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(54) **REFRIGERATION SYSTEM WITH HOT GAS DEFROST MODE**

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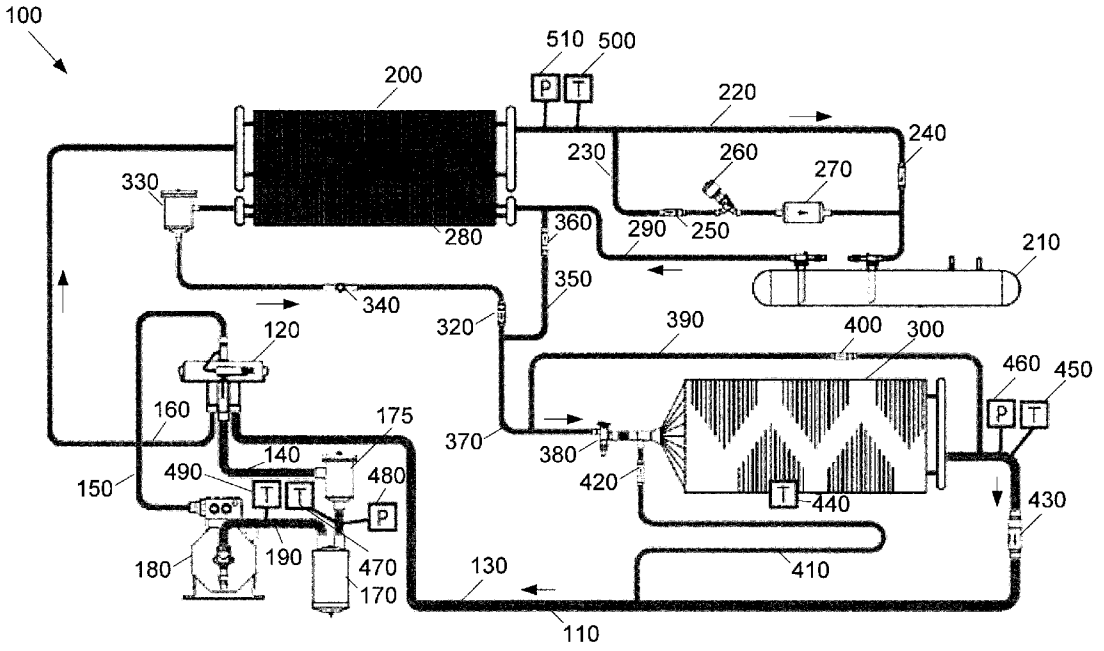
(57) **ABSTRACT**

The present application provides a refrigeration system with a flow of refrigerant therein for a refrigerant mode or a defrost mode. The refrigeration system may include a four way valve, an evaporator in communication with the four way valve, a compressor in communication with the four way valve, and a condenser in communication with the four way valve. The four way valve directs the flow of refrigerant to the condenser in the refrigeration mode or to the evaporator in the defrost mode.



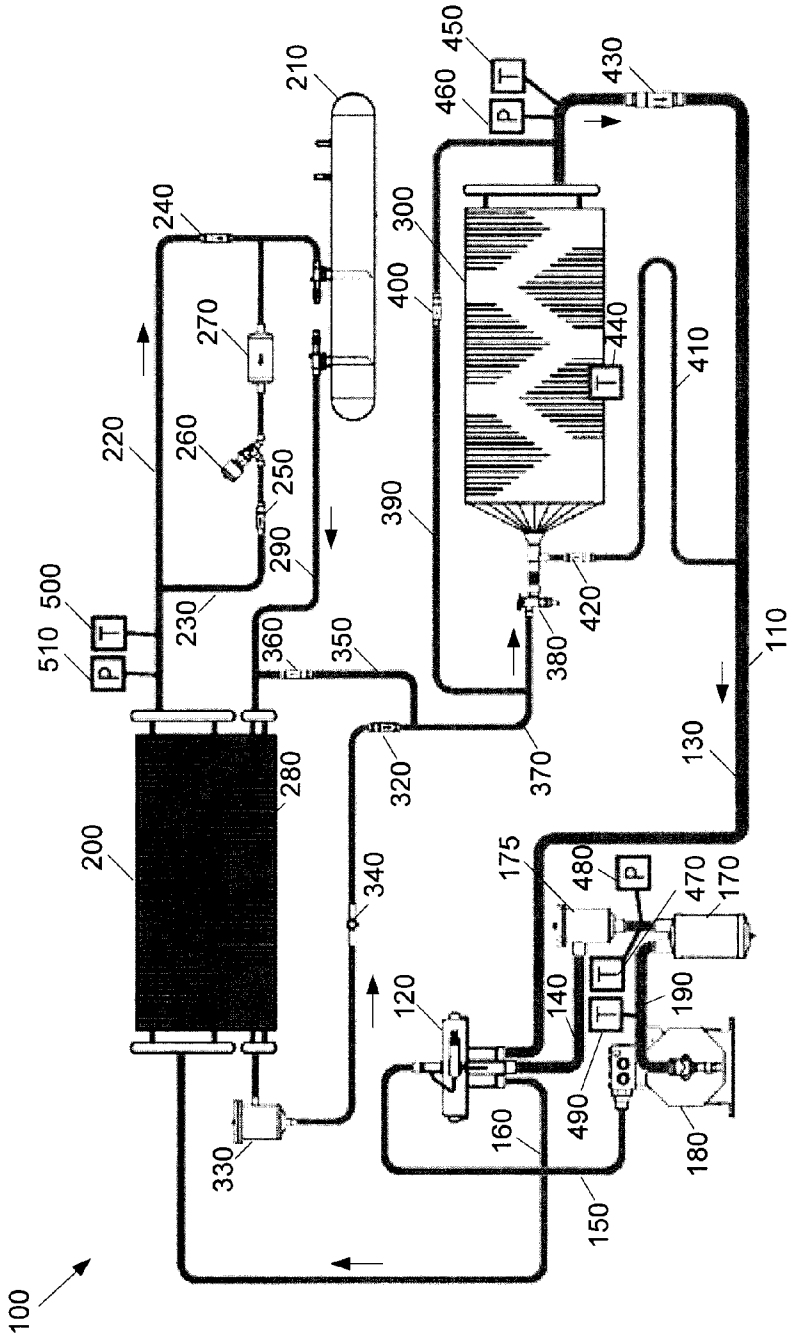

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Fig. 1

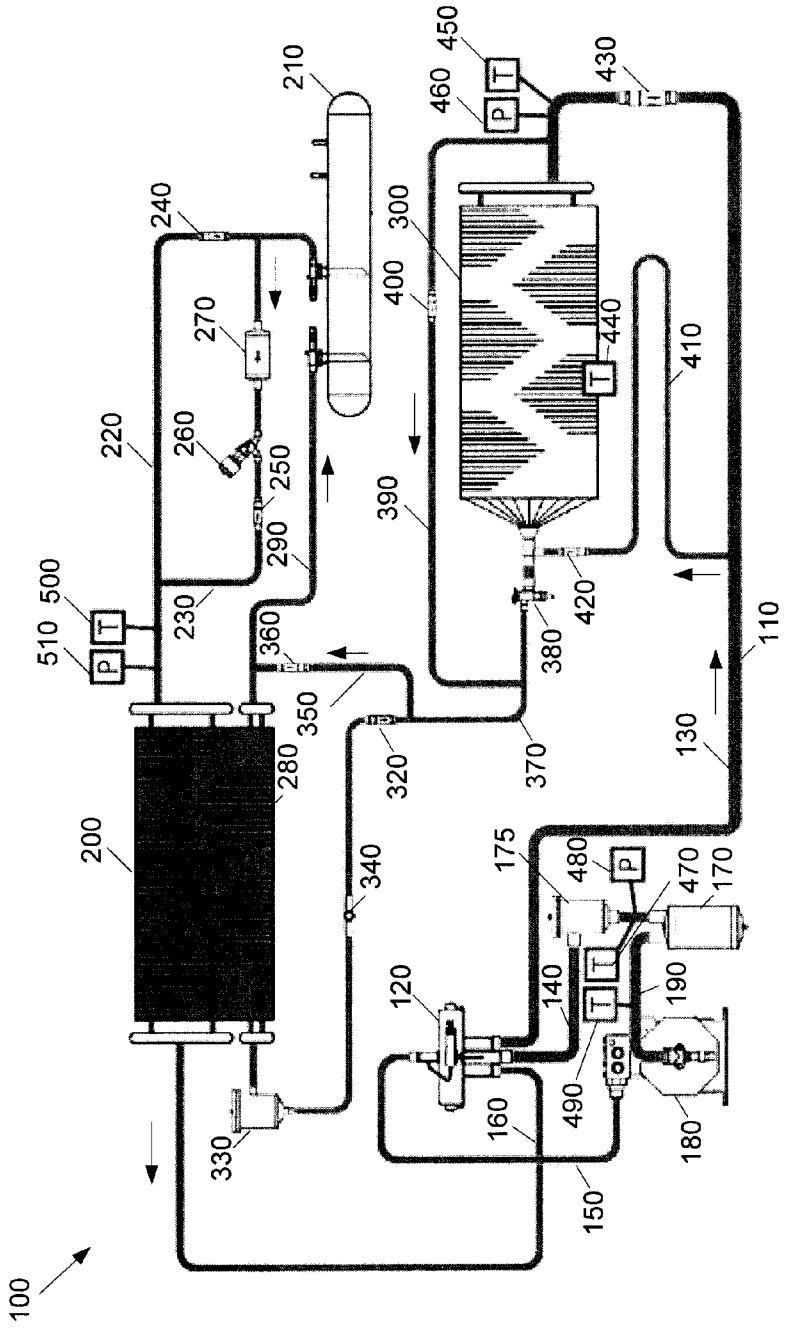
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Fig. 2

REFRIGERATION SYSTEM WITH HOT GAS DEFROST MODE

TECHNICAL FIELD

[0001] This invention relates generally to refrigeration systems and more particularly relate to commercial refrigeration systems using a hot gas defrost mode for periodic defrosting of the evaporator coils and other components.

BACKGROUND OF THE INVENTION

[0002] Generally described, a typical refrigeration system includes one or more evaporators positioned about a space to be cooled, a condenser external to the space, a compressor, and an expansion valve. A refrigerant may be compressed by the compressor. The hot, pressurized refrigerant flows through the condenser to allow the refrigerant to dissipate the heat of pressurization. The refrigerant condenses into liquid and then flows through the expansion valve where the refrigerant moves from a high pressure zone into a low pressure zone so as to expand and evaporate. The refrigerant becomes cold in the evaporator as it passes through the coils therein and absorbs heat from the space to be cooled. Other types of refrigeration cycles and components also may be used.

[0003] Typical refrigeration systems also include some sort of mechanism to prevent a buildup of frost on the evaporator coils. Defrosting may be accomplished in a number of ways. For example, an external heater may heat the evaporator coils. Such external heating methods, however, may be time consuming. Hot gas systems also may be used. In these systems, the flow of the refrigerant may be reversed so as to flow hot refrigerant through the evaporator coils. Known hot gas defrost systems, however, may include multiple valves and controls in a somewhat complicated arrangement so as to cycle between a refrigeration mode and a defrost mode.

SUMMARY OF THE INVENTION

[0004] In certain embodiments, a refrigeration system with a flow of refrigerant therein for a refrigerant mode or a defrost mode is included. The refrigeration system may include a four way valve, an evaporator in communication with the four way valve, a compressor in communication with the four way valve, and a condenser in communication with the four way valve. The four way valve directs the flow of refrigerant to the condenser in the refrigeration mode or to the evaporator in the defrost mode.

[0005] According to some embodiments, a method of operating a refrigeration system in a refrigeration mode or a defrost mode may include the steps of directing a flow of refrigerant by a four way valve to a condenser and then to an evaporator in the refrigeration mode, modulating the flow of refrigerant to the evaporator with an electronic expansion valve in the refrigeration mode, directing the flow refrigerant by the four way valve to the evaporator and then to the condenser in the defrost mode, and modulating the flow of refrigerant to the condenser with an electronic pressure regulator in the defrost mode.

[0006] In particular embodiments, a refrigeration system with a flow of refrigerant therein for a refrigerant mode or a defrost mode may include a four way valve, an evaporator in communication with the four way valve, a condenser in communication with the four way valve, an electronic expansion valve for modulating the flow of refrigerant to the evaporator in the refrigeration mode, and an electronic pressure regulator for modulating the flow of refrigerant to the condenser in the defrost mode. The four way valve directs the flow of refrigerant to the condenser in the refrigeration mode or to the evaporator in the defrost mode.

[0007] These and other features and improvements of certain embodiments of the present disclosure 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

[0008] FIG. **1** is a schematic diagram of a refrigeration system as may be described herein in a refrigeration mode.

[0009] FIG. **2** is a schematic diagram of the refrigeration system of FIG. **1** in a defrost mode.

DETAILED DESCRIPTION

[0010] Referring now to the drawings, in which like numerals refer to like elements throughout the several views, FIGS. **1** and **2** show a refrigeration system **100** as may be described herein. The refrigeration system **100** may be used to cool any type of enclosed or partially enclosed space. The refrigeration system **100** may include a flow of a refrigerant **110** therein. The refrigerant **110** may be a natural refrigerant such as carbon dioxide, a hydrofluorocarbon-based refrigerant, or any other type of conventional refrigerant. The refrigeration system **100** may have any suitable size, shape, configuration, or capacity.

[0011] The refrigeration system **100** may include a four way valve **120**. The refrigeration system **100** may cycle between a refrigeration mode and a defrost mode based in part on the operation of the four way valve **120**. The four way valve **120** may be of conventional design. The four way valve **120** may be in communication with a first side evaporator conduit **130**, a suction accumulator conduit **140**, a compressor conduit **150**, and a condenser conduit **160**. The four way valve **120** may selectively direct the flow of refrigerant **110** through any of the conduits in any direction. The conduits may have any suitable size, shape, or configuration. Other components and other configurations may be used herein.

[0012] The suction accumulator conduit **140** may be in communication with a suction accumulator **170** and/or a suction filter **175**. The suction accumulator **170** and the suction filter **175** may be of conventional design. The suction accumulator **170** prevents compressor damage from a sudden surge of liquid refrigerant **110**. The suction filter **175** serves to remove contaminates in the flow of the refrigerant **110**. Other types of filters also may be used herein.

[0013] The refrigeration system **100** may include a compressor **180**. The compressor **180** may be of conventional design and may have any suitable size, shape, or configuration. The compressor **180** may be a discus compressor and the like. The compressor **180** may be in communication with the suction accumulator **170** via a suction line **190**. The compressor **180** also may be in communication with the four way valve **120** via the compressor conduit **150**. Other components and other configurations may be used herein.

[0014] The refrigeration system **100** may include a condenser **200**. The condenser **200** may be of conventional design and may have any suitable size, shape, or configuration. The condenser **200** may be in communication with the four way valve **120** via the condenser conduit **160**. More than

one condenser **200** may be used herein. An Oil separator also may be used. Other components and other configurations may be used herein.

[0015] The refrigeration system **100** may include a receiver **210**. The receiver **210** may be of conventional design and may have any suitable size, shape, or configuration. The receiver **210** may include a dip tube on both the inlet and the outlet. The receiver **210** may store the refrigerant **110** until needed by the evaporator as may be described below. The receiver **210** may be in communication with the condenser **200** via a refrigeration receiver conduit **220** and a defrost receiver conduit **230**. The refrigeration receiver conduit **220** may include a refrigerant receiver conduit valve **240** thereon. The defrost receiver conduit **230** may include a defrost receiver conduit valve **250** and an electronic pressure regulator **260**. The electronic pressure regulator **260** may be of conventional design and may have any suitable size, shape, or configuration. An electronic expansion valve also could be used herein. The electronic pressure regulator **260** may modulate a flow of the refrigerant **110** to the condenser **200** in the defrost mode. The defrost receiver conduit **230** also optionally may include a filter dryer **270** thereon. The filter dryer **270** may be of conventional design. Other components and other configurations also may be used herein.

[0016] The refrigeration system **100** may include an optional sub-cooler **280**. The sub-cooler **280** may be of conventional design and may have any suitable size, shape, or configuration. The sub-cooler **280** may be physically part of the condenser **200** or the sub-cooler **280** may be a separate stand-alone device. The sub-cooler **280** may be in communication with the receiver **210** via a sub-cooler input conduit **290**. More than one sub-cooler **280** may be used herein. Other components and other configurations also may be used herein.

[0017] The refrigeration system **100** may include an evaporator **300**. The evaporator **300** may be of conventional design and may have any suitable size, shape, or configuration. More than one evaporator **300** may be used herein. The evaporator **300** may be in communication with the sub-cooler **280** via a sub-cooler output conduit **310**. The sub-cooler output conduit **310** may include a sub-cooler output conduit valve **320** thereon. A sub-cooler filter dryer **330** also may be positioned on the sub-cooler output conduit **310**. The sub-cooler filter dryer **330** may be of conventional design. A sightglass **340** also may be positioned on the sub-cooler output conduit **310** or elsewhere. Alternatively, the evaporator **300** may be in communication with the receiver **210** via a sub-cooler bypass conduit **350**. The sub-cooler bypass conduit **350** may have a sub-cooler bypass conduit valve **360** thereon. The sub-cooler output conduit **300** and the sub-cooler bypass conduit **350** may merge into a second side evaporator conduit **370**. Other components and other configurations may be used herein.

[0018] An electronic expansion valve **380** may be positioned on the second side evaporator conduit **370**. The electronic expansion valve **380** may be of conventional design and may have any suitable size, shape, or configuration. The electronic expansion valve **380** may modulate the flow of the refrigerant **110** to the evaporator **300** in the refrigeration mode. An evaporator bypass conduit **390** may extend from the second side evaporator conduit **370** to the first side evaporator conduit **130** for use in the defrost mode. An evaporator bypass conduit valve **400** may be positioned on the evaporator bypass conduit **390**. A drain pan conduit **410** also may extend from the second side evaporator conduit **370** to the first side evaporator conduit **130**. A drain pan conduit valve **420** may be positioned on the drain pan conduit **410**. A first side evaporator conduit valve **430** may be positioned on the first side evaporator conduit **130**. Other components and other configurations may be used herein.

[0019] The refrigeration system **100** may include a number of pressure sensors, temperature sensors, and/or other types of sensors. For example, an evaporator temperature sensor **440** may be positioned about the coils of the evaporator **300**. A second side evaporator conduit temperature sensor **450** and a second side evaporator conduit pressure sensor **460** may be positioned about the second side evaporator conduit **370**. A suction accumulator temperature sensor **470** and a suction accumulator pressure sensor **480** may be positioned about the suction accumulator **170**. A compressor temperature sensor **490** may be positioned on the suction line **190** about the compressor **180**. A condenser temperature sensor **500** and a condenser pressure sensor **510** may be positioned about the condenser **200**. Other types of sensors may be used herein in other positions. The sensors and the valves may be operated via a controller and the like. The controller may be any type programmable logic device. Other components and other configurations may be used herein.

[0020] FIG. **1** shows the refrigeration system **100** in the refrigeration mode. In the refrigeration mode, the four way valve **120** receives a flow of refrigerant **110** from the evaporator **300** via the first side evaporator conduit **130**. The four way valve **120** directs the flow of refrigerant **110** to the suction accumulator **170** via the suction accumulator conduit **140**. The suction accumulator **170** forwards the flow of the refrigerant **110** to the compressor **180** via the suction line **190**. The compressor **180** forwards the flow of the refrigerant **110** back to the four way valve **120** via the compressor conduit **150**. The four way valve **120** in turn forwards the flow of the refrigerant **110** to the condenser **200** via the condenser conduit **160**.

[0021] From the condenser **200**, the flow of the refrigerant **110** flows to the receiver **210**. The refrigeration receiver conduit valve **240** is open on the refrigeration receiver conduit **220** while the defrost receiver conduit valve **250** is closed on the defrost receiver conduit **230**. The electronic pressure regulator **260** is closed. The flow of refrigerant **110** then flows to the sub-cooler **280** via the sub-cooler input conduit **290**. The flow of refrigerant **110** flows to the electronic expansion valve **380** via the sub-cooler output conduit **310** and the second side evaporator conduit **370**. The flow of refrigerant **110** to the evaporator **300** may be modulated by the electronic expansion valve **380**. The sub-cooler output conduit valve **320** may be open while the sub-cooler bypass conduit valve **360** may be closed. Likewise, the evaporator bypass conduit valve **400** may be closed as well as the drain pan conduit valve **420**. The flow of refrigerant **110** then may return to the four way valve **120** via the first side evaporator conduit **130**. The first side evaporator conduit valve **430** may be open. Other components and other configurations may be used herein.

[0022] In transitioning from the refrigeration mode to the defrost mode, the refrigeration system **100** first may deactivate the compressor **180** and open the electronic expansion valve **380** fully so as to equalize the refrigerant pressure between the condenser **200** and the evaporator **300**.

[0023] FIG. **2** shows the refrigeration system **100** in the defrost mode. In the defrost mode, the four way valve **120** may receive the flow of refrigerant **110** from the condenser **200** via the condenser conduit **160**. The four way valve **120**

then forwards the flow to the suction accumulator **170** via the suction accumulator conduit **140** and on to the compressor **180**. The compressor **180** returns the flow to the four way valve **120** via the compressor conduit **150**. The four way valve **120** then forwards the flow of the refrigerant **110** to the evaporator **300** via the first side evaporator conduit **140**. The flow of the refrigerant **110** then may flow through the drain pan conduit **410** and into the evaporator **300**. The drain pan conduit valve **420** may be open. The first side evaporator conduit valve **430** may be closed. The electronic expansion valve **380** may be closed. The flow of refrigerant **110** then may flow through the evaporator bypass conduit **390**. The evaporator bypass conduit valve **400** may be open. The flow of the refrigerant **110** may flow through the sub-cooler bypass conduit **350**. The sub-cooler bypass conduit valve **360** may be open while the sub-cooler output conduit valve **320** may be closed. The flow of refrigerant **110** then may flow through the receiver **210** and through the defrost receiver conduit **230**. The defrost receiver conduit valve **250** may be open and the refrigeration receiver conduit valve **240** may be closed. The electronic pressure regulator **260** thus may modulate the flow of the refrigerant **110** to the condenser **200**. The flow of refrigerant **110** then may return to the four way valve **120** via the condenser conduit **160**. The refrigeration system **100** may return to the refrigeration mode after a predetermined amount of time has passed, after a predetermined temperature has been reached, or based on any other operational parameter.

[0024] The refrigeration system **100** thus provides the hot gas defrost mode with simplified mechanisms and controls through the use of the four way valve **120** instead of multiple solenoid valves on multiple conduits. The four way valve **120** permits easy cycling through the refrigeration mode and the defrost mode. Further, the overall refrigeration charge may be lower than known systems. The overall refrigeration system **100** thus may be highly efficient with a long component life time and limited down time. Moreover, the refrigeration system **100** may be less expensive to construct and to operate as compared to known systems.

[0025] It should be apparent that the foregoing relates only to certain embodiments of the present application and the resulting 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 refrigeration system with a flow of refrigerant therein, comprising:
- a four way valve;
- an evaporator in communication with the four way valve;
- a compressor in communication with the four way valve; and
- a condenser in communication with the four way valve;
- wherein the four way valve directs the flow of refrigerant to the condenser in a refrigeration mode or to the evaporator in a defrost mode.

2. The refrigeration system of claim **1**, further comprising a suction accumulator in communication with the four way valve and the compressor.

3. The refrigeration system of claim **1**, further comprising a receiver in communication with the condenser.

4. The refrigeration system of claim **3**, wherein the receiver is in communication with the condenser via a refrigerant receiver conduit in the refrigeration mode and a defrost receiver conduit in the defrost mode.

5. The refrigeration system of claim **4**, wherein the defrost receiver conduit comprises an electronic pressure regulator thereon to modulate the flow of refrigerant to the condenser in the defrost mode.

6. The refrigeration system of claim **3**, further comprising a sub-cooler in communication with the receiver and the evaporator.

7. The refrigeration system of claim **6**, wherein the sub-cooler is in communication with the receiver via a sub-cooler input conduit.

8. The refrigeration system of claim **6**, wherein the sub-cooler is in communication with the evaporator via a sub-cooler output conduit.

9. The refrigeration system of claim **3**, wherein the receiver is in communication with the evaporator via a sub-cooler bypass conduit in the defrost mode.

10. The refrigeration system of claim **3**, further comprising an evaporator bypass conduit in communication with the four way valve and the receiver in the defrost mode.

11. The refrigeration system of claim **1**, further comprising an electronic expansion valve in communication with the evaporator in the refrigeration mode to modulate the flow of refrigerant thereto.

12. The refrigeration system of claim **1**, further comprising a drain pan loop in communication with the four way valve and the evaporator in the defrost mode.

13. The refrigeration system of claim **1**, further comprising one or more filter driers.

14. The refrigeration system of claim **1**, further comprising a plurality of temperature sensors and a plurality of pressure sensors.

15. A method of operating a refrigeration system, comprising:
- directing a flow of refrigerant by a four way valve to a condenser and then to an evaporator in a refrigeration mode;
- modulating the flow of refrigerant to the evaporator with an electronic expansion valve in the refrigeration mode;
- directing the flow refrigerant by the four way valve to the evaporator and then to the condenser in a defrost mode; and
- modulating the flow of refrigerant to the condenser with an electronic pressure regulator in the defrost mode.

16. A refrigeration system with a flow of refrigerant therein, comprising:
- a four way valve;
- an evaporator in communication with the four way valve;
- a condenser in communication with the four way valve;
- wherein the four way valve directs the flow of refrigerant to the condenser in a refrigeration mode or to the evaporator in a defrost mode;
- an electronic expansion valve for modulating the flow of refrigerant to the evaporator in the refrigeration mode; and
- an electronic pressure regulator for modulating the flow of refrigerant to the condenser in the defrost mode.

17. The refrigeration system of claim **16**, further comprising a compressor and a suction accumulator in communication with the four way valve.

18. The refrigeration system of claim **16**, further comprising a receiver in communication with the condenser and the evaporator.

19. The refrigeration system of claim **18**, wherein the receiver is in communication with the condenser via a refrig-

erant receiver conduit in the refrigeration mode and a defrost receiver conduit for use defrost mode.

20. The refrigeration system of claim **18**, further comprising an evaporator bypass conduit in communication with the four way valve and the receiver in the defrost mode.

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