US 20170307251A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2017/0307251 A1**

BARUCH (43) **Pub. Date: Oct. 26, 2017**

(54) **ATMOSPHERIC WATER GENERATOR**

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(21) Appl. No.: **15/133,379**

(22) Filed: **Apr. 20, 2016**

Publication Classification

(51) **Int. Cl.**

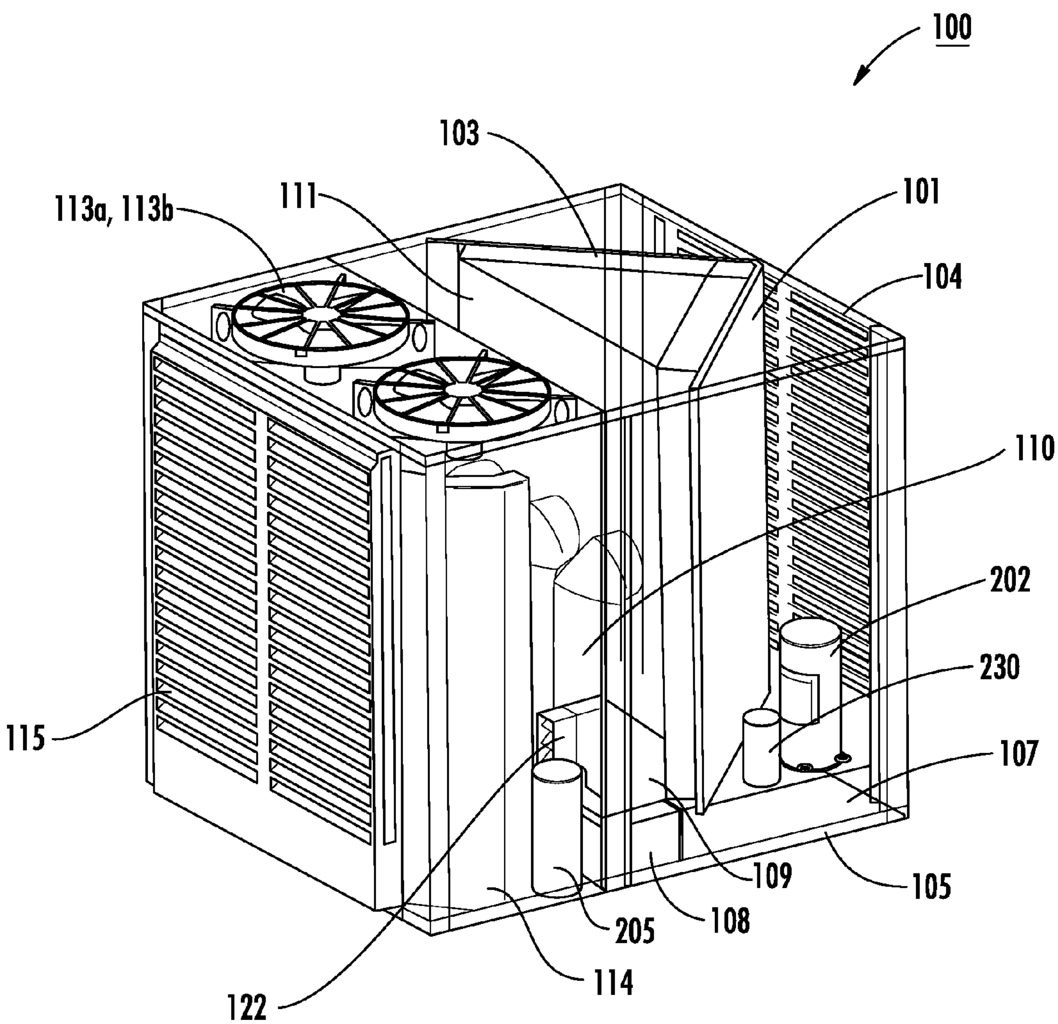
F24F 13/22	(2006.01)
F24F 13/30	(2006.01)
F25B 39/00	(2006.01)
F25B 6/04	(2006.01)
F24F 13/08	(2006.01)
F25B 43/00	(2006.01)
F24F 13/20	(2006.01)
F25B 43/00	(2006.01)
F24F 13/22	(2006.01)
F24F 11/00	(2006.01)
F24F 13/22	(2006.01)

(52) **U.S. Cl.**

CPC ***F24F 13/222*** (2013.01); ***F24F 13/20*** (2013.01); ***F24F 13/30*** (2013.01); ***F25B 39/00*** (2013.01); ***F25B 6/04*** (2013.01); ***F25B 43/006*** (2013.01); ***F24F 13/082*** (2013.01); ***F25B 43/003*** (2013.01); *F24F 2011/0082* (2013.01); *F24F 2013/227* (2013.01); *F24F 2221/56* (2013.01); *F24F 2013/228* (2013.01)

(57) **ABSTRACT**

An atmospheric water generator includes a refrigeration circuit having an evaporator coil and a condenser coil. The condenser coil is positioned proximate to the evaporator coil, and preheats a flow of atmospheric air as the air is forced through the condenser coil before the air passes through the evaporator coil. Liquid water condensate from the preheated air is generated as the air passes through the evaporator coil and is accumulated in a water collection tank. A second condenser coil cooled by a second flow of atmospheric air supplies refrigerant to the evaporator coil.



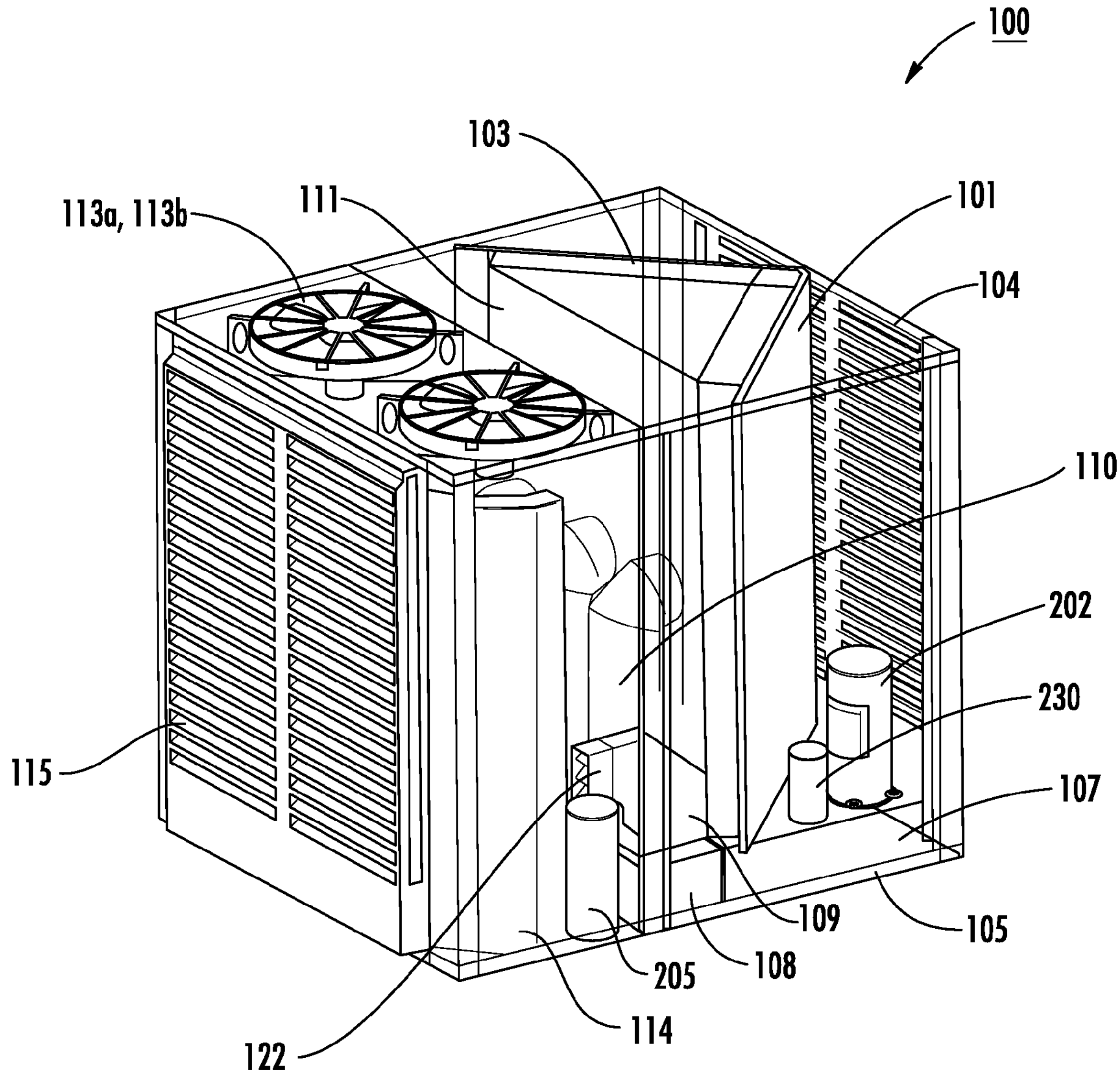

100
103
111
113a, 113b
101
104
110
202
230
115
107
109
105
205
108
122
114

FIG. 1

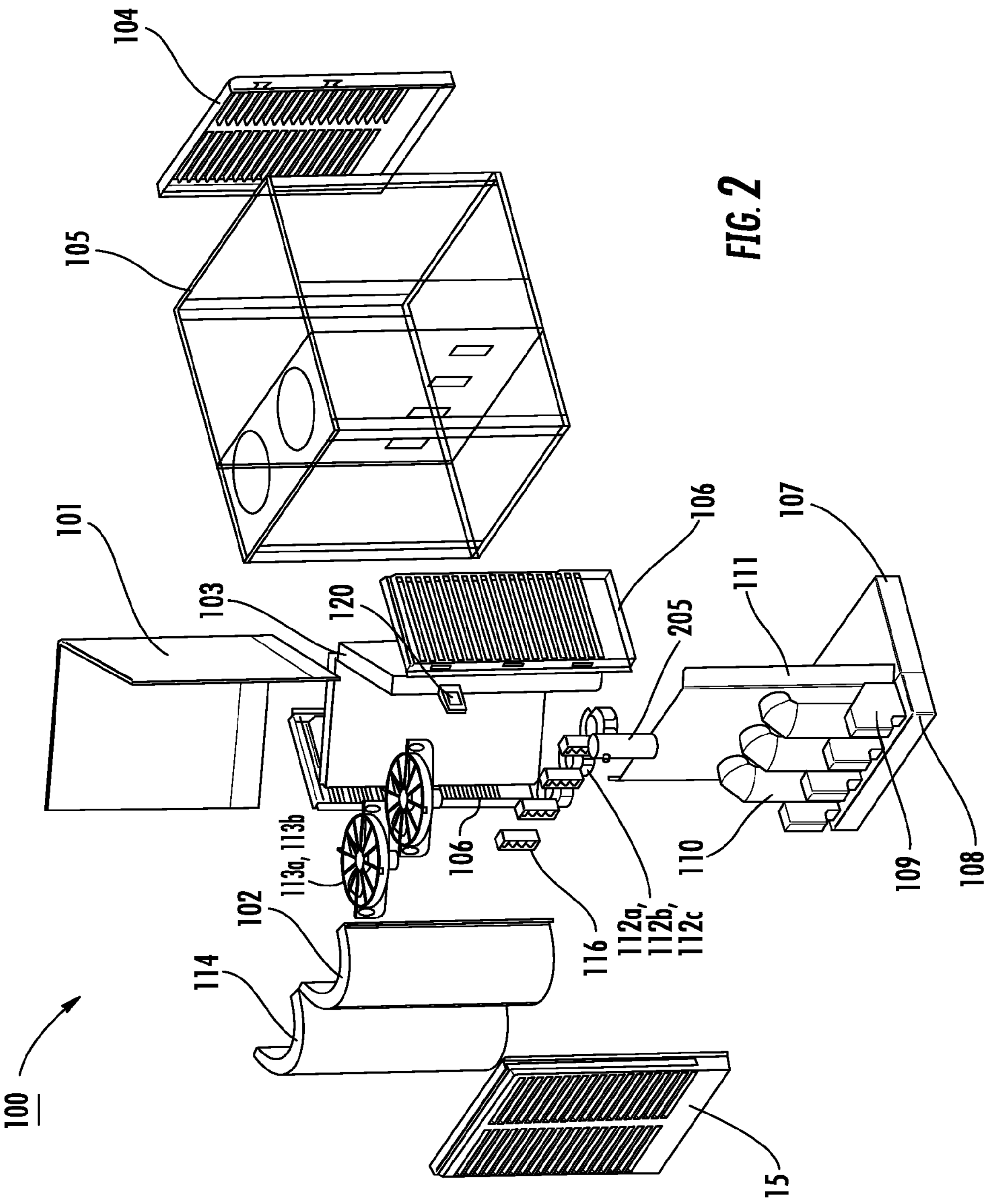

100
101
102
103
104
105
106
106
107
108
109
110
111
112a, 112b, 112c
113a, 113b
114
115
116
120
205

FIG. 2

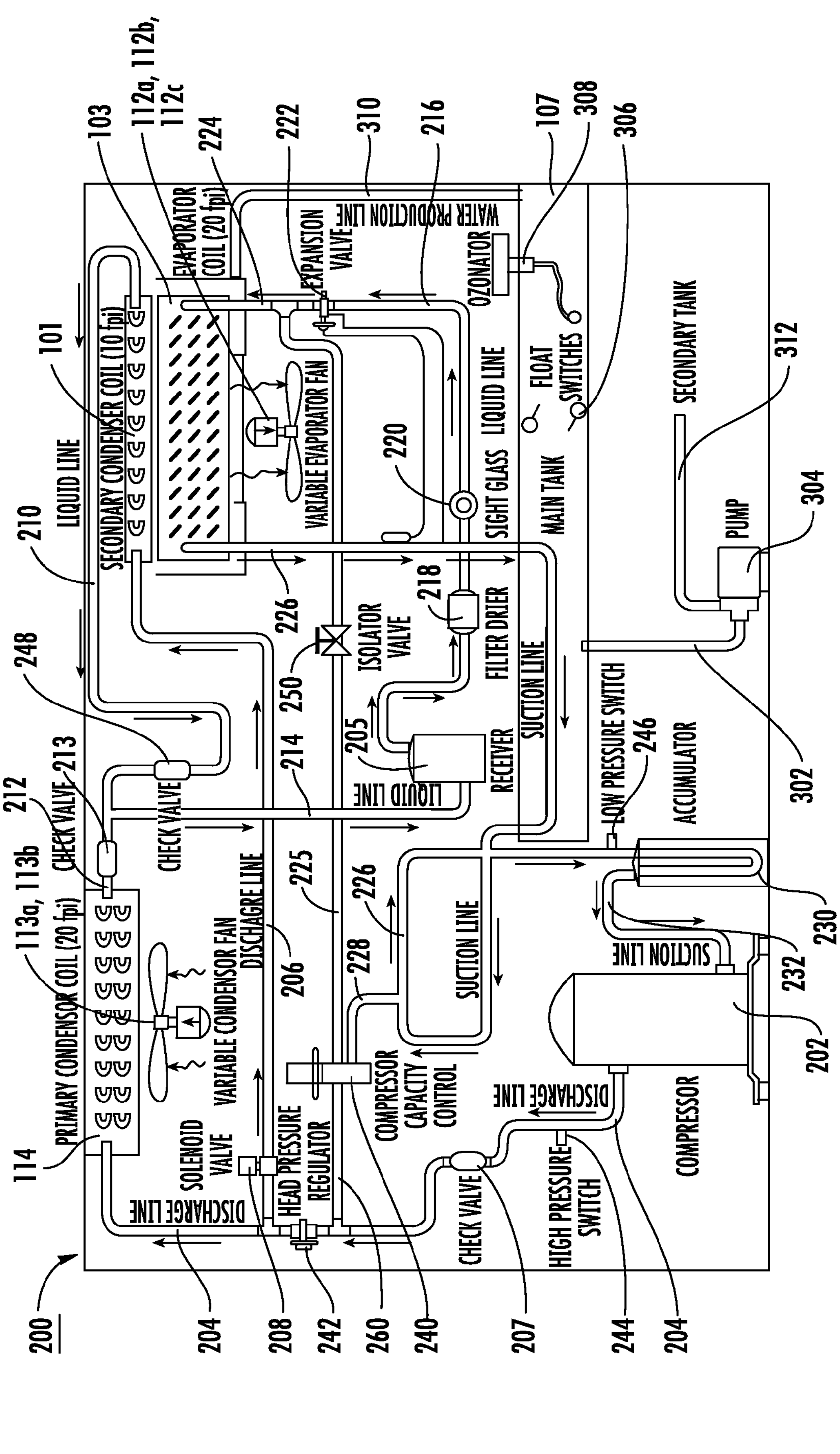

200
204
208
242
260
240
207
244
204
114
113a, 113b
212
213
248
210
101
103
112a, 112b,
112c
224
222
310
216
107
308
306
312
304
302
230
232
202
246
205
214
250
218
220
226
225
228
206
PRIMARY CONDENSOR COIL (20 fpi)
VARIABLE CONDENSOR FAN
DISCHAGRE LINE
CHECK VALVE
SECONDARY CONDENSER COIL (10 fpi)
LIQUID LINE
EVAPORATOR
COIL (20 fpi)
VARIABLE EVAPORATOR FAN
EXPANSION
VALVE
WATER PRODUCTION LINE
OZONATOR
FLOAT
SWITCHES
SECONDARY TANK
PUMP
MAIN TANK
SIGHT GLASS
FILTER DRIER
ISOLATOR
VALVE
RECEIVER
SUCTION LINE
LOW PRESSURE SWITCH
ACCUMULATOR
COMPRESSOR
DISCHARGE LINE
HIGH PRESSURE
SWITCH
COMPRESSOR
CAPACITY
CONTROL
HEAD PRESSURE
REGULATOR
SOLENOID
VALVE

FIG. 3

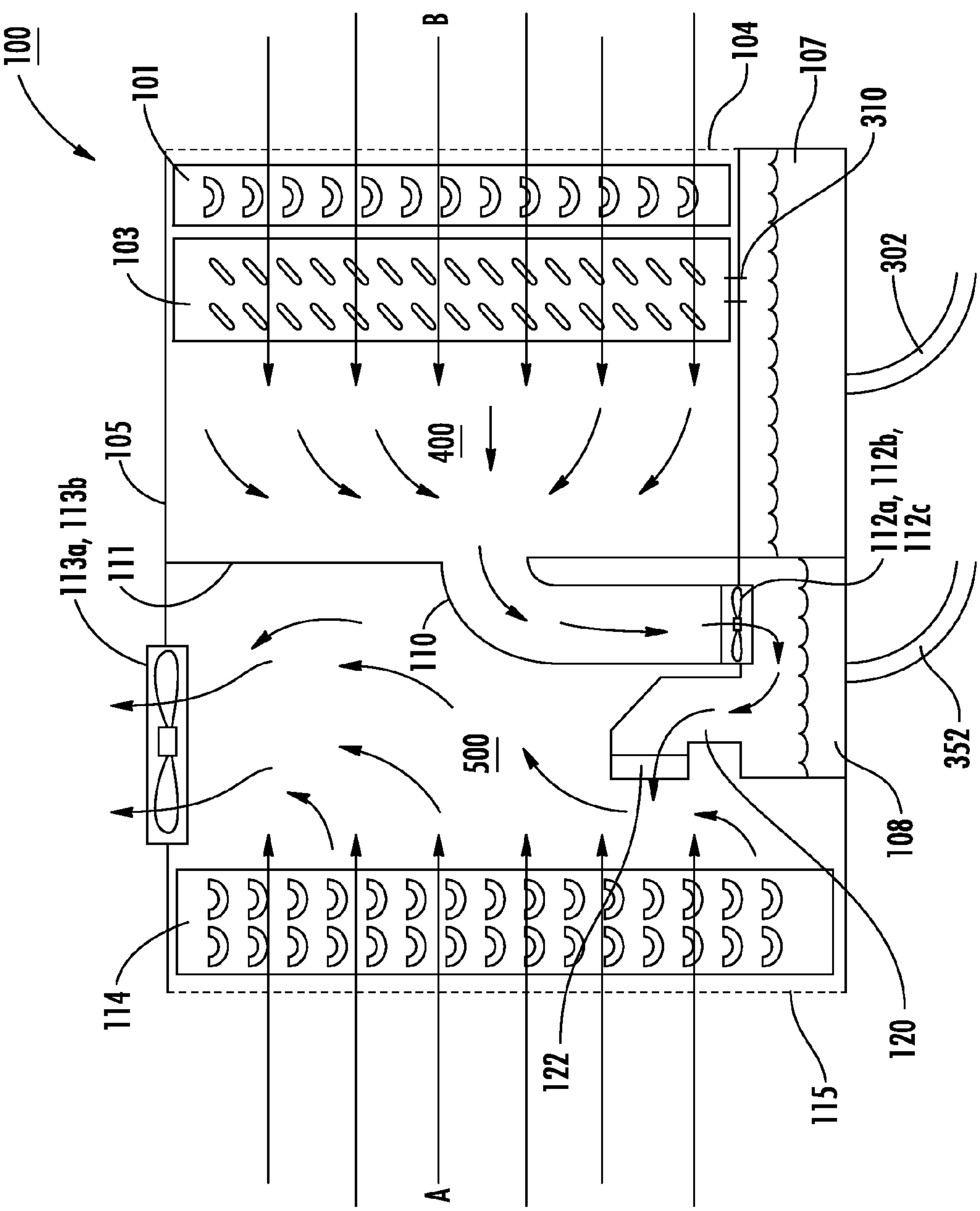

100
101
103
104
105
107
108
110
111
113a, 113b
112a, 112b, 112c
114
115
120
122
302
310
352
400
500
A
B

FIG. 4

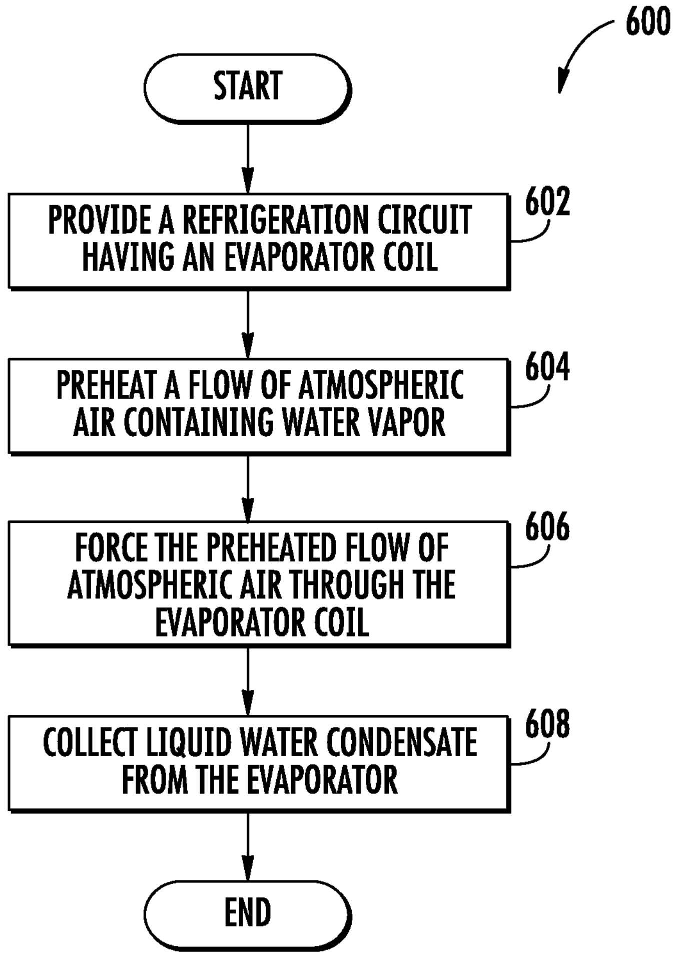

600
START
PROVIDE A REFRIGERATION CIRCUIT HAVING AN EVAPORATOR COIL
602
PREHEAT A FLOW OF ATMOSPHERIC AIR CONTAINING WATER VAPOR
604
FORCE THE PREHEATED FLOW OF ATMOSPHERIC AIR THROUGH THE EVAPORATOR COIL
606
COLLECT LIQUID WATER CONDENSATE FROM THE EVAPORATOR
608
END

FIG. 5

ATMOSPHERIC WATER GENERATOR

BACKGROUND

[0001] Water is a valuable resource which can be scarce in geographic regions which have extremely dry climates and few natural sources of fresh water. Even in such dry climates, however, the local atmospheric air typically contains at least some water in the form of water vapor. Accordingly, it would be desirable to have the ability to extract this available moisture from relatively dry atmospheric air to provide liquid water for drinking, food preparation, bathing, washing, irrigation, livestock, industrial applications, and other common uses. In particular, it would be beneficial to be able to extract substantial quantities of liquid water from atmospheric air having low relative humidity (for example, relative humidity less than or equal to about **35** percent). In addition, it would be helpful to be able to scavenge substantial volumes of liquid water from atmospheric air in cooler climates where atmospheric temperatures are relatively low (for example, locations where the air temperature is less than or equal to about **55** degrees Fahrenheit).

SUMMARY

[0002] One embodiment of an atmospheric water generator according to the invention includes a refrigeration circuit having an evaporator coil and a condenser coil. The condenser coil can be positioned proximate to the evaporator coil, and can be configured to preheat a flow of atmospheric air as the air is forced through the condenser coil and then through the evaporator coil. Liquid water condensate from the preheated air is generated as the air passes through the evaporator coil. The atmospheric water generator can also include a water collection tank configured to accumulate the liquid water condensate. In one arrangement, the evaporator coil and the condenser coil have corresponding non-flat shapes. The atmospheric water generator can further include a second condenser coil which is cooled by a second flow of atmospheric air and supplies refrigerant to the evaporator coil.

[0003] In another embodiment according to the invention, an atmospheric water generator includes a chassis and a refrigeration circuit within the chassis. The refrigeration circuit can include a compressor, a primary condenser coil, a secondary condenser coil, an expansion valve, an evaporator, at least one condenser fan, and at least one evaporator fan. The secondary condenser coil can be positioned proximate to the evaporator coil, and can be configured to preheat atmospheric air before the air is forced through the evaporator by the evaporator fan. Refrigerant can be supplied from the compressor to both the primary condenser coil and the secondary condenser coil, and liquid water condensate from the preheated atmospheric air is generated as the preheated air is forced through the evaporator coil. The condenser fan can be configured to force a first flow of atmospheric air through the primary condenser coil, and the evaporator fan can be configured to force a second flow of atmospheric air through the secondary condenser coil and the evaporator coil. The atmospheric water generator can also include at least one water collection tank configured to collect the liquid water condensate from the evaporator. At least one drain line can be provided to drain the liquid water condensate from the water collection tank, and at least one pump can be configured to pump the liquid water condensate from the drain line to a water storage location.

[0004] The atmospheric water generator can further include a divider panel which separates a condenser chamber and an evaporator chamber within the chassis. At least one dried air duct can be configured to direct dried air from the evaporator chamber to the condenser chamber. In addition, the condenser fan can be configured to exhaust both a first flow of air which passes through the primary condenser and the dried air which enters the condenser chamber from the evaporator chamber through the dried air duct. In one embodiment, the evaporator fan is located at one end of the dried air duct. The atmospheric water generator can also include a second water collection tank, and the dried air duct can be configured to direct dried air from the evaporator chamber into the second water collection tank. The secondary water collection tank can be arranged to collect liquid water condensate from the dried air. At least one dried air vent can be provided to permit the dried air to enter the condenser chamber from the second water collection tank. At least one of the primary condenser coil and the secondary condenser coil can have a non-planar shape.

[0005] The invention also includes a method of generating liquid water from atmospheric air containing water vapor. In one embodiment, the method includes providing a refrigeration circuit having an evaporator, preheating a flow of atmospheric air containing at least some water vapor, passing the flow of preheated air through the evaporator to cause liquid water to condense from the preheated air, and collecting the condensed liquid water. The step of preheating the flow of atmospheric air can include passing the flow of atmospheric air through a condenser coil of the refrigeration system before the air passes through the evaporator coil.

DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a perspective view of one embodiment of an atmospheric water generator according to the present invention with portions of the outer chassis broken away to reveal internal components;

[0007] FIG. **2** is an exploded perspective view of the water generator shown in FIG. **1**;

[0008] FIG. **3** is a schematic showing one embodiment of a refrigeration circuit for use in the water generator shown in FIGS. **1** and **2**;

[0009] FIG. **4** is a graphical representation of a cross section of a water generator like that shown in FIGS. **1** and **2**; and

[0010] FIG. **5** is a flow diagram showing a method of producing liquid water by condensing water vapor from atmospheric air.

DETAILED DESCRIPTION

[0011] One embodiment of an atmospheric water generator (AWG) **100** according to the invention is shown in FIGS. **1-4**. As shown in FIGS. **1** and **2**, the AWG **100** can include a substantially hollow chassis **105**. In the embodiment shown in the figures, the chassis has a box-like shape with four substantially flat sides, a substantially flat top, and a substantially flat bottom. One side of the chassis **105** includes a first air intake grill **115** for admitting a first flow of atmospheric air into the chassis **105**, and an opposite side of the chassis **105** includes a second air intake grill **104** for admitting a second flow of atmospheric air into the chassis

105. The second air intake grill **104** can include a filter (not shown) for preventing particulates and other debris and contaminates from entering the AWG **100** through the second air intake grill **104**.

[0012] The AWG **100** further includes a primary condenser coil **114** located proximate to the first air intake grill **115**. The primary condenser coil **114** is positioned within the chassis **105** such that the first flow of atmospheric air will pass through the primary condenser coil **114**. In the embodiment shown in FIGS. **1** and **2**, the primary condenser coil **114** has a non-planar "m-shape" to maximize the surface area of the primary condenser coil **114** within the confines of the box-shaped chassis **105**. The primary condenser coil **114** can also have other shapes or configurations not shown in the drawings. In one embodiment, the primary condenser coil **114** has about 20 fins per inch. The AWG **100** also includes one or more condenser fans **113***a*, **113***b*. The condenser fans **113***a*, **113***b* can be positioned on top of the chassis **105** and inboard from the primary condenser coil **114** such that the condenser fans **113***a*, **113***b* draw the first flow of air through the first air intake grill **115** and the primary condenser coil **114**, and then upwardly exhaust the first flow of air from the chassis **105**. In one embodiment, the condenser fans **113***a*, **113***b* are enclosed to direct the first flow of air away from second air intake grill **104** as the first flow of air exits the chassis **105**. The condenser fans **113***a*, **113***b* can include 70 degree Celsius direct drive motors, for example. As shown in FIG. **2**, condenser intake grills **106** can be provided on each side of the chassis **105** to permit additional air flow into the condenser region of the chassis **105**.

[0013] The AWG **100** shown in FIGS. **1** and **2** also includes an evaporator coil **103** located proximate to the second air intake grill **104**. The evaporator coil **103** is positioned within the chassis **105** such that the second flow of atmospheric air passes through the evaporator coil **103** after entering the second air intake grill **104**. In the embodiment shown in FIGS. **1** and **2**, the evaporator coil **103** has a non-flat V-shape to maximize its surface area within the confines of the box-shaped chassis **105**. The evaporator coil **103** can also have other shapes or configurations not shown in the drawings. In one embodiment, the evaporator coil **103** is a four-row microtube evaporator coil with about **20** fins per inch. As shown in FIGS. **1** and **2**, the AWG **100** also includes a secondary condenser coil **101** located between the evaporator coil **103** and the second air intake grill **104**. The secondary condenser coil **101** is positioned within the chassis **105** such that the second flow of atmospheric air passes through the secondary condenser coil **101** before passing through the evaporator coil **103**. In the embodiment shown in FIGS. **1** and **2**, the secondary condenser coil **101** also has a V-shape which corresponds to the V-shape of the evaporator coil **103**. The evaporator coil **103** can also have other shapes or configurations not shown in the drawings. Preferably, the shapes of the secondary condenser coil **101** and the evaporator coil **103** are substantially the same such that they can be positioned closely proximate to each other or nested together within the chassis **105**.

[0014] As further shown in FIGS. **1** and **2**, the AWG **100** also includes a partition or divider panel **111** which separates the interior of the chassis **105** into two primary compartments or chambers. In the embodiment shown, the primary condenser **114** and condenser fans **113***a*, **113***b* are located on one side of the divider panel **111**, and the evaporator coil **103** and secondary condenser coil **101** are located on the opposite side of the divider panel **111**. A principal function of the divider panel **111** is to isolate the first air flow through the primary condenser coil **114** from the second air flow through the evaporator coil **103**.

[0015] One embodiment of a refrigeration circuit **200** for use in the AWG **100** shown in FIGS. **1** and **2** is depicted in FIG. **3**. In this embodiment, the circuit **200** includes a compressor **202**, the primary condenser coil **114**, an expansion valve **222**, the evaporator coil **103**, the secondary condenser coil **101**, a liquid receiver **205**, and an accumulator **230**. These components are interconnected by a series of conduits, valves, regulators and controls, as discussed in detail below. Operation of the refrigeration circuit **200** can be controlled by a programmable logic circuit **120**.

[0016] The primary flow path of refrigerant within the refrigeration circuit **200** is described beginning at the compressor **202**. In one embodiment, the compressor **202** is scroll-type compressor. Hot gaseous refrigerant exits the compressor **202** at high pressure through a compressor discharge line **204** and passes to the primary condenser coil **114**. As shown in FIG. **3**, the compressor discharge line **204** can include a high pressure switch **244** configured to shut down the compressor **202** if excessively high pressure is detected in the discharge line **204** proximate to the compressor **202**. In addition, the compressor discharge line **204** can include a check valve **207** to prevent the backflow of refrigerant to the compressor **202** through the discharge line **204**, and a head pressure regulator **242** to restrict the pressure of the refrigerant delivered to the primary condenser **114**. The refrigerant passes through the primary condenser coil **114** where it is cooled by air flow delivered by one or more condenser fans **113***a*, **113***b*. Condensed liquid refrigerant exits the primary condenser coil **114** at high pressure through primary condenser discharge line **212**, and passes to a liquid receiver **205** through condenser discharge line **214**. The primary condenser discharge line **212** can include a check valve **212** to prevent the backflow of refrigerant to the primary condenser coil **114**. The liquid receiver **205** is configured to separate out any gas entrapped in the liquid refrigerant.

[0017] The refrigerant then passes through conduit **216** from receiver **205** to an expansion valve **222**. Conduit **216** can include a filter drier **218** to remove any moisture or debris, and a sight glass **220** to permit observation of the condition of the refrigerant as it exits the filter drier **218**. The refrigerant exits the expansion valve **222** as a cold low-pressure gas/liquid mixture and passes through evaporator supply line **224** to the evaporator **103**. The refrigerant is heated as it passes through the evaporator coil **103** by air flow generated by one or more evaporator fans **112***a*, **112***b*, **112***c*, and exits the evaporator coil **103** through an evaporator discharge line (suction line) **226** in a primarily gaseous state. The refrigerant then passes through the evaporator discharge line **226** to an accumulator **230** which prevents any liquid refrigerant from entering the compressor **202**. The gaseous refrigerant is then returned to the compressor **202**, and the refrigeration cycle is complete.

[0018] As can be seen in FIG. **3**, the refrigeration circuit **200** also includes the secondary condenser coil **101** which is located proximate to the evaporator coil **103**. Hot compressed gas refrigerant is supplied to the secondary condenser coil **101** through condenser bypass line **206** from compressor discharge line **204**. Condenser bypass line **206**

can include an in-line solenoid valve **208** to control the flow of refrigerant to the secondary condenser coil **101**. Operation of the solenoid valve **208** can be controlled by a pre-programmed logic circuit (not shown) based upon various monitored system parameters. The hot gaseous refrigerant is cooled as it passes through the secondary condenser coil **101** by the same airflow that is forced through the evaporator **103** by the evaporator fans **112***a*, **112***b*, **112***c*. Conversely, this air is heated as it passes through the secondary condenser coil **101** and before it reaches the evaporator **103**. The refrigerant exits the secondary condenser coil **101** and is combined with refrigerant exiting the primary condenser coil **114** via secondary condenser discharge line **210**. Accordingly, refrigerant from both the primary condenser coil **114** and the secondary condenser coil **101** pass through the expansion valve **222**. As shown in FIG. **3**, a line **225** can be provided between the compressor discharge line **204** and the evaporator supply line **224**. The line **225** can include a compressor capacity control **240** and an isolator valve **250**, and can be used to selectively direct hot gaseous refrigerant to the evaporator coil **103** in order to prevent the evaporator coil **103** from freezing up.

[0019] As the preheated atmospheric air passes through the evaporator coil **103**, water vapor contained within the air condenses and accumulates under and around the evaporator coil **103**. As shown in FIG. **3**, this condensate is accumulated and drained to a main water tank **107** via a condensate drain **310**. The main water collection tank **107** may be insulated. An ozonator **308** can be provided to sanitize the water as it resides in the tank **107**. The main water tank **107** can include one or more float switches **306** to detect the level of water accumulated within the tank **107**. Once a desired level of water has accumulated in the tank **107** and is detected by the float switch **306**, the water can be automatically pumped from the tank **107** to a water storage location via a pump **304** and water transfer lines **302**, **312**.

[0020] As discussed above, atmospheric air is preheated by the secondary condenser coil **101** before the air passes through the evaporator coil **103**. As a result, the AWG **100** is capable of extracting a substantially larger volume of water from a given mass of atmospheric air than would be possible if the air was not preheated. In addition, preheating the air permits the AWG **100** to be used to extract substantial amounts of liquid water from atmospheric air at relatively low atmospheric temperatures. For example, the AWG **100** can produce liquid water from atmospheric air at temperatures less than or equal to about 55 degrees Fahrenheit.

[0021] FIG. **4** illustrates the flow of air through the AWG **100**. The arrows in FIG. **4** indicate airflow through the AWG **100**. As shown in FIG. **4**, a first flow of atmospheric air “A” is drawn into the chassis **105** through the first intake grill **115** and through the primary condenser coil **114** by condenser fans **113***a*, **113***b*. The heated air exits the primary condenser coil **114** and enters a condenser chamber **500** located between the primary condenser coil **114** and the divider panel **111**. The air is then exhausted from the chassis **105** by the condenser fans **113***a*, **113***b*. Accordingly, the first flow of air “A” acts to continuously cool the primary condenser coil **114** as the AWG **100** operates.

[0022] On the opposite side of the chassis **105**, a second flow of atmospheric air “B” is drawn into the chassis **105** through the second intake grill **104**, through the secondary condenser coil **101**, and through the evaporator coil **103** by evaporator fans **112***a*, **112***b*, **112***c*. As best seen in FIG. **4**, the evaporator fans **112***a*, **112***b*, **112***c* can be positioned at the ends of one or more dried air ducts **110** which are configured to permit the dried air to exit the evaporator chamber **400** by passing through the divider panel **111**. In one embodiment, the evaporator fans **112***a*, **112***b*, **112***c* are low-profile axial fans. As the second flow of atmospheric air “B” exits the evaporator coil **103**, the dried air enters the evaporator chamber **400**. Liquid water which has condensed from the second flow of air “B” as the air passed through the evaporator coil **103** accumulates at the bottom of evaporator chamber **400**, and is drained into the main water collection tank **107**. The dried air within the evaporator chamber **400** is then drawn through the dried air ducts **110** by the evaporator fans **112***a*, **112***b*, **112***c*, and is directed into a secondary water collection tank **108**. The secondary water collection tank **108** can be configured to collect remaining liquid water from the dried air before the dried air enters the dried air vents **120**. A second condensate drain line **352** can be provided to collect accumulated water from the secondary water collection tank **108**. The secondary water collection tank **108** can be in fluid communication with the primary water collection tank **10** such that water can pass between the secondary water collection tank **108** and the primary water collection tank **10**.

[0023] The dried air then passes out of the secondary water collection tank **108** through one or more dried air vents **120**, and enters the condenser chamber **500**. The dried air vents **120** can include adjustable airflow dampers **122** to regulate the flow of air exiting the vents **120**. The dried air is then exhausted from the condenser chamber **500** by the condenser fans **113***a*, **113***b* together with the air exiting the primary condenser coil **114**.

[0024] As shown in FIG. **5**, the invention also includes a method **600** of collecting a substantial quantity of liquid water from atmospheric air. In this method, a refrigerating circuit having an evaporator coil is provided **602**. Atmospheric air is preheated **604**, and the preheated air is then forced through the evaporator coil **606** to cause liquid water to condense from the air. The condensed water is then collected **608**.

[0025] The above descriptions of various embodiments of the invention are intended to illustrate particular aspects and elements of the invention. Persons of ordinary skill in the art will recognize that certain changes or modifications can be made to the described embodiments without departing from the scope of the invention. All such changes and modifications are intended to be within the scope of the appended claims.

What is claimed is:

1. An atmospheric water generator comprising a refrigeration circuit including an evaporator coil and a condenser coil, wherein the condenser coil is positioned proximate to the evaporator coil and is configured to preheat a flow of atmospheric air as the air is forced through the condenser coil and then through the evaporator coil, whereby liquid water condensate from the preheated air is generated as the air passes through the evaporator coil.

2. An atmospheric water generator according to claim **1** and further including a water collection tank configured to accumulate the liquid water condensate.

3. An atmospheric water generator according to claim **1** wherein the evaporator coil and the condenser coil have corresponding non-flat shapes.

4. An atmospheric water generator according to claim **1** further comprising a second condenser coil, wherein the second condenser coil is cooled by a second flow of atmospheric air and supplies refrigerant to the evaporator coil.

5. An atmospheric water generator comprising:

a. a chassis; and

b. a refrigeration circuit within the chassis, the refrigeration circuit comprising:

i. a compressor;

ii. a primary condenser coil;

iii. a secondary condenser coil;

iv. an expansion valve;

v. an evaporator;

vi. at least one condenser fan; and

vii. at least one evaporator fan;

c. wherein the secondary condenser coil is positioned proximate to the evaporator coil and is configured to preheat atmospheric air before the air is forced through the evaporator by the evaporator fan;

d. wherein refrigerant is supplied from the compressor to both the primary condenser coil and the secondary condenser coil; and

e. whereby liquid water condensate from the preheated atmospheric air is generated as the preheated air is forced through the evaporator coil.

7. The atmospheric water generator according to claim **5** wherein the condenser fan is configured to force a first flow of atmospheric air through the primary condenser coil and the evaporator fan is configured to force a second flow of atmospheric air through the secondary condenser coil and the evaporator coil.

8. The atmospheric water generator according to claim **5** further comprising at least one water collection tank configured to collect the liquid water condensate from the evaporator.

9. The atmospheric water generator according to claim **8** further comprising at least one drain line to drain the liquid water condensate from the water collection tank.

10. The atmospheric water generator according to claim **9** further comprising at least one pump configured to pump the liquid water condensate from the drain line to a water storage location.

11. The atmospheric water generator according to claim **5** further comprising a divider panel which separates a condenser chamber and an evaporator chamber within the chassis.

12. The atmospheric water generator according to claim **11** further comprising at least one dried air duct configured to direct dried air from the evaporator chamber to the condenser chamber.

13. The atmospheric water generator according to claim **12** wherein the condenser fan is configured to exhaust both a first flow of air which passes through the primary condenser and the dried air which enters the condenser chamber from the evaporator chamber through the dried air duct.

14. The atmospheric water generator according to claim **12** wherein the evaporator fan is located at one end of the dried air duct.

15. The atmospheric water generator according to claim **12** further comprising a second water collection tank, wherein the dried air duct is configured to direct dried air from the evaporator chamber into the second water collection tank, and wherein the secondary water collection tank is arranged to collect liquid water condensate from the dried air.

16. The atmospheric water generator according to claim **15** further comprising at least one dried air vent configured to permit the dried air to enter the condenser chamber from the second water collection tank

17. The atmospheric water generator according to claim **5** wherein at least one of the primary condenser coil and the secondary condenser coil have a non-planar shape.

18. A method of generating liquid water from atmospheric air containing water vapor, the method comprising:

a. providing a refrigeration circuit having an evaporator;

b. preheating a flow of atmospheric air containing at least some water vapor;

c. passing the flow of preheated air through the evaporator to cause liquid water to condense from the preheated air; and

c. collecting the condensed liquid water.

19. The method of claim **18** wherein preheating the flow of atmospheric air comprises passing the flow of atmospheric air through a condenser coil of the refrigeration system before the air passes through the evaporator coil.

* * * * *