) are all installed indoors (for example, in the inside of a convenience store).

[0039] The four showcases (**12**, **13**, **14**, **15**) are preset at respective compartment temperatures. More specifically, the preset temperature of the first cold storage showcase (**12**) is 10 degrees Centigrade; the preset temperature of the second cold storage showcase (**13**) is 5 degrees Centigrade; the preset temperature of the third cold storage showcase (**14**) is 2 degrees Centigrade; and the freeze storage showcase (**15**) is minus 20 degrees Centigrade.

[0040] The outdoor unit (**11**) has an outdoor circuit (**28**). The first cold storage showcase (**12**) has a first cold storage circuit (**25**). The second cold storage showcase (**13**) has a second cold storage circuit (**35**). The third cold storage showcase (**14**) has a third cold storage circuit (**45**). The freeze storage showcase (**15**) has a freeze storage circuit (**55**). The booster unit (**16**) has a booster circuit (**65**).

[0041] The booster circuit (**65**) includes a booster compressor (**46**). The freeze storage circuit (**55**) and the booster circuit (**65**) are connected together in series. A piping line extending from an inlet port (**53**) of the freeze storage circuit (**55**) to an outlet port (**54**) of the booster circuit (**65**) constitutes a two-stage side circuit (**47**).

[0042] In the refrigerating apparatus (**30**), the cold storage circuits (**25**, **35**, **45**) and the two-stage side circuit (**47**) are connected by a liquid-side interconnecting piping line (**18**) and a gas-side interconnecting piping line (**19**) in parallel with each other with respect to the outdoor circuit (**28**), thereby constituting a refrigerant circuit (**20**). The cold storage showcases (**12**, **13**, **14**) constitute re-

spective single-stage side utilization units while on the other hand the freeze storage showcase (15) constitutes a two-stage side utilization unit.

[0043] The outdoor circuit (28) includes a compressor (29) and an outdoor heat exchanger (17). The compressor (29) is a hermetical, high pressure dome type scroll compressor. The compressor (29) compresses refrigerant drawn therein and discharges it. The outdoor heat exchanger (17) is a fin and tube heat exchanger of the cross fin type and constitutes a heat source-side heat exchanger. Heat transfer between refrigerant and outdoor air is effected in the outdoor heat exchanger (17). In the outdoor unit (11), the pressure of refrigerant at the inlet port of the compressor (29) is approximately equal to the pressure of refrigerant at an inlet port (61) of the outdoor unit (11), and the pressure of refrigerant at the outlet port of the outdoor heat exchanger (17) is approximately equal to the pressure of refrigerant at an outlet port (71) of the outdoor unit (11).

[0044] In each cold storage circuit (25, 35, 45), a cold storage expansion valve (22, 32, 42) and a cold storage heat exchanger (21, 31, 41) are disposed in the order from the liquid-side end towards the gas-side end thereof. Each cold storage heat exchanger (21, 31, 41) is a fin and tube heat exchanger of the cross fin type, constitutes a cooling heat exchanger, and provides cooling of its associated compartment so that the associated compartment is held at a predetermined preset temperature. In the cold storage heat exchangers (21, 31, 41), heat transfer between refrigerant and compartment air is effected. The cold storage expansion valves (22, 32, 42) are formed by electronic expansion valves.

[0045] In the first cold storage showcase (12), the pressure of refrigerant at the inlet port of the cold storage expansion valve (22) is approximately equal to the pressure of refrigerant at an inlet port (23) of the first cold storage showcase (12), and the pressure of refrigerant at the outlet port of the cold storage heat exchanger (21) is approximately equal to the pressure of refrigerant at an outlet port (24) of the first cold storage showcase (12). In addition, in the second cold storage showcase (13), the pressure of refrigerant at the inlet port of the cold storage expansion valve (32) is approximately equal to the pressure of refrigerant at an inlet port (33) of the second cold storage showcase (13), and the pressure of refrigerant at the outlet port of the cold storage heat exchanger (31) is approximately equal to the pressure of refrigerant at an outlet port (34) of the second cold storage showcase (13). In addition, in the third cold storage showcase (14), the pressure of refrigerant at the inlet port of the cold storage expansion valve (42) is approximately equal to the pressure of refrigerant at an inlet port (43) of the third cold storage showcase (14), and the pressure of refrigerant at the outlet port of the cold storage heat exchanger (41) is approximately equal to the pressure of refrigerant at an outlet port (44) of the third cold storage showcase (14).

[0046] In the freeze storage circuit (55), a freeze stor-

age expansion valve (52) and a freeze storage heat exchanger (51) are disposed in the order from the liquid-side end towards the gas-side end thereof. The freeze storage heat exchanger (51) is a fin and tube heat exchanger of the cross fin type, constitutes a cooling heat exchanger, and provides cooling of its associated compartment so that the associated compartment is held at a predetermined preset temperature. In the freeze storage heat exchanger (51), heat transfer between refrigerant and compartment air is effected. The freeze storage expansion valve (52) is formed by an electronic expansion valve.

[0047] The booster compressor (46) of the booster unit (16) is a hermetical, high pressure dome type scroll compressor and is connected, at its inlet port, to the outlet port of the freeze storage heat exchanger (51) of the freeze storage circuit (55). The booster compressor (46) compresses refrigerant drawn therein from the freeze storage heat exchanger (51) and then discharges it.

[0048] In the two-stage side circuit (47) extending from the inlet port (53) of the freeze storage showcase (15) to the outlet port (54) of the booster unit (16), the pressure of refrigerant at the inlet port of the freeze storage expansion valve (52) is approximately equal to the pressure of refrigerant at the inlet port (53) of the two-stage side circuit (47), and the pressure of refrigerant at the discharge outlet port of the booster compressor (46) is approximately equal to the pressure of refrigerant at the outlet port (54) of the two-stage side circuit (47).

[0049] The liquid-side interconnecting piping line (18) is provided with three flow branching points (72, 73, 74) at each of which an interconnecting piping line diverges into two branch interconnecting piping lines. The branch interconnecting piping lines are connected, respectively, to the inlet ports (23, 33, 43) of the cold storage showcases (12, 13, 14) and the inlet port (53) of the two-stage side circuit (47). Of the three flow branching points (72, 73, 74), the nearest to the outdoor unit (11) is the first flow branching point (72); the second nearest to the outdoor unit (11) is the second flow branching point (73); and the third nearest to the outdoor unit (11) is the third flow branching point (74).

[0050] The liquid-side interconnecting piping line (18) is made up of: a main piping line (1) extending from the outlet port (71) of the outdoor unit (11) to the first flow branching point (72); a first connecting piping line (2a) extending from the first flow branching point (72) to the second flow branching point (73); a second connecting piping line (2b) extending from the second flow branching point (73) to the third flow branching point (74); a first branch piping line (3a) extending from the first flow branching point (72) to the inlet port (53) of the two-stage side circuit (47); a second branch piping line (3b) extending from the second flow branching point (73) to the inlet port (43) of the third cold storage showcase (14); a third branch piping line (3c) extending from the third flow branching point (74) to the inlet port (33) of the second cold storage showcase (13); and a fourth branch piping

line (3d) extending from the third flow branching point (74) to the inlet port (23) of the first cold storage showcase (12). In other words, in the liquid-side interconnecting piping line (18) which is a supply-side interconnecting piping line extending from the outlet port (71) of the outdoor unit (11), the two-stage side circuit (47) is connected at the most upstream side, and the lowest of the three cold storage showcases (12, 13, 14) in compartment preset temperature, i.e., the third cold storage showcase (14), is connected at the most upstream side thereamong.

[0051] The gas-side interconnecting piping line (19) is provided with three flow merging points (65, 66, 67) at each of which, two interconnecting piping lines join together. The merged interconnecting piping lines are connected, respectively, to the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) and the outlet port (54) of the two-stage side circuit (47). Of the three flow merging points (65, 66, 67), the nearest to the outdoor unit (11) is the first flow merging point (65); the second nearest to the outdoor unit (11) is the second flow merging point (66); and the third nearest to the outdoor unit (11) is the third flow merging point (67).

[0052] The gas-side interconnecting piping line (19) is made up of: a main piping line (4) extending from the first flow merging point (65) to the inlet port (61) of the outdoor unit (11); a third connecting piping line (5a) extending from the first flow merging point (65) to the second flow merging point (66); a fourth connecting piping line (5b) extending from the second flow merging point (66) to the third flow merging point (67); a first flow merging piping line (6a) extending from the outlet port (54) of the two-stage side circuit (47) to the third flow merging point (67); a second flow merging piping line (6b) extending from the outlet port (44) of the third cold storage showcase (14) to the first flow merging point (65); a third flow merging piping line (6c) extending from the outlet port (34) of the second cold storage showcase (13) to the second flow merging point (66); and a fourth flow merging piping line (6d) extending from the outlet port (24) of the first cold storage showcase (12) to the third flow merging point (67). In other words, in the gas-side interconnecting piping line (19) which is a return-side interconnecting piping line extending to the inlet port (61) of the outdoor unit (11), the two-stage side circuit (47) is connected at the most upstream side, and the lowest of the three cold storage showcases (12, 13, 14) in compartment preset temperature, i.e., the third cold storage showcase (14), is connected at the most downstream side thereamong.

[0053] Here, let L1 be the length of an interconnecting piping line extending from the outlet port (24) of the first cold storage showcase (12) to the inlet port (61) of the outdoor unit (11). The length (L1) is the sum of the length of the main piping line (4), the length of the third connecting piping line (5a), the length of the fourth connecting piping line (5b), and the length of the fourth flow merging piping line (6d). Let L2 be the length of an interconnecting piping line extending from the outlet port (34) of the sec-

ond cold storage showcase (13) to the inlet port (61) of the outdoor unit (11). The length (L2) is the sum of the length of the main piping line (4), the length of the third connecting piping line (5a), and the length of the third flow merging piping line (6c). Let L3 be the length of an interconnecting piping line extending from the outlet port (44) of the third cold storage showcase (14) to the inlet port (61) of the outdoor unit (11). The length (L3) is the sum of the length of the main piping line (4) and the length of the second flow merging piping line (6b). Let L4 be the length of an interconnecting piping line extending from the outlet port (54) of the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11). The length (L4) is the sum of the length of the main piping line (4), the length of the third connecting piping line (5a), the length of the fourth connecting piping line (5b), and the length of the first flow merging piping line (6a).

[0054] The relationship between the lengths of the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44, 54) of the cold storage showcases (12, 13, 14) and the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11) is: $L3 < L2 < L1 < L4$. Stated another way, the length of the interconnecting piping lines extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) is set to become shorter in ascending order of the compartment preset temperature of the cold storage showcases (12, 13, 14). In addition, the length of the interconnecting piping line extending from the outlet port (54) of the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11) is longer than any one of the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11).

[0055] In the refrigerant circuit (20), the pipe diameter of each of the sections (4, 5, 6) in the gas-side (return side) interconnecting piping line (19) is determined depending on the refrigerant flow rate in each section (4, 5, 6). Consequently, the loss of refrigerant pressure caused by the gas-side (return side) interconnecting piping line (19) becomes approximately equal in value per unit length in any one of the interconnecting piping lines. As a result, the loss of refrigerant pressure caused by the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) decreases as the length of the interconnecting piping lines decreases, and as the preset temperature of the cold storage showcases (12, 13, 14) decreases. In addition, the loss of refrigerant pressure caused by the interconnecting piping line extending from the outlet port (54) of the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11) is greater than the refrigerant pressure loss caused by any one of the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11).

RUNNING OPERATION

[0056] Description will be made in regard to the operation of the refrigerating apparatus (30) of the present embodiment. In the refrigerating apparatus (30), refrigerant is circulated between the outdoor unit (11) and each of the cold storage showcase (12, 13, 14), and single-stage compression refrigeration cycles are performed in which the cooling heat exchangers (21, 31, 41) of the cold storage showcases (12, 13, 14) function as evaporators. Further, refrigerant is circulated between the outdoor unit (11) and the two-stage side circuit (47), and two-stage compression refrigeration cycles are performed in which the cooling heat exchanger (51) of the freeze storage showcase (15) functions as an evaporator.

[0057] When the compressor (29) of the outdoor unit (11) is operated, refrigerant is compressed in the compressor (29), passes through the outdoor circuit (28), and flows into the outdoor heat exchanger (17). In the outdoor heat exchanger (17), the refrigerant dissipates heat to outdoor air and becomes condensed. The refrigerant condensed in the outdoor heat exchanger (17) exits the outdoor unit (11) and flows into the main piping line

(1) constituting a part of the liquid-side interconnecting piping line (18). And the refrigerant which has flowed into the main piping line (1) enters the cold storage circuits (25, 35, 45) and the freeze storage circuit (55) from the flow branching points (72, 73, 74).

[0058] The refrigerant which has entered each cold storage showcase (25, 35, 45) is reduced in pressure in each cold storage expansion valve (22, 32, 42) and is then introduced into each cold storage heat exchanger (21, 31, 41). In each cold storage heat exchanger (21, 31, 41), the refrigerant absorbs heat from compartment air and becomes evaporated. In the first cold storage showcase (12), compartment air cooled in the cold storage heat exchanger (21) is supplied into its associated compartment, whereby the associated compartment temperature is held at approximately a preset temperature (10 degrees Centigrade). In the second cold storage showcase (13), compartment air cooled in the cold storage heat exchanger (31) is supplied into its associated compartment, whereby the associated compartment temperature is held at approximately a preset temperature (5 degrees Centigrade). In the third cold storage showcase (14), compartment air cooled in the cold storage heat exchanger (41) is supplied into its associated compartment, whereby the associated compartment temperature is held at approximately a preset temperature (2 degrees Centigrade). The refrigerant evaporated in the cold storage heat exchangers (21, 31, 41) flows into the second to fourth flow merging piping lines (6b, 6c, 6d).

[0059] Meanwhile, the refrigerant which has flowed in-

to the freeze storage circuit (55) is reduced in pressure in the freeze storage expansion mechanism (52) and is then introduced into the freeze storage heat exchanger (51). In the freeze storage heat exchanger (51), the refrigerant absorbs heat from compartment air and becomes evaporated. In the freeze storage showcase (15), compartment air cooled in the freeze storage heat exchanger (51) is supplied into its associated compartment, whereby the compartment temperature is held at approximately a preset temperature (minus 20 degrees Centigrade). The refrigerant evaporated in the freeze storage heat exchanger (51) flows through the freeze storage circuit (55) into the booster circuit (65). The refrigerant which has flowed into the booster circuit (65) is drawn into the booster compressor (46) and discharged after being compressed by the booster compressor (46). The refrigerant discharged out of the booster compressor (46) flows into the first flow merging piping line (6a).

[0060] The loss of refrigerant pressure caused by the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) is set such that the lowest valued refrigerant pressure loss is caused by a return-side interconnecting piping line of the return-side interconnecting piping line (19) that extends from the third cold storage showcase (14). Accordingly, the refrigerant evaporative temperature in each of the cold storage showcases (12, 13, 14) is set as follows. That is, the refrigerant evaporative temperature in the third cold storage showcase (14) is the lowest; the refrigerant evaporative temperature in the second cold storage showcase (13) is the second lowest; and the refrigerant evaporative temperature in the first cold storage showcase (12) is the third lowest, so that the cold storage showcases (12, 13, 14) are maintained at their respective compartment preset temperatures.

[0061] In addition, the refrigerant evaporative temperature in the freeze storage showcase (15) is set lower than any of the cold storage showcases (12, 13, 14). However, before its arrival at the outlet port of the two-stage side circuit (47), the refrigerant from the freeze storage showcase (15) is compressed in the booster compressor (46) and, as a result, its pressure is increased. Therefore, it becomes possible to provide compartment cooling in the freeze storage showcase (15) at high cooling capability, without affecting the evaporative temperature and pressure in the cold storage showcases (12, 13, 14).

[0062] Refrigerant which has entered each flow merging piping line (6a, 6d, 6c, 6d) merges at each flow merging point (65, 66, 67) and flows through the main piping line (4) into the outdoor circuit (28). The refrigerant which has entered the outdoor circuit (28) is drawn into the compressor (29), compressed by the compressor (29), and discharged out of the compressor (29). In the refrigerant circuit (20), such a refrigerant circulation cycle is repeat-

edly carried out.

ADVANTAGEOUS EFFECTS OF THE FIRST EMBODIMENT

[0063] In the first embodiment, the loss of refrigerant pressure caused by the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcase (12, 13, 14) to the inlet port (61) of the outdoor unit (11) decreases as the compartment preset temperature of the cold storage showcases (12, 13, 14) decreases. Consequently, in order that the refrigerant evaporative temperature in the cooling heat exchangers (21, 31, 41) of the cold storage showcases (12, 13, 14) may become adequate with respect to the compartment preset temperature, the refrigerant evaporative temperature is set lower in ascending order of the compartment preset temperature. This therefore enables each of the cold storage showcases (12, 13, 14) to efficiently provide compartment cooling.

[0064] In addition, in the first embodiment, the third cold storage showcase (14) of lowest compartment preset temperature which requires higher cooling capability in comparison with the first and second cold storage showcases (12, 13) is connected in the gas-side (return-side) interconnecting piping line (19) such that refrigerant easily returns to the outdoor unit (11) from the third cold storage showcase (14) while on the other hand the third cold storage showcase (14) is connected in the liquid-side (supply side) interconnecting piping line (18) such that refrigerant easily flows into the third cold storage showcase (14) from the outdoor unit (11), whereby, when compared to the first and second cold storage showcases (12, 13), more refrigerant easily flows through the third cold storage showcase (14). Accordingly, the third cold storage showcase (14) is able to exert cooling capability sufficient enough to maintain its associated compartment at a predetermined preset temperature.

[0065] In addition, in the first embodiment, even when both the evaporative pressure and the evaporative temperature of refrigerant in the freeze storage showcase (15) are set at lower values than the cold storage showcases (12, 13, 14), the refrigerant from the freeze storage showcase (15) is compressed in the booster compressor (46) before its arrival at the outlet port of the two-stage side circuit (47), whereby the refrigerant is increased in pressure. This therefore makes it possible to enable the freeze storage showcase (15) to exert higher cooling capability than the cold storage showcases (12, 13, 14), without affecting the refrigerant evaporating pressure/temperature in the cold storage showcases (12, 13, 14).

[0066] In addition, in the first embodiment, the freeze storage showcase (15) whose refrigerant evaporative pressure and temperature are set at lower values than the cold storage showcases (12, 13, 14) is connected in the liquid-side (supply-side) interconnecting piping line (18) such that refrigerant easily flows into the freeze stor-

age showcase (15). Accordingly, since much liquid refrigerant easily flows into the freeze storage showcase (15), this makes it possible for the freeze storage showcase (15) to exert cooling capability sufficient enough to maintain the associated compartment at a predetermined preset temperature.

FIRST VARIATION OF THE FIRST EMBODIMENT

[0067] Description will be made in regard to a first variation of the first embodiment. The first variation differs from the first embodiment in that the first and second cold storage showcases (12, 13) are modified in their compartment preset temperature and the fourth connecting piping line (5b) and the fourth flow merging piping line (6d) are modified in their thickness (inside diameter).

[0068] In the first variation, the compartment preset temperature of the first cold storage showcase (12) is 5 degrees Centigrade and the compartment preset temperature of the second cold storage showcase (13) is 10 degrees Centigrade. In addition, the thickness of the fourth connecting piping line (5b) and the thickness of the fourth flow merging piping line (6d) are determined so that the sum of the refrigerant pressure loss caused by the fourth connecting piping line (5b) and the refrigerant pressure loss caused by the fourth flow merging piping line (6d) falls below the refrigerant pressure loss caused by the third flow merging piping line (6c). Because of such arrangement, the refrigerant pressure loss caused by the interconnecting piping line extending from the outlet port (24) of the first cold storage showcase (12) to the inlet port (61) of the outdoor unit (11) is smaller than the refrigerant pressure loss caused by the interconnecting piping line extending from the outlet port (34) of the second cold storage showcase (13) to the inlet port (61) of the outdoor unit (11). As a result, the loss of refrigerant pressure which is caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) decreases as the compartment preset temperature of the cold storage showcases (12, 13, 14) decreases, as in the first embodiment.

[0069] In accordance with the first variation, the length of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit does not decrease in ascending order of the compartment preset temperature of the cold storage showcases (12, 13, 14). However, by adjusting the thickness of the interconnecting piping lines, the refrigerant pressure loss caused by the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcase s(12, 13, 14) is made to decrease in ascending order of the compartment preset temperature of the cold storage showcases (12, 13, 14). Accordingly, regardless of the layout of the outdoor

unit (11) and the layout of the cold storage showcases (12, 13, 14), if the refrigerant pressure loss which is caused in the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) is controlled, the evaporative temperature of refrigerant in the cooling heat exchangers (21, 31, 41) of the cold storage showcases (12, 13, 14) is lowered in ascending order of the compartment preset temperature so that the refrigerant evaporative temperature becomes adequate with respect to the compartment preset temperature, thereby enabling the cold storage showcases (12, 13, 14) to efficiently provide compartment cooling.

SECOND VARIATION OF THE FIRST EMBODIMENT

[0070] Description will be made in regard to a second variation of the first embodiment. Referring to Figure 2, there is shown a schematic arrangement of a refrigerating apparatus (30) according to the second variation. Unlike the first embodiment, the refrigerating apparatus (30) of the second variation is provided with neither the freeze storage showcase (15) nor the booster unit (16).

[0071] More specifically, the refrigerating apparatus (30) of the second variation has an outdoor unit (11) and three cold storage showcases (12, 13, 14). And, as in the first embodiment, in the liquid-side interconnecting piping line (18) which is a supply-side interconnecting piping line extending from the outlet port (71) of the outdoor unit (11), the lowest of the three cold storage showcases (12, 13, 14) in compartment preset temperature, i.e., the third cold storage showcase (14), is connected at the most upstream side. In addition, in the gas-side interconnecting piping line (19) which is a return-side interconnecting piping line extending towards the inlet port (61) of the outdoor unit (11), the lowest of the three cold storage showcases (12, 13, 14) in compartment preset temperature, i.e., the third cold storage showcase (14), is connected at the most downstream side.

SECOND EMBODIMENT OF THE PRESENT INVENTION

[0072] Referring now to Figure 3, there is shown a refrigerating apparatus (30) according to a second embodiment of the present invention. Unlike the first embodiment, in the refrigerating apparatus (30) of the second embodiment, the two-stage side circuit (47) is connected at the most downstream side in the gas-side (return-side) interconnecting piping line (19). Hereinafter, the difference of the second embodiment from the first embodiment will be described more specifically.

[0073] The gas-side interconnecting piping line (19) is composed of: a main piping line (4) extending from the first flow merging point (65) to the inlet port (61) of the outdoor unit (11); a third connecting piping line (5a) extending from the first flow merging point (65) to the sec-

ond flow merging point (66); a fourth connecting piping line (5b) extending from the second flow merging point (66) to the third flow merging point (67); a first flow merging piping line (6a) extending from the outlet port (54) of the two-stage side circuit (47) to the first flow merging point (65); a second flow merging piping line (6b) extending from the outlet port (44) of the third cold storage showcase (14) to the second flow merging point (66); a third flow merging piping line (6c) extending from the outlet port (34) of the second cold storage showcase (13) to the third flow merging point (67); and a fourth flow merging piping line (6d) extending from the outlet port (24) of the first cold storage showcase (12) to the third flow merging point (67). In other words, in the gas-side interconnecting piping line (19) which is a return-side interconnecting piping line extending to the inlet port (61) of the outdoor unit (11), the two-stage side circuit (47) is connected at the most downstream side, and the lowest of the three cold storage showcases (12, 13, 14) in compartment preset temperature, i.e., the third cold storage showcase (14), is connected at the most downstream side among the three cold storage showcases (12, 13, 14).

[0074] The length of the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) becomes shorter as the compartment preset temperature of the cold storage showcases (12, 13, 14) becomes lower. In addition, the length of the interconnecting piping line extending from the outlet port (54) of the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11) is shorter than any of the interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11).

[0075] In the refrigerant circuit (20), the pipe diameter of each of the sections (4, 5, 6) in the gas-side (return-side) interconnecting piping line (19) is determined depending on the flow rate of refrigerant in each section. Consequently, the loss of refrigerant pressure caused by the gas-side (return-side) interconnecting piping line (19) becomes approximately equal in value per unit length in any of the interconnecting piping lines. As a result, the loss of refrigerant pressure caused by the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) decreases as the length of the interconnecting piping lines decreases and as the compartment preset temperature of the cold storage showcases (12, 13, 14) decreases. In addition, the loss of refrigerant pressure caused by the interconnecting piping line extending from the outlet port (54) of the two-stage side circuit (47) to the inlet port (61) of the outdoor unit (11) is smaller than the loss of refrigerant pressure caused by any of the interconnecting piping lines extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11).

ADVANTAGEOUS EFFECTS OF THE SECOND EMBODIMENT

[0076] In the second embodiment, as in the first embodiment, the loss of refrigerant pressure caused by the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcase (12, 13, 14) to the inlet port (61) of the outdoor unit (11) decreases as the compartment preset temperature of the cold storage showcases (12, 13, 14) decreases. Consequently, in order that the refrigerant evaporative temperature in the cooling heat exchangers (21, 31, 41) of the cold storage showcases (12, 13, 14) may become adequate with respect to the compartment preset temperature, the refrigerant evaporative temperature is set lower in ascending order of the compartment preset temperature. This therefore enables each of the cold storage showcases (12, 13, 14) to efficiently provide compartment cooling.

[0077] In addition, in the second embodiment, the loss of refrigerant pressure which caused in the return-side interconnecting piping line (19) composed of the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to the inlet port (61) of the outdoor unit (11) is set such that the lowest valued refrigerant pressure loss is caused by a return-side interconnecting piping line of the return-side interconnecting piping line (19) that is connected to the freeze storage showcase (15), and among the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) and the outlet port (54) of the two-stage side circuit (47), the outlet port (54) of the two-stage side circuit (47) has the lowest refrigerant pressure. This therefore makes it possible to suppress and lessen the refrigerant pressure at the outlet port (54) of the freeze storage showcase (15), i.e., the discharge pressure of the booster compressor (46), whereby the difference in pressure between the inlet and outlet ports of the booster compressor (46) can be reduced. Accordingly, it becomes possible to suppress and lessen the amount of power consumption in the booster compressor (46).

ANOTHER EMBODIMENT

[0078] With respect to each of the foregoing embodiments, it may be arranged such that in the liquid-side (supply-side) interconnecting piping line (18) or in the gas-side (return-side) interconnecting piping line (19) the freeze storage showcase (15) is disposed neither at the most upstream side nor at the most downstream side as in the foregoing embodiments, but between two of the cold storage showcases (12, 13, 14).

[0079] In addition, with respect to each of the foregoing embodiments, it may be arranged such that the cold storage showcases (12, 13, 14) are preset at the same compartment preset temperature as each other. In such a

case, it is preferable that the return-side interconnecting piping lines respectively extending from the outlet ports (24, 34, 44) of the cold storage showcases (12, 13, 14) to the inlet port (61) of the outdoor unit (11) cause approximately the same refrigerant pressure loss.

[0080] In addition, with respect to each of the foregoing embodiments, it may be arranged such that the refrigerant circuit (20) is provided with four or more cold storage showcases, and that the four or more cold storage showcases are connected in parallel with the outdoor unit (11).

[0081] In addition, with respect to each of the foregoing embodiments, it may be arranged such that an air conditioning unit is provided in the refrigerant circuit (20). In such a case, it is preferable that the air conditioning unit is connected to the outdoor unit (11) by an interconnecting piping line other than the liquid- and gas-side interconnecting piping lines (18, 19).

[0082] It should be noted that the above-described embodiments are essentially preferable examples which are not intended in any sense to limit the scope of the present invention, its application, or its application range.

INDUSTRIAL APPLICABILITY

[0083] As has been described above, the present invention finds its utility in the field of refrigerating apparatuses in which a plurality of utilization units are connected in parallel with a heat source unit.

Claims

1. A refrigerating apparatus comprising: (a) a plurality of single-stage side utilization units (12, 13, 14) having cooling heat exchangers (21, 31, 41) respectively, each of the cooling heat exchangers (21, 31, 41) being configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature, and (b) a single heat source unit (11) having a compressor (29), wherein in a refrigerant circuit (20) in which the single-stage side utilization units (12, 13, 14) are connected in parallel with the heat source unit (11) by interconnecting piping lines (18, 19) refrigerant is circulated between each of the single-stage side utilization units (12, 13, 14) and the heat source unit (11) whereby single-stage compression refrigeration cycles are performed, wherein the loss of pressure of the refrigerant which is caused in the return-side interconnecting piping line (19) comprising return-side interconnecting piping lines respectively extending from outlet ports (24, 34, 44) of the single-stage side utilization units (12, 13, 14) to an inlet port (61) of the heat source unit (11) is set such that the lowest valued refrigerant pressure loss is caused by a said return-side interconnecting piping line that is connected to the lowest of the single-stage side utilization units (12, 13, 14)

in compartment preset temperature.

2. A refrigerating apparatus comprising: (a) a plurality of single-stage side utilization units **(12, 13, 14)** having cooling heat exchangers **(21, 31, 41)** respectively, each of the cooling heat exchangers **(21, 31, 41)** being configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature, and (b) a single heat source unit **(11)** having a compressor **(29)**, wherein in a refrigerant circuit **(20)** in which the single-stage side utilization units **(12, 13, 14)** are connected in parallel with the heat source unit **(11)** by interconnecting piping lines **(18, 19)** refrigerant is circulated between each of the single-stage side utilization units **(12, 13, 14)** and the heat source unit **(11)** whereby single-stage compression refrigeration cycles are performed, wherein the loss of pressure of the refrigerant which is caused in the return-side interconnecting piping line **(19)** comprising return-side interconnecting piping lines respectively extending from outlet ports **(24, 34, 44)** of the single-stage side utilization units **(12, 13, 14)** to an inlet port **(61)** of the heat source unit **(11)** is set such that the aforesaid refrigerant pressure loss becomes smaller as the compartment preset temperature in the single-stage side utilization units **(12, 13, 14)** connected respectively by the aforesaid return-side interconnecting piping lines to the inlet port **(61)** of the heat source unit **(11)** becomes lower.
3. A refrigerating apparatus comprising: (a) a plurality of single-stage side utilization units **(12, 13, 14)** having cooling heat exchangers **(21, 31, 41)** respectively, each of the cooling heat exchangers **(21, 31, 41)** being configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature, and (b) a single heat source unit **(11)** having a compressor **(29)**, wherein in a refrigerant circuit **(20)** in which the single-stage side utilization units **(12, 13, 14)** are connected in parallel with the heat source unit **(11)** by interconnecting piping lines **(18, 19)** refrigerant is circulated between each of the single-stage side utilization units **(12, 13, 14)** and the heat source unit **(11)** whereby single-stage compression refrigeration cycles are performed, wherein the length of return-side interconnecting piping lines respectively extending from outlet ports **(24, 34, 44)** of the single-stage side utilization units **(12, 13, 14)** to an inlet port **(61)** of the heat source unit **(11)** is set such that a said return-side interconnecting piping line that is connected to the lowest of the single-stage side utilization units **(12, 13, 14)** in compartment preset temperature is the shortest return-side interconnecting piping line.
4. A refrigerating apparatus comprising: (a) a plurality of single-stage side utilization units **(12, 13, 14)** having cooling heat exchangers **(21, 31, 41)** respectively, each of the cooling heat exchangers **(21, 31, 41)** being configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature, and (b) a single heat source unit **(11)** having a compressor **(29)**, wherein in a refrigerant circuit **(20)** in which the single-stage side utilization units **(12, 13, 14)** are connected in parallel with the heat source unit **(11)** by interconnecting piping lines **(18, 19)** refrigerant is circulated between each of the single-stage side utilization units **(12, 13, 14)** and the heat source unit **(11)** whereby single-stage compression refrigeration cycles are performed, wherein the length of return-side interconnecting piping lines respectively extending from outlet ports **(24, 34, 44)** of the single-stage side utilization units **(12, 13, 14)** to an inlet port **(61)** of the heat source unit **(11)** is set such that the aforesaid length becomes shorter as the compartment preset temperature in the single-stage side utilization units **(12, 13, 14)** connected respectively by the aforesaid return-side interconnecting piping lines to the inlet port **(61)** of the heat source unit **(11)** becomes lower.
5. The refrigerating apparatus of any one of claims 1-4, wherein in the return-side interconnecting piping line **(19)** composed of the return-side interconnecting piping lines establishing respective connections between the outlet ports **(24, 34, 44)** of the single-stage side utilization units **(12, 13, 14)** and the inlet port **(61)** of the heat source unit **(11)** the lowest of the single-stage side utilization units **(12, 13, 14)** in compartment preset temperature is connected at the most downstream side.
6. The refrigerating apparatus of claim 5, wherein in the supply-side interconnecting piping line **(18)** composed of supply-side interconnecting piping lines establishing respective connections between an outlet port **(71)** of the heat source unit **(11)** and inlet ports **(23, 33, 43)** of the single-stage side utilization units **(12, 13, 14)** the lowest of the single-stage side utilization units **(12, 13, 14)** in compartment preset temperature is connected at the most upstream side.
7. The refrigerating apparatus of any one of claims 1-4, wherein said refrigerating apparatus further includes a two-stage side circuit **(47)** in which a two-stage side utilization unit **(15)** having a cooling heat exchanger **(51)** configured to provide cooling of its associated compartment so that the associated compartment is kept at a predetermined preset temperature and a booster compressor **(46)** are connected in series;

wherein in the refrigerant circuit **(20)** the two-stage side circuit **(47)** is, together with the single-stage side utilization units **(12, 13, 14)**, connected in parallel with the heat source unit **(11)** by the interconnecting piping lines **(18, 19)** and the refrigerant is circulated between the two-stage side utilization unit **(15)** and the heat source unit **(11)** whereby two-stage compression refrigeration cycles are performed.

8. The refrigerating apparatus of claim 7,
 wherein the two-stage side circuit **(47)** is connected at the most upstream side in the return-side interconnecting piping line **(19)** composed of the return-side interconnecting piping lines establishing respective connections between (i) the outlet ports **(24, 34, 44)** of the single-stage side utilization units **(12, 13, 14)** and an outlet port **(54)** of the two-stage side circuit **(47)** and (ii) the inlet port **(61)** of the heat source unit **(11)**.
9. The refrigerating apparatus of claim 8,
 wherein the two-stage side circuit **(47)** is connected at the most upstream side in the supply-side interconnecting piping line **(18)** composed of the supply-side interconnecting piping lines establishing respective connections between (i) the outlet port **(71)** of the heat source unit **(11)** and (ii) the inlet ports **(23, 33, 43)** of the single-stage side utilization units **(12, 13, 14)** and an inlet port **(53)** of the two-stage side circuit **(47)**.

FIG. 1

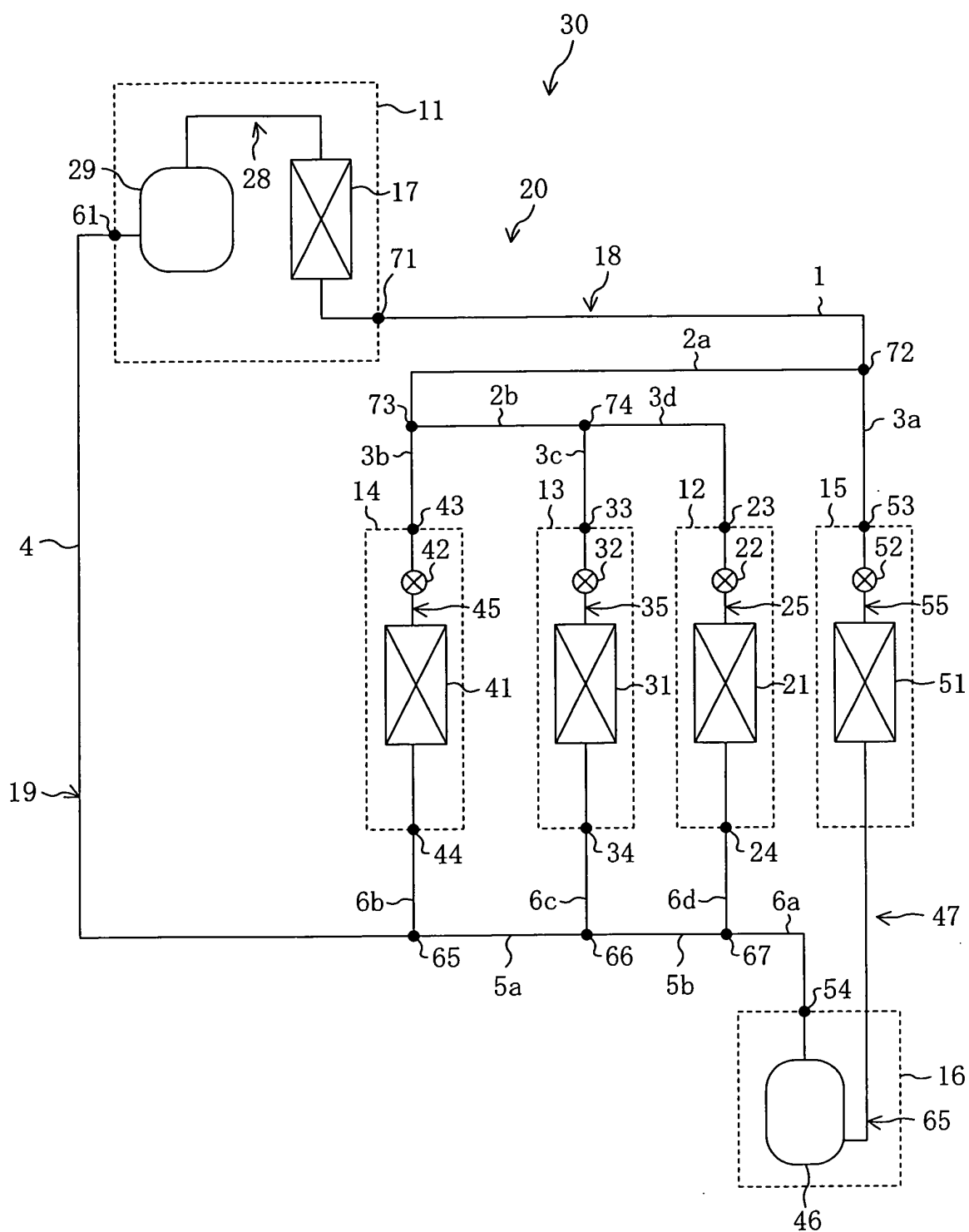


FIG. 2

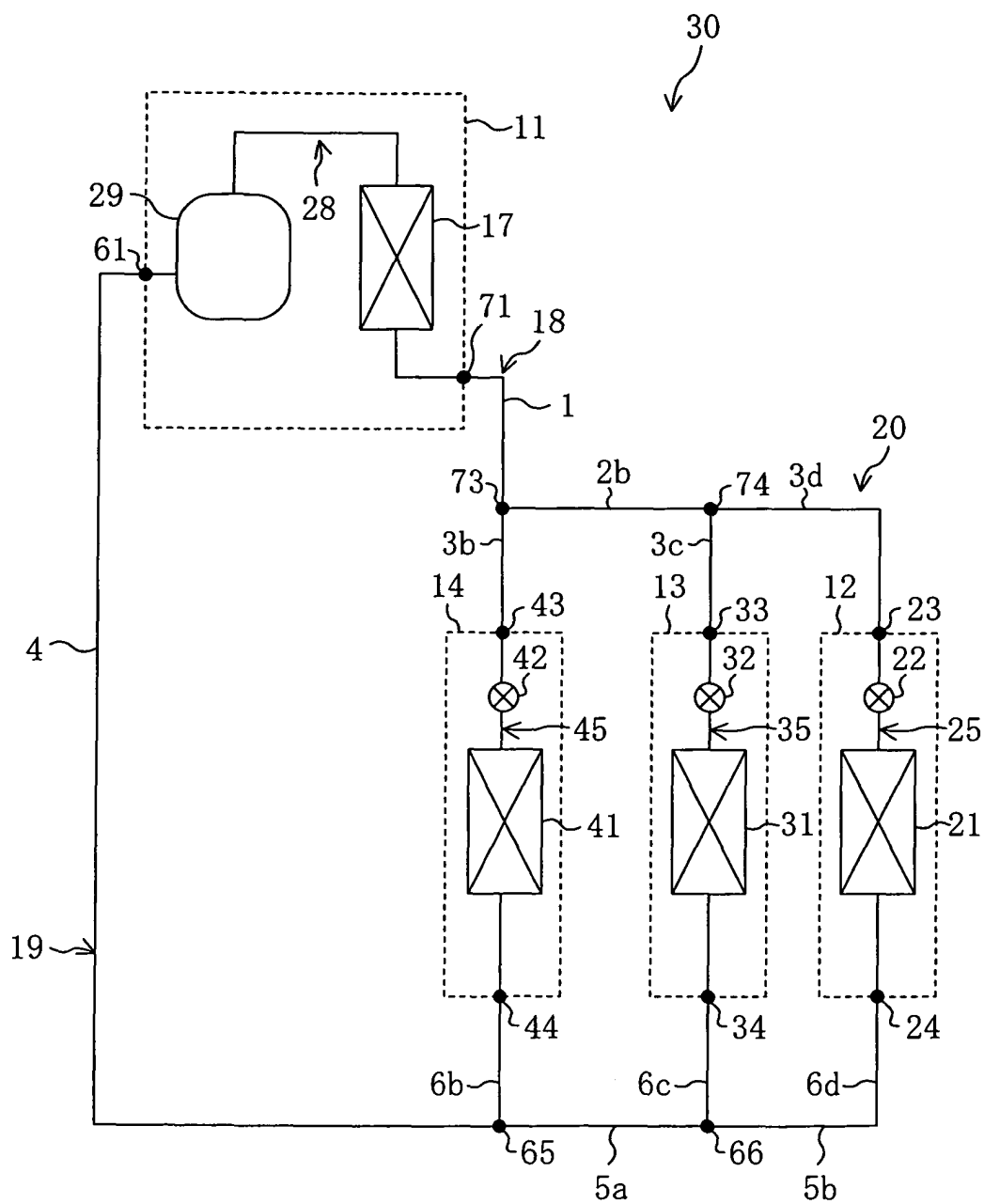
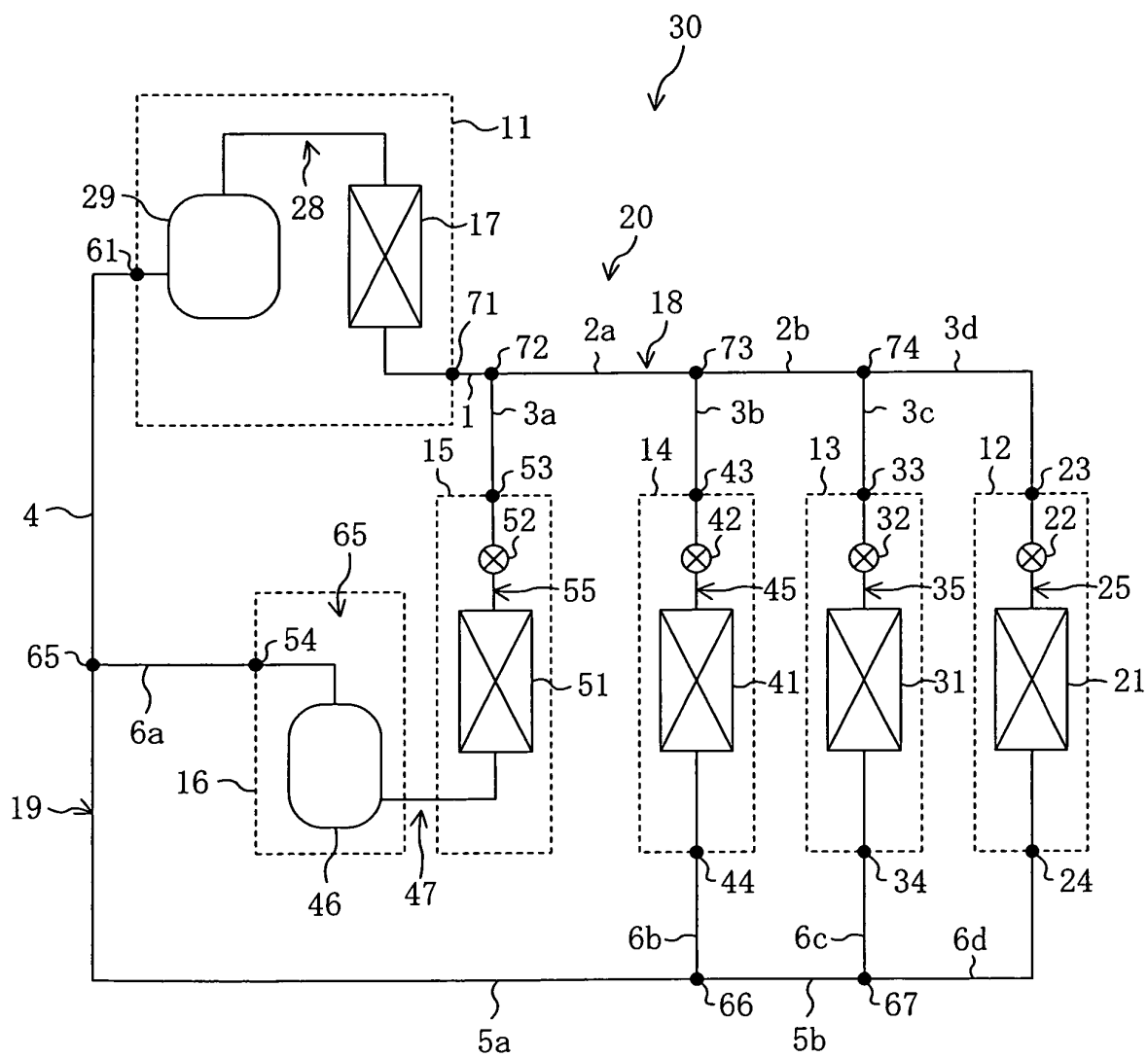


FIG. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/023585

A. CLASSIFICATION OF SUBJECT MATTER

F25B5/02 (2006.01), **F25B1/00** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B5/02 (2006.01), **F25B1/00** (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2003-207220 A (Sanyo Electric Co., Ltd.), 25 July, 2003 (25.07.03), Par. No. [0009]; Fig. 4 (Family: none)	1, 2 3-9
Y	JP 2004-44921 A (Daikin Industries, Ltd.), 12 February, 2004 (12.02.04), Par. Nos. [0004], [0047] to [0049]; Fig. 1 & WO 2004/8048 A1 & EP 1522802 A1 & US 2005-115271 A	3-9
A	JP 2003-172553 A (Denso Corp.), 20 June, 2003 (20.06.03), Full text; Figs. 1 to 8 (Family: none)	1-9

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
28 March, 2006 (28.03.06)Date of mailing of the international search report
04 April, 2006 (04.04.06)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2003314909 A [0003]