

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SCOUT ENERGY MANAGEMENT, LLC, and
CHEVRON U.S.A. INC.

Petitioners

v.

PILOT INTELLECTUAL PROPERTY, LLC,

Patent Owner.

DECLARATION OF DAVID A. ROCKSTRAW, PH. D., P. E.

Case No. IPR2024-00385

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1011	Plaintiffs’ Response in Opposition to Defendants’ Motion to Dismiss For Failure to State a Claim Under FRCP 12(B)(6) (“Opposition”)
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1015	Curriculum Vitae of Dr. David Rockstraw
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1017	https://trc.nist.gov/cryogenics/aboutCryogenics.html (“About Cryonics”)
1018	Encyclopedia of Chemical Technology, Volume 18 (“Kirk”)
1019	Organic Chemistry, Fourth Edition (“Morrison”)
1020	Perry’s Chemical Engineers’ Handbook, Seventh Edition (“Perry”)
1021	Applied Thermodynamics (“DePriester”)
1022	U.S. Pat. No. 4,070,165 (“Colton”)
1023	Schlumberger Energy Glossary Entry for “Natural Gas Liquids”
1024	Sizing of Throttling Device for Gas/Liquid Two-Phase Flow Part 1: Safety Valves (“Diener”)

I. Introduction

1. My name is David A. Rockstraw, Ph. D., P. E. I have prepared this Declaration in connection with Scout Energy Management, LLC and Chevron U.S.A. Inc., for *Inter Partes* Review of U.S. Patent No. 8,505,332 (the “’332 Patent”) (EX1001), which is to be filed concurrently with this Declaration.

2. In the course of preparing this Declaration, I reviewed the ’332 Patent, its prosecution file history, as well as the other documents discussed in this Declaration.

3. I have been retained by Scout Energy Management, LLC and Chevron U.S.A. Inc. (“Petitioners”) as an expert in the fields of chemical engineering and related technologies. I have been asked to provide my opinion regarding the state of the art of the technology described in the ’332 Patent and on the patentability of the claims of this patent. I am being compensated at my normal consulting rate for my time. My compensation is not dependent on and in no way affects the substance of my statements in this Declaration. I have no financial interest in Scout, the ’332 Patent, or the owner of the ’332 Patent.

II. Background and Qualifications

4. My professional qualifications, experience, publications, and presentations, as well as a list of previous cases in which I have provided expert testimony, are outlined in my *Curriculum Vitae* (EX1015).

5. I received a Ph.D. in chemical engineering from the University of Oklahoma in 1989 and a B.S. in chemical engineering from Purdue University in 1986. I have over 40 years of industry and academic experience, and I am the named inventor on several US patents. *See, e.g.*, U.S. Patent No. 6,225,256; U.S. Patent No. 5,157,186; and U.S. Patent No. 5,104,843.

6. I was a Professor of Chemical Engineering at New Mexico State University from 1995 to 2021. While I was a professor, I was a visiting scientist in the Nuclear Materials Testing division of Los Alamos National Laboratory. In my work as a professor, I have taught courses on the development of chemical processing systems, including the simulation of oil and gas separation systems.

7. Prior to becoming a professor, I held the title of Research Engineer in the Process Development Center of Conoco/DuPont and Ethyl Corporation, and Engineer in the R&D division of Kraft, Inc.

8. Much of my research has focused on methods of chemical synthesis and processing. I have also authored or co-authored over 50 papers and presentations in the area of chemical engineering and processing.

9. I am a licensed Professional Engineer in New Mexico, Texas, and California (pending) with extensive industry experience in chemical processing and engineering, including the design and fabrication of large-scale chemical

manufacture processes. I also have an extensive background of experience with chemical process simulation using the AspenTech family of products.

10. I was named a Fellow of the American Institute of Chemical Engineers in 2015. I was also a member of the board of directors for the National Society of Professional Engineers from 2013 to 2015. I have received a number of other honors and awards for my research contributions and teaching, including the Frank Bromilow Award for Teaching Excellence (2016), the NMSU Roush Teaching Award (2014), the Robert Davis Distinguished Professorship (2013), the NMSU Distinguished Achievement Professor Award (2012), the Ed and Harold Foreman Engineering Education Excellence Award (2012), the NSPE, Professional Engineers in Higher Education Engineering Education Excellence Award (2009), the Research Grand Prize, American Academy Environmental Engineers (1998), among others.

III. Documents and Materials Considered

11. In forming my opinions, in addition to my knowledge, education, training, and experience, I have considered the materials cited in this Declaration and the documents and things that I have obtained, or that have been provided to me, as listed in the Table of Exhibits.

12. I reserve the right to supplement or amend this Declaration if additional information that affects my opinions becomes available.

IV. Relevant Legal Principles

13. I am not an attorney, and I offer no opinions on the law. Counsel has informed me of legal standards that apply to the issue of patent validity. I have applied these standards in arriving at my conclusions.

14. I understand that in an *Inter Partes* review the petitioners have the burden of proving a proposition of unpatentability by a preponderance of the evidence. I understand this standard is different from the standard that applies in a district court, where I understand a challenger bears the burden of proving invalidity by clear and convincing evidence.

15. I understand that a patent may not be valid even though the invention is not identically disclosed or described in the prior art if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious to a person having ordinary skill in the art in the relevant subject matter at the time the invention was made.

16. I understand that obviousness must be tested as of the time the invention was made. I understand that the test for obviousness is what the combined teachings of the prior art references would have suggested, disclosed, or taught to one of ordinary skill in the art.

17. To determine if a claim is obvious, the following factors should be considered: (1) the level of ordinary skill in the art at the time the invention was

made; (2) the scope and content of the prior art; (3) the differences between the claimed invention and the prior art; and (4) secondary considerations, including evidence of commercial success, long-felt but unsolved need, unsuccessful attempts by others, copying of the claimed invention, unexpected and superior results, acceptance and praise by others, independent invention by others, and the like.

18. For example, I understand that the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand that an obviousness analysis need not seek out precise teachings directed to the specific subject matter of the challenged claim because a court can take account of the inferences and/or creative steps that a person of ordinary skill in the art would employ.

19. I understand that the following rationales may be used to determine whether a piece of prior art can be combined with other prior art or with other information within the knowledge of one of ordinary skill in the art:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Predictable use or combination of prior art elements according to their established functions;
- Use of known techniques to improve similar devices (methods, or products) in the same way;

- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- “Obvious to try” - choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; or
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

20. I understand that when a work is available in one field of endeavor, design incentives and/or other market forces, for example, can prompt variations of it, either in the same field or a different one. Moreover, if a person of ordinary skill can implement a predictable variation, I understand this likely bars its patentability.

21. I understand that another factor to be considered is common sense. For example, I understand that common sense teaches that familiar items may have obvious uses beyond their primary purposes, and, in many cases, a person of ordinary skill will be able to fit the teachings of multiple patents together like pieces of a puzzle.

22. I understand that the Supreme Court articulated additional guidance for obviousness in its KSR decision. My understanding is that the Supreme Court said that technical people of ordinary skill look for guidance in other solutions to problems of a similar nature, and that the obviousness inquiry must track reality, and

not legal fictions. I have relied on these understandings in expressing the opinions set forth below.

23. I understand that a new use of an old product or material cannot be claimed as a new product; the apparatus or system itself is old and cannot be patented. I further understand that, in general, merely discovering and claiming a new benefit to an old process cannot render the process newly patentable.

24. I understand that, for purposes of my analysis in this inter partes review proceeding, the terms appearing in the patent claims should be interpreted according to their “ordinary and customary meaning.” In determining the ordinary and customary meaning, the words of a claim are first given their plain meaning that those words would have had to a person of ordinary skill in the art (“POSITA”). I understand that the structure of the claims, the specification, and the file history also may be used to better construe a claim insofar as the plain meaning of the claims cannot be understood. Moreover, treatises and dictionaries may be used, albeit under limited circumstances, to determine the meaning attributed by a POSITA to a claim term at the time of filing. I have followed this approach in my analysis, and for all the claim terms considered in this declaration, I have applied the plain and ordinary meaning of those terms.

25. I also understand that the words of the claims should be interpreted as they would have been interpreted by a POSITA at the time the alleged invention was made (not today). I have been asked to use the priority date of May 18, 2007.

V. Person of Ordinary Skill in the Art

26. In order to determine the characteristics of a POSITA of the '332 Patent, I have used May 18, 2007, as the relevant time frame. My understanding is that this is the alleged earliest foreign priority date of the application that resulted in the '332 Patent. For purposes of this Declaration, any reference to the priority date of the '332 Patent is intended to refer to this May 18, 2007, date.

27. In determining the characteristics of a person of ordinary skill in the art for the '332 Patent, I have considered the state of the art of chemical engineering processes at that time, the types of problems encountered with separating petroleum mixtures, and the solutions that then existed. I have also considered the then-existing technology for large-scale separation and distillation systems, including the sophistication of the technology involved, and the education and experience of those working in the field at that time. I have also considered my personal knowledge and experience in the field at that time, including those I worked and interacted with regarding chemical and petroleum engineering. I have also considered the knowledge, education, and experience of those in academia and industry at that time

that were working, innovating, or performing research in the field of chemical and petroleum engineering.

28. A person of ordinary skill in the art (POSITA) would have had: (i) a B.S. degree in chemical engineering, petroleum engineering, or an equivalent field and (ii) two or three years of industry experience in chemical processing systems, oil and gas production or refining; or comparable experience. Additional work experience can substitute for educational or research experience, and vice versa. Given this background, a POSITA would have been familiar hydrocarbon streams, natural gas liquids, and hydrocarbon separation techniques.

29. Based on my background and qualifications, I currently am and was as of the priority date of the '332 Patent at least a POSITA in the subject matter of the '332 Patent.

VI. Technology Background

30. The technology of the '332 Patent relates to recovering and processing oil and natural gas derived from underground oil and natural gas reservoirs. In particular, it relates to methods of processing oil and natural gas recovered using enhanced oil recovery (EOR), which pumps carbon dioxide into the reservoir in order to increase its pressure and force oil and natural gas to the surface. As of the filing date of the '332 Patent, both oil and natural gas processing and EOR were well known and available in the art. *See, e.g.*, EX1005 at 303-05.

31. Oil and natural gas derived from EOR can be contaminated by hydrogen sulfide (H₂S) and carbon dioxide (CO₂). See EX1005 at 305; EX1007 at 53. Both compounds occur naturally in oil and gas reservoirs, but the use of carbon dioxide during EOR can increase the percent contamination. See EX1005 at 305; EX1007. Hydrogen sulfide is considered an acid gas because, when exposed to water, it lowers the pH of the water. See EX1005 at 305 (explaining that hydrogen sulfide is an acid gas). Gas contaminated by hydrogen sulfide is “sour” gas, and gas with the hydrogen sulfide removed is “sweet.” See EX1018 at 575.

32. Hydrocarbons are compounds made up of hydrogen and carbon (hence the name, “hydrocarbon”). Hydrocarbons are mainly differentiated by the number of carbons they have—C₁ for hydrocarbons with one carbon, C₂ for two, and so on. See EX1019 at 86. The name and formula of exemplary alkane hydrocarbons C₁ to C₉ are found below:

	Name	Formula
C₁	Methane	CH ₄
C₂	Ethane	C ₂ H ₆
C₃	Propane	C ₃ H ₈
C₄	Butane	C ₄ H ₁₀
C₅	Pentane	C ₅ H ₁₂
C₆	Hexane	C ₆ H ₁₄
C₇	Heptane	C ₇ H ₁₆
C₈	Octane	C ₈ H ₁₈
C₉	Nonane	C ₉ H ₂₀

EX1019 at 85–87.

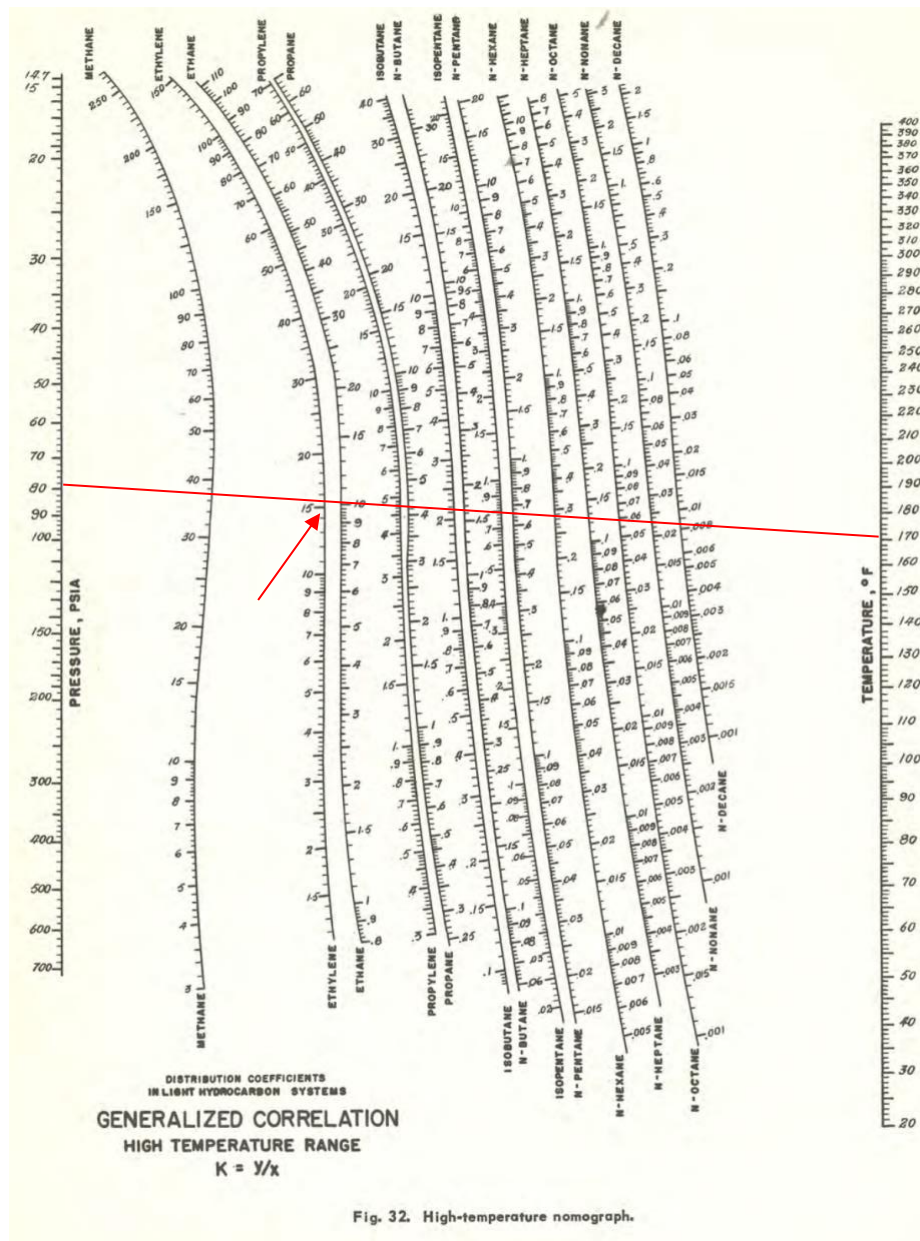
33. The hydrocarbons derived from oil and natural gas wells contain a range of hydrocarbons, from methane (C₁) through nonane (C₉) and higher. *See* EX1005 at 305 (explaining that the gas streams include methane, natural gas liquids, and crude oil); EX1007 at 53 (explaining that the recovered natural gas streams contain C₃₊). Because the properties of these compounds changes as their size increases from C₁ to C₉₊, persons of skill in the art separate them into broad categories that correlate with their chemical properties.

34. The first category of hydrocarbons a person of skill in the art would recognize is natural gas. Natural gas typically refers to methane (C₁) and ethane (C₂), as those two compounds exist as a gas at atmospheric conditions.

35. The second category are the natural gas liquids, or NGLs. These compounds are called NGLs because they can be found as a vapor with natural gas at standard temperature and pressure, but (unlike methane and ethane) can be liquified at room temperature when placed under pressure. The NGLs range from C₃-C₈. *See, e.g.*, EX1004 at 5:41-46.

36. The third category are the crude oils. These are heavy hydrocarbons that can only exist in very small quantities in the vapor phase at standard temperature and pressure. These compounds range from C₉ and higher. *See, e.g.*, EX1004 at 5:41-46.

37. The art describes several different ways to separate oils and natural gas liquids. Two of the most common are phase separation and distillation. Phase separation processes are the simplest: the hydrocarbon stream is fed into a separator, and it is allowed to reside under the influence of gravity. EX1020 at 14-82. Liquids coalesce at the bottom of the separator, while gases rise to the top. *See, e.g.*, EX1005 at 305 (describing the separation of the vapor phase from the liquid phase). This method of separation takes advantage of the different vapor pressure of each hydrocarbon at a given temperature and pressure: more volatile components preferentially leave the top of the phase separator as gases and/or vapors, and less volatile components leave the bottom as liquid. This property is described in “DePriester charts”:

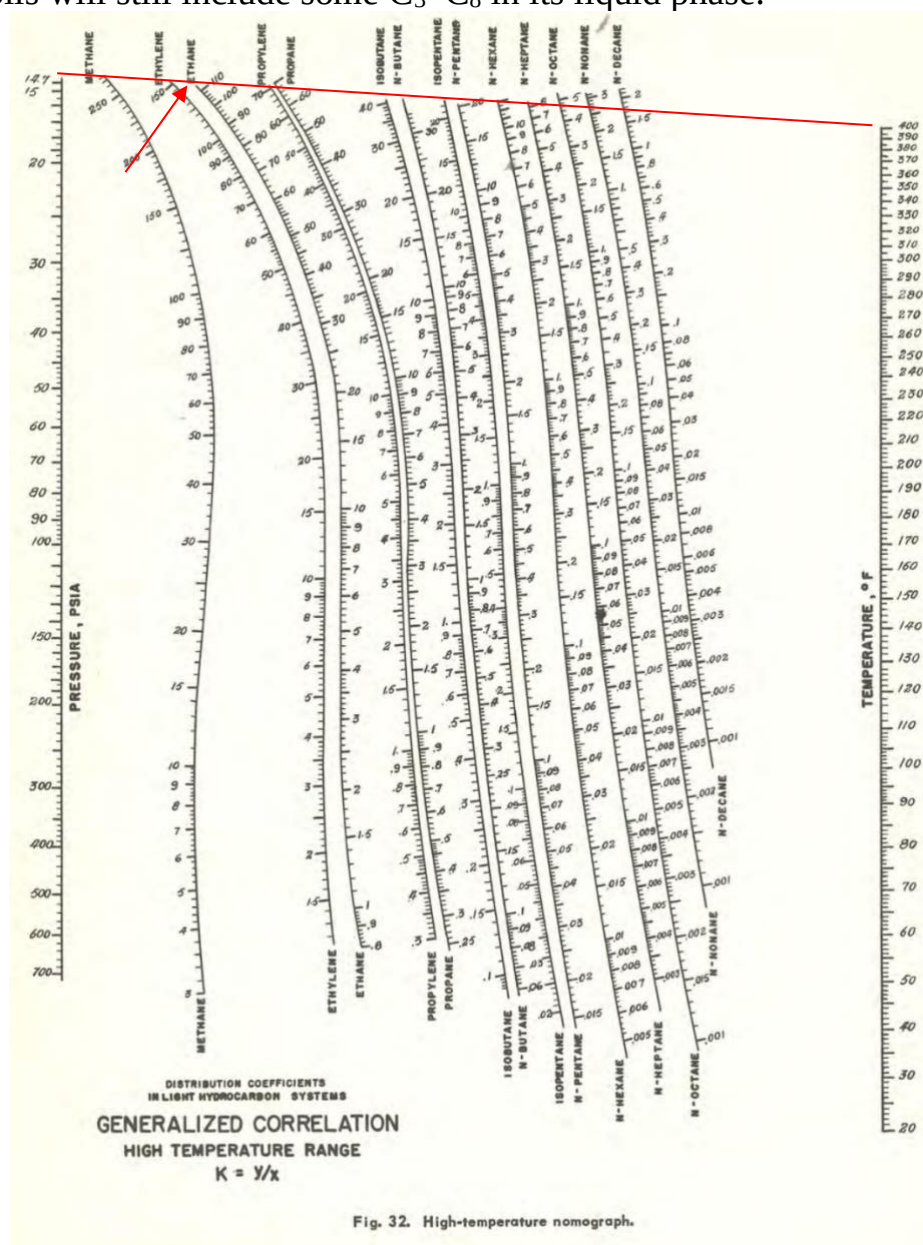


EX1021 at 44 (annotations in red). DePriester charts allow POSITA to determine the relative proportions of liquid and vapor/gas for a given hydrocarbon at a particular temperature and pressure. The way the chart works is simple: draw a line from a chosen pressure to a chosen temperature. Where that line intersects the

hydrocarbon isotherm indicates the relative proportion of vapor/liquid of the hydrocarbon.

38. In the example above, I drew a line from 170 °F to 80 PSIA. That intersects the ethylene line at 15, which indicates that there is a 15:1 ratio of vapor to liquid for ethylene at that temperature and pressure. So a POSITA would expect 15 times more ethylene to leave a phase separator out the top as a vapor as leaves the bottom as a liquid. A POSITA thus understands that phase separations are imperfect, and cannot completely separate one class of hydrocarbons from another in a single equilibrium separation stage. In other words, a POSITA attempting to separate out crude oil (C_{9+}) in the form of liquids from NGLs (C_3-C_8) and lighter hydrocarbons in the form of vapors/gases would still expect some C_{9+} hydrocarbons in the vapor output and some NGLs in the liquid output. For example, even a phase separation performed at a higher temperature (370 °F) and lower pressure (14.7

PSIA; atmospheric pressure) than a POSITA would typically use to separate NGLs from crude oils will still include some C₃–C₈ in its liquid phase:¹

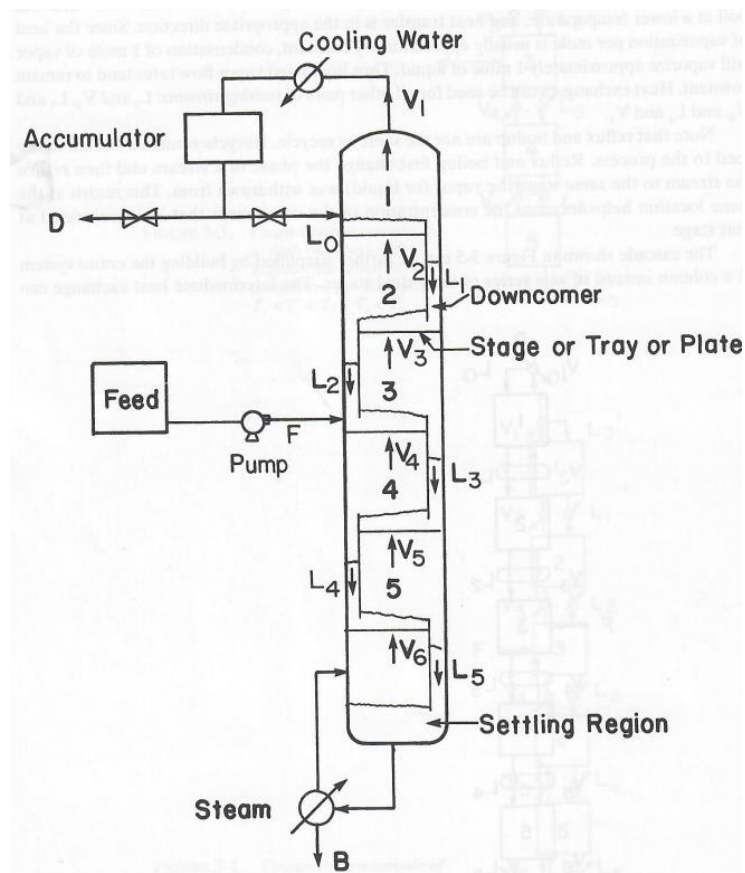


¹ Because oil and gas released from an oil and gas reservoir is under pressure, by definition it is at a higher pressure than 14.7 PSIA (one atmosphere)—otherwise, it

See id. (annotated) (showing that ~0.5–1% of the ethylene and ethane remains in the liquid phase at 14.7 PSIA (i.e., one atm) and 370 °F, and a greater proportion for each heavier hydrocarbon).

39. A second common form of hydrocarbon separation is distillation. This method uses a similar physical process as a single-stage phase separation, but includes a cascade of equilibrium stages across a gradient of temperature and hydraulic pressure (The extension of a cascade of single-stage flash distillation units into a distillation column is described in detail by Wankat in Chapter 3 of Separation Process Engineering, Prentice Hall 2007. EX1012 at 65):

would not escape the ground. Additionally, oil and natural gas is usually formed at between 150 and 300 °F.



EX1012 at FIG. 3-6, 65–69.

40. In distillation, hydrocarbons are fed to a column. Increasing temperature and hydraulic pressure gradients are imposed across the column from top to bottom, typically maintained and managed by use of a reboiler as the bottom stage and a condenser at the top stage. EX1012 at 65-69. Heat added at the reboiler causes vaporization of hydrocarbons, which subsequently rise upward toward the top of the column. *Id.* As the hydrocarbons go up through the column, they cool and begin to condense. *Id.* By heating the bottom and cooling the top, more volatile components (as defined by their K values) preferentially leave the top of the column, and the less volatile materials preferentially leave the bottom of the column. *Id.*

41. Just like phase separation, distillation is an imperfect process, and the stream leaving the top of a distillation column will contain some less volatile components, and the stream leaving the bottom of the column will contain some more volatile components. The extent of separation a distillation column can achieve is also related to the number of equilibrium stages included in the cascade. More stages usually means increased level of separation (though azeotropes like the CO₂/ethane system can lead to exceptions), but at the price of increased capital investment. See EX1012 at 69.

42. A POSITA would also have been aware of processes to sweeten natural gas and natural gas liquid streams by removing toxic hydrogen sulfide from the streams as of the Priority Date. See *e.g.*, EX1022 at 2:59-66. Many methods for removing hydrogen sulfide to “sweeten” a natural gas stream were known in the art including, but not limited to: (i) amine-based purification methods (*id.* at 3:17-27); (ii) hydrated iron oxide methods (*id.* at 3:55-59); (iii) the Stretford process, which washed the gas with an aqueous solution containing sodium carbonate, sodium vanadate, anthraquinone disulfonic acid, and traces of chelated iron (*id.* at 3:60-67); (iv) physical solvent processes (*id.* at 4:7-15); and (v) adsorption techniques to remove sulfur compounds, including molecular sieve processes (*id.* at 4:18-21).

VII. '332 Patent

A. Overview

43. U.S. Patent No. 8,505,332 to Prim is entitled “Natural Gas Liquid Recovery Process” and was issued on August 13, 2013.

44. Carbon dioxide can be injected into oil and gas wells to increase the pressure of those wells and drive the hydrocarbons to the surface. EX1001 at 24-33. The '332 Patent is directed to methods of recovering and purifying natural gas liquids that are received as a result of such carbon dioxide injection. EX1001 at 1:24-33.

B. Background / Applicant Admitted Prior Art

45. According to the '332 Patent, CO₂ injection into subterranean formations was a known method to recover heavy hydrocarbons and natural gas liquids (NGLs) prior to the Priority Date. EX1001 at 1:24-33. A POSITA would have been familiar with the processing of hydrocarbons derived from subterranean formations, and in particular, natural gas wells. Such wells contain a number of different hydrocarbons, ranging from methane (C₁) through nonane (C₉) and higher. Because the properties of these different compounds changes as they range from C₁ to C₉₊, persons of skill in the art separate them into broad categories.

46. I have also reviewed the '332 Patent, including the section of the Specification describing the composition of the hydrocarbon feed stream. EX1001 at 2:61-3:13. I understand that the Patent Owner uses this section to describe how

certain terms were known and used in the art prior to the filing of the '332 Patent. In my opinion, this admitted prior art described in the '332 Patent comports with my understanding as outlined above. *Supra* § VI. The '332 Patent describes four elements in particular:

- Natural gas: “The term ‘natural gas’ may refer to any hydrocarbon that may exist in a gas phase under atmospheric or downhole conditions, and includes methane and ethane, but may also include diminishing amounts of C₃-C₈ hydrocarbons.” *Id.* at 3:1-4.
- Natural gas liquids: “The term ‘natural gas liquids’ or NGLs may refer to natural gas compositions that may be liquified without refrigeration, and may include C₃-C₈ hydrocarbons.” *Id.* at 3:4-7.
- Heavy hydrocarbons. “In contrast, the term ‘heavy hydrocarbons’ may refer to any hydrocarbon composition that may exist in a liquid phase under atmospheric or downhole conditions, and generally includes liquid crude oil, which may comprise C₉₊ hydrocarbons, branched hydrocarbons, aromatic hydrocarbons, and combinations thereof.” *Id.* at 3:8-13.
- Liquid crude oil. “[L]iquid crude oil, which may comprise C₉₊ hydrocarbons.” *Id.* at 3:11-12.

47. The '332 Patent explicitly states that “[b]oth natural gas and NGL are terms known in the art and are used herein as such.” *Id.* at 3:7-8. It is my

understanding, based on reading the '332 Patent, that the terms “heavy hydrocarbons” and “liquid crude oil” are also terms known in the art and used within the '332 Patent as such. *Id.* at 3:8-13. I therefore understand that the '332 Patent uses the terms natural gas, NGL, heavy hydrocarbons, and crude oil in the same way as those terms were used in the art prior to the Priority Date of the '332 Patent.

48. The Patent Owner confirmed this understanding in its statements to the Examiner. EX1003 at 129 (explaining that “NGL is a term of art meaning C₃₊ as shown in the Schlumberger Oilfield Glossary”); EX1023.

49. These prior art concepts that are admitted in the '332 Patent are thus also found in the prior art references that I discuss in the grounds of unpatentability below, as well as in the literature more generally.

C. Prosecution History

50. The '332 Patent was filed as Application No. 12/122,336 (the “'336 Application”) on May 16, 2008 (“U.S. Filing Date”). The '336 Application claims priority to Provisional Application No. 60/938,726, filed May 18, 2007 (“Priority Date”), and listed 20 claims. EX1003 at 31–35. I understand that for this IPR only, Petitioners assume that the '332 Patent can claim the benefit of priority to the U.S. Provisional Application No. 60/938,726 and that the priority date is thus May 18, 2007. All prior art used herein predates that date.

51. During prosecution of the '336 Application, the Examiner rejected Claim 1 as anticipated by U.S. Pat. No. 4,529,411 (“Goddin”). EX1003 at 140. In response to this rejection, the applicant amended Claim 1 to recite “wherein carbon dioxide is not removed from the hydrocarbon feed stream and is not removed from the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream into the NGL rich stream and the purified carbon dioxide recycle stream” and argued that Goddin performed such a separation. EX1003 at 171 (amending Claim 1). In particular, the applicant argued that Goddin “removes carbon dioxide at two locations . . . prior to separating the carbon dioxide recycle stream into the NGL rich stream and the purified carbon dioxide recycle stream.” EX1003 at 182.

52. The Examiner then rejected Claim 1 as obvious over a combination of Goddin and U.S. Pat. No. 6,128,919 (“Daus”). EX1003 at 195. In response to the new rejection, the applicant amended Claim 1 to recite what each stream comprises, and further amended Claim 1 to recite “wherein the hydrocarbon feed stream and the carbon dioxide recycle stream are not subjected to cryogenic conditions, membranes, and solvents between being received and being separated into the NGL rich stream and the purified carbon dioxide recycle stream.” EX1003 at 235. The Applicant argued that (i) Goddin and Daus did not disclose a “sour NGL stream,” and (ii) Goddin and Daus did disclose the use of membranes, cryogenic conditions, and/or carbon dioxide recovery solvents in their separations. EX1003 at 256–58.

53. The Examiner allowed Claims 1-4, 6, and 7, among others, on May 8, 2013 based on the above amendments. EX1003 at 263–65. However, as explained below, these limitations were already taught in the prior art.

D. Priority Date

54. As discussed above, the '336 Application claims priority to a U.S. Provisional Application filed on May 18, 2007. EX1001. For the purposes of this Declaration, I have been told to assume that the earliest priority date of the '332 Patent is May 18, 2007.

VIII. Claim Construction

55. I have interpreted the terms of the '332 Patent according to their plain meaning. In interpreting the terms, I have carefully considered and applied the claim construction standards referred to in Section IV above.

IX. Summary of Opinions

56. In my opinion, Reducing Carbon Dioxide Emissions with Enhanced Oil Recovery Projects: A Life Cycle Assessment Approach (“Aycaguer”), either alone or in combination with U.S. Patent No. 4,474,591 (“Arand”), renders obvious Claim 1, of the '332 Patent (*see infra* §§ X.A & X.B).

57. In my opinion, the combination of Aycaguer and U.S. Patent No. 4,976,849 (“Soldati”), renders obvious claims 1-4, 6, and 7 of the '332 Patent (*see infra* § X.C).

58. In my opinion, the combination of Aycaguer, Soldati, and CO₂ Recovery by the Ryan/Holmes Process (“Ryan”), renders obvious claim 2 of the ’332 Patent (*see infra* § X.D).

59. In my opinion, the combination of Aycaguer, Soldati, and Arand renders obvious claims 1-4, 6, and 7 of the ’332 Patent (*see infra* § X.E).

60. In my opinion, the combination of Aycaguer, Soldati, Ryan, and Arand renders obvious claim 2 of the ’332 Patent (*see infra* § X.E).

61. A table of the grounds is provided below for ease of reference:

Ground	Basis for Rejection	Claims
1	35 U.S.C. § 103 over Aycaguer	1
2	35 U.S.C. § 103 over Aycaguer and Arand	1
3	35 U.S.C. § 103 over Aycaguer and Soldati	1–4, 6 & 7
4	35 U.S.C. § 103 over Aycaguer, Soldati, and Ryan	2
5	35 U.S.C. § 103 over Aycaguer, Soldati, and Arand	1–4, 6 & 7
6	35 U.S.C. § 103 over Aycaguer, Soldati, Ryan, and Arand	2

62. Before the ’332 Patent, techniques to separate out the components of a natural gas liquid stream resulting from CO₂ injection were well-known, as were solutions to purify the stream of the contaminants that result from injection. *See e.g.*, EX1005 at 303-05. Indeed, many elements of the challenged claims are described in the background section of the ’332 Patent. *See* EX1001 at 1:24–33 (explaining that

CO₂ injection into subterranean formations was a known method to recover heavy hydrocarbons and NGLs.

A. Overview of Aycaguer (EX1005)

63. Reducing Carbon Dioxide Emissions with Enhanced Oil Recovery Projects: A Life Cycle Assessment Approach (“Aycaguer”) is an article published in a well-known journal—Energy & Fuel—managed by the American Chemical Society (ACS). The ACS was founded in 1876 and is one of the world’s largest professional societies, with over 170,000 members representing approximately 140 countries. Energy & Fuel, founded in 1987, is one of roughly 100 journals published by ACS, with fossil energy resources focused on chemical engineering and applied chemistry being a primary scope of the journal.

64. Aycaguer describes a life cycle assessment of the use of CO₂ for enhanced oil recovery processes. EX1005 at 303. It analyzes the environmental burden caused by enhanced oil recovery at each stage of the process. *Id.* at 304. In particular, the analysis includes “the extraction of the oil and associated gas from the oil reservoir, the processing of the associated gas for separation of the different components (water, hydrogen sulfide –H₂S, CO₂, CH₄, natural gas liquids), the compression of the separated CO₂ stream destined for injection, and the transport and injection of the CO₂ in the oil reservoir for extraction of additional oil and for long-term storage.” *Id.* at 305.

65. Aycaguer describes a process that includes: (i) taking a stream of oil and natural gas from a reservoir, (ii) removing the crude oil from the stream to create a produced gas stream including natural gas liquids, CO₂, and H₂S (acid gas), (iii) removing the CO₂ from the produced gas stream using a Ryan/Holmes process, leaving the natural gas liquids and H₂S, (iv) removing the H₂S from the natural gas liquids using an amine solution, and (v) converting the captured H₂S to elemental sulfur:

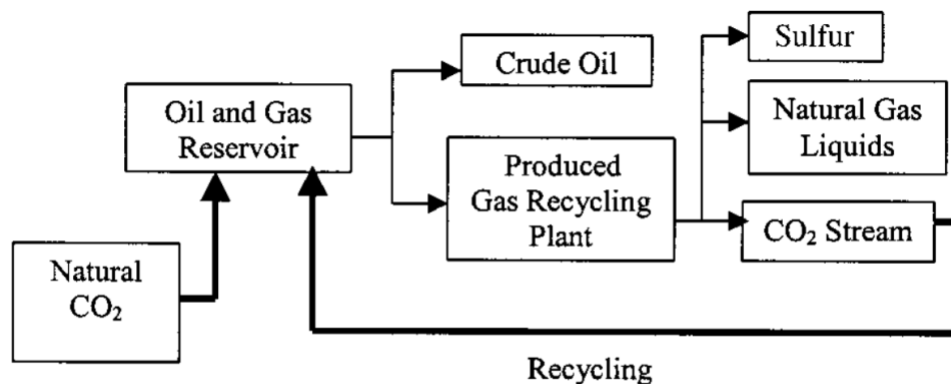


Figure 1. Schematic of processes investigated in the case studies.

Id. at FIG. 1, 305.

66. Aycaguer further explains that the CO₂ derived from its process can be recycled to supply up to 43% of the total CO₂ required for further injection. *Id.* at 306. This recycled CO₂ is combined with CO₂ derived from natural CO₂ reservoirs before injection back into the reservoir:

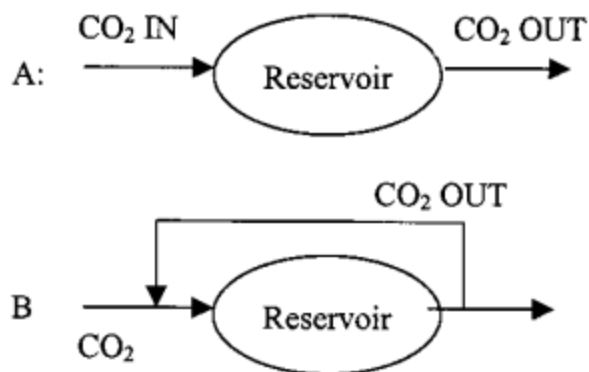


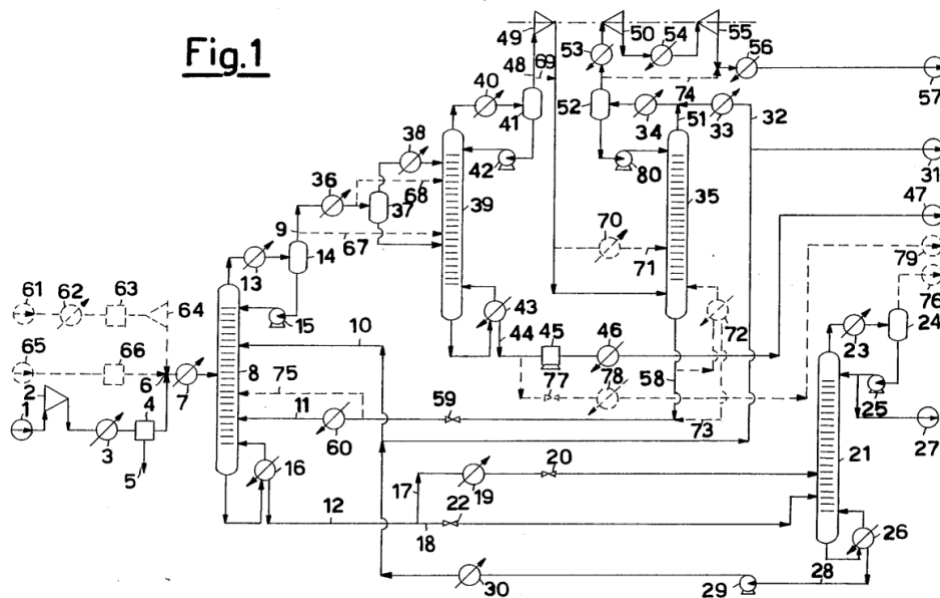
Figure 2. Designs of EOR process operations.

EX1005 at FIG. 2B, 306.

B. Overview of Soldati (EX1006)

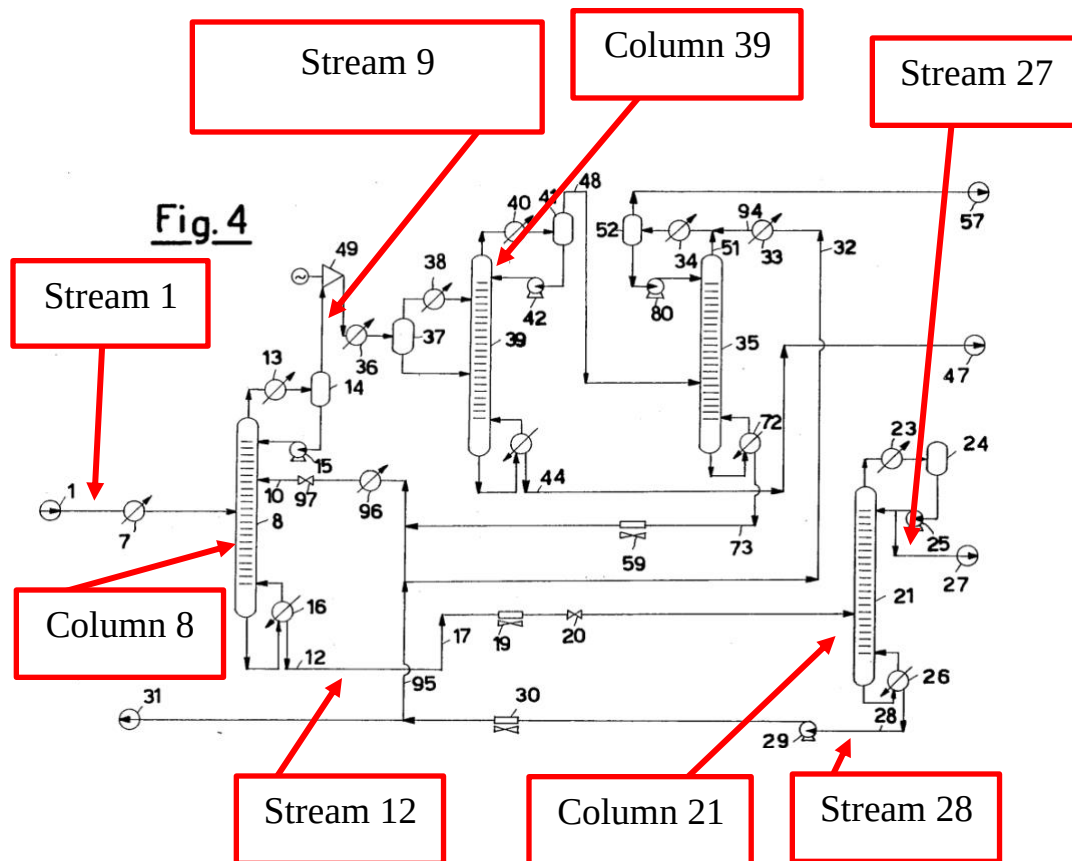
67. U.S. Patent No. 4,976,849 (“Soldati”) was filed as U.S. Application No. 246,744 on September 20, 1988 and was published and issued on December 11, 1990. EX1006 at 1.

68. Similar to Aycaguer, Soldati discloses methods of processing oil and natural gas streams to remove CO₂ and H₂S. Soldati explains that it offers an improved Ryan/Holmes processing method for removal of CO₂, affording a “considerable reduction in energy consumption.” EX1006 at 1:54–58. It outlines its method as including four separations taking place in four distillation columns:



EX1006 at FIG. 1, 1:67–2:26.

69. Soldati further describes a prior-art version of its method, using a more traditional Ryan/Holmes separation of CO₂:



EX1006 at FIG. 4 (annotated), 4:21 (“FIG. 4 is a process diagram of the known prior art.”).

70. According to Soldati, the initial gaseous hydrocarbon stream 1 is introduced into column 8 and separated into two different streams—an upper stream 9 that contains primarily CO₂ and a lower stream 12 that includes “propane and higher hydrocarbons.” See EX1006 at 4:30–32; Table III. The lower stream 12 is also contaminated with H₂S:

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	−13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at Table III.

71. The lower stream 12 from column 8 is brought to column 21, where the hydrogen sulfide and carbon dioxide are removed in stream 27, leaving behind the C₃₊ hydrocarbons in stream 28:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	28	10	95
NITROGEN	—	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	—	46.64	—
METHANE	—	7.03	—
ETHANE	—	10.54	—
PROPANE	12.11	11.97	12.00
N-BUTANE	1092.03	1081.98	1082.60
N-PENTANE	81.06	80.26	80.25
THROUGHPUT KMOLS/H	1513.37	1563.53	1500.00
PHASE	L	L	L
TEMPERATURE °C.	122.0	16.0	48.0
PRESSURE ATA	19.2	39.6	44.0

See EX1006 at Table III.

72. The upper stream 9 from column 8 is further purified in column 39, where it is separated into a predominantly CO₂ stream 44 and a predominantly methane stream 48:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	48	44	73
NITROGEN	16.45	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	47.78	1162.50	46.61
METHANE	64.56	—	7.02
ETHANE	10.56	8.86	10.57
PROPANE	—	1.12	1.17
N-BUTANE	—	0.87	107.65
N-PENTANE	—	—	32.47
HEXANE	—	—	8.02

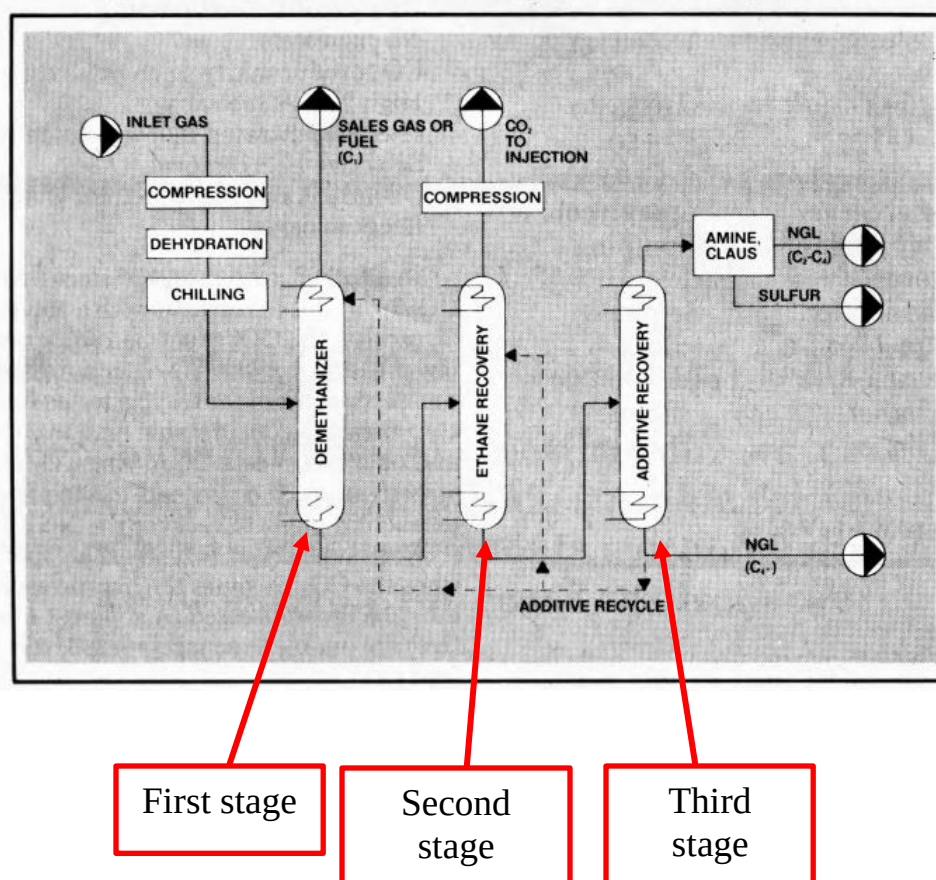
EX1006 at Table III.

73. Soldati teaches that Stream 44 is then pumped to 47 for reinjection into an oil well. *See* EX1006 at 5:8–13.

C. Overview of Ryan (EX1007)

74. CO₂ Recovery by the Ryan/Holmes Process (“Ryan”) is an article published in a well-known journal—Chemical Engineering Progress (CEP)—managed by the American Institute of Chemical Engineers (AIChE). CEP is considered the “flagship” publication of AIChE, and is considered a trade magazine, offering widely applicable guidance and technology overviews written by subject matter experts. Ryan describes methods of processing CO₂ and hydrocarbon liquids derived from natural gas streams. *See* EX1007 at 53. In particular, it relates to processing natural gas streams derived from enhanced oil recovery projects that use CO₂ injection, the same projects described by Aycaguer. *Compare id.* with EX1005 at 303; EX1006 at 5:11-13. One Ryan/Holmes process described in Ryan takes place in three stages:

Figure 2. Three-column Ryan/Holmes process.



EX1007 at FIG. 2 (annotated).

75. In the first stage, the methane is removed from the hydrocarbon stream. *Id.* In the second stage, the CO₂ is removed from the hydrocarbon stream. *Id.* And in the third stage, the stream is separated into a sweet NGL stream with the C₄⁺ hydrocarbons and a sour NGL stream with C₂-C₃ hydrocarbons. *Id.* The sour NGL stream is then sweetened using amine solvent. *Id.*

D. Overview of Arand (EX1004)

76. U.S. Patent No. 4,474,591 (“Arand”) was filed as U.S. Application No. 516,159 on July 21, 1983 and was published and issued on October 2, 1984. EX1004 at 1.

77. Arand describes methods of processing oil and natural gas streams derived from high-pressure underground reservoirs. EX1004 at 1:6-10. In particular, it describes a method of separating a hydrocarbon stream from a gas condensate reservoir into three different streams: “a residue gas stream comprising predominantly methane, a natural gas liquids stream, and a stabilized condensate stream.” *Id.* at 4:1-7. As with the admissions in the ’332 Patent, Arand further explains that natural gas liquids refers to hydrocarbons from C₃-C₈, and heavy condensate refers to hydrocarbons from C₉₊. *Id.* at 5:41-46.

X. Claims 1-4, 6, and 7 are Unpatentable

A. Ground 1: Claim 1 is Obvious Over Aycaguer

78. In my opinion, Aycaguer renders obvious Claim 1 of the ’332 Patent.

1. Claim 1

a. “A method comprising:” [1.P]

79. I understand that the preamble of Claim 1 is not limiting. Nevertheless, to the extent the preamble is limiting, Aycaguer teaches the limitation. Specifically, Aycaguer discloses a method for gas processing, including “the extraction of the oil and associated gas from the oil reservoir, the processing of the associated gas for

separation of the individual components (water, hydrogen sulfide –H₂S, CO₂, CH₄, natural gas liquids), the compression of the separated CO₂ stream destined for injection, and the transport and injection of the CO₂ in the oil reservoir for the extraction of additional oil and for long-term storage.” EX1005 at 305.

b. “receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C3-C8 hydrocarbons, and wherein the heavy hydrocarbons comprise C9+ hydrocarbons” [1.1]

80. As shown below, the process described by Aycaguer includes receiving, from an “Oil and Gas Reservoir,” an oil and associated gas stream (i.e., “a hydrocarbon feed stream”) that has as its components, which are separated into different outputs, “Crude Oil” (i.e., heavy hydrocarbons), “Natural Gas Liquids” (i.e., C₃-C₈), and “CO₂ Stream” (i.e., carbon dioxide):

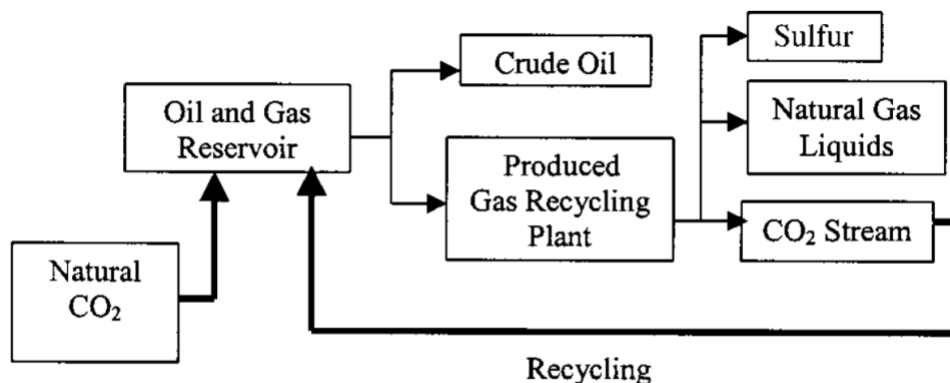


Figure 1. Schematic of processes investigated in the case studies.

EX1005 at FIG. 1.

81. The stream from the oil and gas reservoir is generated from a CO₂ injection process. EX1005 at 305 (“Water is injected alternately with CO₂ in a process called water-alternating gas.”). This stream from the oil and gas reservoir in Aycaguer thus teaches the “hydrocarbon feed stream 152 from a subterranean formation” recovered after “injecting carbon dioxide into an injection well” in the ’332 Patent. EX1001 at 1:28-30 (explaining that hydrocarbons are recovered from a subterranean formation after CO₂ injection), 2:48-50 (explaining that the hydrocarbon feed stream is derived from a subterranean formation).

82. A POSITA, relying on their background knowledge in the art, would have understood that a hydrocarbon feed stream derived from an oil and gas reservoir undergoing enhanced oil recovery with CO₂ injection would include at least C₃-C₉₊ hydrocarbons, carbon dioxide, and hydrogen sulfide. *See e.g.*, EX1004 at 1:16-18, 5:41-46 (explaining that “[n]atural gas comprises different hydrocarbons in varying amounts, plus varying amounts of nitrogen, carbon dioxide, and sometimes hydrogen sulfide” and that natural gas liquids refers to hydrocarbons from C₃-C₈, and heavy condensate refers to hydrocarbons from C₉₊); EX1016 at Abstract, 3:3-12 (disclosing “a method and apparatus for separating and purifying carbon dioxide and natural gas contained in the associated gas of an oil well” including after “recovery processes using carbon dioxide injection;” explaining that the hydrocarbon feed stream may comprise “heavy hydrocarbons,” “carbon dioxide, hydrogen sulfide, and

light hydrocarbons”). Based on this understanding, a POSITA reading Aycaguer would have understood that the stream processed by Aycaguer would contain each of those components.

83. Aycaguer confirms that its hydrocarbon feed stream includes at least C₃ through C₉₊ hydrocarbons, carbon dioxide, and hydrogen sulfide. The first separation described by Aycaguer results in two streams: one that contains “crude oil” and one that is sent to a produced gas recycling plant. See EX1005 at FIG. 1. A POSITA would have understood, and at the very least found it obvious, that crude oil contains C₉₊ (as well as some residual lighter hydrocarbons), and thus the hydrocarbon feed stream described in Aycaguer would have contained at least C₉₊ (which are heavy hydrocarbons) for crude oil to be separated from it. *Supra* at ¶¶ 34-36; EX1004 at 5:41-46 (explaining that C₉₊ are the heavy condensate); EX1001 at 3:11-12 (explaining that liquid crude oil contains C₉₊ hydrocarbons).

84. Similarly, Aycaguer explains that its produced gas recycling plant separates an incoming hydrocarbon stream into natural gas liquids (NGLs) and a CO₂ stream. EX1005 at FIG. 1, 305 (explaining that the stream contains “water, hydrogen sulfide –H₂S, CO₂, CH₄ [i.e., methane], natural gas liquids”). A POSITA reading Aycaguer would have thus understood that: (i) the natural gas liquids and the CO₂ were a part of the stream entering the recycling plant; and (ii) those

components were ultimately derived from the hydrocarbon feed stream that came from the oil and gas reservoir.

85. Based on their background understanding of the technology, a POSITA would understand that “natural gas liquids” is a term that includes C_3 – C_8 hydrocarbons. See, e.g., *supra* at ¶¶ 34-36; EX1004 at 5:44-45. A POSITA reading Aycaguer would have thus understood, and at the very least found it obvious, that the “natural gas liquids” disclosed by Aycaguer include the entire range of C_3 – C_8 —and not just a subset of C_3 – C_8 —because Aycaguer discloses a hydrocarbon feed stream from an oil and natural gas reservoir that contains methane (C_1), natural gas liquids, and crude oil (C_{9+}). Hydrocarbon feed streams from oil and natural gas reservoirs naturally contain all the hydrocarbons within the full range between the lightest produced hydrocarbon and the heaviest produced hydrocarbon; underground oil reservoirs do not “skip” members of the homologous series of alkane hydrocarbons. EX1005 at 305 (explaining that the hydrocarbons derived from the reservoir include methane, natural gas liquids, and crude oil). A *homologous series* is a sequence of compounds with the same functional group and similar chemical properties. Members of the alkane or paraffin homologous series are straight-chained hydrocarbons of the general formula C_nH_{2n+2} ($n \geq 1$). EX1019 at 86. Oil reservoirs do not “skip” members of the homologous series due to how hydrocarbons are formed underground. Hydrocarbons start as large molecules (C_{9+}), and slowly

break down over time to form smaller and smaller molecules. *See e.g.*, EX1018 at 572–73. Thus, the presence of both C₁ and C₉₊ would indicate to a POSITA that the heavy hydrocarbon breakdown hadn't finished yet, and all the intermediate breakdown products (C₂-C₈) are also present in the formation. Thus, a POSITA would have understood a reference describing an oil and natural gas reservoir feed stream that contains methane (C₁), natural gas liquids, and crude oil (C₉₊) to disclose a reservoir that contains some amount of every hydrocarbon between C₁ and C₉₊. If a reference disclosed an oil and natural gas reservoir that did unusually skip a particular hydrocarbon (e.g., a reservoir without C₅), a POSITA would have expected the reference to explicitly indicate that. Because Aycaguer discloses a hydrocarbon feed stream from an oil and natural gas reservoir that contains methane (C₁), natural gas liquids, and crude oil (C₉₊), and because Aycaguer does not explicitly state that its feed stream only contains a subset of C₃-C₈, a POSITA reading Aycaguer would have understood, and at the very least found it obvious, that the hydrocarbon feed stream of Aycaguer includes C₃-C₈. Moreover, this understanding of a POSITA that “natural gas liquids” include C₃-C₈ is confirmed by other prior art. *See, e.g.*, EX1004 at 4:41-46.

86. Furthermore, to the extent that the Patent Owner incorrectly disputes any of the above, the '332 Patent includes admissions about the prior art confirming that a POSITA would have understood that the hydrocarbon feed stream of Aycaguer

to include C₃-C₉₊. As explained by the admissions, the term “Natural Gas Liquids” was a term known in the art to “include C₃-C₈ hydrocarbons.” EX1001 at 3:4-8. As further explained by the admissions, a POSITA would have also understood that “liquid crude oil” comprises “C₉₊ hydrocarbons.” EX1001 at 3:11-13. Thus, a POSITA would have understood, and at the least found it obvious, that the stream produced from the oil and gas reservoir in Aycaguer, which is subsequently split into crude oil (C₉₊) and a gas stream containing NGLs (C₃-C₈), CO₂, and H₂S, included C₃-C₉₊ hydrocarbons.

87. At the very least, a POSITA would have found it obvious to apply the oil and gas processing methods taught in Aycaguer on a feed stream from a reservoir containing each of C₃-C₈. A POSITA would have been motivated to apply the Aycaguer method to a stream containing all components C₃-C₈ because that would allow the system to work as intended to remove the crude oil (C₉₊), and maximize NGLs (C₃-C₈) for recovery. Such a POSITA would have expected the separation steps taught in Aycaguer to successfully result in a separation of such a feed stream due to the well-known and predictable nature of the distillation and processing steps employed.

88. Finally, Aycaguer also teaches that its separation process includes the removal of H₂S from the natural gas liquids to pass safety requirements. EX1005 at 305. Because those natural gas liquids were derived from the hydrocarbon feed

stream, a POSITA would have understood that Aycaguer teaches a hydrocarbon feed stream containing H₂S, which is an acid gas. EX1005 at 305; EX1001 at 5:18–19.

89. Aycaguer thus teaches “receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C₃-C₈ hydrocarbons, and wherein the heavy hydrocarbons comprise C₉₊ hydrocarbons.”

c. “separating the hydrocarbon feed stream into a heavy hydrocarbon rich stream and a carbon dioxide recycle stream, wherein the heavy hydrocarbon rich stream comprises the C₉₊ hydrocarbons, and wherein the carbon dioxide recycle stream comprises the carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas” [1.2]

90. As discussed for claim element [1.1], the hydrocarbon stream released by the oil and gas reservoir described in Aycaguer teaches the claimed “hydrocarbon feed stream.” *Supra* § X.A.1.b. As shown below, the process described by Aycaguer discloses separating the hydrocarbon stream released by the oil and gas reservoir (“hydrocarbon feed stream”) into a “Crude Oil” stream (“heavy hydrocarbon rich stream”) and a stream sent to a Produced Gas Recycling Plant (“carbon dioxide recycle stream”):

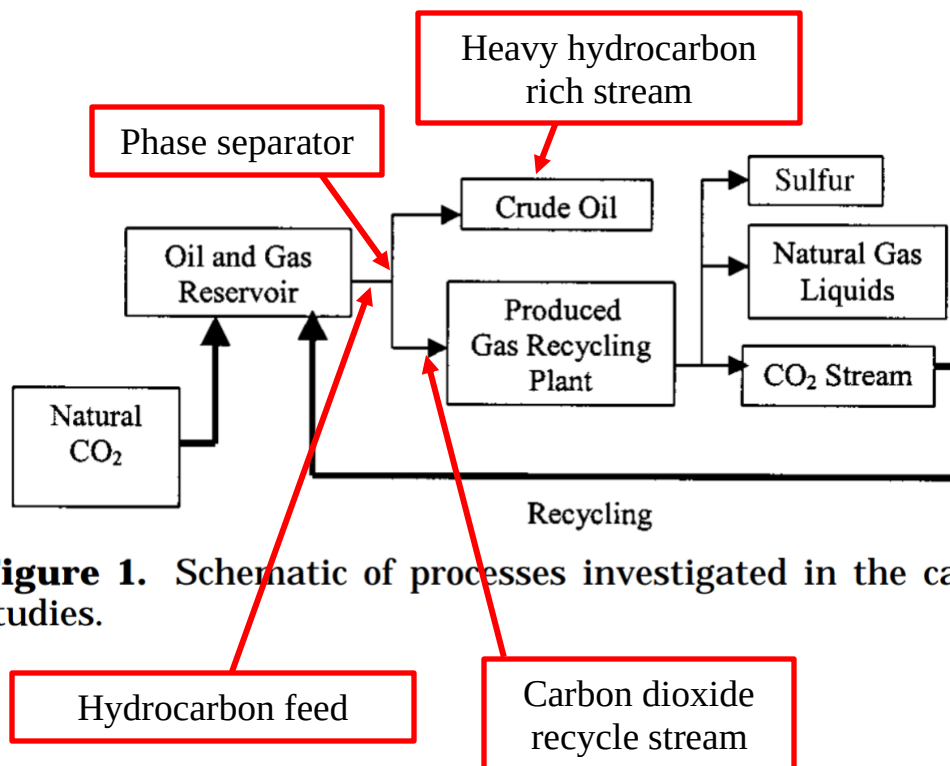


Figure 1. Schematic of processes investigated in the case studies.

EX1005 at 305, FIG. 1 (annotations in red).

91. As explained in Aycaguer, this separation is “a simple process assisted by heat, chemicals, and retention time in the vessels and relies on phase separation.” EX1005 at 305.

92. The liquid phase resulting from Aycaguer’s phase separation includes the “crude oil for sale.” EX1005 at 305. As discussed above for claim element [1.1], a POSITA reading Aycaguer as of the Priority Date would have understood the term “crude oil” to mean a composition with C₉₊ hydrocarbons. *See supra*, ¶¶ 34-36, § X.A.1.b; EX1004 at 5:44-45. Thus, crude oil resulting from the liquid phase of the

phase separator teaches the claimed “heavy hydrocarbon rich stream compris[ing] the C₉₊ hydrocarbons.”

93. Additionally, the ’332 Patent admissions regarding the prior art confirm that Aycaguer teaches the claimed heavy hydrocarbon rich stream. As admitted in the ’332 Patent, a POSITA would have understood—prior to the filing of the ’332 Patent—that liquid crude oil contains C₉₊. EX1001 at 3:9-10. Because, based on the admissions, a POSITA would have understood that the crude oil removed in the liquid phase of Aycaguer is made of C₉₊ hydrocarbons a POSITA would have understood that Aycaguer teaches separating the claimed “heavy hydrocarbon rich stream compris[ing] the C₉₊ hydrocarbons” from a hydrocarbon feed stream. EX1005 at 305, FIG. 1.

94. The gas phase resulting from the phase separation in Aycaguer is sent to the produced gas recycling plant. EX1005 at 305, FIG. 1. Aycaguer explains that this gas phase must be processed to separate the natural gas liquids in the stream from the hydrogen sulfide and carbon dioxide. EX1005 at 305, FIG. 1. Aycaguer thus teaches that the gas phase entering the recycling plant includes natural gas liquids, carbon dioxide, and hydrogen sulfide. EX1005 at 305, FIG. 1. Natural gas liquids are those hydrocarbons capable of being liquified at room temperatures, and are referred to as “natural gas *liquids*” even when they exist in the vapor phase. *See, e.g.*, EX1005 at 305 (disclosing that the NGLs are removed in the gas phase);

EX1001 at 3:5-6 (explaining that a POSITA have understood that NGLs are “natural gases that may be liquefied without refrigeration”); EX1004 at 5:44-45 (explaining “natural gas liquids (C₃-C₈)”).

95. As discussed above in § X.A.1.b, a POSITA reading Aycaguer as of the priority date would have understood that the term “natural gas liquids”—as used in Aycaguer—refers to a composition with at least C₃-C₈ hydrocarbons. *Supra* ¶¶ 34-36; EX1004 at 5:44-45. Because the term “natural gas liquids” as used in Aycaguer refers to C₃-C₈ hydrocarbons, and because hydrogen sulfide is an acid gas, the stream entering into the produced gas recycling plant that contains natural gas liquids, carbon dioxide, and hydrogen sulfide teaches the claimed “carbon dioxide recycle stream compris[ing] carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas.”

96. A POSITA reading Aycaguer would have additionally understood that the natural gas liquids found in the gas phase entering the gas processing plant would include at least C₃-C₈ based on their understanding of how Aycaguer’s phase separation works. EX1005 at 305. Aycaguer’s phase separation—which primarily uses time and temperature to separate out the heavy hydrocarbons—is imperfect; a phase separation designed to separate, for example, C₅- into the gas phase and C₆+ into the liquid phase would include some C₆+ in the gas phase and some C₅- in the liquid phase. *See supra*, at ¶¶ 37-38. Thus, a POSITA would have understood that

performing Aycaguer's phase separation on a hydrocarbon feed stream to remove some NGLs in the liquid phase along with the crude oil—e.g., the NGLs used to make gasoline like C₆, C₇, and C₈—would still result in a gas phase that contains at least some C₆, C₇ and C₈. A POSITA would have thus understood—and certainly have found obvious—that the gas phase disclosed by Aycaguer (i.e., the carbon dioxide recycle stream) contains C₃-C₈.

97. Aycaguer's disclosure additionally teaches that the stream entering into the produced gas recycling plant teaches the claimed "carbon dioxide recycle stream compris[ing] carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas" based on the admissions in the '332 Patent regarding the prior art. As discussed above in for claim element [1.1], the '332 Patent states that the term "NGL" was well known in the art and is used in the '332 Patent as such. *Supra* § X.A.1.b; EX1001 at 3:7-8. The '332 Patent further explains that NGL "may refer to natural gases that may be liquified without refrigeration, and may include the C₃-C₈ hydrocarbons." *Id.* at 3:4-7. This admitted understanding in the '332 Patent is consistent with my understanding of the art as of the Priority Date. *Supra* § X.A.1.b. Based on the admissions, a POSITA reading Aycaguer would therefore have understood, and would have at least found it obvious, that when Aycaguer teaches that the stream entering into the produced recycling plant contains NGL, that stream includes at least the C₃-C₈ hydrocarbons. At the very least, for the reasons described for claim

element [1.1], a POSITA would have found it obvious to apply Aycaguer's separation methods to a stream containing each of C₃-C₈. *See supra* § X.A.1.b.

98. Thus, Aycaguer teaches “separating the hydrocarbon feed stream into a heavy hydrocarbon rich stream and a carbon dioxide recycle stream,” as claimed.

d. “separating the carbon dioxide recycle stream into a sour NGL rich stream and a purified carbon dioxide recycle stream, wherein the sour NGL rich stream comprises the C3-C8 hydrocarbons and the acid gas, and wherein the purified carbon dioxide recycle stream comprises the carbon dioxide; and,” [1.3]

99. As discussed for claim element [1.2], the gas phase resulting from the phase separation of Aycaguer teaches the claimed “carbon dioxide recycle stream.” *Supra* § X.A.1.c. Aycaguer explains this stream is “directed to the gas processing plant.” EX1005 at 305, FIG. 1. Aycaguer then discloses that the gas processing plant may use the “Ryan/Holmes process.” EX1005 at 305, FIG. 1.

100. Aycaguer teaches that the Ryan/Holmes process performed by the gas processing plant is “highly compound-specific and will only separate CO₂ from the remaining gas stream.” EX1005 at 305, FIG. 1. Because—as discussed for claim element [1.2]—a carbon dioxide recycling stream with C₃-C₈ hydrocarbons, CO₂, and H₂S, is directed into the gas processing plant, Aycaguer thus teaches separating the CO₂ from a carbon dioxide recycle stream, resulting in one stream containing CO₂ and a second stream containing C₃-C₈ hydrocarbons and H₂S. EX1005 at 305, FIG. 1. Aycaguer further explains that the H₂S must be removed from the natural

gas liquids after the CO₂ is removed, confirming that the second stream contains both the C₃–C₈ hydrocarbons and H₂S. EX1005 at 305 (“To separate H₂S from the natural gas liquids . . .”).

101. The first stream with CO₂ thus teaches the claimed “purified carbon dioxide recycle stream . . . compris[ing] the carbon dioxide.” The second stream with C₃–C₈ hydrocarbons and H₂S thus teaches the claimed “sour NGL rich stream compris[ing] . . . the C₃–C₈ hydrocarbons and the acid gas.”:

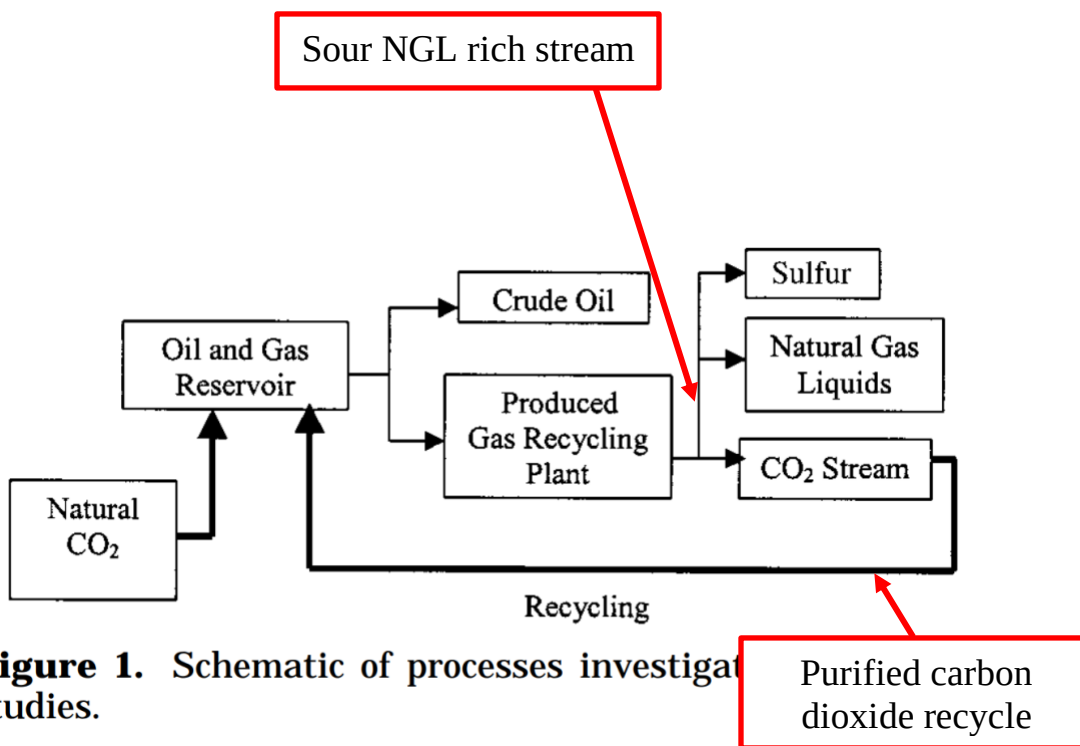


Figure 1. Schematic of processes investigated in the studies.

EX1005 at FIG. 1 (annotated).

102. Aycaguer therefore teaches “separating the carbon dioxide recycle stream into a sour NGL rich stream and a purified carbon dioxide recycle stream,

wherein the sour NGL rich stream comprises the C₃-C₈ hydrocarbons and the acid gas, and wherein the purified carbon dioxide recycle stream comprises the carbon dioxide.”

e. “separating the sour NGL rich stream into a sweet NGL rich stream and an acid gas stream, wherein the sweet NGL rich stream comprises the C₃-C₈ hydrocarbons, and wherein the acid gas stream comprises the acid gas,” [1.4]

103. As discussed for claim element [1.3], Aycaguer teaches that applying the Ryan/Holmes process to a carbon dioxide recycle stream results in a sour NGL rich stream that includes C₃–C₈ hydrocarbons and H₂S. *Supra* § X.A.1.d.

104. Aycaguer further teaches that the gas processing plant uses a “nonselective chemical absorption amine process” to “separate H₂S from the natural gas liquids.” EX1005 at 305, FIG. 1. H₂S is an acid gas, as acknowledged in the ‘332 Patent (*see, e.g.*, EX1001 at 5:15-19). This separation of H₂S results in a sweet natural gas liquids stream described in Figure 1:

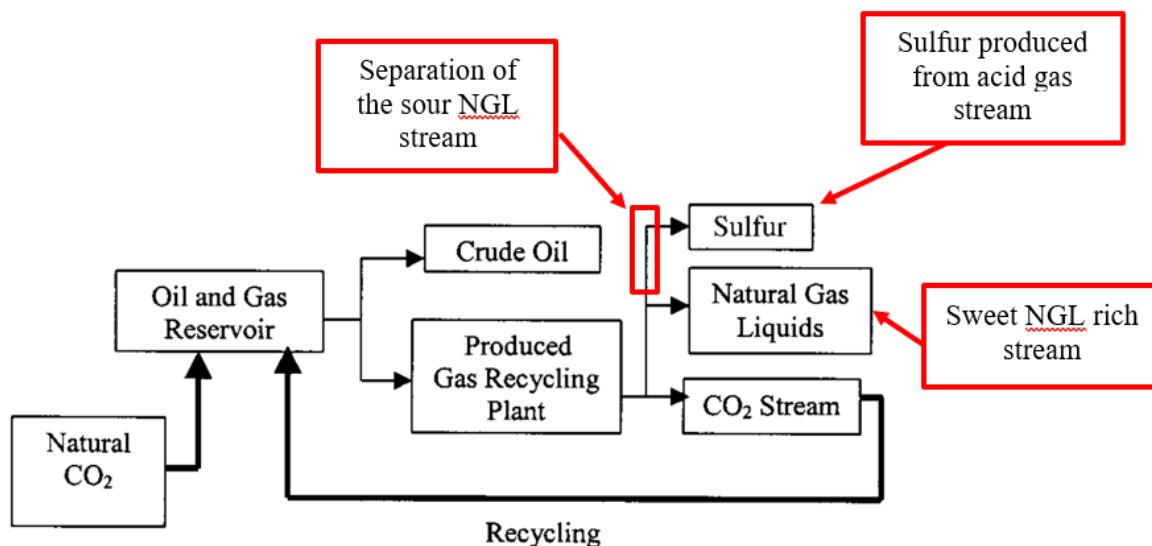


Figure 1. Schematic of processes investigated in the case studies.

EX1005 at 305, FIG. 1 (annotated).

105. The natural gas liquids stream includes the C₃–C₈ originally found in the sour NGL stream. EX1005 at FIG. 1. The H₂S is removed to “pass safety requirements.” EX1005 at 305. An NGL stream with H₂S removed from it was known in the art as a sweet NGL stream. *See supra* at ¶ 42. The sweet NGL stream produced after the H₂S is removed thus teaches the claimed “sweet NGL rich stream.”

106. According to Aycaguer, the H₂S is absorbed into an amine solution before being “transformed into elemental sulfur or incinerated.” EX1005 at 305. This stream of amine/H₂S solution thus teaches the claimed “acid gas stream.”

107. Aycaguer therefore teaches “separating the sour NGL rich stream into a sweet NGL rich stream and an acid gas stream, wherein the sweet NGL rich stream

comprises the C₃-C₈ hydrocarbons, and wherein the acid gas stream comprises the acid gas.”

f. “wherein the carbon dioxide is not removed from the hydrocarbon feed stream and is not removed from the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream, and” [1.5]

108. Aycaguer discloses no steps that remove CO₂ before the carbon dioxide recycle stream is processed using the Ryan/Holmes process:

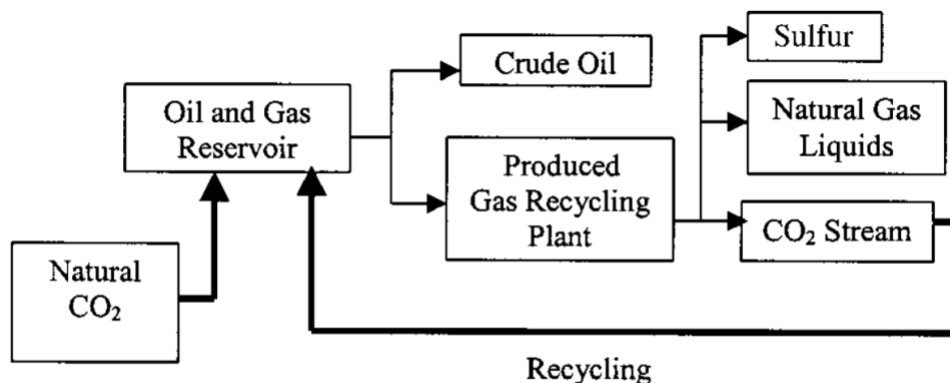


Figure 1. Schematic of processes investigated in the case studies.

See EX1005 at 305, FIG. 1.

109. Aycaguer thus teaches a method “wherein the carbon dioxide is not removed from the hydrocarbon feed stream and is not removed from the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream.”

g. “wherein the hydrocarbon feed stream, the carbon dioxide recycle stream, and the sour NGL rich stream are not subjected to cryogenic conditions, membranes, and carbon dioxide recovery solvents between being received and being separated into the heavy hydrocarbon rich stream, the purified carbon dioxide recycle stream, the sweet NGL rich stream, and the acid gas stream.” [1.6]

110. Aycaguer does not disclose the use of cryogenic conditions, membranes, or carbon dioxide recovery solvents being used at any step. While Aycaguer discloses the use of amine solution to recover the hydrogen sulfide, the amine solution is used only after the CO₂ is removed using the Ryan/Holmes process, and thus is not used to remove CO₂. See EX1005 at 305; EX1011 at 80 (explaining that under the Patent Owner’s understanding of the term “carbon dioxide recovery solvent,” the solvent must be “for carbon dioxide recovery”—and not for another purpose (for example, “dehydrating the stream”)—to qualify as a carbon dioxide recovery solvent. I understand that the Petitioners do not necessarily endorse Patent Owner’s understanding, but I am applying the Patent Owner’s interpretation for the purposes of this ground.

111. The Ryan/Holmes process also does not use cryogenic conditions, membranes, or carbon dioxide recovery solvents. Ryan—which is one of two references cited by Aycaguer to describe the Ryan/Holmes process and evidences a POSITA’s knowledge at the relevant time—expressly distinguishes its process from those using “solvent[s] having CO₂ affinity” or “[m]embrane schemes.” EX1007 at

55. As to cryogenic conditions, Ryan explains that even the coldest temperature for its distillation columns is “–40 to –120 °F,” which does not meet either the NIST definition or Patent Owner’s understanding of the term “cryogenic.” *Compare* EX1011 at 8–9 & n.2 (proposing a “well-accepted meaning of ‘cryogenic conditions’” as –130° F) *with* EX1007 at 55. I understand that the Petitioners also do not necessarily endorse Patent Owner’s understanding, but I am applying the Patent Owner’s interpretation for purposes of this Petition. I note that the National Institute for Standards and Technology defines “cryogenic” as –153 °C (i.e., –243 °F), as that is when the permanent gases begin to liquify. *See* EX1017. Similarly, the other Ryan/Holmes publication cited to by Aycaguer—Holmes—explains that satisfactory results were “obtained using ethylene refrigeration in the overhead condenser (temperatures –110 to –130°F) and also using only propane refrigeration (–30 to –40°F).” EX1010 at 81 (emphasis added). The two pilot systems described in Holmes were operated at –120 °F and –35 °F. *Id.* at 82-83. As such, a POSITA would not have understood either Ryan or Holmes as subjecting its streams to “cryogenic” conditions, as understood by the Patent Owner or NIST definition.

112. Aycaguer thus teaches a method “wherein the hydrocarbon feed stream, the carbon dioxide recycle stream, and the sour NGL rich stream are not subjected to cryogenic conditions, membranes, and carbon dioxide recovery solvents between being received and being separated into the heavy hydrocarbon rich stream, the

purified carbon dioxide recycle stream, the sweet NGL rich stream, and the acid gas stream.”

B. Ground 2: Claim 1 is Obvious Over Aycaguer in Combination with Arand

113. In my opinion, Aycaguer in combination with Arand renders obvious Claim 1 of the ’332 Patent.

1. Motivation to Combine the References

114. Ground 2 combines Aycaguer and Arand. As explained below, Arand teaches a method of processing fluids produced from oil and gas reservoirs to yield a natural gas liquid stream, a residue gas stream, and a stabilized condensate stream. EX1004 at 1:6–13. A POSITA would have been motivated to combine Aycaguer and Arand, and would have had a reasonable expectation of success in doing so, because both references relate to methods of natural gas liquid separation, and for the additional reasons below. EX1005 at 305; EX1004 at 1:6–13.

115. Aycaguer teaches that heavy hydrocarbons, such as the crude oil, should be separated from a hydrocarbon feed stream derived from the oil well before further processing. EX1005 at 305. Aycaguer also teaches that natural gas liquids are a valuable product of oil and gas wells. *Id.* However, Aycaguer does not explicitly disclose the particular hydrocarbons that would be found in the components of natural gas liquids or heavy hydrocarbons.

116. Arand provides such teachings. Arand teaches that natural gas liquids are hydrocarbons that have between three and eight carbon atoms (C_{3-8}). EX1004 at 5:44-45. Arand also teaches that heavy hydrocarbons contain nine or more carbon atoms (C_{9+}). EX1004 at 5:44-45.

117. Thus, a POSITA would have been motivated to implement Aycaguer's Produced Gas Recycling Plant using the understanding of natural gas liquids and heavy hydrocarbons found in Arand to identify the constituent hydrocarbons in the mixtures that would result from the separations performed by Aycaguer.

2. Claim 1

a. Claim elements [1.P], [1.3], [1.4], [1.5], and [1.6].

118. As I explained above for Ground 1, Aycaguer teaches limitations [1.P], [1.3], [1.4], [1.5], and [1.6]. *Supra* §§ X.A.1.a, X.A.1.c–X.A.1.g.

b. “receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C3-C8 hydrocarbons, and wherein the heavy hydrocarbons comprise C9+ hydrocarbons” [1.1]

119. As I explained above for claim element [1.1], Aycaguer teaches this limitation. *Supra* § X.A.1.b. But, to the extent that the Patent Owner disputes that either (i) a POSITA as of the Priority Date would have understood that Aycaguer discloses a hydrocarbon feed stream that includes C_3 - C_{9+} or (ii) a POSITA as of the

Priority Date would have understood that Aycaguer discloses a hydrocarbon feed stream that includes C₃-C₉₊, Arand provides such understanding.

120. As I explained above for claim element [1.1], Aycaguer teaches that the hydrocarbon feed stream includes liquid crude oil, which is separated from the NGLs, CO₂, and H₂S (which are gases that are then processed in the gas plant). *Supra* § X.A.1.b. A POSITA would have understood that the crude oil is the heavy condensate of this separation because the NGLs, CO₂, and H₂S are gases that are lighter than the heavier crude oil. Arand discloses that such heavy condensate includes C₉₊. EX1004 at 5:45. The combination of Aycaguer and Arand thus teaches that Aycaguer's hydrocarbon feed stream includes C₉₊.

121. As I explained above for claim element [1.1], Aycaguer also teaches that its hydrocarbon feed stream includes natural gas liquids. *Supra* at § X.A.1.b. Arand discloses that natural gas liquids include C₃-C₈. EX1004 at 5:44-45. The combination of Aycaguer and Arand thus teaches that Aycaguer's hydrocarbon feed stream includes C₃-C₈. At the very least, a POSITA would have found it obvious to apply the oil and gas processing methods taught in Aycaguer on a feed stream from a reservoir containing C₃-C₈ as expressly taught in Arand. A POSITA would have been motivated to apply the Aycaguer method to a feed stream containing each of C₃-C₈, as taught in Arand, because that would allow the Aycaguer system to work as intended to remove the crude oil (C₉₊), and maximize NGLs (C₃-C₈) for recovery.

Such a POSITA would have expected the separation steps taught in Aycaguer to successfully result in a separation of such a feed stream due to the well-known and predictable nature of the distillation and processing steps employed, and thus the combination of Aycaguer and Arand renders obvious receiving such a stream.

122. The combination of Aycaguer and Arand therefore teaches “receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C₃-C₈ hydrocarbons, and wherein the heavy hydrocarbons comprise C₉₊ hydrocarbons.”

c. “separating the hydrocarbon feed stream into a heavy hydrocarbon rich stream and a carbon dioxide recycle stream, wherein the heavy hydrocarbon rich stream comprises the C₉₊ hydrocarbons, and wherein the carbon dioxide recycle stream comprises the carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas” [1.2]

123. The combination of Aycaguer and Arand teaches this limitation. As discussed above for claim element [1.2], Aycaguer teaches a feed stream from an oil and gas reservoir (“hydrocarbon feed stream”) that is received for processing, and that the feed stream is separated using a phase separator into a stream sent to a Produced Gas Recycling Plant (“carbon dioxide recycle stream”) and a “Crude Oil” stream (“heavy hydrocarbon rich stream”). *Supra* § X.A.1.c.

124. But, to the extent that the Patent Owner incorrectly disputes that (i) a POSITA as of the Priority Date would have understood that Aycaguer discloses a

hydrocarbon feed stream that includes C₃-C₉₊, (ii) a POSITA as of the Priority Date would have understood that Aycaguer discloses a carbon dioxide recycle stream that includes C₃-C₈, or (iii) a POSITA as of the Priority Date would have understood that Aycaguer discloses a heavy hydrocarbon rich stream that includes C₉₊, Arand provides such understanding.

125. As I explained above for claim element [1.1], Aycaguer teaches that the hydrocarbon feed stream includes liquid crude oil, which is separated from the NGLs, CO₂, and H₂S. *Supra* § X.A.1.b. As understood by a POSITA, crude oil is the heavy condensate of this separation, as the NGLs, CO₂, and H₂S are gases that are lighter than the heavier crude oil. *Supra* § VI. Arand discloses that such heavy condensate includes C₉₊. EX1004 at 5:45. The combination of Aycaguer and Arand thus teaches that Aycaguer's crude oil stream includes the C₉₊, and thus teaches the claimed heavy hydrocarbon rich stream separated from the hydrocarbon feed stream.

126. As I explained above for claim element [1.2], Aycaguer also teaches separating the hydrocarbon feed stream into a carbon dioxide recycle stream that contains natural gas liquids. *Supra* at § X.A.1.c. Arand discloses that natural gas liquids range from C₃-C₈. EX1004 at 5:44-45. The combination of Aycaguer and Arand thus teaches that Aycaguer's carbon dioxide recycle stream contains C₃-C₈ hydrocarbons, and thus teaches the claimed carbon dioxide recycle stream. At the very least, for the reasons described for claim element [1.1], a POSITA would have

found it obvious to apply Aycaguer's separation methods to a stream containing each of C₃-C₈ as expressly taught in Arand. *See supra* §X.B.2.b.

127. The combination of Aycaguer and Arand therefore teaches "separating the hydrocarbon feed stream into a heavy hydrocarbon rich stream and a carbon dioxide recycle stream, wherein the heavy hydrocarbon rich stream comprises the C₉₊ hydrocarbons, and wherein the carbon dioxide recycle stream comprises the carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas."

C. Ground 3: Claims 1-4, 6, and 7 are Obvious Over Aycaguer in Combination with Soldati

1. Motivation to Combine Aycaguer and Soldati

128. Ground 3 combines Aycaguer with Soldati such that the fractionation process/plant of Soldati is used to implement the gas processing plant (i.e., the "Produced Gas Recycling Plant" of Figure 1) in Aycaguer, where the natural gas liquids, CO₂, and H₂S described as outputs of that plant in Aycaguer are the outputs of the Soldati fractionation process/plant.

129. A POSITA would have been motivated to combine Aycaguer with Soldati, and would have a reasonable expectation of success in doing so, because both references relate to methods of processing natural gas liquid streams, and for the reasons discussed below. EX1005 at 305; EX1006 at 1:59-66.

130. Aycaguer explains that oil and associated gas derived from subterranean formations must be processed for sale. EX1005 at 305, Figure 1. It

further discloses that the crude oil is separated from the gases as the first step of this processing. *Id.* (“The liquid phase undergoes further separation to recover the crude oil for sale, while the gas phase is directed to the gas processing plant.”) Aycaguer explains that the gas phase is processed in a plant to separate its constituent natural gas liquids, CO₂, and H₂S. Aycaguer discloses already-known processes that could be used to perform that separation. *Id.* (describing the “Ryan/Holmes process” as a method of gas processing and citing to 1982 and 1984 articles outlining the Ryan/Holmes process).

131. Soldati teaches variations of and improvements on the Ryan/Holmes process, which it describes as being used to separate the different components of natural gas liquid mixtures. EX1006 at 1:6-58. The Ryan/Holmes variations disclosed by Soldati further include a sweetening step adapted for use in its process, in which hydrogen sulfide is removed from the natural gas liquid stream through distillation. *See* EX1006 at FIG. 4 (showing column 21, which sweetens the sour NGL stream 17).

132. I understand that a POSITA may be motivated to combine prior art references when the prior art teaches, suggests, or motivates the combination. *See supra*, § IV. Because Aycaguer instructs the reader to use a Ryan/Holmes process, and because Soldati teaches a version of the Ryan/Holmes process, Aycaguer provides an explicit teaching, suggestion, or motivation to combine Aycaguer with

Soldati. *Compare* EX1005 at 305 (“The separation of CO₂ from hydrocarbons and H₂S can be achieved by using the Ryan/Holmes process.”), *with* EX1006 at 8:52–53 (“The process flow diagram of the known art is shown in FIG. 4.”).

133. I also understand that a POSITA may be motivated to combine prior art references when the combination would be a simple substitution of one known element for another to obtain predictable results. *See supra*, § IV. The combination of the system of Aycaguer with the processes of Soldati is a simple substitution of one known element for another to obtain predictable results. Aycaguer generally describes the use of a Ryan/Holmes process to process a natural gas stream into natural gas liquids and carbon dioxide. EX1005 at 305. Soldati discloses a known Ryan/Holmes method to process a natural gas stream into natural gas liquids and carbon dioxide. EX1006 at 1:6-13. A POSITA would have understood that the method of Soldati when applied to the natural gas streams disclosed in Aycaguer would predictably result in the processing of that natural gas stream as described in Soldati and would have had a reasonable expectation of success in doing so.

134. Thus, a POSITA would have been motivated to implement Aycaguer’s Produced Gas Recycling Plant using the natural gas liquid processing methods described by Soldati. This straightforward modification of Aycaguer’s oil and natural gas processing system uses a known process (e.g., the processing steps described in Soldati) to improve a similar system (e.g., the gas processing plant

described in Aycaguer) in the same way (using the Ryan/Holmes process, which is the process used by the gas processing plant in Aycaguer).

2. Claim 1

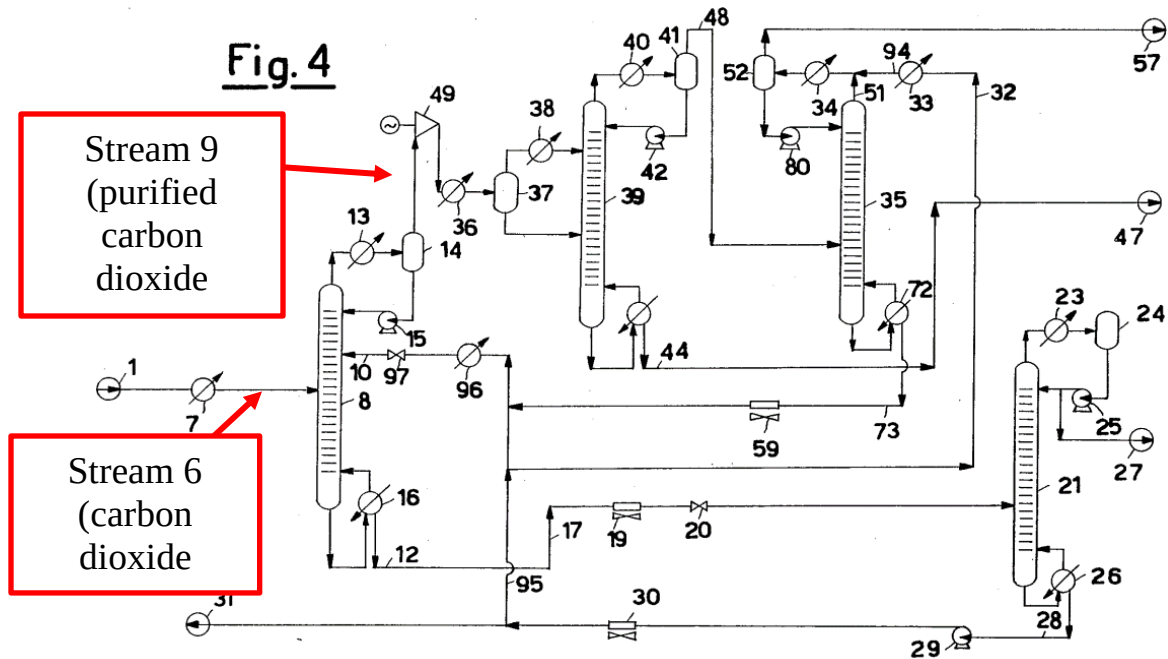
a. Claim elements [1.P], [1.1], and [1.2]

135. As explained above for Ground 1, Aycaguer teaches limitations [1.P], [1.1] and [1.2]. *Supra* §§ X.A.1.a–X.A.1.c.

b. “separating the carbon dioxide recycle stream into a sour NGL rich stream and a purified carbon dioxide recycle stream, wherein the sour NGL rich stream comprises the C3-C8 hydrocarbons and the acid gas, and wherein the purified carbon dioxide recycle stream comprises the carbon dioxide; and,” [1.3]

136. As discussed above for claim element [1.2], the phase separation described in Aycaguer results in (i) a crude oil stream (the heavy hydrocarbon stream) and (ii) a carbon dioxide recycle stream that includes C₃-C₈, CO₂, and H₂S, the latter of which Aycaguer discloses as being sent to a gas processing plant. *Supra* §§ X.A.1.c.

137. In combination with Soldati, a POSITA would have implemented Aycaguer’s gas processing plant (the “Produced Gas Recycling Plant” of its Figure 1) using the gas processing method disclosed in Soldati. Thus, the carbon dioxide recycle stream of Aycaguer containing C₃-C₈, CO₂, and H₂S would enter into the process described in Fig. 4 of Soldati as stream 1, before being compressed and cooled to become stream 6:



EX1006 at FIG. 4. While streams 6 and 9 are not labeled in FIG. 4, a POSITA reading the specification would have understood that the two indicated positions in the annotated figure are streams 6 and 9. Comparing to FIGs. 1 and 3 confirms this understanding, as does Table III, which describes the flow through streams 6 and 9 for the embodiment described in FIG. 4. See EX1006 at 9:6-7 (describing the Fig. 4 process and explaining the “other reference numerals in the figure have the same meaning as on the preceding diagrams”); FIGs. 1, 3, Table III.

138. Soldati teaches that stream 6 enters column 8. EX1006 at FIG. 4. As shown in Figure 4, stream 6 is separated in column 8 into an upper stream 9 and a lower stream 12. EX1006 at FIG. 4. Soldati teaches that upper stream 9 exits separator 14. EX1006 at FIG. 4.

139. Soldati teaches that stream 9 includes CO₂ that was in stream 6:

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	−13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at Table III. Stream 9 has more CO₂ flowing through it than enters into column 8 through stream 6. EX1006 at Table III. This is due to the fact that column 8 is fed by the products of streams 9 and 12, causing a recirculation through the system at stream 10. *See, e.g.*, EX1006 at FIG. 4.

140. A POSITA would have thus understood that running the carbon dioxide recycling stream of Aycaguer through column 8 of Soldati would result in stream 9 containing CO₂. This stream 9 thus teaches the claimed “purified carbon dioxide recycle stream . . . compris[ing] the carbon dioxide.”

141. Soldati also teaches that stream 9 undergoes further processing, and eventually becomes stream 44. EX1006 at FIG. 4, 5:8–13. Stream 44 contains CO₂ from stream 9, and is therefore merely a further-purified version of the purified carbon dioxide stream (stream 9):

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	48	44	73
NITROGEN	16.45	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	47.78	1162.50	46.61
METHANE	64.56	—	7.02
ETHANE	10.56	8.86	10.57
PROPANE	—	1.12	1.17
N-BUTANE	—	0.87	107.65
N-PENTANE	—	—	32.47
HEXANE	—	—	8.02

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at FIG. 4, Table III.

142. Stream 44 was separated from the carbon dioxide recycle stream using columns 8 and 39, and is therefore a claimed purified carbon dioxide recycle stream. According to the '332 Patent, purification of a stream does not change its character. For example, dehydration of the carbon dioxide recycle stream yields the same carbon dioxide recycle stream, despite its composition changing. See EX1001 at Claim 8 (claiming “dehydrating” a carbon dioxide recycle stream “prior to separating the carbon dioxide recycle stream.”). Furthermore, there is nothing in

Claim 1 that prevents the claimed separation from occurring in multiple steps (i.e., using both columns 8 and 39).

143. Soldati explains that stream 12 contains “ethane and higher hydrocarbons.” EX1006 at 7:36-40. A POSITA would have thus understood that running the carbon dioxide recycling stream of Aycaguer (which contains C₃-C₈) through column 8 of Soldati would result in a bottoms stream 12 containing at least C₃-C₈ (because ethane is C₂H₆ and thus heavier hydrocarbons are C₃₊). *See supra* at ¶ 32. At the very least, for the reasons described for claim element [1.1] for Ground 1, a POSITA would have found it obvious to apply Aycuguer’s separation methods to a stream containing each of C₃-C₈. *See supra* § X.A.1.b. A POSITA would have expected the separation of such a stream to occur in a similar fashion and with similar proportions as taught in Soldati due to the predictable nature of the distillation methods taught in Soldati.

144. Soldati also explains that column 8 only partially separates the H₂S, and thus stream 12 is contaminated with hydrogen sulfide:

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	<u>0.03</u>	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	−13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

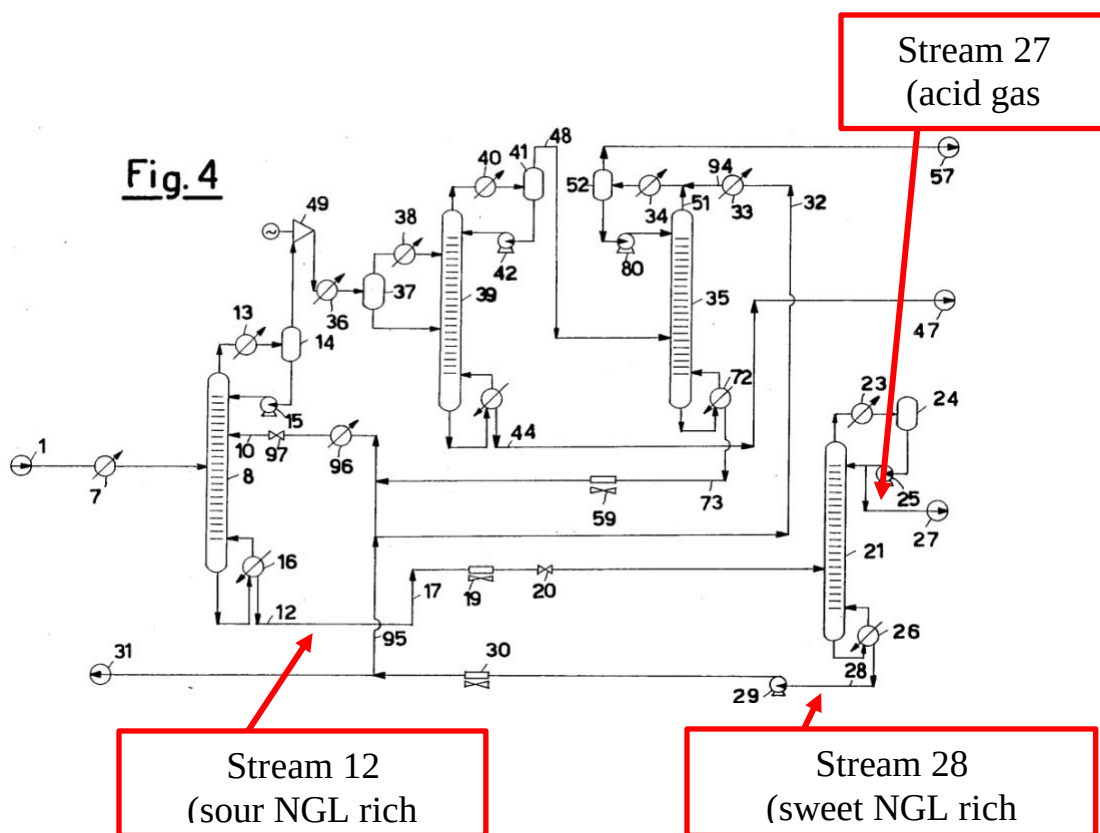
EX1006 at Table III (hydrogen sulfide concentration underlined in red). More H₂S leaves column 8 than enters it through stream 6. EX1006 at Table III. This is due to the fact that column 8 is fed by the products of streams 9 and 12, causing a recirculation through the system at stream 10. *See, e.g.*, EX1006 at FIG. 4.

145. A POSITA would have thus understood that running the carbon dioxide recycle stream of Aycaguer through column 8 of Soldati would result in a stream 12 containing C₃-C₈ and H₂S. Stream 12 thus teaches the claimed “sour NGL rich stream . . . compris[ing] the C₃-C₈ hydrocarbons and the acid gas.”

146. The combination therefore teaches “separating the carbon dioxide recycle stream into a sour NGL rich stream and a purified carbon dioxide recycle stream, wherein the sour NGL rich stream comprises the C₃-C₈ hydrocarbons and the acid gas, and wherein the purified carbon dioxide recycle stream comprises the carbon dioxide.”

c. “separating the sour NGL rich stream into a sweet NGL rich stream and an acid gas stream, wherein the sweet NGL rich stream comprises the C3-C8 hydrocarbons, and wherein the acid gas stream comprises the acid gas,” [1.4]

147. As discussed for claim element [1.3], the combination results in stream 12 (a sour NGL rich stream), which contains C₃-C₈ hydrocarbons and H₂S. *Supra* § X.A.1.d. Soldati teaches that stream 12 enters column 21 and is separated into streams 27 and 28:



EX1006 at FIG. 4.

148. Soldati teaches that column 21 produces a bottom product that includes “propane and heavier hydrocarbons.” EX1006 at 4:57–60. Soldati further discloses that stream 28 includes no hydrogen sulfide or carbon dioxide, as shown in Table III:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	28	10	95
NITROGEN	—	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	—	46.64	—
METHANE	—	7.03	—
ETHANE	—	10.54	—
PROPANE	12.11	11.97	12.00
N-BUTANE	1092.03	1081.98	1082.60
N-PENTANE	81.06	80.26	80.25
THROUGHPUT KMOLS/H	1513.37	1563.53	1500.00
PHASE	L	L	L
TEMPERATURE °C.	122.0	16.0	48.0
PRESSURE ATA	19.2	39.6	44.0

EX1006 at Table III (Stream 28 and amounts of hydrogen sulfide and carbon dioxide highlighted).

149. Because stream 12 contains C₃-C₈ hydrocarbons, and the bottoms product of column 21 includes the C₃₊ hydrocarbons, a POSITA would thus have understood that stream 28 would contain those C₃-C₈ hydrocarbons. Further, by removing H₂S from stream 28, column 21 sweetened this C₃-C₈ hydrocarbon stream. *See supra* ¶42. Stream 28 thus teaches the claimed “sweet NGL rich stream . . . compris[ing] the C₃-C₈ hydrocarbons.”

150. Soldati also teaches that the separation performed in column 21 “produces an overhead product (stream 27).” EX1006 at 7:41-43. According to Table III, this overhead product includes all of the hydrogen sulfide and carbon dioxide from stream 12:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	94	57	27
NITROGEN	—	16.44	—
HYDROGEN SULPHIDE	—	—	<u>0.03</u>
CARBON DIOXIDE	—	1.20	3.65
METHANE	—	57.46	—
ETHANE	—	—	32.57
PROPANE	1.20	0.03	30.51
N-BUTANE	108.25	0.65	0.67
N-PENTANE	32.52	0.05	—
HEXANE	8.03	—	—
THROUGHPUT KMOLS/H	150.00	75.83	67.43
PHASE	L	V	L
TEMPERATURE °C.	−20.0	−35.0	5.5
PRESSURE ATA	41.5	40.5	18.5

EX1006 at Table III (underlining the H₂S in stream 27).

151. Stream 27 thus teaches the claimed “acid gas stream . . . compris[ing] the acid gas.”

152. The combination thus teaches “separating the sour NGL rich stream into a sweet NGL rich stream and an acid gas stream, wherein the sweet NGL rich stream comprises the C₃-C₈ hydrocarbons, and wherein the acid gas stream comprises the acid gas.”

d. “wherein the carbon dioxide is not removed from the hydrocarbon feed stream and is not removed from the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream, and” [1.5]

153. Aycaguer discloses no steps that remove CO₂ before the carbon dioxide recycle stream enters the produced gas recycling plant for processing using the method described in Soldati. Soldati discloses no steps that remove CO₂ before the carbon dioxide recycle stream enters column 8 for separation.

154. The combination thus teaches a method “wherein the carbon dioxide is not removed from the hydrocarbon feed stream and is not removed from the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream.”

e. “wherein the hydrocarbon feed stream, the carbon dioxide recycle stream, and the sour NGL rich stream are not subjected to cryogenic conditions, membranes, and carbon dioxide recovery solvents between being received and being separated into the heavy hydrocarbon rich stream, the purified carbon dioxide recycle stream, the sweet NGL rich stream, and the acid gas stream.” [1.6]

155. Aycaguer does not disclose any cryogenic conditions, membranes, or carbon dioxide recovery solvents before the carbon dioxide recycle stream enters the produced gas recycling plant for processing using the method described in Soldati. Soldati discloses no steps that include cryogenic conditions, membranes, or carbon dioxide recovery solvents. Soldati does not even use the words “membrane” or

“solvent.” *See generally* EX1006. As to “cryogenic conditions,” the minimum temperature disclosed for the streams in Soldati in the Table III embodiment being relied upon for this Petition is -35° C, which is well above Patent Owner’s understanding of the term “cryogenic conditions” as being below -90° C EX1006 at Table III; *see supra* §X.C.2.e; EX1011 at 8-9 & n.2. The combination thus teaches a method “wherein the hydrocarbon feed stream, the carbon dioxide recycle stream, and the sour NGL rich stream are not subjected to cryogenic conditions, membranes, and carbon dioxide recovery solvents between being received and being separated into the heavy hydrocarbon rich stream, the purified carbon dioxide recycle stream, the sweet NGL rich stream, and the acid gas stream.”

3. Claim 2

a. “The method of claim 1, further comprising: compressing the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream” [2.1]

156. As explained above for claim element [1.3], the carbon dioxide recycle stream generated by the phase separator of Aycaguer is directed into the system of Soldati as stream 1. *See supra* at X.C.2.b. As explained in Soldati, before the carbon dioxide recycle stream enters column 8, it is compressed to 28.6 atmospheres:

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	−13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at Table III (showing that stream 6 of the embodiment described in FIG. 4 is compressed). Soldati further explains that the incoming hydrocarbon stream 1 is compressed to a working pressure before entering column 8 as stream 6. EX1006 at 4:26-30.

157. The combination thus teaches “compressing the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream.”

b. “dehydrating at least part of the carbon dioxide recycle stream using a dehydration solvent prior to separating the carbon dioxide recycle stream” [2.2]

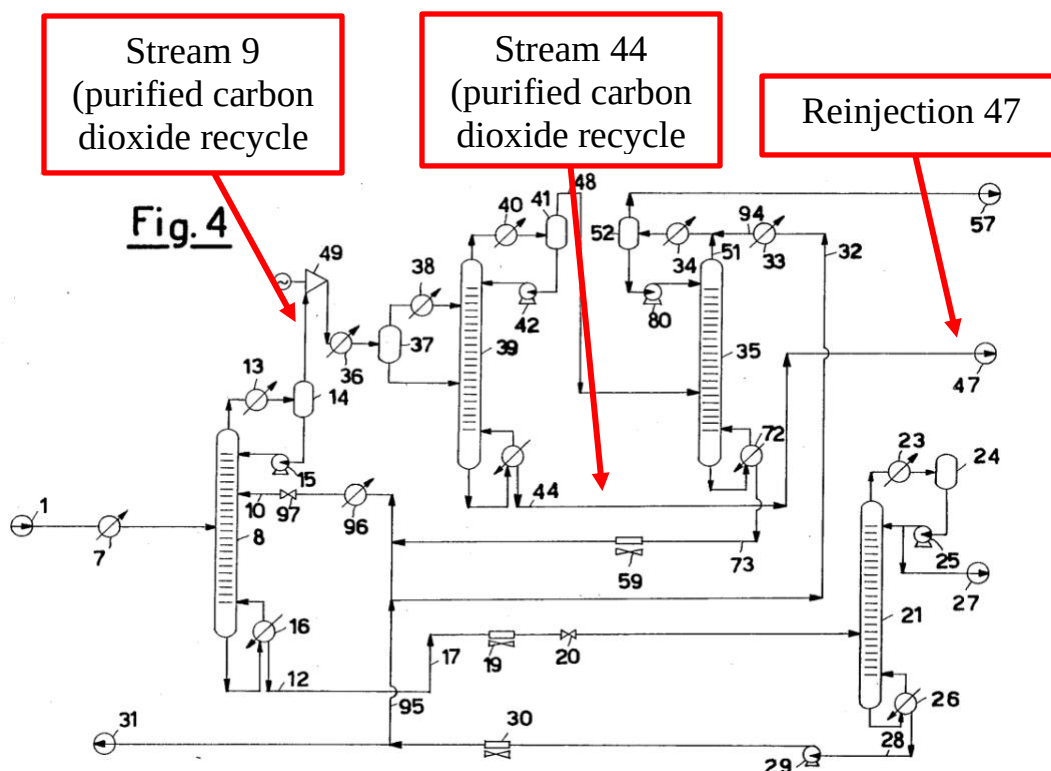
158. As explained above for claim element [2.1], Aycaguer passes a carbon dioxide recycle stream to the system of Soldati. *Supra* § X.C.3.a. Both Aycaguer and Soldati further explain that this stream is dehydrated before processing. See EX1005 at 305 (“The gas is dried to avoid pipeline corrosion arising from the association of CO₂ and water.”); EX1006 at 4:26-30 (“The gaseous hydrocarbon mixture is . . . dehydrated in the dehydrator, from which water is removed.”).

159. A POSITA reading either Aycaguer or Soldati before the Priority Date of the '332 Patent would have known that dehydration solvents were a routine and conventional way to dehydrate hydrocarbon streams. EX1007 at 56. Dehydration not only simplifies downstream separations by removing one component from the steam, but it also reduces corrosion caused by the combination of water, CO₂, and H₂S. One of the most common solvents used to remove water was triethylene glycol (TEG). *See id.* In this well-known process, anhydrous, or “lean,” TEG is contacted with the wet carbon dioxide recycle stream. The water is more soluble in the lean TEG than in the carbon dioxide recycle stream, so it transitions from the carbon dioxide recycle stream to the lean TEG. The hydrated, or “rich,” TEG is then pumped to a separate dehydrator to regenerate the lean TEG. This is an economical means of dehydrating a wet stream, such as the claimed carbon dioxide recycle stream, and has been known and used predictably and successfully in the field for decades. A POSITA would thus have found triethylene glycol an obvious design choice for dehydrating the carbon dioxide recycle stream because it is a known alternative in the prior art, and would have a reasonable expectation of success for the same reason.

160. The combination thus teaches “dehydrating at least part of the carbon dioxide recycle stream using a dehydration solvent prior to separating the carbon dioxide recycle stream.”

c. “combining a carbon dioxide makeup stream external to the method with the purified carbon dioxide recycle stream; and” [2.3]

161. As explained above in claim element [1.3], Soldati creates a purified carbon dioxide recycle stream as stream 9. *Supra* § X.C.2.b. Soldati teaches that this stream undergoes further processing, and eventually becomes stream 44 and is ready for injection into a well at 47:



EX1006 at FIG. 4, 5:8–13.

162. Stream 44 contains CO₂ from stream 9, and is therefore a further-purified version of the purified carbon dioxide stream (stream 9):

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	48	44	73
NITROGEN	16.45	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	47.78	1162.50	46.61
METHANE	64.56	—	7.02
ETHANE	10.56	8.86	10.57
PROPANE	—	1.12	1.17
N-BUTANE	—	0.87	107.65
N-PENTANE	—	—	32.47
HEXANE	—	—	8.02

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at FIG. 4, Table III.

163. Stream 44 was therefore separated from the carbon dioxide recycle stream using columns 9 and 39, and is therefore also the claimed purified carbon dioxide recycle stream. *Supra* note **Error! Bookmark not defined..**

164. Aycaguer also teaches that the CO₂ stream that exits the gas processing plant is injected into a well. EX1005 at 305 (“The separation of the produced gas stream does not isolate all compounds perfectly, and the CO₂ stream destined for reinjection also contains some methane and C₂.”). To this end, Aycaguer describes

a system where the CO₂ stream that exits the gas processing plant is combined with external CO₂ (a CO₂ makeup stream) and then injected into the well:

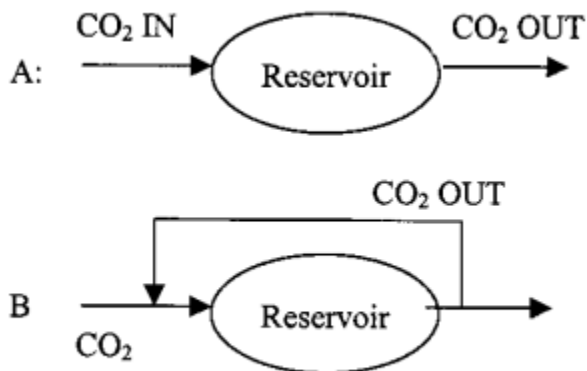


Figure 2. Designs of EOR process operations.

EX1005 at FIG. 2B, 306.

165. Using this system, Aycaguer explains that “approximately 43% of the cumulative CO₂ needed for injection will be supplied by the recycling plant.” EX1005 at 306. Combining the external CO₂ injected into the well with the recycled CO₂ recovered from the well is a common feature of enhanced oil recovery systems. The amount of CO₂ recovered from the well is smaller than the amount that must be pumped down the well to maintain pressure, and thus a makeup stream is required. Combining the external CO₂ with the recycled CO₂ before reinjection allows for the pumping of both gases into the well using the same pumping infrastructure, simplifying the design. Combining the external and recycled CO₂ before reinjection is thus straightforward and predictable.

166. The combination thus teaches “combining a carbon dioxide makeup stream external to the method with the purified carbon dioxide recycle stream.”

d. “injecting the combined carbon dioxide makeup stream and the purified carbon dioxide recycle stream into a subterranean formation.” [2.4]

167. As explained above in claim element [2.3], Aycaguer teaches combining a carbon dioxide makeup stream with the purified carbon dioxide recycle stream derived from the gas processing plant described in Soldati. *Supra* § X.C.3.c.

168. Aycaguer teaches that this combined stream is injected into an oil and gas reservoir (i.e., a subterranean formation):

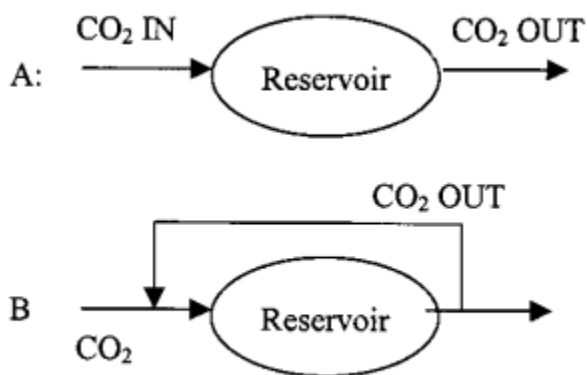


Figure 2. Designs of EOR process operations.

EX1005 at FIG. 2B.

169. Using this system, Aycaguer explains that “approximately 43% of the cumulative CO₂ needed for injection will be supplied by the recycling plant.” EX1005 at 306. Combining the external CO₂ injected into the well with the recycled CO₂ recovered from the well is a common feature of enhanced oil recovery systems.

The amount of CO₂ recovered from the well is smaller than the amount that must be pumped down the well to maintain pressure, and thus a makeup stream is required. Combining the external CO₂ with the recycled CO₂ before reinjection allows for the pumping of both gases into the well using the same pumping infrastructure, simplifying the design. Combining the external and recycled CO₂ before reinjection is thus straightforward and predictable.

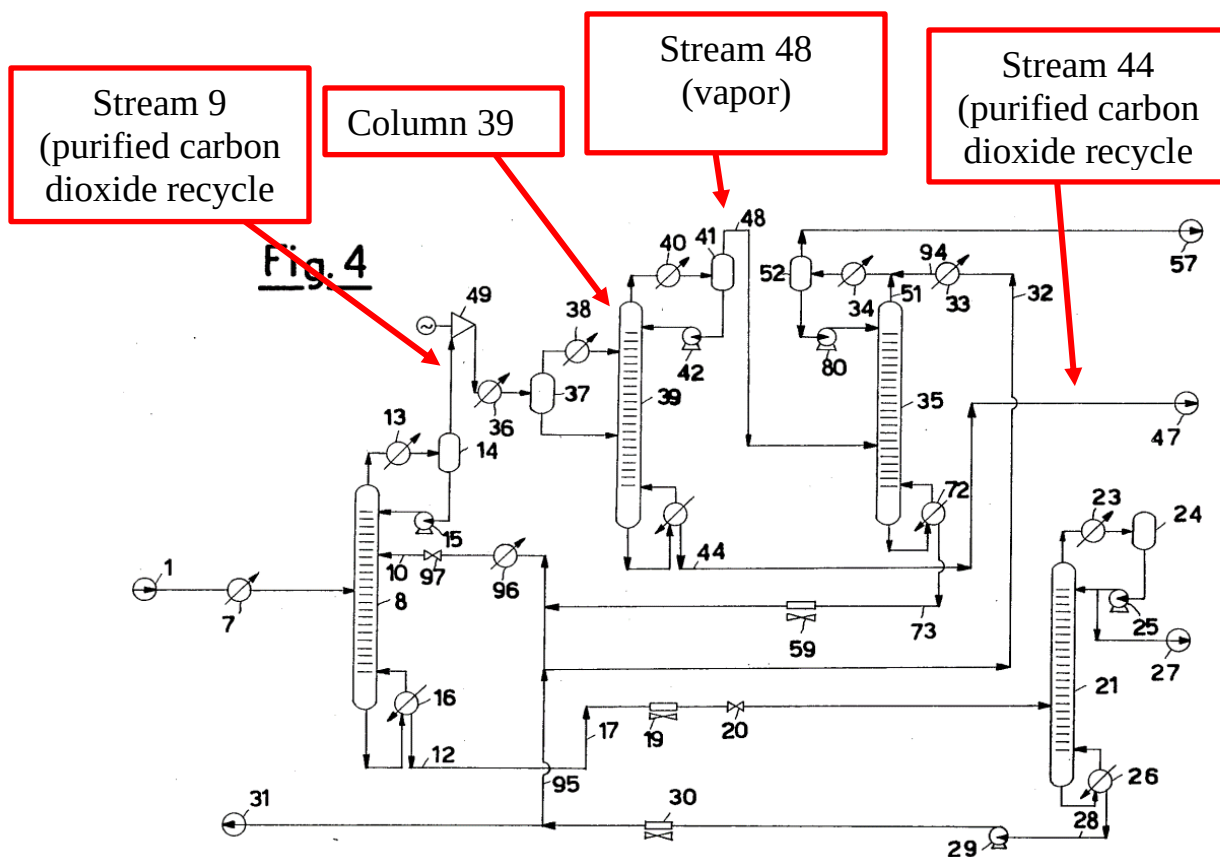
170. The combination thus teaches “injecting the combined carbon dioxide makeup stream and the purified carbon dioxide recycle stream into a subterranean formation.”

4. Claim 3: “The method of claim 1, further comprising cooling the carbon dioxide recycle stream with the purified carbon dioxide recycle stream.”

171. As discussed above for claim element [1.2], the phase separation described in Aycaguer results in a carbon dioxide recycle stream that includes C₃-C₈, CO₂, and H₂S. *Supra* §§ X.A.1.c, X.C.2.a. This stream is then directed into the gas processing system described in Soldati as stream 1. Soldati explains that this gas stream 1 “is cooled in 7 and fed into the column 8.” EX1006 at 4:30-31. Soldati thus teaches cooling the carbon dioxide recycle stream (cooling carbon dioxide recycle stream 1, resulting in cooled carbon dioxide recycle stream 6). As illustrated in Figure 1 of Soldati, this cooling at 7 is in addition and subsequent to a prior condensing and cooling of the mixture that occurs at compressor 2 and heat

exchanger 3. Although not shown in Figure 4, a POSITA would have understood from the description of Soldati that these steps are also included in the Figure 4 embodiment.

172. Soldati also teaches that the “bottom product of the second distillation column [39] can be expanded and the produced cold used for cooling other process streams.” EX1006 at 3:22-24. The second distillation column is the column fed with the “overhead stream from the first column” (EX1006 at 1:33-37)—i.e., column 39:



EX1006 at FIG. 4.

173. Column 39 is fed the purified carbon dioxide (stream 9), and separates it into upper stream 48 and lower stream 44. *Id.*; *supra* § X.C.2.b (explaining that

stream 9 is the purified carbon dioxide stream). Stream 44 contains CO₂ from stream 9, and is therefore a further-purified version of the purified carbon dioxide stream (stream 9):

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	48	44	73
NITROGEN	16.45	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	47.78	1162.50	46.61
METHANE	64.56	—	7.02
ETHANE	10.56	8.86	10.57
PROPANE	—	1.12	1.17
N-BUTANE	—	0.87	107.65
N-PENTANE	—	—	32.47
HEXANE	—	—	8.02

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at FIG. 4, Table III.

174. Stream 44 was therefore separated from the carbon dioxide recycle stream using columns 8 and 39, and therefore alternately teaches the claimed purified carbon dioxide recycle stream. *supra* note **Error! Bookmark not defined..**

175. Thus, because Soldati teaches that the “bottom product [44] of the second distillation column [39] can be expanded and the produced cold be used for cooling other process streams,” it teaches that a purified recycle stream can be used to cool other process streams. EX1006 at 3:22-24. Furthermore, a POSITA would have understood that the carbon dioxide recycle stream (stream 6) is an “other process stream” and thus would have understood Soldati to teach, or at the very least render obvious, that the stream 44 (the purified recycle stream) is used to cool the stream 6 (carbon dioxide recycle stream) at 7. *See* EX1003 at 149 (the Examiner explaining that “[u]tilizing recycled streams is a common practice and is more efficient for upstream cooling or heating to avoid the utilization of external refrigeration.”). This use of streams from one part of a chemical process (e.g., stream 44) to effect a temperature change in another part of a chemical process (e.g., stream 6) is a common way of increasing the efficiency of chemical processing systems. *See id.* Soldati’s explicit disclosure that stream 44 should be used to cool process streams, and Soldati’s explicit disclosure that process stream 6 should be cooled at 7, would certainly motivate a POSITA to use stream 44 to cool stream 6 at 7, and—as explained by the Examiner—such recycled cooling is a common and efficient practice which would provide a reasonable expectation of success. *See* EX1006 at 3:22-24; EX1003 at 149.

176. The combination thus teaches “the method of claim 1, further comprising cooling the carbon dioxide recycle stream with the purified carbon dioxide recycle stream.”

5. **Claim 4: “The method of claim 3, wherein the sweet NGL rich stream comprises no more than 1 molar percent methane, no more than 1 molar percent ethane, and no more than 1 molar percent acid gases.”**

177. As discussed for claim element [1.4], stream 28 teaches the sweet NGL rich stream. *Supra* § X.C.2.b. According to Table III, stream 28 contains *no* methane, ethane, CO₂, or hydrogen sulfide; thus, it includes less than 1% methane, less than 1% ethane, less than 1% CO₂, and less than 1% hydrogen sulfide:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	28	10	95
NITROGEN	—	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	—	46.64	—
METHANE	—	7.03	—
ETHANE	—	10.54	—
PROPANE	12.11	11.97	12.00
N-BUTANE	1092.03	1081.98	1082.60
N-PENTANE	81.06	80.26	80.25
THROUGHPUT KMOLS/H	1513.37	1563.53	1500.00
PHASE	L	L	L
TEMPERATURE °C.	122.0	16.0	48.0
PRESSURE ATA	19.2	39.6	44.0

EX1006 at Table III.

178. While a POSITA would not expect the percentages of components in the sour NGL stream described by Table III of Soldati to exactly match the percentages of components of a sour NGL stream produced by the combination of

Aycaguer and Soldati, a POSITA would expect the percentages to be similar. This is because hydrocarbon streams derived from oil and gas wells all produce different concentrations of particular hydrocarbons. Tables such as Table III, therefore, exist to give POSITA reading the Soldati an idea of what to expect when they apply the teachings of the Soldati to their system. Furthermore, a POSITA would have understood how chemicals interact with changes in temperature and pressure, allowing them to adjust those variables to predictably modify the system output. A POSITA would have reasonably expected that the separation method of Soldati applied to the feed stream of Arand would have resulted in less than 1% methane, less than 1% ethane, less than 1% CO₂, and less than 1% hydrogen sulfide, because Soldati teaches that its separation steps result in none of those components in the sweet NGL rich stream 28.

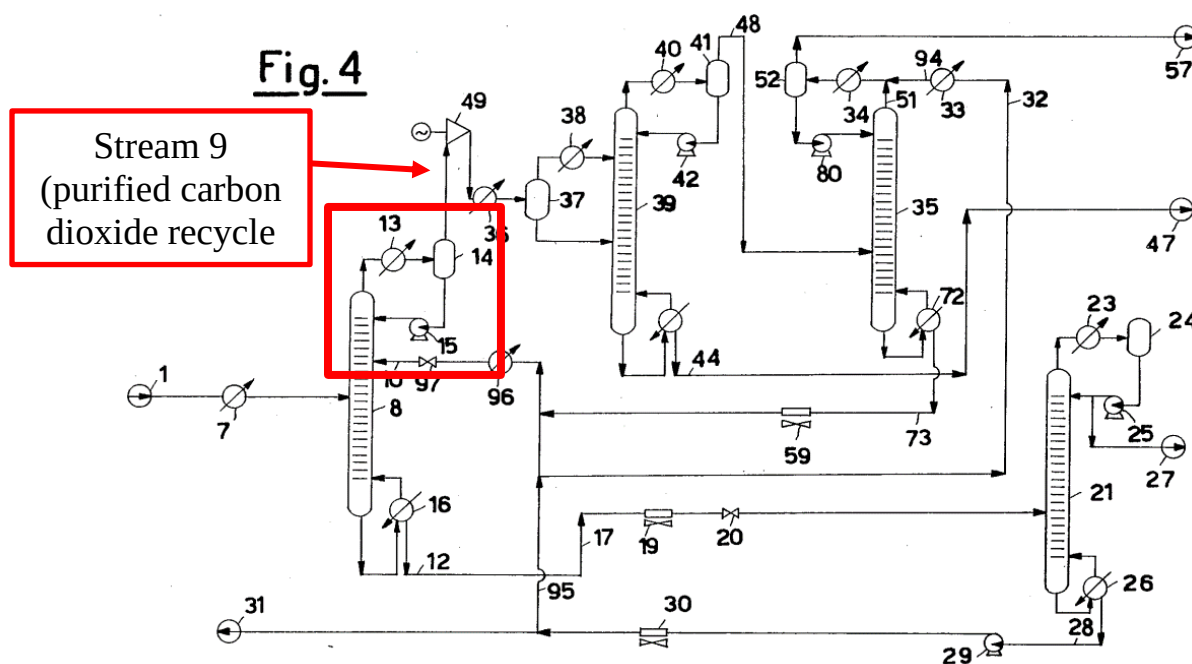
179. The combination thus teaches a method “wherein the sweet NGL rich stream comprises no more than 1 molar percent methane, no more than 1 molar percent ethane, and no more than 1 molar percent acid gases.”

6. Claim 6

a. “The method of claim 1, wherein separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream comprises: refluxing part of the purified carbon dioxide recycle stream;” [6.1]

180. As described in claim element [1.3], column 8 of Soldati separates the carbon dioxide recycle stream into a sour NGL rich stream that exits the bottom of column 8 and a purified carbon dioxide recycle stream that exits the top of column 8. *Supra* § X.C.2.b.

181. Soldati further discloses that column 8 has “the condenser 13, the separator 14, and the pump 15” at its top. EX1006 at 4:44-46:



EX1006 at FIG. 4 (highlighting condenser 13, separator 14, pump 15, and stream 9).

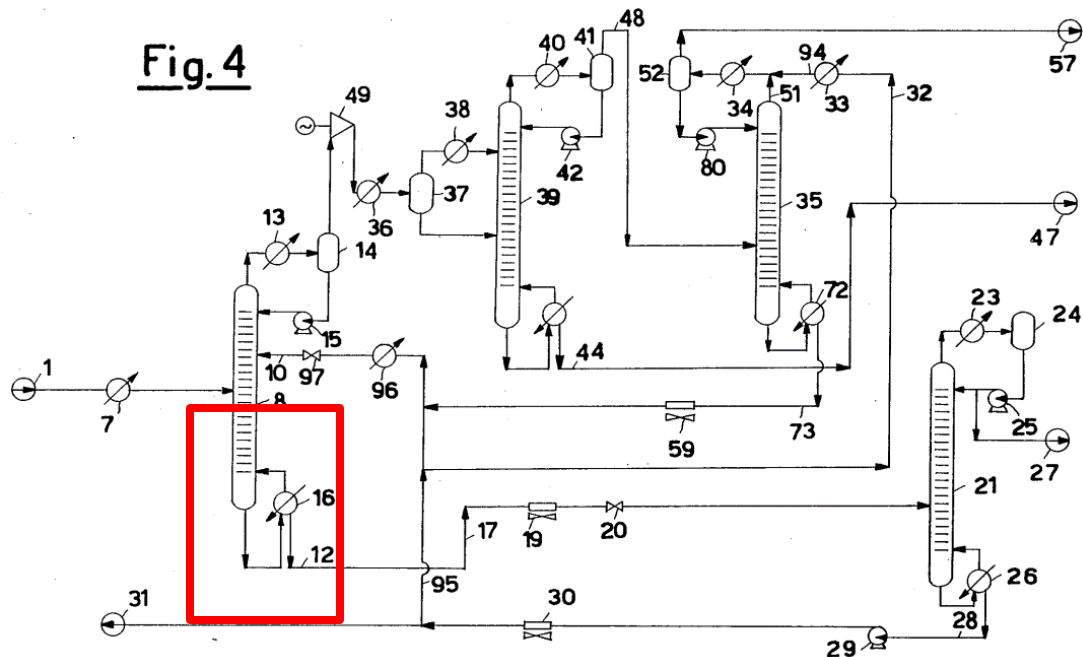
182. A POSITA would have understood that liquid forms at condenser 13 and is separated from the vapor phases by accumulator tank 14. EX1012 at 67. A

fraction of this liquid, called “reflux,” is returned to the column by pump 15. EX1006 at FIG. 4; EX1012 at 67. Thus, the liquid stream in equilibrium with vapor stream 9 (the carbon dioxide recycle stream) exiting the bottom of tank 14 is “refluxed” by pump 15. EX1006 at FIG. 4. Refluxing the stream exiting a distillation column is an essential component of column distillation. See EX1012 at 67-69.

183. The combination thus teaches “separating the carbon dioxide recycle stream into the sour NGL rich stream and the purified carbon dioxide recycle stream comprises: refluxing part of the purified carbon dioxide recycle stream.”

**b. “reboiling part of the sour NGL rich stream; and”
[6.2]**

184. As described above in claim element [1.3], Soldati describes a sour NGL rich stream exiting the bottom of column 8. *Supra* § X.C.2.b. Soldati further discloses that the bottom of column 8 has reboiler 16, which reboils fluid from the bottom of column 8 back into column 8:

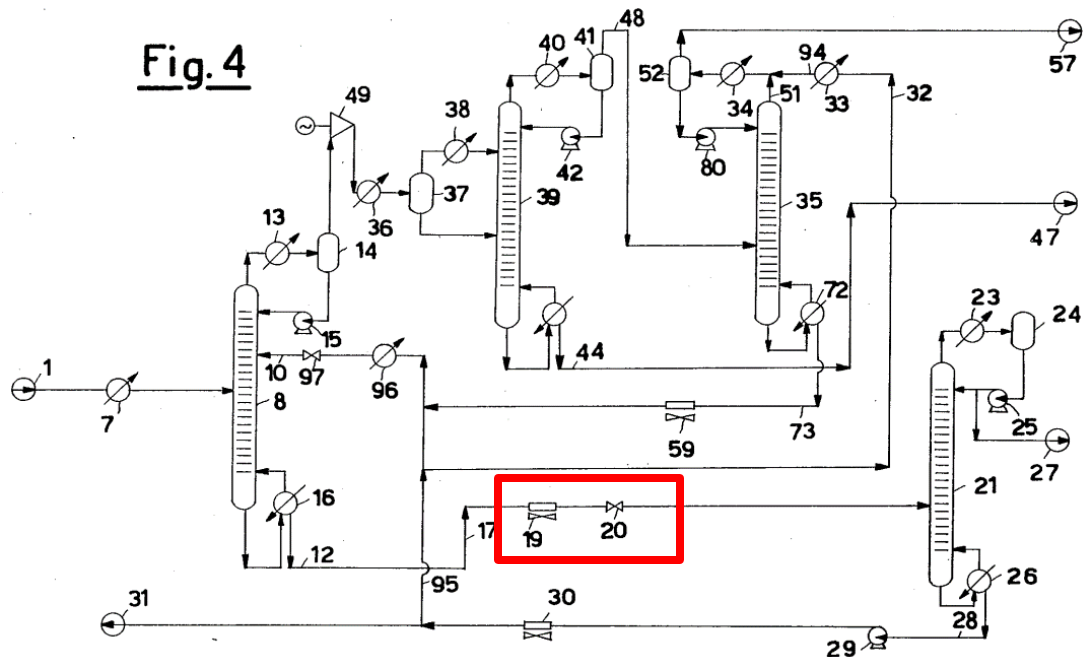


EX1006 at 4:44-46, FIG. 4 (reboiler highlighted). As with refluxing the stream that exits the top of the distillation column, reboiling the stream exiting the bottom of a distillation column is an essential component of column distillation. See EX1012 at 67-69.

185. The combination thus teaches “reboiling part of the sour NGL rich stream.”

**c. “cooling and throttling the sour NGL rich stream.”
[6.3]**

186. As shown in claim element [1.3], a sour NGL rich stream exits the bottom of column 8. *Supra* § X.C.2.b. As the sour NGL rich stream passes from column 8 to column 21, it passes through heat exchanger 19 which cools it. EX1006 at 4:48-50 (explaining that the stream is cooled at element 19), 8:47 (“heat exchanger[] 19”).



EX1006 at FIG. 4 (highlighting the heat exchanger and expansion valve).

187. Following heat exchanger 19, the sour NGL rich stream passes through valve 20. EX1006 at 4:48-50, FIG. 4. Valve 20 expands stream 17. EX1006 at 4:48-50. Valves affect the flow and/or pressure of a fluid by throttling it. EX1024 at 335. A valve that controls pressure independent of flow rate is considered a throttling valve. An expansion valve, in particular, throttles flow through a small aperture to produce a vapor. Therefore valve 20 throttles stream 17.

188. The combination thus teaches “cooling and throttling the sour NGL rich stream.”

7. Claim 7: “The method of claim 6, wherein the sour NGL rich steam comprises no more than 5 molar percent carbon dioxide, no more than 1 molar percent methane, and no more

than 5 molar percent ethane, and wherein the sweet NGL rich stream is substantially free of carbon dioxide.”

189. As described in claim element [1.3], stream 12 is a sour NGL stream.

Supra § X.C.2.b. Stream 12 contains 0.23% carbon dioxide (3.65 KMOLS/H of 1580.83 total KMOLS/H), 0% methane, and 2.1% ethane (32.61 KMOLS/H of 1580.83 total KMOLS/H):

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at Table III.

190. As explained above for claim 4, while a POSITA would not expect the percentages of components in the sour NGL stream described by Table III of Soldati to exactly match the percentages of components of a sour NGL stream produced by the combination of Aycaguer and Soldati, a POSITA would expect the percentages to be similar. This is because hydrocarbon streams derived from oil and gas wells all produce different concentrations of particular hydrocarbons—a fact of which POSITAs are very well aware. Tables such as Table III, therefore, exist to give

POSITA reading Soldati an idea of what to expect when they apply the teachings of Soldati to their particular system. This understanding is buttressed by the fact that a POSITA can predictably alter the conditions under which each separation is performed to change the output, for example, by using resources such as DePriester charts. See, e.g., *supra* ¶¶ 37–38. This predictability would allow a POSITA to adjust their system to arrive at the percentages described in Table III using the stream disclosed in Aycaguer.

191. As described above in claim element [1.4], stream 28 teaches the sweet NGL rich stream. *Supra* § X.C.2.c. Soldati teaches that column 21 removes the CO₂ from stream 12 to yield stream 28:

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	28	10	95
NITROGEN	—	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	—	46.64	—
METHANE	—	7.03	—
ETHANE	—	10.54	—
PROPANE	12.11	11.97	12.00
N-BUTANE	1092.03	1081.98	1082.60
N-PENTANE	81.06	80.26	80.25
THROUGHPUT KMOLS/H	1513.37	1563.53	1500.00
PHASE	L	L	L
TEMPERATURE °C.	122.0	16.0	48.0
PRESSURE ATA	19.2	39.6	44.0

EX1006 at Table III.

192. Additionally, a POSITA would have found it obvious that the carbon dioxide recycle stream disclosed by Aycaguer could have had the same composition

as stream 6 of Soldati, as Aycaguer teaches removing crude oil from a hydrocarbon feed stream to yield a carbon dioxide recycle stream with NGLs, and Soldati teaches a carbon dioxide recycle stream with NGLs. EX1006 at Table III. Processing such a stream through the system of Soldati would achieve the same percentages found in Table III, and thus result in a sour NGL rich stream with “no more than 5 molar percent carbon dioxide, no more than 1 molar percent methane, and no more than 5 molar percent ethane” and a sweet NGL rich stream “substantially free of carbon dioxide.”

193. Furthermore, a POSITA would have been motivated to optimize the separation steps in the combined Aycaguer and Soldati system such that the sour NGL rich stream contains minimal carbon dioxide, methane, and ethane, and the sweet NGL rich stream is substantially free of carbon dioxide, as required in Claim 7. The successful extraction of NGLs from a carbon dioxide-rich reservoir stream (i.e., the separation of CO₂ from NGLs) is the entire point of NGL distillations as taught in Aycaguer and Soldati. And Soldati expressly taught minimal carbon dioxide in its sour NGL rich stream and no carbon dioxide in its sweet NGL rich stream. Additionally, a POSITA would have expected the percentages of methane and ethane in the NGL rich stream to be low as compared with the NGLs (which a POSITA would have understood to be the C₃-C₈) because the system is designed for NGL recovery. The 1% and 5% thresholds recited in Claim 7 are merely design

choices that a POSITA could have easily achieved using routine and predictable optimizations to the process variables (for instance, by adjusting the reboiler temperature).

194. The combination thus teaches that “the sour NGL rich steam comprises no more than 5 molar percent carbon dioxide, no more than 1 molar percent methane, and no more than 5 molar percent ethane, and wherein the sweet NGL rich stream is substantially free of carbon dioxide.”

D. Ground 4: Claim 2 is Obvious Over Aycaguer, Soldati, and Ryan

195. In my opinion, Aycaguer in combination with Soldati and Ryan renders obvious claim 2 of the '332 Patent.

1. Motivation to Combine Aycaguer, Soldati, and Ryan

196. Ground 4 combines Aycaguer and Soldati (as discussed in Ground 3) with Ryan. *Supra* § X.C. As explained below, Ryan teaches a method of dehydrating a natural gas feed stream before it is used in a distillation separation, and it would have been obvious to implement such a method of dehydration as the “dehydrator” in Soldati.

197. A POSITA would have been motivated to combine Aycaguer and Soldati with Ryan, and would have had a reasonable expectation of success in doing so, because all three references relate to methods of natural gas liquid separation. *See* EX1005 at 305; EX1006 at 1:67–2:26; EX1007 at 53. Indeed, Aycaguer

explicitly refers to the Ryan reference and describes it as an acceptable method of natural gas liquid separation, and Soldati describes itself as an improved version of the Ryan/Holmes process. *See* EX1005 at 305; EX1006 at 1:54–58.

198. Both Aycaguer and Soldati teach that the natural gas liquid stream should be dehydrated before it is separated. EX1005 at 305; EX1006 at 4:24–30, Table III (showing dehydrated mixture 6). However, neither Aycaguer nor Soldati specify what dehydrator to use.

199. I understand that a POSITA may be motivated to combine prior art references when the prior art teaches, suggests, or motivates the combination. *See supra*, § IV. Because Ryan teaches that “[f]eed dehydration by TEG” is an appropriate method of dehydrating oil and natural gas feed streams for use in distillation approaches to enhance oil recovery operations, Ryan provides an explicit teaching, suggestion, or motivation to combine with Soldati. *Compare* EX1006 at 4:24–30 (describing the need for a dehydrator) *with* EX1007 at 56 (disclosing a dehydrator for use in distillation methods of processing natural gas).

200. I also understand that a POSITA may be motivated to combine prior art references when the combination would be a simple substitution of one known element for another to obtain predictable results. *See supra*, § IV. The substitution of the generic dehydrator of Soldati with the specific TEG dehydration of Ryan is a simple substitution of one known element for another to obtain predictable results

and a POSITA would have had a reasonable expectation of success in using TEG for dehydration. *See supra*, § IV. This could also be considered filling in a gap in the description provided by Soldati with the explicit teaching of Ryan. *See supra*, § IV. Soldati generically recites the well-known requirement for a “dehydrator,” and Ryan provides a well-known system to perform that function. *See* EX1006 at 4:24–30; EX1007 at 56.

201. Thus, a POSITA would be motivated to implement Aycaguer’s Produced Gas Recycling Plant using the natural gas liquid processing methods described by Soldati, and a POSITA would be further motivated to use the TEG dehydration method described in Ryan to perform the dehydration disclosed by Soldati’s method.

2. Claim 2

202. As explained above for Ground 3, Aycaguer and Soldati teaches the limitations of Claim 1. *Supra* §§ X.C.2.a-X.C.2.e. The combination of Aycaguer, Soldati, and Ryan teaches the additional limitations of Claim 2.

a. “The method of claim 1, further comprising: compressing the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream” [2.1]

203. As explained above for claim element [1.3], the carbon dioxide recycle stream generated by the phase separator of Aycaguer is directed into the system of

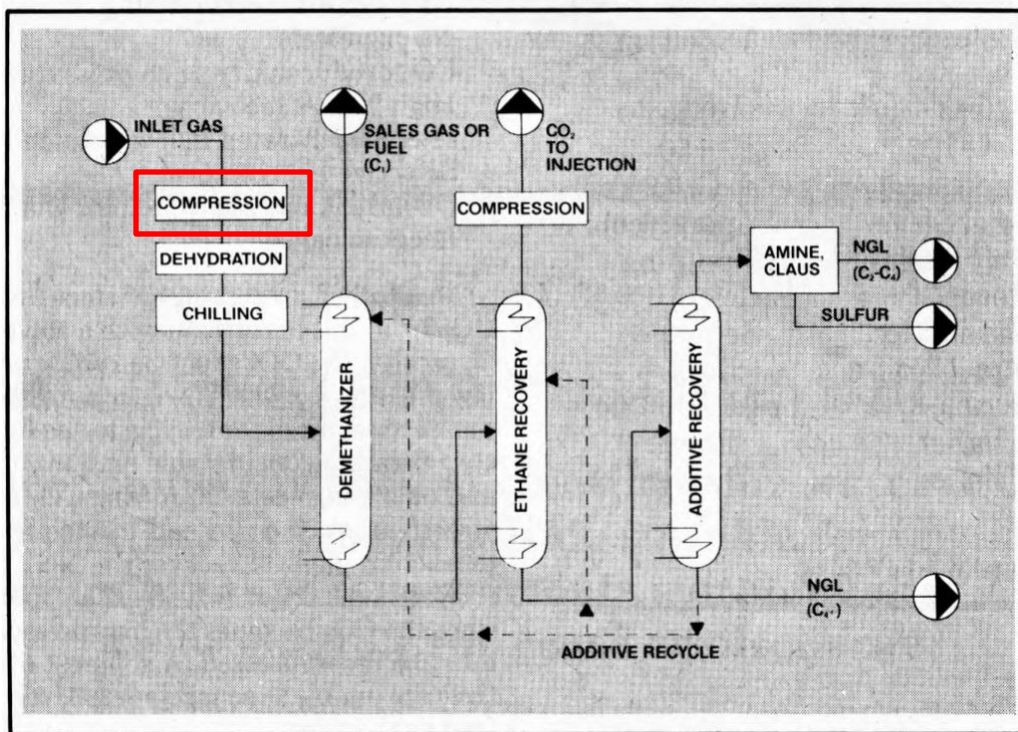
Soldati as stream 1. *See* X.C.2.b. As explained in Soldati, before the carbon dioxide recycle stream enters column 8, it is compressed to 28.6 atmospheres:

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	<u>28.6</u>	27.8	42.0	27.0

EX1006 at Table III, 4:26-30 (explaining that the incoming hydrocarbon stream 1 is compressed to a working pressure before entering Column 8).

204. Ryan agrees, and also describes a compressor used to increase the pressure of the carbon dioxide recycle stream before it flows into the first separation column:

Figure 2. Three-column Ryan/Holmes process.



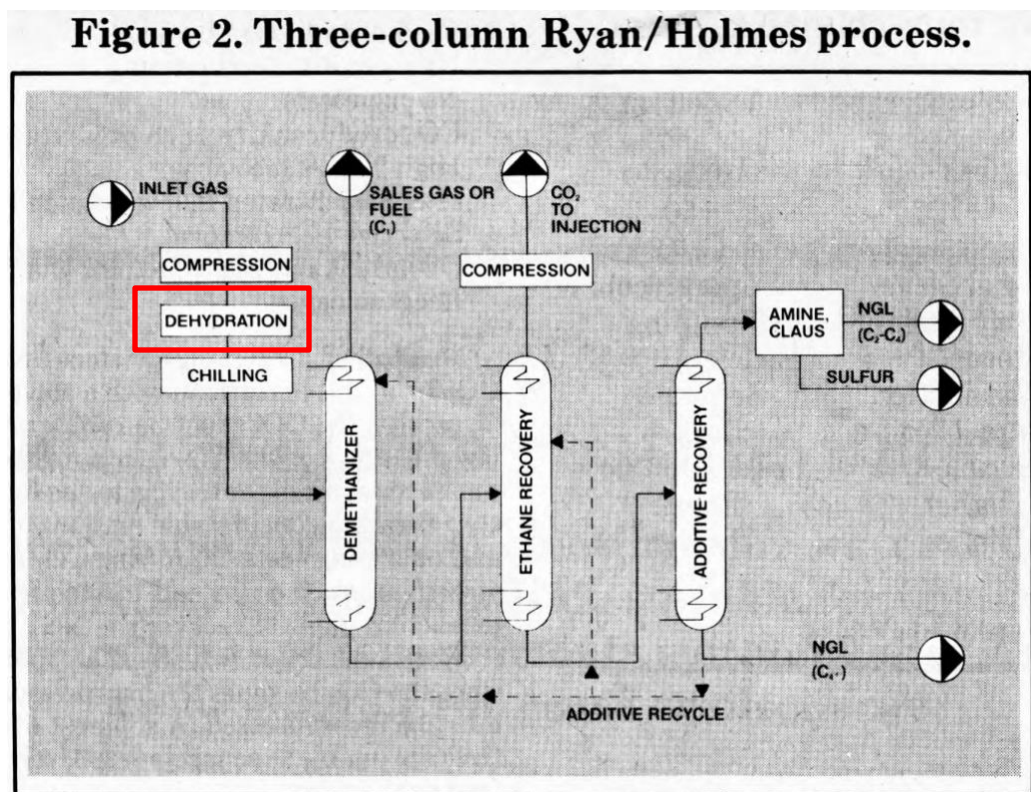
EX1007 at FIG. 2 (compressor highlighted).

205. The combination thus teaches “compressing the carbon dioxide recycle stream prior to separating the carbon dioxide recycle stream.”

b. “dehydrating at least part of the carbon dioxide recycle stream using a dehydration solvent prior to separating the carbon dioxide recycle stream” [2.2]

206. As explained above for claim element [2.2], Aycaguer passes a carbon dioxide recycle stream to the system of Soldati. *Supra* § X.C.3.b. Both Aycaguer and Soldati further explain that this stream should be dehydrated before it is processed. See EX1005 at 305 (“The gas is dried to avoid pipeline corrosion arising from the association of CO₂ and water.”); EX1006 at 4:26-30. However, neither Aycaguer nor Soldati discloses the specific dehydrator to use.

207. Ryan discloses “[f]eed dehydration by TEG.” EX1007 at 56. A POSITA would have understood that TEG stands for “triethylene glycol,” a solvent commonly used to extract water from gas streams. *See, e.g., id.* Ryan further discloses that this dehydration should occur after compression but before separation in the distillation column:

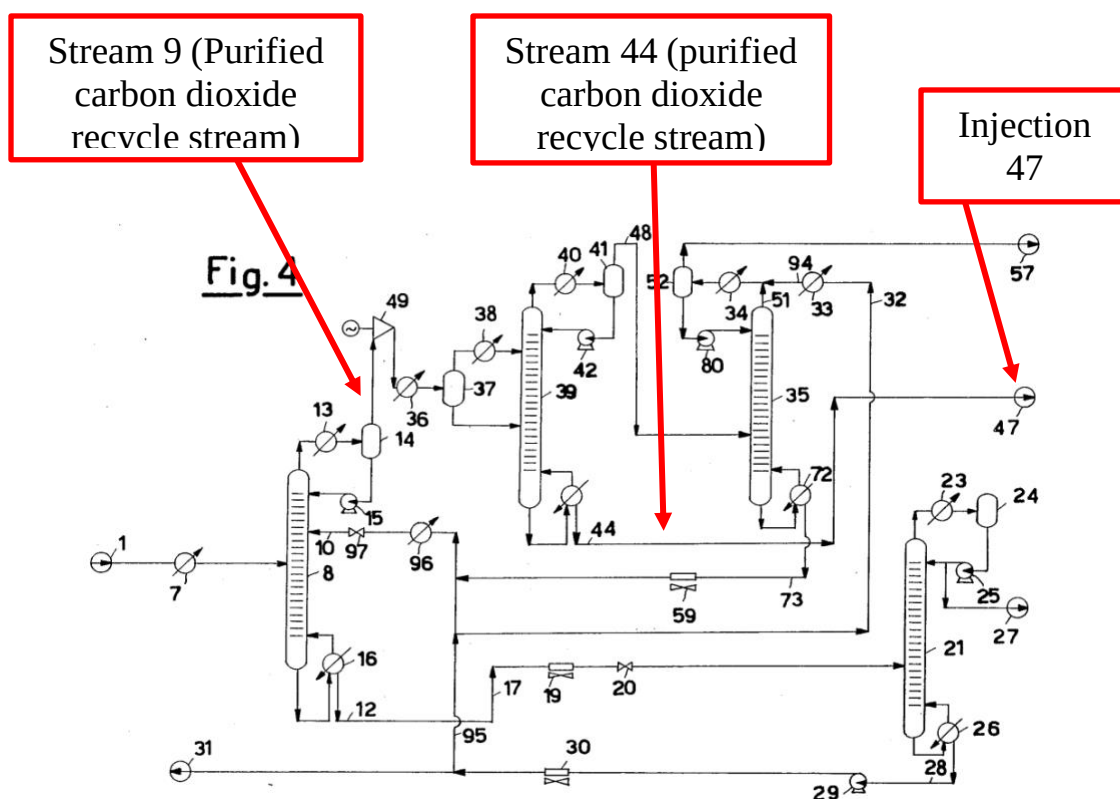


EX1007 at FIG. 2 (dehydrator highlighted).

208. The combination thus teaches “dehydrating at least part of the carbon dioxide recycle stream using a dehydration solvent prior to separating the carbon dioxide recycle stream.”

c. “combining a carbon dioxide makeup stream external to the method with the purified carbon dioxide recycle stream; and” [2.3]

209. As explained above in claim element [2.2], Soldati provides a purified carbon dioxide recycle stream as stream 9. *Supra* X.C.2.b. Soldati teaches that this stream undergoes further processing, and eventually becomes stream 44 and is ready for injection into a well at 47:



EX1006 at FIG. 4 (annotated), 5:8-13.

210. Stream 44 contains almost all of the CO₂ from stream 9, and is therefore merely a further-purified version of the purified carbon dioxide stream (stream 9):

COMPONENT THROUGHPUT KMOLS/H	STREAM		
	48	44	73
NITROGEN	16.45	—	—
HYDROGEN SULPHIDE	—	—	—
CARBON DIOXIDE	47.78	1162.50	46.61
METHANE	64.56	—	7.02
ETHANE	10.56	8.86	10.57
PROPANE	—	1.12	1.17
N-BUTANE	—	0.87	107.65
N-PENTANE	—	—	32.47
HEXANE	—	—	8.02

COMPONENT THROUGHPUT KMOLS/H	STREAM			
	6	12	31	9
NITROGEN	16.46	0.00	—	16.46
HYDROGEN SULPHIDE	0.03	0.03	—	0.03
CARBON DIOXIDE	1167.21	3.65	—	1210.20
METHANE	57.59	0.00	—	64.62
ETHANE	41.50	32.61	—	19.44
PROPANE	31.79	42.63	0.10	1.13
N-BUTANE	11.57	1092.68	9.59	0.87
N-PENTANE	3.06	328.17	2.88	—
HEXANE	0.80	81.06	0.71	—
THROUGHPUT KMOLS/H	1330.01	1580.83	13.28	1312.75
PHASE	V	L	L	V
TEMPERATURE °C.	40.0	138.0	48.0	—13.1
PRESSURE ATA	28.6	27.8	42.0	27.0

EX1006 at FIG. 4, Table III.

211. Stream 44 was therefore separated from the carbon dioxide recycle stream using columns 9 and 39, and is therefore also the claimed purified carbon dioxide recycle stream. *Supra* note **Error! Bookmark not defined..**

212. Aycaguer also teaches that the CO₂ stream that exits the gas processing plant should be injected into a well. EX1005 at 305 (“The separation of the produced gas stream does not isolate all compounds perfectly, and the CO₂ stream destined for reinjection also contains some methane and C₂”).

213. To this end, Aycaguer describes a system where the CO₂ stream that exits the gas processing plant is combined with external CO₂ and then injected into the well:

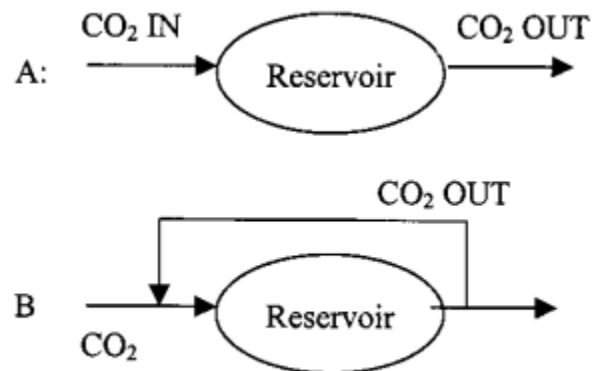


Figure 2. Designs of EOR process operations.

EX1005 at FIG. 2B, 306.

214. Using this system, Aycaguer explains that “approximately 43% of the cumulative CO₂ needed for injection will be supplied by the recycling plant.” EX1005 at 306. Combining the external CO₂ injected into the well with the recycled CO₂ recovered from the well is a common feature of enhanced oil recovery systems. The amount of CO₂ recovered from the well is smaller than the amount that must be pumped down the well to maintain pressure, and thus a makeup stream is required.

Combining the external CO₂ with the recycled CO₂ before reinjection allows for the pumping of both gases into the well using the same pumping infrastructure, simplifying the design. Combining the external and recycled CO₂ before reinjection is thus straightforward and predictable.

215. The combination thus teaches “combining a carbon dioxide makeup stream external to the method with the purified carbon dioxide recycle stream.”

d. “injecting the combined carbon dioxide makeup stream and the purified carbon dioxide recycle stream into a subterranean formation.” [2.4]

216. As explained above in claim element [2.3], Aycaguer teaches combining a carbon dioxide makeup stream with the purified carbon dioxide recycle stream derived from the gas processing plant described in Soldati. *Supra* § X.C.3.c, X.D.2.c.

217. Aycaguer teaches that this combination stream is injected into an oil and gas reservoir (i.e., a subterranean formation):

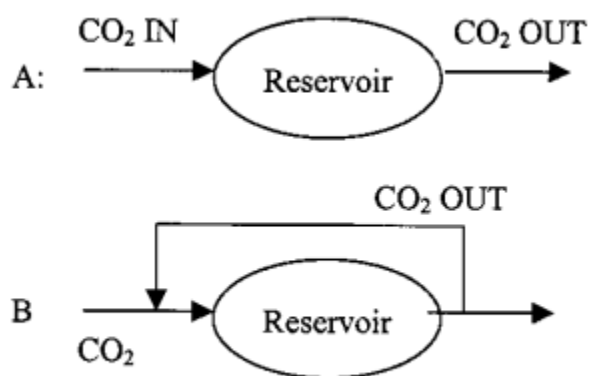


Figure 2. Designs of EOR process operations.

EX1005 at FIG. 2B.

218. Using this system, Aycaguer explains that “approximately 43% of the cumulative CO₂ needed for injection will be supplied by the recycling plant.” EX1005 at 306. Combining the external CO₂ injected into the well with the recycled CO₂ recovered from the well is a common feature of enhanced oil recovery systems. The amount of CO₂ recovered from the well is smaller than the amount that must be pumped down the well to maintain pressure, and thus a makeup stream is required. Combining the external CO₂ with the recycled CO₂ before reinjection allows for the pumping of both gases into the well using the same pumping infrastructure, simplifying the design. Combining the external and recycled CO₂ before reinjection is thus straightforward and predictable.

219. The combination thus teaches “injecting the combined carbon dioxide makeup stream and the purified carbon dioxide recycle stream into a subterranean formation.”

E. Grounds 5 and 6: Claims 1-4 and 6-7 are obvious over Aycaguer, Soldati, and Arand (Ground 5) and Claim 2 is obvious over Aycaguer, Soldati, Ryan, and Arand (Ground 6)

220. In my opinion, Aycaguer in combination with Soldati and Arand renders obvious claims 1-4, 6, and 7 of the '332 Patent. Further, in my opinion, Aycaguer in combination with Soldati, Ryan, and Arand renders obvious claim 2 of the '332 Patent.

1. Motivation to Combine the References

221. Ground 5 combines Aycaguer and Soldati (as discussed in Ground 3) with Arand. *Supra* § X.C. Ground 6 combines Aycaguer, Soldati and Ryan (as discussed in Ground 4) with Arand. *Supra* § X.D. As discussed above in § IX.D, Arand expressly discloses that natural gas liquids comprise C₃-C₈ hydrocarbons and that heavy condensate (i.e., heavy hydrocarbons) comprises C₉₊ hydrocarbons, and is used in Ground 2 (and is used similarly here in Ground 5 and 6) in the event Patent Owner incorrectly argues against the use of the admissions in the '332 Patent. Ground 3 explains the motivation to combine Aycaguer and Soldati and Ground 4 explains the motivation for the further combination with Ryan. *See supra* at §§ X.C.1, X.D.1. As discussed below, a POSITA would have been further motivated to combine the teachings of Arand with those of Aycaguer in both of these combinations discussed above.

222. As explained below, Arand teaches a method of processing fluids produced from oil and gas reservoirs to yield a natural gas liquid stream, a residue gas stream, and a stabilized condensate stream. *See* EX1004 at 1:6–13. A POSITA would have been motivated to combine Aycaguer and Arand, and would have had a reasonable expectation of success in doing so, because both references relate to methods of natural gas liquid separation, and for the additional reasons below. *See* EX1005 at 305; EX1006 at 1:67–2:26; EX1004 at 1:6–13.

223. Aycaguer teaches that heavy hydrocarbons, such as the crude oil, should be separated from a hydrocarbon feed stream derived from the oil well before further processing. *See* EX1005 at 305. Aycaguer also teaches that natural gas liquids are a valuable product of oil and gas wells. *Id.* However, Aycaguer does not explicitly disclose the particular hydrocarbons that would be found in the components of natural gas liquids or heavy hydrocarbons.

224. Arand provides such teachings. Arand teaches that natural gas liquids are hydrocarbons that have between three and eight carbon atoms (C_{3-8}). EX1004 at 5:44-45. Arand also teaches that heavy hydrocarbons contain nine or more carbon atoms (C_{9+}). EX1004 at 5:44-45.

225. Thus, a POSITA would have been motivated to implement Aycaguer's Produced Gas Recycling Plant using the natural gas liquid processing methods described by Soldati, and a POSITA would have been further motivated to use the understanding of natural gas liquids and heavy hydrocarbons found in Arand to identify the constituent hydrocarbons in the mixtures that would result from the separations performed by Aycaguer and Soldati.

2. Claim 1

a. Claim elements [1.P], [1.3], [1.4], [1.5], and [1.6]

226. As explained above for Ground 3, Aycaguer and Soldati teach limitations [1.P], [1.3], [1.4], [1.5], and [1.6]. *Supra* §§ X.A.1.a, X.C.2.b-X.C.2.e.

b. “receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C3-C8 hydrocarbons, and wherein the heavy hydrocarbons comprise C9+ hydrocarbons” [1.1]

227. As explained above for claim element [1.1], Aycaguer teaches this limitation. *Supra* § X.A.1.b.

228. I understand that the Patent Owner may dispute my obviousness opinions. To the extent that the Patent Owner disputes that either (i) a POSITA as of the Priority Date would not have understood that Aycaguer discloses a hydrocarbon feed stream that includes C₃-C₉₊ or (ii) a POSITA as of the Priority Date would not have understood that Aycaguer discloses a hydrocarbon feed stream that includes C₃-C₉₊, this limitation is also taught by Aycaguer in view of Soldati and Arand.

229. As explained above for claim element [1.1], Aycaguer teaches that the hydrocarbon feed stream includes liquid crude oil, which is separated from the NGLs, CO₂, and H₂S (which are gases that are then processed in the gas plant). *Supra* § X.A.1.b. A POSITA would have understood that the crude oil is the heavy condensate of this separation as the NGLs, CO₂, and H₂S are gases that are lighter than the heavier crude oil. Arand discloses that such heavy condensate includes C₉₊. *See* EX1004 at 5:45. The combination of Aycaguer and Arand thus teaches that Aycaguer’s hydrocarbon feed stream includes C₉₊.

230. As explained above for claim element [1.1], Aycaguer also teaches that its hydrocarbon feed includes natural gas liquids. *Supra* at § X.A.1.b. Arand discloses that natural gas liquids include C₃-C₈. EX1004 at 5:44-45. The combination of Aycaguer and Arand thus teaches that Aycaguer's hydrocarbon feed stream includes C₃-C₈. At the very least, a POSITA would have found it obvious to apply the oil and gas processing methods taught in Aycaguer on a feed stream from a reservoir containing C₃-C₈ as expressly taught in Arand. A POSITA would have been motivated to apply the Aycaguer method to a feed stream containing each of C₃-C₈, as taught in Arand, because that would allow the Aycaguer system to work as intended to remove the crude oil (C₉₊), and maximize NGLs (C₃-C₈) for recovery. Such a POSITA would have expected the separation steps taught in Aycaguer to successfully result in a separation of such a feed stream due to the well-known and predictable nature of the distillation and processing steps employed.

231. The combination of Aycaguer, Soldati, and Arand therefore teaches "receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C₃-C₈ hydrocarbons, and wherein the heavy hydrocarbons comprise C₉₊ hydrocarbons."

c. “separating the hydrocarbon feed stream into a heavy hydrocarbon rich stream and a carbon dioxide recycle stream, wherein the heavy hydrocarbon rich stream comprises the C₉+ hydrocarbons, and wherein the carbon dioxide recycle stream comprises the carbon dioxide, the C₃-C₈ hydrocarbons, and the acid gas” [1.2]

232. The combination of Aycaguer, Soldati, and Arand teaches this limitation. As discussed above for claim element [1.2], Aycaguer teaches a hydrocarbon feed stream that is received for processing, and that the feed stream should be separated using a phase separator into a NGL component and a crude oil component. *Supra* § X.A.1.c.

233. I understand that the Patent Owner may dispute my obviousness opinions. To the extent that the Patent Owner disputes that (i) a POSITA as of the Priority Date would have understood that Aycaguer discloses a hydrocarbon feed stream that includes C₃-C₉+, (ii) a POSITA as of the Priority Date would have understood that Aycaguer discloses a carbon dioxide recycle stream that includes C₃-C₈, or (iii) a POSITA as of the Priority Date would have understood that Aycaguer discloses a heavy hydrocarbon rich stream that includes C₉+, Arand provides such understanding.

234. As explained above for claim element [1.2], Aycaguer teaches that the hydrocarbon feed stream includes liquid crude oil, which is separated from the NGLs, CO₂, and H₂S. *Supra* § X.A.1.c. As understood by a POSITA, crude oil is the heavy condensate of this separation, as the NGLs, CO₂, and H₂S are gases that are

lighter than the heavier crude oil. Arand discloses that such heavy condensate includes C₉₊. EX1004 at 5:45. The combination of Aycaguer and Arand thus teaches that Aycaguer's crude oil stream includes the C₉₊, and thus teaches the claimed heavy hydrocarbon rich stream separated from the hydrocarbon feed stream.

235. As explained above for claim element [1.2], Aycaguer also teaches separating the hydrocarbon feed stream into a carbon dioxide recycle stream that contains natural gas liquids. *Supra* at § X.A.1.c. Arand discloses that natural gas liquids range from C₃-C₈. EX1004 at 5:44-45. The combination of Aycaguer and Arand thus teaches that Aycaguer's carbon dioxide recycle stream contains C₃-C₈ hydrocarbons, and thus teaches the claimed carbon dioxide recycle stream. At the very least, for the reasons described for claim element [1.1], a POSITA would have found it obvious to apply Aycaguer's separation methods to a stream containing each of C₃-C₈ as expressly taught in Arand. *See supra* § X.A.1.c.

236. The combination of Aycaguer, Soldati, and Arand therefore teaches "receiving a hydrocarbon feed stream, wherein the hydrocarbon feed stream comprises carbon dioxide, natural gas liquid (NGL), heavy hydrocarbons, and acid gas, wherein the NGL comprises C₃-C₈ hydrocarbons, and wherein the heavy hydrocarbons comprise C₉₊ hydrocarbons."

3. Claims 2–4, 6 & 7

237. As explained above for Ground 3, Aycaguer and Soldati teach the additional limitations of Claims 2–4, 6, and 7. *Supra* §§ X.C.3-X.C.7. And as explained above for Ground 4, Aycaguer, Soldati and Ryan also teach the additional limitations of Claim 2. *Supra* § X.D.2.a-X.D.2.d.

I, David A. Rockstraw, Ph. D., P. E., declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, under Section 1001 of Title 18 of the United States Code.

Dated: 01/22/2024



David A. Rockstraw, Ph. D., P. E.