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(54) Title: MULTI-STAGE SEPARATION USING A SINGLE VESSEL

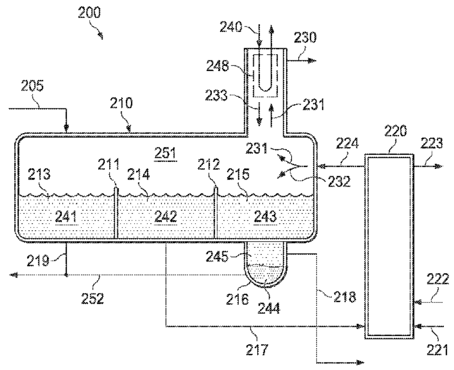

FIG. 2

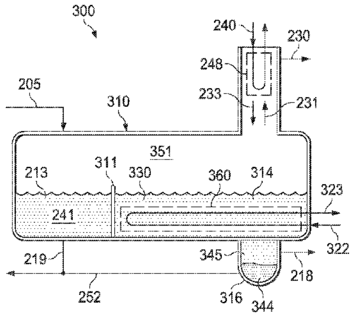

FIG. 4

(57) Abstract: Apparatuses and methods are disclosed herein for separating well fluids into gaseous and liquid components using a single vessel that achieves multiple stages of separation. In one example embodiment, a system for separating a fluid mixture into different components is disclosed. The system comprises a separator. The separator comprises a first inlet configured to receive a stream of the fluid mixture, a first stage separation section configured to provide a first stage of separation to separate the stream into a first liquid, a second liquid, and a gas at a first temperature, and a second stage separation section in fluid communication with the first stage separation section such that the first stage and the second stage separation sections operate at substantially the same pressure. The second stage separation section is configured to provide a second stage of separation to further separate the second liquid at a second temperature.

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MULTI-STAGE SEPARATION USING A SINGLE VESSEL

CROSS REFERENCE TO RELATED APPLICAITONS

[0001] This application claims the priority benefit of both United States Provisional Patent Application 62/097,930 filed December 30, 2014 entitled MULTI-STAGE SEPARATION USING A SINGLE VESSEL, and United States Provisional Patent Application 62/249,563 filed November 2, 2015 entitled MULTI-STAGE SEPARATION USING A SINGLE VESSEL, the entirety of which are incorporated by reference herein.

FIELD OF THE INVENTION

[0002] This disclosure relates to apparatuses and methods for separating well fluids into gaseous and liquid components. More particularly, this disclosure relates to separation using a single vessel that achieves multiple stages of separation and associated processes.

BACKGROUND

[0003] This section is intended to introduce various aspects of the art, which may be associated with exemplary embodiments of the present techniques. This discussion is believed to assist in providing a framework to facilitate a better understanding of particular aspects of the present techniques. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0004] Fluids produced from a well-head include various combinations of hydrocarbon, gas, and water in liquid and gaseous forms. A separation process and associated vessels are typically used to separate the well-head fluids into constituent forms of hydrocarbon, water, and gas.

[0005] In a conventional system, well fluid may enter a first-stage separator in which the fluid is separated into hydrocarbon, water, and gas for further processing. Collected water proceeds to further water treatment, and gas proceeds to further gas conditioning. Collected hydrocarbon is heated downstream of this first-stage separator in a second-stage separator. The first-stage and second-stage separators are typically different vessels with one or more valves and/or one or more heat exchangers positioned in between. The first-stage separator may operate at a high pressure relative to the pressure in the second-stage separator. Further separation in the second-stage separator may take place in a similar fashion to that of the first-stage separator. Gas produced by the second-stage separator is compressed and sent to the same gas conditioning process as the gas exiting the first-stage separator. Further heating of the hydrocarbon and separation at lower pressures subsequent to the second-stage separator may take place as well.

[0006] While the aforementioned configuration represents a conventional system and process for initiating separation of well fluid, the conventional system and associated process does have processing shortcomings. Some of the shortcomings include increased vapor (gas) recompression from lower pressure separators to higher pressures, lack of a means to pre-condition the produced gas prior to the primary gas conditioning process, use of a high number of components requiring expensive capital outlays, high operation energy requirements, resulting in high energy costs, or other shortcomings. The systems, devices, and methods disclosed herein may address at least one of these shortcomings or other shortcomings known in the art.

SUMMARY

[0007] An embodiment provides a system for separating a fluid mixture into different components, the system including a separator including a first inlet configured to receive a stream of the fluid mixture, a first stage separation section configured to provide a first stage of separation at a first temperature to separate the stream into a first liquid, a second liquid, and a first gas, a second stage separation section disposed horizontally adjacent to the first stage separation section and in fluid communication with the first stage separation section, wherein the second stage separation section is configured to provide a second stage of separation at a second temperature higher than the first temperature to further separate a second gas from the second liquid, and a gas collection section in fluid communication with the first stage separation section and the second stage separation section, and configured to receive the first gas and the second gas to form a gas mixture.

[0008] Another embodiment provides a vessel for separating a mixture into different components, the vessel including an inlet configured to receive the mixture, a first partial chamber configured to receive a first component of the mixture, a second partial chamber disposed horizontally adjacent to the first partial chamber and configured to receive a second component of the mixture, a heat exchanger located in the second partial chamber configured to transfer thermal energy to the second component to vaporize a portion of the mixture and separate a vapor from the second component, a vapor collection portion disposed above and in communication with the first partial chamber and the second partial chamber and configured to receive the vapor, and a vapor outlet configured to pass the vapor from the vessel.

[0009] Another embodiment provides a method of separating a stream in a separator, the method including separating the stream into a first component and a second component, separating the second component from a third component at a higher temperature than the first component, wherein the first component comprises a first mixture of water and hydrocarbon, wherein the second component comprises a second mixture of water and hydrocarbon, wherein the second mixture has a higher concentration of hydrocarbon than the first mixture, and wherein the third component comprises a gas, and passing at least a portion of the second component out of the separator, and passing at least a portion the third component out of the separator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The advantages of the present techniques are better understood by referring to the following detailed description and the attached drawings, in which:

[0011] Fig. 1 is a schematic representation of a conventional separation system and the associated process flow;

[0012] Fig. 2 is a schematic representation of an exemplary embodiment of a separation system and the associated process flow;

[0013] Fig. 3 is a simplified process flow diagram corresponding to the system in Fig. 2;

[0014] Fig. 4 is a schematic representation of another exemplary embodiment of a separation system and the associated process flow;

[0015] Fig. 5 is a flowchart setting forth an exemplary method for processing fluid from a wellhead using a single separator;

[0016] Figure 6 is a schematic representation of the embodiment of Figure 2 incorporating means to conduct mass transfer within the separation system; and

[0017] Figure 7 is a schematic representation of the embodiment of Figure 4 incorporating means to conduct mass transfer within the separation system.

DETAILED DESCRIPTION OF THE DRAWINGS

[0018] In the following detailed description section, specific embodiments of the present systems, devices, and techniques are described. However, to the extent that the following description is specific to a particular embodiment or a particular use of the present systems, devices, and techniques, this is intended to be for exemplary purposes only and simply provides a description of the exemplary embodiments. Accordingly, the systems, devices, and techniques are not limited to the specific embodiments described below, but rather, include all alternatives, modifications, and equivalents falling within the spirit and scope of the appended claims.

[0019] Apparatuses and associated processes are disclosed herein that incorporate a separator to initiate hydrocarbon stabilization and gas pre-treatment in a unique configuration. An arrangement is introduced that separates a well stream fluid into its water, hydrocarbon, and gas (vapor) constituent components. The apparatus includes a separation vessel or separator and a means to exchange heat with the well stream fluid that together achieves a greater than one stage of hydrocarbon vapor-liquid separation via an imposed temperature gradient.

[0020] The proposed configurations combine functional aspects of a first-stage separator, such as separator **110** of Fig. 1, with multiple heat-integrated pieces to initialize stabilization of hydrocarbon at a first-stage separator pressure as well as to provide initial gas treatment. Proposed embodiments may lower capital expenditures (CAPEX) by removing a need for a compressor and a second separator. Proposed embodiments may also lower operational expenditures (OPEX) by reducing total operational energy requirements.

[0021] Fig. 1 is a schematic representation of a conventional separation system **100** and the associated process flow. The separation system **100** comprises a first separator **110** and a second separator **140**. The first separator **110** receives a stream **105**. In some embodiments, the stream **105** is received from a well or wellhead, and the stream **105** comprises a mixture of hydrocarbon, water, and gas. In some embodiments, there is no pressure drop from the wellhead and the stream **105** is at a temperature of about 30 °C to about 50 °C (Celsius), although other pressures and temperatures are contemplated.

[0022] A cross-section of the separator **110** is illustrated. In this example, the separator

110 comprises separation internals (not shown) that are well known in the art for separating water, hydrocarbon, and gas. For example, the separation internals may comprise a distributor baffle or an inlet vane distributor that interacts with the stream **105** to facilitate separation of gas from the stream and separation of hydrocarbon from water. As a result of the stream **105** interacting with separation internals, some amount of gas is separated from the stream **105**, and a first liquid **113** is collected in a first partial chamber **117** and a second liquid **112** is collected in a second partial chamber **118**. The liquids **112** and **113** may be mixtures of water and hydrocarbon with different proportions, with the first liquid **113** having a greater percentage of water relative to hydrocarbon and the second liquid **112** having a greater percentage of hydrocarbon relative to water. The partial chambers **117** and **118** can be defined by the outer walls of the separator **110** and a divider **111**. The divider **111** may comprise a plate or other rigid structure for dividing a portion of the separator **110** into partial chambers. Gas may be collected in the vapor collection portion **119** of the separator **110** above the partial chambers **117** and **118**. The partial chambers **117** and **118** are examples of regions or sections of the separator **110**. The liquid **112** in the second partial chamber **118** may have a different composition of hydrocarbon and water than the liquid **113** because of separation that takes place due to different densities in the first partial chamber **117** with the lighter hydrocarbon constituents overflowing the first partial chamber **117** into the second partial chamber **118**.

[0023] In this embodiment, the separator **110** comprises at least three outlets. The first partial chamber **117** may comprise or may be coupled to a first outlet for carrying an outlet stream **114**. The outlet stream **114** may comprise mostly water and may be transported to a water treatment system (not shown) for further treatment. A second outlet may be coupled to the separator **110** at the portion **119** for carrying outlet stream **116**. The outlet stream **116** may comprise mostly gas and be transported to a gas conditioning system (not shown) for further gas conditioning. The partial chamber **118** may comprise or may be coupled to a third outlet for carrying outlet stream **115**. The outlet stream **115** may be transported for further processing in the separation system **100**.

[0024] In this embodiment, the outlet stream **115** is provided to heat exchanger **120**. In some embodiments, the outlet stream **115** at the input to the heat exchanger **120** is between about 30 °C to 50 °C, and the output stream **122** flowing from the heat exchanger **120** is between about 70 °C to 90 °C. The output stream **122** passes through a valve **130** to produce stream **132**. The valve **130** reduces the pressure of the stream **122** as it becomes stream **132**.

[0025] The stream **132** from the valve **130** is provided to the second separator **140**. In an embodiment, the second separator **140** comprises an inlet for receiving the stream **132**. In this example, the separator **140** comprises separation internals (not shown) that are well known in the art for separating fluids in the stream **132**. For example, as discussed earlier the separation internals may comprise a distributor baffle, an inlet vane distributor, or other separation internals. The stream **132** may still comprise a mixture of hydrocarbon, water, and gas, with the proportion of hydrocarbon being higher than the original stream **105** from the wellhead.

[0026] As a result of the stream **132** interacting with separation internals, some amount of gas is separated from the stream **132**, and a first liquid **143** is collected in a first partial chamber **147** and a second liquid **142** is collected in a second partial chamber **148**. The liquids **142** and **143** may be mixtures of water and hydrocarbon with different proportions or concentrations, with the first liquid **143** having a greater percentage of water than hydrocarbon and the second liquid **142** having a greater percentage of hydrocarbons than water. The partial chambers **147** and **148** can be defined by the outer walls of the separator **140** and a divider **141**. The divider **141** may be a plate or other rigid structure for dividing a portion of the separator **140** into partial chambers. A gas may collect in a vapor collection portion **149** of the separator **140** above the partial chambers **147** and **148**.

[0027] The separator **140** comprises at least three outlets. The first partial chamber **147** may comprise or may be coupled to a first outlet for carrying an outlet stream **144**. The outlet stream **144** may be transported to a water treatment system for further water treatment. A second outlet is coupled to the separator **140** at the portion **149** for carrying outlet stream **150**. The outlet stream **150** may be transported to a compressor **160**. The outlet stream **150** may comprise mostly gas. The partial chamber **148** may comprise or may be coupled to a third outlet for carrying outlet stream **145**. The outlet stream **145** may be transported to a hydrocarbon treatment system.

[0028] The compressor **160** produces a pressure differential between input stream **150** and output stream **161**, with the output stream **161** being at a higher pressure than the input stream **150**. The stream **161** may be mixed with the stream **116**, with the mixture transported to a gas conditioning system.

[0029] Fig. 2 is a schematic representation of an exemplary embodiment of a separation system **200** and the associated process flow. The separation system **200** comprises a separator **210** and a heat exchanger **220**. The separator **210** receives a stream **205**. In some embodiments, the stream **205** is from a well or wellhead, and the stream **205** comprises a mixture of hydrocarbons, water, and gas. In some embodiments, there is no pressure drop from the wellhead and the stream **205** is at a temperature of about 30 °C to about 50 °C.

[0030] A cross-section of the separator **210** is illustrated. In this example, the separator **210** comprises separation internals (not shown) that are well known in the art for separating water, hydrocarbons, and gas. For example, the separation internals may comprise a distributor baffle, an inlet vane distributor, or other distributor that interacts with the stream **205** to facilitate separation of gas from the stream and separation of hydrocarbons from water. As a result of the stream **205** interacting with separation internals, some amount of gas is separated from the stream **205**, and a first liquid **213** is collected in a first partial chamber **241** and a second liquid **214** is collected in a second partial chamber **242**. The liquids **213** and **214** may be mixtures of water and hydrocarbon with different proportions, with the first liquid **213** having more water than hydrocarbon and the second liquid **214** having more hydrocarbon than water. The partial chambers **241** and **242** can be defined by the outer walls of the separator **210** and dividers **211** and **212** as shown. The dividers **211** and **212** may each comprise a plate or other rigid structure for dividing a portion of the separator **210** into partial chambers, e.g., a weir, and may each extend vertically across some but not all of the separator **210**. The liquid **214** in the second partial chamber **242** may have a different composition of hydrocarbon and water than the liquid **213** because of separation that takes place due to different densities in the first partial chamber **241** with the lighter hydrocarbon constituents overflowing into the second partial chamber **242**.

[0031] The separator **210** may comprise or may be coupled to at least four outlets. The first partial chamber **241** may comprise or may be coupled to a first outlet for carrying an outlet stream **219**. The outlet stream **219** may comprise mostly water and may be transported to a water treatment system (not shown) for further treatment. The second partial chamber **242** may comprise or may be coupled to a second outlet for carrying outlet stream **217**. The hydrocarbon-water mixture **214** is withdrawn from the second partial chamber **242** and provided to the heat exchanger **220** as stream **217**. The heat exchanger **220** may be a forced-flow thermosiphon, a natural-convection thermosiphon, calandria, kettle, or other applicable style exchanger to effectively increase the temperature of the fluid entering via the stream **217** and to initiate vaporization of light-end components intermingled with the heavy-end components comprising the bulk of the hydrocarbons in the stream **217**. Additionally, an optional stream of gas **221** (from the separator **210** or elsewhere) may be utilized to assist with flow of the hydrocarbon-water mixture through this heat exchanger unit. The heating medium used to heat the hydrocarbon-water part of the incoming stream **217** may comprise any appropriate heating medium, such as air or water. The heating medium enters the heat exchanger **220** in stream **222** and exits the heat exchanger in stream **223**. In typical scenarios, the heating medium does not intermingle with the hydrocarbon-water and/or vapor mixture in the heat exchanger **220**.

[0032] Heated fluid exits the heat exchanger **220** in stream **224**, and stream **224** is provided to the separator **210**. After being heated in the heat exchanger **220**, the stream **224** comprises gas **231** and liquid **232**. The stream **224** enters the separator **210** via an inlet located relative to a third partial chamber **243** such that the liquid **232** is collected primarily in the third partial chamber **243**. The partial chambers **241**-**243** are examples of regions, sections, or portions of the separator **210** in fluid communication with the vapor collection portion **251**.

[0033] In this exemplary embodiment, the separator **210** further comprises a condenser **248**. A cooling medium **240** may be provided to a condenser **248** for condensing some of the gas **231**. In an embodiment, the condenser **248** may be shaped and located as a reflux (or drip-back or knock-back) condenser. Gas may collect in a portion of the separator **210** above the partial chambers **241-243**. The separator **210** may comprise or may be coupled to a fourth outlet for carrying outlet stream **230**. The outlet stream **230** may comprise mostly gas and may be transported to a gas conditioning system for further gas conditioning.

[0034] The condenser **248** may be located in the separator **210** directly above the third partial chamber **243** and is arranged to condense some vapor particles as they pass toward the outlet carrying outlet stream **230**. Condensate **233** may, for example, form on the condenser **248** and then fall into the third partial chamber **243** due to gravity. Thus, the liquid **215** in the third partial chamber **243** may comprise liquid **232** and condensate **233**. In this example, the liquid **215** comprises a higher concentration of hydrocarbons than the liquids **213** or **214**.

[0035] The separator **210** further comprises a boot **216**. The boot **216** is coupled to the third partial chamber **243**, and the boot **216** permits further separation of the liquid **215** due to differences in density between various constituents. The liquid **215** in the boot **216** separates into a first constituent **244** and a second constituent **245**. For example, the first constituent **244** is predominately water and collects at the bottom of the boot, and the second constituent

245 is predominately hydrocarbon and separates from the first constituent **244**. Water **244** from the boot may proceed to further water treatment via stream **252** (which may be combined with stream **219** as shown), and hydrocarbons from the boot **216** may proceed to further hydrocarbon treatment via stream **218**.

[0036] The performance of the separation system **200** in Fig. 2 has been compared against the performance of the separation system **100** in Fig. 1. Both systems were simulated using the same representative well stream having the same temperature, pressure, composition, and flow rate. In a simulated example, the separation system **200** used 11% less energy to process the simulated well stream than the conventional separation system **100**, which helps to confirm that the separation system **200** yields OPEX savings. Furthermore, the separation system **200** is a less costly system than the separation system **100** due to a reduction in components, which leads to lower CAPEX. For example, the separation system **100** comprises two separators, a valve, and a compressor, whereas the separation system **200** comprises only one separator, which reduces capital outlays.

[0037] Fig. 6 is another schematic representation of an exemplary embodiment of a separation system **200** and the associated process flow, and is similar to the embodiment shown in Fig. 2. The separation system **200** comprises a separator **210** and a heat exchanger **220** similar to that depicted in Fig. 2. In addition to the configuration depicted in Fig. 2, the embodiment shown in Fig. 6 includes a mass transfer section **260** located between the condenser **248** and the separator **210**. The component gas **231** of stream **224** enters the mass transfer section **260**, exits as a hydrocarbon heavies depleted vapor **262**, and proceeds to the condenser **248** for further processing as previously described in Fig. 2. Condensate **233** from the condenser **248** enters the mass transfer section **260**, exits as a hydrocarbon heavies enriched liquid **263**, and proceeds to the third partial chamber **243** for further processing as previously described for the process depicted in Fig. 2. The gas **231** and the condensate **233** preferentially flow counter-currently to each other within the mass transfer section **260**. The mass transfer section **260** is comprised of internals of varying configurations (not shown) that are well known in the art for achieving mass transfer between liquid and gas streams. For example, these internals may be comprised of trays, shed decks, random packing, structured packing, grid packing, mesh, or other structures that promote the interaction of liquid and gas for the purpose of achieving effective mass transfer between said streams.

[0038] Fig. 3 is a simplified process flow diagram corresponding to the system **200** in

Fig. 2. Stream **205** enters the separator **210** and is separated into partial chambers **241** and **242**. The separator **210** operates at a single pressure, which may be the same pressure as the separator **110** in Fig. 1. For example, as one of ordinary skill in the art would recognize, since partial chambers **241** and **242** are within the separator **210** and the separator **210** comprises a single vessel, the pressure in the separator **210**, and particularly in the partial chambers **241** and **242**, is a single equilibrium pressure. The equilibrium pressure is generally a uniform value throughout the partial chambers **241** and **242**, but a person of ordinary skill in the art would recognize that there may be small variations of pressure (e.g., less than 1% variation) throughout the volume due to random fluctuations. Accordingly, the pressure in partial chambers **241** and **242** is substantially the same.

[0039] Initially separated gas proceeds down the length of the separator **210** to reach another section **251** of the separator. Initially separated water **219** exits the heat-integrated separator for further water treatment. Initially separated hydrocarbon **217** exits the partial chamber **242** and proceeds though a heat exchanger **220** to heat the stream to a predetermined temperature, vaporizing part of the stream. From the heat exchanger, the stream **224** re-enters the separator **210** at another portion of the separator (labeled as **243/251/216**). Upon re-entry into the separator **210**, vapor and liquid separate. Liquid entering the separator **210** in stream **224** falls into a third partial chamber **243** and then proceeds to further hydrocarbon treatment in stream **218**. Although not shown in Fig. 3, additional water separation may also take place in the boot **216** as depicted in Fig. 2. Vapor entering the separator **210** in stream **224** rises in the vessel, joining with initially separated vapor **301** and proceeds to the condenser **248**. Within the condenser **248**, condensable components fall back into the partial chamber **243**, while gas exits the separator **210** for additional treatment via stream **230**.

[0040] Fig. 4 is a schematic representation of another exemplary embodiment of a separation system **300** and the associated process flow. Elements of system **300** that are similar to corresponding elements of system **200** are given the same number. The system **300** comprises a separator **310**, and the separator **310** receives a stream **205**. As described previously, in some embodiments the stream **205** is received from a well or wellhead, and the stream **205** comprises a mixture of hydrocarbons, water, and gas. In some embodiments, there is no pressure drop from the wellhead and the stream **205** is at a temperature of about 30 °C to about 50 °C.

[0041] A cross-section of the separator **310** is illustrated. In this example, the separator

310 comprises separation internals (not shown) that are well known in the art for separating water, hydrocarbon, and gas. As a result of the stream **205** interacting with separation internals, a first liquid **213** is collected in a first partial chamber **241** and a second liquid **314** is collected in a second partial chamber **330**. The liquids **213** and **314** may be mixtures of water and hydrocarbons with different proportions or concentrations, with the first liquid **213** having a greater percentage of water than hydrocarbon and the second liquid **214** having a greater percentage of hydrocarbon than water. The partial chambers **241** and **330** can be defined by the outer walls of the separator **310** and divider **311**. The divider **311** may be a plate or other rigid structure for dividing a portion of the separator **310** into partial chambers. A gas may collect in the vapor collection portion **351** of the separator **310** disposed above and in communication with the partial chambers **241** and **330**.

[0042] As compared to the separator **210** in Fig. 2, the separator **310** employs the implementation of a heat exchanger **360** located in the second partial chamber **330** to initialize stabilization of hydrocarbon in the liquid **314**. The heat exchanger **360** may comprise tubes or passages occupying part of the volume of partial chamber **330**, and a heating medium may be contained in the tubes or passages. The heat exchanger **360** is configured to promote higher heat transfer at a lower portion (e.g., near the illustrated inlet portion of stream **322**) of the separator **310** than at an upper portion (e.g., near the illustrated outlet portion of stream **323**), thereby promoting an internal circulation to the liquid **314** to enhance disassociation and separation of light-end components intermingled with heavy-end components constituting the bulk of the hydrocarbons in the liquid **314**. For example, the input inlet portion **322** may be in a relatively lower portion of the partial chamber **330** as compared to the upper outlet portion **323**, so the heating medium in the heat exchanger **360** may provide more thermal energy in a lower portion of the partial chamber **330** than in an upper portion of the partial chamber **330**. Thus, the heat exchanger **360** may induce a temperature gradient in the liquid **314** in which the liquid is warmer in a lower portion of the partial chamber **330** than in an upper portion of the partial chamber **330**. The fluid used to heat the hydrocarbon-water part of the incoming well stream fluid in the heat exchanger **360** may comprise any appropriate heating medium, such as air or water.

[0043] A vapor component **231** released from the liquid **314** due at least in part to heating mixes with free gas already passing through the separator **310** and proceeds to a second heat exchanger of this process – condenser **248**. As discussed previously, the condenser **248** may be a reflux (or drip-back or knock-back) condenser. Within the condenser **248**, the exiting gas temperature can be controlled to remove undesired condensable components via a cooling medium passing through tubes (or passages) encased within the condenser **248**. A fluid used to condense part of the gas within the condenser **248** may comprise any appropriate coolant, such as air or water. The condenser **248** may be located in the separator **310** directly above the second partial chamber **330** so that condensate **233** from the condenser **248** refluxes or drips-back directly within the separator **310**. The resulting treated or pre-conditioned gas **230** then proceeds to further gas conditioning. The separator **310** comprises a boot **316** that facilitates further separation of the liquid **314** into water **344** and hydrocarbon **345**.

[0044] Fig. 7 is another schematic representation of an exemplary embodiment of a separation system **300** and the associated process flow, and is similar to the embodiment shown in Fig. 4. The separation system **300** comprises a separator **310**. In addition to the configuration depicted in Fig 4, the embodiment shown in Fig. 7 includes a mass transfer section **260** located between the condenser **248** and the separator **310**. The vapor component **231** released from the liquid **314** enters the mass transfer section **260**, exits as a hydrocarbon heavies depleted vapor **262**, and proceeds to the condenser **248** for further processing as previous described in Fig. 4. Condensate **233** from the condenser **248** enters the mass transfer section **260**, exits as a hydrocarbon heavies enriched liquid **263**, and proceeds to the second partial chamber **230** for further processing as previously described for the process depicted in Fig. 4. The vapor component **231** released from the liquid **314** and the condensate **233** preferentially flow counter-currently to each other within the mass transfer section **260**. The mass transfer section **260** is comprised of internals of varying configurations (not shown) that are well known in the art for achieving mass transfer between liquid and gas streams. For example, these internals may be comprised of trays, shed decks, random packing, structured packing, grid packing, mesh, or other structures that promote the interaction of liquid and gas for the purpose of achieving effective mass transfer between said streams.

[0045] The separators **210** and **310** in Figs. 2 and 4, respectively, may be referred to as horizontal separators because a horizontal dimension is greater than a vertical dimension. Additionally, the partial chambers **241/242/243** and/or **241/351** may be disposed such that each partial chamber is horizontally adjacent to another partial chamber. The principles and embodiments described herein are also applicable to vertical separators, or separators whose vertical dimension is greater than a horizontal dimension.

[0046] A further embodiment of a separation system (not shown) and the associated separation process may comprise heating either internally (e.g., using a heat exchanger similar to **360**) or externally (e.g., using a heat exchanger similar to **220**) by similar aforementioned methods the liquid **213** in the first partial chamber **241** of either separator **210** or separator **310** to accelerate the separation of hydrocarbons and water in a collection boot or in subsequent equipment located downstream of the separator. A heat exchanger configured similarly to heat exchanger **220** or heat exchanger **360** may be used for this purpose.

[0047] Fig. 5 is a flowchart setting forth an exemplary method **400** for processing fluid from a wellhead using a single separator. The method **400** may be implemented in a separator, such as separator **210** or **310**. The method **400** begins in block **410**. In block **410**, fluid is received from a wellhead into a separator. The fluid may be received via an inlet of the separator, and the fluid may be produced intermittently or continuously by a hydrocarbon source. In some embodiments, instead of being received from a wellhead, the fluid is received from other sources, such as a storage facility or other locations. The method may proceed to block **420** in which a first stage of separation is performed in the separator. The first stage of separation may comprise separating liquid from gas and collecting the liquid in one or more partial chambers of the separator. For example, if a separator **210** or **310** is employed, liquid may be collected in partial chambers **241** and **242** as described previously. An example first stage separation section of separators **210** or **310** can comprise various combinations of an inlet for receiving a stream, separation internals, and partial chambers. A first stage separation section may perform blocks **410** and **420**.

[0048] The method may next proceed to block **430**. In block **430**, a second stage of separation is performed in the same separator. The second stage of separation comprises performing additional separation of liquid from gas and may comprise further separation of the liquid into constituent components, such as hydrocarbons and water. The second stage of separation may comprise using a heat exchanger, such as heat exchanger **220** with separator **210** or heat exchanger **360** with separator **310** as described previously. Vapor may be produced from the use of a heat exchanger and may be treated using a condenser, such as condenser **248**. Gas produced in this process is withdrawn from the separator for further gas treatment. Mass transfer between vapor and liquid may occur in an optional mass transfer section **260** located between the condenser **248** and the separator **210** or **310**.

[0049] An example second stage separation section of separator **210** for performing block

430 can comprise various combinations of an inlet for receiving a heated flow from a heat exchanger, a partial chamber for receiving liquid from the heated flow, and a boot integral with the partial chamber. An example second stage separation section of separator **310** for performing block **430** can comprise various combinations of a partial chamber, a heat exchanger within the partial chamber, and a boot integral with the partial chamber.

[0050] While the present techniques may be susceptible to various modifications and alternative forms, the embodiments discussed above have been shown only by way of example. However, it should again be understood that the techniques is not intended to be limited to the particular embodiments disclosed herein. Indeed, the present techniques include all alternatives, modifications, and equivalents falling within the true spirit and scope of the appended claims.

CLAIMS

1. A system for separating a fluid mixture into different components, the system including:

a separator including:

a first inlet configured to receive a stream of the fluid mixture;

a first stage separation section configured to provide a first stage of separation at a first temperature to separate the stream into a first liquid, a second liquid, and a first gas;

a second stage separation section disposed horizontally adjacent to the first stage separation section and in fluid communication with the first stage separation section, wherein the second stage separation section is configured to provide a second stage of separation at a second temperature higher than the first temperature to further separate a second gas from the second liquid; and

a gas collection section in fluid communication with the first stage separation section and the second stage separation section, and configured to receive the first gas and the second gas to form a gas mixture.

2. The system of claim 1, wherein the first stage separation section comprises a first partial chamber and a second partial chamber, wherein the first partial chamber is configured to collect the first liquid, and wherein the second partial chamber is configured to collect the second liquid.

3. The system of claims 2 or 1, wherein the first stage of separation and the second stage of separation occur within the same vessel.

4. The system of claim 2, further including:

a heat exchanger coupled to the separator, wherein the heat exchanger is configured to:

receive a stream of the second liquid from the separator;

provide heat to the stream of the second liquid to generate a heated stream; and

produce the heated stream to the separator, and wherein the separator further comprises a third partial chamber configured to collect a liquid portion of the heated stream.

5. The system of claim 4, wherein the gas collection section comprises a gas outlet, wherein the gas outlet comprises a condenser configured to cool the gas mixture and generate a condensate, and wherein the condenser is positioned so that the condensate collects in the third partial chamber.

6. The system of claims 4 or 5, wherein the separator further comprises a boot coupled to a bottom end of the third partial chamber.

7. The system of any of claims 4-6, wherein the separator further comprises a mass transfer section located between the condenser and the separator in which condensate from the condenser passes downward through a mass transfer section counter-current to rising vapor from the separator.

8. The system of claim 2, wherein the separator further comprises a second inlet configured to receive a stream of the second liquid that has been heated by a heat exchanger, wherein the second inlet is located near the third partial chamber to allow a component of the second liquid to fall into the third partial chamber.

9. A vessel for separating a mixture into different components, the vessel including:

an inlet configured to receive the mixture;

a first partial chamber configured to receive a first component of the mixture;

a second partial chamber disposed horizontally adjacent to the first partial chamber and configured to receive a second component of the mixture;

a heat exchanger located in the second partial chamber configured to transfer thermal energy to the second component to vaporize a portion of the mixture and separate a vapor from the second component;

a vapor collection portion disposed above and in communication with the first partial chamber and the second partial chamber and configured to receive the vapor; and

a vapor outlet configured to pass the vapor from the vessel.

10. The vessel of claim 9, wherein the first partial chamber is arranged to maintain the first component at a first temperature, and wherein the second partial chamber is arranged to maintain the second component is at a second temperature.

11. The vessel of claims 9 or 10, wherein the heat exchanger is configured to provide greater heat to a lower portion of the second partial chamber than in an upper portion of the second partial chamber to provide for circulation of the second component.

12. The vessel of any of claims 9-11, wherein the heat exchanger comprises tubing configured to receive a heating medium to transfer thermal energy to the second component.

13. The vessel of any of claims 9-12, further including a boot connected to the second partial chamber configured to permit further separation of the second component into a water component and a hydrocarbon component.

14. The vessel of any claims 9-13, further including a mass transfer section located between the condenser and the separator in which condensate from the condenser passes downward through a mass transfer section counter-current to rising vapor from the separator.

15. A method of separating a stream in a separator, the method including:

separating the stream into a first component and a second component;

separating the second component from a third component at a higher temperature than the first component, wherein the first component comprises a first mixture of water and hydrocarbon, wherein the second component comprises a second mixture of water and hydrocarbon, wherein the second mixture has a higher concentration of hydrocarbon than the first mixture, and wherein the third component comprises a gas; and

passing at least a portion of the second component out of the separator; and

passing at least a portion the third component out of the separator.

16. The method of claim 15, wherein the stream is received from a wellhead, wherein separating the stream and separating the second component are performed at substantially the same pressure, wherein the first component occupies at least part of a first section of the separator, wherein the second component occupies at least part of a second section of the separator, and wherein the third component occupies at least part of a third section of the separator.

17. The method of claims 15 or 16, further including:

performing a third stage of separation of the stream into a fourth component, wherein the fourth component comprises a third mixture of water and hydrocarbon, and wherein the third mixture has a higher concentration of hydrocarbon than the second mixture.

18. The method of any of claims 15 or 16, wherein performing the second stage of separation comprises heating the second component in the separator using a heat exchanger located in the second section of the separator.

19. The method of claim 16, further comprising:

withdrawing the second component from the separator;

heating the second component; and

returning the heated second component to the separator for further separation.

20. The method of claim 19, wherein the heated second component comprises a heated liquid portion and a vapor portion, and wherein the heated liquid portion falls into the third section.

21. The method of claim 20, further comprising cooling the vapor portion such that a condensate separates from the vapor portion and falls into the third section, and wherein a gas remaining after removing the condensate is withdrawn from the separator for further processing.

22. The method of any of claim 21, wherein cooling the vapor portion further comprises cooling a second vapor portion obtained from the first component.

23. The method of claim 21 where in the separated condensate passes downward through a mass transfer section counter-current to rising vapor from the separator.

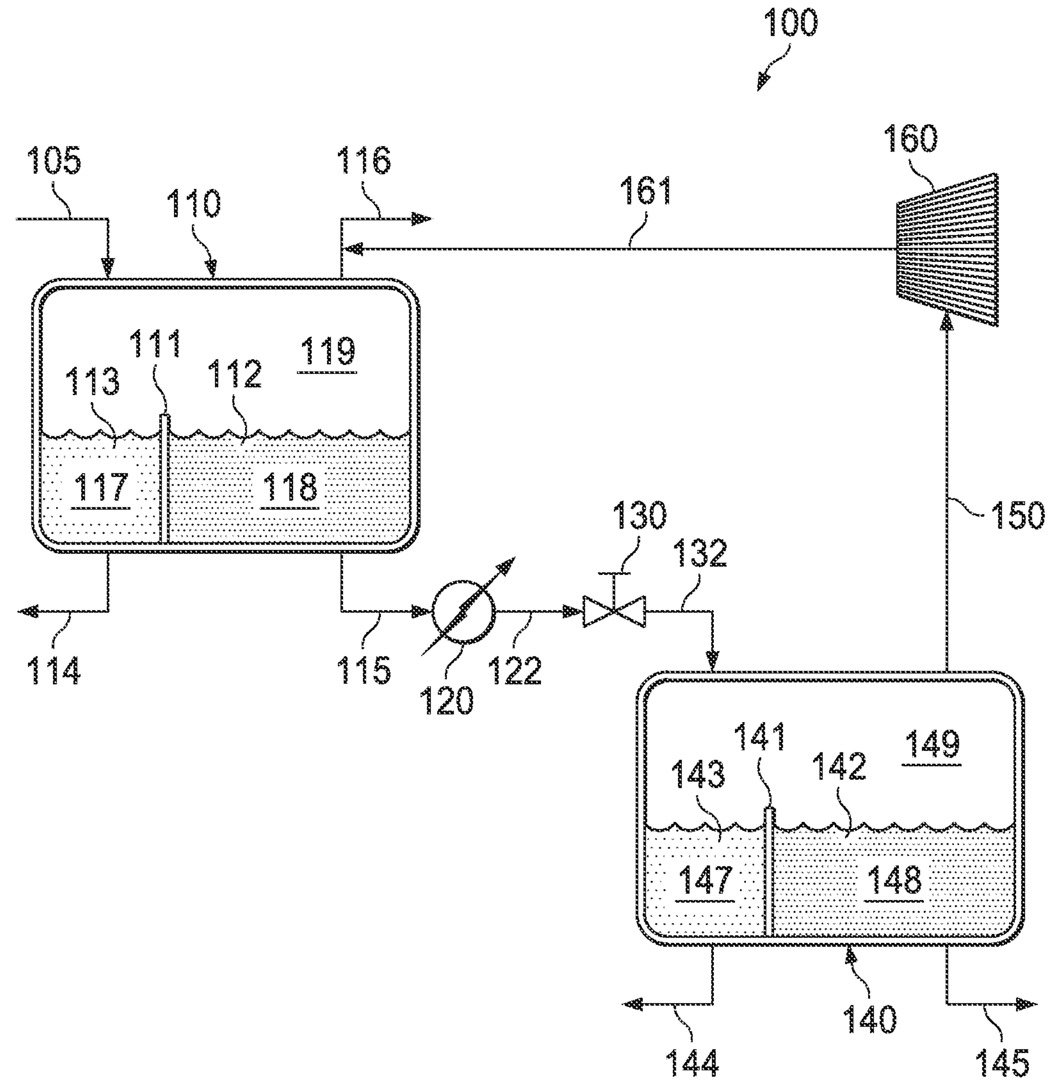
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FIG. 1

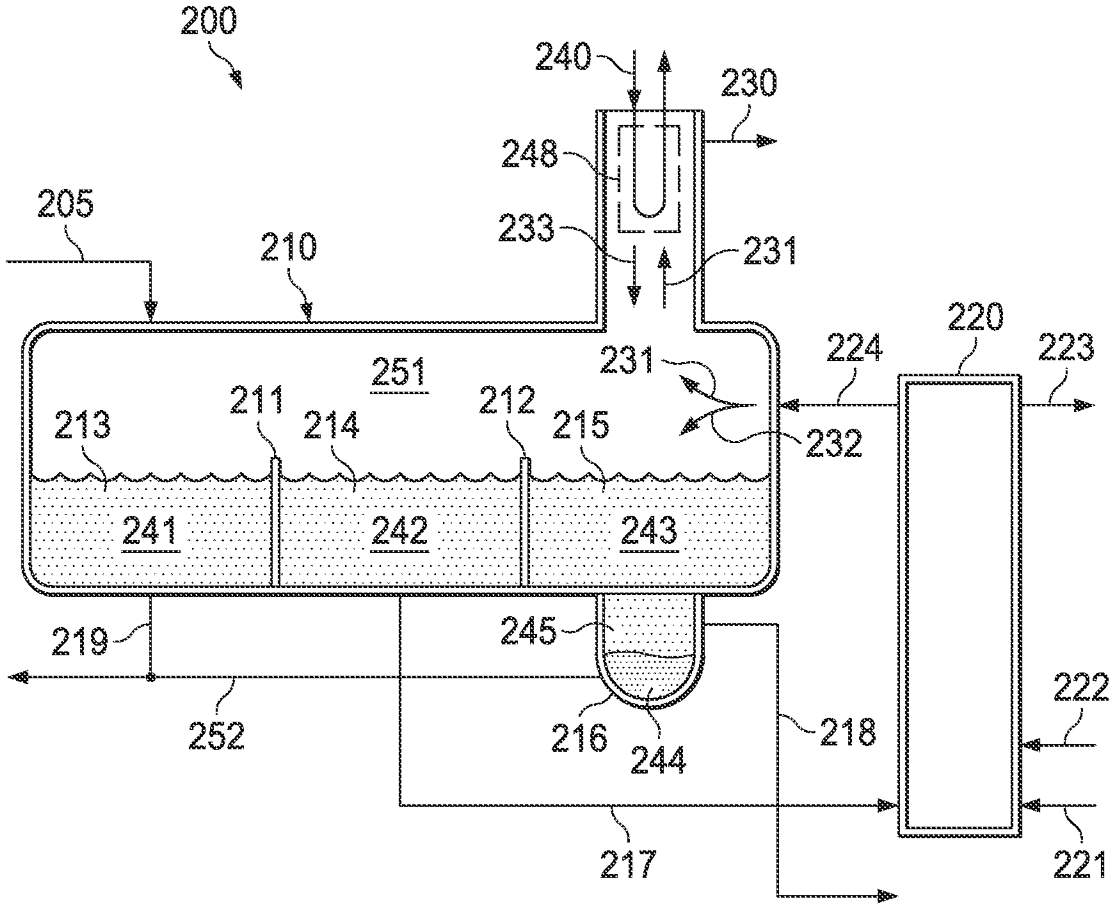

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FIG. 2

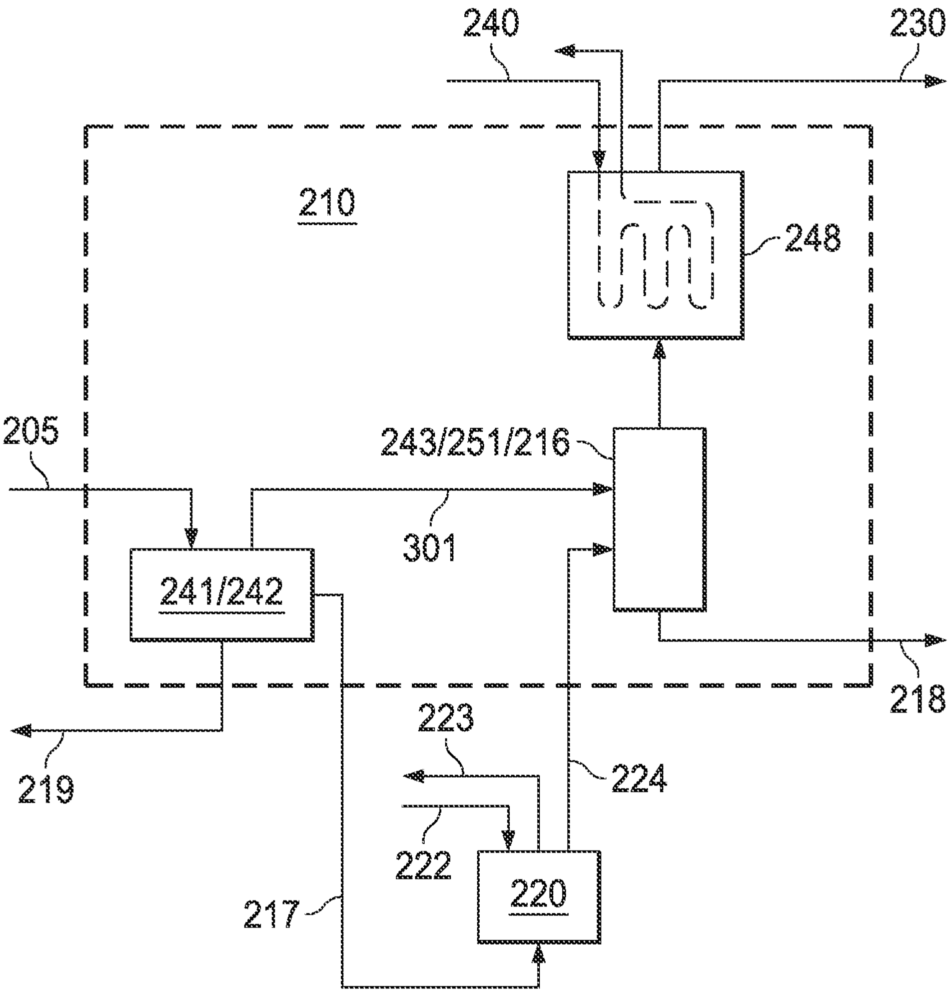
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FIG. 3

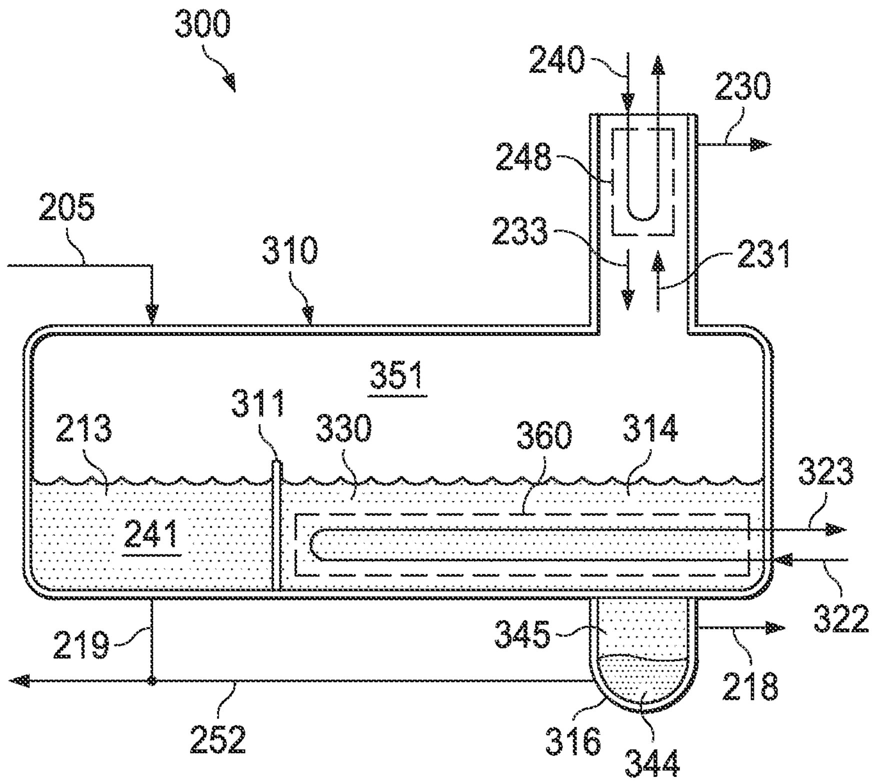
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FIG. 4

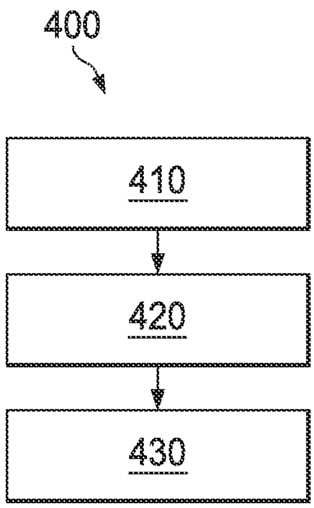
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FIG. 5

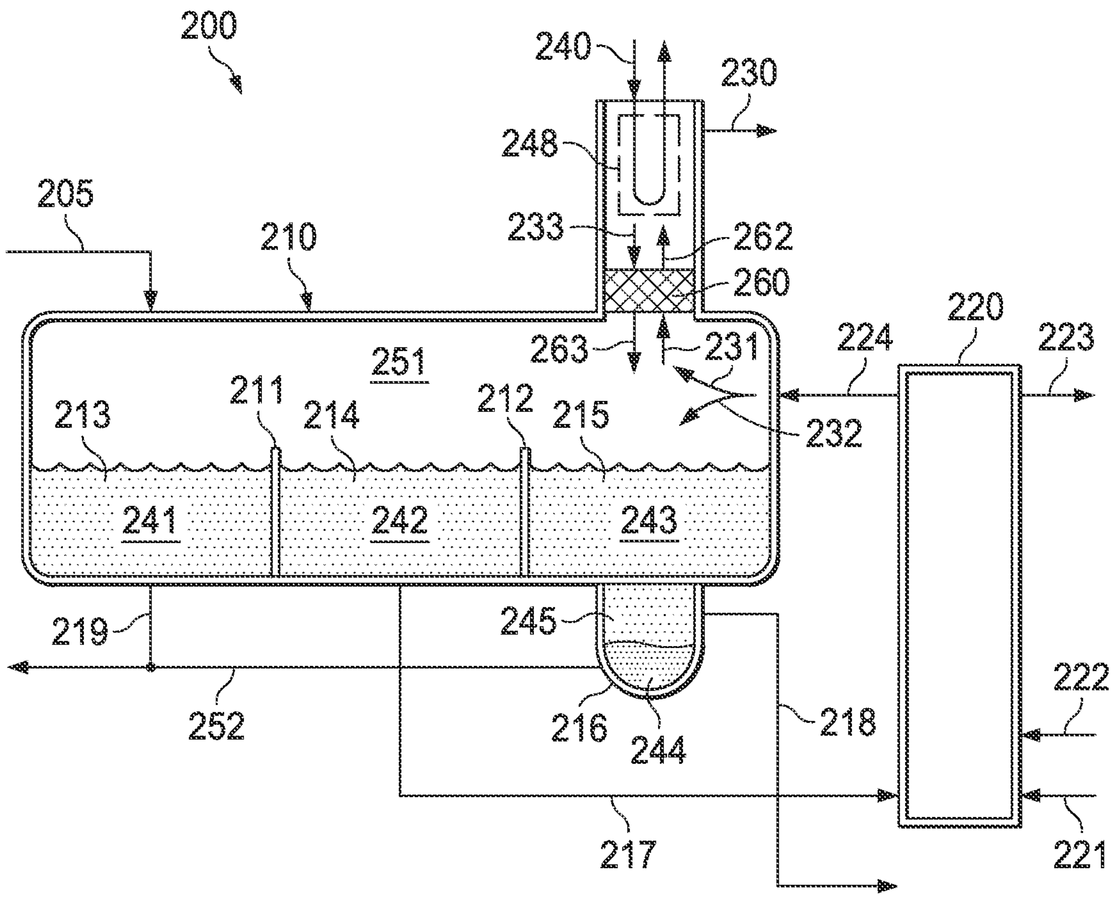

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FIG. 6

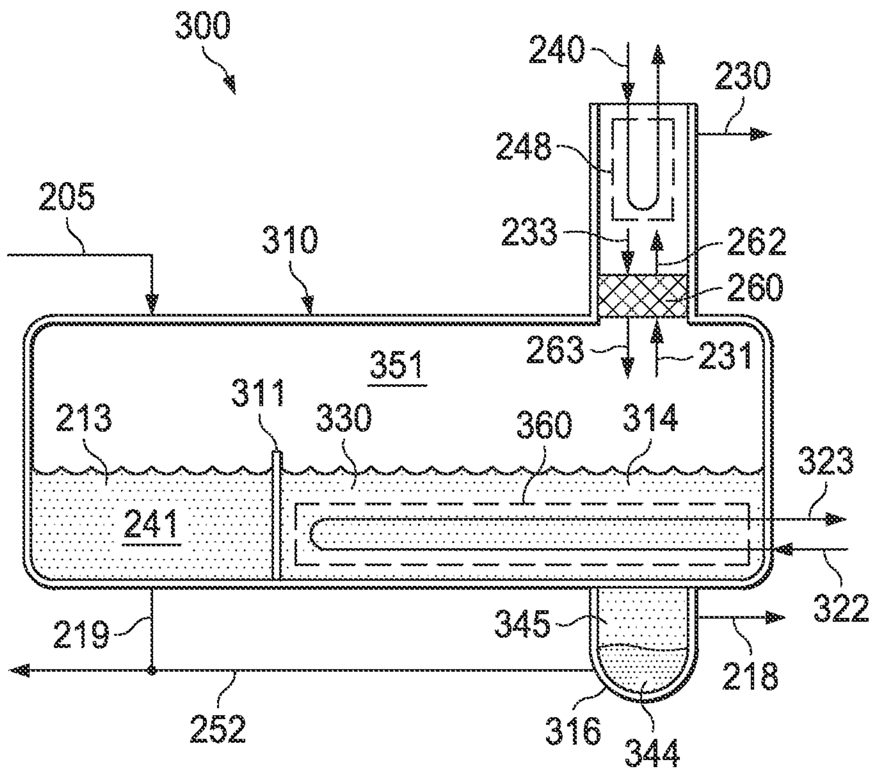

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FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/062890

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D17/02 B01D17/04 B01D19/00 E21B43/34
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 397 206 A1 (SHELL INT RESEARCH [NL]) 21 December 2011 (2011-12-21) paragraphs [0021] - [0041]; figures 1-3	1-4,6, 8-13,15, 16,18,19
X	US 3 664 093 A (MURDOCK FORREST L SR) 23 May 1972 (1972-05-23) fig.4, column 3 line 57 - column 4 line 32	1-4,6,8, 13
X	US 3 009 536 A (GLASGOW CLARENCE O) 21 November 1961 (1961-11-21) fig.3, column 7 line 12 - column 8 line 67	1,3,5,7, 14,17, 20-23
A	US 3 394 530 A (O'NEILL DAVID J ET AL) 30 July 1968 (1968-07-30) figure 1	1-23

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 February 2016	17/02/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Weber, Christian

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/062890

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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