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(54) **REFRIGERATION SYSTEM**

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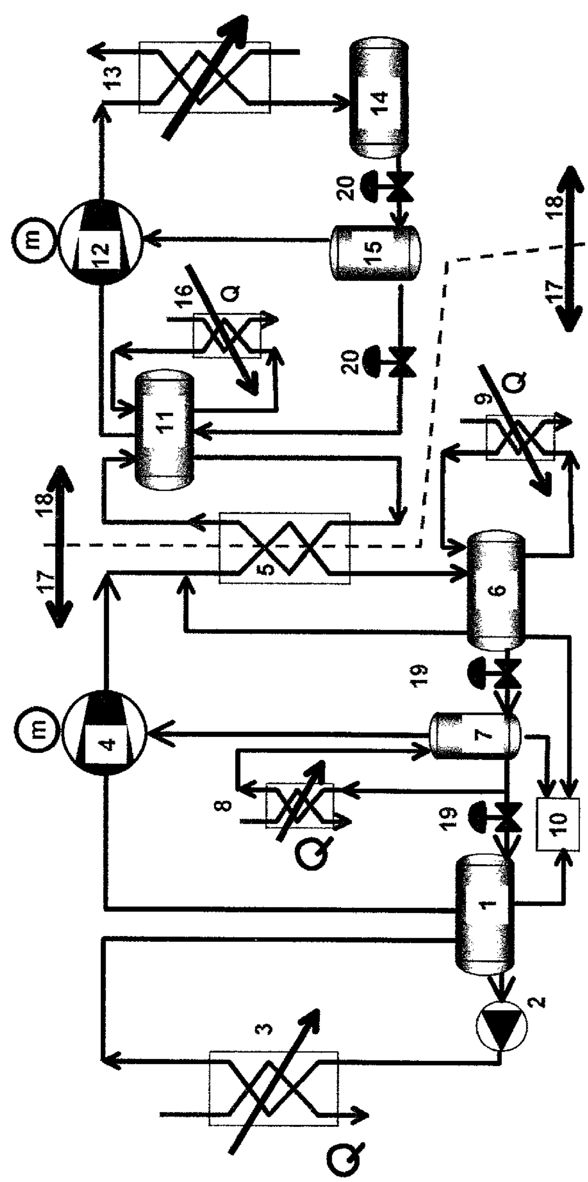
(57) **ABSTRACT**

The invention relates to a refrigeration system that includes a first and a second refrigeration circuit wherein the first refrigeration circuit uses CO_2 as the refrigerant, the second refrigeration circuit uses a second refrigerant, and the second refrigeration circuit is arranged to refrigerate the first refrigeration circuit by means of a cascade heat exchange connection. The first refrigerant is at a pressure above about 120 psig. The refrigeration system is energy efficient and is particularly useful in the food industry. The invention further relates to a method of refrigeration using the refrigerator system.



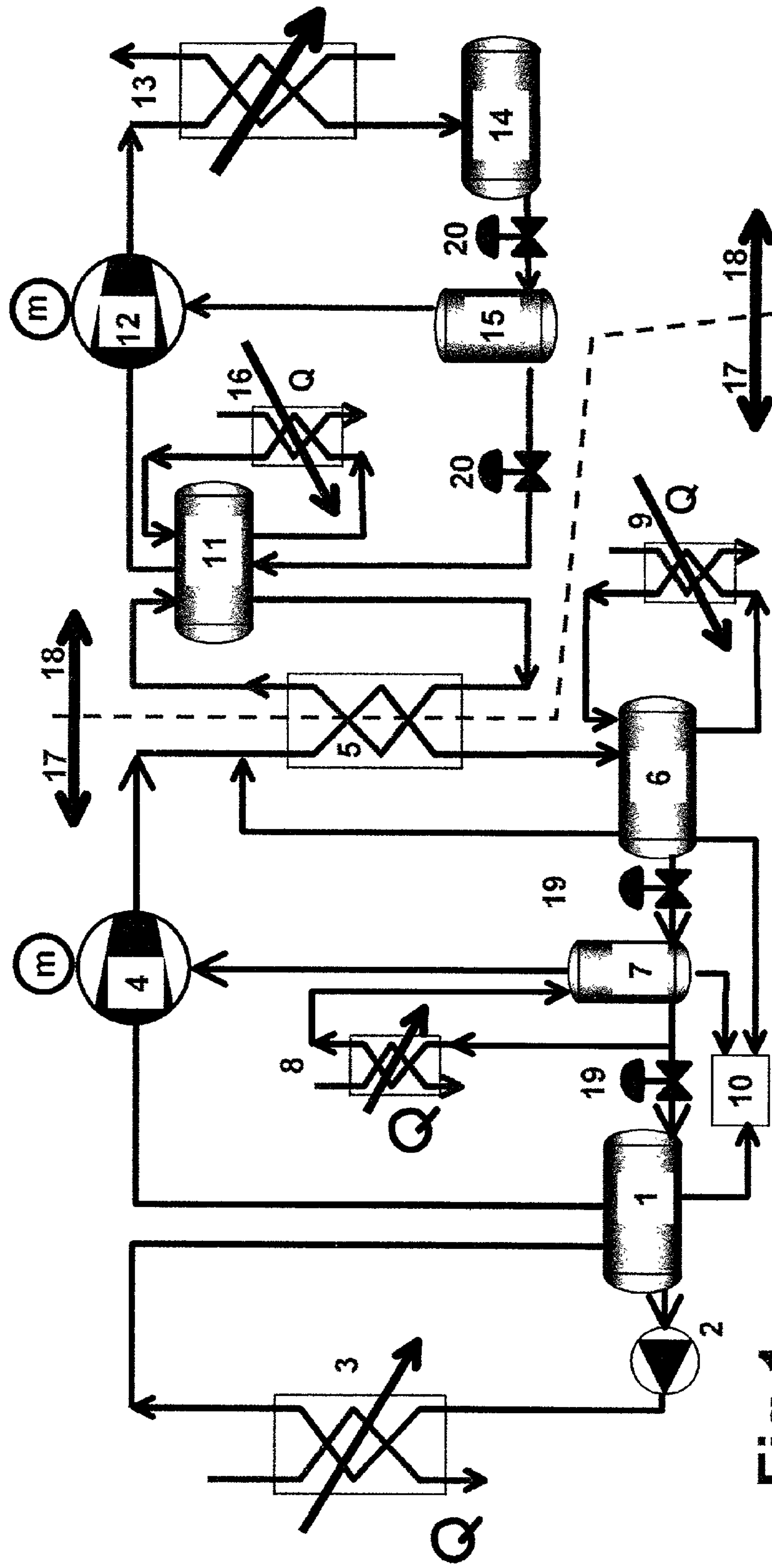


Fig 1

REFRIGERATION SYSTEM

FIELD OF THE INVENTION

[0001] The invention relates to a refrigeration system comprising a first and a second closed refrigeration circuit, the second refrigeration circuit being arranged to refrigerate the first refrigeration circuit by means of a cascade heat exchange connection. The refrigeration system provides refrigeration that is energy efficient. The refrigeration system is particularly suitable for use in the food industry. The invention also relates to a method of refrigeration using the refrigeration system of the invention.

BACKGROUND OF THE INVENTION

[0002] The refrigeration industry is faced with a number of issues that are making it more difficult to use conventional refrigerants and conventional system designs. For environmental reasons, many of the popular synthetic refrigerants, such as Chloro-Fluoro-Carbons (CFC's) can not be used, due to their high ozone depletion potential. Other refrigerants such as Hydro-Chloro-Fluoro-Carbons (e.g., HCFC-22) are also being phased out for the same reason. Furthermore, the use of new replacement refrigerants, such as Hydro-Fluoro-Carbons (HFC's), may also be restricted due to their high potential to cause global warming. Concerns about global warming are expected to result in increased pressure to use more energy efficient refrigeration operations.

[0003] Historically, the most popular natural refrigerant has been ammonia as it allows for simple, efficient systems. In recent years this has been the preferred industrial alternative to the CFC's and HCFC's. Due to its toxicity, however, there is now increased pressure worldwide to limit the use of ammonia. In many countries, industrial ammonia refrigeration systems must now meet rigorous chemical industry standards for management of safety. In some cases the use of ammonia is severely restricted, or even prevented.

[0004] Prior to the introduction of CFC's and HCFC's, CO_2 was widely used as a refrigerant, especially in applications where the toxicity of ammonia was unacceptable. This was the case for example in shipboard refrigeration. These refrigeration units, however, were single or multi stage compression systems where the refrigerant was condensed at very high pressures using air or water. Cascade systems were not used. This type of system, however, has significant disadvantages due to the very high working pressures in the condenser and the low critical temperature, limiting the temperature at which the CO_2 could be condensed. When the system is operated above the critical temperature (i.e. supercritical) the efficiency of the system is lower than alternative systems using CFC's, HCFC's, or ammonia.

[0005] U.S. Pat. No. 5,042,262 describes a food freezer, which uses CO_2 as a low temperature refrigerant, being cooled in cascade by another evaporating refrigerant operating at a higher temperature. The patent recommends pressures in the CO_2 evaporator of between 60.4 psig and 120 psig. Also recommended is a compressor pressure of less than 325 psig. The specifically recommended pressure limits disclosed in this patent makes the system significantly less efficient than a conventional industrial refrigeration system. The users of the system will be operating the system with evaporation pressures below 120 psig, which corresponds to a saturation temperature of −44° F. (−42° C.), and condensing pressures below 325 psig, which corresponds to a saturation temperature of +6° F. (−14° C.), irrespective of the actual temperature needed by the user at the evaporator and the optimum operating conditions in the cascade heat exchanger. In refrigeration systems, the system efficiency decreases as the evaporation temperature decreases. This results in higher power consumption than a conventional 2 stage refrigeration system, which can operate only at the needed evaporation pressure and an optimised intermediate pressure.

[0006] Therefore, to be competitive with conventional two-stage refrigeration systems, there is a need for a refrigeration system that uses CO_2 as a refrigerant but is capable of working more efficiently.

SUMMARY OF THE INVENTION

[0007] The present invention relates to a refrigeration system. The refrigeration system includes a first closed refrigeration circuit for containing a first refrigerant comprising a high pressure side and a low pressure side, a first evaporator for evaporating a first refrigerant liquid to provide a first refrigerant vapor, a first compressor for compressing the first refrigerant vapor, a first condenser for condensing the first refrigerant vapor, and a first control valve for controlling the pressure difference between a high pressure side and a low pressure side of the first refrigeration circuit; a second closed refrigeration circuit for containing a second refrigerant, comprising a high pressure side and a low pressure side, a second evaporator for evaporating a second refrigerant liquid to provide a second refrigerant vapor, a second compressor for compressing the second refrigerant vapor, a second condenser for condensing the second refrigerant vapor, and a second control valve for controlling the pressure difference between the high pressure side and the low pressure side of the second circuit; and a cascade heat exchanger comprising the first condenser and the second evaporator arranged so that the first condenser is cooled by evaporation of the second refrigerant liquid in the second evaporator, wherein the first refrigerant comprises CO_2 and the first evaporator is operated at pressures above about 120 psig.

[0008] The first evaporator may be at a pressure of between about 120 psig and 1056 psig, preferably about 120 psig and 580 psig. The first compressor may compresses the first refrigerant vapor to a pressure above about 325 psig., preferably to a pressure of from about 325 psig to 580 psig and the second compressor may compresses the second refrigerant vapor to a pressure below about 325 psig.

[0009] The refrigeration system may further include an open flash economizer vessel subsequent to the first condenser to cool the first liquid refrigerant to a temperature intermediate between the temperature of the first refrigerant liquid in the high pressure side and the temperature of the first refrigerant liquid in the low pressure side by evaporating some of the first liquid refrigerant to provide a first refrigerant vapor, wherein the economizer vessel is connected to an economizer port of the first compressor so that the first refrigerant vapor can be compressed by the compressor. In another embodiment the refrigeration system further includes a heat exchanger subsequent to the first condenser to cool the first liquid refrigerant to a temperature intermediate between the temperature of the first refrigerant liquid in the high pressure side and the first refrigerant liquid in the low pressure side by evaporating some of the first liquid refrigerant to provide a first refrigerant vapor, wherein the heat exchanger is connected to the economizer port of the first compressor so that first refrigerant vapor can be compressed by the compressor.

[0010] In one embodiment the second evaporator may be operated at a pressure such that the temperature difference between the second evaporator and the first condenser is no more than about 5° F.

[0011] The refrigeration system may further include a package refrigeration system in the first refrigeration circuit to control the pressure in the first refrigeration circuit by cooling the CO_2 when the refrigeration system is not being used.

[0012] The second refrigerant may be ammonia, a hydrofluorocarbon, or a hydrocarbon.

[0013] The invention further relates to a method of refrigerating an article. The method involves providing a first refrigerant of CO_2 in a first refrigeration circuit and second refrigerant in a second refrigeration circuit;

[0014] circulating the first refrigerant in the first refrigeration circuit and evaporating the first refrigerant at a pressure greater than about 120 psig to provide a first refrigerant vapor and to cool a medium, compressing the first refrigerant vapor to provide a compressed first refrigerant vapor, and condensing the compressed first refrigerant vapor to provide a first refrigerant liquid;

[0015] circulating the second refrigerant in the second refrigeration circuit and evaporating the second refrigerant to provide a second refrigerant vapor and to cool and condense the first refrigerant, compressing the second refrigerant vapor to provide a compressed second refrigerant vapor, and condensing the compressed second refrigerant vapor to provide a second refrigerant liquid; and

[0016] placing an article in the cooled medium.

[0017] Preferably, the method of the invention uses the refrigeration system of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] **FIG. 1** is a schematic depicting the refrigeration system of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The invention relates to an efficient refrigeration system that uses CO_2. The refrigeration system comprises:

[0020] a first closed refrigeration circuit for containing a first refrigerant comprising a high pressure side and a low pressure side, a first evaporator for evaporating a first refrigerant liquid to provide a first refrigerant vapor, a first compressor for compressing the first refrigerant vapor, a first condenser for condensing the first refrigerant vapor, and a first control valve for controlling the pressure difference between a high pressure side and a low pressure side of the first refrigeration circuit,

[0021] a second closed refrigeration circuit for containing a second refrigerant, comprising a high pressure side and a low pressure side, a second evaporator for evaporating a second refrigerant liquid to provide a second refrigerant vapor, a second compressor for compressing the second refrigerant vapor, a second condenser for condensing the second refrigerant vapor, and a second control valve for controlling the pressure difference between the high pressure side and the low pressure side of the second circuit, and

[0022] a cascade heat exchanger comprising the first condenser and the second evaporator arranged so that the first condenser is cooled by evaporation of the second refrigerant liquid in the second evaporator, wherein the first refrigerant comprises CO_2 and the first evaporator is operated at pressures above about 120 psig.

[0023] The high pressure side is the part of the refrigeration circuit between the exit of the compressor and the entry of the control valve. The low pressure side is the rest of the circuit; i.e., between the exit of the valve and the entry of the compressor.

[0024] Surprisingly we have found that a high pressure CO_2 refrigeration system, operating in cascade with a second refrigeration system operating at a higher temperature, can be made at least as efficient as a conventional industrial refrigeration system, and in some cases more efficient.

[0025] The refrigeration system according to the invention allows the operating conditions of the system to be set so that they match the needs of the user. In particular the evaporating pressure of the first refrigerant, which determines the corresponding evaporating temperature, can be set by the user. Due to the refrigeration systems ability to work at high pressures, it is possible to select a pressure in the evaporators that corresponds to an evaporation temperature in the range from about −44° F. to −10° F.

[0026] Furthermore, the resulting system is significantly safer than ammonia systems since the ammonia in the manufacturing areas is replaced with CO_2, which is significantly less toxic. This makes the refrigeration system of the invention particularly suitable for use in the food industry. In addition the refrigeration system has been shown to be competitive in capital costs and energy efficiency.

[0027] Preferably, the operating pressure throughout the first refrigeration circuit is between about 120 psig and 1056 psig. 1056 psig is the critical point for CO_2, above which CO_2 cannot be condensed to liquid. A more preferred operation pressure throughout the first refrigeration circuit is from about 120 psig to 580 psig. Operating the system in the indicated ranges improves the energy efficiency of the cascade system by allowing the evaporators to operate at a pressure that most suits the needs of the medium being cooled and to optimize heat transfer between the first and second refrigerants.

[0028] The phrase "operating pressure throughout the first refrigeration circuit", as used herein means the maximum pressure that would be observed at any point in the circuit.

[0029] The first compressor **4** preferably has an operation pressures above about 325 psig at the discharge of the compressor **4**, more preferably from about 325 psig to 580 psig, and most preferably from about 350 psig to about 425 psig. With these operating pressures in the first circuit and the first compressor a particularly energy efficient cascade refrigeration system is obtained.

[**0030**] In a preferred embodiment of the invention the operation pressure throughout the second refrigeration circuit is below about 350 psig so that standard refrigeration components can be used.

[**0031**] Furthermore it is preferred that the first evaporator is operated at pressures from about 120 psig to 580 psig, more preferably from about 120 psig to 180 psig, most preferably from about 122 to 160 psig.

[**0032**] Advantageously, the first refrigeration circuit comprises means for cooling the first refrigerant liquid subsequent to it condensing in the first condenser. The means for cooling the first refrigerant may comprise an open flash economizer vessel connected to the first compressor in which some of the first refrigerant liquid is evaporated, cooling the rest of the first refrigerant liquid to a temperature intermediate between the temperature of the first refrigerant liquid in the high pressure vessel and the temperature of the first refrigerant liquid in the low pressure vessel, and allowing the vapor to be forwarded to the economizer port of the first compressor. Alternatively, a heat exchanger may be used to cool the first refrigerant liquid. In this way the efficiency of the refrigeration systems is improved by cooling the liquid CO_2 by evaporation in the economizer vessel or in the heat exchanger prior to going to the low pressure part of the CO_2 system, with the resulting vapor going to the economizer port on the CO_2 compressor. It has been found that it is particular advantageous to apply these measures to the first refrigeration circuit to make it more energy efficient.

[**0033**] In a preferred embodiment of the invention, the operating pressure of the second evaporator corresponds to a saturation temperature that is as close as possible to the saturation temperature equivalent to the pressure of the first refrigerant in the first condenser. Preferably, this temperature difference should be about 5° F. (2° C.). The advantage of this is that the pressure in the second evaporator is as high as possible, which also improves system efficiency.

[**0034**] The invention will now be discussed in further detail with reference to **FIG. 1**, showing an example of a preferred refrigeration system according to the invention.

[**0035**] **FIG. 1** shows a refrigeration system having a first refrigeration circuit **17** and a second refrigeration circuit **18** arranged in cascade. According to the invention, the first refrigerant is CO_2.

[**0036**] Liquid CO_2 is pumped by means of a pump **2** from a low-pressure CO_2 vessel **1** to one or more evaporators **3** operating in parallel, where it evaporates, removing heat (Q) from the medium being cooled. The pumping rate to the evaporators is at least equal to the evaporation rate; but could be more to ensure wetting on the CO_2 side of each evaporator. Alternatively, the liquid can be supplied without a pump by using natural circulation.

[**0037**] The evaporators **3** may be any conventional evaporator, but designed for working pressures that correspond to the nature of the medium being cooled. Suitable evaporators for use in the invention include, but are not limited to, plate evaporators, fin-coil units, scraped surface evaporators, and tubular coolers. Subsequently the mixture of CO_2 liquid and vapor returns to the low-pressure CO_2 vessel **1**, where the liquid and vapor are separated. The liquid is then available to be sent back to the evaporators. The CO_2 vapor goes to a CO_2 compressor **4**, where it is compressed to a pressure preferably exceeding about 325 psig, but less than the CO_2 critical point (1056 psig). To improve system efficiency, the compressor **4** may advantageously be fitted with an "economizer port" to accept additional vapor from a CO_2 economizer vessel **7**.

[**0038**] The compressors **4** may be any type suitable for the required duty. The preferred compressor type, however, is an oil injected screw compressor with gravity and coalescing oil separator. Suitable compressors may be obtained from Mycom Chemical Process Corp. of Torrance, Calif.; Sabroe Refrigeration AB of Sweden; or FES Corp of York, Pa., for example. If needed tertiary oil separation may be provided using activated carbon or other similar material. Another type of a compressor which is suitable for the present application is a reciprocating compressor.

[**0039**] In one embodiment there are multiple compressors operating in parallel.

[**0040**] The compressed CO_2 is then cooled and condensed in a cascade heat exchanger **5**, which is cooled by the evaporation of a second refrigerant that can operate at higher saturation temperatures than CO_2 with pressures below 350 psig in order to permit the use of standard commercial refrigeration components in the second refrigerant circuit. A plate type heat exchanger is preferred to minimize the temperature difference between the condensing CO_2 and the evaporating second refrigerant in order to improve the efficiency of the system. Optionally, there may be multiple cascade heat exchangers arranged in parallel. Suitable plate type heat exchangers are, for example, available from Alfa Laval Thermal Inc. of Richmond, Va. In one embodiment there are multiple compressors operating in parallel.

[**0041**] Alternatively, a purpose built shell and tube heat exchanger may be used. The condensed CO_2 is stored in a high-pressure CO_2 vessel **6**, until it is needed in the evaporators **3**. Alternatively, storage could be in the low pressure CO_2 vessel **1** or the CO_2 economizer vessel **7**. In this case, a control valve is needed after the cascade heat exchanger **5** to maintain pressure in the cascade heat exchanger **5** (the first condenser). This control valve has a function similar to control valve **19** described below.

[**0042**] When needed in the low pressure part of the system, liquid CO_2 is fed to the low-pressure CO_2 vessel **1** through a control valve **19** where pressure is decreased to that of the low-pressure vessel **1**, with a portion of the CO_2 evaporating to cool the liquid. The resulting liquid/vapor mixture flows to the low-pressure vessel **1**, where the liquid and vapor components are separated. The vapor is combined with the vapor from the evaporator **3**, with both going to the compressor **4**. This completes the closed circulation of the CO_2. To improve CO_2 circuit efficiency, the liquid may first go through a control valve **19** to a CO_2 economizer vessel or heat exchanger **7**, operating at a pressure intermediate between that of the high-pressure CO_2 vessel **6** and the low-pressure CO_2 vessel **1**. At this intermediate pressure, some of the liquid CO_2 evaporates, cooling the remainder of the liquid. The vapor is separated from the liquid and goes to the "economizer port" on the compressor **4**.

[0043] Optionally, the high-pressure CO_2 vessel **6** and CO_2 economizer vessel **7** are connected to additional evaporators **9** and **8**, respectively, to provide cooling at operating temperatures higher than that of the main evaporators **3**. The method of liquid and vapor circulation is the same as for evaporator **3**.

[0044] To control the pressure in the CO_2 circuit, the vessels, evaporators, and heat exchangers may be fitted with safety relief valves and/or other pressure activated devices to release vapor from the CO_2 circuit, reducing the pressure. Alternatively, any or each vessel, evaporator, or heat exchanger in the CO_2 circuit may be connected to a small package refrigeration system **10**, to control the pressure by cooling the CO_2 when the main plant is shut down. By this method, it is possible to construct a CO_2 circuit that has a safe working pressures below that which would otherwise be required, reducing the capital cost.

[0045] The phrase "package refrigeration system" as used herein means a small single stage refrigeration device about the size of a domestic freezer.

[0046] On small CO_2 circuits, the pressure control during shutdown may also be achieved by installing an additional vessel that permits all of the CO_2 in the circuit to be stored as vapor at pressures below the safe working pressure of the system. These vessels are usually referred to as a "fade out" vessel.

[0047] The second refrigeration circuit **18** comprises a second liquid refrigerant. The second refrigerant is fed from a low-pressure vessel **11**, to the cascade heat exchanger **5**, where it evaporates, cooling and condensing the CO_2. The liquid second refrigerant can be pumped or fed by natural circulation to the cascade heat exchanger **5**. The feed rate of the liquid second refrigerant will at least equal the evaporation rate, but could be higher to ensure wetting of the second refrigerant side of the heat exchanger **5**.

[0048] The mixture of second refrigerant liquid and vapor returns to the low-pressure vessel **11**, where they are separated. The liquid is then available to be sent back to the cascade heat exchanger **5**. The separated second refrigerant vapor goes to the compressor **12**, where it is compressed to an appropriate pressure that permits condensing in the condenser **13**. This compressor may also be fitted with an "economizer port" to take additional vapor from an economizer vessel **15** to improve system efficiency.

[0049] The compressed second refrigerant is cooled and condensed in the second condenser **13**. The second condenser is cooled by air, water, or other suitable cooling medium. The rejected heat may be recovered and used for other purposes to improve overall system efficiency. In one embodiment there are multiple condensers **13** arranged in parallel.

[0050] The condensed second refrigerant may then be stored in a high-pressure vessel **14**, until it is needed in the cascade heat exchanger **5**. Alternatively, the condensed second refrigerant may be stored in the low-pressure vessel **11**. In this case, a control valve is needed after the condenser **13** to maintain pressure in the second condenser **13**. This control valve has a function similar to the function of control valve **19**.

[0051] When needed in the low pressure part of the second refrigerant system, liquid second refrigerant goes to the low pressure vessel **11** through a control valve **20** where pressure is decreased to that of the low-pressure vessel **11**, with a portion of the second refrigerant evaporating to cool the liquid. The resulting liquid/vapor mixture flows to the low-pressure vessel **11**, where the liquid and vapor components are separated. The vapor goes to the second refrigerant compressor **12** and is combined with the vapor from the second evaporator **5**. This, completes the closed circulation of the second refrigerant.

[0052] To improve efficiency of the second refrigerant circuit, the liquid second refrigerant may first go through a control valve **20** to an economizer vessel or heat exchanger **15**, operating at a pressure intermediate between that of the high-pressure vessel **14** and the low-pressure vessel **11**. At this intermediate pressure, some of the liquid evaporates, cooling the remainder of the liquid. The vapor is then separated from the liquid and goes to the "economizer port" on the compressor **12**.

[0053] Optionally, the low-pressure vessel **11**, may also be connected to evaporators **16** to provide cooling at temperatures higher than the operating conditions of the CO_2 circuit. The method of liquid and vapor circulation is the same as for the CO_2 evaporators **3**.

[0054] Preferably, the second refrigerant is ammonia. It may, however, be any available refrigerant that can operate at pressures that are compatible with the saturated condensing temperature of the condenser **13**. An example of another suitable refrigerant is HFC-134A.

[0055] Except for the cascade heat exchanger **5**, which must be designed for the pressure of the CO_2 circuit, it is preferred that the second refrigerant circuit is constructed using all standard available refrigeration components. Suitable components may be obtained from Mycom Chemical Process Corp.; York International Corporation of York, Pa.; and Grasso Inc. of Evansville, Ind., for example. High-pressure heat exchangers are well known in the petrochemical industry. Such high-pressure heat exchangers may be adapted to include circuitry for evaporating and condensing refrigerants.

[0056] The refrigeration system according to the invention may be used in any freezer or cooler. The refrigeration system has been found to be particularly suitable for use in food freezers due to its safety, efficiency, and environmentally friendly operation. The following are examples of applications in which the refrigeration system is particularly suitable:

[0057] A. Plate freezers, wherein the product to be frozen is placed between plates and held at low temperatures until they are frozen. Typically, the product is usually packed in boxes that are loaded and discharged by an automatic loading and discharging system. The heat transfer is by direct contact between the plates and the boxed product. The plates are the first evaporation circuit. The cooling results from CO_2 evaporating inside the plates. A preferred evaporation pressure is about 122 psig corresponding to a saturation temperature of −43° F. (−42° C.). The cooling apparatus is contained inside an insulated enclosure.

[0058] B. Air blast freezers, wherein the product is conveyed through the freezer on a chain mesh or similar conveyor. This conveyor can be a spiral or straight belt, for example. The product is cooled by re-circulated air that is cooled by a fin-coil air cooler by evaporating CO_2 in a first refrigeration circuit. The fin-coil air coolers are cooled by CO_2 evaporating inside the coils. The evaporation pressure is about 122 psig corresponding to a saturation temperature of −43° F. (−42° C.).

[0059] C. Scraped surface coolers, wherein a liquid or paste product is cooled as it is pumped through a cylindrical barrel. Inside the barrel is a rotating scraper that agitates the product and removes frozen product from the barrel walls. The barrel is cooled by CO_2 evaporating inside the surrounding jacket. CO_2 circulation is achieved by a natural thermosyphon effect or by being pumped. A preferred evaporation pressure is about 158 psig corresponding to a saturation temperature of 30° F. (−34° C.). Product temperature may be controlled by varying the CO_2 pressure in the barrel.

[0060] D. Other examples for which the refrigeration system according to the invention conveniently may be applied are fluid bed freezers, contact band freezers, and cold storage and tempering rooms.

[0061] A second aspect, this invention provides a method of refrigeration. The method of refrigeration comprises:

[0062] providing a first refrigerant of CO_2 in a first refrigeration circuit and second refrigerant in a second refrigeration circuit;

[0063] circulating the first refrigerant in the first refrigeration circuit and evaporating the first refrigerant at a pressure greater than about 120 psig provide a first refrigerant vapor and to cool a medium, compressing the first refrigerant vapor to provide a compressed first refrigerant vapor, and condensing the compressed first refrigerant vapor to provide a first refrigerant liquid;

[0064] circulating the second refrigerant in the second refrigeration circuit and evaporating the second refrigerant to provide a second refrigerant vapor and to cool and condense the first refrigerant, compressing the second refrigerant vapor to provide a compressed second refrigerant vapor, and condensing the compressed second refrigerant vapor to provide a second refrigerant liquid; and

[0065] placing an article in the cooled medium

[0066] Preferably, the method of the invention uses the refrigeration system of the invention and the preferred operation conditions mentioned in relation thereto.

What is claimed is:

1. A refrigeration system comprising:

a first closed refrigeration circuit for containing a first refrigerant comprising a high pressure side and a low pressure side, a first evaporator for evaporating a first refrigerant liquid to provide a first refrigerant vapor, a first compressor for compressing the first refrigerant vapor, a first condenser for condensing the first refrigerant vapor, and a first control valve for controlling the pressure difference between a high pressure side and a low pressure side of the first refrigeration circuit;

a second closed refrigeration circuit for containing a second refrigerant, comprising a high pressure side and a low pressure side, a second evaporator for evaporating a second refrigerant liquid to provide a second refrigerant vapor, a second compressor for compressing the second refrigerant vapor, a second condenser for condensing the second refrigerant vapor, and a second control valve for controlling the pressure difference between the high pressure side and the low pressure side of the second circuit; and

a cascade heat exchanger comprising the first condenser and the second evaporator arranged so that the first condenser is cooled by evaporation of the second refrigerant liquid in the second evaporator, wherein the first refrigerant comprises CO_2 and the first evaporator is operated at pressures above about 120 psig.

2. The refrigeration system of claim 1, wherein the first evaporator is at a pressure of between about 120 psig and 1056 psig.

3. The refrigeration system of claim 1, wherein the first evaporator is at a pressure of between about 120 psig and 580 psig.

4. The refrigeration system of claim 1, wherein the first compressor compresses the first refrigerant vapor to a pressure above about 325 psig.

5. The refrigeration system of claim 4, wherein the first compressor compresses the first refrigerant vapor to a pressure of from about 325 psig to 580 psig.

6. The refrigeration system of claim 4, wherein the second compressor compresses the second refrigerant vapor to a pressure below about 325 psig.

7. The refrigeration system of claim 1, further comprising an open flash economizer vessel subsequent to the first condenser to cool the first liquid refrigerant liquid to a temperature intermediate between the temperature of the first refrigerant liquid in the high pressure side and the temperature of the first refrigerant liquid in the low pressure side by evaporating part of the first liquid refrigerant to provide a first refrigerant vapor, wherein the economizer vessel is connected to an economizer port on the first compressor so that the first refrigerant vapor can be compressed by the compressor.

8. The refrigeration system of claim 1, further comprising a heat exchanger subsequent to the first condenser to cool the first liquid refrigerant to a temperature intermediate between the temperature of the first refrigerant liquid in the high pressure side and the temperature of the first refrigerant liquid in the low pressure side by evaporating part of the first liquid refrigerant to provide a first refrigerant vapor, wherein the heat exchanger is connected to an economizer port of the first compressor so that the first refrigerant vapor can be compressed by the compressor.

9. The refrigeration system of claim 1, wherein the second evaporator is operated at a pressure such that the temperature difference between the second evaporator and the first condenser is about 5° F.

10. The refrigeration system of claim 1, further comprising a package refrigeration system in the first refrigeration circuit to control the pressure in the first refrigeration circuit by cooling the CO_2 when the refrigeration system is not being used.

11. The refrigeration system of claim 1, wherein the second refrigerant is ammonia, a hydrofluorocarbon, or a hydrocarbon.

12. A method of refrigerating an article comprising:

providing a first refrigerant of CO_2 in a first closed refrigeration circuit and second refrigerant in a second closed refrigeration circuit;

circulating the first refrigerant in the first refrigeration circuit and evaporating the first refrigerant at a pressure greater than about 120 psig to provide a first refrigerant vapor and to cool a medium, compressing the first refrigerant vapor to provide a compressed first refrigerant vapor, and condensing the compressed first refrigerant vapor to provide a first refrigerant liquid;

circulating the second refrigerant in the second refrigeration circuit and evaporating the second refrigerant to provide a second refrigerant vapor and to cool and condense the first refrigerant, compressing the second refrigerant vapor to provide a compressed second refrigerant vapor, and condensing the compressed second refrigerant vapor to provide a second refrigerant liquid; and

placing an article in the cooled medium.

13. The method of claim 12, wherein

the first closed refrigeration circuit comprises a high pressure side and a low pressure side, a first evaporator for evaporating the first refrigerant liquid to provide the first refrigerant vapor, a first compressor for compressing the first refrigerant vapor, a first condenser for condensing the first refrigerant vapor, and a first control valve for controlling the pressure difference between a high pressure side and a low pressure side of the first refrigeration circuit;

the second closed refrigeration circuit for comprises a high pressure side and a low pressure side, a second evaporator for evaporating the second refrigerant liquid to provide the second refrigerant vapor, a second compressor for compressing the second refrigerant vapor, a second condenser for condensing the second refrigerant vapor, and a second control valve for controlling the pressure difference between the high pressure side and the low pressure side of the second circuit; and

a cascade heat exchanger comprising the first condenser and the second evaporator arranged so that the first condenser is cooled by evaporation of the second refrigerant liquid in the second evaporator.

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