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**(54) REFRIGERATING SYSTEM AND METHOD OF OPERATING A REFRIGERATING SYSTEM**

**KÜHLSYSTEM UND VERFAHREN FÜR DEN BETRIEB EINES KÜHLSYSTEMS**

**SYSTÈME DE RÉFRIGÉRATION ET PROCÉDÉ DE FONCTIONNEMENT D'UN SYSTÈME DE  
RÉFRIGÉRATION**

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(74) Representative: **Schmitt-Nilson Schraud Waibel  
Wohlfrom  
Patentanwälte Partnerschaft mbB  
Destouchesstraße 68  
80796 München (DE)**

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(73) Proprietor: **Carrier Corporation  
Farmington, CT 06034-4015 (US)**

(72) Inventor: **LEWEKE, Peter  
50389 Wesseling (DE)**

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## Description

**[0001]** The invention relates to a refrigerating system and to a method of operating a refrigerating system.

**[0002]** Conventional vapour compression refrigerating systems are well-known. It is also known for refrigerating systems to comprise a normal refrigeration portion and a freezer portion. For example, a supermarket refrigerating system may provide for the cooling of both the sales furniture having a normal refrigeration level and the sales furniture having a freezing temperature level. In this context, so-called booster systems are known that employ a first compressor for the normal refrigeration portion of the refrigeration system and a second compressor unit for the freezing portion of the refrigeration system, wherein the compressed refrigerant from the pressure side of the second compressor is supplied to the suction side of the first compressor.

**[0003]** Such refrigerating systems having a normal refrigeration portion and a freezing portion, wherein both portions have their own expansion devices and evaporators and a joint compressor and wherein the freezing portion has an additional freezing portion compressor, are known from EP 1 914 491 A2 and WO 2006/015741 A1.

**[0004]** Both documents disclose refrigerating systems according to the preamble of claim 1.

**[0005]** At present, these booster systems are very sensitive to changes in the operating conditions, which in turn leads to substantial control efforts being necessary and system inefficiencies arising therefrom.

**[0006]** Accordingly, it would be beneficial to provide a refrigerating system and a corresponding method of operating a refrigerating system that decrease the sensitivity of the refrigerating system to operating condition changes and increase the efficiency of the refrigerating system.

**[0007]** The first aspect of the invention concerns a refrigeration system according to claim 1.

**[0008]** The second aspect of the invention concerns a method according to claim 12.

**[0009]** Exemplary embodiments of the invention will be described in greater detail below with reference to the accompanying drawing.

**[0010]** Fig. 1 shows a connection diagram of a refrigerating system according to an exemplary embodiment of the invention.

**[0011]** The refrigerant circuit of the refrigerating system 2 comprises, in flow direction of the refrigerant, a first compressor unit 4 having three compressors connected in parallel, a pressure conduit 34 leading to a condenser/gas cooler 6, an intermediate expansion device 8, and a collecting container 10 in which liquid refrigerant collects in the lower liquid refrigerant portion and gaseous refrigerant collects in the upper gaseous refrigerant portion. From the liquid refrigerant portion, a cooling branch supply conduit 18 runs liquid refrigerant through a heat exchanger 20 and supplies the liquid refrigerant to a nor-

mal refrigeration branch and a freezing branch. The normal refrigeration branch includes a first expansion device 22 and a first evaporator 24, from which the refrigerant reaches the first compressor unit 4 via normal refrigeration branch outlet conduit 36. The freezing branch includes, in flow direction of the refrigerant, a second expansion device 26, a second evaporator 28, a second compressor unit 30 and a desuperheating device 32, from which the refrigerant reaches the first compressor unit 4 via freezing branch outlet conduit 38. The refrigerant circuit further comprises a cooling branch bypass conduit 16, which is coupled to the gaseous refrigerant portion of the collecting container 10 via a gaseous refrigerant expansion device 12 and to the liquid refrigerant portion of the collecting container 10 via a liquid refrigerant expansion device 14. The cooling branch bypass conduit 16 runs through the heat exchanger 20 and is connected to the first compressor unit 4. The heat exchanger 20 establishes a heat exchange relationship between the cooling branch bypass conduit 16 and the cooling branch supply conduit 18, i.e. between the refrigerant in the cooling branch bypass conduit 16 and the refrigerant in the cooling branch supply conduit 18.

**[0012]** The operation of the refrigerating system 2 is described hereinafter. For the following discussion, it is assumed that the refrigerant used in the refrigerating system 2 is CO<sub>2</sub>.

**[0013]** The refrigerant is compressed by the first compressor unit 4, through which the refrigerant assumes a temperature in the pressure conduit 34 that greatly exceeds common ambient air temperatures. In the condenser/gas cooler 6, the refrigerant is cooled down against a secondary medium. In the exemplary embodiment of Fig. 1, the secondary medium is air. However, other secondary media, such as water or air enriched with water particles, may also be used. In the case of CO<sub>2</sub> being the refrigerant, the condenser/gas cooler is referred to as a gas cooler, as the refrigerant leaves the gas cooler 6 in a gaseous phase. For other refrigerants, a condensation may take place in the condenser/gas cooler 6, such that this refrigerant circuit element is referred to as a condenser.

**[0014]** The refrigerant is expended to an intermediate pressure level in the intermediate expansion device 8. After said expansion, the CO<sub>2</sub> is present partially in its gaseous phase and partially in its liquid phase, with the liquid refrigerant collecting in the lower liquid refrigerant portion of the collecting container 10 and the gaseous refrigerant collecting in the upper gaseous refrigerant portion of the collecting container 10.

**[0015]** Liquid refrigerant is flown from the liquid refrigerant portion of the collecting container 10 into the cooling branch supply conduit 18 in order to supply the normal refrigeration branch and the freezing branch with refrigerant. The refrigerant passes through the heat exchanger 20, where it is cooled further down from the temperature assumed after the intermediate expansion device 8, as will be described in more detail later. After the heat ex-

changer 20, the refrigerant supply conduit 18 branches off into the normal refrigeration branch and the freezing branch.

**[0016]** In the normal refrigeration branch, the refrigerant is further expanded by the first expansion device 22, through which the pressure and the temperature of the refrigerant are further reduced. In the exemplary embodiment of Fig. 2, the symbol of the first evaporator 24 stands for a plurality of cold consumers at a normal refrigeration level, for example a plurality of refrigerated sales shelves in a supermarket. In these cold consumers, air is cooled against the refrigerant leaving the first expansion device 22. The cooled air keeps the contents of the refrigerated space of the cold consumers cold. The first expansion device 22 is controlled in a way such that the refrigerated space temperature of the cold consumers stays constant. A typical desired temperature is between 5 °C and 10 °C. In this case, the refrigerant exits the first evaporator 24 at about 0 °C. From the outlet of the first evaporator 24, the refrigerant reaches the suction side of the first compressor unit 4 via normal refrigeration branch outlet conduit 36. The first evaporator 24 may also be a single cold consumer, such as a single cooling shelf.

**[0017]** In the freezing branch, the refrigerant is flown to the second expansion device 26, through which the refrigerant is expanded to a pressure and temperature lower than the pressure and temperature after the first expansion device 22. Accordingly, the second evaporator 28 cools down air to a freezing temperature, such that a freezing functionality is achieved. The evaporator 28 stands for one or a plurality of cold consumers, such as an array of freezers in a supermarket. The air space of these freezers is cooled down to a below 0 °C temperature. After the evaporator 28, the refrigerant is flown to a second compressor unit 30, where the refrigerant is compressed, which leads to an increase of the refrigerant temperature, to approximately 70-80 °C. The second compressor unit 30 is shown to have 3 compressors, but may be comprised of a smaller or greater number.

**[0018]** The refrigerant is then cooled against a secondary medium in the desuperheating device 32. The secondary medium may be air, water, air enriched with water particles, a brine or any other suitable secondary medium. The refrigerant is brought into a heat exchange relationship with the secondary medium, such that the refrigerant is desuperheated. The desuperheating device may be placed within a machine room of the refrigerating system or at an outdoor location. In the case of the secondary medium being air, the refrigerant is cooled down to a temperature corresponding to and some degrees above the respective ambient temperature. In this way, a portion of the heat added to the refrigerant in the evaporator 28 is withdrawn from the refrigerant in the desuperheating device 32. The desuperheated refrigerant is flown through the freezing branch outlet conduit 38 into the cooling branch bypass conduit 16 - after the heat exchanger 20 - and from there to the suction side of the

first compressor unit 4. The freezing branch outlet conduit 38 may equally be joined with the normal refrigeration branch outlet conduit 36 or may be coupled directly to the suction side of the first compressor unit 4.

**[0019]** The second compressor unit 30 compresses the refrigerant to a pressure substantially equal to the pressure of the refrigerant after leaving the first expansion device 22. In this way, the refrigerant portions in the normal refrigeration branch outlet conduit 36 and the freezing branch outlet conduit 38 do not exhibit substantial pressure differences, such that a mixing of these refrigerant portions without the occurrence of counter-flow in one of the two outlet conduits is achieved. However, this pressure correspondence is not mandatory. The refrigerant leaves the first evaporator 24 of the normal refrigeration branch at a temperature of around 0 °C, whereas the refrigerant leaves the desuperheating device 32 at a temperature of ca. 20-35 °C. Accordingly, the refrigerant at the suction side of the first compressor unit 4 has a resulting temperature in between the respective branch outlet temperatures.

**[0020]** The temperature of the refrigerant at the suction side of the first compressor unit 4 determines the temperature of the refrigerant at the pressure side of the first compressor unit 4, assuming a given compressor performance. The temperature of the refrigerant in the pressure conduit 34 is a critical parameter, particularly because the first compressor unit 4 and the condenser/gas cooler 6 have a maximum operating temperature. In order for the system to operate safely, the temperature of the refrigerant in the pressure conduit 34 cannot exceed a predetermined threshold. A temperature sensor (not shown) in the pressure conduit senses the temperature of the refrigerant, such that the temperature can be monitored over time and an exceeding of the predetermined threshold value can be avoided. Also, the temperature sensor may be placed at the suction side of the first compressor unit 32, with the corresponding temperature in the pressure conduit 34 being calculated from a given first compressor unit performance. Alternatively, a pressure sensor may be arranged in the pressure conduit 34, with the temperature of the refrigerant being deduced from known refrigerant properties.

**[0021]** By desuperheating the refrigerant in the freezing branch, the refrigerant reaching the pressure conduit 34 carries inherently less heat than in a refrigerating system without the desuperheating device 32. Accordingly, more degrees of freedom are given to a system designer due to the presence of the desuperheating device 32. In other words, for the rest of the refrigerating system being identical, the presence of the desuperheating device 34 drastically decreases the probability of the temperature in the pressure conduit 34 reaching a critical value.

**[0022]** As a further means of controlling the temperature of the refrigerant in the pressure conduit 34, the cooling branch bypass conduit 16 is provided. In the exemplary embodiment of Fig. 1, refrigerant from the collecting container 10 is flown into the normal refrigeration branch

outlet conduit 36. The cooling branch bypass conduit 16 is connected to the gaseous refrigerant portion of the collecting container 10 via the gaseous refrigerant expansion device 12 and to the liquid refrigerant portion of the collecting container 10 via the liquid refrigerant expansion device 14, respectively. The gaseous and liquid refrigerant expansion devices 12 and 14 are controlled separately. Both of these expansion devices expand the refrigerant, such that low temperature refrigerant can be mixed with the refrigerant portions coming from the first evaporator 24 and the desuperheating device 32. Accordingly, the gaseous and liquid refrigerant expansion devices 12 and 14 are operated in a way to control the temperature of the refrigerant in the pressure conduit 34. It is pointed out that it is also possible to have only one of the gaseous refrigerant expansion device 12 and the liquid refrigerant expansion device 14 in place, in order to bring down the refrigerant temperature at the pressure conduit 34.

**[0023]** In the exemplary embodiment of Fig. 1, liquid refrigerant is supplied to the normal refrigeration branch and the freezing branch. Gaseous refrigerant, also referred to as flash gas, is the preferred phase of the refrigerant to be used for controlling the temperature of the refrigerant in the pressure conduit 34. Therefore, the gaseous refrigerant expansion device 12 is primarily operated for introducing unused refrigerant, i.e. refrigerant not used in cold consumers, into the suction side of the first compressor unit 4. Should the introduction of the flash gas not be sufficient for maintaining a desired temperature working point in the pressure conduit 34, the liquid refrigerant expansion device 14 is operated additionally to introduce more unused refrigerant for purposes of reducing the controlled temperature.

**[0024]** The exemplary embodiment of Fig. 1 further comprises the heat exchanger 20, which brings the cooling branch supply conduit 18 and the cooling branch bypass conduit 16 into a heat exchange relationship. As the heat exchanger is arranged behind the gaseous refrigerant expansion device 12 and the liquid refrigerant expansion device 14, the refrigerant in the cooling branch bypass conduit 16 is at a lower temperature than the refrigerant in the cooling branch supply conduit 18. Therefore, the refrigerant in the cooling branch supply conduit 16 is cooled below the temperature of the refrigerant in the collecting container 10. The refrigerant in the cooling branch bypass conduit 16 may achieve a lowering of the refrigerant temperature in the pressure conduit in two ways. Firstly, it lowers the temperature of the refrigerant in the cooling branch supply conduit 18, such that, if the same amount of thermal energy is absorbed by the refrigerant in the normal refrigeration branch and the freezing branch, the refrigerant reaches the suction side of the first compressor unit 4 at a lower temperature. Secondly, the refrigerant in the cooling branch bypass conduit itself provides for a reduction of the refrigerant mix at the suction side of the first compressor unit 4. It is also possible that the refrigerant in the normal refrigera-

tion branch and the freezing branch absorbs more thermal energy from the secondary media in the first evaporator 24 and the second evaporator 28 due to its lower evaporator inlet temperature, such that a more effective cooling of the cold consumers is achieved.

**[0025]** The heat exchanger 20 may be controllable. For this purpose, the level of heat exchange between the cooling branch supply conduit 18 and the cooling branch bypass conduit 16 may be adaptable. This can be achieved via suitable conduits in the heat exchanger 20, such that the length of the conduits effecting the heat exchange is selectively chosen, for example by providing multiple refrigerant branches in the heat exchanger and according directing of the refrigerant. Accordingly, it can be set by a controller to what extent the available cooling capacity of the refrigerant in the cooling branch bypass conduit is used for the cooling purposes in the first and second evaporators 24 and 28 and to what extent it is directly used for reducing the temperature of the refrigerant mixture at the suction side of the first compressor unit 4.

**[0026]** The performance of the desuperheating device 32 may also be adjustable, for example by setting the speed of a fan that blows a secondary medium through the desuperheating device 32 for absorbing thermal energy from the refrigerant or by switching on/off a suitable number of a plurality of fans.

**[0027]** A controller or control unit (not shown) is provided, which is connected to the temperature sensor in the pressure conduit 34. Depending on the temperature sensed, the controller controls the one or more of the gaseous refrigerant expansion device 12, the liquid refrigerant expansion device 14, the heat exchanger 20 and the desuperheating device 32. Providing a control unit that controls the gaseous refrigerant expansion device 12 and the liquid refrigerant expansion device 14 only as a response to the refrigerant temperature in the pressure conduit 34 allows for an excellent trade off between control algorithm complexity, control loop stability and control reaction time.

**[0028]** A concrete application example will further illustrate the advantages of the present invention. Assume that the refrigerating system 2 is the refrigerating system of a supermarket. The first evaporator 24 comprises an array of cooling shelves operated between 5°C and 10°C, with the cooling shelves being open for the consumer to conveniently take refrigerated goods, such a dairy products, out of the shelves. The second evaporator 28 comprises an array of freezers operated between -20°C and -15°C, with the freezers being either chest freezers with sliding covers or stand-up freezers with doors. Temperature sensors are provided in the array of cooling shelves as well as in the array of freezers. Based on the measured temperatures, the first and second expansion devices 22 and 26 are controlled in order provide sufficient refrigerant to the first and second evaporators 24 and 28 in order to maintain the respective desired temperatures. It is also possible that each cold consumer, in the present example

each cooling shelf and each freezer, has its own expansion device associated therewith.

**[0029]** It is further assumed that, during business hours of the supermarket, the array of freezers consumes 20% of the cooling power of the refrigerating system 2, whereas the array of cooling shelves consumes 80% of the cooling power of the refrigerating system 2. In a stationary operation, this results in a substantially constant mixture of refrigerant from the normal refrigeration branch and from the freezing branch. After business hours, the cooling shelves are covered to conserve energy. Accordingly, the cold air is kept more effectively in the air space of the cooling shelves, such that less cooling power is needed. In contrast thereto, the cooling power requirements for the freezing branch remains substantially constant. Therefore, it can be assumed that the freezing branch consumes 40% of the cooling power after business hours, whereas the normal refrigeration branch comprises 60% of the cooling power of the refrigerating system 2. Hence, the mixing temperature of the refrigerant at the suction side of the first compressor unit 4, and therewith in the pressure conduit 34, increases as compared to during business hours. However, due to the desuperheating of the refrigerant in the freezing branch in the desuperheating device 32, the change in mixing temperature is not as high as in conventional booster systems without desuperheating device. The reason for this is that the temperature difference between the refrigerant exiting the normal refrigeration branch and the refrigerant exiting the freezing branch is drastically reduced by the desuperheating device 32. Accordingly, a ratio change between the two refrigerant portions of the two branches does not have as much of an effect on the refrigerant temperature in the pressure conduit 34 as in the case without the desuperheating device 32. As a result, the control requirements for the refrigerating system 2 as a whole are reduced substantially. The provision of the cooling branch bypass conduit 16 as well as the gaseous refrigerant expansion device 12 and the liquid refrigerant expansion device 14 allows for safely controlling the refrigerating system 2 over a wide range of operating conditions. Through the provision of the desuperheating device 32, it is ensured that a comparatively low level of controlling measures are to be taken in order to keep the system in a desired operating condition. Also, the provision of the efficient temperature reduction functionality via flash gas and liquid refrigerant through the cooling branch bypass conduit 16 allows for very quick response times of the refrigerating system 2 to a change in the operating conditions.

**[0030]** In the exemplary embodiment of Fig. 1, the desuperheating device 32 is positioned in the machine room of the refrigerating system 2. Should the refrigerating system 2 not have its own machine room, the desuperheating device may be positioned in a general machine room of the building, for example in a machine room / storage room of the supermarket. By placing the desuperheating device 32 indoors, it is ensured that, even in the winter

time, the secondary medium is not at such a low temperature that the refrigerant condenses or partially condenses in the desuperheating device 32. Therefore, stable operating conditions for the refrigerant mixing at the suction side of the first compressor unit 4 and during the compressing operation in the first compressor unit 4 are achieved. During the winter time, the machine room may even be heated by the desuperheating device. In warmer regions of the world, the desuperheating device 32 may be positioned at an outdoor location, where a greater reduction of the refrigerant temperature may be achieved than at an indoor location, particularly when the heat exchange with the secondary medium is designed efficiently via a strong secondary medium flow. It is also possible to provide two desuperheating devices, one of which being positioned at an outdoor location and the other one being positioned in the machine room. Suitable ducting with a branching element after the second compressor unit 30 and a reunification of the ducts before the first compressor unit 4, together with suitable means for directing the refrigerant flow, allows for heating the machine room and preventing refrigerant condensation in the winter as well as maximum refrigerant temperature reduction outdoors in the summer.

**[0031]** Exemplary embodiments of the invention as described above allow for an energy-efficient refrigerating system with low control requirements. The desuperheating device allows for a desuperheating of the refrigerant against readily available secondary media, i.e. without the consumption of further cooling power. Moreover, the desuperheating device in the freezing branch makes the refrigerating system more robust by decreasing the sensitivity against operating condition changes, particularly against changes in the ratio of cooling power consumed in the normal refrigeration branch vs. cooling power consumed in the freezing branch. Consequently, not a lot of energy has to be invested in controlling the refrigerating system, as the system deviates slower from a desired operating point. Particularly for large systems with many cold consumers, the control expenses saved are very substantial.

**[0032]** According to a further exemplary embodiment, the refrigerant circuit further comprises a cooling branch bypass conduit coupled between the collecting container and the suction side of the first compressor unit, wherein the cooling branch bypass conduit is coupled to the collecting container via a bypass conduit expansion device. The provision of the cooling branch bypass conduit and the bypass conduit expansion device allows for an efficient controlling of the refrigerant mix at the suction side of the first compressor unit. Moreover, the temperature of the refrigerant at the pressure side of the first compressor unit can be held in acceptable limits in a very efficient manner.

**[0033]** The refrigerant circuit may further comprise a heat exchanger establishing a heat exchange relationship between the cooling branch bypass conduit and a cooling branch supply conduit coupling the collecting

container to the first and second expansion devices. In this way, the refrigerant deducted from the collecting container into the cooling branch bypass conduit improves the cooling performance achieved in the first and second evaporators of the normal refrigeration and the freezing branches via a further reduction of the temperature of the refrigerant flown to the cold consumers. The heat exchanger may be disposed at such a position that the refrigerant in the cooling branch bypass conduit interacts with the refrigerant in the cooling branch supply conduit before the cooling branch supply conduit branches out into the normal refrigeration branch and the freezing branch. In this way, the cooling performance of both the normal refrigeration branch and the freezing branch is improved. It is, however, possible to effect the heat exchange between the cooling branch bypass conduit and only one of normal refrigeration branch and freezing branch.

**[0034]** In a further exemplary embodiment, the refrigerating system further comprises a temperature sensor disposed at one of the suction side of the first compressor unit and a pressure side of the first compressor unit, and a control unit coupled to the temperature sensor and configured to control at least one of the desuperheating device, the bypass conduit expansion device and the heat exchanger. In this way, temperatures critical for the high pressure portion of the refrigerant circuit, i.e. critical for one of the first compressor unit, the pressure conduit and the condenser/gas cooler, can be efficiently prevented. Making one of or any subset of the desuperheating device, the heat exchanger and the bypass conduit expansion device controllable allows for an effective control of the refrigerating system. Moreover, having a plurality of such controllable devices allows for great flexibility and a high number of degrees of freedom when designing the control algorithm of the refrigerating system. In this way, an excellent trade off between control algorithm complexity, control reaction time and energy invested for control purposes can be found. Also, this trade off may be adapted to the particular refrigerating system installation efficiently.

**[0035]** According to another exemplary embodiment, the refrigerant circuit comprises an intermediate expansion device disposed between the condenser/gas cooler and the collecting container, such that the collecting container is operated at an intermediate pressure level. This allows for the provision of a two stage refrigerant expansion system, which improves the efficiency of the overall refrigerating system, as another degree of freedom for controlling the refrigerant flow is introduced.

**[0036]** The collecting container may comprise a gaseous refrigerant portion and a liquid refrigerant portion, with the refrigerant in operation being separated into gaseous refrigerant in the gaseous refrigerant portion and liquid refrigerant in the liquid refrigerant portion. The separation of refrigerant allows for only supplying refrigerant in one phase to the normal refrigeration branch and the freezing branch, which provides for a better stability and

predictability of the refrigerating system. The refrigerant circuit may further comprise a cooling branch supply conduit coupling the liquid refrigerant portion of the collecting container to the first and second expansion devices. In this way, only the liquid refrigerant, which is able to absorb more thermal energy than the gaseous refrigerant, is flown to the cold consumers, which allows for a higher cooling rate at a reference refrigerant flow rate.

**[0037]** In a further exemplary embodiment, the refrigerant circuit comprises a cooling branch bypass conduit coupled between the collecting container and the suction side of the first compressor unit, wherein the cooling branch bypass conduit is coupled to the gaseous refrigerant portion of the collecting container via a gaseous refrigerant expansion device. In this way, the gaseous refrigerant, which is less desirable for cooling purposes in the cold consumers, can be brought to good use for regulating the temperature at the suction side, and therefore at the pressure side, of the first compressor unit. It is also possible that the cooling branch bypass conduit is coupled to the liquid refrigerant portion of the collecting container via a liquid refrigerant expansion device. Accordingly, should the provision of the flash gas for the purpose of reducing the refrigerant mix temperature at the suction side of the first compressor unit not be sufficient, additional refrigerant from the collecting container may be introduced. As this refrigerant is in the liquid phase, the effect on the reduction of the temperature on the suction/pressure side of the first compressor unit is particularly high.

**[0038]** In a further exemplary embodiment, the refrigerating system further comprises a temperature sensor disposed at one of the suction side of the first compressor unit and a pressure side of the first compressor unit, and a control unit coupled to the temperature sensor and configured to control at least one of the desuperheating device, the gaseous refrigerant expansion device, the liquid refrigerant expansion device and the heat exchanger. In this way, temperatures critical for the high pressure portion of the refrigerant circuit, i.e. critical for one of the first compressor unit, the pressure conduit and the condenser/gas cooler, can be efficiently prevented. Making one of or any subset of the desuperheating device, the heat exchanger, the gaseous refrigerant expansion device and the liquid refrigerant expansion device controllable allows for an effective control of the refrigerating system. Moreover, having a plurality of such controllable devices allows for great flexibility and a high number of degrees of freedom when designing the control algorithm of the refrigerating system. In this way, an excellent trade off between control algorithm complexity, control reaction time and energy invested for control purposes can be found. Also, this trade off may be adapted to the particular refrigerating system installation efficiently.

**[0039]** In a particular exemplary embodiment, the refrigerant is CO<sub>2</sub>. The properties of CO<sub>2</sub> in connection with the structure of the refrigerating system allow for a highly efficient overall system. However, the refrigerating

system is generally suitable for a wide variety of refrigerants.

**[0040]** The desuperheating device may be positioned in a machine room of the refrigerating system. This allows for a prevention of condensation of the refrigerant in the desuperheating device and a heating of the machine room. Also, the desuperheating device may be positioned in an outdoor location, which allows for a greater reduction of the refrigerant temperature in the desuperheating device in scenarios when the outdoor temperature is lower than, for example, an indoor machine room temperature.

**[0041]** It is also possible that the desuperheating device is positioned in a machine room of the refrigerating system and that the freezing branch comprises a second desuperheating device positioned in an outdoor location and arranged in parallel - in refrigerant circuit terms - with the desuperheating device in the machine room, with the refrigerant in operation being selectively directed to the desuperheating device in the machine room and the second desuperheating device. In this way, the advantages of having the desuperheating device in a machine room and the advantages of having the desuperheating device in an outdoor location can be selectively chosen, depending on the momentary system and environment conditions. The selective choice may be carried out automatically, for example via a control unit having a thermostat.

**[0042]** All the advantages and the embodiments that have been described with respect to the refrigerating circuit also hold true for the corresponding method of operating a refrigerating system. These advantages and embodiments are herewith explicitly disclosed also in terms of corresponding method steps, however without repeating them again.

**[0043]** While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt the particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

List of reference numerals:

**[0044]**

- |    |                                      |  |
|----|--------------------------------------|--|
| 2  | Refrigerating system                 |  |
| 4  | First compressor unit                |  |
| 6  | Condenser/gas cooler                 |  |
| 8  | Intermediate expansion device        |  |
| 10 | Collecting container                 |  |
| 12 | Gaseous refrigerant expansion device |  |
| 14 | Liquid refrigerant expansion device  |  |

- |    |                                            |
|----|--------------------------------------------|
| 16 | Cooling branch bypass conduit              |
| 18 | Cooling branch supply conduit              |
| 20 | Heat exchanger                             |
| 22 | First expansion device                     |
| 24 | First evaporator                           |
| 26 | Second expansion device                    |
| 28 | Second evaporator                          |
| 30 | Second compressor unit                     |
| 32 | Desuperheating device                      |
| 34 | Pressure conduit                           |
| 36 | Normal refrigeration branch outlet conduit |
| 38 | Freezing branch outlet conduit             |

## 15 Claims

1. Refrigerating system (2) comprising a refrigerant circuit having the following elements:

a first compressor unit (4), a condenser/gas cooler (6), a collecting container (10), and an intermediate expansion device (8) disposed between the condenser/gas cooler (6) and the collecting container (10), such that the collecting container (10) is operated at an intermediate pressure level,

a normal refrigeration branch coupled between the collecting container (10) and a suction side of the first compressor unit (4), the normal refrigeration branch comprising a first expansion device (22) and a first evaporator (24), wherein a normal refrigeration branch outlet conduit (36) is coupled between the first evaporator (24) and the first compressor unit (4),

a freezing branch coupled between the collecting container (10) and the suction side of the first compressor unit (4), the freezing branch comprising a second expansion device (26), a second evaporator (28), a second compressor unit (30) and a desuperheating device (32), wherein a freezing branch outlet conduit (38) is coupled between the desuperheating device (32) and the first compressor unit (4),

a cooling branch bypass conduit (16) coupled between the collecting container (10) and the suction side of the first compressor unit (4), wherein the cooling branch bypass conduit (16) is coupled to the collecting container (10) via a bypass conduit expansion device, and

wherein the refrigerant circuit further comprises refrigerant conduits for connecting said elements and for circulating the refrigerant there-through.

**Characterised by** a heat exchanger (20) establishing a heat exchange relationship between the cooling branch bypass conduit (16) and a cooling branch supply conduit (18) coupling the collecting container (10) to the first and second

ex-pansion devices (22, 26),  
wherein the desuperheating device (32) is  
adapted to cool the refrigerant against a sec-  
ondary medium.

2. Refrigerating system (2) according to claim 1, where-  
in the heat exchanger (20) is disposed at such a po-  
sition that the refrigerant in the cooling branch by-  
pass conduit interacts with the refrigerant in the cool-  
ing branch supply conduit (18) before the cooling  
branch supply conduit (18) branches out into the nor-  
mal refrigeration branch and the freezing branch.
3. Refrigerating system (2) according to claim 1 or 2,  
further comprising;  
a temperature sensor disposed at one of the suction  
side of the first compressor unit (4) and a pressure  
side of the first compressor unit (4), and  
a control unit coupled to the temperature sensor and  
configured to control at least one of the desuperheat-  
ing device (32), the bypass conduit expansion device  
and the heat exchanger (20).
4. Refrigerating system (2) according to claim 1 or 2,  
wherein the collecting container (10) comprises a  
gaseous refrigerant portion and a liquid refrigerant  
portion, with the refrigerant in operation being sep-  
arated into gaseous refrigerant in the gaseous re-  
frigerant portion and liquid refrigerant in the liquid  
refrigerant portion.
5. Refrigerating system (2) according to claim 4, where-  
in the refrigerant circuit comprises a cooling branch  
supply conduit (18) coupling the liquid refrigerant  
portion of the collecting container (10) to the first and  
second expansion devices (22, 26).
6. Refrigerating system (2) according to claim 4 or 5,  
wherein the cooling branch bypass conduit (16) is  
coupled to the gaseous refrigerant portion of the col-  
lecting container (10) and wherein the bypass con-  
duit expansion device is a gaseous refrigerant ex-  
pansion device (12).
7. Refrigerating system (2) according to claim 6, where-  
in the cooling branch bypass conduit (16) is coupled  
to the liquid refrigerant portion of the collecting con-  
tainer (10) via a liquid refrigerant expansion device  
(14).
8. Refrigerating system (2) according to any of the  
claims 1, 4 to 7, further comprising:  
  
a temperature sensor disposed at one of the  
suction side of the first compressor unit (4) and  
a pressure side of the first compressor unit (4),  
and  
a control unit coupled to the temperature sensor

and configured to control at least one of the des-  
uperheating device (32), the gaseous refrigerant  
expansion device (12), the liquid refrigerant ex-  
pansion device (14) and the heat exchanger  
(20).

9. Refrigerating system (2) according to any of the pre-  
vious claims, wherein the refrigerant is CO<sub>2</sub>.
10. Refrigerating system (2) according to any of the pre-  
vious claims, wherein the desuperheating device  
(32) is positioned in a machine room of the refrigerat-  
ing system or wherein the desuperheating device  
(32) is positioned in an outdoor location.
11. Refrigerating system (2) according to claims 1 - 9  
wherein the desuperheating device (32) is posi-  
tioned in a machine room of the refrigerating system  
and the freezing branch comprises a second desu-  
perheating device positioned in an outdoor location  
and arranged in parallel with the desuperheating de-  
vice (32) in the machine room, with the refrigerant in  
operation being selectively directed to the desuper-  
heating device (32) in the machine room and the  
second desuperheating device.
12. Method of operating a refrigerating system (2), com-  
prising:  
  
circulating a refrigerant through a refrigerant cir-  
cuit comprising a first compressor unit (4), a con-  
denser/gas cooler (6), a collecting container  
(10), an intermediate expansion device (8) dis-  
posed between the condenser/gas cooler (6)  
and the collecting container (10), a normal re-  
frigeration branch having a first expansion de-  
vice (22) and a first evaporator (24), a freezing  
branch having a second expansion device (26)  
and a second evaporator (28), a cooling branch  
bypass conduit (16) coupled to the collecting  
container (10) via a bypass conduit expansion  
device, and a heat exchanger (20) establishing  
a heat exchange relationship between the cool-  
ing branch bypass conduit and a cooling branch  
supply conduit (18) coupling the collecting con-  
tainer (10) to the first and second expansion de-  
vices (22, 26), and  
desuperheating the refrigerant in the freezing  
branch by providing a second compressor unit  
(30) and a desuperheating device (32) in the  
freezing branch, wherein the refrigerant is  
cooled against a secondary medium in the des-  
uperheating device (32),  
  
wherein the refrigerant reaches the first compressor  
unit (4) from the first evaporator (24) via a normal  
refrigeration branch outlet conduit (36),  
wherein the refrigerant reaches the first compressor

unit (4) from the desuperheating device (32) via a freezing branch outlet conduit (38), and wherein the refrigerant reaches the first compressor unit (4) from the cooling branch bypass conduit (16).

## Patentansprüche

1. Kühltssystem (2), umfassend einen Kältemittelkreislauf, der die folgenden Elemente aufweist:

eine erste Verdichtereinheit (4), einen Kondensator/Gaskühler (6), einen Sammelbehälter (10) und eine Zwischen-Expansionseinrichtung (8), die zwischen dem Kondensator/Gaskühler (6) und dem Sammelbehälter (10) angeordnet ist, sodass der Sammelbehälter (10) bei einem mittleren Druckpegel betrieben wird, einen Normalkühlungs-Zweig, der zwischen dem Sammelbehälter (10) und einer Ansaugseite der ersten Verdichtereinheit (4) gekoppelt ist, wobei der Normalkühlungs-Zweig eine erste Expansionseinrichtung (22) und einen ersten Verdampfer (24) umfasst, wobei eine Auslassleitung (36) des Normalkühlungs-Zweigs zwischen dem ersten Verdampfer (24) und der ersten Verdichtereinheit (4) gekoppelt ist, einen Gefrierzweig, der zwischen dem Sammelbehälter (10) und der Ansaugseite der ersten Verdichtereinheit (4) gekoppelt ist, wobei der Gefrierzweig eine zweite Expansionseinrichtung (26), einen zweiten Verdampfer (28), eine zweite Verdichtereinheit (30) und eine Entüberhitzungseinrichtung (32) umfasst, wobei eine Auslassleitung (38) des Gefrierzweigs zwischen der Entüberhitzungseinrichtung (32) und der ersten Verdichtereinheit (4) gekoppelt ist, eine Kühlzweigumgehungsleitung (16), die zwischen dem Sammelbehälter (10) und der Ansaugseite der ersten Verdichtereinheit (4) gekoppelt ist, wobei die Kühlzweigumgehungsleitung (16) über eine Umgehungsleitungs-Expansionseinrichtung an den Sammelbehälter (10) gekoppelt ist, und **gekennzeichnet durch** einen Wärmetauscher (20), der eine Wärmeaustauschbeziehung zwischen der Kühlzweigumgehungsleitung (16) und einer Kühlzweigzuführungsleitung (18), die den Sammelbehälter (10) mit der ersten und der zweiten Expansionseinrichtung (22, 26) koppelt, herstellt, wobei die Entüberhitzungseinrichtung (32) dazu ausgelegt ist, das Kältemittel gegen ein sekundäres Medium zu kühlen, und wobei der Kältemittelkreislauf ferner Kältemittelleitungen zum Verbinden der Elemente und zum Zirkulieren des Kältemittels durch diese umfasst.

2. Kühltssystem (2) nach Anspruch 1, wobei der Wärmetauscher (20) an einer derartigen Position angeordnet ist, dass das Kältemittel in der Kühlzweigumgehungsleitung mit dem Kältemittel in der Kühlzweigzuführungsleitung (18) interagiert, bevor sich die Kühlzweigzuführungsleitung (18) in den Normalkühlungs-Zweig und den Gefrierzweig aufzweigt.

3. Kühltssystem (2) nach Anspruch 1 oder 2, ferner umfassend:

einen Temperatursensor, der entweder an der Ansaugseite der ersten Verdichtereinheit (4) oder an einer Druckseite der ersten Verdichtereinheit (4) angeordnet ist, und eine Steuereinheit, die mit dem Temperatursensor gekoppelt ist und dazu konfiguriert ist, mindestens eines der Entüberhitzungseinrichtung (32), der Umgehungsleitungs-Expansionseinrichtung und des Wärmetauschers (20) zu steuern.

4. Kühltssystem (2) nach Anspruch 1 oder 2, wobei der Sammelbehälter (10) einen Bereich für gasförmiges Kältemittel und einen Bereich für flüssiges Kältemittel umfasst, wobei das Kältemittel bei Betrieb in gasförmiges Kältemittel im Bereich für gasförmiges Kältemittel und flüssiges Kältemittel im Bereich für flüssiges Kältemittel aufgeteilt wird.

5. Kühltssystem (2) nach Anspruch 4, wobei der Kältemittelkreislauf eine Kühlzweigzuführungsleitung (18) umfasst, der den Bereich für flüssiges Kältemittel des Sammelbehälters (10) mit der ersten und der zweiten Expansionseinrichtung (22, 26) koppelt.

6. Kühltssystem (2) nach Anspruch 4 oder 5, wobei die Kühlzweigumgehungsleitung (16) an den Bereich für gasförmiges Kältemittel des Sammelbehälters (10) gekoppelt ist und wobei die Umgehungsleitungs-Expansionseinrichtung eine Expansionseinrichtung (12) für gasförmiges Kältemittel ist.

7. Kühltssystem (2) nach Anspruch 6, wobei die Kühlzweigumgehungsleitung (16) über eine Expansionseinrichtung (14) für flüssiges Kältemittel an den Bereich für flüssiges Kältemittel des Sammelbehälters (10) gekoppelt ist.

8. Kühltssystem (2) nach einem der Ansprüche 1, 4 bis 7, ferner umfassend:

einen Temperatursensor, der entweder an der Ansaugseite der ersten Verdichtereinheit (4) oder an einer Druckseite der ersten Verdichtereinheit (4) angeordnet ist, und eine Steuereinheit, die mit dem Temperatursensor gekoppelt ist und dazu konfiguriert ist, min-

destens eines der Entüberhitzungseinrichtung (32), der Expansionseinrichtung (12) für gasförmiges Kältemittel, der Expansionseinrichtung (14) für flüssiges Kältemittel und des Wärmetauschers (20) zu steuern.

9. Kältesystem (2) nach einem der vorhergehenden Ansprüche, wobei das Kältemittel CO<sub>2</sub> ist.

10. Kältesystem (2) nach einem der vorhergehenden Ansprüche, wobei die Entüberhitzungseinrichtung (32) in einem Maschinenraum des Kältesystems positioniert ist oder wobei die Entüberhitzungseinrichtung (32) in einem Außenbereich positioniert ist.

11. Kältesystem (2) nach einem der Ansprüche 1-9, wobei die Entüberhitzungseinrichtung (32) in einem Maschinenraum des Kältesystems positioniert ist und der Gefrierzweig eine zweite Entüberhitzungseinrichtung umfasst, die in einem Außenbereich positioniert ist und parallel mit der Entüberhitzungseinrichtung (32) im Maschinenraum angeordnet ist, wobei das Kältemittel bei Betrieb selektiv zu der Entüberhitzungseinrichtung (32) im Maschinenraum und der zweiten Entüberhitzungseinrichtung geleitet wird.

12. Verfahren zum Betreiben eines Kältesystems (2), umfassend:

Zirkulieren eines Kältemittels durch einen Kältemittelkreislauf, der eine erste Verdichtereinheit (4), einen Kondensator/Gaskühler (6), einen Sammelbehälter (10), eine Zwischen-Expansionseinrichtung (8), die zwischen dem Kondensator/Gaskühler (6) und dem Sammelbehälter (10) angeordnet ist, einen Normalkühlungs-Zweig, der eine erste Expansionseinrichtung (22) und einen ersten Verdampfer (24) aufweist, einen Gefrierzweig, der eine zweite Expansionseinrichtung (26) und einen zweiten Verdampfer (28) aufweist, eine Kühlzweigumgehungsleitung (16), die über eine Umgehungsleitungs-Expansionseinrichtung an den Sammelbehälter (10) gekoppelt ist, und einen Wärmetauscher (20), der eine Wärmeaustauschbeziehung zwischen der Kühlzweigumgehungsleitung und einer Kühlzweigzuführungsleitung (18) herstellt, die den Sammelbehälter (10) mit der ersten und der zweiten Expansionseinrichtung (22, 26) koppelt, umfasst, und Entüberhitzen des Kältemittels im Gefrierzweig durch Bereitstellen einer zweiten Verdichtereinheit (30) und einer Entüberhitzungseinrichtung (32) im Gefrierzweig,

wobei das Kältemittel gegen ein sekundäres Medium in der Entüberhitzungseinrichtung (32) gekühlt

wird,

wobei das Kältemittel die erste Verdichtereinheit (4) von dem ersten Verdampfer (24) über eine Auslassleitung (36) des Normalkühlungs-Zweigs erreicht, wobei das Kältemittel die erste Verdichtereinheit (4) von der Entüberhitzungseinrichtung (32) über eine Auslassleitung (38) des Gefrierzweigs erreicht und wobei das Kältemittel die erste Verdichtereinheit (4) von der Kühlzweigumgehungsleitung (16) erreicht.

## Revendications

1. Système de réfrigération (2) comprenant un circuit de réfrigération comportant les éléments suivants :

une première unité de compression (4), un condenseur/refroidisseur de gaz (6), un récipient de collecte (10) et un détendeur intermédiaire (8) disposé entre le condenseur/refroidisseur de gaz (6) et le récipient de collecte (10), de sorte que le récipient de collecte (10) est actionné à un niveau de pression intermédiaire, un branchement de réfrigération normale couplé entre le récipient de collecte (10) et un côté d'aspiration de la première unité de compression (4), le branchement de réfrigération normale comprenant un premier détendeur (22) et un premier évaporateur (24), dans lequel une conduite de sortie à branchement de réfrigération normale (36) est couplée entre le premier évaporateur (24) et la première unité de compression (4), un branchement de congélation couplé entre le récipient de collecte (10) et le côté d'aspiration de la première unité de compression (4), le branchement de congélation comprenant un second détendeur (26), un second évaporateur (28), une seconde unité de compression (30) et un dispositif de désurchauffage (32), dans lequel une conduite de sortie à branchement de congélation (38) est couplée entre le dispositif de désurchauffage (32) et la première unité de compression (4), une conduite de dérivation à branchement de refroidissement (16) couplée entre le récipient de collecte (10) et le côté d'aspiration de la première unité de compression (4), dans lequel la conduite de dérivation à branchement de refroidissement (16) est couplée au récipient de collecte (10) via un détendeur de conduite de dérivation, et dans lequel le circuit de réfrigération comprend des conduites de réfrigération destinées à relier lesdits éléments et à faire circuler le réfrigérant à travers celles-ci,

caractérisé par un échangeur thermique (20) établissant une relation d'échange thermique entre la

- conduite de dérivation à branchement de refroidissement (16) et une conduite d'alimentation à branchement de refroidissement (18) couplant le récipient de collecte (10) aux premier et second détendeurs (22, 26), dans lequel le dispositif désurchauffage (32) est conçu pour refroidir le réfrigérant par rapport à un milieu secondaire.
2. Système de réfrigération (2) selon la revendication 1, dans lequel l'échangeur thermique (20) est disposé dans une position telle que le réfrigérant dans le conduit de dérivation à branchement de refroidissement interagit avec le réfrigérant dans la conduite d'alimentation à branchement de refroidissement (18) avant que la conduite d'alimentation à branchement de refroidissement (18) bifurque dans le branchement de réfrigération normale et dans le branchement de congélation.
  3. Système de réfrigération (2) selon la revendication 1 ou 2, comprenant en outre :
    - un capteur de température disposé au niveau de l'un des côtés d'aspiration de la première unité de compression (4) et d'un côté de pression de la première unité de compression (4), et une unité de commande couplée au capteur de température et conçue pour commander au moins l'un du dispositif de désurchauffage (32), du détendeur à conduite de dérivation et de l'échangeur thermique (20).
  4. Système de réfrigération (2) selon la revendication 1 ou 2, dans lequel le récipient de collecte (10) comprend une partie réfrigérante gazeuse et une partie réfrigérante liquide, le réfrigérant en fonctionnement étant séparé en réfrigérant gazeux dans la partie réfrigérante gazeuse et en réfrigérant liquide dans la partie réfrigérante liquide.
  5. Système de réfrigération (2) selon la revendication 4, dans lequel le circuit de réfrigération comprend une conduite d'alimentation à branchement de refroidissement (18) couplant la partie réfrigérante liquide du récipient de collecte (10) aux premier et second détendeurs (22, 26).
  6. Système de réfrigération (2) selon la revendication 4 ou 5, dans lequel la conduite de dérivation à branchement de refroidissement (16) est couplée à la partie réfrigérante gazeuse du récipient de collecte (10) et dans lequel le détendeur à conduite de dérivation est un détendeur à réfrigérant gazeux (12).
  7. Système de réfrigération (2) selon la revendication 6, dans lequel la conduite de dérivation à branchement de refroidissement (16) est couplée à la partie
- réfrigérante liquide du récipient de collecte (10) via un détendeur à réfrigérant liquide (14).
8. Système de réfrigération (2) selon l'une quelconque des revendications 1, 4 à 7, comprenant en outre :
    - un capteur de température disposé au niveau de l'un des côtés d'aspiration de la première unité de compression (4) et d'un côté de pression de la première unité de compression (4), et une unité de commande couplée au capteur de température et conçue pour commander au moins l'un du dispositif de désurchauffage (32), du détendeur réfrigérant gazeux (12), du détendeur réfrigérant liquide (14) et de l'échangeur thermique (20).
  9. Système de réfrigération (2) selon l'une quelconque des revendications précédentes, dans lequel le réfrigérant est du CO<sub>2</sub>.
  10. Système de réfrigération (2) selon l'une quelconque des revendications précédentes, dans lequel le dispositif de désurchauffage (32) est positionné dans une salle des machines du système de réfrigération ou dans lequel le dispositif de désurchauffage (32) est placé dans un endroit situé à l'extérieur.
  11. Système de réfrigération (2) selon l'une des revendications 1 à 9, dans lequel le dispositif de désurchauffage (32) est positionné dans une salle des machines du système de réfrigération et le branchement de congélation comprend un second dispositif de désurchauffage placé dans un endroit situé à l'extérieur et agencé parallèlement au dispositif de désurchauffage (32) dans la salle des machines, le réfrigérant en fonctionnement étant dirigé de manière sélective vers le dispositif de désurchauffage (32) dans la salle des machines et le second dispositif de désurchauffage.
  12. Procédé de fonctionnement d'un système de réfrigération (2), comprenant :
    - la circulation d'un réfrigérant à travers un circuit de réfrigération comportant une première unité de compression (4), un condenseur/refroidisseur de gaz (6), un récipient de collecte (10), un détendeur intermédiaire (8) disposé entre le condenseur/refroidisseur de gaz (6) et le récipient de collecte (10), un branchement de réfrigération normale ayant un premier détendeur (22) et un premier évaporateur (24), un branchement de congélation comportant un second détendeur (26) et un second évaporateur (28), une conduite de dérivation à branchement de refroidissement (16) couplée au récipient de collecte (10) via un détendeur de conduite de dé-

rivation, et un échangeur thermique (20) établissant une relation d'échange thermique entre la conduite de dérivation à branchement de refroidissement et une conduite d'alimentation à branchement de refroidissement (18) couplant le récipient de collecte (10) aux premier et second détenteurs (22, 26), et le désurchauffage du réfrigérant dans le branchement de congélation en prévoyant une seconde unité de compression (30) et un dispositif de désurchauffage (32) dans le branchement de congélation, dans lequel le réfrigérant est refroidi par rapport à un milieu secondaire dans le dispositif de désurchauffage (32),

dans lequel le réfrigérant atteint la première unité de compression (4) depuis le premier évaporateur (24) via une conduite de sortie à branchement de réfrigération normale (36), dans lequel le réfrigérant atteint la première unité de compression (4) depuis le dispositif de désurchauffage (32) via une conduite de sortie à branchement de congélation (38), et dans lequel le réfrigérant atteint la première unité de compression (4) depuis la conduite de dérivation à branchement de refroidissement (16).

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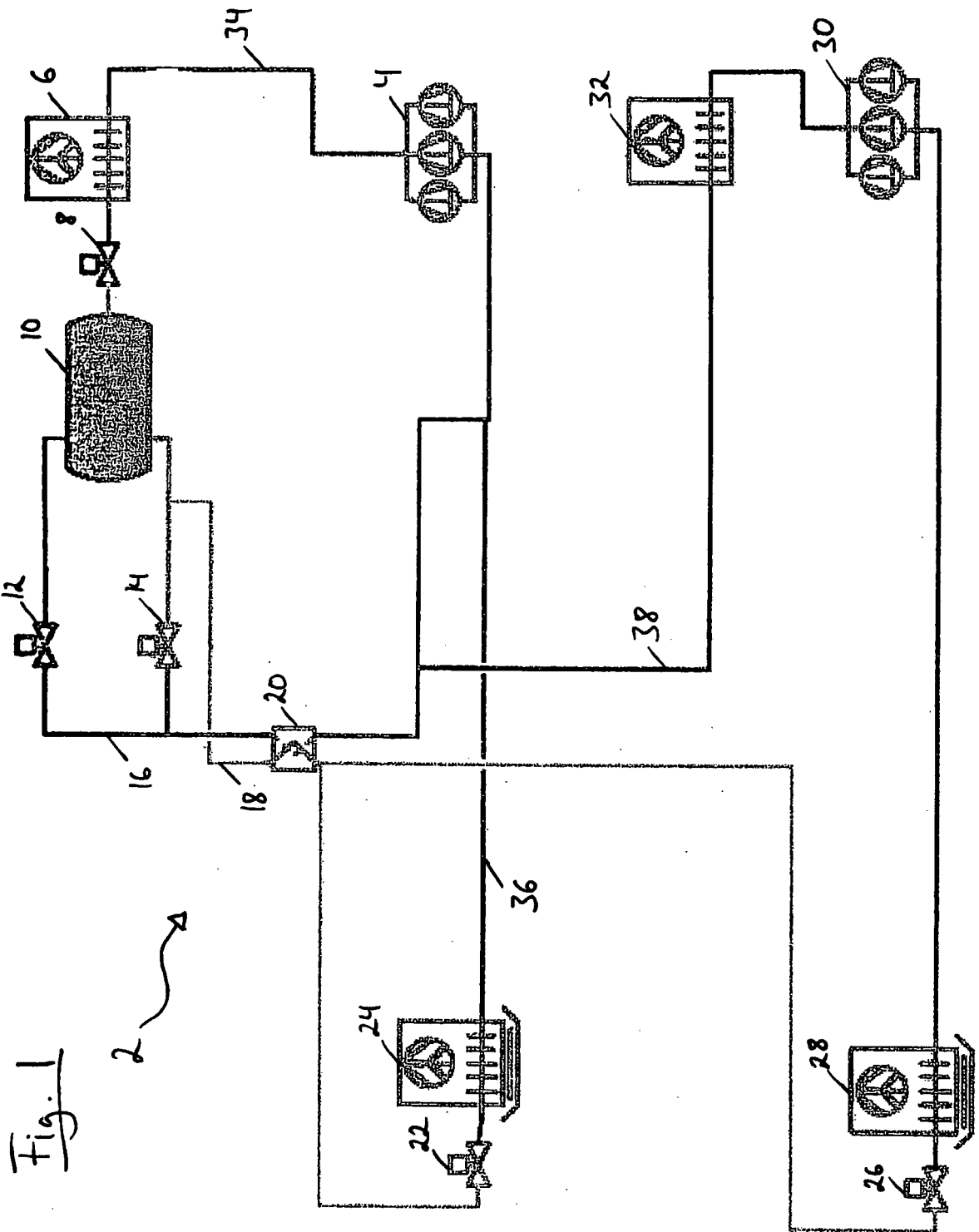
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**REFERENCES CITED IN THE DESCRIPTION**

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