(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 552 906 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **93300302.2**

(51) Int. Cl.[5] : **F25D 21/00**

(22) Date of filing : **18.01.93**

A request for correction claim 12 has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 2.2).

(30) Priority : **21.01.92 JP 49020/92**

(43) Date of publication of application : **28.07.93 Bulletin 93/30**

(84) Designated Contracting States : **CH DE DK ES FR GB IT LI SE**

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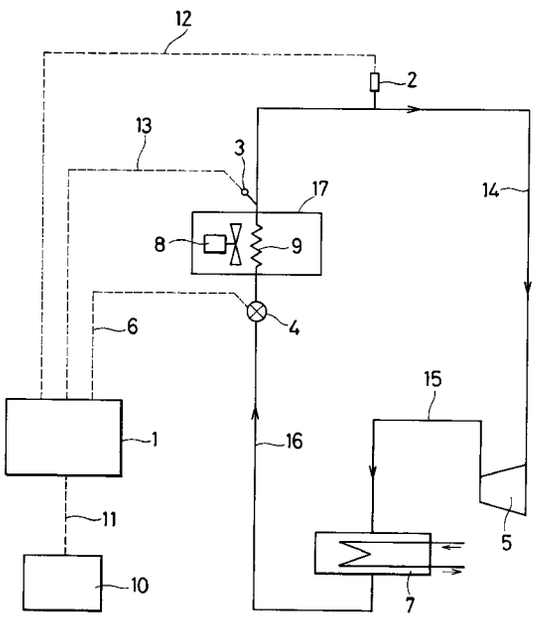
(54) Defrost starting method and device for refrigerant evaporators.

(57) The expansion valve is controlled by expansion valve controlling computer. When the maximum valve capacity of the expansion valve became lower value than the setting value by increase of the frost amount which has accumulated on the refrigerant evaporator, defrost starts its running by the signal from expansion valve controlling computer. By using this method, we can protect the individual difference of the operator conducting defrosting for setting defrost starting time and the periodical defrosting regardless of the amount of accumulated frost.

Fig. 1



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BACKGROUND OF INVENTION

Field of the invention:

This invention relates to a defrost starting method and device on refrigerant evaporators by sensing the decrease of the cooling efficiency during the operation. Description of the prior art:

Conventionally, water spinkling, or refrigerant hot gas methods using the principle of latent and sensible heat have been applied as defrost devices for refrigerant evaporators.

Among automatic defrost starting devices and methods for low-temperature air coolers, the following can be mentioned;

(1) direct method of measuring the thickness of the frost which sticks to the refrigerant evaporator,

(2) method of measuring the pressure drop of the air passing through the refrigerant evaporator,

(3) method of measuring the power consumption of fan,

(4) method of defrosting regularly at the set times, etc.

The conventional defrost starting methods for refrigerant evaporators such as method (1), (2) and (3) all have the disadvantage of subjective judgment, differing from one person to another, as the starting time is set either by the visual confirmation of an actual front situation or by personal experience, i.e. the most suitable defrost starting time cannot be clearly defined. Sometimes defrosting was started at an earlier stage than necessary, when the cooling efficiency of the evaporator was not low enough or, at other times, in spite of low efficiency operation caused by too must frost, the defrosting was started too late, thus resulting in a higher room temperature and a long time compressor operation with low efficiency, which leads not only to a lower quality of the refrigerated objects but also to excessive energy consumption.

Method (4) has the disadvantage of sometimes starting defrosting too early and sometimes too late, as the defrosting starts at a fixed time, regardless amount of frost, which does not accumulate constantly, but differs from time to time depending on the opening and closing of the door in a low temperature hold, loading and dispatching of goods to be cooled, the temperature of goods to be cooled and the humidity situation. This disadvantage leads to a longer operation time of the compressor, thus shortening its life time without being able to save energy.

SUMMARY OF THE INVENTION

An object of the present invention is to offer a defrost starting method and device for refrigerant evaporators detecting the most suitable time for defrost start by detecting the frost amount which has accumulated on the refrigerant evaporator via the expansion valve controlling computer and starting defrost automatically when necessary.

Another object of the present invention is to offer defrost starting method and device for refrigerant evaporators which is indepedent on the individual difference of the operator conducting defrosting for setting defrost starting time or at regular set times, regardless of the amount of accumulated frost.

In order to achieve the abovementioned objects, this invention has the characteristic to control the expansion valve supplying the refrigerant to the refrigerant evaporator by using the expansion valve controlling computer linked to the temperature and pressure sensor with each signalling cable and placed at the lower part of the refrigerant flow.

The controlling computer intends to let the expansion valve for refrigerant supply remember the maximum valve capacity which is most suitable in accordance with the refrigeration capacity of the evaporator by self-research. When the frost accumulates much on the refrigerant evaporator, the controlling computer detects the decrease in the refrigerating efficiency as temperature and pressure via the abovementioned temperature and pressure sensors, decreases the maximum valve capacity value via the expansion valve controlling computer and starts defrosting when the maximum valve capacity value falls below the pre-set value regarding it as the most suitable defrost starting time.

Furthermore, the system starts defrosting by using a publicly known defrosting device, applying either the maximum, minimum or average value of the maximum valve capacity of each expansion valve by means of the temperature and pressure at the lower part of the refrigerant flow of the refrigerant evaporator of each circuit of several refrigerant circulation circuits connected to the same compressor and condenser.

BRIEF EXPLANATIONS OF DRAWINGS

Fig. 1 is a piping and wiring diagram in the application of a single refrigerant evaporator installed in a single cooling room;

Fig. 2 is a piping and wiring diagram in the application of several refrigerant evaporators in a single cooling room;

Fig. 3 is a griping and wiring diagram in the application of several refrigerant evaporators in several cooling rooms; and

Fig. 4 shows the relationship between the actual valve capacity and the maximum valve capacity in accordance with the superheat degree of the temperature sensor part.

DETAILED DESCRIPTION OF THE INVENTION

The following is a detailed explanation on the attached drawings of an application of the defrost starting device for refrigerant evaporators in practice using this invention.

A computer 1 for expansion valve control calculates the difference between the refrigerant evaporating pressure measured by a pressure sensor 2 and converted into evaporating temperature by the computer 1 and the temperature measured by a temperature sensor 3, i.e, the superheat degree, and controls the refrigerant flow amount of an electronic expansion valve 4 proportionally in a refrigeration circle where the refrigerant is supplied from a compressor 5 to a condenser 7 via a high-pressure gas pipe 15, decreasing the pressure of the refrigerant by the electronic expansion valve 4 via a high-pressure liquid pipe 16, heat-exchanging with the air coming from a fan 8 by an evaporator 9 in the cooling room and returning to the compressor 5 via a low-pressure gas pipe 14, The computer 1 is connected to the pressure sensor 2 measuring the refrigerant evaporating pressure, the temperature sensor 3 measuring the refrigerant evaporating temperature placed at the low pressure gas pipe 14 of the lower part of the refrigerant evaporator 9 and the electronic expansion valve 4 via signal cables 12, 13 and 6.

A control panel 10 for low-temperature air cooler is connected to the abovementioned computer 1 for expansion valve control via a signal cable 11 and controls publicly known defrost devices (not shown in the drawing). When more frost is accumulated on the evaporator 9, the temperature measured by the temperature sensor 3 decreases gradually and exceeds the range of the proportional control.

The computer 1 for expansion valve control detects that the cooling capacity of the refrigerant evaporator 9 has decreased, decreases the maximum valve capacity of the electronic expansion valve 4, compares it with the maximum set valve capacity for starting defrost which is memorized in the computer 1 and starts defrost when the decreased maximum valve capacity falls below the set maximum valve capacity for starting defrost.

Fig. 3 shows cooling rooms 18 and 19 each provided with a fan 8a, 8b connecting several electronic expansion valves 4a and 4b by diverging the high-pressure liquid pipe 16 and equipped with refrigerant evaporators 9a and 9b. 3a and 3b are temperature sensors as above mentioned placed at the lower part of the refrigerant evaporators 9a and 9b before the diverging part to the low-pressure gas pipe 14.

6a and 6b are signal cables connecting the electronic expansion valves 4a and 4b and the computer 1 for expansion valve control. 12 is a pressure signal cable which connects the pressure sensor 2 placed at the low-pressure gas pipe 14 and the computer 1 as mentioned before.

13a and 13b are temperature signal cables connecting the temperature sensors 3a and 3b and the computer 1. The computer 1 and the control panel 10 for low-temperature air cooler device controlling the defrost of the evaporators 9a and 9b in the cooling rooms 18 and 19 are connected to each other by signal cables 11a and 11b.

Fig. 4 shows that point A is the initial setting of the maximum expansion valve capacity and the superheat degrees of the temperature sensors 3, 3a and 3b apply to the heat load change so that the superheat degrees remain within the range of the proportional band I (the superheat degree of the temperature sensor part at the beginning of the expansion valve opening) and II (the superheat degree of the temperature sensor part when the expansion valve has the maximum capacity).

The actual valve capacity is adjusted one after another on the line IA, IB and IC. When there is much frost on the refrigerant evaporators 9, 9a and 9b, the superheat degrees of the temperature sensors 3, 3a and 3b will decrease, and when reaching below the superheat 1 of the temperature sensor part at the valve opening, the maximum valve capacity will decrease from point A → point B → point C, and when reaching joint D, or when the maximum, minimum or average value of the maximum valve capacity of the expansion valve 4a and 4b reaches to point D or below, the computer 1 for expansion valve control judges it as the most suitable time for starting defrosting and sends defrost start signals to the control panel 10 for low-temperature air coolers via the signal cables 11, 11a and 11b.

It is possible to control the flow amount of the liquid refrigerant of the expansion valve 4 by calculating the difference between the value which is converted from the pressure detected by the sensor 2 for refrigerant evaporating pressure via the compoulter 1 and the temperature detected by the temperature sensor 3 attached at the lower part of the refrigerant flow of the evaporator 9, i.e. superheat degree by using the computer 1 linked to the pressure sensor 2 detecting the refrigerant evaporating pressure and attached at the lower part of the refrigerant flow of the evaporator 9 and the temperature sensor 3 detecting the refrigerant temperature.

When much frost is accumulated on the refrigerant evaporator 9, the temperature detected by the temperature sensor 3 decreases frequently exceeding the range of the proportional control. The computer 1 for controlling the expansion valve decreases the maximum valve capacity of the electronic expansion valve 4 and adjusts the capacity of the electronic valve 4 so that the refrigeration capacity of the evaporator 9 and the capacity of the electronic expansion valve 4 will balance.

When more frost is accumulated on the refriger-

ant evaporator 9, the computer 1 for controlling the expansion valve decreases the maximum valve capacity of the electronic expansion valve 4 furthermore, compares it with the set maximum valve capacity which is memorized in the computer 1 in order to set the defrost starting time, judges the time where the maximum valve capacity is the same as or below the set maximum valve capacity for starting defrost as the most suitable time for defrost start and sends defrost starting signals to the control panel 10 of the low-temperature air cooler system.

This invention saves not only energy, but also prolongs the life time of the compressor by shortening its operation time without damaging the quality of goods stored in a low temperature room thanks to the abovementioned structure. Although only little frost is accumulated partly on the low-temperature air cooler, the system catches the decrease of the maximum valve capacity of the expansion valves 4, 4a and 4b of the refrigerant evaporators 9, 9a and 9b due to frost accumulation and judges that it is the most suitable time for starting defrosting and starts defrost. Therefore, in spite of the change in the situation of the cooling air (humidity), change in the refrigeration capacity of the compressor or other disturbance from outside, etc., the system grasps the most suitable time for starting defrosting with certainty by knowing that the decrease of the maximum expansion and starts defrosting of the refrigerant evaporators 9, 9a and 9b in a steady way.

The features disclosed in the foregoing description in the following claims and/or the,accompanying drawings may, both separately and in any combination thereof be material for realising the invention in diverse forms thereof.

Claims

1. A defrost starting method on refrigerant evaporators of low-temperature air cooling devices where the refrigerant is supplied from the expansion valve, which is connected to the refrigerant evaporator by cooling the air, using the evaporating latent heat of the refrigerant which has the characteristic of starting defrosting on there surface of the refrigerant evaporator, using a publicly known defrost device, which detects the decrease of the maximum capacity of the expansion valve obtained by detecting the temperature and pressure at the lower part of the refrigerant evaporator via the applied computer, when it falls below the reference value.

2. A defrost starting method on refrigerant evaporators which have the characteristic of starting defrosting of a low-temperature air cooler consisting of one compressor and one condenser with several expansion valves and refrigerant evaporators supplying the refrigerant from each expansion valve and cooling, the air by utilizing the evaporating latent heat of the refrigerant, using a publicly known defrost device by applying either the maximum, minimum, or average valve capacity of several expansion valves obtained by measuring the temperature and pressure of the lower part of the refrigerant evaporator via the applied computer.

3. A defrost starting device on refrigerant evaporators which have the characteristic of starting defrosting by inputting a defrost start signal into the control panel by measuring the decrease below the reference value of the maximum capacity of the expansion valve obtained by measuring the temperature and pressure of the lower part of the refrigerant evaporator via the applied computer of a low-temperature aircooler consisting of a compressor, condenser, expansion valves and refrigerant evaporators interconnected by pipes, through which the refrigerant is supplied, returning it to the compressor and circulated, provided with the applied computer, which controls the expansion valve with a temperature and a pressure sensor connected to the pipes of the lower part of the refrigerant evaporator via each signal cable and a control panel of a low-temperature air cooler controlling the defrost of the evaporator connected to the applied computer via a defrost signal cable.

4. A defrost starting device on refrigerant evaporators of a low-temperature air cooler consisting of one compressor, one condenser and several expansion valves and refrigerant evaporators possessing the characteristic of starting defrosting by inputting a defrost starting signal, which results from either the maximun, minimumn or average value of the maximum valve capacity of several expansion valves into the control panel connected to the applied computer via a defrost signal cable measuring the temperature and pressure at the refrigerant outlet of the refrigerant evaporator by means of a temperature and a pressure sensor and controlling the opening and closing of the expansion valve using the publicly known defrost device.

5. A method of defrosting a refrigerant evaporator of a cooling device, which method comprises supplying a refrigerant to at least one refrigerant evaporator by means of at least one valve and, in the case of one or more refrigerant evaporator(s) and a single valve, initiating the defrosting process when the maximum capacity of the single valve falls to below a set predetermined value or,

in the case of two or more refrigerant evaporators and one or more valves, initiating the defrosting process when the maximum, minimum or average value of the maximum capacities of the one or more valves falls to below a set predetermined value.

6. A method according to Claim 5, wherein the at least one valve comprises an electronically controlled expansion valve.

7. A method according to Claim 6 or 7, further comprising monitoring the refrigeration efficiency of the at least one refrigerant evaporator, changing the maximum capacity of the at least one valve in accordance with the monitored refrigeration efficiency and comparing the actual maximum capacity of the at least one valve with the set predetermined value.

8. A method according to Claim 7, wherein, when the refrigeration efficiency of the at least one refrigerant evaporator decreases, the maximum capacity of the at least one valve is also decreased so as to balance the supply of refrigerant to the at least one refrigerant evaporator with the monitored refrigeration efficiency of the at least one refrigerant evaporator.

9. A method according to Claim 7 or 8, wherein, the refrigeration efficiency of the at least one refrigerant evaporator is monitored by detecting in the refrigerant evaporating pressure and the refrigerant evaporating temperature at a position adjacent the at least one refrigerant evaporator, converting the reading of refrigerant evaporating pressure to a reading of refrigerant evaporating temperature, and calculating the degree of superheat from the difference between the detected values of refrigerant evaporating pressure and refrigerant evaporating temperature.

10. A method according to any one of Claims 5 to 9, further comprising evaporating the refrigerant under low pressure in the at least one refrigerant evaporator and circulating the refrigerant from the at least one refrigerant evaporator to a compressor via a low pressure gas pipe, from the compressor to a condenser via a high pressure gas pipe and then via a high pressure liquid pipe and at least one expansion valve back to the at least one refrigerant evaporator.

11. A method according to any one of Claims 5 to 10, further comprising defrosting the at least one refrigerant evaporator by means of a control panel and a defrosting device, wherein the defrosting device controls the defrosting process by controlling the opening and closing of the at least one valve.

12. A system for defrosting at least one refrigerant evaporator of a cooling device, which system comprises at least one valve, the at least one valve supplying refrigerant to the at least one refrigerant evaporator and a computer, which computer, in the case where there is one or more refrigerant evaporators and a single valve, causes the defrosting process to be initiated when the maximum capacity of the valve falls below a set predetermined value or which, in the case where there is one or more refrigerant evaporators and one or more valves, causes the defrosting process to be initiated when the maximum, minimum or average value of the maximum capacities of the two or more valves falls below a set predetermined value.

13. A system according to Claim 12, wherein the at least one valve comprises an electronically controlled expansion valve.

14. A system according to Claim 13, wherein the at least one refrigerant evaporator has an inlet though which refrigerant enters the at least one refrigerant evaporator and an outlet through which refrigerant leaves the at least one refrigerant evaporator and wherein a pressure sensor and a temperature sensor are located in the low pressure gas pipe adjacent the outlet of the at least one refrigerant evaporator for detecting the refrigerant evaporating pressure and the refrigerant evaporating temperature, the pressure sensor and the temperature sensor each being connected to the computer via a signal cable, wherein the computer uses the readings of refrigerant evaporating pressure and refrigerant evaporating temperature to determine the refrigerating efficiency of the at least one refrigerant evaporator and wherein the computer changes the maximum capacity of the at least one valve, in accordance with the refrigerating efficiency, by means of a signal cable connecting the computer to the at least one valve.

15. A system according to any one of Claims 12 to 14, further comprising a low pressure gas pipe for transferring the refrigerant from the at least one refrigerant evaporator to a compressor, a high pressure gas pipe for transferring the refrigerant from the compressor to a condenser, and a high pressure liquid pipe for transferring the refrigerant from the condenser back to the at least one refrigerant evaporator via the at least one valve.

16. A system according to any one of Claims 12 to 15,

further comprising a defrosting device which is controlled by the computer via a signal cable and control panel and which controls defrosting of the at least one refrigerant evaporator by controlling the opening and closing of the at least one valve.

Fig. 1

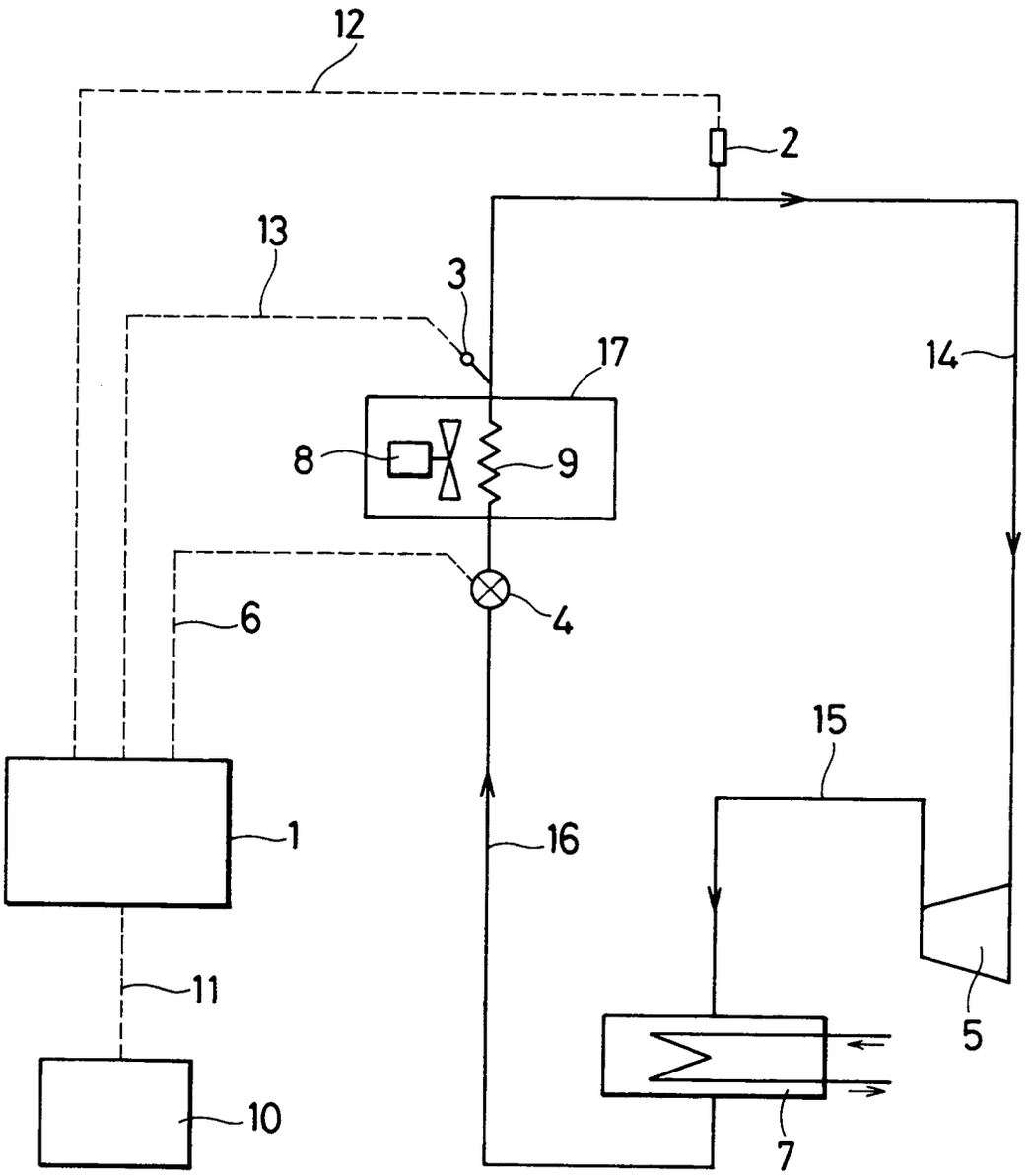


Fig. 2

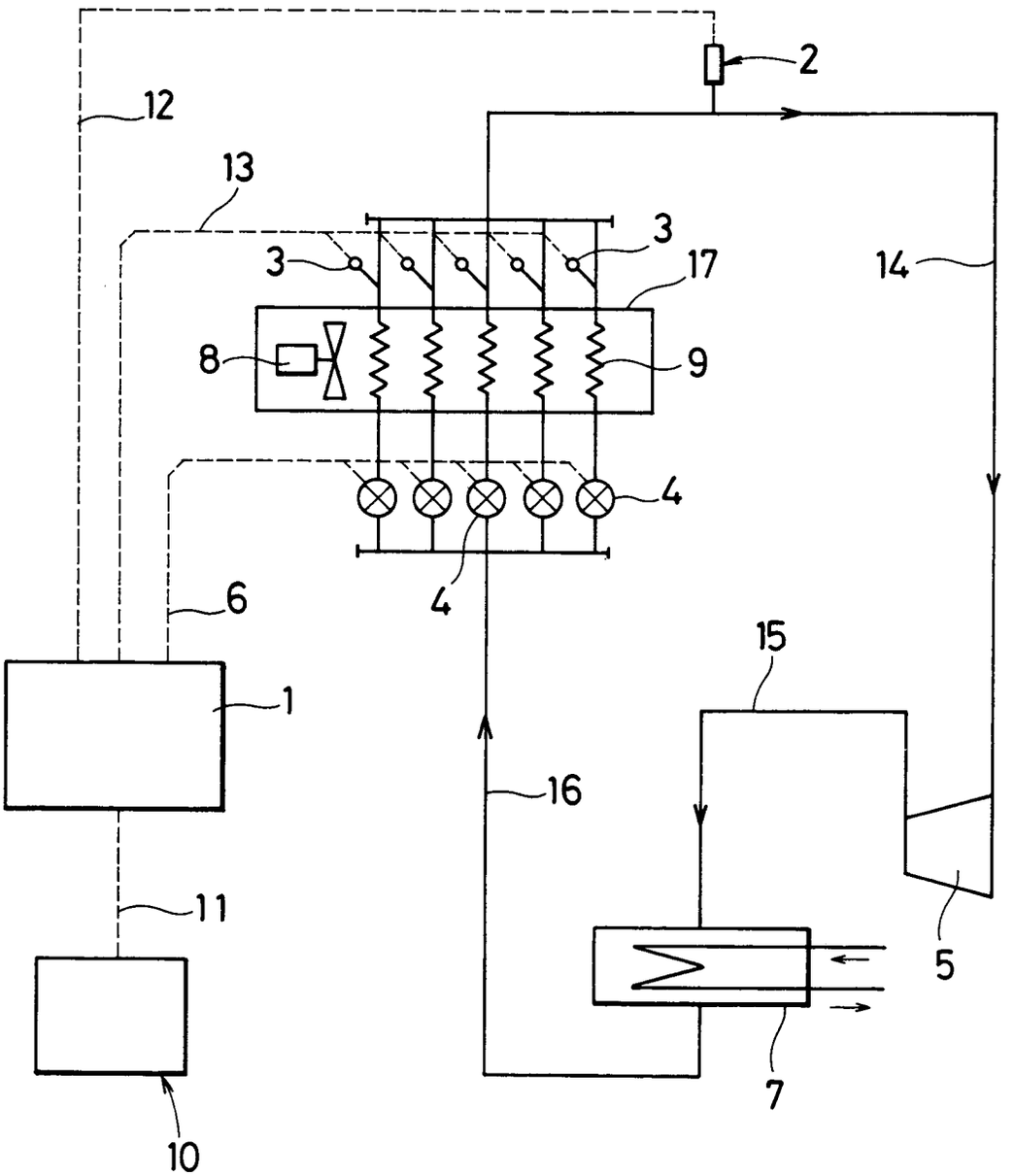
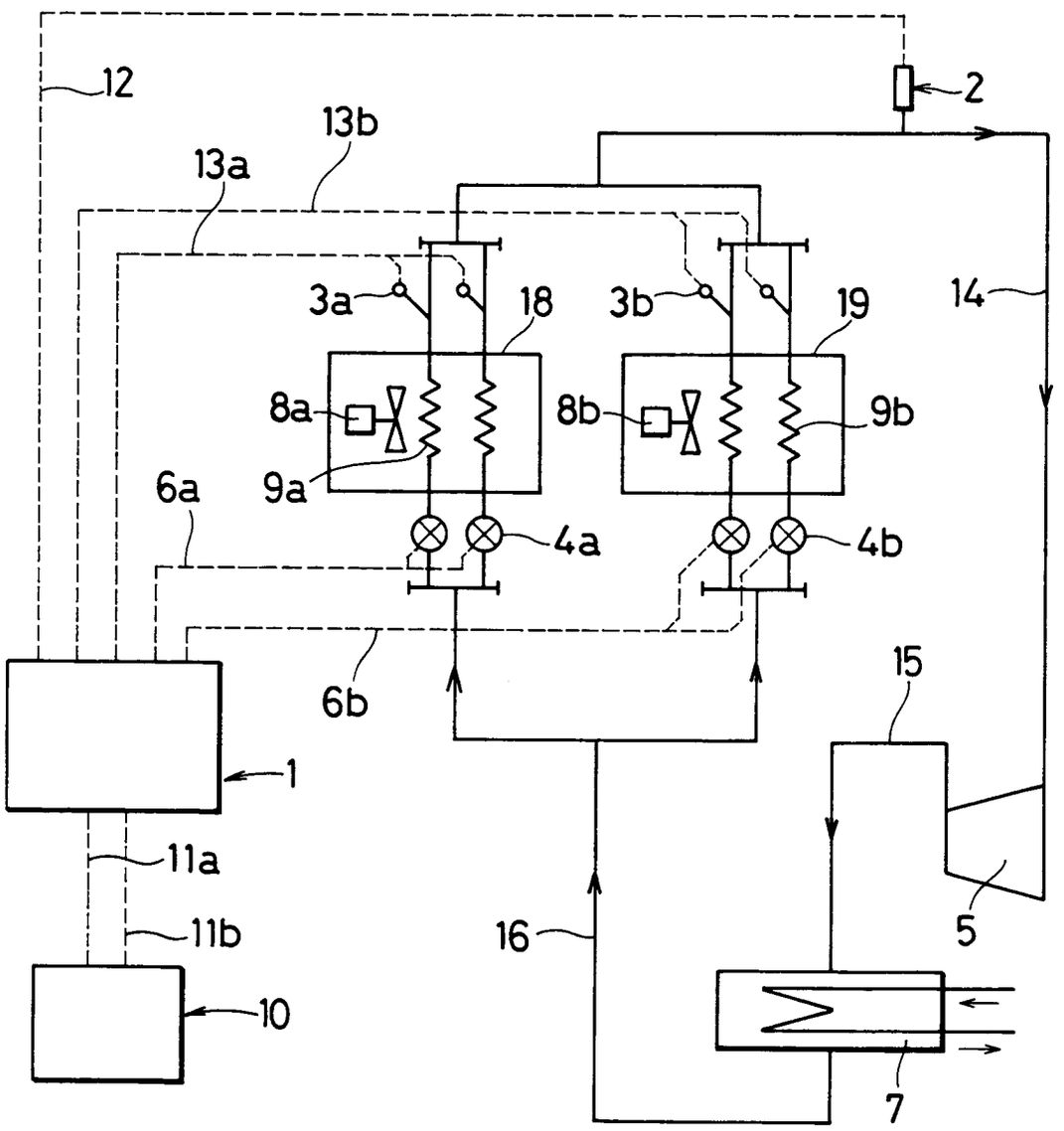


Fig. 3


12
2
13b
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18
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14
8a
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4b
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11b
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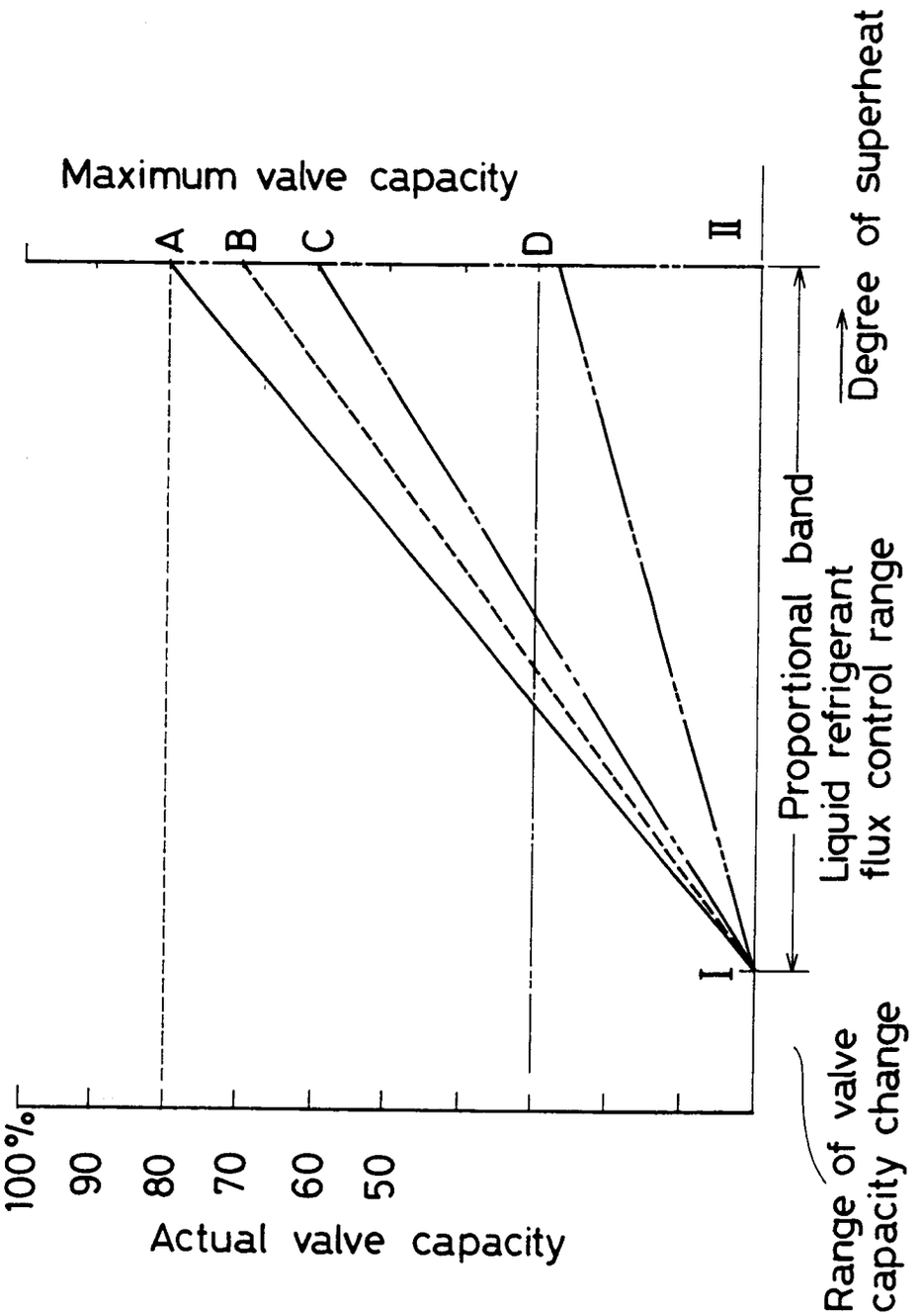
10
7

Fig. 4


Maximum valve capacity
A
B
C
D
II
I
Degree of superheat
Proportional band
Liquid refrigerant
flux control range
Range of valve
capacity change
100%
90
80
70
60
50
Actual valve capacity