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(54) Title: REMOVAL OF COMPONENTS FROM A GAS STREAM

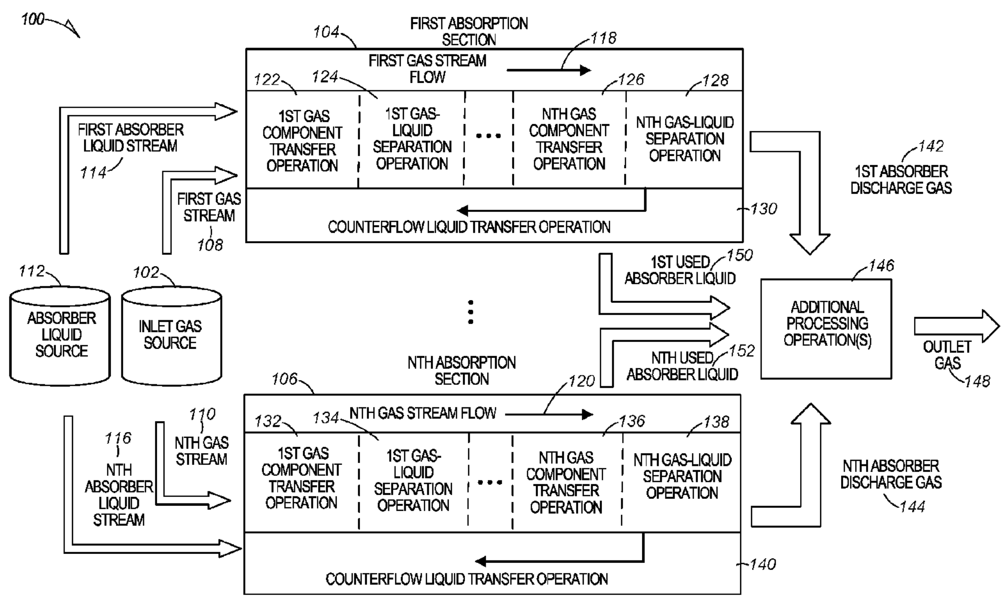

FIG. 1

(57) **Abstract:** The systems and processes described herein can use horizontally arranged equipment to remove impurities from a gas stream using an absorber liquid that can include one or more solvents. The system can include an absorption section that contacts a gas stream with a solvent that removes one or more components from the gas stream and binds the one or more components with the solvent. The solvent with the bound gas components can then be separated from the gas stream to produce a modified gas stream having a lesser amount of the one or more components than the initial gas stream. In at least some cases, the system can include a number of absorption sections arranged sequentially and arranged horizontally and with each absorption section in the series, the amount of the one or more components included in the gas stream decreases.

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REMOVAL OF COMPONENTS FROM A GAS STREAM

CLAIM TO PRIORITY

[001] This patent application claims the benefit of priority to U.S. Provisional Patent Application Serial No. 63/492,594, filed March 28, 2023, which is incorporated by reference herein in its entirety.

TECHNOLOGICAL FIELD

[002] The present disclosure relates to implementations of systems and processes to remove components from a gas stream. More particularly, the present disclosure relates to systems and processes that implement horizontally arranged equipment to remove impurities, such as carbon dioxide (CO_2), from a gas stream.

BACKGROUND

[003] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventor(s), to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

[004] The removal of components from a gas stream are typically performed by unit operations that take place in towers or columns where a flue gas stream moves from a top portion of a tower to a bottom portion while being contacted with one or more liquids. The flue gas stream can be produced as part of an industrial operation and the towers can be used to remove impurities from the gas stream. In at least some cases, the flue gas streams can be emissions from power plants, cement factories, or from diesel power generation and the impurities removed from the emissions can include CO_2, or one or more sulfur-containing gases, or one or more gases derived from sulfur. The liquids used in the towers are selected to bind with one or more components of the gas stream to separate the one or more components from the bulk gas stream and to produce an auxiliary liquid stream that includes gas components bound to molecules included in the liquids.

[005] Typically, towers that remove components from flue gas have heights on the order of 40 meters (m) to 80 m and diameters on the order of 10 m to 15 m. Additionally, these towers can remove many hundreds of thousands of metric tons of gas impurities per year up to several million metric tons of the gas impurities per year. However, the majority of facilities that could benefit from the removal of impurities from flue gas streams generate less than 500,000 metrics tons of gas impurities with many of the facilities generating less than 100,000 metric tons of gas impurities. The existing tower-based technologies used to remove components from flue gas streams do not scale down to sizes where impurities can efficiently and cost-effectively be removed on the order of 500,000 or so metric tons per year of the gas impurities or less. As a result, millions of metric tons of gas impurities go uncaptured each year that, if removed from the flue gas, could prove to be beneficial to the environment and economically beneficial to entities that capture the gas impurities. Thus, there are technological and cost-related considerations around the removal of gas impurities at rates less than 500,000 or so metric tons per year that are not satisfied by existing systems and processes.

SUMMARY

[006] The following presents a simplified summary of one or more implementations of the present disclosure in order to provide a basic understanding of such implementations. This summary is not an extensive overview of all contemplated implementations and is intended to neither identify key or critical elements of all implementations, nor delineate the scope of any or all implementations.

[007] In one or more implementations, a system to remove components from a gas stream can include a number of operations that are performed using horizontally arranged equipment. For example, a system can include a vessel having an inlet configured to direct the gas stream into the vessel, where the gas stream includes a first amount of gas impurities. The vessel can also include a first section that includes one or more nozzles to produce a dispersed droplet stream. The dispersed droplet stream can comprise an amount of solvent to remove a portion of the first amount of gas impurities from the gas stream and to produce a solvent-gas mixture within the first section that includes the portion of the first amount of gas impurities. Additionally, the vessel can include a second section that includes a separation device through which at least a portion of the solvent-gas mixture passes. The filtering device can remove an amount of the solvent from the solvent-gas mixture and produce a modified gas stream. The modified gas stream can include a second amount of gas impurities that is less than the first amount of gas impurities. The vessel can include an outlet disposed below the filtering device to drain the first amount of solvent from the vessel. In various examples, the vessel can also include a second outlet to direct the modified gas stream out of the vessel.

[008] While multiple implementations are disclosed, still other implementations of the present disclosure will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative implementations of the invention. As will be realized, the various implementations of the present disclosure are capable of modifications in various obvious aspects, all without departing from the spirit and scope of the present disclosure. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[009] While the specification concludes with claims particularly pointing out and distinctly claiming the subject matter that is regarded as forming the various implementations of the present disclosure, it is believed that the invention will be better understood from the following description taken in conjunction with the accompanying figures. In the figures, the depicted structural elements are not to scale, and certain components may be enlarged relative to the other components for purposes of emphasis and understanding.

[010] FIG. 1 is a diagram of a system to remove components from a gas stream using one or more absorption operations, according to one or more example implementations.

[011] FIG. 2 is a diagram of a system that includes multiple horizontally arranged absorber vessels to remove one or more components from a gas stream using one or more solvents, according to one or more example implementations.

[012] FIG. 3 is a diagram of a system to transfer heat between solutions used in the removal of one or more components from a liquid stream and to produce a regenerated solvent, according to one or more example implementations.

[013] FIG. 4 is a diagram of vessel to contact a gas stream with a solvent that removes one or more components from the gas stream and a filtering device to separate the solvent from a modified gas stream, according to one or more example implementations.

[014] FIG. 5 is a diagram of a container that includes a horizontally arranged train having equipment to remove one or more components from a gas stream using a solvent, according to one or more example implementations.

[015] FIG. 6 is a diagram depicting interior components of a container that includes a horizontally arranged train having equipment to remove one or more components from a gas stream using a solvent, according to one or more example implementations.

[016] FIG. 7 is a diagram of a container that includes multiple horizontally arranged trains having equipment to remove one or more components from a gas stream using a solvent, according to one or more example implementations.

[017] FIG. 8 is a picture of a horizontally arranged system to remove one or more components from a gas stream using a solvent, according to one or more example implementations.

[018] FIG. 9 is a diagram of a system to remove one or more components from an inlet gas stream that is pretreated prior to the gas stream being provided to one or more absorption operations, according to one or more example implementations.

[019] FIG. 10 is a graph showing amounts of impurities removed from a gas stream and amounts of gas absorbed by a solvent in a system that causes solvent to run counter to the flow of the gas stream, according to one or more example implementations.

[020] FIG. 11 is flow diagram of a process to remove one or more components from a gas stream using a solvent, according to one or more example implementations.

DETAILED DESCRIPTION

[021] The present disclosure, in one or more implementations, relates to systems and processes to remove components from a gas stream. More particularly, the systems and processes can use horizontally arranged equipment to remove impurities from a gas stream using an absorber liquid that can include one or more solvents. For example, a system can include an absorption section that contacts a gas stream with a solvent that removes one or more components from the gas stream and binds the one or more components with the solvent. The solvent with the bound gas components can then be separated from the gas stream to produce a modified gas stream having a lesser amount of the one or more components than the initial gas stream. In various examples, the system can include a number of absorption sections arranged sequentially and arranged horizontally. With each absorption section in the series, the amount of the one or more components included in the gas stream decreases. Additionally, solvent from later absorption sections can be directed back to previous absorption sections to be used in the removal of the one or more components from the gas stream. In this way, the flow of the solvent between the absorption sections is in a direction counter to the flow of the gas stream. In at least some examples, one or more components of a gas stream can be removed in amounts less than 500,000 metric tons per year.

[022] FIG. 1 is a diagram of a system 100 to remove components from a gas stream using one or more absorption operations, according to one or more example implementations. The system

100 includes an inlet gas source 102. The inlet gas source 102 can include one or more gas producers. In one or more examples, the inlet gas source 102 can include an industrial facility. In one or more additional examples, the inlet gas source 102 can include a power generation facility. For example, the inlet gas source 102 can include a coal-fired power plant. In one or more further examples, the inlet gas source 102 can include a hydraulic fracturing operation. In various examples, the inlet gas source 102 can be produced by one or more post-combustion processes or one or more pre-combustion processes.

[023] The inlet gas source 102 can produce a gas stream that includes a number of components. To illustrate, the inlet gas source 102 can produce a gas stream that includes at least one of one or more carbon-containing components, one or more components derived from carbon, one or more sulfur-containing components, one or more components derived from sulfur, one or more components including carbon and sulfur, or one or more components derived from carbon and sulfur. In one or more illustrative examples, the inlet gas source 102 can produce a gas stream including at least one of carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), carbonyl sulfide (COS), or carbon disulfide (CS_2).

[024] In at least some examples, one or more components of the gas stream can be an impurity. An impurity, as used herein, can correspond to an unwanted component within the gas stream that is to be removed. In one or more examples, an impurity can correspond to a substance that is considered harmful to at least one of humans, animals, or the environment. In one or more illustrative examples, the inlet gas source 102 can produce a gas stream having one or more impurities that include at least one of CO_2, CO, NO_x, SO_x, H_2S, CH_4, N_2O, O_2, H_2O, SO_2, COS, or CS_2.

[025] The system 100 can include a number of absorption sections to separate one or more gas components from a gas stream produced by the inlet gas source 102. For example, the system 100 can include a first absorption section 104. In situations where the system 100 include multiple absorption sections, the system 100 can include up to an Nth absorption section 106. In various examples, the number of absorption sections included in the system 100 can correspond to a capacity of the system 100 in relation separating one or more components from the gas stream produced by the inlet gas source 102. In one or more illustrative examples, with respect to one or more components included in a gas stream produced by the inlet gas source 102, an individual absorption section can remove from about 1000 metric tons per year to about 20,000 metric tons per year of the one or more gas components from the gas stream, from about 2000 metric tons per year to about 15,000 metric tons per year of the one or more gas components from the gas stream, from about 3000 metric tons per year to about 10,000 metric tons per year of the one or more gas components from the gas stream, from about 1000 metric tons per year to about 5000 metric tons per year of the one or more gas components from the gas stream, from about 2000 metric tons per year to about 6000 metric tons per year of the one or more gas components from the gas stream, from about 3000 metric tons per year to about 7000 metric tons per year of the one or more gas components from the gas stream, from about 4000 metric tons per year to about 8000 metric tons per year of the one or more gas components from the gas stream, or from about 5000 metric tons per year to about 10,000 metric tons per year of the one or more gas components from the gas stream.

[026] Additionally, in scenarios where the system 100 includes multiple absorption sections, the gas stream produced by the inlet gas source 102 can be separated into multiple gas streams. To illustrate, a gas stream produced by an inlet gas source 102 can be divided into a first gas stream 108 that is provided to the first absorption section 104 up to an Nth gas stream 110 that is provided to the Nth absorption section 106. In one or more examples, an amount of one or more components in the first gas stream 108 can be similar to or the same as an amount of the one or more components in the Nth gas stream 110. In addition, an amount of one or more components in the first gas stream 108 can be different from an amount of the one or more components in the Nth gas stream 110. In various examples, a flow rate of the first gas stream 108 can be similar to or the same as the flow rate of the Nth gas stream 110. Further, a flow rate of the first gas stream 108 can be different from a flow rate of the Nth gas stream 110. The flow rate of the first gas stream 108 and the Nth gas stream 110 can be from about 0.005 cubic meters/second to about 50 cubic meters/second, from about 0.01 cubic meters/second to about 30 cubic meters/second, from about 0.1 cubic meters/second to about 20 cubic meters per second, or from about 1 cubic meter/second to about 10 cubic meters/second. In at least some examples, the first gas stream 108 can be delivered to the first absorption section 104 and the Nth gas stream 110 can be delivered to the Nth absorption section 106 at pressures no greater than about 500 kilopascals (kPa), no greater than 400 kPa, no greater than 300 kPa, no greater than 200 kPa, or no greater than 100 kPa. In one or more illustrative examples, the first gas stream 108 can be delivered to the first absorption section 104 and the Nth gas stream 110 can be delivered to the Nth absorption section 106 at pressures from about 10 kPa to about 500 kPa, from about 50 kPa to about 400 kPa, or from about 100 kPa to about 200 kPa.

[027] The system 100 can also include an absorber liquid source 112. The absorber liquid source 112 can supply the first absorption section 104 up to the Nth absorption section 106 with a supply of absorber liquid to separate one or more gas components from the first gas stream 108 up to the Nth gas stream 110. In various examples, the absorber liquid provided by the absorber liquid source 112 can be recycled in the absorption sections of the system 100. In these scenarios, the absorber liquid source 112 can provide an initial allocation of the absorber liquid to absorption sections included in the system 100 and then replenish depleted amounts of absorber liquid on an as-needed basis. In situations where the system 100 includes multiple absorption sections, an amount of the absorber liquid can be provided to individual absorption sections. For example, the absorber liquid source 112 can provide a first absorber liquid stream 114 to the first absorption section up to an Nth absorber liquid stream 116 to the Nth absorption section 106. In one or more examples, the absorber liquid source 112 can supply an amount of absorber liquid to modify a concentration of absorber liquid that was used by the first absorption section 104 or the Nth absorption section 106 and subsequently regenerated in a desorption section.

[028] The absorber liquid can include one or more solvents. In one or more examples, the absorber liquid can include aqueous solutions that include one or more amines. In one or more additional examples, the absorber liquid can include a minimal amount of water, such as no greater than 5% by weight water, trace amounts of water, or no water. In one or more further examples, the absorber liquid can include CO_2-binding organic liquids (CO_2BOLs). CO_2BOLs can include one or more alcohols and bases that include and/or are derived from amidinium or guanidinium alkylcarbonate salts. In still other examples, the absorber liquid can include, but is not limited to, chemical solvents comprising at least one of amines, salt solutions, or ammonia and/or physical solvents comprising at least one of glycols, methanol, ethers, propylene carbonate, pyrrolidone, glycerol, or sulfolane. In one or more illustrative examples, the composition of the absorber liquid can correspond to the composition of the gas stream produced by the inlet gas source 102. In various examples, the composition of the absorber liquid can also correspond to one or more components that are to be removed from the gas stream produced by the inlet gas source 102. To illustrate, the composition of the absorber liquid can include one or more solvents that can bind to one or more components that are to be removed from the first gas stream 108 up to the Nth gas stream 110. For examples, the absorber liquid can include one or more solvents having at least one of a physical affinity or a chemical affinity towards gas impurities included in the first gas stream 108 up to the Nth gas stream 110.

[029] The first absorption section 104 up to the Nth absorption section 106 can be horizontally arranged such that the first gas stream 108 flows in a direction indicated by arrow 118 and the Nth gas stream flows in a direction indicated by arrow 120. As used herein, the term horizontally arranged can indicate that the flow of at least one of gas or liquid through a piece of equipment is parallel to or substantially parallel to a plane that is parallel to or substantially parallel to the horizon.

[030] The first absorption section 104 can include a number of pieces of equipment that can perform operations to remove one or more components from the first gas stream 108. In one or more examples, the first absorption section 104 can include a number of distinct areas in which the operations to remove the one or more components from the first gas stream 108 can be performed. In one or more additional examples, the first absorption section 104 can include a number of vessels that are used to perform operations to remove the one or more components from the first gas stream 108. The number of vessels can be arranged serially and in fluid communication with one another. In one or more further examples, at least a portion of the first absorption section 104 can include a single conduit, such as a pipe or cylinder, in which one or more operations are performed that separate the one or more components from the first gas stream 108. In these scenarios, the first absorption section 104 can include one or more areas within the conduit in which at least a portion of the operations to remove the one or more components from the first gas stream 108 are performed.

[031] In the illustrative example of FIG. 1, the first absorption section 104 can perform a first gas component transfer operation 122. The first gas component transfer operation 122 can include transferring one or more components of the first gas stream 108 to the first absorber liquid stream 114. In one or more examples, the absorber liquid included in the first absorber liquid stream 114 can bind one or more components of the first gas stream 108 to produce a gas-liquid mixture. The gas-liquid mixture can include free gas molecules, free absorber liquid molecules, and gas molecules bound to absorber liquid molecules. In various examples, the first gas component transfer operation 122 can include contacting the first gas stream 108 with dispersed droplets of the absorber liquid.

[032] In one or more illustrative examples, the absorber liquid used to contact the first gas stream 108 as part of the first gas component transfer operation 122 can include less than a threshold amount of the one or more components of the first gas stream 108 that are to be removed. That is, a loading of one or more impurities of the first gas stream 108 within the absorber liquid used in the first gas component transfer operation 122 can be relatively low. In one or more additional illustrative examples, the absorber liquid used in the first gas component transfer operation 122 can include an amount of the one or more impurities that are to be removed from the first gas stream 108 that is no greater than about 4% by weight with respect to a total weight of components of the absorber liquid, no greater than about 3.5% by weight with respect to a total weight of components the absorber liquid, no greater than about 3% by weight with respect to a total weight of components of the absorber liquid, no greater than about 2.5% by weight with respect to a total weight of components of the absorber liquid, no greater than about 2% by weight with respect to a total weight of components of the absorber liquid, no greater than about 1.5% by weight with respect to a total weight of components of the absorber liquid, or no greater than about 1% by weight with respect to a total weight of components of the absorber liquid. In various examples, the absorber liquid used in the first gas component transfer operation 122 can include an amount of one or more impurities that are to be removed from the first gas stream 108 that can be from about 0.5% by weight to about 4% by weight with respect to a total weight of components of the absorber liquid, from about 1% by weight to about 3.5% by weight with respect to a total weight of components of the absorber liquid, or from about 1.5% by weight to about 3% by weight with respect to a total weight of components of the absorber liquid. In at least some scenarios, the absorber liquid used in the first gas component transfer operation 122 can be free of an amount of the one or more impurities that are to be removed from the first gas stream 108.

[033] The first absorption section 104 can also perform a first gas-liquid separation operation 124 with regard to the gas-liquid mixture produced by the first gas component transfer operation 122. The first gas-liquid separation operation 124 can include separating a liquid portion of the gas-liquid mixture from a gas portion. In one or more examples, the first gas-liquid separation operation 124 can be performed using a filtering device that separates the liquid portion of the gas-liquid mixture from the gas portion. In various examples, the filtering device can include a vane pack that provides a tortious path that causes the liquid portion of the liquid-gas mixture to separate from the gas portion.

[034] The first gas-liquid separation operation 124 can separate an amount of liquid from the gas-liquid mixture. The amount of liquid separated from the liquid-gas mixture includes one or more solvents and an amount of one or more components of the first gas stream 108 bound to the one or more solvents. For example, the amount of liquid separated from the liquid-gas mixture can include one or more impurities included in the first gas stream 108. Additionally, the first gas-liquid separation operation 124 can produce a modified gas stream that has an amount of one or more components that is less than the amount of the one or more components in the first gas stream 108. To illustrate, the first gas stream 108 can include a first amount of one or more components and the first gas-liquid separation operation 124 can include a second amount of the one or more components of the first gas stream 108 that is less than the first amount. In one or more illustrative examples, the first gas-liquid separation operation 124 can produce a modified gas stream having an amount of one or more impurities that is less than the amount of the one or more impurities in the first gas stream 108.

[035] In at least some examples, the first absorption section 104 can include multiple gas component transfer operations and multiple gas-liquid separation operations. For example, the first absorption section 104 can include up to an Nth gas component transfer operation 126 and up to an Nth gas-liquid separation operation 128. In one or more examples, individual gas component transfer operations performed by the first absorption section 104 can take place within individual areas of the first absorption section 104. To illustrate, the first gas component transfer operation 122 can be performed in a first area of the first absorption section 104 and the Nth gas component transfer operation 126 can be performed in an additional area of the first absorption section 104. In one or more additional examples, a plurality of gas component transfer operations can be performed in a single area of the first absorption section 104.

[036] Further, individual gas-liquid separation operations can take place within individual areas of the first absorption section 104. For example, the first gas-liquid separation operation 124 can be performed in a first area of the first absorption section 104 and the Nth gas-liquid separation operation 128 can be performed in an additional area of the first absorption section 104. In still other examples, a plurality of gas-liquid separation operations can be performed in a single area of the first absorption section 104. To illustrate, the first gas-liquid separation operation 124 and the Nth gas-liquid separation operation 128 can be performed in a single area of the first absorption section 104.

[037] In one or more examples, at least a portion of the liquid produced by the gas-liquid separation operations performed by the first absorption section 104 can be processed in a counterflow liquid transfer operation 130. The counterflow liquid transfer operation 130 can cause liquid produced by one or more of the gas-liquid separation operations to flow in a direction that is opposite to the direction of the first gas stream flow indicated by the arrow 118. In various examples, the liquid produced by gas-liquid separation operations subsequent to the first gas-liquid separation operation 124, can be used in gas component transfer operations that precede the gas-liquid separation operation that produced the liquid. For example, the liquid produced by the Nth gas liquid separation operation 128 can be used in a gas component transfer operation that precedes the Nth gas-liquid separation operation 128, such as a second gas component transfer operation or a third gas component transfer operation that is performed by the first absorption section 104. By implementing a counterflow liquid transfer operation 130, the first absorption section 104 can recycle at least portions of the first absorber liquid stream 114. In one or more illustrative examples, the counterflow liquid transfer operation 130 can include one or more desorption operations that remove the one or more gas components from the used absorber liquid such that the used absorber liquid can be regenerated and recycled.

[038] Additionally, the first absorption section 104 can be configured such that the liquid produced by a given gas-liquid separation operation and used in an individual gas component transfer operation has an amount of one or more solvents to capture one or more components of the first gas stream 108 that corresponds to the amount of the one or more components of the first gas stream 108 to be removed. For example, as the amount of one or more impurities in a modified gas stream produced by the gas-liquid separation operations of the first absorption section 104 decreases, the lower the concentration of one or more solvents included in the absorber liquid used in the gas component transfer operation that is being performed with respect to the modified gas stream. To illustrate, an amount of one or more solvents included in the absorber liquid used to perform the Nth gas component transfer operation 126 is less than the amount of the one or more solvents included in the absorber liquid used to perform the first gas component transfer operation 122 because the amount of one or more impurities included in the gas stream processed by the Nth gas component transfer operation 126 is less than the amount of one or more impurities included in the gas stream processed by the first gas component transfer operation 122. That is, as the gas stream moves through the absorption section 104, a greater amount of one or more impurities are extracted from the gas stream and the amount of the one or more impurities included in gas streams processed by subsequent gas component transfer operations decreases. Thus, the potency of the absorber liquid used in the gas-liquid separation operations decreases as the gas stream moves through the absorption section 104.

[039] The Nth absorption section 106 can perform a first gas component transfer operation 132 and a first gas-liquid separation operation 134. In situations where the Nth absorption section 106 performs multiple gas component transfer operations and multiple gas-liquid separation operations, the Nth absorption section 106 can perform up to an Nth gas component transfer operation 136 and up to an Nth gas-liquid separation operation 138. The Nth absorption section 106 can also perform a counterflow liquid transfer operation 140. In various examples the operations performed by the Nth absorption section 106 can be similar to or the same as the operations performed by the first absorption section 104. For example, the gas component transfer operations 122 up to 126 performed by the first absorption section 104 can be similar to the gas component transfer operations 132 up to 136 performed by the Nth absorption section 106. Additionally, the gas-liquid separation operations 124 up to 128 performed by the first absorption section 104 can be similar to the gas-liquid separation operations 134 up to 138 performed by the Nth absorption section 106. In one or more additional examples, the Nth absorption section 106 can be configured similar to the first absorption section 104 in that when the first absorption section 104 includes a number of individual sections to perform at least a portion of the operations 122, 124, 126, 128, the Nth absorption section 106 can also include a number of individual sections to perform at least a portion of the operations 132, 134, 136, 138. Further, in scenarios where the first absorption section 104 performs a set of operations including at least two of operations 122, 124, 126, or 128 in a single section, the Nth absorption section 106 can also perform the set of operations including at least two of operations 132, 134, 136, or 138 in a single section.

[040] The first absorption section 104 can produce a first absorber discharge gas 142. The first absorber discharge gas 142 can include an amount of one or more components that is less than the amount of the one or more components included in the first gas stream 108. In this way, the operations performed by the first absorption section 104 can remove an amount of the one or more components from the first gas stream 108. In situations where the system 100 includes the Nth absorption section 106, the Nth absorption section 106 can produce a Nth absorber discharge gas 144 that includes an amount of one or more components that is less than the amount of the one or more components included in the Nth gas stream 110.

[041] The first absorber discharge gas 142 up to the Nth absorber discharge gas 144 can be provided to one or more additional processing operations 146. In various examples, the one or more additional processing operations 146 can be performed by one or more pieces of equipment that perform the one or more additional processing operations 146 with respect to a combination of absorber discharge gases produced by a number of absorption sections. In one or more illustrative examples, the first absorber discharge gas 142 can be combined with up to the Nth absorber discharge gas 144 and the one or more additional processing operations 146 can be performed in relation to the combination of the first absorber discharge gas 142 up to the Nth absorber discharge gas 144. Additionally, the one or more additional processing operations 146 can be performed using separate pieces of equipment for absorber discharge gas produced by respective absorption sections. For example, the one or more additional processing operations 146 can be performed with respect to the first absorber discharge gas 142 by one or more first pieces of equipment and the one or more additional processing operations 146 can be performed with respect to the Nth absorber discharge gas 144 by one or more additional pieces of equipment that are separate from the one or more first pieces of equipment. The one or more additional processing operations 146 can produce an outlet gas 148. The outlet gas 148 can have reduced amounts of one or more components included in the first gas stream 108 up to the Nth gas stream 110. In at least some examples, the outlet gas 148 can have reduced amounts of one or more impurities with respect to amounts of the one or more impurities included in the first gas stream 108 up to the Nth gas stream 110.

[042] In one or more examples, the one or more additional processing operations 146 can include one or more additional absorption operations to remove an amount of at least one component from the first absorber discharge gas 142 and/or the Nth absorber discharge gas 144. For example, the one or more additional processing operations 146 can include one or more stripping operations. The one or more stripping operations can be performed to further remove an amount of the one or more components from at least one of the first absorber discharge gas 142 or the Nth absorber discharge gas 144 that were removed by the first absorption section 104. In one or more additional examples, the one or more stripping operations can be performed to remove an amount of one or more different components from the first absorber discharge gas 142 and/or the Nth absorber discharge gas 144 than the one or more components removed from the first gas stream 108 and/or the Nth gas stream 110. In one or more illustrative examples, the one or more additional processing operations 146 can include one or more water scrubbing operations to remove an amount of at least one component from at least one of the first absorber discharge gas 142 or the Nth absorber discharge gas 144.

[043] The one or more additional processing operations 146 can also include one or more polishing operations that are performed with respect to the first absorber discharge gas 142 and/or the Nth absorber discharge gas 144. The one or more polishing operations can include performing one or more additional gas-liquid separation operations without first performing a gas component transfer operation. To illustrate, the one or more additional processing operations 146 can include causing at least one of the first absorber discharge gas 142 or the Nth absorber discharge gas 144 to pass through one or more additional filtering devices to remove an amount of at least one or more components of at least one of the first absorber discharge gas 142 or the Nth absorber discharge gas 144.

[044] In at least some examples, the one or more additional processing operations 146 can include at least one operation performed in relation to liquids used in the first absorption section 104 up to the Nth absorption section 106. For example, the one or more additional processing operations 146 can include at least one operation performed with respect to first used absorber liquid 150 up to Nth used absorber liquid 152. The first used absorber liquid 150 can include an amount of the first absorber liquid stream 114 that is used in at least one of the first gas component transfer operation 122 up to the Nth gas component transfer operation 126 to remove an amount of one or more components from one or more gas streams passing through the first absorption section 104. Additionally, the Nth used absorber liquid 152 can include an amount of the Nth absorber liquid stream 116 that is used in at least one of the first gas component transfer operation 132 up to the Nth gas component transfer operation 136 to remove an amount of one or more components from one or more gas streams passing through the Nth absorption section 106. In one or more illustrative examples, the one or more additional processing operations 146 can produce a regenerated amount of absorber liquid that can be recycled for one or more gas component transfer operations performed by the first absorption section 104 and/or the Nth absorption section 106.

[045] In one or more additional illustrative examples, the one or more additional processing operations 146 can include performing at least one of one or more heating operations or one or more cooling operations with respect to the first used absorber liquid 150 up to the Nth used absorber liquid 152. For example, the one or more additional processing operations 146 can be performed by one or more heat exchangers that transfer heat in relation to the first used absorber liquid 150 up to the Nth used absorber liquid 152. In various examples the one or more additional processing operations 146 can include transferring heat between the first used absorber liquid 150 and one or more gas streams of the first absorption section 104 and/or transferring heat between the Nth used absorber liquid 152 and one or more gas streams of the Nth absorption section 106.

[046] Although not shown explicitly in the illustrative example of FIG. 1, in still other examples, the one or more additional processing operations 146 can include one or more preprocessing operations performed on the first gas stream 108 up the Nth gas stream 110. To illustrate, the one or more additional processing operations 146 can include one or more operations to remove one or more additional components from the first gas stream 108 prior to the first gas stream 108 entering the first absorption section 104 up to removing the one or more additional components from the Nth gas stream 110 before the Nth gas stream 110 enters the Nth absorption section 106. In at least some examples, the one or more additional processing operations 146 can remove different components from the first gas stream 108 up to the Nth gas stream 110 than the first absorption section 104 up to the Nth absorption section 106. In various examples, the one or more additional processing operations can implement one or more separation techniques to remove an amount of one or more additional components from the first gas stream 108 up to the Nth gas stream 110. In at least some examples, the one or more additional processing operations 146 can remove one or more particulates from the first gas stream 108 up to the Nth gas stream 110. In one or more further examples, the preprocessing operations can include cooling at least one of the first gas stream 108, the Nth gas stream 110, the first absorber liquid stream 114, or the Nth absorber liquid stream 116.

[047] FIG. 2 is a diagram of a system 200 that includes multiple horizontally arranged absorber vessels to remove one or more components from a gas stream using one or more solvents, according to one or more example implementations. An inlet gas stream 202 can be provided to the system 200. The inlet gas stream 202 can include one or more impurities that are to be removed by the system 200. In one or more illustrative examples, the system 200 can remove an amount of carbon dioxide from the inlet gas stream 202.

[048] The system 200 can include a first absorber vessel 204 that includes one or more first nozzles 206. The one or more first nozzles 206 can produce a dispersed droplet stream that contacts the inlet gas stream 202 with an absorber liquid that includes an amount of a solvent. The solvent included in the dispersed droplet stream can absorb a first amount of one or more impurities included in the inlet gas stream 202. Contacting the inlet gas stream 202 with the dispersed droplet stream can produce a first liquid-gas mixture within the first absorber vessel 204. The first absorber vessel 204 can also include a first filtering device 208. The first filtering device 208 can separate the liquid components from the gas components of the first liquid gas mixture. The first filtering device 208 can produce a first modified gas stream 210 that includes an amount of the one or more impurities that is less than the amount of the one or more impurities in the inlet gas stream 202. The one or more first nozzles 206 can be located in a first area of the first absorber vessel 204 and the first filtering device 208 can be included in a second area of the first absorber vessel 204 that is distinct from the first area.

[049] In one or more illustrative examples, an amount of one or more impurities present in the first modified gas stream 210 can be at least about 2% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 4% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 6% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 8% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 10% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 15% by weight of the amount of the one or more impurities present in the inlet gas stream 202, at least about 20% by weight of the amount of the one or more impurities present in the inlet gas stream 202, or at least about 25% by weight of the amount of the one or more impurities present in the inlet gas stream 202. In various examples, an amount of one or more impurities captured from the first modified gas stream 210 by the absorber liquid in the first absorber vessel 204 can be from about 2% by weight to about 25% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 4% by weight to about 20% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 6% by weight to about 15% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 2% by weight to about 10% by weight by weight of the amount of the one or more impurities present in the inlet gas stream 202, or from about 10% by weight to about 20% by weight by weight of the amount of the one or more impurities present in the inlet gas stream 202.

[050] The first filtering device 208 can also produce first used absorber liquid 212 that includes an amount of a solvent and an amount of one or more impurities included in the inlet gas stream 202 that have been captured by the absorber liquid. In various examples, the first used absorber liquid 212 can be stored in a first storage tank 214. The first storage tank 214 can be coupled to a first pump 216 that can transport an amount of the first used absorber liquid 212 from the first storage tank 214 to an additional location that is included in the system 200 or is coupled to the system 200, such as a desorption system. In one or more illustrative examples, the first pump 216 can include a positive displacement pump. For example, the first pump 216 can include a gear pump.

[051] The system 200 can also include a second absorber vessel 218 that includes one or more second nozzles 220 and a second filtering device 222. The one or more second nozzles 220 can produce a dispersed droplet stream that contacts the first modified gas stream 210 with an absorber liquid that includes an amount of a solvent. The solvent included in the dispersed droplet stream can absorb a second amount of the one or more impurities included in the first modified gas stream 210. Contacting the first modified gas stream 210 with the dispersed droplet stream can produce a second liquid-gas mixture within the second absorber vessel 218. The second absorber vessel 218 can also include a second filtering device 222. The second filtering device 222 can separate the liquid components from the gas components of the second liquid gas mixture. The second filtering device 222 can produce a second modified gas stream 224 that includes an amount of the one or more impurities that is less than the amount of the one or more impurities in the first modified gas stream 210. The one or more second nozzles 220 can be located in a first area of the second absorber vessel 218 and the second filtering device 222 can be included in a second area of the second absorber vessel 218 that is distinct from the first area.

[052] In one or more additional illustrative examples, an amount of one or more impurities present in the second modified gas stream 224 can be at least about 2% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 4% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 6% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 8% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 10% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 12% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 18% by weight of the amount of the one or more impurities present in the first modified gas stream 210, at least about 20% by weight of the amount of the one or more impurities present in the first modified gas stream 210, or at least about 25% by weight of the amount of the one or more impurities present in the first modified gas stream 210. In various examples, an amount of one or more impurities captured from the first modified gas stream 210 by the absorber liquid in the second absorber vessel 218 can be from about 2% by weight to about 25% by weight of the amount of the one or more impurities present in the first modified gas stream 210, from about 4% by weight to about 18% by weight of the amount of the one or more impurities present in the first modified gas stream 210, from about 6% by weight to about 15% by weight of the amount of the one or more impurities present in the first modified gas stream 210, from about 2% by weight to about 10% by weight by weight of the amount of the one or more impurities present in the first modified gas stream 210, or from about 10% by weight to about 20% by weight of the amount of the one or more impurities present in the first modified gas stream 210. In at least some examples, the amount of impurities removed by the absorption operations in the second modified gas stream 224 and the first modified gas stream 210 can be relatively the same or different based on temperature and/or pressure differences in the absorber vessels 204, 218 and based on solvent compositions of the dispersed droplet streams of the absorber vessels 204, 218. In various examples, the amount of the one or more impurities captured by the absorber liquid of the dispersed droplet stream of the second absorber vessel 218 can be less than the amount of impurities captured by the absorber liquid of the dispersed droplet stream of the first absorber vessel 204.

[053] The second filtering device 222 can also produce a second used absorber liquid 226 that includes an amount of one or more solvents and an amount of one or more impurities included in the first modified gas stream 210 that have been captured by the absorber liquid. In various examples, the second used absorber liquid 226 can be stored in a second storage tank 228. The second storage tank 228 can be coupled to a second pump 230 that can transport an amount of the second used absorber liquid 226 from the second storage tank 228 to the first absorber vessel 204. In this way, the second used absorber liquid 226 can be used to produce the dispersed droplet stream of the first absorber vessel 204 that contacts the inlet gas stream 202. In one or more illustrative examples, the second pump 230 can include a positive displacement pump. For example, the second pump 230 can include a gear pump.

[054] Additionally, the system 200 can include a third absorber vessel 232 that includes one or more third nozzles 234 and a third filtering device 236. The one or more third nozzles 234 can produce a dispersed droplet stream that contacts the second modified gas stream 224 with an absorber liquid that includes an amount of a solvent. The solvent included in the dispersed droplet stream can absorb a third amount of the one or more impurities included in the second modified gas stream 224. Contacting the second modified gas stream 224 with the dispersed droplet stream can produce a third liquid-gas mixture within the third absorber vessel 232. The third absorber vessel 232 can also include a third filtering device 236. The third filtering device 236 can separate the liquid components from the gas components of the third liquid gas mixture. The third filtering device 236 can produce a third modified gas stream 238 that includes an amount of the one or more impurities that is less than the amount of the one or more impurities in the second modified gas stream 224. The one or more third nozzles 234 can be located in a first area of the third absorber vessel 232 and the third filtering device 236 can be included in a second area of the third absorber vessel 232 that is distinct from the first area.

[055] In one or more further illustrative examples, an amount of one or more impurities present in the third modified gas stream 238 can be at least about 2% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 4%

by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 6% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 8% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 10% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 12% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 18% by weight of the amount of the one or more impurities present in the second modified gas stream 224, at least about 20% by weight of the amount of the one or more impurities present in the second modified gas stream 224, or at least about 25% by weight of the amount of the one or more impurities present in the second modified gas stream 224. In various examples, an amount of one or more impurities captured from the second modified gas stream 224 by the absorber liquid in the third absorber vessel 232 can be from about 2% by weight to about 25% by weight of the amount of the one or more impurities present in the second modified gas stream 224, from about 4% by weight to about 18% by weight of the amount of the one or more impurities present in the second modified gas stream 224, from about 6% by weight to about 15% by weight of the amount of the one or more impurities present in the second modified gas stream 224, from about 2% by weight to about 10% by weight by weight of the amount of the one or more impurities present in the second modified gas stream 224, or from about 10% by weight to about 20% by weight of the amount of the one or more impurities present in the second modified gas stream 224. In at least some examples, the amount of impurities removed by the absorption operations in the third modified gas stream 238, the second modified gas stream 224, and the first modified gas stream 210 can be relatively the same or different based on temperature and/or pressure differences in the absorber vessels 204, 218, 232 and based on solvent compositions of the dispersed droplet streams of the absorber vessels 204, 218, 232. In various examples, the amount of the one or more impurities captured by the absorber liquid of the dispersed droplet stream of the third absorber vessel 232 can be less than the amount of impurities captured by the absorber liquid of the dispersed droplet stream of the first absorber vessel 204 and/or the second absorber vessel 218.

[056] The third filtering device 236 can also produce a third used absorber liquid 240 that includes an amount of one or more solvents and an amount of one or more impurities included in the second modified gas stream 224 that have been captured by the absorber liquid. In various examples, the third used absorber liquid 240 can be stored in a third storage tank 242.

The third storage tank 242 can be coupled to a third pump 244 that can transport an amount of the third used absorber liquid 240 from the third storage tank 242 to the second absorber vessel 218. In this way, the third used absorber liquid 240 can be used to produce the dispersed droplet stream of the second absorber vessel 218 that contacts the first modified gas stream 210 in the second absorber vessel 218. In one or more illustrative examples, the third pump 244 can include a positive displacement pump. For example, the third pump 244 can include a gear pump. By using the second used absorber liquid 226 to remove impurities from the inlet gas stream 202 within the first absorber vessel 204 and by using the third used absorber liquid 240 to remove impurities from the first modified gas stream 210 in the second absorber vessel 218, the system 200 can implement a counterflow arrangement where the gas flows through the absorber vessels 204, 218, 232 in a first direction and the absorber liquid flows in a second direction opposite the first direction from the third absorber vessel 232 to the second absorber vessel 218 and from the second absorber vessel 218 to the first absorber vessel 204.

[057] The system 200 can also include a fourth absorber vessel 246 that performs one or more absorber polishing operations with respect to the third modified gas stream 238. In one or more examples, the fourth absorber vessel 246 can include a fourth filtering device 248. The fourth filtering device 248 can separate one or more gas components, such as one or more impurities, from the third modified gas stream 238 to produce a fourth modified gas stream 250. In one or more illustrative examples, the one or more impurities removed from the third modified gas stream 238 can be different from one or more impurities removed by the filtering devices 208, 222, 236. In various examples, the fourth filtering device 248 can remove at least one of particulate matter or liquid droplets from the third modified gas stream 238. In at least some examples, the fourth filtering device 248 can include one or more carbon-containing filtration devices.

[058] The system 200 can include a fifth absorber vessel 252 that includes one or more additional nozzles 254 and a fifth filtering device 256. The one or more additional nozzles 254 can produce a dispersed droplet stream that includes an amount of water. In at least some examples, the dispersed droplet stream produced by the one or more additional nozzles 254 can include at least about 50% by weight water, at least about 60% by weight water, at least about 70% by weight water, at least about 80% by weight water, at least about 90% by weight water, or at least about 95% by weight water. In various examples, the dispersed droplet stream produced by the one or more additional nozzles 254 can remove one or more further impurities from the fourth modified gas stream 250. To illustrate, water molecules included in the dispersed droplet stream produced by the one or more additional nozzles 254 can capture one or more components of the fourth modified gas stream 250. An additional modified liquid-gas mixture can be produced within the fifth absorber vessel 252 by contacting the fourth modified gas stream 250 with the dispersed droplet stream produced by the one or more additional nozzles 254. The fifth filtering device 256 can produce a discharge gas stream 258 from the liquid-gas mixture produced within the fifth absorber vessel 252. The discharge gas stream 258 can have an amount of one or more impurities that is less than the amount of the one or more impurities present in the fourth modified gas stream 250.

[059] In one or more illustrative examples, the amount of one or more impurities present in the discharge gas stream 258 can be no greater than about 10% by weight of the amount of the one or more impurities present in the inlet gas stream 202, no greater than about 15% by weight of the amount of the one or more impurities present in the inlet gas stream 202, no greater than about 20% by weight of the amount of the one or more impurities present in the inlet gas stream 202, or no greater than about 25% by weight of the amount of the one or more impurities present in the inlet gas stream 202. In various examples, the amount of one or more impurities present in the discharge gas stream can be from about 1% by weight to about 25% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 2% by weight to about 20% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 5% by weight to about 15% by weight of the amount of the one or more impurities present in the inlet gas stream 202, from about 2% by weight to about 10% by weight of the amount of the one or more impurities present in the inlet gas stream 202, or from about 5% by weight to about 15% by weight of the amount of the one or more impurities present in the inlet gas stream 202. In scenarios where the system 200 is configured to remove carbon dioxide from the inlet gas stream 202, the system 200 may remove at least about 50% by weight of the carbon dioxide present in the inlet gas stream 202, at least about 60% by weight of the carbon dioxide present in the inlet gas stream 202, at least about 70% by weight of the carbon dioxide present in the inlet gas stream 202, at least about 80% by weight of the carbon dioxide present in the inlet gas stream 202, at least about 90% by weight of the carbon dioxide present in the inlet gas stream 202, or at least about 95% by weight of the carbon dioxide present in the inlet gas stream 202.

[060] The fifth filtering device 256 can also produce a used water wash stream 260 that includes an amount of water and an amount of one or more impurities included in the fourth modified gas stream 250 that have been captured by the water included in the dispersed droplet stream produced by the one or more additional nozzles 254. In various examples, the used water wash stream 260 can be stored in an additional storage tank 262. The additional storage tank 262 can be coupled to an additional pump 264 that can transport an amount of the used water wash stream 260 from the additional storage tank 262 to a carbon filter 266. The carbon filter 266 can produce a purified water stream 268 that is pumped by the additional pump 264 out of the system 200. In this way, the water used to produce the dispersed droplet stream within the fifth absorber vessel 252 can be purified before being leaving the system 200.

[061] Although the illustrative example of FIG. 2 includes three absorber vessels 204, 218, 246, that contact a gas stream with one or more absorber liquids, in additional implementations, the system 200 can include more absorber vessels or fewer absorber vessels that contact a gas stream with one or more absorber liquids. Additionally, in various other implementations, the system 200 can include more or fewer polishing absorber vessels than the fourth absorber vessel 246 and more or fewer water wash absorber vessels than the fifth absorber vessel 252 included in the illustrative example of FIG. 2.

[062] FIG. 3 is a diagram of a system 300 to transfer heat between solutions used in the removal of one or more components from a gas stream, according to one or more example implementations. In at least some examples, the system 300 can also be implemented to regenerate absorber liquid used in the system 200. For example, the system 300 can be implemented to remove one or more gas components that were captured by the absorber liquid used in the system 200 to remove the one or more components from a gas stream. In this way, the regenerated absorber liquid can be re-used in the system 200 and waste of the absorber liquid can be minimized. In one or more illustrative examples, the system 200 can include a desorption system.

[063] The system 300 can include a first heat transfer device 302 that receives used absorber liquid 304, such as the first used absorber liquid 212 of FIG. 2. The system 300 can also include a gas component conduit 306 that includes a plurality of inlets and one or more outlets. In various examples, the gas component conduit 306 can store and/or transfer at least a portion of the one or more gas components removed from the used absorber liquid 304. The gas component conduit 306 can produce an aggregate gas component stream 308 that is provided to the first heat transfer device 302. The first heat transfer device 302 can cause an amount of heat to be transferred between the used absorber liquid 304 and the aggregate gas component stream 308. In one or more examples, the first heat transfer device 302 can cause a temperature of the used absorber liquid 304 to increase and a temperature of the aggregate gas component stream 308 to decrease. In one or more examples, the first heat transfer device 302 can include a heat exchanger. In one or more illustrative examples, the first heat transfer device 302 can include a cross heat exchanger.

[064] The system 300 can also include a second heat transfer device 310. The second heat transfer device 310 can transfer an amount of heat between the used absorber liquid 304 from the first heat transfer device 302 and an amount of regenerated absorber liquid. In one or more examples, the second heat transfer device 310 can cause a temperature of the used absorber liquid 304 to decrease and a temperature of the regenerated absorber liquid to increase. In one or more examples, the second heat transfer device 310 can include a heat exchanger. In one or more illustrative examples, the second heat transfer device 310 can include a cross heat exchanger.

[065] In addition, the system 300 can include a first regenerator vessel 312 that includes one or more first nozzles 314. The one or more first nozzles 314 can produce a dispersed droplet stream that includes the used absorber liquid 304 that is received from the second heat transfer device 310. The dispersed droplet stream produced within the first generator vessel can pass through a first filtering device 316. The first filtering device 316 can cause one or more gas components captured by the used absorber liquid 304 to separate from the molecules of the absorber liquid to produce a first gas component stream 318 and first regenerated absorber liquid 320. The first gas component stream 318 can include an amount of the one or more gas components captured by the used absorber liquid 304 and the first regenerated absorber liquid 320 can include a decreased amount of the one or more gas components along with an increased concentration of one or more solvents included in the used absorber liquid 304. The first gas component stream 318 can be transported to the gas component conduit 306. The first regenerated absorber liquid 320 can be stored in a first storage tank 322. The first storage tank 322 can be coupled to a first pump 324 that can transfer an amount of the first regenerated absorber liquid 320 to a heating device 326. The heating device 326 can increase a temperature of the first regenerated absorber liquid 320.

[066] The heated first regenerated absorber liquid 320 can be transferred to a second regenerator vessel 328. The second regenerator vessel 328 can include one or more second nozzles 330 to produce a dispersed droplet stream that includes the first regenerated absorber liquid 320. The second regenerator vessel 328 can also include a second filtering device 332. The second filtering device 332 can cause one or more gas components captured by the first regenerated absorber liquid 320 to separate from the molecules of the absorber liquid to produce a second gas component stream 334 and second regenerated absorber liquid 336. In one or more illustrative examples, the first filtering device 316 and the second filtering device 332 can include a vane pack. In various examples, the first filtering device 316 can provide a tortious path that causes separation between one or more gas components and one or more liquid solvents included in the used absorber liquid 304. Further, the second filtering device 332 can provide a tortious path that causes separation between one or more gas components and one or more liquid solvents included in the first regenerated absorber liquid 320. In one or more illustrative examples, the tortious path can be comprised of at least one of one or more metallic materials, one or more polymeric materials. or one or more composite materials.

[067] The second gas component stream 334 can include an amount of the one or more gas components captured by the first regenerated absorber liquid 320 and the second regenerated absorber liquid 336 can include a decreased amount of the one or more gas components in conjunction with an increased concentration of one or more solvents included in the first regenerated absorber liquid 320. The second gas component stream 334 can be transported to the gas component conduit 306. The aggregate gas component stream 308 can be produced in the gas component conduit 306 by combining the first gas component stream 318 and the second gas component stream 334. The second regenerated absorber liquid 336 can be stored in a second storage tank 338. The second storage tank 338 can be coupled to a second pump 340. The second pump 340 can transport the second regenerated absorber liquid 336 to the second heat transfer device 310. In one or more examples, the second regenerated absorber liquid 336 can be transported from the second heat transfer device 310 to one or more absorber vessels to contact a gas stream and cause separation between one or more gas components of a gas stream. In one or more illustrative examples, the second regenerated absorber liquid 336 can be provided to the third absorber vessel 232 of FIG. 2. In this way, absorber liquid can be recycled and used to remove one or more gas components from a stage of an absorption section after previously being used to remove the one or more gas components from a previous stage of the absorption section.

[068] In various examples, the system 300 can include a knockout pot 342. The knockout pot 342 can store an amount of the liquid condensate from the cooled gas component stream 308 after the aggregate gas component stream 308 passes through the first heat transfer device 302. In one or more examples, the aggregate gas component stream 308 can be transported out of the knockout pot 342 and outside of the system 300. In one or more additional examples, the aggregate gas component stream 308 can be transported to a storage facility for the one or more components included in the aggregate gas component stream 308. In scenarios where the aggregate gas component stream 308 includes carbon dioxide removed from a gas stream, the aggregate gas component stream 308 can be stored in a carbon dioxide storage facility.

[069] FIG. 4 is a diagram of vessel 400 to contact a gas stream 402 with an absorber liquid that removes one or more components from the gas stream 402 and a filtering device 404 to separate the used absorber liquid 406 from a modified gas stream 408, according to one or more example implementations. In one or more examples, the vessel 400 can include an inlet 410 through which the gas stream 402 passes. In at least some examples, the inlet 410 can have an inner diameter from about 2 cm to about 400 cm, from about 10 cm to about 350 cm, from about 25 cm to about 300 cm, from about 50 cm to about 250 cm, from about 75 cm to about 200 cm, from about 10 cm to about 100 cm, or from about 25 cm to about 150 cm. The vessel 400 can also include a first area 412 and a number of nozzles 414 can be located in the first area 412. The number of nozzles 414 can produce a dispersed droplet stream that includes an absorber liquid that contacts the gas stream 402. The absorber liquid that comprises the dispersed droplet stream can capture an amount of one or more components of the gas stream 402 to produce a gas-liquid mixture within the first area 412. In various examples, the absorber liquid can be configured to bind molecules of one or more components of the gas stream 402. In one or more illustrative examples, the number of nozzles 414 can have a diameter from about 1 mm to about 100 mm, from about 10 mm to about 80 mm, from about 20 mm to about 60 mm, from about 10 mm to about 50 mm, or from about 60 mm to about 100 mm. The temperature and pressure conditions within the first area 412 can correspond to conditions that enable the absorber liquid to bind molecules of impurities in the gas stream 402.

[070] The vessel 400 can also include a second area 416 in which the filtering device 404 is located. In at least some examples, a maximum inner diameter of the absorber vessel 400 with respect to the second area 416 can be from about 2 cm to about 400 cm, from about 10 cm to about 350 cm, from about 25 cm to about 300 cm, from about 50 cm to about 250 cm, from about 100 cm to about 200 cm, from about 25 cm to about 100 cm, or from about 50 cm to about 150 cm. In one or more examples, the filtering device 404 can include a vane pack having a tortious path that produces the modified gas stream 408. The modified gas stream 408 can exit the vessel through a first outlet 418. The modified gas stream 408 can include an amount of one or more components that is less than the amount of the one or more components of the gas stream 402. In one or more illustrative examples, the modified gas stream 408 can include an amount of carbon dioxide that is less than an amount of carbon dioxide included in the gas stream 402. The filtering device 404 can also produce the used absorber liquid 406. The used absorber liquid 406 can include an amount of one or more solvents that have captured an amount of one or more components included in the gas stream 402. The vessel 400 can include a second outlet 420 through which the used absorber liquid 406 passes.

[071] In one or more illustrative examples, one or more instances of the vessel 400 can be implemented to perform at least one of the first gas component transfer operation 122, the first gas-liquid separation operation 124, the Nth gas component transfer operation 126, the Nth gas-liquid separation operation 128, the first gas component transfer operation 132, the first gas-liquid separation operation 134, the Nth gas component transfer operation 136, or the Nth gas-liquid separation operation 138. In various examples, the vessel 400 can used to perform the first gas component transfer operation 122 and the first gas-liquid separation operation 124. For example, the first gas component transfer operation 122 can be performed within the first area 412 by contacting the gas stream 402 with a dispersed droplet stream produced by the number of nozzles 414. Additionally, the first gas-liquid separation operation 124 can be performed by the filtering device 404 to produce the modified gas stream 408 and the used absorber liquid 406. Further, one or more instances of the vessel 400 can correspond to the first vessel 204, the second vessel 218, the third vessel 232, and the fifth absorber vessel 252 described in relation to FIG. 2. One or more instances of the vessel 400 can also correspond to the first regenerator vessel 312 and the second regenerator vessel 328 described in relation to FIG. 3.

[072] FIG. 5 is a diagram of a container 500 that includes horizontally arranged train 502 having equipment to remove one or more components from a gas stream using a solvent, according to one or more example implementations. In one or more examples, the container 500 can be portable, such that the container 500 can be transportable from a first location to a second location. In various examples, the container 500 can have a length from about 5 m to about 30 m, from about 10 m to about 20 m, from about 5 m to about 15 m, or from about 15 m to about 25 m. Additionally, the container 500 can have a width from about 1 m to about 8 m, from about 2 m to about 6 m, from about 1 m to about 5 m, or from about 2 m to about 4 m.

[073] The train 502 can include an absorption section 504. The absorption section 504 can include a number of pieces of equipment to remove one or more components from a gas stream using an absorber liquid. For example, the absorption section 504 can perform at least a portion of the operations described with respect to the first absorption section 104 of FIG. 1. In one or more illustrative examples, the absorption section 504 can include a number of vessels that correspond to the vessel 400 described with respect to FIG. 4. In one or more additional illustrative examples, the absorption section 504 can correspond to the system 200 described with respect to FIG. 2.

[074] The train 502 can include a number of pieces of equipment in addition to the pieces of equipment that correspond to the absorption section 504. To illustrate, the train 502 can include a stripping operation section 506. The stripping operation section 506 can operate to remove one or more additional components from a discharge gas produced by the absorption section 504. In one or more examples, the stripping operation section 506 can include a number of additional vessels that correspond to the vessel 400 described with respect to FIG. 5.

[075] FIG. 6 is a diagram depicting features of a horizontally arranged train 600 having equipment to remove one or more components from a gas stream using a solvent, according to one or more example implementations. The train 600 can include an inlet section 602 to receive a gas stream. The train 600 can also include a number of sections that include one or more devices for separating one or more components of the gas stream. For example, the train 600 can include a first section 604, a second section 606, a third section 608, a fourth section 610, a fifth section 612, a sixth section 614, and a seventh section 616. The train 600 can terminate in an outlet section 618 that discharges an outlet gas. Although the illustrative example of FIG. 6 shows the train 600 having seven sections, in other implementations, the train 600 can have fewer sections or more sections.

[076] A first vane pack 620 can be located in the first section 604 and a second vane pack 622 can be located in the second section 606. A heat exchanger 624 can also be disposed in the train 600 after the second vane pack 622. In one or more examples, the heat exchanger 624 can include a shell and tube heat exchanger. In the illustrative example of FIG. 6, the heat exchanger 624 can be located in the second section 606, while in other implementations, the shell and tube heat exchanger 624 can be located in other sections of the train 600 or form its own section of the train 600. A third vane pack 626 can be located in the third section 606 and a fourth vane pack 628 can be located in the fourth section 608. Additionally, a fifth vane pack 630 can be located in the fifth section 612, a sixth vane pack 632 can be located in the sixth section 614, and a seventh vane pack 634 can be located in the seventh section 616.

[077] At least a portion of the sections of the train 600 can be separated by baffle walls. For example, a first baffle wall 636 can be disposed between the inlet section 602 and the first section 604. In addition, a second baffle wall 638 can be disposed between the first section 604 and the second section 606. Further, a third baffle wall 640 can be disposed after the heat exchanger 624 and prior to the third section 608. A fourth baffle wall 642 can be disposed between the third section 608 and the fourth section 610 and a fifth baffle wall 644 can be disposed between the fourth section 610 and the fifth section 612. A sixth baffle wall 646 can be disposed between the fifth section 612 and the sixth section 614 and a seventh baffle wall 648 can be disposed between the sixth section 614 and the seventh section 616.

[078] The sections 604, 606, 608, 610, 612, 614, 616 can have a diameter from about 20 cm to about 50 cm, from about 25 cm to about 45 cm, or from about 30 cm to about 40 cm. Additionally, the train 600 can have a length 650. The length 650 can be from about 5 meters to about 15 meters, from about 6 meters to about 12 meters, or from about 7 meters to about 10 meters. In one or more illustrative examples, the arrangement of the devices and sizes of components of the train 600 can be configured to optimize removal of one or more components of the inlet gas stream, such as carbon dioxide.

[079] FIG. 7 is a diagram of a container 700 that includes multiple horizontally arranged trains having equipment to remove one or more components from a gas stream using an absorber liquid, according to one or more example implementations. For example, the container 700 can include a first train 702, a second train 704, and a number of additional trains. In various examples, the first train 702 and the second train 704 can individually correspond to the train 502 described in relation to FIG. 5. In one or more examples, the trains located in the container 700 can be coupled via a piping system (not shown in FIG. 7). The piping system can include a number of piping sections to transport inlet gas to each of the trains located in the container 700. In addition, the piping system can include a number of piping sections to transport absorber fluid within the individual trains and/or between the individual trains. Further, the piping system can include a number of piping sections to transport discharge gas out of the individual trains located in the container 700. In at least some examples, one or more pumps can be located in the container to transport at least one of liquids or gases through the trains located in the container 700. In one or more additional examples, one or more pumps that are activated to move at least one of liquids or gases through the trains can be located outside of the container 700, such as in another container.

[080] In one or more examples, a number of trains included in the container 700 can correspond to a desired capacity for the removal of one or more components from a gas stream. For example, in situations where a capacity to remove a relatively large amount of one or more components from a gas stream, such as from about 300,000 metric tons per year to about 500,000 metric tons per year, the container 700 can include a number of trains that is greater than in scenarios where lesser amounts of the one or more components are desired to be removed from the gas stream, such as from about 50,000 metric tons per year to about 250,000 metric tons per year. Additionally, a number of trains that are operational at a given time can be configured based on a desired capacity for removal of one or more components of a gas stream. To illustrate, a first number of trains can be operational to produce a first capacity of gas impurity removal and a second number of trains can be operational to produce a second capacity of gas impurity removal that is different from the first capacity. In various examples, the first capacity for gas impurity removal can be higher than the second capacity for gas impurity removal and the first number of operational trains can be greater than the second number of operational trains. In one or more illustrative examples, the first number of operational trains can produce 95% removal of impurities from the gas stream and the second number of operational trains can produce 40% removal of impurities from the gas stream.

[081] FIG. 8 is a picture of a horizontally arranged system 800 to remove one or more components from a gas stream using an absorber liquid, according to one or more example implementations. The system 800 can include an inlet 802 through which the gas stream enters the system 800. The gas stream can be provided to the inlet 802 from a gas source 804. The system 800 can also include a first area 806 that includes a number of nozzles to produce a dispersed droplet stream in the first area 806 to contact the gas stream. The dispersed droplet stream can comprise an absorber liquid supplied by an absorber liquid source 808. A gas-liquid mixture can be produced in the first area 806 in response to the dispersed droplet stream contacting the gas stream. The system 800 can also include a second area 810 that includes a vane pack 812. The vane pack 812 can cause the gas-liquid mixture to be separated into a used absorber liquid stream that is provided to a storage tank 814 and a modified gas stream that exits the system 800 via an outlet 816. The system 800 can cause an amount of one or more components included in the gas stream to be reduced in the modified gas stream because a portion of the amount of the one or more components included in the gas stream is captured by the absorber liquid that comprises the dispersed droplet stream.

[082] FIG. 9 is a diagram of a system 900 to remove one or more components from an inlet gas stream that is pretreated prior to the gas stream being provided to one or more absorption operations, according to one or more example implementations. The system 900 can include a pretreatment system 902 that receives flue gas 904. The flue gas 904 can include one or more impurities. In various examples, the flue gas 904 can include gas impurities, such as carbon dioxide and/or one or more sulfur-containing gas components. Additionally, the flue gas 904 can include one or more particulates. The composition of the flue gas 904 can be based on a source of the flue gas 904. For example, the flue gas 904 can have a first composition when the flue gas 904 is produced by a coal-fired power plant and a second composition when the flue gas 904 is produced by a diesel-powered generator.

[083] In one or more illustrative examples, the pretreatment system 902 can implement one or more purification techniques to remove one or more impurities from the flue gas 904. In one or more additional illustrative examples, the pretreatment system 902 can modify a temperature of the flue gas 904. For example, the pretreatment system 902 can reduce a temperature of the flue gas 904. In at least some examples, an initial temperature of the flue gas 904 before entering the pretreatment system 902 can be from about 35 °C to about 65 °C, from about 40 °C to about 60 °C, from about 45 °C to about 55 °C, or from about 50 °C to about 60 °C. The pretreatment system 902 can cool the flue gas 904 to an outlet temperature from about 10 °C to about 40 °C, from about 15 °C to about 35 °C, from about 20 °C to about 30 °C, or from about 15 °C to about 25 °C. The flue gas 904 can be provided at pressures from about 500 kilopascals (kPa) to about 1500 kPa, from about 700 kPa to about 1200 kPa, or from about 900 kPa to about 1100 kPa. In at least some examples, the pretreatment system 902 can reduce the pressure of the flue gas 904 such that outlet streams from the pretreatment system 902 can be provided at from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa.

[084] The system 900 can also include an absorption unit 906. The absorption unit 906 can reduce an amount of one or more impurities present in the flue gas by contacting the flue gas with an absorber liquid. In one or more examples, the absorption unit 906 can include a number of stages. For example, the absorption unit 906 can include the first absorption section 104 described with respect to FIG. 1 and/or the system 200 described with respect to FIG. 2. The absorption unit 906 can produce an outlet gas 908 that has a lower amount of one or more impurities in relation to the amount of the one or more impurities present in the flue gas 904. The outlet gas 908 can be heated in relation to a temperature of the flue gas 904 after leaving the pretreatment system 902. To illustrate, the outlet gas 908 can have a temperature from about 40 °C to about 80 °C, from about 45 °C to about 75 °C, from about 50 °C to about 70 °C, or from about 55 °C to about 65 °C. The absorption unit 906 can also produce used absorber liquid 910 that includes an amount of one or more components of the flue gas 904 that have been captured by the absorber liquid used in the absorption unit 906. The used absorber liquid 910 can be cooled in relation to the absorber liquid present in the absorption unit 906. In one or more illustrative examples, the used absorber liquid 910 can have a temperature from about 35 °C to about 65 °C, from about 40 °C to about 60 °C, or from about 45 °C to about 55 °C. In various examples, inlet pressures and outlet pressures from the absorption unit 906 can be from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa.

[085] The outlet gas 908 can be provided to a water wash unit 912 that contacts the outlet gas 908 with a dispersed droplet stream comprised of at least 70% by weight water to remove one or more additional impurities from the outlet gas 908. The water wash unit 912 can also reduce the temperature of the outlet gas 908. For example, the gas leaving the water wash unit 912 can have a temperature from about 35 °C to about 55 °C or from about 40 °C to about 50 °C. In one or more illustrative examples, the water wash unit 912 can include the fifth absorber vessel 252 described with respect to FIG. 2. In at least some examples, the outlet gas 908 provided to the water wash unit 912 and gas outlets from the water wash unit 912 can be from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa. In one or more examples, a water wash stream can be provided to the water wash unit 912 at pressures from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa. One or more liquid outlets from the water wash unit 912 can be discharged at pressures from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa.

[086] Additionally, the used absorber liquid 910 can be provided to a desorption unit 914. The desorption unit 914 can remove one or more gas impurities captured by the used absorber liquid 910 to produce regenerated absorber liquid 916. The regenerated absorber liquid 916 can have higher concentrations of one or more solvents included in the input absorber liquid 920 than the concentrations of the one or more solvents in the used absorber liquid 910. Further, the concentrations of the one or more impurities present in the regenerated absorber liquid 916 can be less than the concentrations of the one or more impurities present in the used absorber liquid 910. In this way, the regenerated absorber liquid 916 can be re-used in the absorption unit 906. The desorption unit 914 can heat the used absorber liquid 910, such that the temperature of the regenerated absorber liquid 916 is greater than the temperature of the used absorber liquid 910. For example, the regenerated absorber liquid 916 can have a temperature from about 45 °C to about 80 °C, from about 50 °C to about 75 °C, or from about 55 °C to about 65 °C. In one or more illustrative examples, the desorption unit 914 can include the system 300 described in relation to FIG. 3. In various examples, input streams and output streams for the desorption unit 914 can be from about 50 kPa to about 500 kPa, from about 100 kPa to about 400 kPa, or from about 200 kPa to about 300 kPa.

[087] In various examples, the regenerated absorber liquid 916 can be provided to an absorber liquid unit 918. The absorber liquid unit 918 can produce input absorber liquid 920 that is provided to the absorption unit 906. The input absorber liquid 920 can include, at least in part, the regenerated absorber liquid 916. In one or more examples, the absorber liquid unit 918 can add one or more liquid components to the regenerated absorber liquid 916 to produce the input absorber liquid 920. For example, at least one of an amount of water or an amount of one or more solvents can be added to the regenerated absorber liquid 916 to produce the input absorber liquid 920. In various examples, the absorber liquid unit 918 can add at least one of an amount of water or an amount of one or more solvents to the regenerated absorber liquid 916 to produce the input absorber liquid 920 such that the concentration of one or more solvents present in the input absorber liquid 920 is within a target concentration range for the one or more solvents. In one or more illustrative examples, the absorber liquid unit 918 can add an amount of one or more solvents to the regenerated absorber liquid 916 to increase a concentration of the one or more solvents in the input absorber liquid 920 such that the concentration of the one or more solvents in the input absorber liquid 920 is within a target concentration for the one or more solvents. In one or more additional illustrative examples, the absorber liquid unit 918 can add an amount of water to the regenerated absorber liquid 916 to reduce a concentration of one or more solvents present in the regenerated absorber liquid 916 such that the concentration of the one or more solvents in the input absorber liquid 920 is within a target concentration for the one or more solvents. In at least some examples, the temperature of the input absorber liquid 920 can correspond to the temperature of the regenerated absorber liquid 916. To illustrate, the input absorber liquid 920 can have a temperature from about 45 °C to about 80 °C, from about 50 °C to about 75 °C, or from about 55 °C to about 65 °C. In at least some examples, pressures of inlet streams and outlet streams for the input absorber liquid 920 can be from about 50 kPa to about 500 kPa, from about 70 kPa to about 200 kPa, or from about 100 kPa to about 200 kPa.

[088] FIG. 10 is a graph showing amounts of impurities removed from a gas stream and amounts of gas absorbed by a solvent in a system that causes solvent to run counter to the flow of the gas stream, according to one or more example implementations. The graph indicates that inlet gas in section 1 of an absorption system has a first concentration of gas impurities, and that the concentration of the gas impurities decreases as the gas stream moves through additional sections of the absorption system. Additionally, the concentration of the gas impurities in the solvent increases in the opposite direction as the concentration of the gas impurities in the gas stream. For example, the concentration of impurities in the solvent is lower in later sections of the absorption system and increases in the earlier sections of the absorption system. That is, the solvent can capture greater amounts of gas impurities present in the gas stream when the concentration of the gas impurities present in the solvent is lowest and the solvent concentration is highest.

[089] FIG. 11 is flow diagram of a process 1100 to remove one or more components from a gas stream using an absorption liquid, according to one or more example implementations. At 1102, the process 1100 can include providing a gas stream having a first amount of gas impurities to an absorption section of a gas purification system. In one or more illustrative examples, the gas purification system can remove an amount of carbon dioxide from the gas stream. Additionally, the gas stream can be produced by a diesel-powered generator or a coal-fired power plant.

[090] In addition, the process 1100 can include, at operation 1104, contacting the gas stream in the absorption section with a dispersed droplet stream to remove a portion of the first amount of gas impurities from the gas stream and to produce a liquid-gas mixture within the absorption section. In one or more examples, the dispersed droplet stream can include an absorber liquid having one or more solvents that capture the gas impurities. In this way, the absorber liquid can bind molecules of one or more gas impurities present in the gas stream.

[091] The process 1100 can also include, at operation 1106, removing an amount of the absorber liquid from the liquid-gas mixture to produce a modified gas stream having a second amount of impurities that is less than the first amount of impurities. In one or more examples, the amount of absorber liquid can be separated from the liquid-gas mixture using a filtering device that is present in the absorption section. In one or more illustrative examples, the filtering device can provide a tortious path that separates the absorber liquid from the modified gas stream. In at least some examples, the absorber liquid removed from the liquid-gas mixture can have a loading of an amount of impurities absorbed from the inlet gas stream. Further, at operation 1108, the process 1100 can include draining the amount of the absorber liquid out of the absorption section. The absorption section can include an outlet through which the absorber liquid can be drained from the absorption section.

[092] The process 1100 can include, at operation 1110, directing the modified gas stream to an additional portion of the gas purification system. For example, the absorption section can include an additional outlet that directs the modified gas stream to the additional portion of the gas purification system. In one or more examples, the additional portion of the gas purification system can include an additional absorption section where additional amounts of the gas impurities can be removed from the modified gas stream. In one or more additional examples, the additional portion of the gas purification system can include an absorber polishing section that can further remove one or more gas impurities from the modified gas stream. In one or more further examples, the additional portion of the gas purification system can include a water wash unit to remove one or more additional gas impurities from the modified gas stream. In still other examples, the additional portion of the gas purification system can include a stripping operation system to remove one or more further components from the modified gas stream.

[093] Although a flowchart or block diagram may illustrate a method as comprising sequential steps or a process as having a particular order of operations, many of the steps or operations in the flowchart(s) or block diagram(s) illustrated herein can be performed in parallel or concurrently, and the flowchart(s) or block diagram(s) should be read in the context of the various implementations of the present disclosure. In addition, the order of the method steps or process operations illustrated in a flowchart or block diagram may be rearranged for some implementations. Similarly, a method or process illustrated in a flow chart or block diagram could have additional steps or operations not included therein or fewer steps or operations than those shown. Moreover, a method step may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc.

[094] As used herein, the terms “substantially” or “generally” refer to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is “substantially” or “generally” enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking, the nearness of completion will be so as to have generally the same overall result as if absolute and total completion were obtained. The use of “substantially” or “generally” is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result. For example, an element, combination, implementation, or composition that is “substantially free of” or “generally free of” an element may still actually contain such element as long as there is generally no significant effect thereof.

[095] In the foregoing description various implementations of the present disclosure have been presented for the purpose of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The various implementations were chosen and described to provide the best illustration of the principals of the disclosure and their practical application, and to enable one of ordinary skill in the art to utilize the various implementations with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the present disclosure as determined by the appended claims when interpreted in accordance with the breadth they are fairly, legally, and equitably entitled.

[096] A numbered non-limiting list of examples of the present subject matter is presented below.

[097] Example 1. A system to remove gas impurities from a gas stream, the system comprising: an absorption section that is arranged horizontally and includes: an inlet configured to direct the gas stream into the absorption section, the gas stream includes a first amount of gas impurities; a first area including one or more nozzles to produce a dispersed droplet stream, the dispersed droplet stream comprising a first amount of a solvent to remove a portion of the first amount of gas impurities from the gas stream and to produce a solvent-gas mixture within the first area that includes the portion of the first amount of gas impurities; a second area including a filtering device through which at least a portion of the solvent-gas mixture passes, wherein the filtering device removes an amount of the solvent from the solvent-gas mixture and produces a modified gas stream having a second amount of gas impurities that is less than the first amount of gas impurities; a first outlet disposed below the filtering device, the first outlet to drain the amount of the solvent from the absorption section; and a second outlet to direct the modified gas stream out of the absorption section.

[098] In Example 2, the subject matter of example 1, wherein the dispersed droplet stream is comprised of droplets having an average diameter no greater than 100 micrometers.

[099] In Example 3, the subject matter of example 1 or 2, comprising: an additional absorption section that receives the modified gas stream and produces an additional modified gas stream having a third amount of gas impurities that is less than the second amount of gas impurities.

[0100] In Example 4, the subject matter of example 3, wherein the additional absorption section includes one or more additional nozzles to produce an additional dispersed droplet stream, the additional dispersed droplet stream comprising a second amount of solvent that is less concentrated in impurities than the first amount of solvent.

[0101] In Example 5, the subject matter of example 4, wherein the additional absorption section includes: an additional first area that includes the one or more additional nozzles; and an additional second area that includes an additional filtering device and an additional second drain being present in the second section.

[0102] In Example 6, the subject matter of any one of examples 4-5, wherein the additional dispersed droplet stream comprises at least 1% by weight H2O.

[0103] In Example 7, the subject matter of any one of examples 4-6, wherein the additional absorption section includes a first area and a second area with nozzles being absent from the first area.

[0104] In Example 8, the subject matter of any one of examples 4-7, wherein the additional absorption section includes an additional first outlet and an additional second outlet.

[0105] In Example 9, the subject matter of example 8, comprising a pump coupled to the first additional outlet, wherein the pump is configured to move the additional solvent to the one or more nozzles of the vessel or other vessels.

[0106] In Example 10, the subject matter of any one of examples 1-9, wherein the solvent comprises components that have physical and chemical affinity towards gas impurities.

[0107] In Example 11, the subject matter of any one of examples 1-10, wherein a flow rate of the gas stream is from about 10 cfm to about 100,000 cfm.

[0108] In Example 12, the subject matter of any one of examples 1-11, wherein the gas stream is provided to the absorption section at pressures no greater than 15 kilopascals (kPa).

[0109] In Example 13, the subject matter of any one of examples 1-12, wherein the first outlet is coupled to a tank to capture the amount of solvent.

[0110] In Example 14, the subject matter of any one of examples 1-13, wherein the one or more nozzles have a diameter from about 1mm to about 100mm.

[0111] In Example 15, the subject matter of any one of examples 1-14, wherein the inlet has an inner diameter from about 2 centimeters to about 200 centimeters.

[0112] In Example 16, the subject matter of any one of examples 1-15, wherein the second area of the absorption section has an inner diameter from about 2 centimeters to about 400 centimeters.

[0113] In Example 17, the subject matter of any one of examples 1-16, wherein the filtering device includes a vane pack to separate the liquid droplets from the gas stream.

[0114] In Example 18, the subject matter of example 17, wherein the vane pack includes a tortious path composed of at least one of one or more metallic materials, one or more polymeric materials, or one or more composite materials.

[0115] In Example 19, the subject matter of any one of examples 1-18, wherein the gas impurities include carbon dioxide, carbon monoxide, sulfur dioxide or water.

[0116] Example 20. A system comprising: a series of vessels to separate an amount of gas impurities from a gas stream, the series of vessels including; an absorption section having one or more first vessels that are horizontally arranged, individual first vessels of the one or more first vessels including an inlet, an outlet, a nozzle, and a drain, wherein: the inlet receives an inlet gas having a first amount of gas impurities; the outlet discharges an outlet gas having a second amount of gas impurities that is less than the first amount of gas impurities; and the nozzle produces a dispersed droplet stream that comprises a solvent that absorbs a portion of the first amount of gas impurities from the inlet gas to produce a solvent-gas mixture; a desorption section having one or more second vessels that are horizontally arranged and coupled to at least one of the first vessels, individual second vessels of the one or more second vessels including an additional inlet, an additional outlet, and an additional nozzle, wherein: the additional inlet receiving an additional inlet gas having a first additional amount of gas impurities; the additional outlet discharges an additional outlet gas having a second amount of gas impurities that is greater than the first additional amount of gas impurities; and the additional nozzle that produces an additional dispersed droplet stream that comprises an amount of solvent-gas mixture, wherein the solvent-gas mixture includes a first amount of solvent and the additional dispersed droplet stream produces an amount of liquid having a second amount of solvent greater concentrated in impurities than the first amount of solvent.

[0117] In Example 21, the subject matter of example 20, wherein the one or more first vessels individually include a vane pack to separate an amount of solvent from the solvent-gas mixture.

[0118] In Example 22, the subject matter of example 20 or 21, wherein the one or more second vessels individually include an additional filter bank to separate an additional amount of the solvent from the amount of solvent-gas mixture provided to the additional nozzle.

[0119] In Example 23, the subject matter of any one of examples 20-22, wherein an amount of gas impurities present in the gas stream decreases as the gas stream moves through a series of first vessels included in the absorption section.

[0120] In Example 24, the subject matter of any one of examples 20-23, comprising a container to house the series of vessels.

[0121] In Example 25, the subject matter of example 24, comprising an additional series of vessels arranged in the container, the additional series of vessels to separate an additional amount of gas impurities from an additional gas stream, the additional series of vessels including an additional absorption section having one or more additional first vessels and an additional desorption section having one or more additional second vessels.

[0122] In Example 26, the subject matter of example 25, wherein the series of vessels and the additional series of vessels are coupled via a piping system located in the container.

[0123] In Example 27, the subject matter of example 25 or 26, comprising one or more pumps coupled to the series of vessels and the additional series of vessels.

[0124] In Example, the subject matter of example 27, wherein the one or more pumps are arranged in the container.

[0125] In Example 29, the subject matter of any one of examples 20-28, wherein the series of vessels produces an outlet gas having at least 30% by weight gas impurities.

[0126] In Example 30, the subject matter of any one of examples 20-29, wherein the series of vessels produces from about 15 metric tons of gas impurities to about 300,000 metric tons of gas impurities during a year.

[0127] In Example 31, the subject matter of any one of examples 20-30, wherein the gas stream is generated by a source that includes a petroleum extraction operation, a coal-based power generation plant, diesel power generators, or a natural gas extraction operation.

[0128] In Example 32, the subject matter of any one of examples 20-31, wherein at least one of a composition of the solvent and a diameter of the nozzle are selected based on a composition of the gas stream.

[0129] Example 33. A system comprising: a first vessel including: a first inlet to receive a first gas stream, the first gas stream having a first amount of gas impurities; one or more first nozzles to produce a first dispersed droplet stream comprising a first amount of a solvent to remove a first portion of the gas impurities from the first gas stream to produce (1) a second gas stream having a second amount of gas impurities that is less than the first amount of gas impurities and (2) a first recovery liquid that includes the solvent and an amount of gas impurities; a first outlet to direct the second gas stream out of the first vessel; and a second outlet to direct the first recovery liquid out of the first vessel; a second vessel including: a second inlet to receive the second gas stream from the first outlet; one or more second nozzles to produce a second dispersed droplet stream comprising a first additional amount of the solvent to remove a second portion of the gas impurities from the second gas stream to produce (1) a third gas stream having a second additional amount of gas impurities that is less than the first additional amount of gas impurities and (2) a second recovery liquid that includes the solvent and an additional amount of gas impurities; a first additional outlet to direct the third gas stream out of the second vessel; and a second additional outlet coupled to the one or more first nozzles such that the first dispersed droplet stream comprises the second recovery liquid.

[0130] In Example 34, the subject matter of example 33, comprising: a third vessel including: a third inlet to receive the third gas stream from the second outlet; a filtering device to produce a fourth gas stream having a third additional amount of gas impurities that is less than the second additional amount of gas impurities; and a third outlet to direct the fourth gas stream out of the third vessel.

[0131] In Example 35, the subject matter of example 34, comprising: a fourth vessel including: a fourth inlet to receive the fourth gas stream from the third outlet; one or more additional nozzles to produce an additional dispersed droplet stream comprising at least about 1% by weight H2O, remove an additional portion of the gas impurities from the fourth gas stream to produce (1) a fifth gas stream having a fourth additional amount of gas impurities that is less than the third additional amount of gas impurities and (2) an H2O recovery liquid that includes H2O. solvent, chemicals, and a further amount of gas impurities; an additional outlet to direct the fifth gas stream out of the fourth vessel; and a further outlet coupled to direct the H2O recovery liquid from the fourth vessel.

[0132] In Example 36, the subject matter of example 35, comprising one or more pumps to cause the second recovery liquid to move from a solvent recovery tank coupled to the second vessel to the one or more first nozzles.

[0133] In Example 37, the subject matter of example 35 or 36 comprising: a heater coupled to the second outlet to produce a heated recovery liquid; and a desorption vessel including: a fifth inlet to receive the fifth gas stream one or more further nozzles to produce a further dispersed droplet stream comprising the first recovery liquid to produce a sixth gas stream having a fifth additional amount of gas impurities that is greater than the first amount of gas impurities.

[0134] In Example 38, the subject matter of any one of examples 35-37, comprising a heat exchanger to transfer heat from the fifth gas stream to the first recovery liquid.

CLAIMS

What is claimed is:

1. A system to remove gas impurities from a gas stream, the system comprising:

an absorption section that is arranged horizontally and includes:

an inlet configured to direct the gas stream into the absorption section, the gas stream includes a first amount of gas impurities;

a first area including one or more nozzles to produce a dispersed droplet stream, the dispersed droplet stream comprising a first amount of a solvent to remove a portion of the first amount of gas impurities from the gas stream and to produce a solvent-gas mixture within the first area that includes the portion of the first amount of gas impurities;

a second area including a filtering device through which at least a portion of the solvent-gas mixture passes, wherein the filtering device removes an amount of the solvent from the solvent-gas mixture and produces a modified gas stream having a second amount of gas impurities that is less than the first amount of gas impurities;

a first outlet disposed below the filtering device, the first outlet to drain the amount of the solvent from the absorption section; and

a second outlet to direct the modified gas stream out of the absorption section.

2. The system of claim 1, wherein the dispersed droplet stream is comprised of droplets having an average diameter no greater than 100 micrometers.

3. The system of claim 1, comprising:

an additional absorption section that receives the modified gas stream and produces an additional modified gas stream having a third amount of gas impurities that is less than the second amount of gas impurities.

4. The system of claim 3, wherein the additional absorption section includes one or more additional nozzles to produce an additional dispersed droplet stream, the additional

dispersed droplet stream comprising a second amount of solvent that is less concentrated in impurities than the first amount of solvent.

5. The system of claim 4, wherein the additional absorption section includes:

an additional first area that includes the one or more additional nozzles; and

an additional second area that includes an additional filtering device and an additional second drain being present in the second section.

6. The system of claim 4, wherein the additional dispersed droplet stream comprises at least 1% by weight H_2O.

7. The system of claim 4, wherein the additional absorption section includes a first area and a second area with nozzles being absent from the first area.

8. The system of claim 4, wherein the additional absorption section includes an additional first outlet and an additional second outlet.

9. The system of claim 8, comprising a pump coupled to the additional first outlet, wherein the pump is configured to move the additional solvent to the one or more nozzles of a section of a train including the one or more nozzles or to other parts of the system.

10. The system of claim 1, wherein the solvent comprises components that have physical and chemical affinity towards gas impurities.

11. The system of claim 1, wherein a flow rate of the gas stream is from about 10 cfm to about 100,000 cfm.

12. The system of claim 1, wherein the gas stream is provided to the absorption section at pressures no greater than 15 kilopascals (kPa).

13. The system of claim 1, wherein the first outlet is coupled to a tank to capture the amount of solvent.

14. The system of claim 1, wherein the one or more nozzles have a diameter from about 1mm to about 100mm.

15. The system of claim 1, wherein the inlet has an inner diameter from about 2 centimeters to about 200 centimeters.

16. The system of claim 1, wherein the second area of the absorption section has an inner diameter from about 2 centimeters to about 400 centimeters.

17. The system of claim 1, wherein the filtering device includes a vane pack to separate liquid droplets from the gas stream.

18. The system of claim 17, wherein the vane pack includes a tortious path composed of at least one of one or more metallic materials, one or more polymeric materials, or one or more composite materials.

19. The system of claim 1, wherein the gas impurities include carbon dioxide, carbon monoxide, sulfur dioxide or water.

20. A system comprising:

a series of vessels to separate an amount of gas impurities from a gas stream, the series of vessels including;

an absorption section having one or more first vessels that are horizontally arranged, individual first vessels of the one or more first vessels including an inlet, an outlet, a nozzle, and a drain, wherein:

the inlet receives an inlet gas having a first amount of gas impurities;

the outlet discharges an outlet gas having a second amount of gas impurities that is less than the first amount of gas impurities; and

the nozzle produces a dispersed droplet stream that comprises a solvent that absorbs a portion of the first amount of gas impurities from the inlet gas to produce a solvent-gas mixture; and

a desorption section having one or more second vessels that are horizontally arranged and coupled to at least one of the one or more first vessels, individual second vessels of the one or more second vessels including an additional inlet, an additional outlet, and an additional nozzle, wherein:

the additional inlet receiving an additional inlet gas having a first additional amount of gas impurities;

the additional outlet discharges an additional outlet gas having a second amount of gas impurities that is greater than the first additional amount of gas impurities; and

the additional nozzle that produces an additional dispersed droplet stream that comprises an amount of solvent-gas mixture, wherein the solvent-gas mixture includes a first amount of solvent and the additional dispersed droplet stream produces an amount of liquid having a second amount of solvent greater concentrated in impurities than the first amount of solvent.

21. The system of claim 20, wherein the one or more first vessels individually include a vane pack to separate an amount of solvent from the solvent-gas mixture.

22. The system of claim 20, wherein the one or more second vessels individually include an additional filter bank to separate an additional amount of the solvent from the amount of solvent-gas mixture provided to the additional nozzle.

23. The system of claim 20, wherein an amount of gas impurities present in the gas stream decreases as the gas stream moves through a series of first vessels included in the absorption section.

24. The system of claim 20, comprising a container to house the series of vessels.

25. The system of claim 24, comprising an additional series of vessels arranged in the container, the additional series of vessels to separate an additional amount of gas impurities from an additional gas stream, the additional series of vessels including an additional absorption section having one or more additional first vessels and an additional desorption section having one or more additional second vessels.

26. The system of claim 25, wherein the series of vessels and the additional series of vessels are coupled via a piping system located in the container.

27. The system of claim 25, comprising one or more pumps coupled to the series of vessels and the additional series of vessels.

28. The system of claim 27, wherein the one or more pumps are arranged in the container.

29. The system of claim 20, wherein the series of vessels produces an outlet gas having at least 30% by weight gas impurities.

30. The system of claim 20, wherein the series of vessels produces from about 15 metric tons of gas impurities to about 300,000 metric tons of gas impurities during a year.

31. The system of claim 20, wherein the gas stream is generated by a source that includes a petroleum extraction operation, a coal-based power generation plant, diesel power generators, or a natural gas extraction operation.

32. The system of claim 20, wherein at least one of a composition of the solvent and a diameter of the nozzle are selected based on a composition of the gas stream.

33. A system comprising:

a first vessel including:

a first inlet to receive a first gas stream, the first gas stream having a first amount of gas impurities;

one or more first nozzles to produce a first dispersed droplet stream comprising a first amount of a solvent to remove a first portion of the gas impurities from the first gas stream to produce (1) a second gas stream having a second amount of gas impurities that is less than the first amount of gas impurities and (2) a first recovery liquid that includes the solvent and an amount of gas impurities;

a first outlet to direct the second gas stream out of the first vessel; and

a second outlet to direct the first recovery liquid out of the first vessel;

a second vessel including:

a second inlet to receive the second gas stream from the first outlet;

one or more second nozzles to produce a second dispersed droplet stream comprising a first additional amount of the solvent to remove a second portion of the gas impurities from the second gas stream to produce (1) a third gas stream having a second additional amount of gas impurities that is less than the first additional amount of gas impurities and (2) a second recovery liquid that includes the solvent and an additional amount of gas impurities;

a first additional outlet to direct the third gas stream out of the second vessel; and

a second additional outlet coupled to the one or more first nozzles such that the first dispersed droplet stream comprises the second recovery liquid.

34. The system of claim 33, comprising:

a third vessel including:

a third inlet to receive the third gas stream from the second outlet;

a filtering device to produce a fourth gas stream having a third additional amount of gas impurities that is less than the second additional amount of gas impurities; and

a third outlet to direct the fourth gas stream out of the third vessel.

35. The system of claim 34, comprising:

a fourth vessel including:

a fourth inlet to receive the fourth gas stream from the third outlet;

one or more additional nozzles to produce an additional dispersed droplet stream comprising at least about 1% by weight H_2O, remove an additional portion of the gas impurities from the fourth gas stream to produce (1) a fifth gas stream having a fourth additional amount of gas impurities that is less than the third additional amount of gas impurities and (2) an H_2O recovery liquid that includes H_2O. solvent, chemicals, and a further amount of gas impurities;

an additional outlet to direct the fifth gas stream out of the fourth vessel; and

a further outlet coupled to direct the H_2O recovery liquid from the fourth vessel.

36. The system of claim 35, comprising one or more pumps to cause the second recovery liquid to move from a solvent recovery tank coupled to the second vessel to the one or more first nozzles.

37. The system of claim 35, comprising:

a heater coupled to the second outlet to produce a heated recovery liquid; and

a desorption vessel including:

a fifth inlet to receive the fifth gas stream;

one or more further nozzles to produce a further dispersed droplet stream comprising the first recovery liquid to produce a sixth gas stream having a fifth additional amount of gas impurities that is greater than the first amount of gas impurities.

38. The system of claim 35, comprising a heat exchanger to transfer heat from the fifth gas stream to the first recovery liquid.

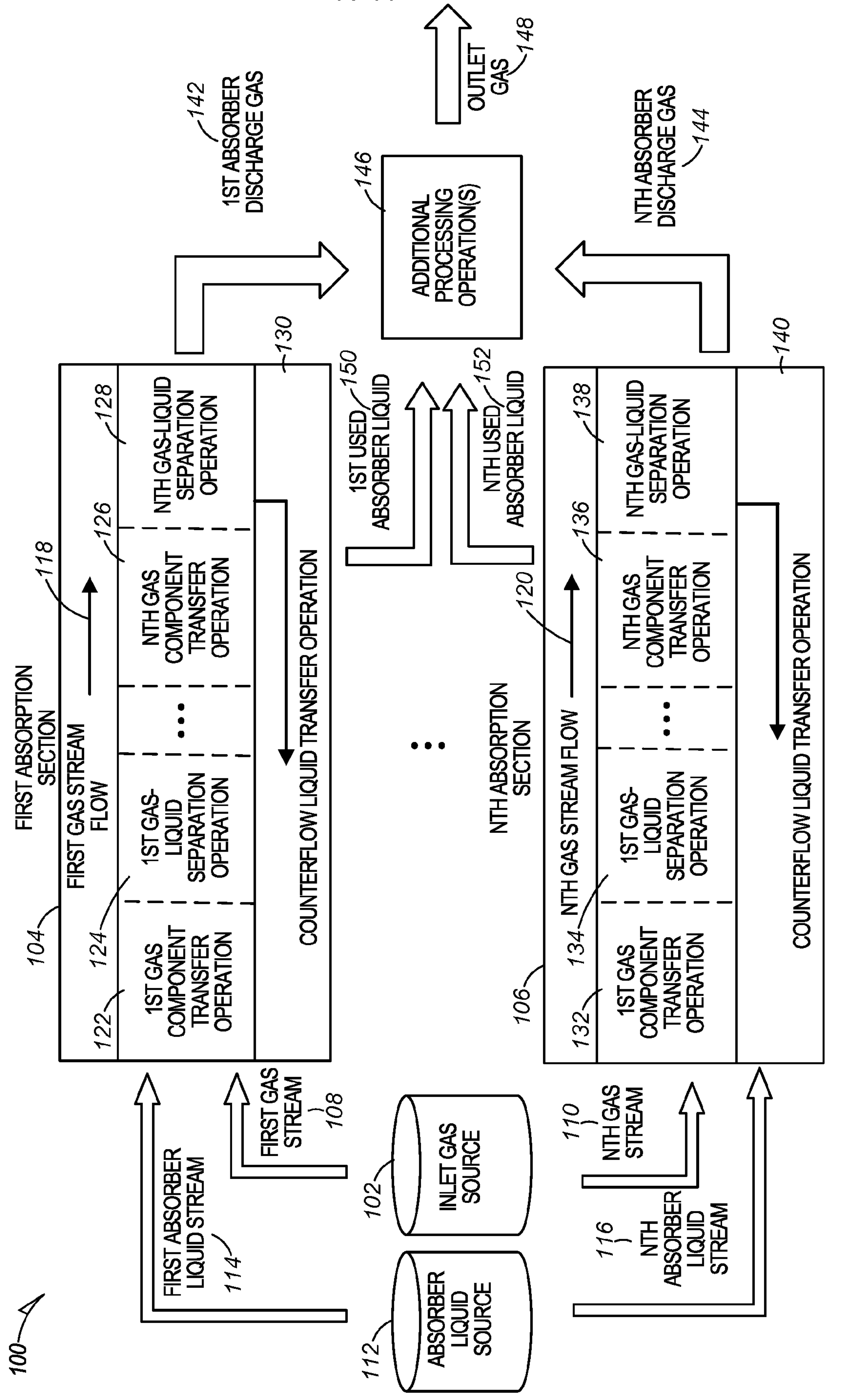
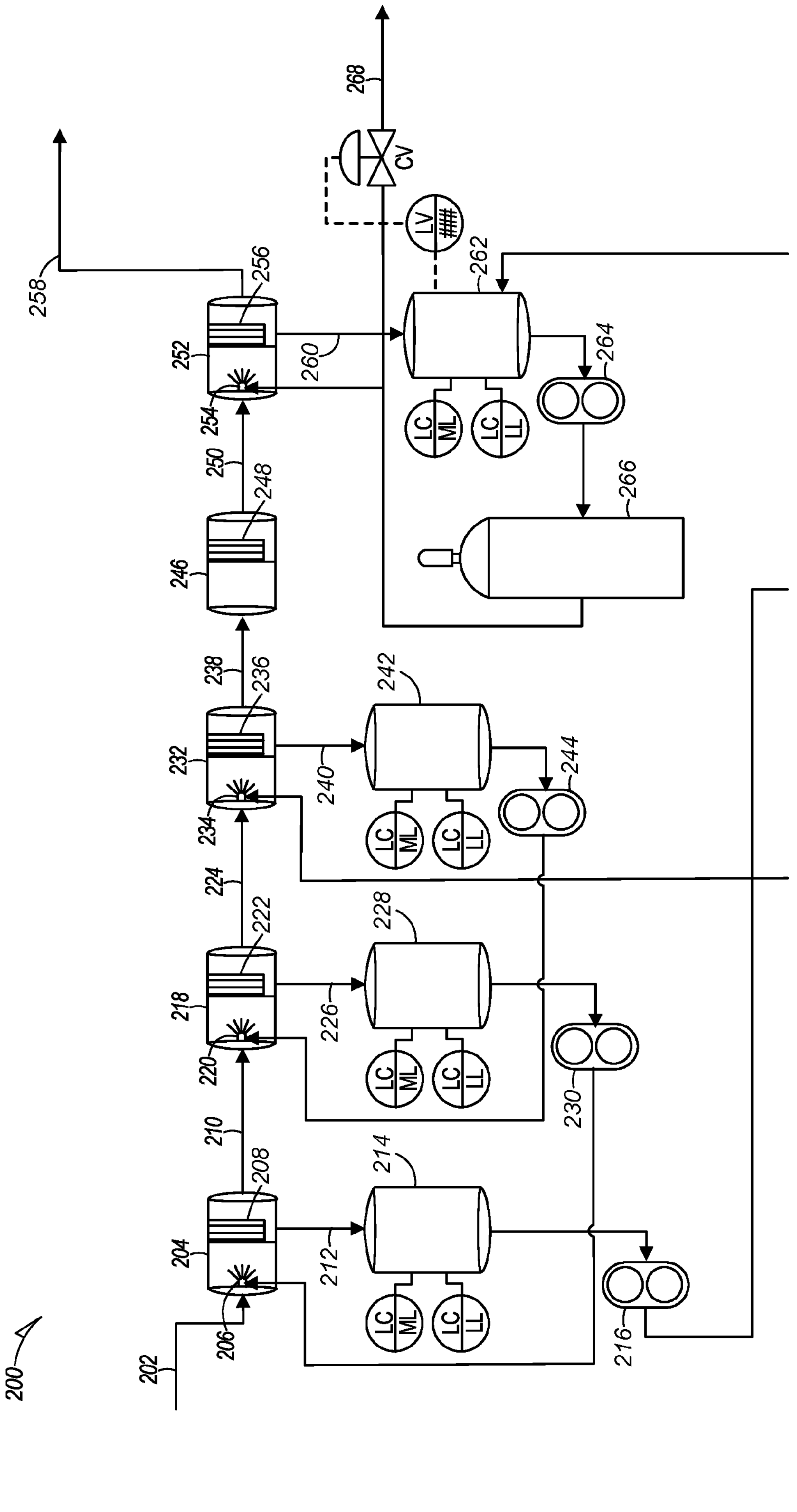

100
ABSORBER LIQUID SOURCE
112
INLET GAS SOURCE
102
FIRST ABSORBER LIQUID STREAM
114
FIRST GAS STREAM
108
NTH GAS STREAM
110
NTH ABSORBER LIQUID STREAM
116
FIRST ABSORPTION SECTION
104
FIRST GAS STREAM FLOW
118
1ST GAS COMPONENT TRANSFER OPERATION
122
1ST GAS-LIQUID SEPARATION OPERATION
124
NTH GAS COMPONENT TRANSFER OPERATION
126
NTH GAS-LIQUID SEPARATION OPERATION
128
COUNTERFLOW LIQUID TRANSFER OPERATION
130
NTH ABSORPTION SECTION
106
NTH GAS STREAM FLOW
120
1ST GAS COMPONENT TRANSFER OPERATION
132
1ST GAS-LIQUID SEPARATION OPERATION
134
NTH GAS COMPONENT TRANSFER OPERATION
136
NTH GAS-LIQUID SEPARATION OPERATION
138
COUNTERFLOW LIQUID TRANSFER OPERATION
140
1ST USED ABSORBER LIQUID
150
NTH USED ABSORBER LIQUID
152
ADDITIONAL PROCESSING OPERATION(S)
146
1ST ABSORBER DISCHARGE GAS
142
NTH ABSORBER DISCHARGE GAS
144
OUTLET GAS
148

FIG. 1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240
242
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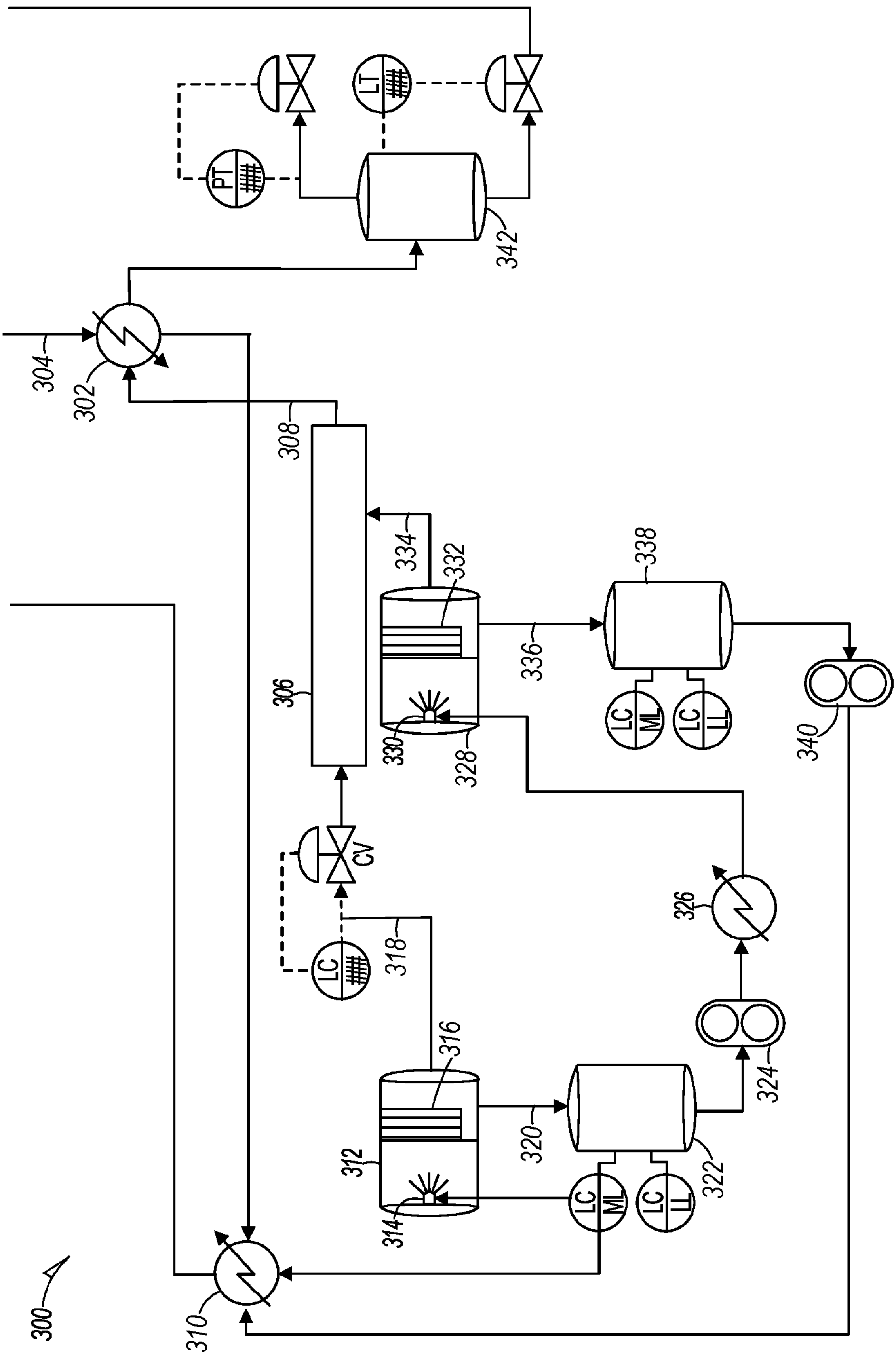
262
264
266
268
CV
LV
LC
ML
LL

FIG. 2


300
302
304
306
308
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312
314
316
318
320
322
324
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330
332
334
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338
340
342
PT
LT
LC
CV
LC
ML
LC
LL

FIG. 3

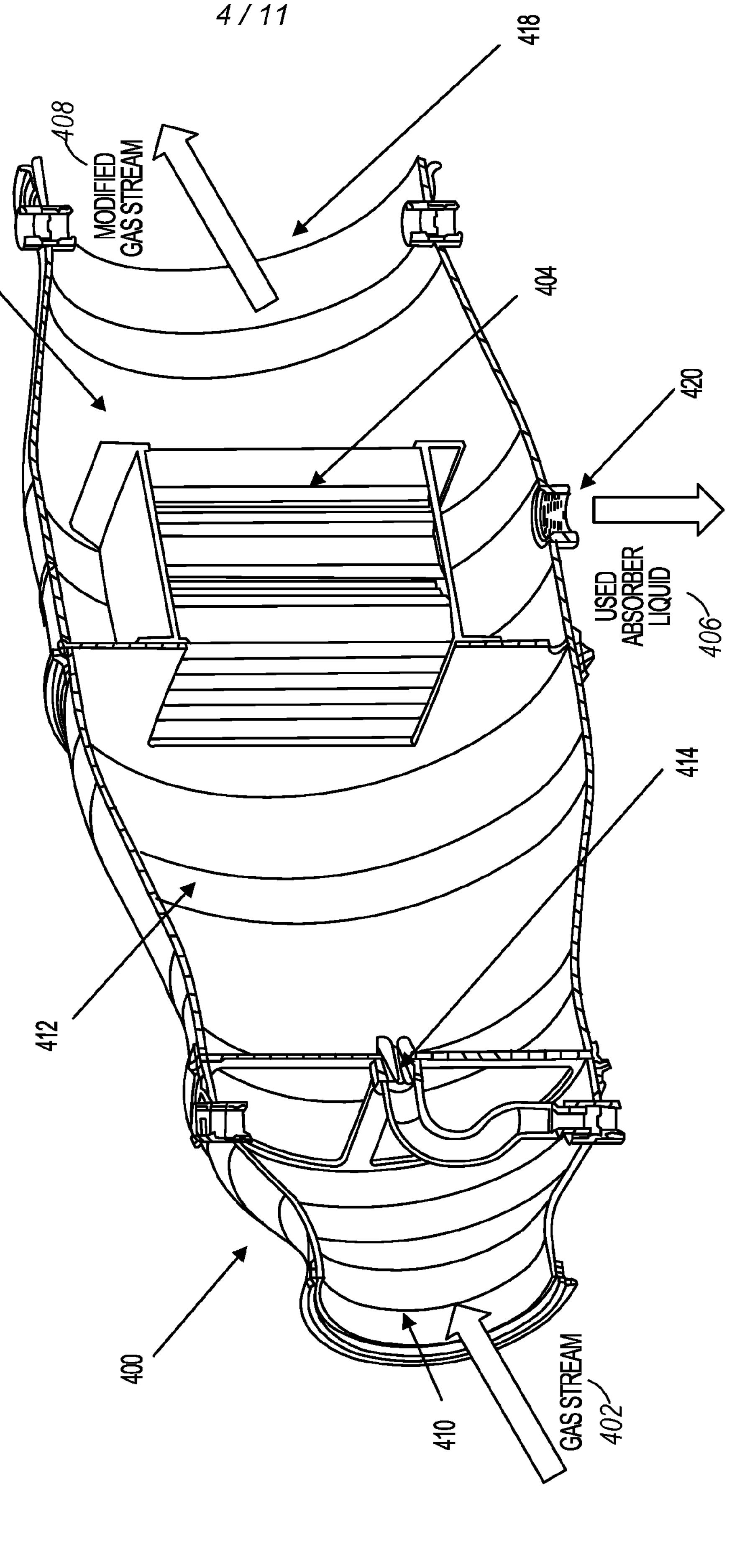

418
408
MODIFIED GAS STREAM
416
404
420
USED ABSORBER LIQUID
406
414
412
400
410
GAS STREAM
402

FIG. 4

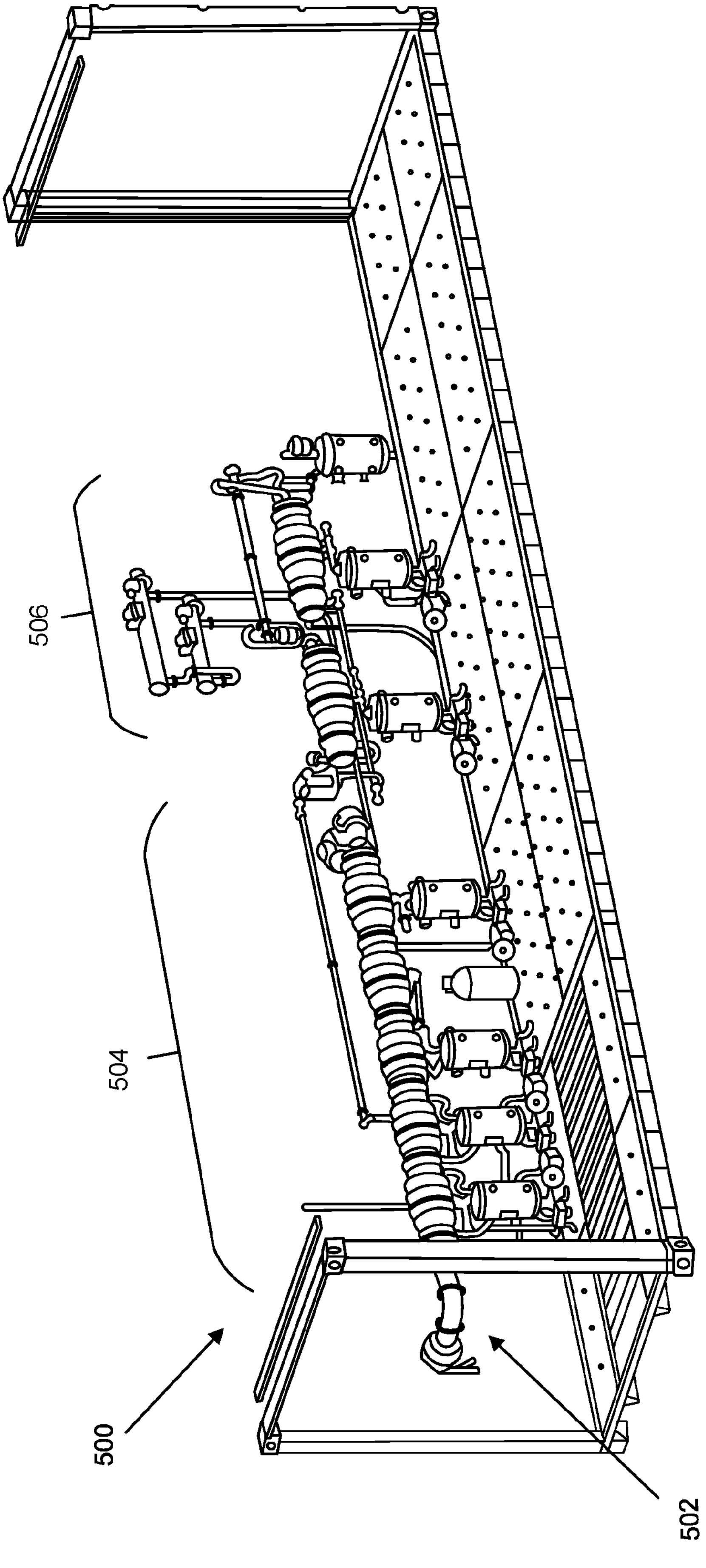
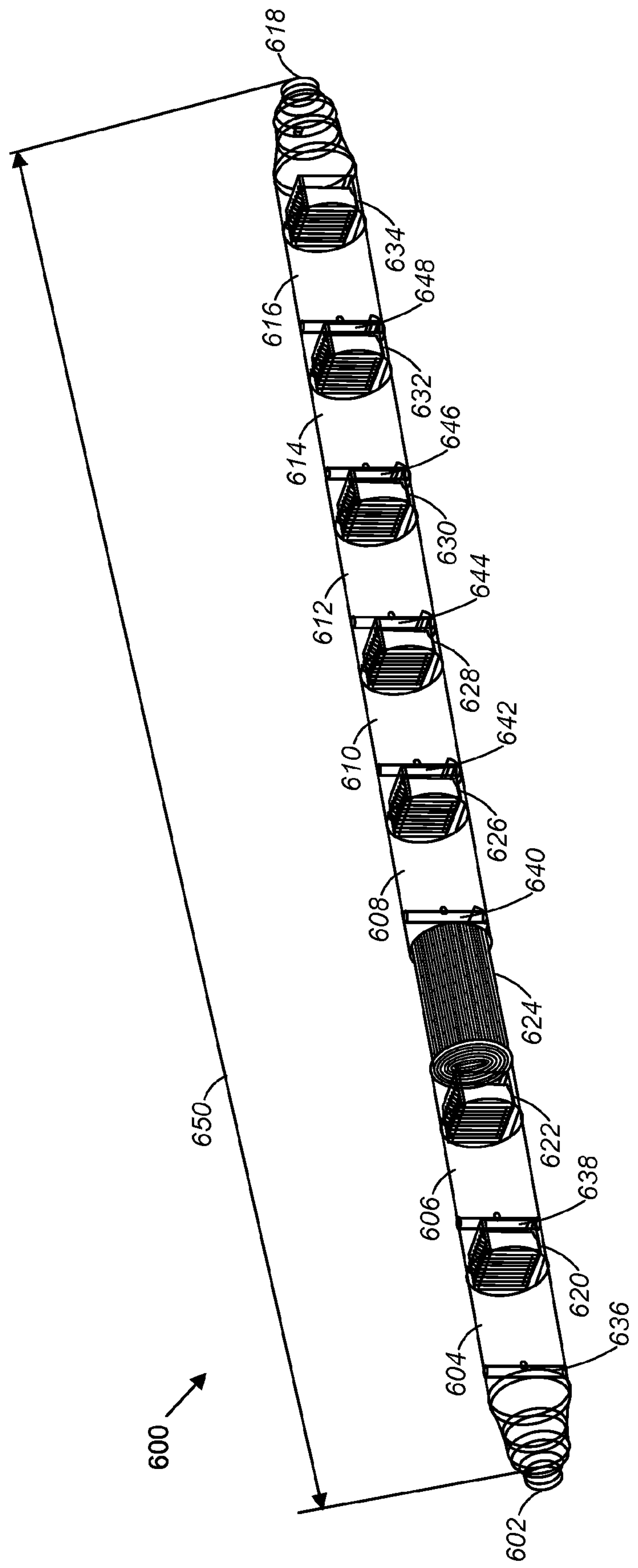


FIG.5


618
634
648
616
632
646
614
630
644
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628
642
610
626
640
608
624
650
622
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606
620
636
604
600
602

FIG. 6

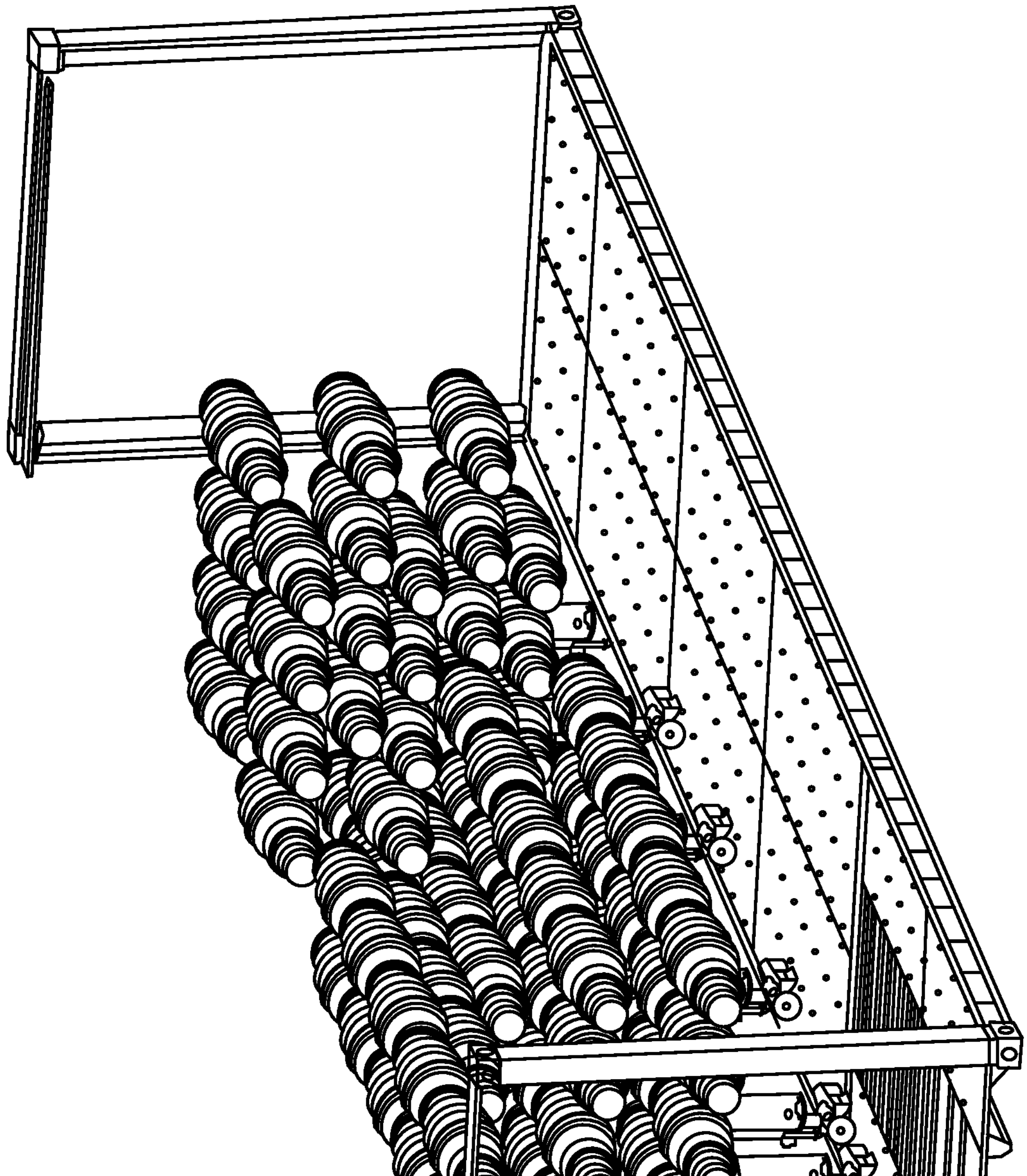
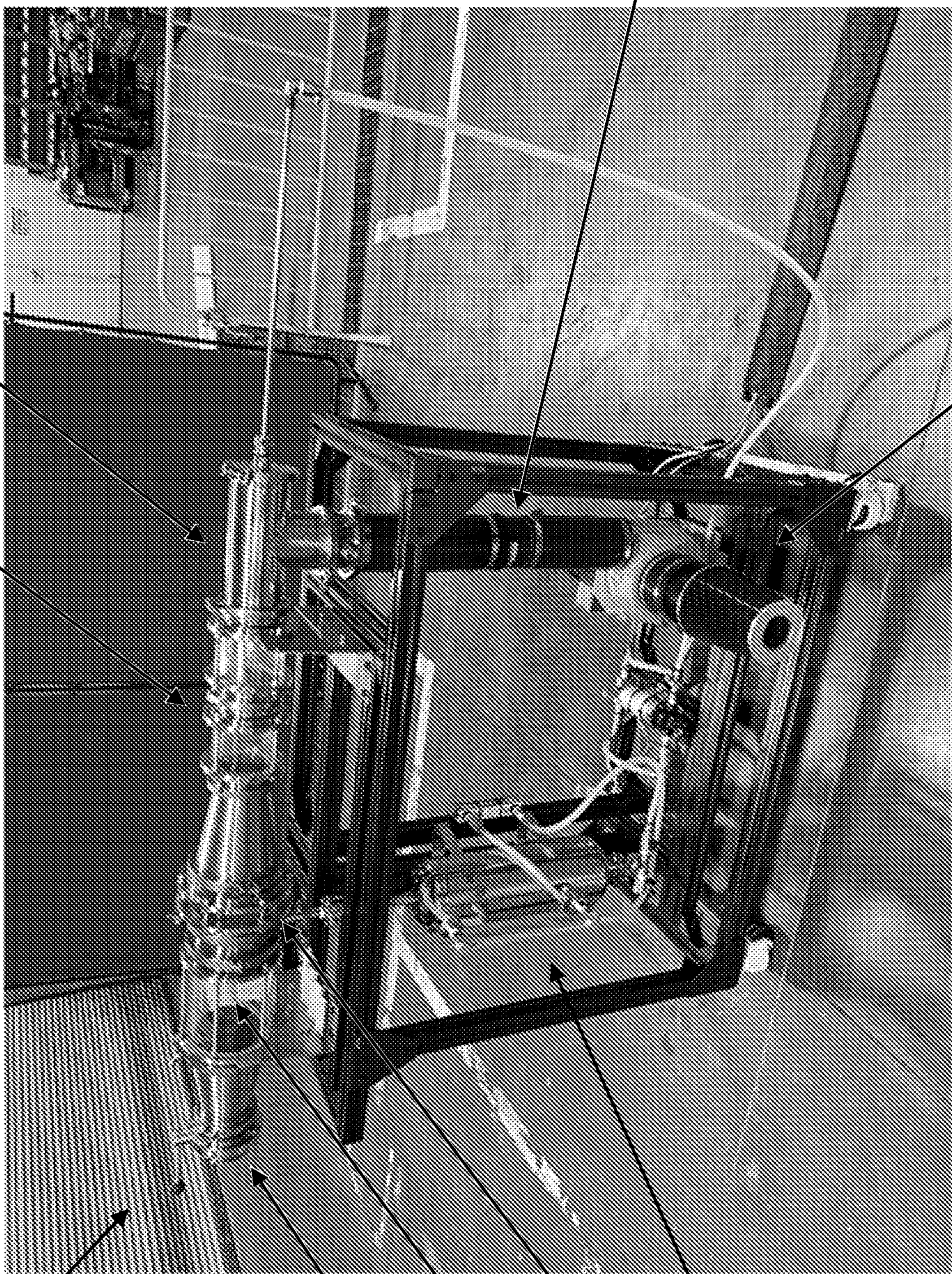


FIG. 7



802
806
808
804
800
816
810
812
814

FIG. 8

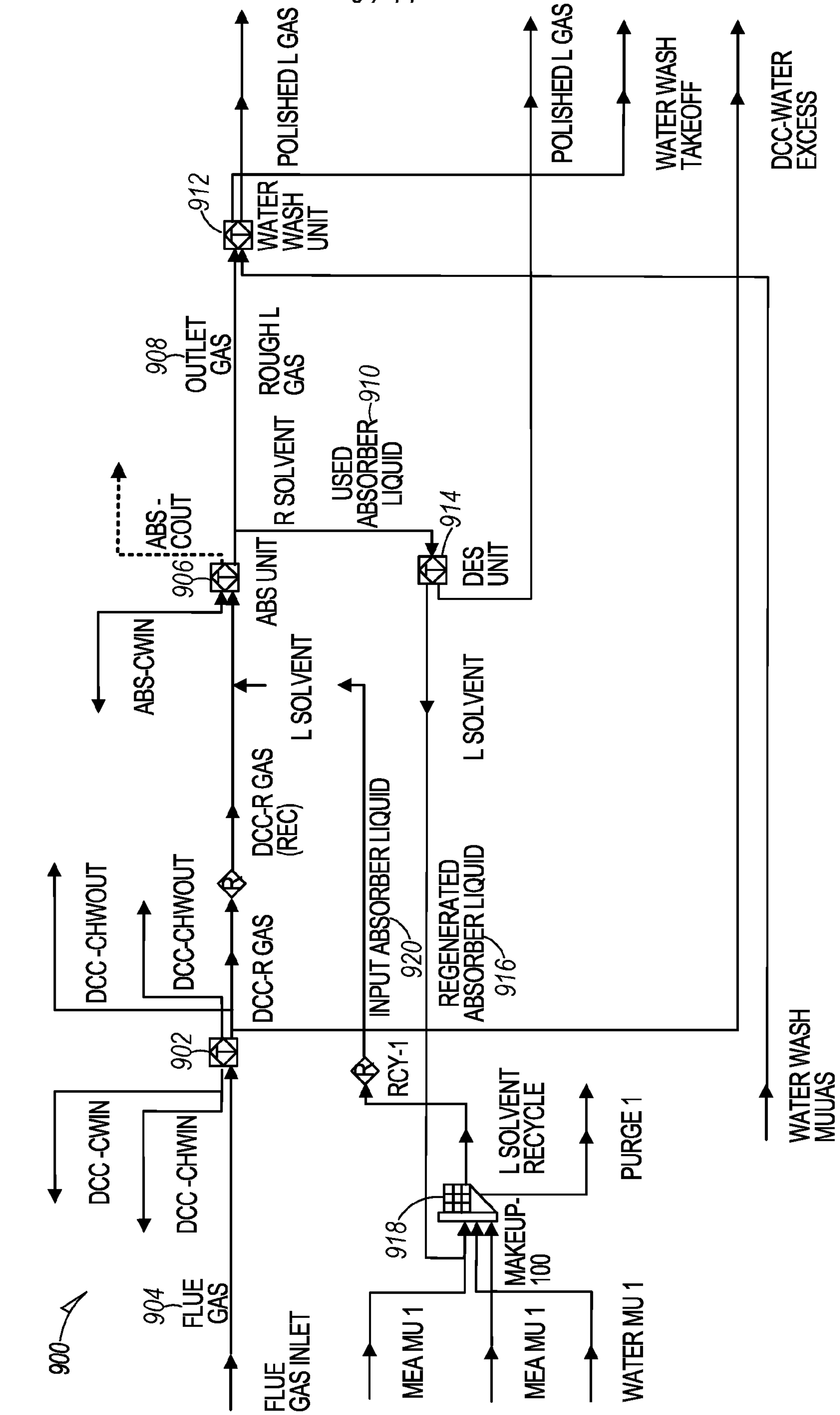

900
FLUE GAS INLET
904
FLUE GAS
DCC-CWIN
DCC -CHWIN
902
DCC-CWOUT
DCC-CHWOUT
DCC-R GAS
DCC-R GAS (REC)
ABS-CWIN
L SOLVENT
906
ABS-COUT
ABS UNIT
R SOLVENT
908
OUTLET GAS
ROUGH L GAS
912
WATER WASH UNIT
POLISHED L GAS
USED ABSORBER LIQUID
910
914
DES UNIT
POLISHED L GAS
WATER WASH TAKEOFF
DCC-WATER EXCESS
L SOLVENT
INPUT ABSORBER LIQUID
920
REGENERATED ABSORBER LIQUID
916
RCY-1
918
L SOLVENT RECYCLE
PURGE 1
MAKEUP-100
MEA MU 1
MEA MU 1
WATER MU 1
WATER WASH MUUAS

FIG. 9

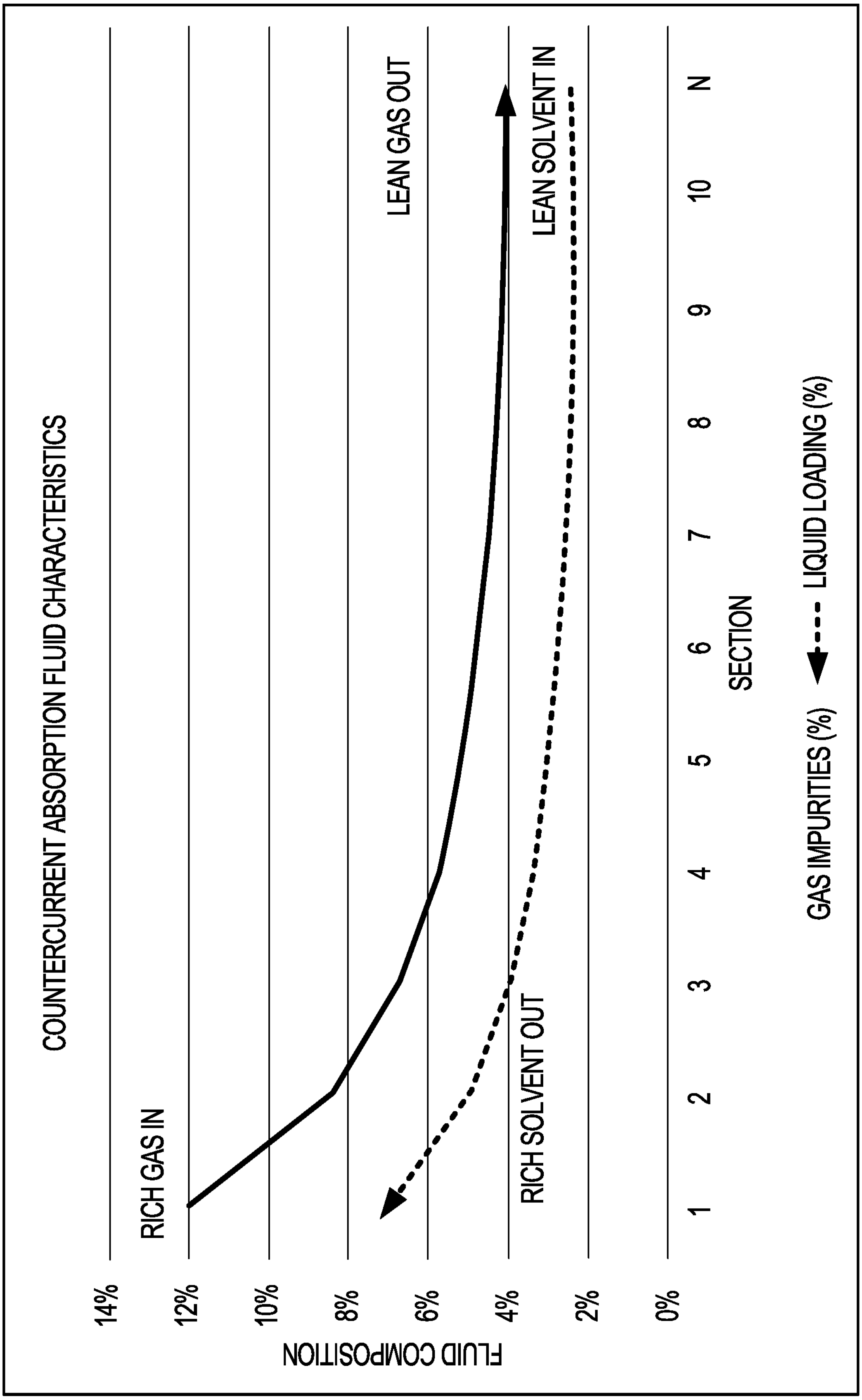

COUNTERCURRENT ABSORPTION FLUID CHARACTERISTICS
FLUID COMPOSITION
14%
12%
10%
8%
6%
4%
2%
0%
RICH GAS IN
RICH SOLVENT OUT
LEAN GAS OUT
LEAN SOLVENT IN
1
2
3
4
5
6
7
8
9
10
N
SECTION
GAS IMPURITIES (%)
LIQUID LOADING (%)

FIG. 10

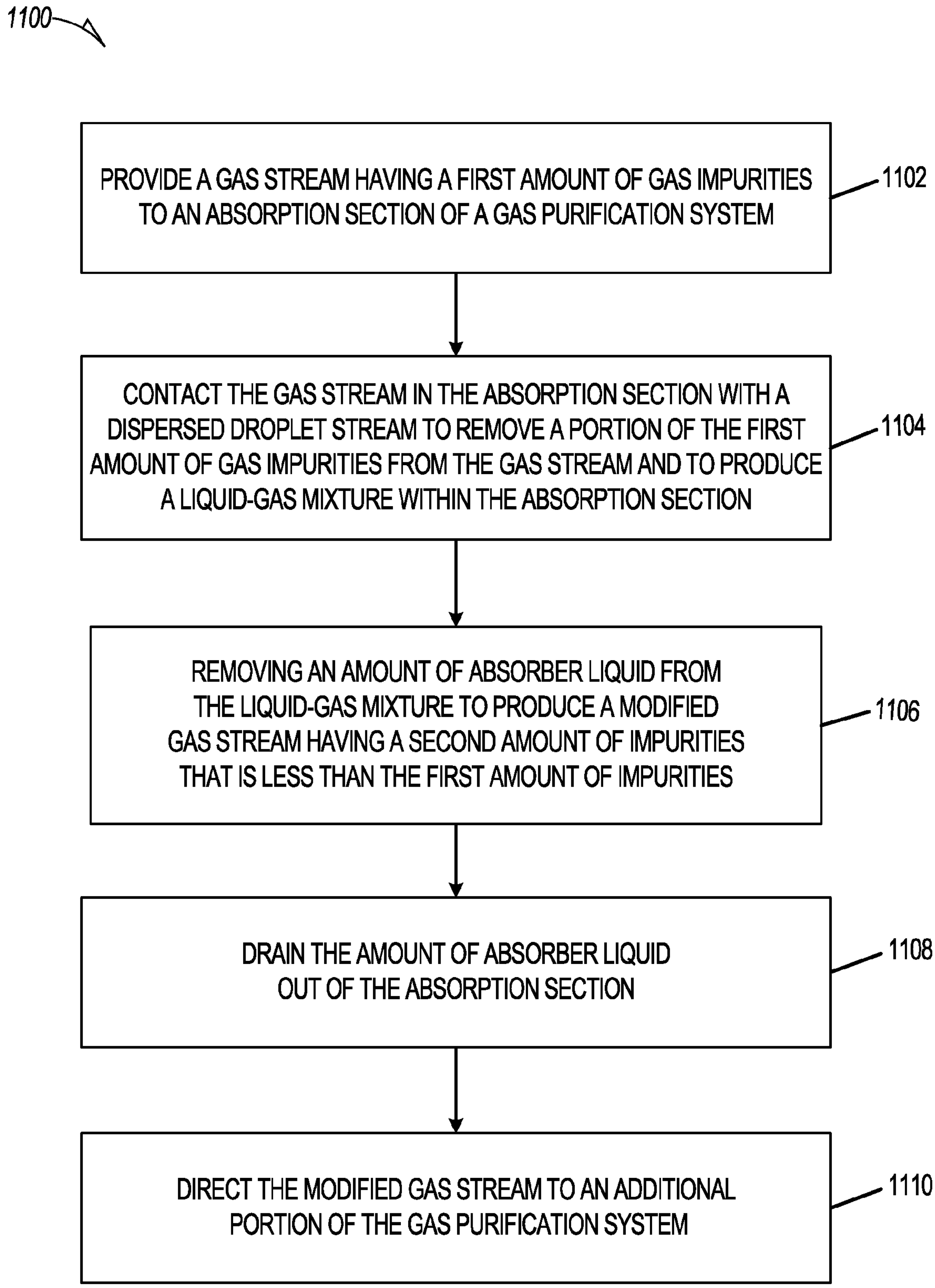

1100
PROVIDE A GAS STREAM HAVING A FIRST AMOUNT OF GAS IMPURITIES TO AN ABSORPTION SECTION OF A GAS PURIFICATION SYSTEM
1102
CONTACT THE GAS STREAM IN THE ABSORPTION SECTION WITH A DISPERSED DROPLET STREAM TO REMOVE A PORTION OF THE FIRST AMOUNT OF GAS IMPURITIES FROM THE GAS STREAM AND TO PRODUCE A LIQUID-GAS MIXTURE WITHIN THE ABSORPTION SECTION
1104
REMOVING AN AMOUNT OF ABSORBER LIQUID FROM THE LIQUID-GAS MIXTURE TO PRODUCE A MODIFIED GAS STREAM HAVING A SECOND AMOUNT OF IMPURITIES THAT IS LESS THAN THE FIRST AMOUNT OF IMPURITIES
1106
DRAIN THE AMOUNT OF ABSORBER LIQUID OUT OF THE ABSORPTION SECTION
1108
DIRECT THE MODIFIED GAS STREAM TO AN ADDITIONAL PORTION OF THE GAS PURIFICATION SYSTEM
1110

FIG. 11