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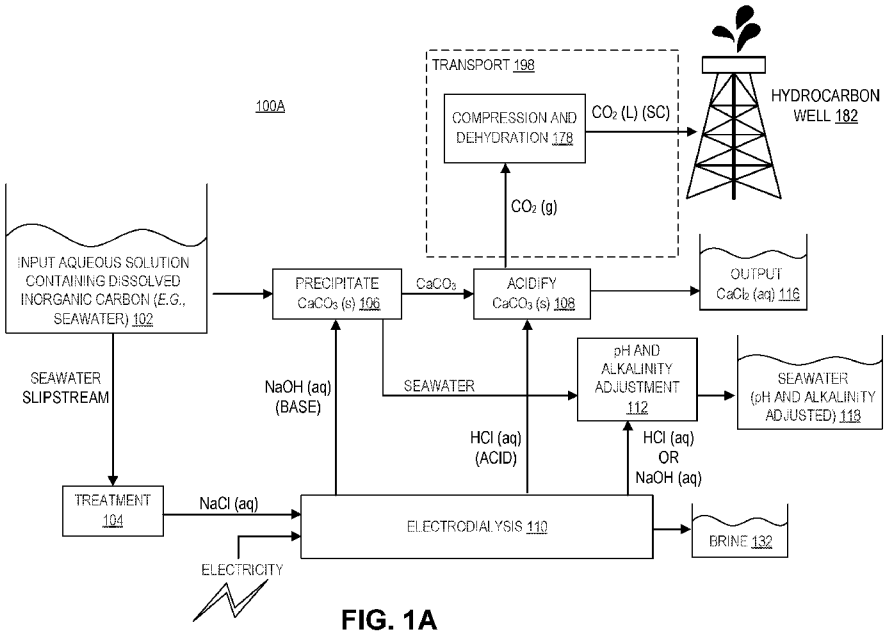


FIG. 1A

(57) Abstract: A method of extracting hydrocarbons from a hydrocarbon well includes receiving an aqueous solution including dissolved inorganic carbon, and extracting the dissolved inorganic carbon from the aqueous solution to create CO_2 by changing a pH of the aqueous solution. The method also includes pumping the CO_2 into the hydrocarbon well and, in response to pumping the CO_2 into the hydrocarbon well, extracting the hydrocarbons from the hydrocarbon well.

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[Continued on next page]

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ENHANCED HYDROCARBON EXTRACTION

TECHNICAL FIELD

[0001] This disclosure relates generally to hydrocarbon extraction.

BACKGROUND INFORMATION

[0002] Pure carbon dioxide (CO_2) has many industrial uses. The separation of CO_2 from a mixed-gas source may be accomplished by a capture and regeneration process. More specifically, the process generally includes a selective capture of CO_2, by, for example, contacting a mixed-gas source with a solid or liquid adsorber/absorber followed by a generation or desorption of CO_2 from the adsorber/absorber. One technique describes the use of bipolar membrane electrodialysis for CO_2 extraction/removal from potassium carbonate and bicarbonate solutions.

[0003] For capture/regeneration systems, a volume of gas that is processed is generally inversely related to a concentration of CO_2 in the mixed-gas source, adding significant challenges to the separation of CO_2 from dilute sources such as the atmosphere. CO_2 in the atmosphere, however, establishes equilibrium with the total dissolved inorganic carbon in the oceans, which is largely in the form of bicarbonate ions (HCO_3-) at an ocean pH of 8.1-8.3. Therefore, a method for extracting CO_2 from the dissolved inorganic carbon of the oceans would effectively enable the separation of CO_2 from atmosphere without the need to process large volumes of air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Non-limiting and non-exhaustive embodiments of the invention are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles being described.

[0005] FIG. 1A is an illustration of a system for extracting hydrocarbons from a hydrocarbon well, in accordance with an embodiment of the disclosure.

[0006] FIG. 1B is an illustration of a system for extracting hydrocarbons from a hydrocarbon well, in accordance with an embodiment of the disclosure.

[0007] FIG. 2 is an example electrodialysis unit, in accordance with an embodiment of the disclosure.

[0008] FIG. 3 is an illustration of a method for extracting hydrocarbons from a hydrocarbon well, in accordance with an embodiment of the disclosure.

DETAILED DESCRIPTION

[0009] Embodiments of an apparatus and method for enhanced hydrocarbon extraction are described herein. In the following description numerous specific details are set forth to provide a thorough understanding of the embodiments. One skilled in the relevant art will recognize, however, that the techniques described herein can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring certain aspects.

[0010] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0011] Throughout the specification and claims, compounds/elements are referred to both by their chemical name (*e.g.,* carbon dioxide) and chemical symbol (*e.g.,* CO_2). It is appreciated that both chemical names and symbols may be used interchangeably and have the same meaning.

[0012] This disclosure provides for the removal of carbon from water sources containing dissolved inorganic carbon (*e.g.,* bicarbonate ions HCO_3-), converting the dissolved carbon into dissolved CO_2 gas, stripping the CO_2 gas from the water source, and using the CO_2 to extract oil or natural gas from hydrocarbon wells. Enhanced oil recovery (EOR) is a method for extracting additional fossil fuel from an existing well by injecting CO_2 into the well to displace and eject hydrocarbons. The economic potential for EOR in nearshore and offshore wells is enormous. Using CO_2 extracted from the ocean to remove hydrocarbons from existing oil wells may be more environmentally friendly than drilling a new well. CO_2 from the ocean is sequestered in the existing well to help offset the hydrocarbons extracted. In addition, the alkalinity of the decarbonized seawater is restored by addition of NaOH prior to returning the water to the ocean, resulting in reabsorption of CO_2 from the atmosphere into the parcel of returned water. Further, there is no need to drill a new well, limiting further environmental damage and reducing the chance of drilling accidents.

[0013] FIG. 1A is an illustration of system 100A for extracting hydrocarbons from hydrocarbon well 182, in accordance with an embodiment of the disclosure. System 100A

includes: input 102 (to input an aqueous solution containing dissolved inorganic carbon), treatment unit 104, precipitation unit 106, acidification unit 108, electrodialysis unit 110, pH and alkalinity adjustment unit 112, $CaCl_2$ output 116, water output 118, brine output 132, transport system 198 (including compression and dehydration unit 178), and hydrocarbon well 182.

[0014] As shown, input 102 is coupled to a water reservoir containing dissolved inorganic carbon (*e.g.,* bicarbonate ions). The water reservoir may be an ocean, lake, river, manmade reservoir, or brine outflow from a reverse osmosis ("RO") process. Input 102 may receive the water through a system of channels, pipes, and/or pumps depending on the specific design of the facility. As shown, water received through input 102 is diverted into two separate sections of system 100A. A first (smaller) portion of the water is diverted to treatment unit 104, while a second (larger) portion of the water is diverted to precipitation unit 106. One skilled in the art will appreciate that large aggregate may be removed from the water at any time during the intake process.

[0015] In the illustrated embodiment, the first portion of water is diverted into treatment unit 104. Treatment unit 104 outputs a relatively pure stream of aqueous NaCl. In other words, an aqueous solution (possibly including seawater) is input to treatment unit 104, and aqueous NaCl is output from treatment unit 104. Treatment unit 104 may be used to remove organic compounds and other minerals (other than NaCl) not needed in, or harmful to, subsequent processing steps. For example, removal of chemicals in the water may mitigate scale buildup in electrodialysis unit 110. Treatment unit 104 may include filtering systems such as: nanofilters, RO units, ion exchange resins, precipitation units, microfilters, screen filters, disk filters, media filters, sand filters, cloth filters, and biological filters (such as algae scrubbers), or the like. Additionally, treatment unit 104 may include chemical filters to removed dissolved minerals/ions. One skilled in the art will appreciate that any number of screening and/or filtering methods may be used by treatment unit 104 to remove materials, chemicals, aggregate, biologicals, or the like.

[0016] Electrodialysis unit 110 is coupled to receive aqueous NaCl and electricity, and output aqueous HCl, aqueous NaOH, and brine (to brine output 132). Aqueous HCl and aqueous NaOH output from electrodialysis unit 110 may be used to drive chemical reactions in system 100A. The specific design and internal geometry of electrodialysis unit 110 is discussed in greater detail in connection with FIG. 2 (*see infra* FIG. 2). Brine output from electrodialysis unit 110 may be used in any applicable portion of system 100A. For example, brine may be cycled back into electrodialysis unit 110 as a source of aqueous NaCl, or may be simply expelled from system 100A as wastewater.

[0017] In the illustrated embodiment, precipitation unit 106 has a first input coupled to receive an aqueous solution including dissolved inorganic carbon (*e.g.,* seawater) from input 102. Precipitation unit 106 also has a second input coupled to electrodialysis unit 110 to receive aqueous NaOH. In response to receiving the aqueous solution and the aqueous NaOH, precipitation unit 106 precipitates calcium salts (for example, but not limited to, $CaCO_3$) and outputs the aqueous solution. However, in other embodiments, other chemical processes may be used to basify the aqueous solution in precipitation unit 106. For example, other bases (not derived from the input aqueous solution) may be added to the aqueous solution to precipitate calcium salts.

[0018] In one embodiment, NaOH is added to incoming seawater until the pH is sufficiently high to allow precipitation of calcium salts without significant precipitation of $Mg(OH)_2$. The exact pH when precipitation of $CaCO_3$ occurs (without significant precipitation of $Mg(OH)_2$) will depend on the properties of the incoming seawater (alkalinity, temperature, composition, etc.); however, a pH of 9.3 is typical of seawater at a temperature of 25 ^oC. In a different embodiment, the quantity of NaOH added is sufficient to precipitate $CaCO_3$ and $Mg(OH)_2$, then the pH is lowered (*e.g.,* by adding HCl from electrodialysis unit 110 until the pH is <9.3) so that the $Mg(OH)_2$ (but not $CaCO_3$) redissolves.

[0019] In one embodiment, precipitation unit 106 may be a large vat or tank. In other embodiments precipitation unit 106 may include a series of ponds/pools. In this embodiment, precipitation of calcium salts may occur via evaporation driven concentration (for example using solar ponds) rather than, or in combination with, adding basic substances. Precipitation unit 106 may contain internal structures with a high surface area to promote nucleation of $CaCO_3$; these high surface area structures may be removed from the precipitation unit 106 to collect nucleated $CaCO_3$. Precipitation unit 106 may include an interior with $CaCO_3$ to increase nucleation kinetics by supplying seed crystals. The bottom of precipitation unit 106 may be designed to continually collect and extract precipitate to prevent large quantities of scale buildup.

[0020] In another or the same embodiment, heat may be used to aid precipitation. For example solar ponds may be used to heat basified water. In continuously flowing systems, low temperature waste heat solution may be flowed through heat exchange tubes with basified seawater on the outside of the tubes. Alternatively, heating the bottom of precipitation unit 106 may be used to speed up precipitation.

[0021] After $CaCO_3$ is precipitated from the water, $CaCO_3$ is transferred to acidification unit 108. In the depicted embodiment, acidification unit 108 is coupled to receive $CaCO_3$ from precipitation unit 106 and coupled to receive aqueous HCl from electrodialysis unit 110. In

response to receiving $CaCO_3$ and aqueous HCl, acidification unit 108 produces CO_2. In the depicted embodiment, acidification unit 108 is used to evolve $CaCO_3$ into CO_2 gas and aqueous $CaCl_2$ according to the following reaction: $CaCO_3$ (s) + 2HCl (aq) → $CaCl_2$ (aq) + H_2O (l) + CO_2 (g). Reaction kinetics may be increased by agitating/heating the acidified mixture. By adding HCl to $CaCO_3$, CO_2 is spontaneously released due to the high equilibrium partial pressure of CO_2 gas. This may eliminate the need for membrane contactors or vacuum systems.

[0022] Acidification unit 108 is coupled to transport system 198. In the depicted embodiment transport system 198 may be a system of pipes, pumps, chambers, and/or gas cylinders coupled directly between acidification unit 108 and hydrocarbon well 182. However, in other embodiments, transport system 198 may not be directly coupled. In other words, the CO_2 extracted from acidification unit 108 may be contained in compress gas cylinders or the like, which are transported to hydrocarbon well 182 to displace the hydrocarbons (*e.g.,* oil and natural gas) from hydrocarbon well 182. However, for purposes of this disclosure it may be said that transport system 198 is "coupled" to both acidification unit 108 and hydrocarbon well 182 even when the CO_2 is contained in chambers and trucked to hydrocarbon well 182 for hydrocarbon extraction. Discontinuity in the transport process is contemplated by the claims in the instant application.

[0023] In one embodiment, transport system 198 may alter the temperature or the pressure of the CO_2 prior to or after transport, so the CO_2 is denser than the gas phase of CO_2 when the CO_2 enters hydrocarbon well 182. To accomplish this, transport system 198 may include compression and dehydration unit 178 to remove water from the CO_2 and to change a phase of the CO_2 into at least one of a liquid or a supercritical fluid.

[0024] CO_2 used in EOR is of a purity > 95%, and the temperature and pressure of the CO_2 is adjusted to ensure that the CO_2 is in a denser phase than the gas phase of CO_2 (either liquid or supercritical)—for CO_2, a supercritical fluid occurs at temperatures greater than 31.1°C, and pressures greater than 7.38 MPa. One noteworthy advantage of system 100A is that producing CO_2 from $CaCO_3$ eliminates the need for N_2/O_2 degassing steps; the CO_2 extracted by addition of HCl to $CaCO_3$(s) can be sent directly to compression and dehydration unit 178 to produce the > 95% purity liquid or supercritical CO_2 appropriate for EOR.

[0025] Once all CO_2 has been extracted from acidification unit 108, wastewater containing $CaCl_2$ is output from system 100A via $CaCl_2$ output 116. In one embodiment, the wastewater is returned to the ocean or other water source after the pH of the wastewater has been adjusted. In other embodiments, the wastewater is sequestered in hydrocarbon well 182 and used as part of the EOR process (water injection).

[0026] In the depicted embodiment, the second portion of seawater (that was used as a carbon source in precipitation unit 106) is flowed to a pH and alkalinity adjustment unit 112. The pH and alkalinity adjustment unit 112 is coupled to electrodialysis unit 110 to receive HCl and NaOH, and adjust a pH and alkalinity of the combined second portion of the aqueous solution and basic solution to a pH and alkalinity of seawater (or other environmentally safe pH value). In one embodiment, the pH and alkalinity of wastewater flowed into pH and alkalinity adjustment unit 112 is monitored in real time, and HCl or NaOH is flowed into pH and alkalinity adjustment unit 112 in response to the real time measurements. Adjusting the pH of wastewater flowing from system 100A ensures minimal environmental impact of running system 100A, while adjusting the alkalinity ensures sufficient reabsorption of atmospheric CO_2 once the water is returned to the ocean.

[0027] FIG. 1B is an illustration of system 100B for extracting hydrocarbons from hydrocarbon well 182, in accordance with an embodiment of the disclosure. System 100B is similar in many respects to system 100A of FIG. 1A. However, one major difference is system 100B has degasification unit 107, in lieu of precipitation unit 106 and acidification unit 108.

[0028] In the depicted embodiment, electrodialysis unit 110 is coupled to receive aqueous NaCl, and to output aqueous HCl and aqueous NaOH. Degasification unit 107 has a first input coupled to receive an aqueous solution including dissolved inorganic carbon, and a second input coupled to electrodialysis unit 110 to receive the aqueous HCl. In response to receiving the aqueous solution and the aqueous HCl, degasification unit 107 evolves CO_2 from the aqueous solution and outputs the aqueous solution. As shown, the aqueous solution may include seawater, and the aqueous NaCl may also be derived, at least in part, from seawater. Degasification unit 107 may include membrane contactors to remove dissolved N_2 and O_2 gas from the aqueous solution, prior to evolving the CO_2 from the aqueous solution. This results in >95% purity CO_2 at the outset of the degasification and dehydration process. It is worth noting that in other embodiments, other gases may be extracted from the aqueous solution. Furthermore, any of the processes described above may be vacuum assisted.

[0029] Transport system 198 is coupled to degasification unit 107 to transport the CO_2 from degasification unit 107 into hydrocarbon well 182 (to displace the hydrocarbons in hydrocarbon well 182). In one embodiment, the transport system 198 alters at least one of a temperature or a pressure of the CO_2 either before or after transport so the CO_2 is denser than the gas phase of CO_2 when the CO_2 enters hydrocarbon well 182. In the depicted embodiment, transport system 198 includes compression and dehydration unit 178 to remove water from the CO_2 and to change a phase of the CO_2 into at least one of a liquid or a supercritical fluid.

[0030] Systems 100A-100B may be coupled to, and run by, electronic control systems. Regulation and monitoring may be accomplished by a number of sensors throughout the system that either send signals to a controller or are queried by controller. For example, with reference to electrodialysis unit 110, monitors may include one or more pH gauges to monitor a pH within the units as well as pressure sensors to monitor a pressure among the compartments in electrodialysis unit 110 (to avoid inadvertent mechanical damage to electrodialysis unit 110). Another monitor may be a pH gauge placed within precipitation unit 106 to monitor a pH within the tank. The signals from such pH monitor or monitors allows a controller to control a flow of brine solution (from input 102) and a basified solution (from electrodialysis unit 110) to maintain a pH value of a combined solution that will result in a precipitation of $CaCO_3$.

[0031] Alternatively, systems 100A-100B may be controlled manually. For example, a worker may open and close valves to control the various water, acid, and base flows in systems 100A-100B. Additionally, a worker may remove precipitated calcium salts from precipitation unit 106. However, one skilled in the relevant art will appreciate that systems 100A-100B may be controlled by a combination of manual labor and mechanical automation, in accordance with the teachings of the present disclosure.

[0032] FIG. 2 is an example electrodialysis unit 110 (*e.g.*, electrodialysis unit 110 of FIG. 1A-1B), in accordance with an embodiment of the disclosure. Electrodialysis unit 110 may be used to convert seawater (or other NaCl-containing aqueous solutions) into NaOH and HCl. As shown, in FIGs. 1A-1B, NaOH and HCl may be used to adjust the pH of the aqueous solution to precipitate calcium salts and evolve CO_2 gas. In one embodiment electrodialysis unit 110 is a bipolar membrane electrodialysis unit.

[0033] In the depicted embodiment, electrodialysis unit 110 representatively consists of several cells in series, with each cell including a basified solution compartment (compartments 210A and 210B illustrated); an acidified solution compartment (compartments 225A and 225B illustrated); and a brine solution compartment (compartments 215A and 215B). FIG. 2 also shows a bipolar membrane (BPM) between a basified solution compartment and an acidified solution compartment (BPM 220A and 220B illustrated). A suitable BPM is a Neosepta BP-1E, commercially available from Ameridia Corp. Also depicted are anion exchange membranes (AEM), such as Neosepta ACS (commercially available from Ameridia Corp.), disposed between a brine compartment and an acidified solution compartment (AEM 230A and 230B illustrated). A cation exchange membrane (CEM) such as Neosepta CMX-S (commercially available from Ameridia Corp.), is disposed adjacent to a brine compartment (CEM 240A and CEM 240B illustrated). Finally, FIG. 2 shows end cap membranes 245A and 245B (such as

Nafion® membranes) that separate the membrane stack from electrode solution compartment 250A and electrode solution compartment 250B, respectively.

[0034] Broadly speaking, under an applied voltage provided to electrodialysis unit 110, water dissociation inside the BPM (and the ion-selective membranes comprising a BPM) will result in the transport of hydrogen ions (H+) from one side of the BPM, and hydroxyl ions (OH-) from the opposite side. AEMs/CEMs, as their names suggest, allow the transport of negatively/positively charged ions through the membrane. The properties of these membranes such as electrical resistance, burst strength, and thickness are provided by the manufacturer (*e.g.*, Neosepta ACS and CMX-S are monovalent-anion and monovalent-cation permselective membranes, respectively). In one embodiment, electrodialysis unit 110 includes electrodes 260A and 260B of, for example, nickel manufactured by De Nora Tech Inc. FIG. 2 also shows electrode solution compartment 250A and electrode solution compartment 250B through which, in one embodiment, a NaOH(aq) solution is flowed. Where electrode 260A is a positively-charged electrode, sodium ions (Na+) will be encouraged to move across cap membrane 245A and where electrode 260B is negatively-charged, sodium ions will be attracted to electrode solution compartment 250B. In one embodiment, the solution compartments between adjacent membranes are filled with polyethylene mesh spacers (e.g., 762 μm thick polyethylene mesh spacers), and these compartments are sealed against leaks using axial pressure and 794 mm thick EPDM rubber gaskets.

[0035] FIG. 3 is a flow chart illustrating a method 300 for extracting hydrocarbons from a hydrocarbon (oil and/or natural gas) well, in accordance with an embodiment of the disclosure. The order in which some or all of process blocks 301 - 307 appear in method 300 should not be deemed limiting. Rather, one of ordinary skill in the art having the benefit of the present disclosure will understand that some of method 300 may be executed in a variety of orders not illustrated, or even in parallel. Additionally, method 300 may include additional blocks or have fewer blocks than shown, in accordance with the teachings of the present disclosure.

[0036] Block 301 illustrates receiving an aqueous solution including dissolved inorganic carbon. In one embodiment, the aqueous solution includes seawater containing bicarbonate ions (HCO_3-).

[0037] Block 303 discloses extracting the dissolved inorganic carbon from the aqueous solution to create CO_2 by changing a pH of the aqueous solution. In one embodiment this may include increasing the pH of the aqueous solution to precipitate salts containing carbon, and applying acid to the salts to evolve CO_2 gas. This process may include adding aqueous NaOH to the aqueous solution (to increase the pH), and applying HCl to the salts (to evolve the CO_2). In an

alternate embodiment, extracting the dissolved inorganic carbon includes decreasing the pH of the aqueous solution to remove CO_2 gas from the aqueous solution. In this embodiment, decreasing the pH includes adding aqueous HCl to the aqueous solution, and the aqueous HCl is produced by an electrodialysis unit. Further, N_2 and O_2 may be removed from the aqueous solution before decreasing the pH of the aqueous solution.

[0038] Block 305 shows pumping the CO_2 into the hydrocarbon well. In one embodiment, the density of the CO_2 may be altered to be greater than the density of CO_2 gas by adjusting the temperature or and/or pressure. Thus, the CO_2 pumped into the well may be a liquid or a supercritical fluid of greater than 95% purity.

[0039] Block 307 illustrates extracting the hydrocarbons from the hydrocarbon well, in response to pumping CO_2 into the well. The CO_2 may mix with and/or displace hydrocarbons (*e.g.,* oil or natural gas) in the well, resulting in their migration towards the surface. CO_2 injection into a hydrocarbon well is a miscible displacement process. A miscible displacement process may maintain pressure in the well and improve oil displacement due to reduced interfacial tension between oil and water in the well. Carbon dioxide may be best suited for miscible displacement because it reduces oil viscosity, and may be less expensive than other gases.

[0040] In the case of CO_2 EOR, the first step includes injecting water into the well. In one embodiment this may include wastewater from the CO_2 extraction process. Once the reservoir is pressurized with water, CO_2 is pumped down into the well. The CO_2 gas then comes in contact with the oil. The oil-CO_2 contact area creates a miscible zone that is easily moved/extracted. In some instances, oil field workers may alternate between injection of CO_2 and water, because water helps sweep oil towards the production area. Method 300 disclosed here may be used for producing CO_2 in places where there is ample seawater but no CO_2 supply chain. Thus, method 300 may enable the recovery of millions of barrels of otherwise inaccessible oil.

[0041] The above description of illustrated embodiments of the invention, including what is described in the Abstract, is not intended to be exhaustive or to limit the invention to the precise forms disclosed. While specific embodiments of, and examples for, the invention are described herein for illustrative purposes, various modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize.

[0042] These modifications can be made to the invention in light of the above detailed description. The terms used in the following claims should not be construed to limit the invention to the specific embodiments disclosed in the specification. Rather, the scope of the

invention is to be determined entirely by the following claims, which are to be construed in accordance with established doctrines of claim interpretation.

CLAIMS

What is claimed is:

1. A method of extracting hydrocarbons from a hydrocarbon well, comprising:

receiving an aqueous solution including dissolved inorganic carbon;

extracting the dissolved inorganic carbon from the aqueous solution to create CO_2 by changing a pH of the aqueous solution;

pumping the CO_2 into the hydrocarbon well; and

in response to pumping the CO_2 into the hydrocarbon well, extracting the hydrocarbons from the hydrocarbon well.

2. The method of claim 1, wherein extracting the dissolved inorganic carbon includes:

increasing the pH of the aqueous solution to precipitate salts containing carbon; and

applying acid to the salts to evolve CO_2 gas.

3. The method of claim 2, wherein increasing the pH includes adding aqueous NaOH to the aqueous solution, and wherein applying the acid to the salts includes applying aqueous HCl to the salts.

4. The method of claim 3, further comprising producing the aqueous NaOH and the aqueous HCl with an electrodialysis unit.

5. The method of claim 1, wherein extracting the dissolved inorganic carbon includes decreasing the pH of the aqueous solution to remove CO_2 gas from the aqueous solution.

6. The method of claim 5, wherein decreasing the pH includes adding aqueous HCl to the aqueous solution, wherein the aqueous HCl is produced by an electrodialysis unit.

7. The method of claim 6, further comprising removing N_2 and O_2 from the aqueous solution before decreasing the pH of the aqueous solution.

8. The method of claim 1, further comprising altering the density of the CO_2 to be greater than a density of CO_2 gas by adjusting at least one of a temperature or a pressure.

9. The method of claim 1, wherein the CO_2 pumped into the hydrocarbon well is at least one of a liquid or a supercritical fluid.

10. The method of claim 1, wherein the CO_2 is greater than 95% pure.

11. A system for extracting hydrocarbons from a hydrocarbon well, comprising:

an electrodialysis unit coupled to receive aqueous NaCl and to output aqueous HCl and aqueous NaOH;

a precipitation unit with a first input coupled to receive an aqueous solution including dissolved inorganic carbon, and a second input coupled to the electrodialysis unit to receive the aqueous NaOH, wherein in response to receiving the aqueous solution and the aqueous NaOH, the precipitation unit precipitates calcium salts and outputs the aqueous solution;

an acidification unit coupled to receive the calcium salts from the precipitation unit and the aqueous HCl from the electrodialysis unit, wherein in response to receiving the calcium salts and the aqueous HCl, the acidification unit produces CO_2; and

a transport system coupled to transport the CO_2 from the acidification unit into the hydrocarbon well to displace the hydrocarbons from the hydrocarbon well.

12. The system of claim 11, wherein the aqueous solution includes seawater, wherein the aqueous NaCl is derived, at least in part, from seawater, and wherein the calcium salts include $CaCO_3$.

13. The system of claim 11, wherein the transport system alters at least one of a temperature or a pressure of the CO_2 so the CO_2 is denser than a gas phase of CO_2 when the CO_2 enters the hydrocarbon well.

14. The system of claim 11, wherein the transport system includes a compression and dehydration unit to remove water from the CO_2 and to change a phase of the CO_2 into at least one of a liquid or a supercritical fluid.

15. A system for extracting hydrocarbons from a hydrocarbon well, comprising:

an electrodialysis unit coupled to receive aqueous NaCl, and to output aqueous HCl and aqueous NaOH;

a degasification unit with a first input coupled to receive an aqueous solution including dissolved inorganic carbon, and a second input coupled to the electrodialysis unit to receive the aqueous HCl, wherein in response to receiving the aqueous solution and the aqueous HCl, the degasification unit evolves CO_2 from the aqueous solution and outputs the aqueous solution; and

a transport system coupled to the degasification unit to transport the CO_2 from the degasification unit into the hydrocarbon well to displace the hydrocarbons from the hydrocarbon well.

16. The system of claim 15, wherein the aqueous solution includes seawater, and wherein the aqueous NaCl is derived, at least in part, from seawater.

17. The system of claim 15, wherein the degasification unit includes membrane contactors to remove dissolved N_2 and O_2 gas from the aqueous solution prior to evolving the CO_2 from the aqueous solution.

18. The system of claim 17, wherein the transport system alters at least one of a temperature or a pressure of the CO_2 so the CO_2 is denser than a gas phase of CO_2 when the CO_2 enters the hydrocarbon well.

19. The system of claim 15, wherein the transport system includes a compression and dehydration unit to remove water from the CO_2 and to change a phase of the CO_2 into at least one of a liquid or a supercritical fluid.

20. The system of claim 15, wherein the hydrocarbons include at least one of oil or natural gas.

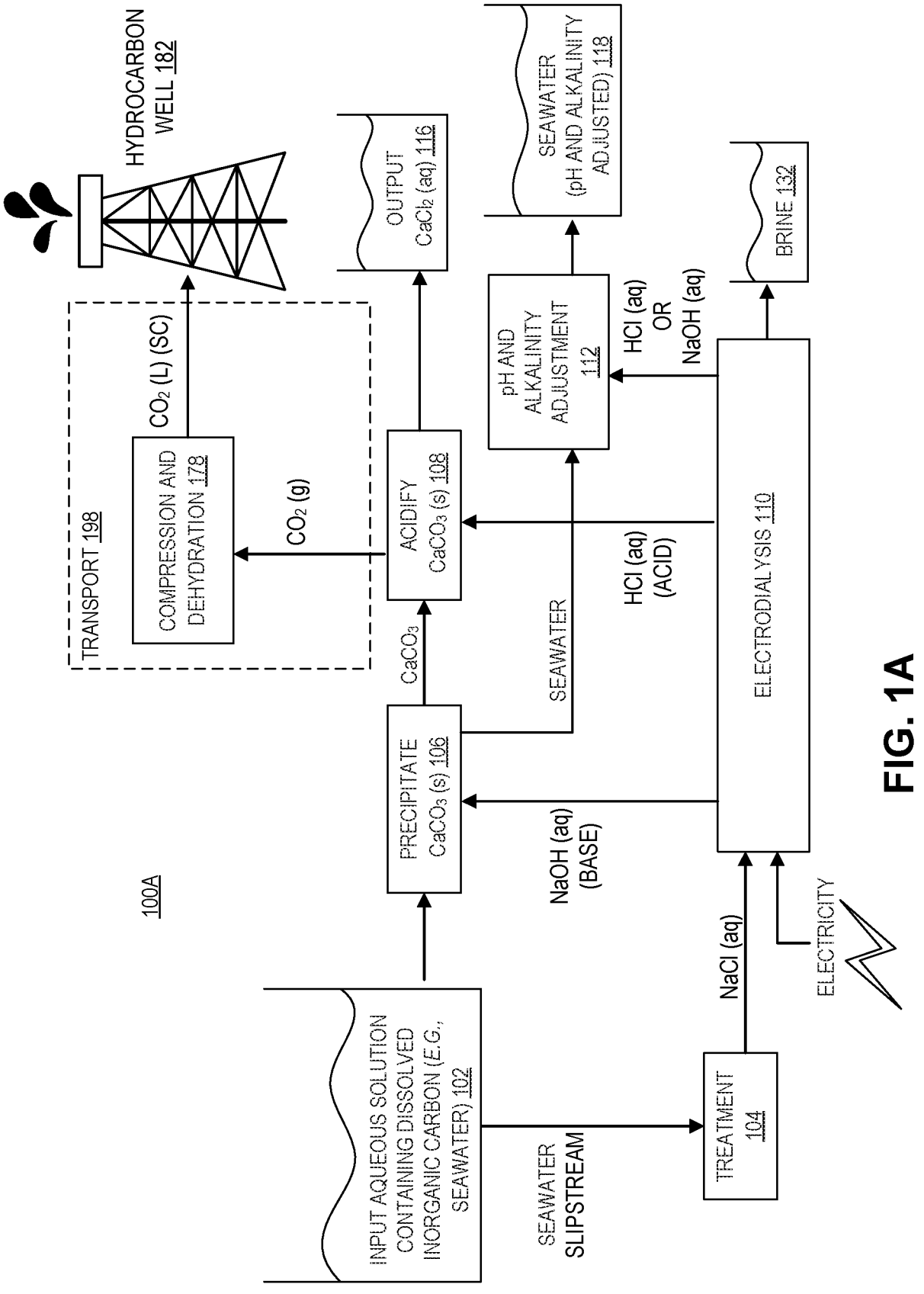

HYDROCARBON WELL 182
OUTPUT $CaCl_2$ (aq) 116
SEAWATER (pH AND ALKALINITY ADJUSTED) 118
BRINE 132
TRANSPORT 198
CO_2 (L) (SC)
COMPRESSION AND DEHYDRATION 178
CO_2 (g)
ACIDIFY $CaCO_3$ (s) 108
pH AND ALKALINITY ADJUSTMENT 112
HCl (aq) OR NaOH (aq)
$CaCO_3$
SEAWATER
HCl (aq) (ACID)
ELECTRODIALYSIS 110
100A
PRECIPITATE $CaCO_3$ (s) 106
NaOH (aq) (BASE)
INPUT AQUEOUS SOLUTION CONTAINING DISSOLVED INORGANIC CARBON (E.G., SEAWATER) 102
SEAWATER SLIPSTREAM
TREATMENT 104
NaCl (aq)
ELECTRICITY

FIG. 1A

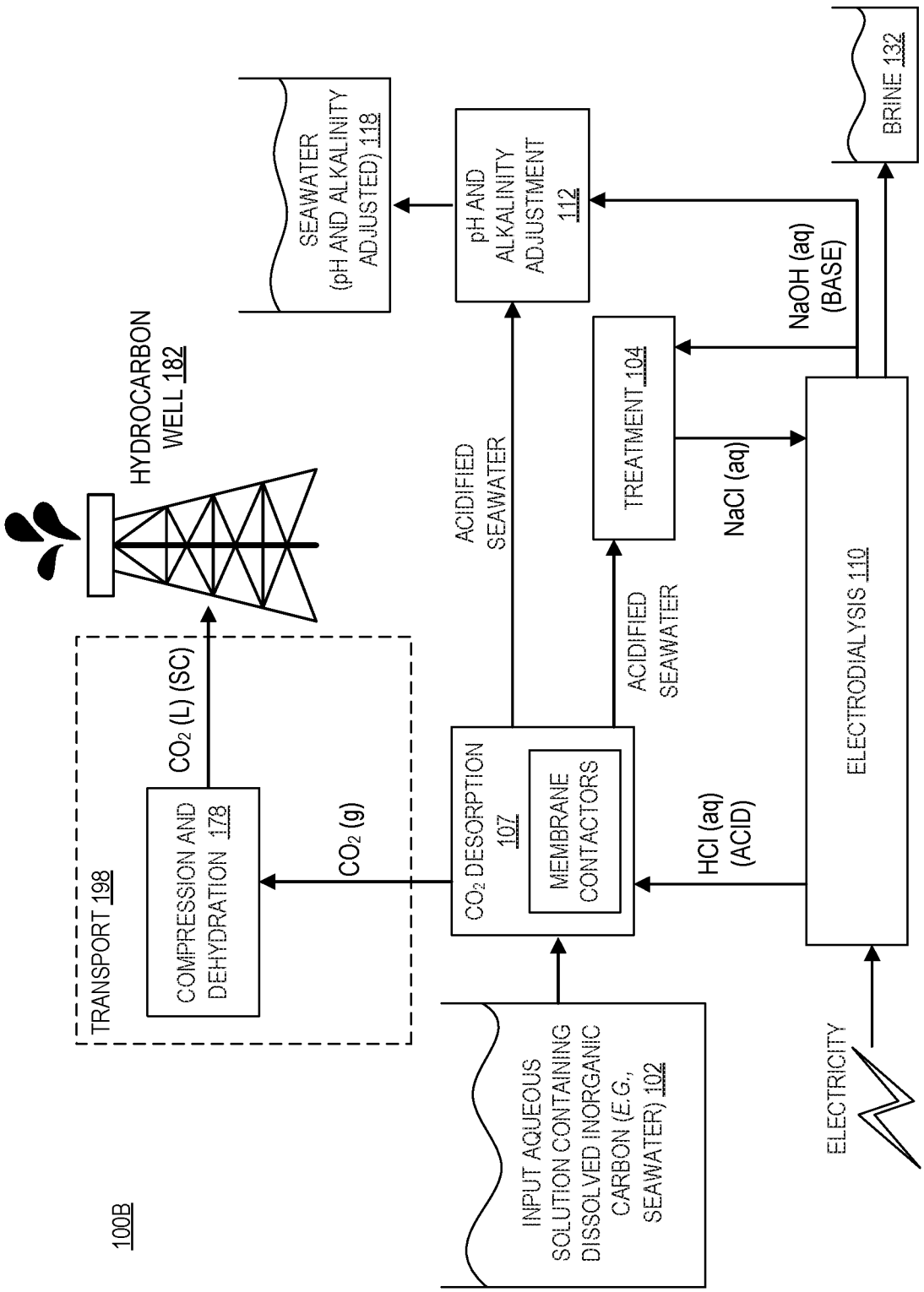

100B
INPUT AQUEOUS SOLUTION CONTAINING DISSOLVED INORGANIC CARBON (E.G., SEAWATER) 102
ELECTRICITY
ELECTRODIALYSIS 110
HCl (aq) (ACID)
NaCl (aq)
NaOH (aq) (BASE)
BRINE 132
CO2 DESORPTION 107
MEMBRANE CONTACTORS
ACIDIFIED SEAWATER
ACIDIFIED SEAWATER
TREATMENT 104
pH AND ALKALINITY ADJUSTMENT 112
SEAWATER (pH AND ALKALINITY ADJUSTED) 118
CO2 (g)
COMPRESSION AND DEHYDRATION 178
CO2 (L) (SC)
TRANSPORT 198
HYDROCARBON WELL 182

FIG. 1B

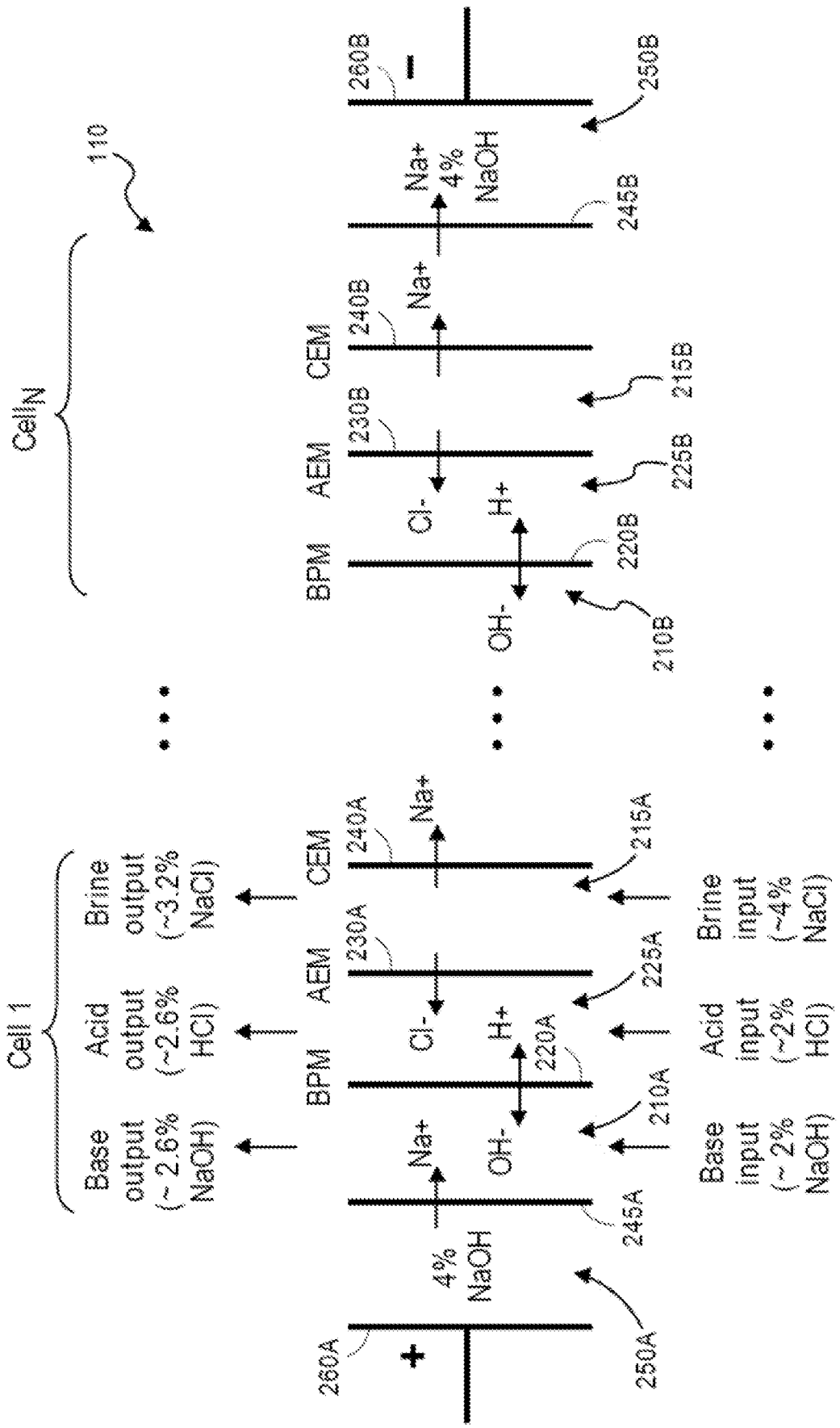

110
Cell 1
Cell N
Base output (~2.6% NaOH)
Acid output (~2.6% HCl)
Brine output (~3.2% NaCl)
Base input (~2% NaOH)
Acid input (~2% HCl)
Brine input (~4% NaCl)
BPM
AEM
CEM
4% NaOH
Na+
OH-
Cl-
H+
260A
250A
245A
210A
220A
225A
230A
240A
215A
260B
250B
245B
210B
220B
225B
230B
240B
215B

FIG. 2

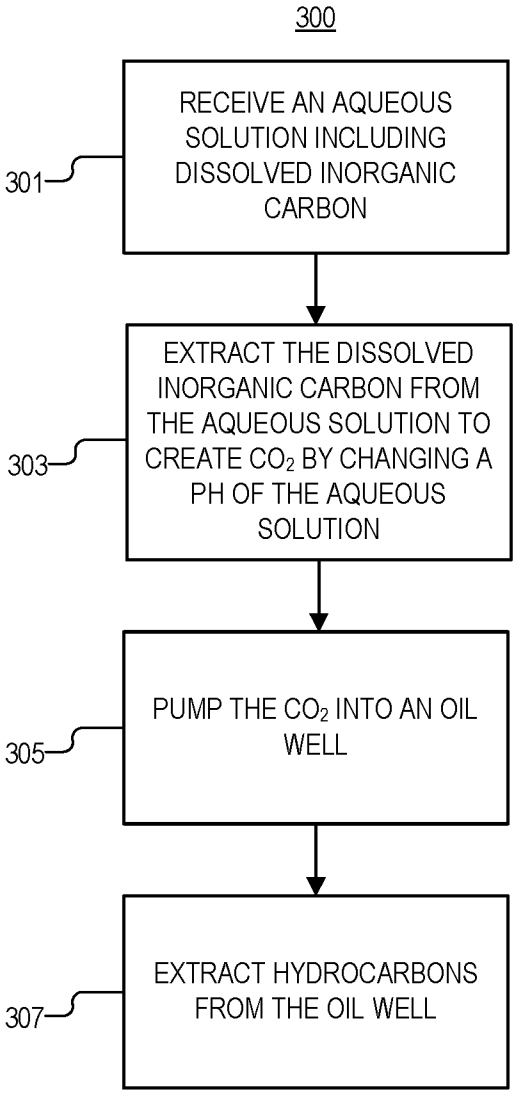

300
RECEIVE AN AQUEOUS SOLUTION INCLUDING DISSOLVED INORGANIC CARBON
301
EXTRACT THE DISSOLVED INORGANIC CARBON FROM THE AQUEOUS SOLUTION TO CREATE CO_2 BY CHANGING A PH OF THE AQUEOUS SOLUTION
303
PUMP THE CO_2 INTO AN OIL WELL
305
EXTRACT HYDROCARBONS FROM THE OIL WELL
307

FIG. 3