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(54) **CARBON DIOXIDE BASED AUXILIARY COOLING SYSTEM**

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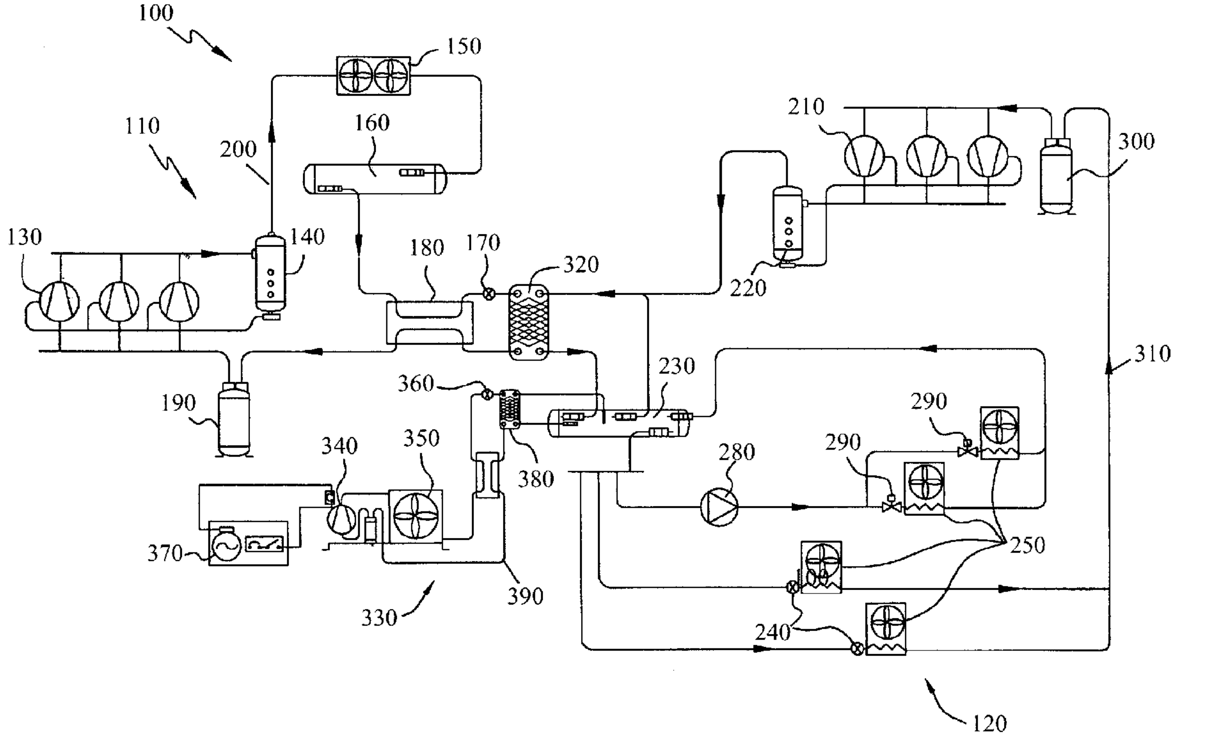
(57) **ABSTRACT**

The present application provides a cascade refrigeration system. The cascade refrigeration system may include a first side cycle, a second side cycle with a second side cycle carbon dioxide refrigerant, and an auxiliary cooling system to cool the second side cycle carbon dioxide refrigerant in the event of a power outage. The auxiliary cooling system may include an auxiliary carbon dioxide refrigerant.



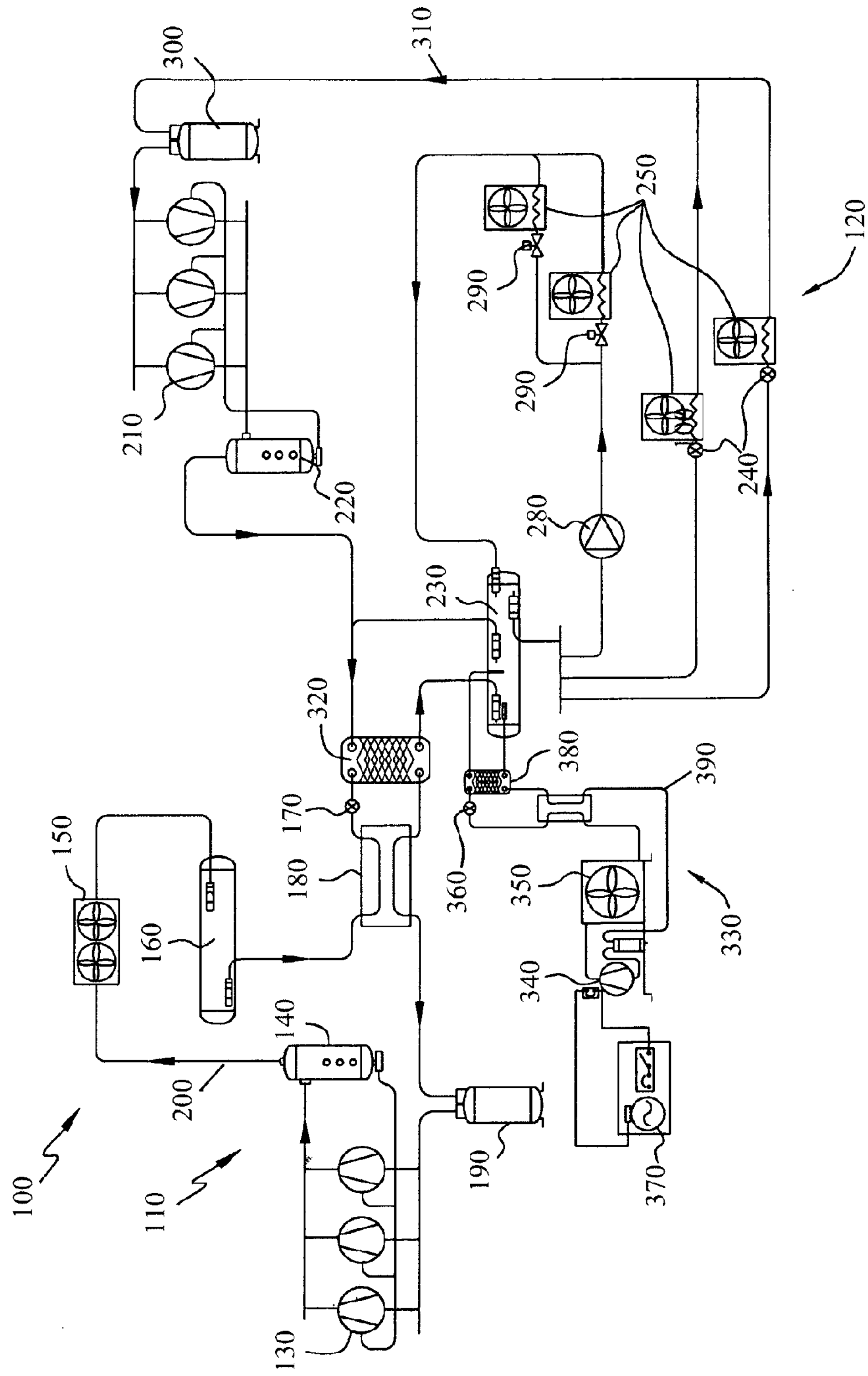

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Fig. 1

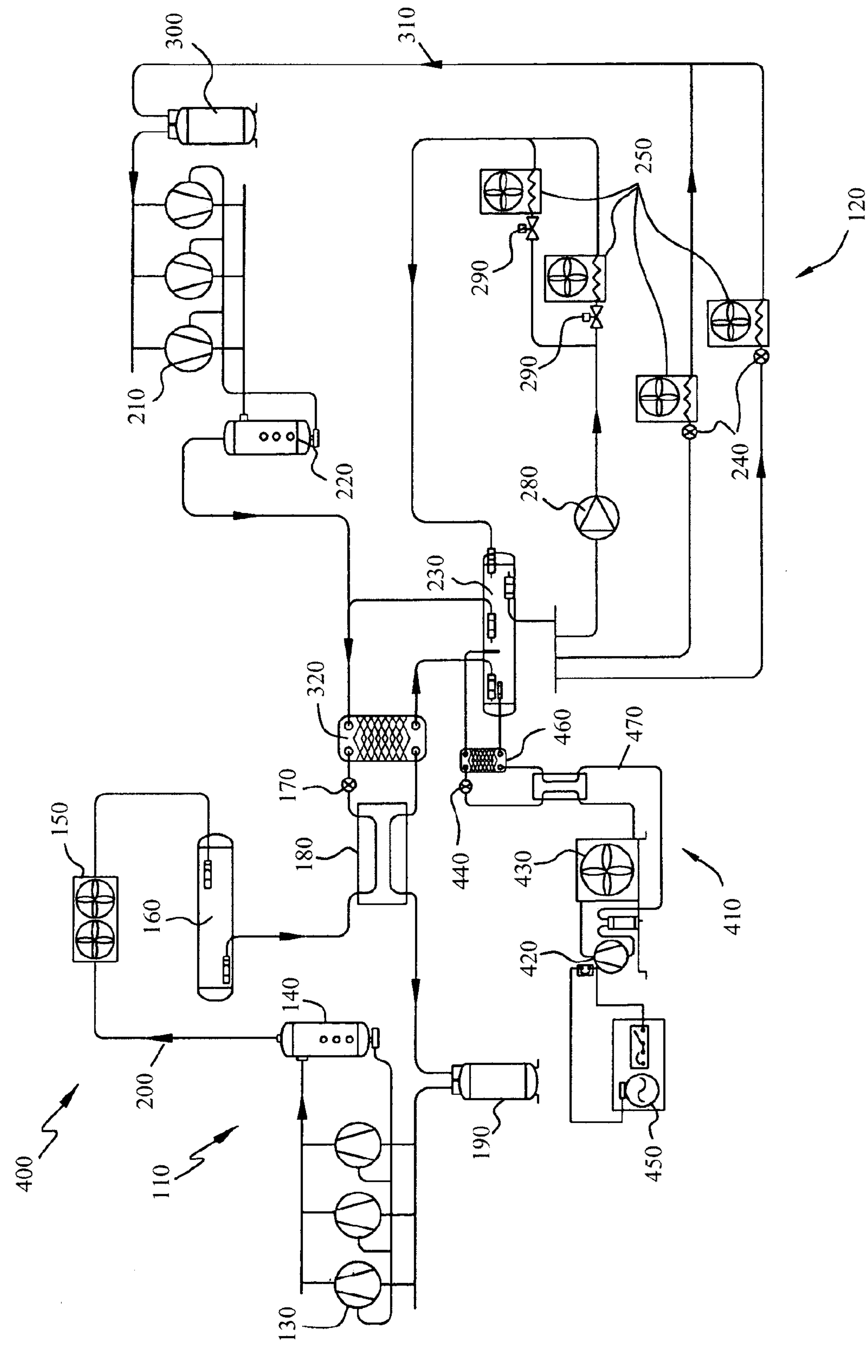
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Fig. 2

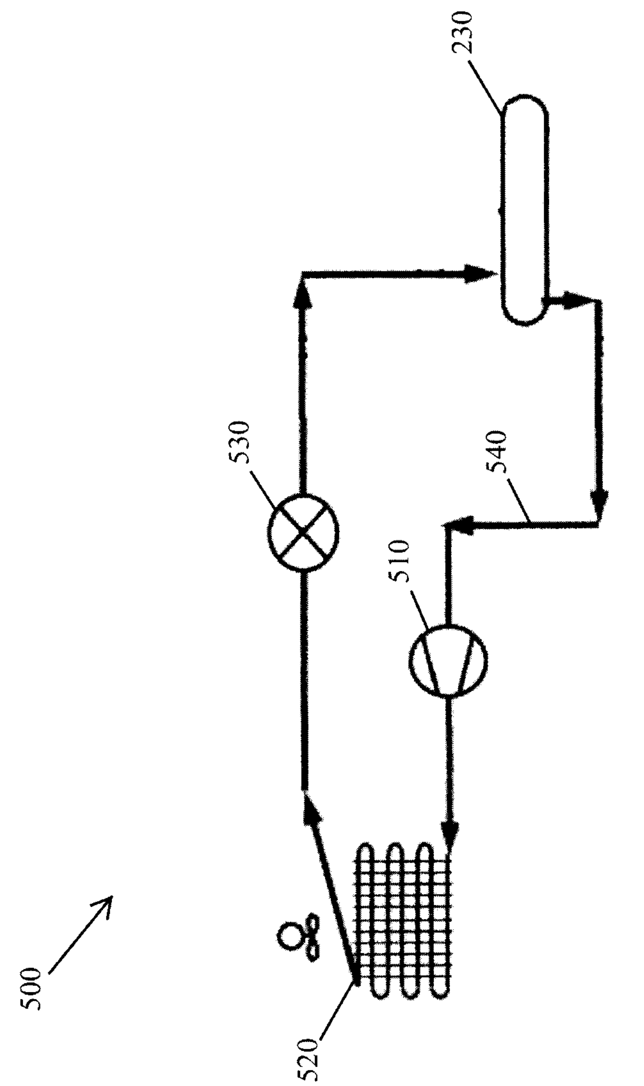

Fig 3

CARBON DIOXIDE BASED AUXILIARY COOLING SYSTEM

TECHNICAL FIELD

[0001] The present application and the resultant patent relate generally to refrigeration systems and more particularly relate to a carbon dioxide based auxiliary cooling system for a refrigeration system that may be free of the use of hydrofluorocarbons and the like.

BACKGROUND OF THE INVENTION

[0002] Cascade refrigeration systems generally include a first side cooling cycle, or a high side cycle, and a second side cooling cycle, or a low side cooling cycle. The two cooling cycles interface through a common heat exchanger, i.e., a cascade evaporator-condenser. The cascade refrigeration system may provide cooling at very low temperatures in a highly efficient manner.

[0003] Current refrigeration trends promote the use of carbon dioxide and other types of natural refrigerants as opposed to conventional hydrofluorocarbon based refrigerants. Unlike hydrofluorocarbons, however, carbon dioxide based systems may lose refrigerant during power outages. In the case of a power outage, the carbon dioxide based system may start gaining heat such that the refrigerant pressure may rise and exceed the design pressure of the overall refrigeration system. The refrigeration system generally must be vented to the atmosphere in such a situation.

[0004] In order to avoid venting the refrigerant, carbon dioxide based refrigeration systems may include a backup condensing unit with an independent power source to keep the carbon dioxide cool. These known backup devices, however, generally use hydrofluorocarbon based refrigerants such that the refrigeration system as a whole cannot be considered truly "green" or hydrofluorocarbon free.

[0005] There is thus a desire for a refrigeration system such as cascade refrigeration systems that provide auxiliary cooling without the use of hydrofluorocarbons. Such an auxiliary cooling system would provide efficient cooling in a truly hydrofluorocarbon free design.

SUMMARY OF THE INVENTION

[0006] The present application and the resultant patent thus provide a cascade refrigeration system. The cascade refrigeration system may include a first side cycle, a second side cycle with a second side cycle carbon dioxide refrigerant, and an auxiliary cooling system to cool the second side cycle carbon dioxide refrigerant in the event of a power outage. The auxiliary cooling system may include an auxiliary carbon dioxide refrigerant.

[0007] The present application and the resultant patent further provide a method of providing auxiliary cooling in a refrigeration system. The method may include the steps of flowing a natural refrigerant through a first side cycle, flowing a carbon dioxide refrigerant through a second side cycle, providing an auxiliary cooling system to cool the flow of the carbon dioxide refrigerant in the case of a power loss, and flowing an auxiliary carbon dioxide refrigerant through the auxiliary cooling system.

[0008] The present application and the resulting patent further provide a carbon dioxide based refrigeration system. The carbon dioxide based refrigeration system may include a receiver, a carbon dioxide refrigerant, and an auxiliary cooling system in communication with the receiver to cool the carbon dioxide refrigerant in the event of a power outage. The auxiliary cooling system may include an auxiliary carbon dioxide refrigerant.

[0009] These and other features and improvements of the present application and the resultant patent will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic diagram of a known cascade refrigeration system with a high side cycle and a low side cycle.

[0011] FIG. **2** is a schematic diagram of a cascade refrigeration system with a carbon dioxide base auxiliary cooling system as may be described herein.

[0012] FIG. **3** is a schematic diagram of an alternative embodiment of a carbon dioxide based auxiliary cooling system as may be described herein.

DETAILED DESCRIPTION

[0013] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, FIG. **1** shows an example of a cascade refrigeration system **100**. The cascade refrigeration system **100** may be used to cool any type of enclosure for use in, for example, supermarkets, cold storage, and the like. The cascade refrigeration system **100** also may be applicable to heating, ventilation, and air conditioning and/or different types of industrial applications. The overall cascade refrigeration system **100** may have any suitable size or capacity.

[0014] Generally described, the cascade refrigeration system **100** may include a first or a high side cycle **110** and a second or a low side cycle **120**. The high side cycle **110** may include a high side compressor **130**, a high side oil separator **140**, a high side condenser **150**, a high side receiver **160**, and a high side expansion device **170**. The high side cycle **110** also may include a suction/liquid heat exchanger **180** and a suction accumulator **190**. The high side cycle **110** may include a flow of a natural refrigerant **200**. The natural refrigerant **200** may include a flow of ammonia, a flow of hydrocarbons, and the like. Other components and other configurations may be used herein.

[0015] The low side cycle **120** similarly may include a low side compressor **210**, a low side oil separator **220**, a low side receiver **230**, a low side expansion device **240**, and one or more low side evaporators **250**. The low side cycle **120** may include a medium temperature loop **260** with a pump **270** and a number of flow valves **280** as well as a low temperature loop **290**. An accumulator **300** also may be used therein. The low side cycle **120** may include a flow of a carbon dioxide based refrigerant **310** and the like. Other components and other configurations may be used herein.

[0016] The two cycles **110**, **120** may interface through a cascade evaporator/condenser **320**. The respective flows of the refrigerants **200**, **310** may exchange heat via the cascade evaporator/condenser **320**. The cascade evaporator/condenser **320** may have any suitable size or capacity. Other components and other configurations may be used herein.

[0017] The natural refrigerant **200** may be compressed by the high side compressor **210** and condensed in the high side condenser **150**. The refrigerant **200** may be stored in the high side receiver **160** and may be withdrawn as needed to satisfy the load on the cascade evaporator/condenser **320**. The refrigerant **200** then may pass through the high side expansion device **170** and returns to the high side compressor **130**. The suction/liquid heat exchanger **180** may be used to sub-cool the refrigerant **200** before entry into the cascade evaporator/condenser **320**.

[0018] The low side cycle **120** may be similar. The carbon dioxide based refrigerant **310** may be compressed by the low side compressor **210** and then pass through the cascade evaporator/condenser **320**. The refrigerant **310** may be stored within the low side receiver **230** and withdrawn as needed. The refrigerant **310** may pass through one or more low side expansion devices **240** and one or more low side evaporators **250**. The low side cycle **120** may be separated into the low temperature loop **290** and the medium temperature loop **260**.

[0019] The cascade refrigeration system **100** also may include an auxiliary cooling system **330**. The cooling auxiliary system **330** may be used to cool the flow of the carbon dioxide refrigerant **310** via an interface with the low side receiver **230** or elsewhere. The auxiliary cooling system **330** may include an auxiliary compressor **340**, an auxiliary condenser **350**, and an auxiliary expansion device. The cooling auxiliary system **330** may include a generator **370** or other type of independent power supply. The auxiliary cooling system **330** may interface with the low side cycle **120** via an auxiliary condenser/evaporator **380**. Known auxiliary cooling systems **330** generally use a hydrofluorocarbon based refrigerant **390** such as R404A or R407A. Other components and other configurations may be used herein.

[0020] FIG. **2** shows a cascade refrigeration system **400** as may be described herein. The cascade refrigeration system **400** may include the same or a similar high side cycle **110** and low side cycle **120**. The two cycles may interface via the cascade evaporator/condenser **320** and the like. As described above, the low side cycle **120** includes the flow of the carbon dioxide based refrigerant **310**.

[0021] The cascade refrigeration system **400** also may include a carbon dioxide based auxiliary cooling system **410**. The carbon dioxide auxiliary cooling system **410** may include an auxiliary compressor **420**, an auxiliary condenser **430**, and an auxiliary expansion device **440**. The carbon dioxide auxiliary cooling system **410** may include an auxiliary generator **450** or other type of independent power supply. The carbon dioxide auxiliary cooling system **410** may interface with the low side cycle **120** via an auxiliary condenser/evaporator **460** or other type of heat exchange device. The carbon dioxide auxiliary cooling system **410** may include a flow of a carbon dioxide based refrigerant **470** therein. Other types of natural refrigerants also may be used herein. Other components and other configurations may be used herein.

[0022] In the event of the loss of power, the carbon dioxide auxiliary cooling system **410** may be used to cool the flow of the carbon dioxide refrigerant **310** in the low side cycle **120** via the carbon dioxide refrigerant **470** circulating therein and interfacing at the auxiliary condenser/evaporator **460**. The cascade refrigeration system **400** thus is truly a hydrofluorocarbon free system. The carbon dioxide based auxiliary cooling system **410** may provide a faster overall response time in a proactive method of cooling the flow of carbon dioxide refrigerant **310** without venting. Multiple carbon dioxide auxiliary cooling systems **410** may be used herein.

[0023] FIG. **3** shows an alternative embodiment of a carbon dioxide auxiliary cooling system **500** as may be described herein. The carbon dioxide auxiliary cooling system **500** may include an auxiliary compressor **510**, an auxiliary gas cooler **520** or condenser, and an auxiliary expansion device **530**. The carbon dioxide auxiliary cooling system **500** also may include an auxiliary generator or other type of independent power source. The carbon dioxide auxiliary cooling system **500** also may include a flow of a carbon dioxide based refrigerant **540** therein. Other components and other configurations may be used herein.

[0024] The carbon dioxide auxiliary system **500** may tie directly into the low side cycle **120** via the low side cycle receiver **230** for heat exchange therewith. The carbon dioxide auxiliary system **500** thus avoids the need for an auxiliary condenser/evaporator and/or pump in a truly a hydrofluorocarbon free system. The carbon dioxide based auxiliary system **500** also may provide a faster overall response time in a proactive method of cooling the flow of carbon dioxide refrigerant **310** without venting.

[0025] Although the carbon dioxide based auxiliary cooling systems have been shown in the context of a cascade refrigeration system, the carbon dioxide based auxiliary cooling systems may be used in any type of carbon dioxide refrigeration system. Specifically, any type of carbon dioxide refrigeration system using a large receiver tank and the like.

[0026] It should be apparent that the foregoing relates only to certain embodiments of the present application and the resultant patent. Numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the general spirit and scope of the invention as defined by the following claims and the equivalents thereof.

We claim:

1. A cascade refrigeration system, comprising:
a first side cycle;
a second side cycle;
the second side cycle comprising a second side cycle carbon dioxide refrigerant; and
an auxiliary cooling system to cool the second side cycle carbon dioxide refrigerant in the event of a power outage;
the auxiliary cooling system comprising an auxiliary carbon dioxide refrigerant.

2. The cascade refrigeration system of claim **1**, wherein the auxiliary cooling system comprises an auxiliary compressor and an auxiliary expansion valve.

3. The cascade refrigeration system of claim **1**, wherein the auxiliary cooling system comprises an auxiliary condenser.

4. The cascade refrigeration system of claim **1**, wherein the auxiliary cooling system comprises an auxiliary gas cooler.

5. The cascade refrigeration system of claim **1**, wherein the auxiliary cooling system comprises auxiliary condenser/evaporator.

6. The cascade refrigeration system of claim **1**, wherein the second side cycle comprises a second side cycle receiver and wherein the auxiliary cooling system is in communication with the second side cycle receiver.

7. The cascade refrigeration system of claim **1**, wherein the auxiliary cooling system comprises an auxiliary generator.

8. The cascade refrigeration system of claim **1**, wherein the first side cycle and the second side cycle interface via a cascade evaporator/condenser.

9. The cascade refrigeration system of claim **1**, wherein the first side cycle comprises a flow of an ammonia or a hydrocarbon refrigerant.

10. The cascade refrigeration system of claim **1**, wherein the first side comprises a suction/liquid heat exchanger.

11. The cascade refrigeration system of claim **1**, wherein the first side cycle comprises a first side compressor, a first side condenser, and a first side expansion device.

12. The cascade refrigeration system of claim **1**, wherein the second side cycle comprises a second side compressor, a second side expansion device, and a second side evaporator.

13. The cascade refrigeration system of claim **1**, wherein the second side cycle comprises a medium temperature loop and a medium temperature loop.

14. The cascade refrigeration system of claim **1**, further comprising a plurality of auxiliary cooling systems.

15. An method of providing auxiliary cooling in a refrigeration system, comprising:

flowing a natural refrigerant through a first side cycle;

flowing a carbon dioxide refrigerant through a second side cycle;

providing an auxiliary cooling system to cool the flow of the carbon dioxide refrigerant in the case of a power loss; and

flowing an auxiliary carbon dioxide refrigerant through the auxiliary cooling system.

16. A carbon dioxide based refrigeration system, comprising:

a receiver;

a carbon dioxide refrigerant; and

an auxiliary cooling system in communication with the receiver to cool the carbon dioxide refrigerant in the event of a power outage;

the auxiliary cooling system comprising an auxiliary carbon dioxide refrigerant.

17. The carbon dioxide refrigeration system of claim **16**, wherein the auxiliary cooling system comprises an auxiliary condenser.

18. The carbon dioxide refrigeration system of claim **16**, wherein the auxiliary cooling system comprises an auxiliary gas cooler.

19. The carbon dioxide refrigeration system of claim **16**, wherein the auxiliary cooling system comprises an auxiliary generator.

20. The carbon dioxide refrigeration system of claim **16**, wherein the carbon dioxide refrigeration system comprises a cascade refrigeration system.

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