(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 June 2015 (11.06.2015)

(10) International Publication Number
WO 2015/084495 A2

(51) International Patent Classification: Not classified

(21) International Application Number: PCT/US2014/061004

(22) International Filing Date: 17 October 2014 (17.10.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/912,959 6 December 2013 (06.12.2013) US

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: METHOD AND SYSTEM OF MAINTAINING A LIQUID LEVEL IN A DISTILLATION TOWER

(57) **Abstract**: The present disclosure provides a distillation tower that may include a stripper section constructed and arranged to separate a feed stream at a temperature and pressure at which the feed stream forms no solid; a controlled freeze zone section constructed and arranged to separate the feed stream at a temperature and pressure at which the feed stream forms a solid; a melt tray assembly in the controlled freeze zone section that includes a liquid; an underflow weir in the controlled freeze zone section that alters a flow of the liquid in the melt tray assembly; an overflow weir in the controlled freeze zone section that works with the underflow weir to alter the flow of the liquid in the melt tray assembly and is adjacent to the underflow weir; and a covering element in the controlled freeze zone section that is connected to and extends from the underflow weir.

WO 2015/084495 A2

METHOD AND SYSTEM OF MAINTAINING A LIQUID LEVEL IN A DISTILLATION TOWER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority benefit of United States Patent Application 61/912,959 filed December 6, 2013 entitled METHOD AND SYSTEM OF MAINTAINING A LIQUID LEVEL IN A DISTILLATION TOWER, the entirety of which is incorporated by reference herein.

[0002] This application is related to but does not claim priority to U.S. Provisional patent application numbers: 61/912,957 filed on December 6, 2013 entitled METHOD AND DEVICE FOR SEPARATING HYDROCARBONS AND CONTAMINANTS WITH A SPRAY ASSEMBLY; 62/044,770 filed on September 2, 2014 entitled METHOD AND DEVICE FOR SEPARATING HYDROCARBONS AND CONTAMINANTS WITH A SPRAY ASSEMBLY; 61/912,964 filed on December 6, 2013 entitled METHOD AND DEVICE FOR SEPARATING A FEED STREAM USING RADIATION DETECTORS; 61/912,970 filed on December 6, 2013 entitled METHOD AND SYSTEM OF DEHYDRATING A FEED STREAM PROCESSED IN A DISTILLATION TOWER; 61/912,975 filed on December 6, 2013 entitled METHOD AND SYSTEM FOR SEPARATING A FEED STREAM WITH A FEED STREAM DISTRIBUTION MECHANISM; 61/912,978 filed on December 6, 2013 entitled METHOD AND SYSTEM FOR PREVENTING ACCUMULATION OF SOLIDS IN A DISTILLATION TOWER; 61/912,983 filed on December 6, 2013 entitled METHOD OF REMOVING SOLDS BY MODIFYING A LIQUID LEVEL IN A DISTILLATION TOWER; 61/912,984 filed on December 6, 2013 entitled METHOD AND SYSTEM OF MODIFYING A LIQUID LEVEL DURING START-UP OPERATIONS; 61/912,986 filed on December 6, 2013 entitled METHOD AND DEVICE FOR SEPARATING HYDROCARBONS AND CONTAMINANTS WITH A HEATING MECHANISM TO DESTABILIZE AND/OR PREVENT ADHESION OF SOLIDS; 61/912,987 filed on December 6, 2013 entitled METHOD AND DEVICE FOR SEPARATING HYDROCARBONS AND CONTAMINANTS WITH A SURFACE TREATMENT MECHANISM.

BACKGROUND

Fields of Disclosure

[0003] The disclosure relates generally to the field of fluid separation. More specifically, the disclosure relates to the cryogenic separation of contaminants, such as acid gas, from a hydrocarbon.

Description of Related Art

[0004] This section is intended to introduce various aspects of the art, which may be associated with the present disclosure. This discussion is intended to provide a framework to facilitate a better understanding of particular aspects of the present disclosure. Accordingly, it should be understood that this section should be read in this light, and not necessarily as admissions of prior art.

[0005] The production of natural gas hydrocarbons, such as methane and ethane, from a reservoir oftentimes carries with it the incidental production of non-hydrocarbon gases. Such gases include contaminants, such as at least one of carbon dioxide (“CO_2”), hydrogen sulfide (“H_2S”), carbonyl sulfide, carbon disulfide and various mercaptans. When a feed stream being produced from a reservoir includes these contaminants mixed with hydrocarbons, the stream is oftentimes referred to as “sour gas.”

[0006] Many natural gas reservoirs have relatively low percentages of hydrocarbons and relatively high percentages of contaminants. Contaminants may act as a diluent and lower the heat content of hydrocarbons. Some contaminants, like sulfur-bearing compounds, are noxious and may even be lethal. Additionally, in the presence of water some contaminants can become quite corrosive.

[0007] It is desirable to remove contaminants from a stream containing hydrocarbons to produce sweet and concentrated hydrocarbons. Specifications for pipeline quality natural gas typically call for a maximum of 2 – 4% CO_2 and ¼ grain H_2S per 100 scf (4 ppmv) or 5 mg/Nm3 H_2S. Specifications for lower temperature processes such as natural gas liquefaction plants or nitrogen rejection units typically require less than 50 ppm CO_2.

[0008] The separation of contaminants from hydrocarbons is difficult and consequently significant work has been applied to the development of hydrocarbon/contaminant separation methods. These methods can be placed into three general classes: absorption by solvents (physical, chemical and hybrids), adsorption by solids, and distillation.

[0009] Separation by distillation of some mixtures can be relatively simple and, as such, is widely used in the natural gas industry. However, distillation of mixtures of natural gas hydrocarbons, primarily methane, and one of the most common contaminants in natural gas, carbon dioxide, can present significant difficulties. Conventional distillation principles and conventional distillation equipment are predicated on the presence of only vapor and liquid phases throughout the distillation tower. The separation of CO_2 from methane by distillation involves temperature and pressure conditions that result in solidification of CO_2 if a pipeline or better quality hydrocarbon product is desired. The required temperatures are cold temperatures typically referred to as cryogenic temperatures.

[0010] Certain cryogenic distillations can overcome the above mentioned difficulties. These cryogenic distillations provide the appropriate mechanism to handle the formation and subsequent melting of solids during the separation of solid-forming contaminants from hydrocarbons. The formation of solid contaminants in equilibrium with vapor-liquid mixtures of hydrocarbons and contaminants at particular conditions of temperature and pressure takes place in a controlled freeze zone section.

[0011] The solid contaminants formed in the controlled freeze zone section fall into a liquid of the controlled freeze zone section that is held above the melting point of the solid contaminants. The liquid is held at a sufficiently warm temperature to melt the solid contaminants. The liquid is part of a melt tray assembly of the controlled freeze zone section. To ensure that all of the solid contaminants melt in the liquid and none exit the controlled freeze zone section and/or plug a liquid discharge line, there needs to be sufficient warm liquid thermal mass in the controlled freeze zone section. In other words, the liquid in the melt tray assembly needs to at least be at a predetermined liquid level.

[0012] Liquid level indicators, such as differential pressure cells, guided wave radar sensors and a nucleonic mechanism have been used to help determine the liquid level, but these indicators have disadvantages. Differential pressure cells do not work well in determining the liquid level if the solid contaminants plug the differential pressure cells or associated pressure taps. Guided wave radar sensors do not work well because the temperature and pressure of the controlled freeze zone section is too close to the critical conditions of liquid and vapor, thereby making liquid and vapor nearly indistinguishable. Furthermore, compositional and pressure changes of the stream can cause changes in fluid density, making measurements inconsistent over time. The nucleonic mechanism does not work well in the presence of unsteady amounts of solids.

[0013] A need exists for improved technology that maintains at least a predetermined liquid level in a distillation tower so that a minimum warm liquid thermal mass is provided to reliably melt all solid contaminants in the liquid of the melt tray assembly and so that plugging of the controlled freeze zone section liquid discharge is avoided.

SUMMARY

[0014] The present disclosure provides a device and method for separating contaminants from hydrocarbons, among other things.

[0015] A distillation tower may comprise a stripper section constructed and arranged to separate a feed stream at a temperature and pressure at which the feed stream forms no solid; a controlled freeze zone section constructed and arranged to separate the feed stream at a temperature and pressure at which the feed stream forms a solid; a melt tray assembly in the controlled freeze zone section that includes a liquid; an underflow weir in the controlled freeze zone section that alters a flow of the liquid in the melt tray assembly; an overflow weir in the controlled freeze zone section that works with the underflow weir to alter the flow of the liquid in the melt tray assembly and is adjacent to the underflow weir; and a covering element in the controlled freeze zone section that is connected to and extends from the underflow weir.

[0016] A method of maintaining a liquid level in a distillation tower may comprise forming a freezing zone vapor stream from a feed stream in a stripper section of a distillation tower at a temperature and pressure at which no solid forms in the stripper section; forming a solid in a controlled freeze zone section of the distillation tower from the feed stream; and maintaining a predetermined liquid level of liquid in a melt tray assembly of the controlled freeze zone section by: altering a flow of the liquid in the melt tray assembly such that the liquid flows from a bottom melt tray assembly portion of the melt tray assembly to a top melt tray assembly portion of the melt tray assembly; and altering the flow of the liquid in the melt tray assembly such that the liquid flows from the top melt tray assembly portion toward the stripper section.

[0017] A method for producing hydrocarbons may comprise forming a freezing zone vapor stream from a feed stream in a stripper section of a distillation tower at a temperature and pressure at which no solid forms in the stripper section; forming a solid in a controlled freeze zone section of the distillation tower from the feed stream; maintaining a predetermined liquid level of liquid in a melt tray assembly of the controlled freeze zone section by: altering a flow of the liquid in the melt tray assembly such that the liquid flows from a bottom melt tray assembly portion of the melt tray assembly to a top melt tray assembly portion of the melt tray assembly; and altering the flow of the liquid in the melt tray assembly such that the liquid flows from the top melt tray assembly portion toward the stripper section; and producing hydrocarbons from the feed stream.

[0018] The foregoing has broadly outlined the features of the present disclosure in order that the detailed description that follows may be better understood. Additional features will also be described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] These and other features, aspects and advantages of the disclosure will become apparent from the following description, appending claims and the accompanying drawings, which are briefly described below.

[0020] Figure 1 is a schematic diagram of a tower with sections within a single vessel.

[0021] Figure 2 is a schematic diagram of a tower with sections within multiple vessels.

[0022] Figure 3 is a schematic diagram of a tower with sections within a single vessel.

[0023] Figure 4 is a schematic diagram of a tower with sections within multiple vessels.

[0024] Figure 5 is a schematic diagram of a portion of a distillation tower.

[0025] Figure 6 is a schematic diagram of a portion of a distillation tower.

[0026] Figure 7 is a flowchart of a method within the scope of the present disclosure.

[0027] It should be noted that the figures are merely examples and no limitations on the scope of the present disclosure are intended thereby. Further, the figures are generally not drawn to scale, but are drafted for purposes of convenience and clarity in illustrating various aspects of the disclosure.

DETAILED DESCRIPTION

[0028] For the purpose of promoting an understanding of the principles of the disclosure, reference will now be made to the features illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is thereby intended. Any alterations and further modifications, and any further applications of the principles of the disclosure as described herein are contemplated as would normally occur to one skilled in the art to which the disclosure relates. It will be apparent to those skilled in the relevant art that some features that are not relevant to the present disclosure may not be shown in the drawings for the sake of clarity.

[0029] As referenced in this application, the terms “stream,” “gas stream,” “vapor stream,” and “liquid stream” refer to different stages of a feed stream as the feed stream is processed in a distillation tower that separates methane, the primary hydrocarbon in natural gas, from contaminants. Although the phrases “gas stream,” “vapor stream,” and “liquid stream,” refer to situations where a gas, vapor, and liquid is mainly present in the stream, respectively, there may be other phases also present within the stream. For example, a gas may also be present in a “liquid stream.” In some instances, the terms “gas stream” and “vapor stream” may be used interchangeably.

[0030] The disclosure relates to a system and method for separating a feed stream in a distillation tower. The system and method maintains a predetermined liquid level in the controlled freeze zone section. Figures 1-7 of the disclosure display various aspects of the system and method.

[0031] The system and method may separate a feed stream having methane and contaminants. The system may comprise a distillation tower **104**, **204** (Figures 1-2). The distillation tower **104**, **204** may separate the contaminants from the methane.

[0032] The distillation tower **104**, **204** may be separated into three functional sections: a lower section **106**, a middle controlled freeze zone section **108** and an upper section **110**. The distillation tower **104**, **204** may incorporate three functional sections when the upper section **110** is needed and/or desired.

[0033] The distillation tower **104**, **204** may incorporate only two functional sections when the upper section **110** is not needed and/or desired. When the distillation tower does not include an upper section **110**, a portion of vapor leaving the middle controlled freeze zone section **108** may be condensed in a condenser **122** and returned as a liquid stream via a spray assembly **129**. Moreover, lines **18** and **20** may be eliminated, elements **124** and **126** may be one and the same, and elements **150** and **128** may be one and the same. The stream in line **14**, now taking the vapors leaving the middle controlled freeze section **108**, directs these vapors to the condenser **122**.

[0034] The lower section **106** may also be referred to as a stripper section. The middle controlled section **108** may also be referred to as the controlled freeze zone section. The upper section **110** may also be referred to as a rectifier section.

[0035] The sections of the distillation tower **104** may be housed within a single vessel (Figures 1 and 3). For example, the lower section **106**, the middle controlled freeze zone section **108**, and the upper section **110** may be housed within a single vessel **164**.

[0036] The sections of the distillation tower **204** may be housed within a plurality of vessels to form a split-tower configuration (Figures 2 and 4). Each of the vessels may be separate from the other vessels. Piping and/or another suitable mechanism may connect one vessel to another vessel. In this instance, the lower section **106**, middle controlled freeze zone section **108** and upper section **110** may be housed within two or more vessels. For example, as shown in Figures 2 and 4, the upper section **110** may be housed within a single vessel **254** and the lower and middle controlled freeze zone sections **106**, **108** may be housed within a single vessel **264**. When this is the case, a liquid stream exiting the upper section **110**, may exit through a liquid outlet bottom **260**. The liquid outlet bottom **260** is at the bottom of the upper section **110**. Although not shown, each of the sections may be housed within its own separate vessel, or one or more section may be housed within separate vessels, or the upper and middle controlled freeze zone sections may be housed within a single vessel and the lower section may be housed within a single vessel, etc. When sections of the distillation tower are housed within vessels, the vessels may be side-by-side along a horizontal line and/or above each other along a vertical line.

[0037] The split-tower configuration may be beneficial in situations where the height of the distillation tower, motion considerations, and/or transportation issues, such as for remote locations, need to be considered. This split-tower configuration allows for the independent operation of one or more sections. For example, when the upper section is housed within a single vessel and the lower and middle controlled freeze zone sections are housed within a single vessel, independent generation of reflux liquids using a substantially contaminant-free, largely hydrocarbon stream from a packed gas pipeline or an adjacent hydrocarbon line, may occur in the upper section. And the reflux may be used to cool the upper section, establish an appropriate temperature profile in the upper section, and/or build up liquid inventory at the bottom of the upper section to serve as an initial source of spray liquids for the middle controlled freeze zone section. Moreover, the middle controlled freeze zone and lower sections may be independently prepared by chilling the feed stream, feeding it to the optimal location be that in the lower section or in the middle controlled freeze zone section, generating liquids for the lower and the middle controlled freeze zone sections, and/or disposing the vapors off the middle controlled freeze zone section while they are off specification with too high a contaminant content. Also, liquid from the upper section may be intermittently or continuously sprayed, building up liquid level in the bottom of the middle controlled freeze zone section and bringing the contaminant content in the middle controlled freeze zone section down and near steady state level so that the two vessels may be connected to send the vapor stream from the middle controlled freeze zone section to the upper section, continuously spraying liquid from the bottom of the upper section into the middle controlled freeze zone section and stabilizing operations into steady state conditions. The split tower configuration may utilize a sump of the upper section as a liquid receiver for the pump **128**, therefore obviating the need for a liquid receiver **126** in Figures 1 and 3.

[0038] The system may also include a heat exchanger **100** (Figures 1-4). The feed stream **10** may enter the heat exchanger **100** before entering the distillation tower **104**, **204**. The feed stream **10** may be cooled within the heat exchanger **100**. The heat exchanger **100** helps drop the temperature of the feed stream **10** to a level suitable for introduction into the distillation tower **104**, **204**.

[0039] The system may include an expander device **102** (Figures 1-4). The feed stream **10** may enter the expander device **102** before entering the distillation tower **104**, **204**. The feed stream **10** may be expanded in the expander device **102** after exiting the heat exchanger **100**. The expander device **102** helps drop the temperature of the feed stream **10** to a level suitable for introduction into the distillation tower **104**, **204**. The expander device **102** may be any suitable device, such as a valve. If the expander device **102** is a valve, the valve may be any suitable valve that may aid in cooling the feed stream **10** before it enters the distillation tower **104**, **204**. For example, the valve **102** may comprise a Joule-Thompson (J-T) valve.

[0040] The system may include a feed separator **103** (Figures 3-4). The feed stream may enter the feed separator before entering the distillation tower **104**, **204**. The feed separator may separate a feed stream having a mixed liquid and vapor stream into a liquid stream and a vapor stream. Lines **12** may extend from the feed separator to the distillation tower **104**, **204**. One of the lines **12** may receive the vapor stream from the feed separator. Another one of the lines **12** may receive the liquid stream from the feed separator. Each of the lines **12** may extend to the same and/or different sections (i.e. middle controlled freeze zone, and lower sections) of the distillation tower **104**, **204**. The expander device **102** may or may not be downstream of the feed separator **103**. The expander device **102** may comprise a plurality of expander devices **102** such that each line **12** has an expander device **102**.

[0041] The system may include a dehydration unit **261** (Figures 1-4). The feed stream **10** may enter the dehydration unit **261** before entering the distillation tower **104**, **204**. The feed stream **10** enters the dehydration unit **261** before entering the heat exchanger **100** and/or the expander device **102**. The dehydration unit **261** removes water from the feed stream **10** to prevent water from later presenting a problem in the heat exchanger **100**, expander device **102**, feed separator **103**, or distillation tower **104**, **204**. The water can present a problem by forming a separate water phase (i.e., ice and/or hydrate) that plugs lines, equipment or negatively affects the distillation process. The dehydration unit **261** dehydrates the feed stream to a dew point sufficiently low to ensure a separate water phase does not form at any point downstream during the rest of the process. The dehydration unit may be any suitable dehydration mechanism, such as a molecular sieve or a glycol dehydration unit.

[0042] The system may include a filtering unit (not shown). The feed stream **10** may enter the filtering unit before entering the distillation tower **104**, **204**. The filtering unit may remove undesirable contaminants from the feed stream before the feed stream enters the distillation tower **104**, **204**. Depending on what contaminants are to be removed, the filtering unit may be before or after the dehydration unit **261** and/or before or after the heat exchanger **100**.

[0043] The system may include a line **12** (Figures 1-4). The line may also be referred to as an inlet channel **12**. The feed stream **10** may be introduced into the distillation tower **104**, **204** through the line **12**. The line **12** may extend to the lower section **106** or the middle controlled freeze zone section **108** of the distillation tower **104**, **204**. For example, the line **12** may extend to the lower section **106** such that the feed stream **10** may enter the lower section **106** of the distillation tower **104**, **204** (Figures 1-4). The line **12** may directly or indirectly extend to the lower section **106** or the middle controlled freeze zone section **108**. The line **12** may extend to an outer surface of the distillation tower **104**, **204** before entering the distillation tower.

[0044] If the system includes the feed separator **103** (Figures 3-4), the line **12** may comprise a plurality of lines **12**. Each line may be the same line as one of the lines that extends from the feed separator to a specific portion of the distillation tower **104**, **204**.

[0045] The lower section **106** is constructed and arranged to separate the feed stream **10** into an enriched contaminant bottom liquid stream (i.e., liquid stream) and a freezing zone vapor stream (i.e., vapor stream), **301**. The lower section **106** separates the feed stream at a temperature, pressure, and/or composition at which no solids form. The liquid stream may comprise a greater quantity of contaminants than of methane. The vapor stream may comprise a greater quantity of methane than of contaminants. In any case, the vapor stream is lighter than the liquid stream. As a result, the vapor stream rises from the lower section **106** and the liquid stream falls to the bottom of the lower section **106**.

[0046] The lower section **106** may include and/or connect to equipment that separates the feed stream. The equipment may comprise any suitable equipment for separating methane from contaminants, such as one or more packed sections **181**, or one or more distillation trays with perforations, downcomers and weirs (Figures 1-4).

[0047] The equipment may include components that apply heat to the stream to form the vapor stream and the liquid stream. For example, the equipment may comprise a first reboiler **112** that applies heat to the stream. The first reboiler **112** may be located outside of the distillation tower **104**, **204**. The equipment may also comprise a second reboiler **172** that applies heat to the stream. The second reboiler **172** may be located outside of the distillation tower **104**, **204**. Line **117** may lead from the distillation tower to the second reboiler **172**. Line **17** may lead from the second reboiler **172** to the distillation tower. Additional reboilers, set up similarly to the second reboiler described above, may also be used.

[0048] The first reboiler **112** may apply heat to the liquid stream that exits the lower section **106** through a liquid outlet **160** of the lower section **106**. The liquid stream may travel from the liquid outlet **160** through line **28** to reach the first reboiler **112** (Figures 1-4). The amount of heat applied to the liquid stream by the first reboiler **112** can be increased to separate more methane from contaminants. The more heat applied by the reboiler **112** to the stream, the more methane separated from the liquid contaminants, though more contaminants will also be vaporized.

[0049] The first reboiler **112** may also apply heat to the stream within the distillation tower **104, 204**. Specifically, the heat applied by the first reboiler **112** warms up the lower section **106**. This heat travels up the lower section **106** and supplies heat to warm solids entering a melt tray assembly **139** (Figures 1-2) of the middle controlled freeze zone section 108 so that the solids form a liquids and/or slurry mix.

[0050] The second reboiler **172** applies heat to the stream within the lower section **106**. This heat is applied closer to the middle controlled freeze zone section **108** than the heat applied by the first reboiler **112**. As a result, the heat applied by the second reboiler **172** reaches the middle controlled freeze zone section **108** faster than the heat applied by the first reboiler **112**. The second reboiler **172** also helps with energy integration.

[0051] The equipment may include one or more chimney assemblies **135** (Figures 1-4). While falling to the bottom of the lower section **106**, the liquid stream may encounter one or more of the chimney assemblies **135**.

[0052] Each chimney assembly **135** includes a chimney tray **131** that collects the liquid stream within the lower section **106**. The liquid stream that collects on the chimney tray **131** may be fed to the second reboiler **172**. After the liquid stream is heated in the second reboiler **172**, the stream may return to the middle controlled freeze zone section **106** to supply heat to the middle controlled freeze zone section **106** and/or the melt tray assembly **139**. Unvaporized stream exiting the second reboiler **172** may be fed back to the distillation tower **104**, **204** below the chimney tray **131**. Vapor stream exiting the second reboiler **172** may be routed under or above the chimney tray **131** when the vapor stream enters the distillation tower **104**, **204**.

[0053] The chimney tray **131** may include one or more chimneys **137**. The chimney **137** serves as a channel that the vapor stream in the lower section **106** traverses. The vapor stream travels through an opening in the chimney tray **131** at the bottom of the chimney **137** to the top of the chimney **137**. The opening is closer to the bottom of the lower section **106** than it is to the bottom of the middle controlled freeze zone section **108**. The top is closer to the bottom of the middle controlled freeze zone section **108** than it is to the bottom of the lower section **106**.

[0054] Each chimney **137** has attached to it a chimney cap **133**. The chimney cap **133** covers a chimney top opening **138** of the chimney **137**. The chimney cap **133** prevents the liquid stream from entering the chimney **137**. The vapor stream exits the chimney assembly **135** via the chimney top opening **138**.

[0055] After falling to the bottom of the lower section **106**, the liquid stream exits the distillation tower **104**, **204** through the liquid outlet **160**. The liquid outlet **160** is within the lower section **106** (Figures 1-4). The liquid outlet **160** may be located at the bottom of the lower section **106**.

[0056] After exiting through the liquid outlet **160**, the feed stream may travel via line **28** to the first reboiler **112**. The feed stream may be heated by the first reboiler **112** and vapor may then re-enter the lower section **106** through line **30**. Unvaporized liquid may continue out of the distillation process via line **24**.

[0057] The system may include an expander device **114** (Figures 1-4). After entering line **24**, the heated liquid stream may be expanded in the expander device **114**. The expander device **114** may be any suitable device, such as a valve. The valve **114** may be any suitable valve, such as a J-T valve.

[0058] The system may include a heat exchanger **116** (Figures 1-4). The liquid stream heated by the first reboiler **112** may be cooled or heated by the heat exchanger **116**. The heat exchanger **116** may be a direct heat exchanger or an indirect heat exchanger. The heat exchanger **116** may comprise any suitable heat exchanger.

[0059] The vapor stream in the lower section **106** rises from the lower section **106** to the middle controlled freeze zone section **108**. The middle controlled freeze zone section **108** is constructed and arranged to separate the feed stream **10** introduced into the middle controlled freeze zone section, or into the top of lower section **106**, into a solid and a vapor stream. The solid may be comprised more of contaminants than of methane. The vapor stream (i.e., methane-enriched vapor stream) may comprise more methane than contaminants. The middle controlled freeze zone section **108** operates at least one of a temperature, pressure and composition at which the feed stream forms the solid and the vapor stream **302** (Figure 7).

[0060] The middle controlled freeze zone section **108** includes a lower section **40** and an upper section **39** (Figure 5). The lower section **40** is below the upper section **39**. The lower section **40** directly abuts the upper section **39**. The lower section **40** is primarily but not exclusively a heating section of the middle controlled freeze zone section **108**. The upper section **39** is primarily but not exclusively a cooling section of the middle controlled freeze zone section **108**. At least one of the temperature, pressure, and/or composition of the upper section **39** is chosen so that the solid can form in the middle controlled freeze zone section **108**.

[0061] The middle controlled freeze zone section **108** may comprise a melt tray assembly **139** that is maintained in the middle controlled freeze zone section **108** (Figures 1-5). The melt tray assembly **139** is within the lower section **40** of the middle controlled freeze section **108**. The melt tray assembly **139** is not within the upper section **39** of the middle controlled freeze zone section **108**.

[0062] The melt tray assembly **139** is constructed and arranged to melt solids formed in the middle controlled freeze zone section **108**. When the warm vapor stream rises from the lower section **106** to the middle controlled freeze zone section **108**, the vapor stream immediately encounters the melt tray assembly **139** and supplies heat to melt the solids. The melt tray assembly **139** may comprise at least one of a melt tray **118**, a bubble cap **132**, a liquid **130** and heat mechanism(s) **134**.

[0063] The melt tray **118** may collect a liquid and/or slurry mix. The melt tray **118** divides at least a portion of the middle controlled freeze zone section **108** from the lower section **106**. Consequently, the melt tray **118** is at the bottom **45** of the middle controlled freeze zone section **108**.

[0064] One or more bubble caps **132** may act as a channel for the vapor stream rising from the lower section **106** to the middle controlled freeze zone section **108**. The bubble cap **132** may provide a path for the vapor stream up the riser **140** and then down and around the riser **140** to the melt tray **118**. The riser **140** is covered by a cap **141**. The cap **141** prevents the liquid **130** from travelling into the riser and it also helps prevent solids from travelling into the riser **140**. The vapor stream's traversal through the bubble cap **132** allows the vapor stream to transfer heat to the liquid **130** within the melt tray assembly **139**.

[0065] One or more heat mechanisms **134** may further heat up the liquid **130** to facilitate melting of the solids into a liquid and/or slurry mix. The heat mechanism(s) **134** may be located anywhere within the melt tray assembly **139**. For example, as shown in Figures 1-4, a heat mechanism **134** may be located around bubble caps **132**. The heat mechanism **134** may be any suitable mechanism, such as a heat coil. The heat source of the heat mechanism **134** may be any suitable heat source. .

[0066] The liquid **130** in the melt tray assembly is heated by the vapor stream. The liquid **130** may also be heated by the one or more heat mechanisms **134**. The liquid **130** helps melt the solids formed in the middle controlled freeze zone section **108** into a liquid and/or slurry mix. Specifically, the heat transferred by the vapor stream heats up the liquid, thereby enabling the heat to melt the solids.

[0067] The liquid **130** accumulates in the melt tray assembly **139**. The liquid **130** rises to reach a certain liquid level **217**. For all of the solids to melt, the liquid level **217** needs to at least be equal to a predetermined liquid level. The predetermined liquid level is one that provides a sufficient warm thermal mass to reliably melt all solids. When the liquid level is at least at this predetermined liquid level, it is more likely that the middle controlled freeze zone section **108** will operate properly by forming solids and vapors and melting the solids in the melt tray assembly **139**, such that the methane in the feed stream is separated out from the contaminants in the feed stream.

[0068] The middle controlled freeze zone section **108** may also comprise an underflow weir **216** and an overflow weir **215** (Figures 5-6). The underflow weir **216** and the overflow weir **215** work together to alter the flow of the liquid in the melt tray assembly **139** to help the liquid at least be at the predetermined liquid level **303** (Figure 7). The overflow weir **215** may be directly adjacent to the underflow weir **216**. The overflow weir **215** may also be directly adjacent to the controlled freeze zone wall **46** of the middle controlled freeze zone section **108**.

[0069] Without both an overflow weir **215** and an underflow weir **216**, solids and/or colder liquid may fall from the middle controlled freeze zone section **108** to the lower section **106**, thereby preventing adequate separation of the feed stream. The solids may fall, for example, if the middle controlled freeze zone section **108** only includes an overflow weir **215** because solids may fall between the overflow weir **215** and a controlled freeze zone wall **46** of the middle controlled freeze zone section **108**. The colder liquid may fall, for example, because the colder liquid is at the top of the melt tray assembly **139** and, therefore, the most likely to travel over the overflow weir **216** and down to the bottom distillation section **106**. The warmer liquid, which is what is most desired to fall to the bottom distillation section **106**, is at the bottom of the melt tray assembly **139**.

[0070] With both the overflow weir **215** and the underflow weir **216**, the warmer liquid at the bottom of the melt tray assembly **139** flows to the bottom distillation section **106**. The underflow weir **216** alters the flow of the liquid such that the liquid flows from a melt tray assembly bottom portion **230** of the melt tray assembly **139** to a melt tray assembly top portion **231** of the melt tray assembly **139**, **304** (Figure 7). When the liquid flows from the melt tray assembly bottom portion **230**, the liquid flows through an underflow gap **290**

(Figures 5-6) of the underflow weir **216** to in between the underflow weir **216** and the overflow weir **215** and then to the melt tray assembly top portion **231**. From there the overflow weir **215** alters the flow of the liquid such that the liquid flows from the melt tray assembly top portion **231** toward the lower section **106**, **305** (Figure 7). When the liquid flows from the melt tray assembly top portion **231**, the liquid travels through an overflow gap **291** (Figures 5-6) of the overflow weir **215** and then travels between the overflow weir **215** and the controlled freeze zone wall **46** toward the lower section **106**.

[0071] When the warmer liquid travels between the overflow weir **215** and the controlled freeze zone wall **46** the warmer liquid may directly or indirectly travel from the middle controlled freeze zone section **108** to the lower section **106**. A channel **22** (Figures 5-6) may connect the middle controlled freeze zone section **108** to the lower section **106**.

[0072] The channel **22** may comprise an internal channel **22a** (Figure 5). The internal channel **22a** is inside of the middle controlled freeze zone section **108** and the lower section **106** (Figure 5). The internal channel **22a** includes the overflow weir **215**. The internal channel **22a** separates the controlled freeze zone wall **46** from the overflow weir **215**. The internal channel **22a** may or may not include a flow control device. When the internal channel **22a** includes a flow control device (not shown), the maximum liquid level of the liquid **130** can fluctuate. The flow control device regulates the amount of liquid that flows from the middle controlled freeze zone section **108** to the lower section **106**. For example, when the flow control device is fully open, the maximum liquid level is the predetermined liquid level set by the overflow weir **215** and when the flow control device is fully closed the maximum liquid level is greater than the predetermined liquid level. The higher liquid level allowed by the partially or fully closed flow control device allows for the liquid to melt solids that may accumulate above the predetermined liquid level if the liquid remains at the higher level for a sufficient period of time. A sufficient period of time may be, for example, from 5 to 30 minutes. The flow control device may be any suitable device, such as a sliding port or a control valve. When the internal channel **22a** does not include a flow control device (Figure 5), the maximum liquid level is the predetermined liquid level.

[0073] The channel **22** may comprise an external channel **22b**. The external channel **22b** is outside of the middle controlled freeze zone section **108** and the lower section **106** (Figure 6). The external channel **22b** is not within the distillation tower **104**, **204**. The external channel **22b** may or may not include a flow control device. When the external channel **22b**

includes a flow control device **23** (Figure 6), the maximum liquid level of the liquid **130** can fluctuate. The flow control device **23** regulates the amount of liquid that flows from the middle controlled freeze zone section **108** to the lower section **106**. For example, when the flow control device is fully open, the maximum liquid level is the predetermined liquid level set by the overflow weir **215** and when the flow control device is fully closed the maximum liquid level is greater than the predetermined liquid level. The higher liquid level allowed by the partially or fully closed flow control device **23** allows for the liquid to melt solids that may accumulate above the predetermined liquid level if the liquid remains at the higher level for a sufficient period of time. A sufficient period of time may be, for example, from 5 to 30 minutes. The flow control device **23** may be any suitable device, such as a control valve or a sliding port. When the external channel **22b** does not include a flow control device (not shown), the maximum liquid level is the predetermined liquid level.

[0074] While the above two paragraphs discuss the channel **22** comprising an internal channel **22a** or an external channel **22b**, the channel **22** could comprise an internal channel **22a** and an external channel **22b**.

[0075] To prevent solids from falling between the overflow weir **215** and the controlled freeze zone wall **46** and undesirably exiting to the lower section **106**, the middle controlled freeze zone section **108** may include a covering element **213** (Figures 5-6). The covering element **213** may also help prevent accumulation of solid in the middle controlled freeze zone section **108** by having a suitably steep angle **296**. The angle **296** may be any angle within and including the range of 1 to 45 degrees relative to the controlled freeze zone wall **46**. The covering element **213** is connected to and extends from the underflow weir **216**. The covering element **213** extends from the underflow weir **216** toward the controlled freeze zone wall **46** (Figures 5-6). The covering element **213** may be detached from the controlled freeze zone wall **46** (Figures 5-6). The covering element **213** may extend toward the overflow weir **215** from the underflow weir **216** and over the overflow weir **215**. The covering element **213** may be detached from the overflow weir **215**. Because the covering element **213** extends from the underflow weir **216** toward the controlled freeze zone wall **46**, solids that could otherwise fall between the underflow weir **215**, the overflow weir **216** and/or the controlled freeze zone wall **46** if there was no covering element **213**, are prevented from falling between the overflow weir **215** and the controlled freeze zone wall **46**. Additionally or alternatively, solids may also be prevented from falling between the overflow weir **215** and the underflow weir **216**.

[0076] Vapor may accumulate in the space between the controlled freeze zone wall **46** and the overflow weir **215** when the warm liquid reaches this space. To prevent accumulation of the vapor in the middle controlled freeze zone section **108** while altering the flow of the liquid, the middle controlled freeze zone section **108** may include an anti-vapor lock **214**. If the vapor accumulates, it may be stuck between the controlled freeze zone wall **46** and the overflow weir **215** without an anti-vapor lock. The anti-vapor lock may extend from the controlled freeze zone wall **46** to the covering element **213**.

[0077] The anti-vapor lock **214** may extend from the controlled freeze zone wall **46** to the covering element **213** at an acute angle to the controlled freeze zone wall **46**. The anti-vapor lock **214** may be at a suitable angle **295** (Figures 5-6) to prevent solids accumulations. For example, the anti-vapor lock **214** may be any angle **295** including and within the range of 1 to 45 degrees relative to the controlled freeze zone wall **46**.

[0078] There is a gap **293** (Figures 5-6) between the end of the anti-vapor lock **214** that is closest to an end of the covering element **213** . The gap **293** between the end of the covering element **213** and the anti-vapor lock **214** can provide anti-vapor lock capabilities. The gap **293** allows vapor, which would otherwise be stuck between the controlled freeze zone wall **46** and the overflow weir **215**, to exit the space between the controlled freeze zone wall **46** and the overflow weir **215** and flow upwards toward the upper section **39** of the middle controlled freeze zone section **108**. The gap **293** is wide enough to prevent solids from plugging the gap (e.g., greater than 0.5 cm). The gap **293** can also prevent solids from falling between the overflow weir **215** and the controlled freeze zone wall **46** to the lower section **106**.

[0079] The underflow weir **216** may comprise a plurality of underflow weirs and/or the overflow weir **215** may comprise a plurality of overflow weirs **215**. When the system comprises one or more underflow weirs **216** and/or one or more overflow weirs **215**, the weirs may be positioned at any suitable place within the lower portion of the middle controlled freeze zone section **108**. For example, one underflow weir **216** and one overflow weir **215** may be on a left side **46a** of the controlled freeze zone wall **46** while a second underflow weir **216** and a second overflow weir **215** may be on a right side **46b** of the controlled freeze zone wall **46**.

[0080] In addition to the underflow weir **216** and overflow weir **215**, and despite their potential limitations, the middle controlled freeze zone section **108** may comprise a liquid level indicator **212** (Figures 5-6). The liquid level indicator **212** may be constructed and arranged to detect the liquid level of the liquid **130**. The liquid level indicator **212** may be any suitable liquid level indicator **212**. For example, the liquid level indicator **212** may be at least one of differential pressure cells, guided wave radar sensors and a nucleonic mechanism. The nucleonic mechanism may comprise, for example, the radiation detector and radiation source disclosed in the application entitled “Method and Device for Separating a Feed Stream Using Radiation Detectors” (USSN 61/912,964) by Jaime Valencia et al. and having the same priority date as this disclosure.

[0081] The middle controlled freeze zone section **108** may also comprise a spray assembly **129**. The spray assembly **129** cools the vapor stream that rises from the lower section **40**. The spray assembly **129** sprays liquid, which is cooler than the vapor stream, on the vapor stream to cool the vapor stream. The spray assembly **129** is within the upper section **39**. The spray assembly **129** is not within the lower section **40**. The spray assembly **129** is above the melt tray assembly **139**. In other words, the melt tray assembly **139** is below the spray assembly **129**.

[0082] The spray assembly **129** includes one or more spray nozzles **120** (Figures 1-4). Each spray nozzle **120** sprays liquid on the vapor stream. The spray assembly **129** may also include a spray pump **128** (Figures 1-4) that pumps the liquid. Instead of a spray pump **128**, gravity may induce flow in the liquid.

[0083] The liquid sprayed by the spray assembly **129** contacts the vapor stream at a temperature and pressure at which solids form. The liquid may also contact the vapor stream at a composition at which solids form. Solids, containing mainly contaminants, form when the sprayed liquid contacts the vapor stream (Figure 7). The solids fall toward the melt tray assembly **139**.

[0084] The temperature in the middle controlled freeze zone section **108** cools down as the vapor stream travels from the bottom of the middle controlled freeze zone section **108** to the top of the middle controlled freeze zone section **108**. The methane in the vapor stream rises from the middle controlled freeze zone section **108** to the upper section **110**. Some contaminants may remain in the methane and also rise. The contaminants in the vapor stream tend to condense or solidify with the colder temperatures and fall to the bottom of the middle controlled freeze zone section **108**.

[0085] The solids form the liquid and/or slurry mix when in the liquid **130**. The liquid and/or slurry mix flows from the middle controlled freeze zone section **108** to the lower distillation section **106**. The liquid and/or slurry mix flows from the bottom of the middle controlled freeze zone section **108** to the top of the lower section **106** via a line **22** (Figures 1-4). The line **22** may be an exterior line. The line **22** may extend from the distillation tower **104**, **204**. The line **22** may extend from the middle controlled freeze zone section **108**. The line may extend to the lower section **106**. The line **22** may extend from an outer surface of the distillation tower **104**, **204**.

[0086] The vapor stream that rises in the middle controlled freeze zone section **108** and does not form solids or otherwise fall to the bottom of the middle controlled freeze zone section **108**, rises to the upper section **110**. The upper section **110** operates at, at least one of a temperature, a pressure and a composition and contaminant concentration at which no solid forms. The upper section **110** is constructed and arranged to cool the vapor stream to separate the methane from the contaminants. Reflux in the upper section **110** cools the vapor stream. The reflux is introduced into the upper section **110** via line **18**. Line **18** may extend to the upper section **110**. Line **18** may extend from an outer surface of the distillation tower **104**, **204**.

[0087] After contacting the reflux in the upper section **110**, the feed stream forms a vapor stream and a liquid stream. The vapor stream mainly comprises methane. The liquid stream comprises relatively more contaminants. The vapor stream rises in the upper section **110** and the liquid falls to a bottom of the upper section **110**.

[0088] To facilitate separation of the methane from the contaminants when the stream contacts the reflux, the upper section **110** may include one or more mass transfer devices **176**. Each mass transfer device **176** helps separate the methane from the contaminants. Each mass transfer device **176** may comprise any suitable separation device, such as a tray with perforations, or a section of random or structured packing to facilitate contact of the vapor and liquid phases.

[0089] After rising, the vapor stream may exit the distillation tower **104**, **204** through line **14**. The line **14** may emanate from an upper part of the upper section **110**. The line **14** may extend from an outer surface of the upper section **110**.

[0090] From line **14**, the vapor stream may enter a condenser **122**. The condenser **122** cools the vapor stream to form a cooled stream. The condenser **122** at least partially condenses the stream.

[0091] After exiting the condenser **122**, the cooled stream may enter a separator **124**. The separator **124** separates the vapor stream into liquid and vapor streams. The separator may be any suitable separator that can separate a stream into liquid and vapor streams, such as a reflux drum.

[0092] Once separated, the vapor stream may exit the separator **124** as sales product. The sales product may travel through line **16** for subsequent sale to a pipeline and/or condensation to be a liquefied natural gas.

[0093] Once separated, the liquid stream may return to the upper section **110** through line **18** as the reflux. The reflux may travel to the upper section **110** via any suitable mechanism, such as a reflux pump **150** (Figures 1 and 3) or gravity (Figures 2 and 4).

[0094] The liquid stream (i.e., freezing zone liquid stream) that falls to the bottom of the upper section **110** collects at the bottom of the upper section **110**. The liquid may collect on tray **183** (Figures 1 and 3) or at the bottommost portion of the upper section **110** (Figures 2 and 4). The collected liquid may exit the distillation tower **104**, **204** through line **20** (Figures 1 and 3) or outlet **260** (Figures 2 and 4). The line **20** may emanate from the upper section **110**. The line **20** may emanate from a bottom end of the upper section **110**. The line **20** may extend from an outer surface of the upper section **110**.

[0095] The line **20** and/or outlet **260** connect to a line **41**. The line **41** leads to the spray assembly **129** in the middle controlled freeze zone section **108**. The line **41** emanates from the holding vessel **126**. The line **41** may extend to an outer surface of the middle controlled freeze zone section **110**.

[0096] The line **20** and/or outlet **260** may directly or indirectly (Figures 1-4) connect to the line **41**. When the line **20** and/or outlet **260** directly connect to the line **41**, the liquid spray may be pumped to the spray nozzle(s) **120** via any suitable mechanism, such as the spray pump **128** or gravity. When the line **20** and/or outlet **260** indirectly connect to the line **41**, the lines **20**, **41** and/or outlet **260** and line **41** may directly connect to a holding vessel **126** (Figures 1 and 3). The holding vessel **126** may house at least some of the liquid spray before it is sprayed by the nozzle(s). The liquid spray may be pumped from the holding vessel **126** to the spray nozzle(s) **120** via any suitable mechanism, such as the spray pump **128** (Figures 1-4) or gravity. The holding vessel **126** may be needed when there is not a sufficient amount of liquid stream at the bottom of the upper section **110** to feed the spray nozzles **120**.

[0097] It is important to note that the steps depicted in Figure 7 provided for illustrative purposes only and a particular step may not be required to perform the inventive methodology. The claims, and only the claims, define the inventive system and methodology.

[0098] Disclosed aspects may be used in hydrocarbon management activities. As used herein, "hydrocarbon management" or "managing hydrocarbons" includes hydrocarbon extraction, hydrocarbon production, hydrocarbon exploration, identifying potential hydrocarbon resources, identifying well locations, determining well injection and/or extraction rates, identifying reservoir connectivity, acquiring, disposing of and/ or abandoning hydrocarbon resources, reviewing prior hydrocarbon management decisions, and any other hydrocarbon-related acts or activities. The term "hydrocarbon management" is also used for the injection or storage of hydrocarbons or CO_2, for example the sequestration of CO_2, such as reservoir evaluation, development planning, and reservoir management. The disclosed methodologies and techniques may be used to produce hydrocarbons in a feed stream extracted from, for example, a subsurface region. The feed stream extracted may be processed in the distillation tower **104**, **204** and separated into methane and contaminants. The separated methane exits the middle controlled freeze zone section **108** or the upper section **110** of the distillation tower. Some or all of the methane that exits is produced as produced hydrocarbons, **307** (Figure 7). Hydrocarbon extraction may be conducted to remove the feed stream from, for example, the subsurface region, which may be accomplished by drilling a well using oil well drilling equipment. The equipment and techniques used to drill a well and/or extract the hydrocarbons are well known by those skilled in the relevant art. Other hydrocarbon extraction activities and, more generally, other hydrocarbon management activities, may be performed according to known principles.

[0099] As utilized herein, the terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numeral ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and considered to be within the scope of the disclosure.

[0100] It should be understood that numerous changes, modifications, and alternatives to the preceding disclosure can be made without departing from the scope of the disclosure. The preceding description, therefore, is not meant to limit the scope of the disclosure. Rather, the scope of the disclosure is to be determined only by the appended claims and their equivalents. It is also contemplated that structures and features in the present examples can be altered, rearranged, substituted, deleted, duplicated, combined, or added to each other.

[0101] The articles "the", "a" and "an" are not necessarily limited to mean only one, but rather are inclusive and open ended so as to include, optionally, multiple such elements.

CLAIMS

What is claimed is:

1. A distillation tower comprising:

a stripper section constructed and arranged to separate a feed stream at a temperature and pressure at which the feed stream forms no solid;

a controlled freeze zone section constructed and arranged to separate the feed stream at a temperature and pressure at which the feed stream forms a solid;

a melt tray assembly in the controlled freeze zone section that includes a liquid;

an underflow weir in the controlled freeze zone section that alters a flow of the liquid in the melt tray assembly;

an overflow weir in the controlled freeze zone section that works with the underflow weir to alter the flow of the liquid in the melt tray assembly and is adjacent to the underflow weir; and

a covering element in the controlled freeze zone section that is connected to and extends from the underflow weir.

2. The distillation tower of claim 1, wherein the controlled freeze zone section includes a controlled freeze zone wall and wherein the overflow weir is directly adjacent to the controlled freeze zone wall.

3. The distillation tower of any one of claim 1-2, wherein the controlled freeze zone section includes a controlled freeze zone wall and wherein the covering element extends from the underflow weir to the controlled freeze zone wall.

4. The distillation tower of any one of claim 1-3, wherein the controlled freeze zone section includes a controlled freeze zone wall and wherein the covering element is one of detached from and attached to the controlled freeze zone wall.

5. The distillation tower of any one of claim 1-4, wherein the controlled freeze zone section includes a controlled freeze zone wall and wherein the distillation tower further comprises an anti-vapor lock that extends from the controlled freeze zone wall toward the covering element.

6. The distillation tower of any one of claim 1-5, wherein the underflow weir is directly adjacent to the overflow weir.

7. The distillation tower of any one of claim 1-6, wherein the underflow weir comprises a plurality of underflow weirs and the overflow weir comprises a plurality of overflow weirs.

8. The distillation tower of any one of claim 1-7, wherein the covering element extends from the underflow weir toward the overflow weir and over the overflow weir.

9. The distillation tower of any one of claim 1-8, wherein the covering element is detached from the overflow weir.

10. The distillation tower of any one of claim 1-9, further comprising a channel connecting the stripper section to the controlled freeze zone section.

11. The distillation tower of claim 10, wherein the channel comprises at least one of an internal channel and an external channel.

12. The distillation tower of claim 11, wherein the internal channel is inside of the controlled freeze zone section and the stripper section and wherein the internal channel includes the overflow weir.

13. The distillation tower of claim 11, wherein at least one of the internal channel and the external channel comprises a flow control device.

14. The distillation tower of any one of claim 1-13, further comprising a liquid level indicator that is constructed and arranged to detect a liquid level of the liquid within the controlled freeze zone section.

15. A method of maintaining a liquid level in a distillation tower, the method comprising:

forming a freezing zone vapor stream from a feed stream in a stripper section of a distillation tower at a temperature and pressure at which no solid forms in the stripper section;

forming a solid in a controlled freeze zone section of the distillation tower from the feed stream; and

maintaining a predetermined liquid level of liquid in a melt tray assembly of the controlled freeze zone section by:

altering a flow of the liquid in the melt tray assembly such that the liquid flows from a bottom melt tray assembly portion of the melt tray assembly to a top melt tray assembly portion of the melt tray assembly; and

altering the flow of the liquid in the melt tray assembly such that the liquid flows from the top melt tray assembly portion toward the stripper section.

16. The method of claim 15, further comprising preventing an accumulation of the solid in the controlled freeze zone section by at least one of (i) maintaining a predetermined liquid level, (ii) providing a covering element and (ii) providing an anti-vapor lock.

17. The method of any one of claim 15-16, further comprising preventing an accumulation of vapor in the controlled freeze zone section while altering the flow of the liquid.

18. The method of any one of claim 15-17, further comprising directing vapor that accumulated while altering the flow of the liquid, upwards toward the top section of the controlled freeze zone section.

19. A method of producing hydrocarbons, the method comprising:

forming a freezing zone vapor stream from a feed stream in a stripper section of a distillation tower at a temperature and pressure at which no solid forms in the stripper section;

forming a solid in a controlled freeze zone section of the distillation tower from the feed stream;

maintaining a predetermined liquid level of liquid in a melt tray assembly of the controlled freeze zone section by:

altering a flow of the liquid in the melt tray assembly such that the liquid flows from a bottom melt tray assembly portion of the melt tray assembly to a top melt tray assembly portion of the melt tray assembly; and

altering the flow of the liquid in the melt tray assembly such that the liquid flows from the top melt tray assembly portion toward the stripper section; and

producing hydrocarbons from the feed stream.

20. The method of claim 19, further comprising preventing an accumulation of the solid in the controlled freeze zone section by at least one of (i) maintaining a predetermined liquid level, (ii) providing a covering element and (ii) providing an anti-vapor lock.

21. The method of any one of claim 19-20, further comprising preventing an accumulation of vapor in the controlled freeze zone section while altering the flow of the liquid.

22. The method of any one of claim 19-21, further comprising directing vapor, that accumulated while altering the flow of the liquid, upwards toward the top section of the controlled freeze zone section.

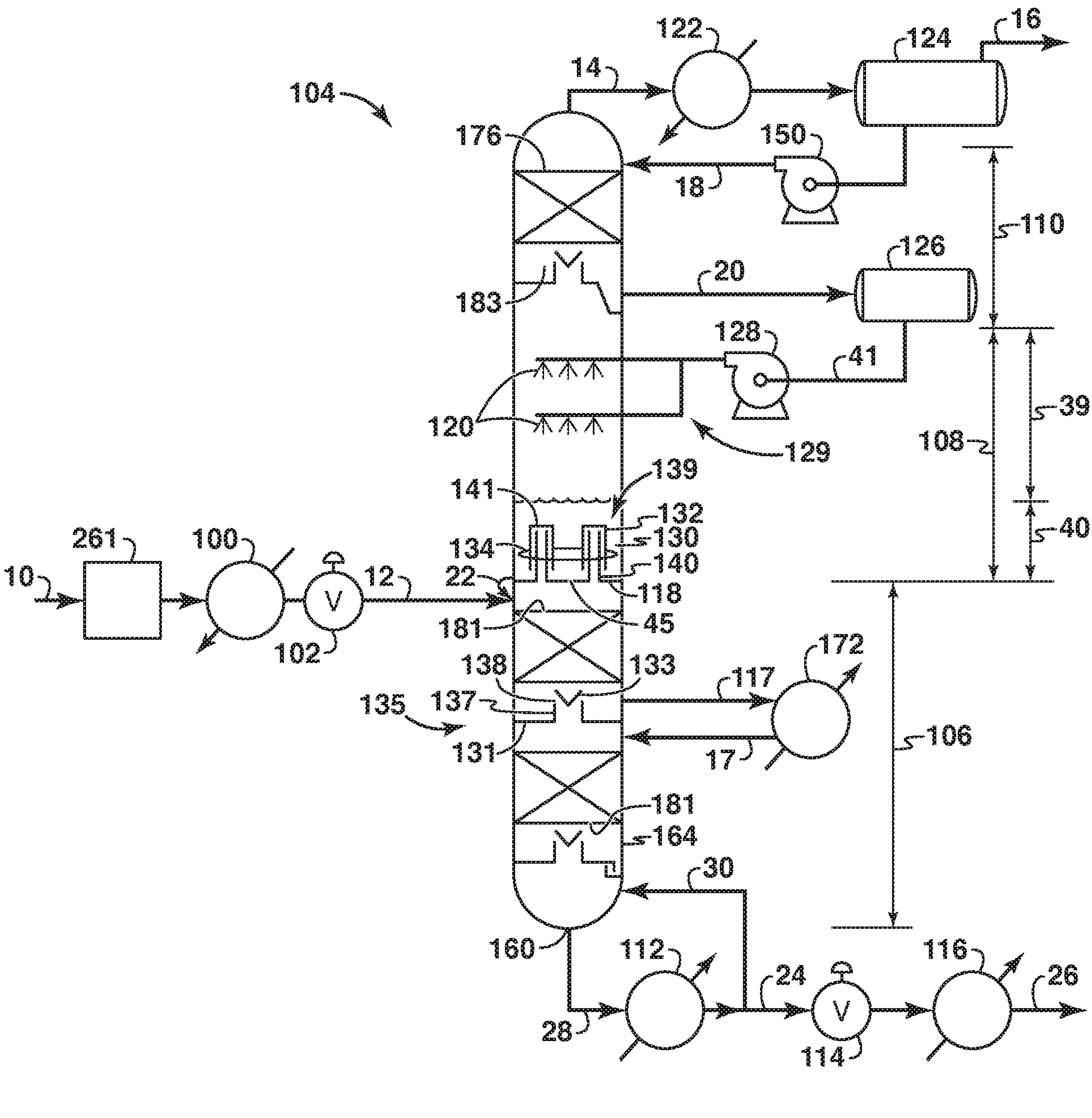
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FIG. 1

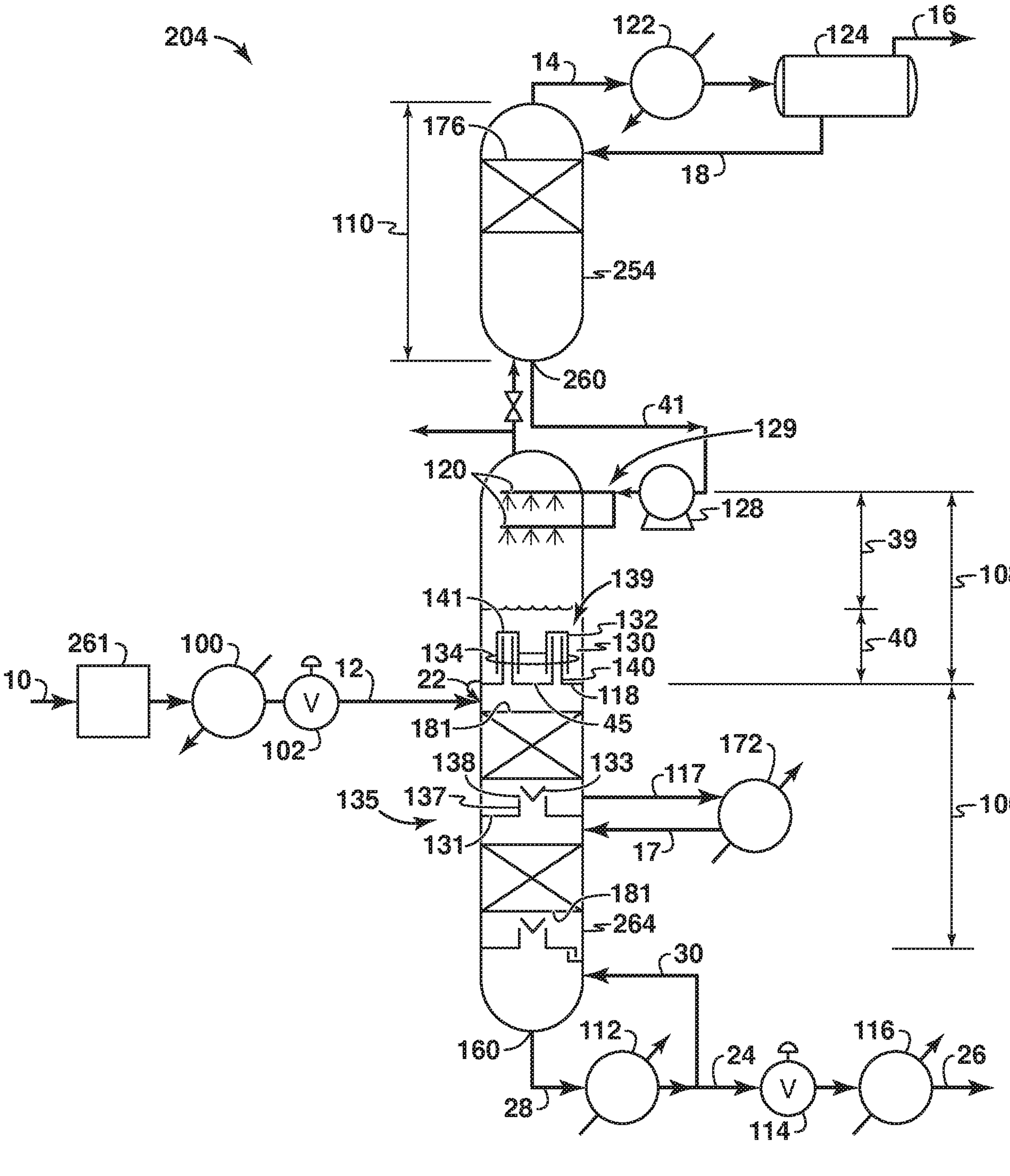

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FIG. 2

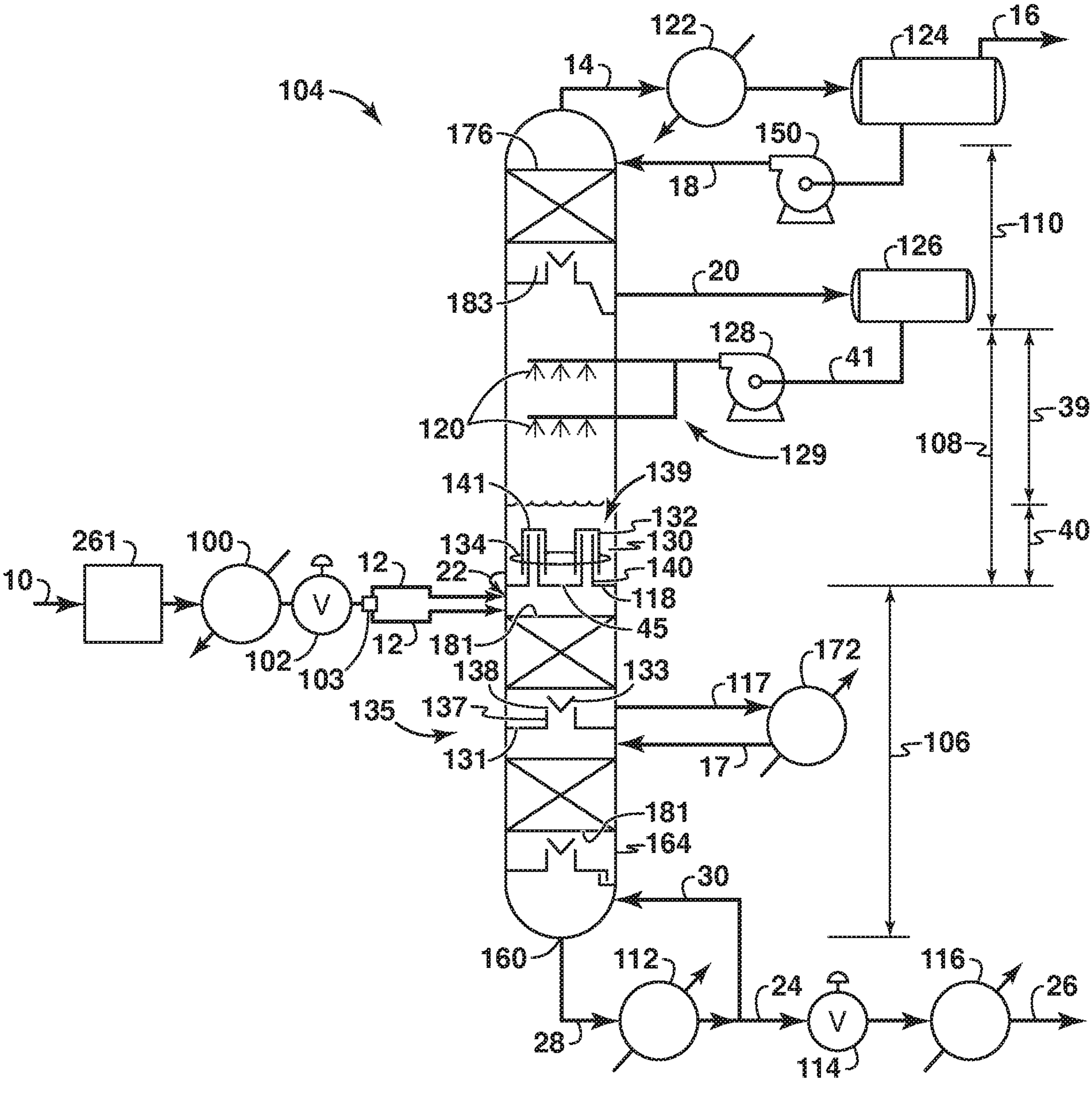
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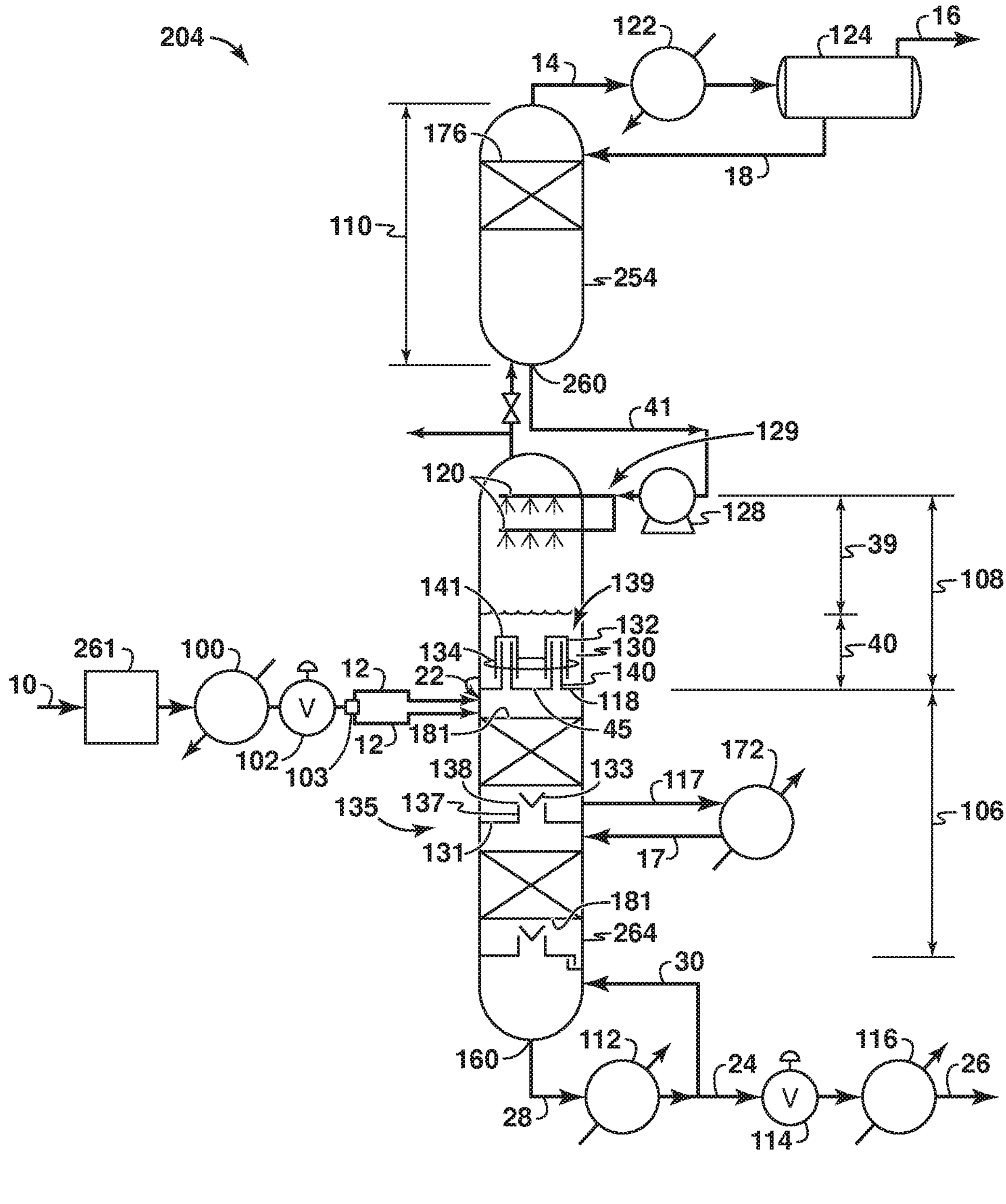
FIG. 3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131
17
181
264
30
160
112
116
24
26
V
28
114

FIG. 4

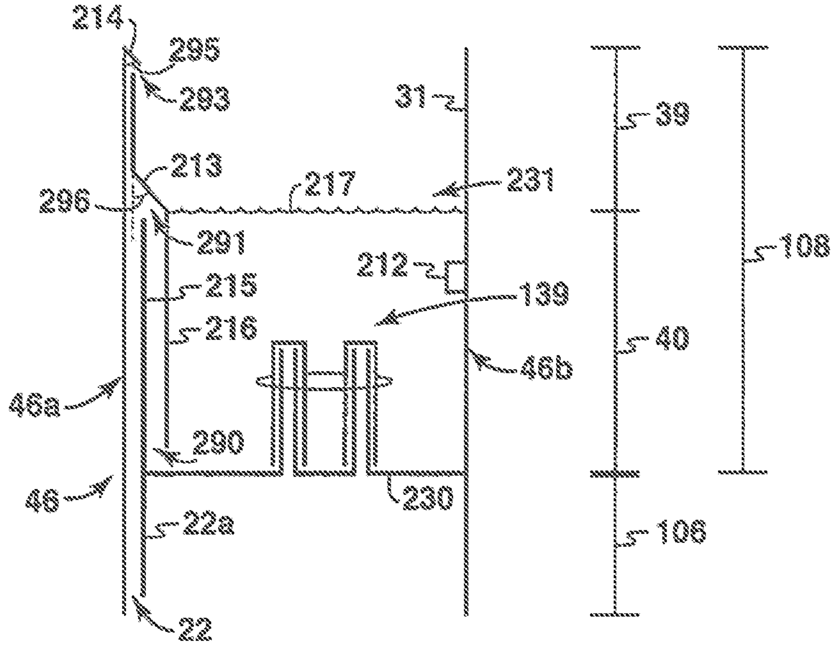
214
295
293
31
39
213
217
231
296
291
212
108
215
139
216
40
46b
46a
290
46
230
22a
106
22

FIG. 5

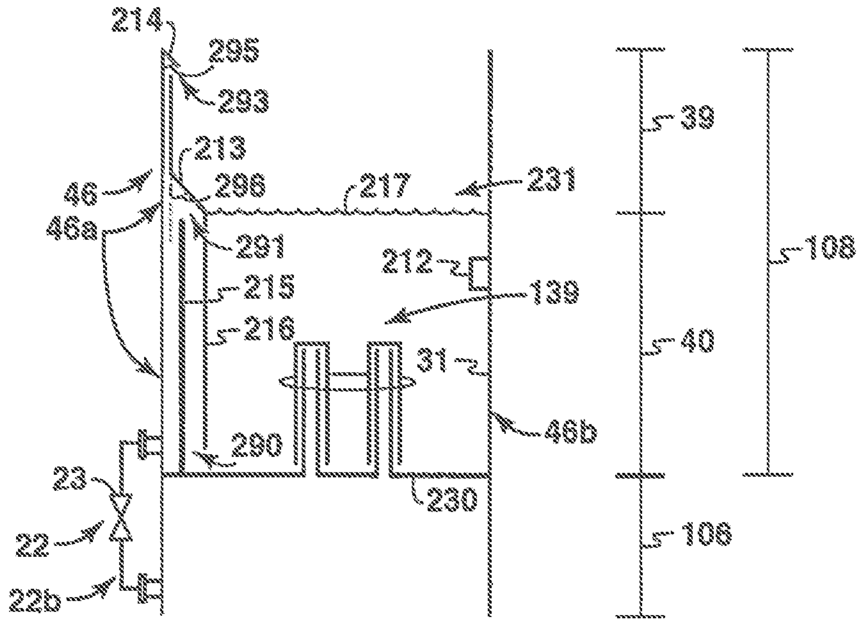
214
295
293
39
213
46
296
217
231
46a
291
212
108
215
139
216
40
31
46b
290
23
230
22
106
22b

FIG. 6

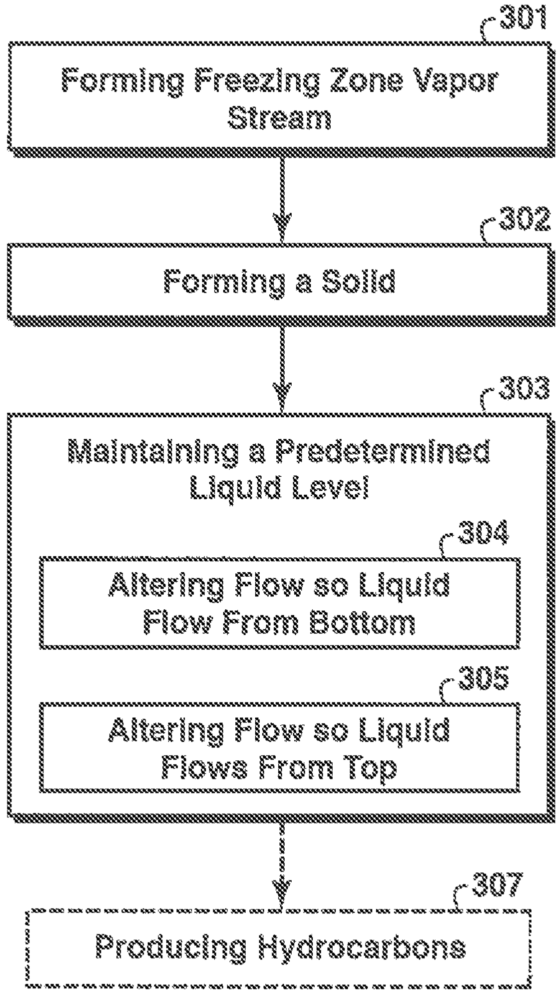
301
Forming Freezing Zone Vapor Stream
302
Forming a Solid
303
Maintaining a Predetermined Liquid Level
304
Altering Flow so Liquid Flow From Bottom
305
Altering Flow so Liquid Flows From Top
307
Producing Hydrocarbons

FIG. 7