



US 20170167767A1

(19) **United States**(12) **Patent Application Publication**
Shi et al.(10) **Pub. No.: US 2017/0167767 A1**(43) **Pub. Date: Jun. 15, 2017**(54) **EJECTOR CYCLE HEAT RECOVERY
REFRIGERANT SEPARATOR****Publication Classification**

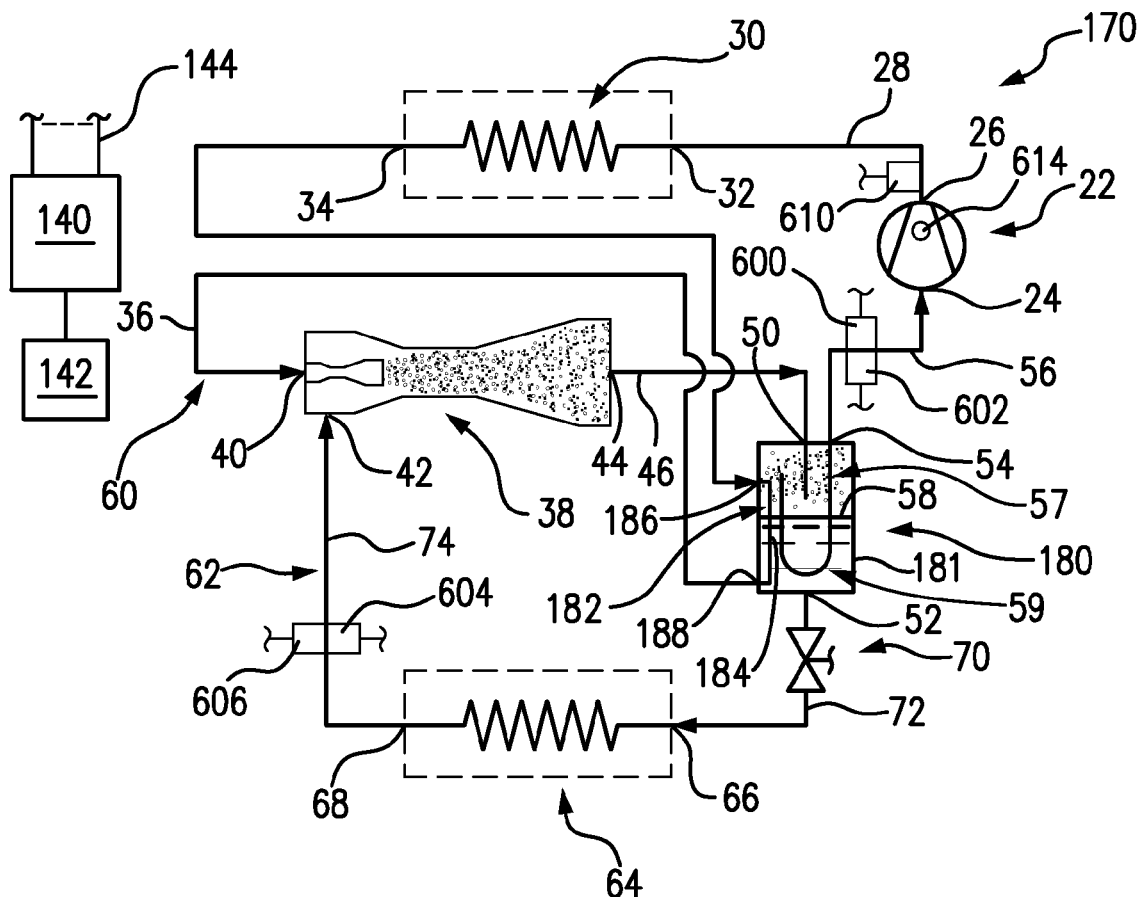
(51) **Int. Cl.**
F25B 43/00 (2006.01)
F25B 1/00 (2006.01)
F25B 9/08 (2006.01)
(52) **U.S. Cl.**
CPC *F25B 43/006* (2013.01); *F25B 9/08*
(2013.01); *F25B 43/00* (2013.01); *F25B 1/00*
(2013.01)

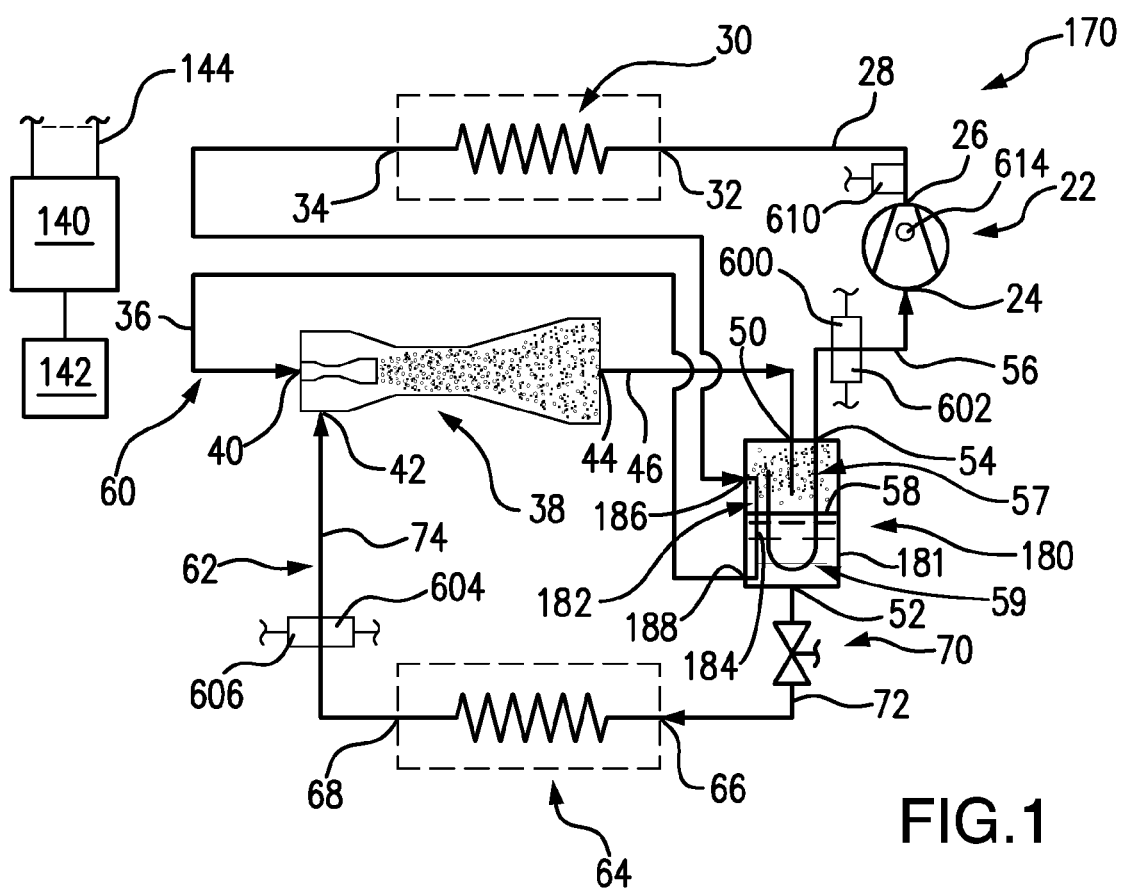
(71) Applicant: **Carrier Corporation**, Jupiter, FL (US)(72) Inventors: **Zuojun Shi**, Marcellus, NY (US);
Parmesh Verma, South Windsor, CT
(US); **Alexander Lifson**, Manlius, NY
(US)(73) Assignee: **Carrier Corporation**, Jupiter, FL (US)(21) Appl. No.: **15/116,934**(22) PCT Filed: **Feb. 3, 2015**(86) PCT No.: **PCT/US15/14159**

§ 371 (c)(1),

(2) Date: **Aug. 5, 2016****Related U.S. Application Data**(60) Provisional application No. 61/936,781, filed on Feb.
6, 2014.(57) **ABSTRACT**

A system (170; 300; 400) comprising a compressor (22). A heat rejection heat exchanger (30; 420) is coupled to the compressor to receive refrigerant compressed by the compressor. A separator (180) has: a vessel (181); an inlet (50) coupled to the heat rejection heat exchanger to receive refrigerant; a first outlet (54) in communication with a headspace of the vessel; and a second outlet (52, 52') in communication with a lower portion of the vessel. The system has a heat exchanger (182; 220; 220'; 220'') for transferring heat from refrigerant passing from a heat rejection heat exchanger to liquid refrigerant in the separator.





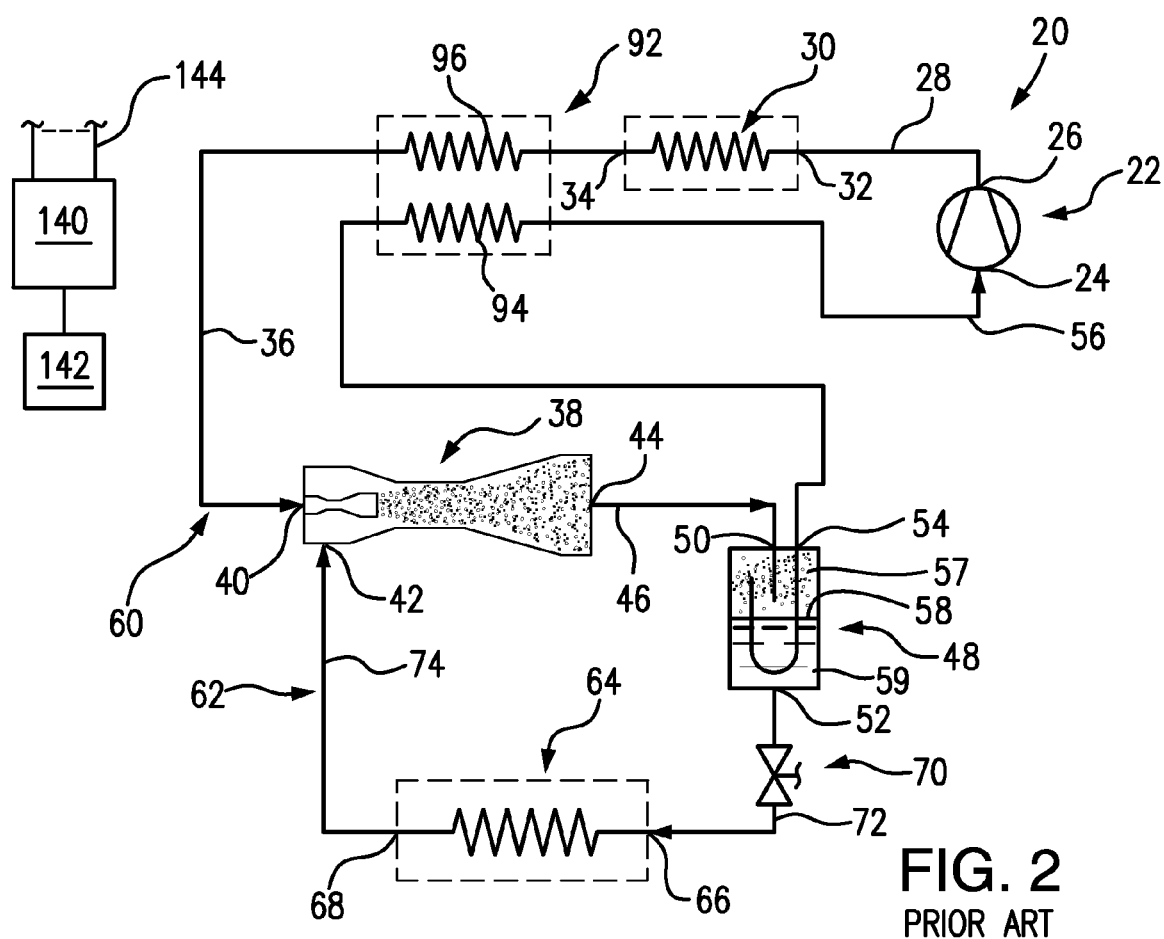


FIG. 2
PRIOR ART

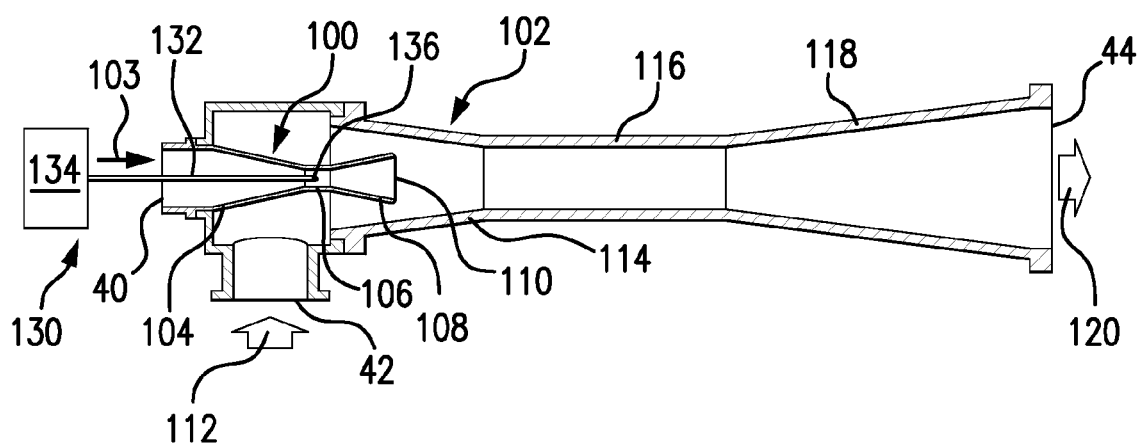


FIG. 3
PRIOR ART

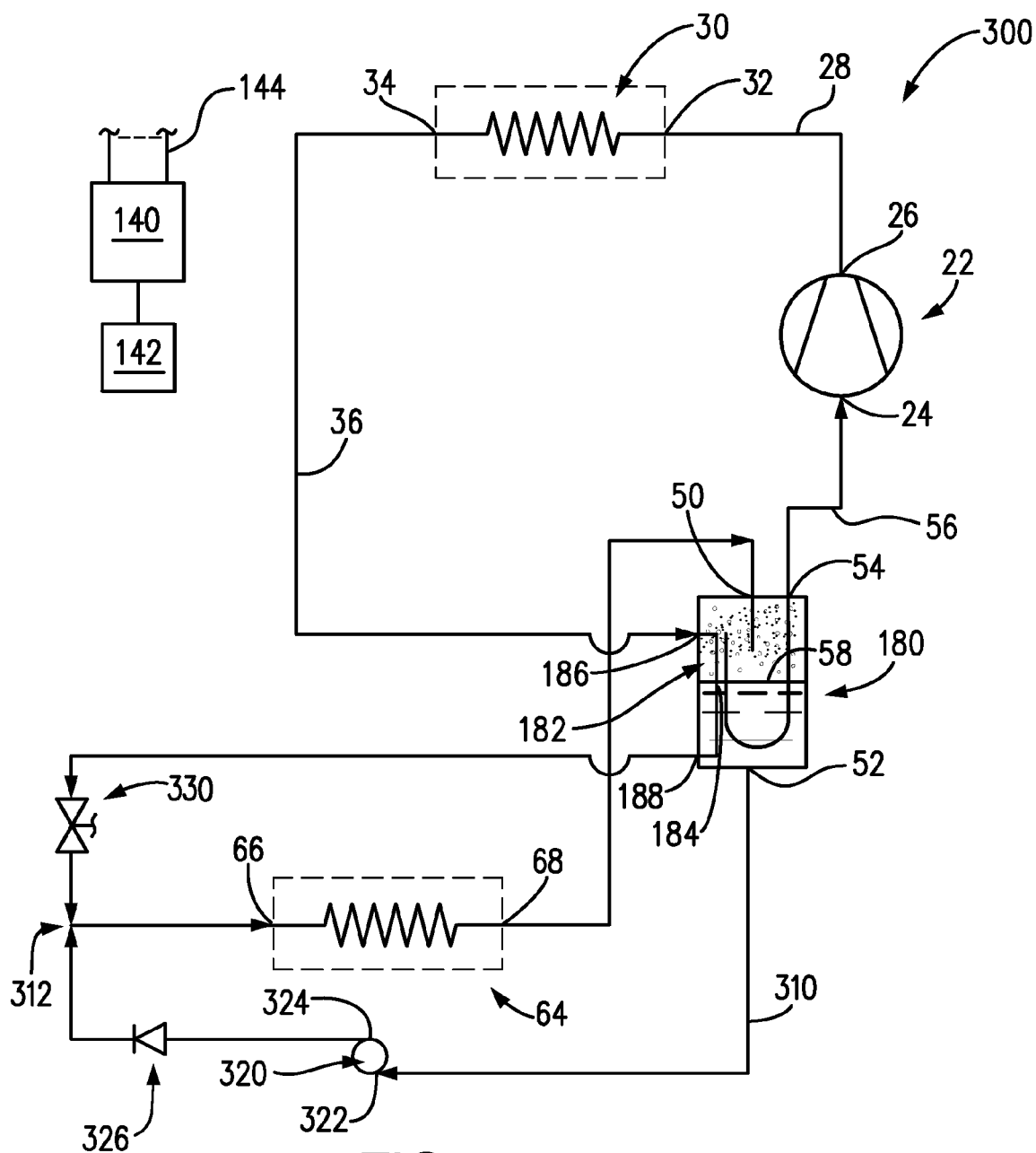


FIG. 4

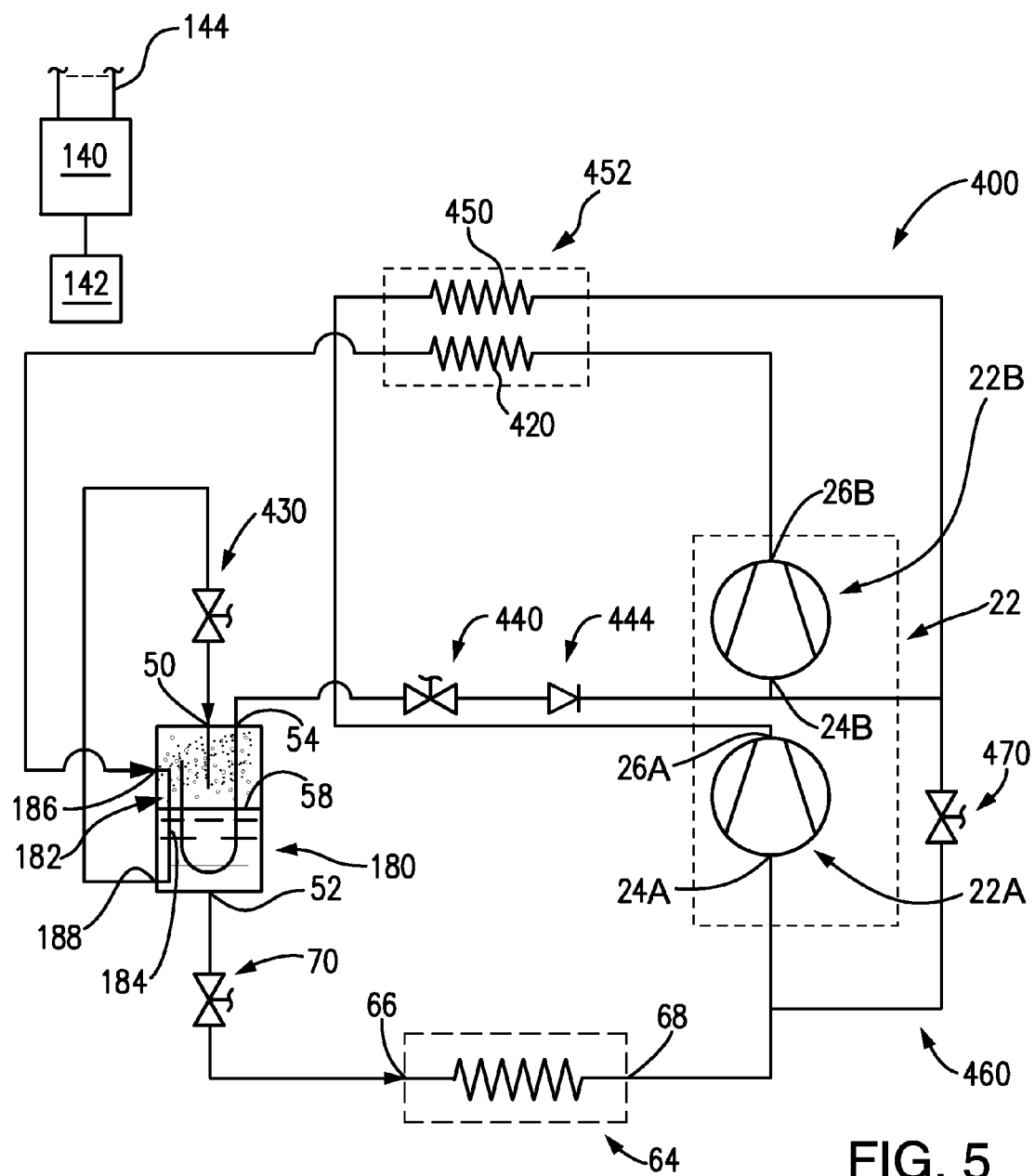


FIG. 5

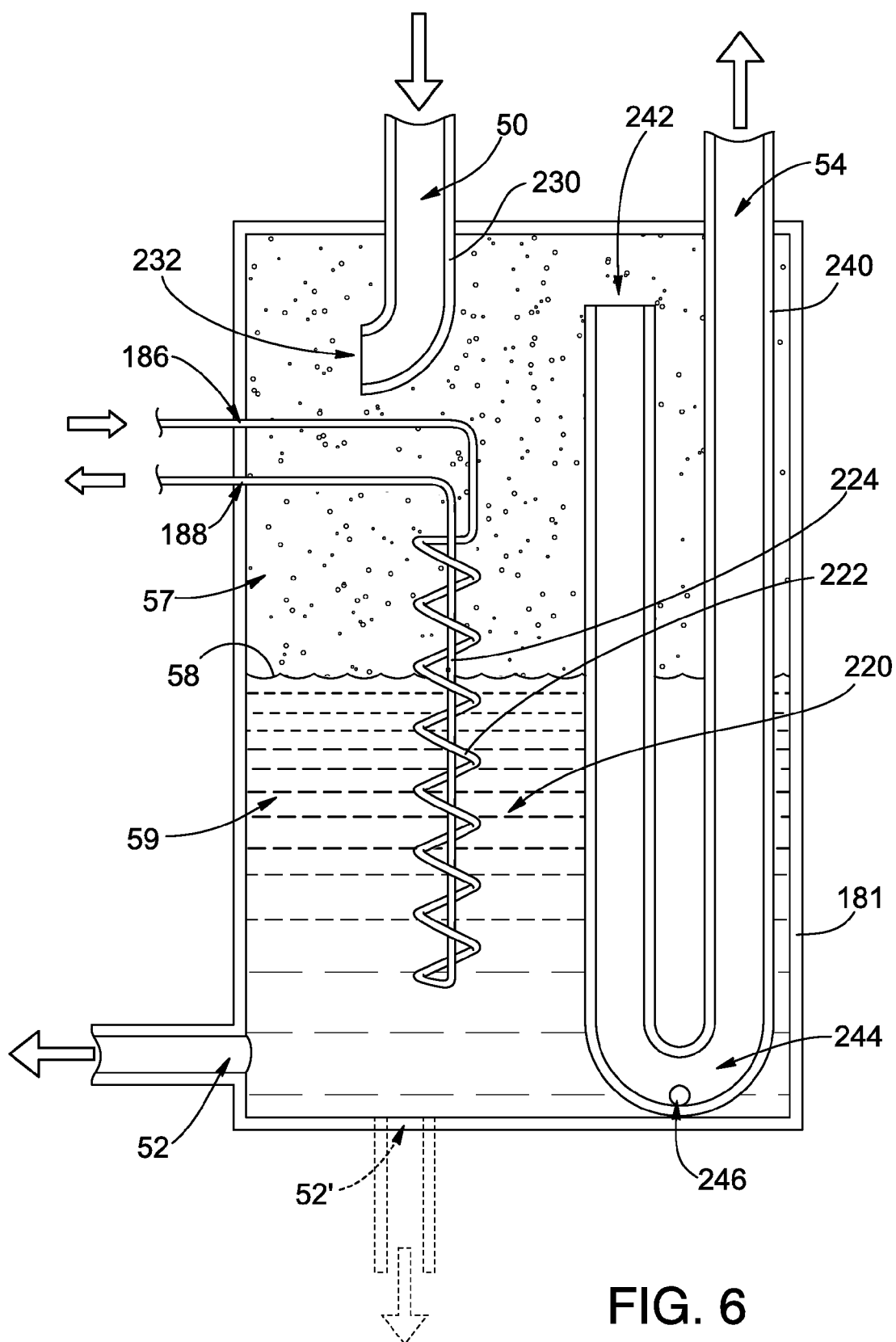
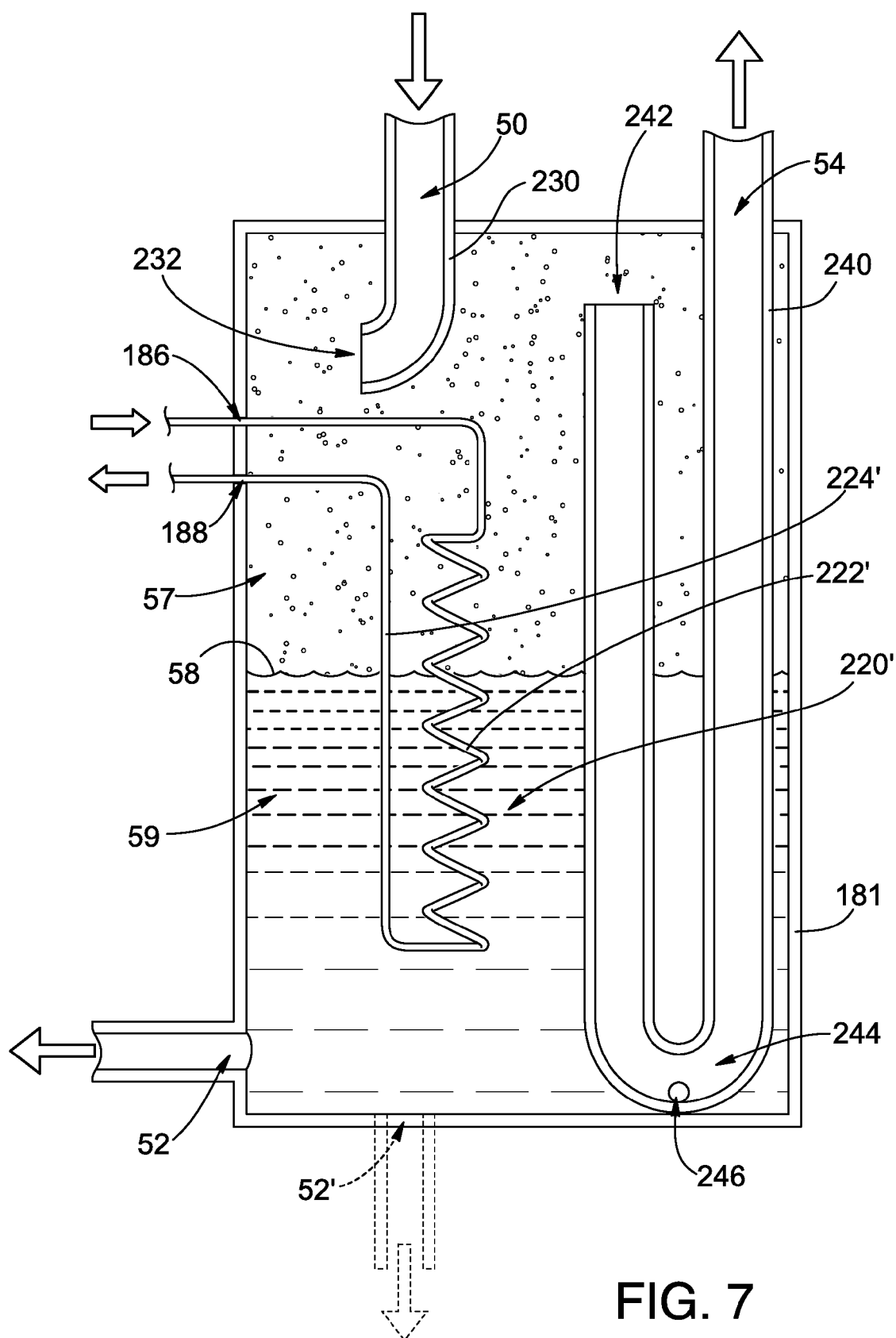


FIG. 6



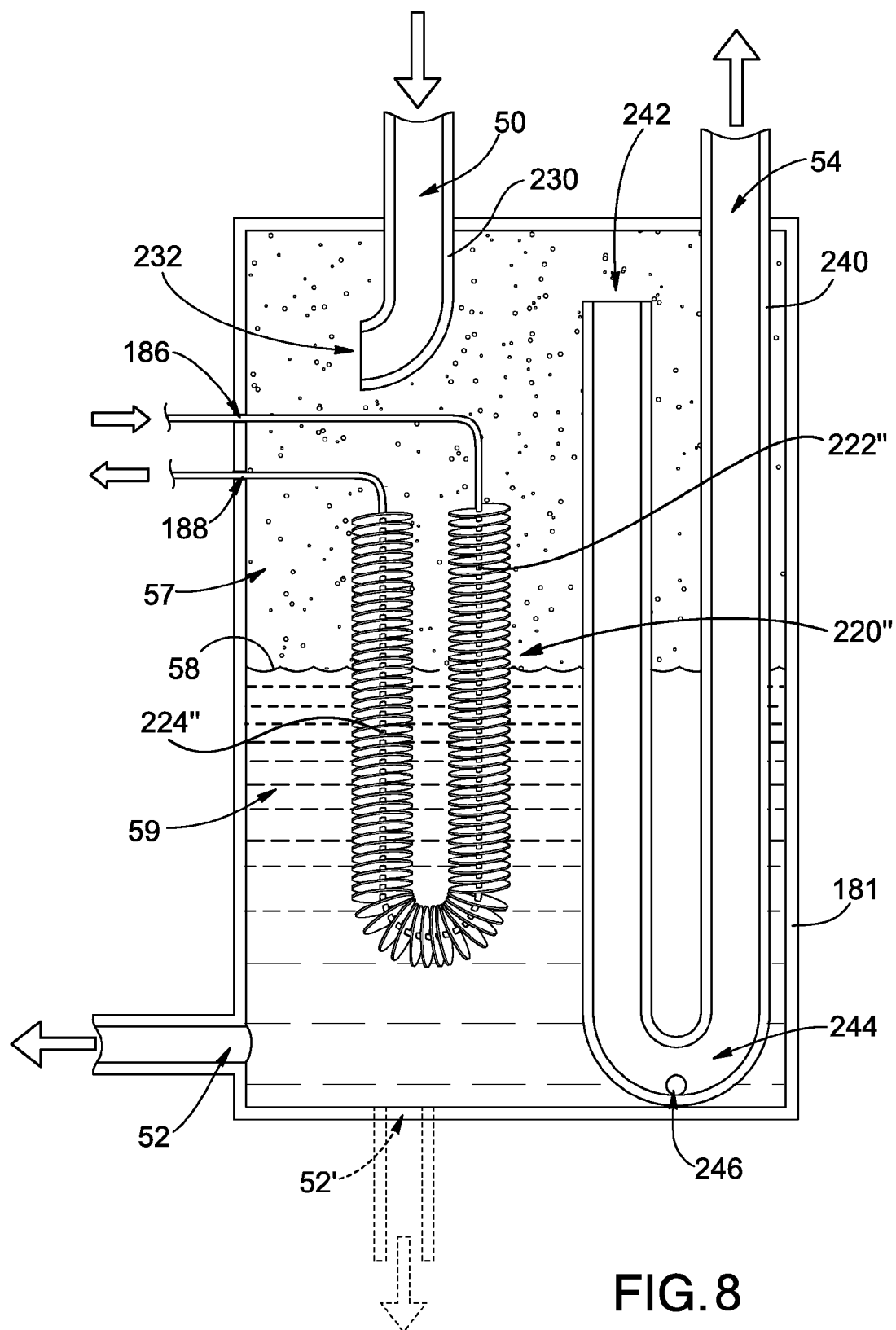


FIG. 8

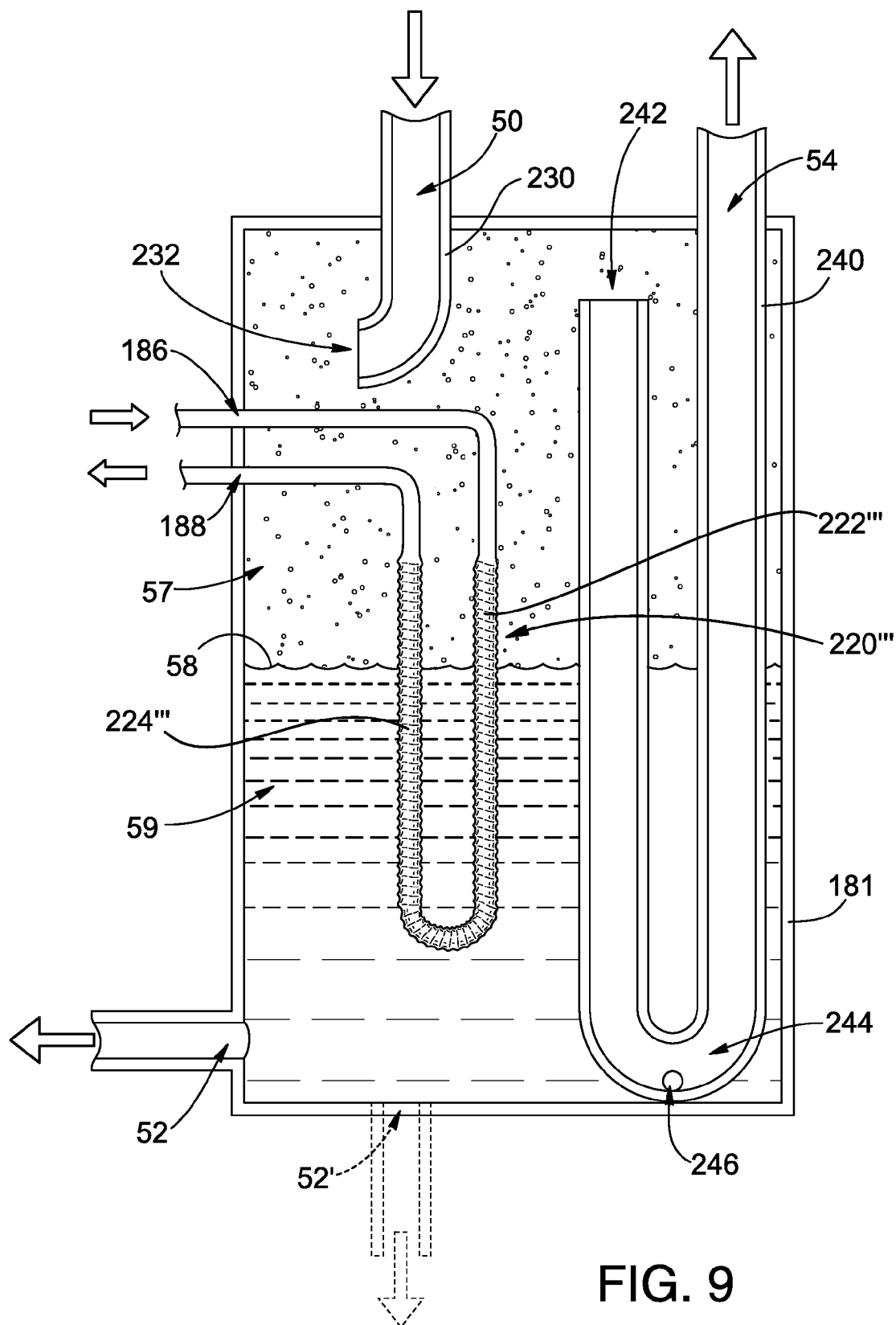


FIG. 9

EJECTOR CYCLE HEAT RECOVERY REFRIGERANT SEPARATOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Benefit is claimed of U.S. Patent Application Ser. No. 61/936,781, filed Feb. 6, 2014, and entitled "Ejector Cycle Heat Recovery Refrigerant Separator", the disclosure of which is incorporated by reference herein in its entirety as if set forth at length.

BACKGROUND

[0002] The present disclosure relates to refrigeration. More particularly, it relates to ejector refrigeration systems.

[0003] Early proposals for ejector refrigeration systems are found in U.S. Pat. No. 1,836,318 and U.S. Pat. No. 3,277,660. FIG. 2 shows one basic example of an ejector refrigeration system 20 drawn from US Patent Application Publication 2013/0111934 (the '934 publication) the disclosure of which is incorporated in its entirety herein as is set forth at length. The system includes a compressor 22 having an inlet (suction port) 24 and an outlet (discharge port) 26. The compressor and other system components are positioned along a refrigerant circuit or flowpath 27 and connected via various conduits (lines). A discharge line 28 extends from the outlet 26 to the inlet 32 of a heat exchanger (a heat rejection heat exchanger in a normal mode of system operation (e.g., a condenser or gas cooler)) 30. A line 36 extends from the outlet 34 of the heat rejection heat exchanger 30 to a primary inlet (liquid or supercritical or two-phase inlet) 40 of an ejector 38. The ejector 38 also has a secondary inlet (saturated or superheated vapor or two-phase inlet) 42 and an outlet 44. A line 46 extends from the ejector outlet 44 to an inlet 50 of a separator 48. The separator has a liquid outlet 52 and a gas outlet 54. A suction line 56 extends from the gas outlet 54 to the compressor suction port 24. The lines 28, 36, 46, 56, and components therebetween define a primary loop 60 of the refrigerant circuit 27. A secondary loop 62 of the refrigerant circuit 27 includes a heat exchanger 64 (in a normal operational mode being a heat absorption heat exchanger (e.g., evaporator)). The evaporator 64 includes an inlet 66 and an outlet 68 along the secondary loop 62 and expansion device 70 is positioned in a line 72 which extends between the separator liquid outlet 52 and the evaporator inlet 66. An ejector secondary inlet line 74 extends from the evaporator outlet 68 to the ejector secondary inlet 42.

[0004] In the normal mode of operation, gaseous refrigerant is drawn by the compressor 22 through the suction line 56 and inlet 24 and compressed and discharged from the discharge port 26 into the discharge line 28. In the heat rejection heat exchanger, the refrigerant loses/rejects heat to a heat transfer fluid (e.g., fan-forced air or water or other liquid). Cooled refrigerant exits the heat rejection heat exchanger via the outlet 34 and enters the ejector primary inlet 40 via the line 36.

[0005] The exemplary ejector 38 (FIG. 3) is formed as the combination of a motive (primary) nozzle 100 nested within an outer member 102. The primary inlet 40 is the inlet to the motive nozzle 100. The outlet 44 is the outlet of the outer member 102. The primary refrigerant flow 103 enters the inlet 40 and then passes into a convergent section 104 of the motive nozzle 100. It then passes through a throat section

106 and an expansion (divergent) section 108 through an outlet 110 of the motive nozzle 100. The motive nozzle 100 accelerates the flow 103 and decreases the pressure of the flow. The secondary inlet 42 forms an inlet of the outer member 102. The pressure reduction caused to the primary flow by the motive nozzle helps draw the secondary flow 112 into the outer member. The outer member includes a mixer having a convergent section 114 and an elongate throat or mixing section 116. The outer member also has a divergent section or diffuser 118 downstream of the elongate throat or mixing section 116. The motive nozzle outlet 110 is positioned within the secondary nozzle convergent section 114. As the flow 103 exits the outlet 110, it begins to mix with the flow 112 with further mixing occurring through the mixing section 116 which provides a mixing zone. In operation, the primary flow 103 may typically be supercritical upon entering the ejector and subcritical upon exiting the motive nozzle. The secondary flow 112 is gaseous (or a mixture of gas with a smaller amount of liquid) upon entering the secondary inlet port 42. The resulting combined flow 120 is a liquid/vapor mixture and decelerates and recovers pressure in the diffuser 118 while remaining a mixture. Upon entering the separator, the flow 120 is separated back into the flows 103 and 112. The flow 103 passes as a gas through the compressor suction line as discussed above. The flow 112 passes as a liquid to the expansion valve 70. The flow 112 may be expanded by the valve 70 (e.g., to a low quality (two-phase with small amount of vapor)) and passed to the evaporator 64. Within the evaporator 64, the refrigerant absorbs heat from a heat transfer fluid (e.g., from a fan-forced air flow or water or other liquid) and is discharged from the outlet 68 to the line 74 as the aforementioned gas.

[0006] Use of an ejector serves to recover pressure/work. Work recovered from the expansion process is used to compress the gaseous refrigerant prior to entering the compressor. Accordingly, the pressure ratio of the compressor (and thus the power consumption) may be reduced for a given desired evaporator pressure. The quality of refrigerant entering the evaporator may also be reduced. Thus, the refrigeration effect per unit mass flow may be increased (relative to the non-ejector system). The distribution of fluid entering the evaporator is improved (thereby improving evaporator performance). Because the evaporator does not directly feed the compressor, the evaporator is not required to produce superheated refrigerant outflow. The use of an ejector cycle may thus allow reduction or elimination of the superheated zone of the evaporator. This may allow the evaporator to operate in a two-phase state which provides a higher heat transfer performance (e.g., facilitating reduction in the evaporator size for a given capability).

[0007] The exemplary ejector may be a fixed geometry ejector or may be a controllable ejector. FIG. 2 shows controllability provided by a needle valve 130 having a needle 132 and an actuator 134. The actuator 134 shifts a tip portion 136 of the needle into and out of the throat section 106 of the motive nozzle 100 to modulate flow through the motive nozzle and, in turn, the ejector overall. Exemplary actuators 134 are electric (e.g., solenoid or the like). The actuator 134 may be coupled to and controlled by a controller 140 which may receive user inputs from an input device 142 (e.g., switches, keyboard, or the like) and sensors (not shown). The controller 140 may be coupled to the actuator and other controllable system components (e.g., valves, the compressor motor, and the like) via control lines

144 (e.g., hardwired or wireless communication paths). The controller may include one or more: processors; memory (e.g., for storing program information for execution by the processor to perform the operational methods and for storing data used or generated by the program(s)); and hardware interface devices (e.g., ports) for interfacing with input/output devices and controllable system components.

[0008] The system features a suction line heat exchanger **92** having a leg **94** (heat absorption leg) along the suction line between the separator gas outlet and the compressor inlet. The leg **94** is in heat exchange relationship with a leg **96** (heat rejection leg) in the heat rejection heat exchanger outlet line between the heat rejection heat exchanger outlet and the ejector primary inlet.

SUMMARY

[0009] One aspect of the disclosure involves a system comprising a compressor. A heat rejection heat exchanger is coupled to the compressor to receive refrigerant compressed by the compressor. A separator has: a vessel; an inlet coupled to the heat rejection heat exchanger to receive refrigerant; a first outlet in communication with a headspace of the vessel; and a second outlet in communication with a lower portion of the vessel. The system has means for transferring heat from refrigerant passing from a heat rejection heat exchanger to liquid refrigerant in the separator.

[0010] A further embodiment may additionally and/or alternatively include an expansion device between the heat rejection heat exchanger and the separator inlet.

[0011] A further embodiment may additionally and/or alternatively include the expansion device being an ejector having: a primary inlet coupled to the heat rejection heat exchanger to receive refrigerant; a secondary inlet; and an outlet coupled to the separator inlet.

[0012] A further embodiment may additionally and/or alternatively include the ejector secondary inlet being coupled to receive refrigerant from the separator second outlet by an additional expansion device and the heat rejection heat exchanger.

[0013] A further embodiment may additionally and/or alternatively include the separator first outlet being coupled to a suction port of the compressor.

[0014] A further embodiment may additionally and/or alternatively include the expansion device being an expansion valve.

[0015] A further embodiment may additionally and/or alternatively include a pump coupling the separator second outlet to an inlet of the heat absorption heat exchanger.

[0016] A further embodiment may additionally and/or alternatively include a flowpath through the pump merging with a flowpath through the expansion valve at a junction upstream of the inlet of the heat absorption heat exchanger.

[0017] A further embodiment may additionally and/or alternatively include the separator first outlet being coupled to the compressor.

[0018] A further embodiment may additionally and/or alternatively include the separator first outlet being coupled to a suction port of the compressor.

[0019] A further embodiment may additionally and/or alternatively include the outlet being coupled to an inter-stage of the compressor.

[0020] A further embodiment may additionally and/or alternatively include the compressor being the high pressure stage of a two-stage system.

[0021] A further embodiment may additionally and/or alternatively include the separator being configured to: provide mainly liquid refrigerant to an expansion device upstream of the heat absorption heat exchanger; and provide mainly vapor refrigerant to the suction port of the compressor.

[0022] A further embodiment may additionally and/or alternatively include the refrigerant comprises at least 50% carbon dioxide, by weight.

[0023] Another aspect of the disclosure involves a method for operating the system comprising running the compressor in a first mode wherein: the refrigerant is compressed in the compressor; refrigerant received from the compressor by the heat rejection heat exchanger rejects heat in the heat rejection heat exchanger to produce initially cooled refrigerant; the initially cooled refrigerant passes through the expansion device; an outlet flow of refrigerant from the expansion device passes to the separator to separate said liquid refrigerant from refrigerant vapor; said heat is transferred from said refrigerant passing from the heat rejection heat exchanger to said liquid refrigerant.

[0024] Another aspect of the disclosure involves a refrigerant separator comprising: a vessel; an inlet; a first outlet in communication with a headspace of the vessel; a second outlet in communication with a lower portion of the vessel; and a heat exchanger. The heat exchanger has: an inlet; an outlet; and a portion through the lower portion of the vessel.

[0025] A further embodiment may additionally and/or alternatively include the heat exchanger having an upstream spiral leg and a downstream straight leg.

[0026] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features, objects, and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. 1 is a schematic view of a first ejector refrigeration system.

[0028] FIG. 2 is a schematic view of a prior art ejector refrigeration system.

[0029] FIG. 3 is an axial sectional view of an ejector

[0030] FIG. 4 is a schematic view of a second non-ejector refrigeration system.

[0031] FIG. 5 is a schematic view of a third non-ejector refrigeration system.

[0032] FIG. 6 is a partially schematic vertical sectional/cutaway view of a heat exchange separator.

[0033] FIG. 7 is a partially schematic vertical sectional/cutaway view of another heat exchange separator.

[0034] FIG. 8 is a partially schematic vertical sectional/cutaway view of another heat exchange separator.

[0035] FIG. 9 is a partially schematic vertical sectional/cutaway view of another heat exchange separator.

[0036] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0037] FIG. 1 shows an ejector cycle vapor compression (refrigeration) system **170**. The system **170** may be made as a modification of the system **20** or of another system or as an original manufacture/configuration. In the exemplary embodiment, like components which may be preserved from the system **20** are shown with like reference numerals.

Operation may be similar to that of the system 20 except as discussed below with the controller 140 controlling operation responsive to inputs from various temperature sensors and pressure sensors.

[0038] The FIG. 1 embodiment replaces the FIG. 2 separator 48 and suction line heat exchanger 92 with a combined separator and heat exchanger 180 having a vessel 181. The heat exchanger 180 has a conventional main inlet 50 coupled to the line 46 from the ejector outlet 44. A conventional liquid outlet 52 and vapor outlet 54 are also provided. FIG. 1 further shows a surface 58 of a body of liquid refrigerant in the lower portion of the vessel 181 with vapor in a headspace thereabove. The unit 180, however, is in heat exchange relationship with refrigerant passing along the line 36 from the outlet 34 of the heat rejection heat exchanger 30 to the primary inlet 40 of the ejector. The heat exchanger portion of 180 is shown as 182 having a leg 184 extending between an inlet 186 and an outlet 188 in heat exchange relation with refrigerant in the unit interior.

[0039] In normal operation, refrigerant passing along the primary flowpath through line 36 passes into the heat exchanger 182 via inlet 186 and rejects heat to the accumulated refrigerant. A portion of the leg 184 (e.g., a lower portion) extends low on the unit 180 to be immersed in liquid refrigerant below the surface 58. This immersion allows the greatest rejection of heat from the primary flowpath before entering the ejector inlet.

[0040] Whereas the separator 48 of FIG. 2 or the combined separator and heat exchanger 180 deliver essentially pure vapor from their vapor outlets 54, and essentially pure liquid from their liquid outlets 52, the '934 publication discloses that it may be desirable to replace one or both of these flows with a slightly mixed state flow.

[0041] For example, by feeding a two-phase mixture into the compressor, the discharge temperature of the compressor can be reduced if desired (thus extending the compressor system operating range). Feeding a suction line heat exchanger (SLHX) and/or compressor with small amount liquid are also expected to improve both SLHX and compressor efficiency. Exemplary refrigerant is delivered as 85-99% quality (vapor mass flow percentage), more narrowly, 90-98% or 94-98%. The power required for compression of a vapor increases which increased suction enthalpy. For hermetic compressors the refrigerant vapor is used to cool the motor. For example, in many compressors, the suction flow is first passed over the motor before entering the compression chamber (raising the temperature of refrigerant reaching the compression chamber). By supplying a small amount of liquid in the vapor of the suction flow, the motor can be cooled while reducing the temperature increase of the refrigerant as it passes over the motor. Furthermore, some compressors are tolerant of small amounts of liquid entering the suction chamber. If the compression process is begun with some liquid, the refrigerant will remain cooler than it otherwise would, and less power is required for the compression process. This is especially beneficial with refrigerants that exhibit a large degree of heating during compression, such as CO₂. The negative side of providing liquid refrigerant to the compressor is that the liquid is no longer available for producing cooling in the evaporator 64. The optimum choice of quality provided to line 56 is determined by the specific characteristics of the system to balance these considerations.

[0042] A small amount of liquid refrigerant can also be used to improve the performance of a SLHX. SLHXs are typically of counter-flow design. The total heat transfer is limited by the fluid side that has the minimum product of flow rate and specific heat. For a refrigeration system SLHX with pure vapor on the cold side and pure liquid on the hot side, the cold-side vapor is limiting. However, a small amount of liquid provided to the cold-side effectively increases its specific heat. Thus more heat may be transferred from the same SLHX, or conversely, for the same heat transfer a smaller heat exchanger may be used if a small amount of liquid is added to the vapor.

[0043] Also by feeding a two-phase mixture to the expansion valve upstream of the evaporator one can precisely control the system capacity, which can prevent unnecessary system shutdowns (comfort and improved reliability) and improve temperature control. This may help improve refrigerant distribution in the evaporator manifold and further improve evaporator performance. Exemplary refrigerant is delivered as 1-10% quality (vapor mass flow percentage), more narrowly 2-6%. Direct expansion evaporators typically have poor heat transfer in the very low and very high quality ranges. For these evaporator designs providing higher quality may improve the heat transfer coefficient at the entrance region of the evaporator (where quality is the lowest).

[0044] Thus, the separator/heat exchanger 180 may have means for providing at least one of the 1-10% quality refrigerant to the heat absorption heat exchanger and the 90-99% quality refrigerant to at least one of the compressor and, at present, a suction line heat exchanger.

[0045] Examples of such means involving configuration of tubes and their inlets is disclosed in the '934 publication.

[0046] The controller may control an operation in response to input from a plurality of sensors such as temperature sensors and pressure sensors. A first exemplary pair of these sensors 600 (self heat sensor) and 602 (regular sensor) is shown in the suction line 56 between the outlet 186 and the suction port 24 of FIG. 1. A second exemplary pair 604, 606 is shown along the line 74 downstream of the evaporator and upstream of the ejector secondary inlet in FIG. 1. An alternative method is to use the measured discharge superheat and, through known calibration of the compressor isotropic efficiency, have the controller determine the suction quality condition. This may be determined via a discharge superheat sensor 610 in the discharge line at the exit of the compressor. This may be a relatively cost effective method for measuring the quality of refrigerant discharged from the outlet 186. A third variation involves a superheat sensor 614 (FIG. 1) within the compressor downstream of the motor.

[0047] FIG. 4 shows use of the separator/heat exchanger 180 in an ejector-less system 300. An expansion device 330 (e.g., similar to the expansion device 70) replaces the ejector and has an inlet along the line 36 downstream of the heat exchanger 182 (e.g., the heat exchanger outlet 188 is coupled to the inlet of the expansion device 330 via an appropriate conduit). The outlet of the expansion device 330 feeds the inlet 66 of the heat rejection heat exchanger 64 flow from the outlet 68 of the heat rejection heat exchanger 64 passes to the separator/heat exchanger inlet 50. Liquid refrigerant from the outlet 52 is passed to the inlet 66 of the heat rejection heat exchanger via a conduit 310 defining a flowpath extending to a junction 312 with the line 36 and its flowpath. A pump 320 having an inlet 322 and an outlet 324

is located along the lines or conduit **310** so as to pump the liquid refrigerant to create an open loop flow via the line **310**, through the heat rejection heat exchanger **64**, and returning to the separator inlet **50**. The exemplary pump **320** is a centrifugal pump driven by an electric motor.

[0048] Operation of the pump **320** and expansion valve **330** may be under the control of the controller **140**. For example, expansion valve **330** may be an electronic expansion valve (EXV) or may be a thermal expansion valve (TXV) controlled by superheat at inlet port of compressor at pipe **56**. Pump **320** may be controlled in response to superheat of inlet port of compressor at pipe **56** or refrigerant liquid level **58** in the phase separator. For example, as long as superheat is less than a threshold such as 0.5°C ., or refrigerant liquid level is at least at a threshold such as $\frac{3}{4}$ of the separator height, the controller will run the pump to pump refrigerant liquid back to the evaporator. A check valve **326** downstream of the pump serves to prevent refrigerant flow back to the pump.

[0049] FIG. 5 shows a second ejector-less system **400** utilizing the separator/heat exchanger **180**. There is a two-stage compressor **22** having stages **22A** and **22B**. This may alternatively represent two separate compressors **22A** and **22B**. The discharge port **26B** of the second stage connects to a discharge line to in turn feed a heat exchanger **420** before entering the heat exchanger **182** and feeding back into the inlet **50** of the separator/heat exchanger **180**. In the exemplary implementation, an expansion device **430** is in the line between the heat exchanger **182** and the inlet **150**. The exemplary expansion device **430** is a high pressure expansion valve such as an EXV. The high pressure expansion valve serves to convert supercritical refrigerant (e.g., CO_2) to a two-phase state.

[0050] The refrigerant from the liquid outlet **52** passes through the expansion device **70** and the heat rejection heat exchanger **64** to return to the inlet **24A** of the low pressure compressor or stage **22A**. A vapor line from the outlet line **54** may extend to the inlet **24B** of the high pressure compressor or stage **22B**.

[0051] FIG. 5 shows an economizer valve **440** (allowing an economizer mode when open) and a one-way check valve **442** located between the outlet **54** and the inlet **24B** to prevent reverse low pressure flow back into the separator/heat exchanger through the outlet **54**. The outlet **26A** of the first compressor or stage **22A** is connected to a heat exchanger **450**. The exemplary heat exchangers **420** and **450** are refrigerant-air heat exchangers integrated in a unit **452** where a fan (not shown) drives an airflow across the heat exchanger **420** then the heat exchanger **450** so as to reject heat to the environment. **420** is upstream along the airflow because it is desirable that this receive the coldest air to determine downstream conditions along the refrigerant flowpath. Alternative configurations may involve separate airflows across the two heat exchangers **420** and **450**.

[0052] A line from the outlet of the heat exchanger **450** extends back to a suction location of the high pressure compressor or stage **22B**. Thus, in some operational modes, flows may merge from the outlet **54** and the first stage to feed the second stage. FIG. 5 also shows a bypass **460** between the suction location of the first compressor and the suction location of the second compressor. The bypass line through which flow is controlled by a valve **470**. The exemplary valve **470** is an unload bypass valve and is used to bypass

refrigerant around the first stage compressor **22A** when the loading requirement is low (and the first stage is shut off).

[0053] FIG. 6 shows one example of the heat exchanger as a twisted spiral tube heat exchanger **220** having an upstream spiral leg **222** extending downward and a downstream straight leg **224** extending upward within the spiral.

[0054] FIG. 6 also shows various optional variations on the basic separator structure. The separator has an inlet tube **230** extending to an outlet end **232** to deliver refrigerant toward an interior sidewall surface of the vessel to be deflected with liquid descending into the accumulation in the lower portion **59** and thus avoid/limit foaming. Also well up in the headspace (shown even higher than the outlet end **232** is the inlet end **242** of an outlet conduit **240**. the exemplary outlet conduit **240** is a J-tube having a lower end portion or turn **244** near the bottom of the vessel. near the bottom of the lower end **244**, the conduit includes an aperture or orifice **246** which serves as an oil pickup to entrain oil into vapor flow through the conduit **240**. In an exemplary embodiment, an upper extreme of the orifice is below a lower extreme of the outlet **52** so as to keep a level of any oil accumulation below the outlet **52** to limit/prevent oil flow out the outlet **52**.

[0055] An exemplary spacing of the outlet lower end above the orifice upper end is at least 2 mm (e.g., 2 mm to 10 mm, or at least 5 mm). In an exemplary embodiment, a lower extreme of the heat exchanger is above an upper extreme of the outlet **52** so as to keep the surface level **58** of liquid refrigerant sufficiently above the outlet **52** to limit/prevent vapor flow out the outlet **52** (e.g., the heat exchanger will not be able to boil off refrigerant below its lower end). An exemplary spacing of the heat exchanger lower end above the outlet upper end is at least 5 mm (e.g., 5 mm to 20 mm, or at least 10 mm while still in a lower half or third or quarter or fifth of the vessel interior height). An alternative outlet location **52'** at the bottom of the vessel is shown in broken lines.

[0056] FIG. 7 shows an alternative variation otherwise similar to FIG. 6 but where the downstream leg **224'** of the heat exchanger **220'** is aside rather than within the spiral upstream leg **222'**.

[0057] FIG. 8 shows an alternative variation otherwise similar to FIG. 6 but where the upstream leg **222''** and downstream leg **224''** of the heat exchanger **220''** are legs of a U-tube and the tube is finned to enhance heat transfer. Fins may be plate fins or one or more helical fins.

[0058] FIG. 9 shows an alternative variation otherwise similar to FIG. 8 but where the U portion of the heat exchanger **220'''** tube along its legs **222'''**, **224'''** and base has a heli-enhanced deformed sidewall (e.g., double helix outward deformation shown).

[0059] The system may be fabricated from conventional components using conventional techniques appropriate for the particular intended uses.

[0060] Although an embodiment is described above in detail, such description is not intended for limiting the scope of the present disclosure. It will be understood that various modifications may be made without departing from the spirit and scope of the disclosure. For example, when implemented in the remanufacturing of an existing system or the reengineering of an existing system configuration, details of the existing configuration may influence or dictate details of

any particular implementation. Accordingly, other embodiments are within the scope of the following claims.

1. A system (170; 300; 400) comprising:
 - a compressor (22);
 - a heat rejection heat exchanger (30; 420) coupled to the compressor to receive refrigerant compressed by the compressor;
 - a separator (180) having:
 - a vessel (181);
 - an inlet (50) coupled to the heat rejection heat exchanger to receive refrigerant;
 - a first outlet (54) in communication with a headspace of the vessel;
 - a second outlet (52, 52') in communication with a lower portion of the vessel;
 - a heat absorption heat exchanger (64); and
 - means (182; 220; 220'; 220"; 220''') for transferring heat from refrigerant passing from the heat rejection heat exchanger to liquid refrigerant in the separator.
2. The system of claim 1 further comprising:
 - an expansion device (38; 330; 430) between the heat rejection heat exchanger and the separator inlet.
3. The system of claim 2 wherein the expansion device is:
 - an ejector (38) having:
 - a primary inlet (40) coupled to the heat rejection heat exchanger to receive refrigerant;
 - a secondary inlet (42); and
 - an outlet (44) coupled to the separator inlet.
4. The system of claim 3 wherein the ejector secondary inlet is coupled to receive refrigerant from the separator second outlet by an additional expansion device (70) and the heat rejection heat exchanger.
5. The system of claim 3 wherein the separator first outlet is coupled to a suction port (24) of the compressor.
6. The system of claim 2 wherein the expansion device is:
 - an expansion valve (330; 430).
7. The system of claim 6 further comprising:
 - a pump (320) coupling the separator second outlet to an inlet (66) of the heat absorption heat exchanger.
8. The system of claim 7 wherein:
 - a flowpath through the pump merges with a flowpath through the expansion valve at a junction (312) upstream of the inlet (66) of the heat absorption heat exchanger.
9. The system of claim 1 wherein the separator first outlet is coupled to the compressor.
10. The system of claim 9 wherein the separator first outlet is coupled to a suction port (24) of the compressor.
11. The system of claim 9 wherein the outlet is coupled to an interstage of the compressor.
12. The system of claim 9 wherein the compressor is the high pressure stage (22B) of a two-stage system.
13. The system of claim 9 wherein the separator is configured to:

provide mainly liquid refrigerant to an expansion device upstream of the heat absorption heat exchanger; and provide mainly vapor refrigerant to the suction port of the compressor.

14. The system of claim 1 wherein:
 - refrigerant comprises at least 50% carbon dioxide, by weight.
15. A method for operating the system of claim 1 comprising running the compressor in a first mode wherein:
 - the refrigerant is compressed in the compressor;
 - refrigerant received from the compressor by the heat rejection heat exchanger rejects heat in the heat rejection heat exchanger to produce initially cooled refrigerant;
 - the initially cooled refrigerant passes through the expansion device;
 - an outlet flow of refrigerant from the expansion device passes to the separator to separate said liquid refrigerant from refrigerant vapor;
 - said heat is transferred from said refrigerant passing from the heat rejection heat exchanger to said liquid refrigerant.
16. A refrigerant separator comprising:
 - a vessel (181);
 - an inlet (50);
 - a first outlet (54) in communication with a headspace of the vessel;
 - a second outlet (52; 52') in communication with a lower portion of the vessel; and
 - a heat exchanger (182) having:
 - an inlet (186);
 - an outlet (188); and
 - a portion through the lower portion of the vessel.
17. The system of claim 16 wherein the heat exchanger comprises:
 - an upstream spiral leg and a downstream straight leg.
18. A system comprising the refrigerant separator of claim 16 and further comprising:
 - a compressor (22);
 - a heat rejection heat exchanger (30; 420) coupled to the compressor to receive refrigerant compressed by the compressor; and
 - an ejector (38) having:
 - a primary inlet (40) coupled to the heat rejection heat exchanger to receive refrigerant;
 - a secondary inlet (42); and
 - an outlet (44) coupled to the separator inlet.
19. The system of claim 1, wherein the means comprises a heat exchanger (182) having:
 - an inlet (186);
 - an outlet (188); and
 - a portion through the lower portion of the vessel.
20. The system of claim 19 the heat exchanger comprises:
 - an upstream spiral leg and a downstream straight leg.

* * * * *