

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LIBERTY ENERGY, INC. AND LIBERTY OILFIELD SERVICES LLC,
Petitioners,

v.

U.S. WELL SERVICES, LLC,
Patent Owner.

Case IPR2025-00066
Patent No. 10,598,258

DECLARATION OF DR. ROBERT A. DURHAM

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4. 11[c]: “a variable frequency drive connected to the plurality of motors to control the speeds of the plurality of motors; and” 220

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I, Robert A Durham, hereby declare as follows:

I. INTRODUCTION & QUALIFICATIONS

1. My name is Dr. Robert A. Durham. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

2. I have been asked to provide technical assistance in the *inter partes* review of U.S. Patent No. 10,598,258, which I may abbreviate as “the ’258 Patent” or refer to as the “Challenged Patent.” This declaration is a statement of my opinions on issues related to the unpatentability of claims of the ’258 Patent. I am being compensated at my normal hourly rate for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

3. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are stated more fully in my curriculum vitae, which has been provided as Appendix A. My CV also lists publications on which I am a named author and identifies parties on behalf of whom I have previously provided expert testimony within the past four years. Here, I provide a brief summary of my qualifications.

4. I am a consulting engineer with experience in a number of technical areas. I have expertise in the oil and gas industry from drilling and completion to

downstream. I have been working with oil field production companies, refining and chemical plants and equipment manufacturers and technology development companies, as a consultant, for nearly twenty years. My work relates to the subject matter of the '258 Patent, which I describe below in Section VI ("Overview of the Challenged Patent").

5. I received my Bachelor of Science in Electrical Engineering and Master of Engineering and Technology Management degrees, from the University of Tulsa in 1992 and 1997, respectively. After years of professional work and research I received my Ph.D. in Engineering Management from Kennedy Western University in 2004.

6. I have also served in positions of leadership in the Petroleum and Chemical Industry Committee (PCIC) of the Institute of Electrical and Electronics Engineers (IEEE) for nearly twenty years. IEEE is the world's largest technical professional association. The PCIC is the premier forum for the exchange of electrical applications technology related to the petroleum and chemical industry. From 2005 – 2012, I served as secretary, then vice chair and then ultimately chair of the Production Subcommittee of the PCIC. The Production Subcommittee is the primary method for PCIC members to communicate technical papers related to drilling, well head, and facilities operations of oil and gas wells. In 2013, I was appointed as Vice-Chair of the Standards Subcommittee of the PCIC, a role which

transitioned to Chair in 2014. I served as Chair until 2022. The Standards Subcommittee of the PCIC is the Sponsor of IEEE standards relating to electrification and electrical equipment operations in the Oil and Gas Industry. The PCIC Standards Subcommittees sponsors nearly 50 electrical and oil and gas related standards. In September 2022, I was elected as an Executive Officer of the PCIC. I will serve as an Executive Officer for a total of eight years, serving two-year terms in each of the following positions: Secretary; Vice Chair; Chair; and Chair of Advisory and Awards.

7. My peers have recognized my contributions, particularly in the area of electrical equipment in the oil and gas industry. Because of this recognition, in 2019 I was elevated to the grade of Fellow of the IEEE for “contributions to submersible electrical equipment analysis and multi-point ground methods in hazardous petroleum and chemical environments.” The IEEE Fellow grade is limited to the top 0.1% of the membership of IEEE worldwide.

8. I have worked directly in the area of electrification of oil and gas fields both as an employee and as a consulting engineer. From 2000 until the end of 2002, I was employed as Manager of Electric Infrastructure for New Dominion, LLC (NDL). In that capacity I administratively owned and was responsible for all electrical equipment including overhead power lines, transformers, switchgear, drives and motors throughout NDL’s production, exploration and drilling areas.

9. After a brief stint as Vice President for EDG Power Group, responsible for Engineering and Project Management of generation and co-generation facilities across the U.S., I transitioned to the role of consulting engineer. In that role I have served as consulting engineer relating to the design, construction, and analysis of all kinds of power systems, especially those in the oil and gas industry. This has included not only design and selection of equipment but also analysis of failures of equipment in the oil and gas field from drilling / completion sites to production facilities, midstream and downstream (refinery) locations.

10. In addition, I am a principal of PEDOCS, Inc., an oil and gas production company operating over 50 oil and gas production wells in Oklahoma. As such, I am familiar with operations of oil and gas wells including well stimulation, completion, hydraulic fracturing and production.

11. I have been familiar with oil and gas drilling, fracturing (fracking), completion, production, midstream and downstream operations for over twenty years.

12. I have been familiar with power distribution, including generation transmission and distribution equipment. As an employee I worked as a design and construction engineer for generation facilities for Central and Southwest (now American Electric Power AEP). I was also responsible for design and construction of generation facilities when employed by EDG Power Group, as discussed above.

While at AEP, I spent three years as a transmission planner, responsible for modeling transmission systems and developing plans for increased power distribution capacities at high voltages. While at New Dominion LLC, I owned and was responsible for design, construction and maintenance of several hundred miles of medium voltage (5 – 25 kV) distribution lines, switchgear, drives and motors used for oil and gas drilling, completion and production. Over the last ~ 20 years I have consulted with numerous clients ranging from utilities to oil and gas development and production companies on the design, upgrades and maintenance of generation and power distribution facilities.

13. I have been familiar with the design, installation, tuning, and programming of process control systems for nearly my entire career. As an engineering intern, and later as engineer, for Central & Southwest (now AEP), I was responsible for the design, configuration and installation of control systems for continuous process operations in power generation applications. These included relatively simple systems, such as process air control or treatment of water for general use, so called “service water”. Additionally, I worked on much more advanced control systems such as boiler water feed, ASD (VFD) control for combustion air, and control of the entire steam generating, recovery and reuse process for steam driven turbines. As chief electrical engineer (later VP of Engineering & PM) at EDG Power Group, I had primary responsibility for the design

and configuration of control systems for gas turbine generators, as well as heat recovery systems to heat water for use in associated applications, such as refinery steam or hot water driven heating / cooling operations. Further, I have consulted on several control system projects, both inside and outside the oil and gas industry, over the past 20 plus years as a consultant. I am a licensed professional controls engineer.

14. I have been familiar with Occupational Safety and Health Administration (“OSHA”) and its responsibilities at oil and gas locations. I have consulted and investigated incidents on multiple oil and gas sites where OSHA has also performed investigations with regard to injuries and fatalities that have occurred at oil and gas locations, including drilling, fracturing and completion operations. As Principal Scientist of THEWAY Labs, part of my responsibilities include overseeing the Health Safety and Environmental (HSE) program at THEWAY Labs, including establishing policies and procedures commensurate with OSHA requirements at all locations, including requirement for oil and gas sites.

15. I am the author or co-author of over fifty published papers and five books. A list of publications that I have authored over the last thirty years is included in my professional CV, which is attached as Appendix A.

16. Therefore, based on my education, professional experience of over 30 years, and scholarly books and publications, I am an expert in the relevant field of the '258 Patent and have been an expert in this field since before the '258 Patent was

filed with the United States Patent and Trademark Office (“USPTO”). I am familiar with how a person having ordinary skill in the art would have understood and used the terminology found in the ’258 Patent at the time of filing.

II. TASK SUMMARY AND MATERIALS REVIEWED

17. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged Patent, to review certain prior-art references, and analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent. The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art (POSITA).

III. LIST OF EXHIBITS

18. In forming my opinions, I have reviewed the Challenged Patent, its prosecution history and references cited by the Examiner, the materials cited in the List of Exhibits, and the materials cited throughout my declaration.

Ex.	Description
1001	U.S. Patent No. 10,598,258 to Oehring <i>et al.</i> entitled “Multi-plunger Pumps and Associated Drive Systems” (the “’258 Patent”)
1002	File History for U.S. Patent No. 10,598,258
1003	Declaration of Dr. Robert Durham

1004	U.S. Patent Publication No. 2020/0256429 to Buckley, “Electric Drive Pump for Well Stimulation,” (“ <i>Buckley</i> ”) filed September 25, 2018 and published August 13, 2020.
1005	U.S. Provisional Application No. 62/562,943 to Buckley <i>et al.</i> , “Electric Drive Pump for Well Stimulation,” (“ <i>Buckley Provisional</i> ”) filed September 25, 2017.
1006	U.S. Patent Publication No. 2015/0361736 to Bergan <i>et al.</i> , “Heave Compensation Winches,” (“ <i>Bergan</i> ”), filed June 13, 2014 and published December 17, 2015.
1007	United States Patent No. 4,100,822 to Rosman, “Drive System for a Moving Mechanism,” (“ <i>Rosman</i> ”) filed April 19, 1976 and granted July 18, 1978.
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1038	Intentionally omitted
1039	Claim Listing for Claims of '258 Patent
1040	Intentionally omitted
1041	Intentionally omitted
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IV. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE

19. After reviewing the materials identified in the List of Exhibits, I have concluded that each of the Challenged Claims of the '258 Patent would have been obvious to a person of ordinary skill in the art, based on the following grounds.

Ground	'258 Claims	Basis for Challenge
1A	1, 3, 6	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i>
1B	1, 3, 6	Obvious over <i>Yi</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i>
2A	4, 5	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Tutterow</i>

2B	4, 5	Obvious over <i>Yi</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Tutterow</i>
3A	7, 15, 17	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
3B	7, 15, 17	Obvious over <i>Yi</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
4A	2, 16	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , <i>Rosman</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
4B	2, 16	Obvious over <i>Yi</i> in view of <i>Bergan</i> , <i>Rosman</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
5A	8-11, 13	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i>
5B	8-11, 13	Obvious over <i>Yi</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i>
6A	12	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , <i>Payne</i> , <i>Rosman</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
6B	12	Obvious over <i>Yi</i> in view of <i>Bergan</i> , <i>Payne</i> , <i>Rosman</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>

7A	14	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Tutterow</i>
7B	14	Obvious over <i>Yi</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Tutterow</i>
8A	18	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> , <i>Tutterow</i> , and <i>Nesbitt</i>
8B	18	Obvious over <i>Yi</i> in view of <i>Bergan</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> , <i>Tutterow</i> , and <i>Nesbitt</i>
9A	19, 20	Obvious over <i>Buckley</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>
9B	19, 20	Obvious over <i>Yi</i> in view of <i>Bergan</i> , <i>Payne</i> , the Knowledge of a POSITA and, in the alternative, <i>Jelaska</i> and <i>Nesbitt</i>

V. LEGAL STANDARDS

A. LEVEL OF ORDINARY SKILL IN THE ART

20. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to the patent-in-suit as well as the level of ordinary skill in that art at the time of the claimed invention. The “art” is the field of technology to which the patent is related.

21. I have been instructed by counsel that the person of ordinary skill in the art (“**POSITA**”) is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of ordinary skill. I further understand that the factors that may be considered in determining the level of skill include: the types of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

B. LEGAL STANDARD FOR CLAIM CONSTRUCTION

22. I understand that the first step in determining whether a patent claim would have been anticipated or obvious is to ascertain how a POSITA would have understood the claim terms.

23. I have been instructed by counsel on the law regarding claim construction and patent claims, and I understand that a patent may include two types of claims: independent claims and dependent claims. An independent claim stands alone and includes only the limitations it recites. A dependent claim can depend from an independent claim, or it can further depend from another dependent claim. I understand that a dependent claim includes all the limitations that it recites, in addition to all the limitations recited in the claim(s) from which it depends.

24. It is my understanding that in proceedings before the USPTO, the claims of a patent are to be construed under what is referred to as the “Phillips standard.” I understand that this means that claim terms of a patent are given the meaning the terms would have to a POSITA, in view of the description provided in the patent itself and the patent’s file history.

25. I understand that to determine how a person of ordinary skill would understand a claim term, one should look to those sources available that show what a person of skill in the art would have understood the disputed claim language to mean. I understand that, in construing a claim term, one looks primarily to the intrinsic patent evidence, including the words of the claims themselves, the remainder of the patent, and the patent’s prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

26. I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the remainder of the patent, and the prosecution history are of paramount importance. Additionally, the patent and its prosecution history must be consulted to confirm whether the patentee has acted as its own lexicographer (i.e., provided its own special meaning to any

disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

27. In comparing the claims of the Challenged Patent to the prior art, I have considered the Challenged Patent and its file history in light of the understanding of a person of skill at the time of the alleged invention.

C. ANTICIPATION

28. It is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in a single prior art reference or system. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily or implicitly present in the allegedly anticipating reference, and that it would have been so recognized by a POSITA. In addition, I understand that an enabling disclosure is a disclosure that allows a POSITA to make the invention without undue experimentation. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the primary reference has enabling disclosure, to explain the meaning of a term used in the primary reference, and/or to show that a characteristic is inherent in the primary reference.

D. OBVIOUSNESS

29. I understand that the prior art may render a patent claim “obvious.” I understand that two or more prior art references (e.g., prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way. I understand that this motivation to combine need not be explicit in any of the prior art, but may be inferred from the knowledge of one of ordinary skill in the art at the time the patent was filed. I also understand that one of ordinary skill in the art is not an automaton, but is a person having ordinary creativity. I further understand that one or more prior art references, articles, patents or publications that disclose fewer than all of the elements of a patent claim may render a patent claim obvious if including the missing element would have been obvious to one of skill in the art (e.g., the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system).

30. I understand that under the doctrine of obviousness, a claim may be invalid if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a POSITA to which the subject matter pertains.

31. To assess obviousness, I understand that I am to consider the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and any secondary considerations to the extent they exist.

32. I understand that any evidence of secondary indicia of non-obviousness should be considered when evaluating whether a claimed invention would have been obvious to one of ordinary skill at the time of invention. These secondary indicia of non-obviousness may include, for example:

- a long felt but unmet need in the prior art that was satisfied by the claimed invention;
- commercial success of processes claimed by the patent;
- unexpected results achieved by the invention;
- praise of the invention by others skilled in the art;
- the taking of licenses under the patent by others; and
- deliberate copying of the invention.

33. I understand that there must be a nexus between any such secondary indicia and the claimed invention.

34. It is also my understanding that there are additional considerations that may be used as further guidance as to when the above factors will result in a finding that a claim is obvious, including the following:

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;

- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- the claimed subject matter would have been “obvious to try” choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that 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 a POSITA;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent’s claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

35. Finally, I understand that a claim may be deemed invalid for obviousness in light of a single prior art reference, without the need to combine references, if the elements of the claim that are not found in the reference can be supplied by the knowledge or common sense of one of ordinary skill in the relevant art.

E. PRIORITY DATE

36. I understand that, subject to the next paragraph, the asserted “priority date” of a patent is the earlier of: (a) the date on which a patent application is filed;

or (b) the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application.

37. I understand that it is not enough for a patent to merely claim the benefit of an earlier-filed application, but that additional criteria must be met. In particular, the prior application itself must describe the claimed invention, and must do so in sufficient detail that one skilled in the art can clearly conclude that the inventor invented the claimed invention as of the filing date sought. First, I understand that a priority-date analysis is on a claim-by-claim basis. Second, I understand that, in order for a patent claim to be entitled to the filing date of an earlier patent application, a “Section 112 analysis” must be conducted. I am informed that a “Section 112” analysis encompasses looking to the earlier patent application, and ascertaining whether that earlier patent application meets both the written-description and enablement requirements as of the filing date of the earlier application. I understand that it is not enough that the claim would have been obvious from the earlier application, but that application itself must describe the claimed invention.

38. I understand that in order to satisfy the written description requirement the earlier application must reasonably convey to those skilled in the art that the inventors had possession of the subject matter of the patent as of the filing date of the earlier application. I have been informed that it is the disclosures of the earlier patent application that count, and that while the meaning of terms, phrases, or

diagrams in the earlier patent application must be interpreted from the vantage point of one skilled in the art, all of the claimed limitations must appear in the specification. Further, I understand that this analysis is not a question of whether one skilled in the art might be able to construct the claimed invention from the teachings of the disclosure. The question is not whether a claimed invention is an obvious variant of that which is disclosed in the specification; rather, I understand that an earlier application must itself describe each of the claim limitations.

39. I also understand that in order to satisfy the enablement requirement, the earlier application must enable a person of ordinary skill in the art to practice the claimed invention without undue experimentation.

VI. OVERVIEW OF THE CHALLENGED PATENT

40. I have reviewed U.S. Patent No. 10,655,435 (“the ’258 Patent”), which is entitled “Smart Fracturing System and Method.” I understand that the patent was filed on October 25, 2018, and that it was issued on May 19, 2020. The ’258 Patent claims priority to Provisional application No. 62/577,056 filed on October 25, 2017.¹

¹ Ex. 1001 Cover.

A. THE SUBJECT MATTER OF THE CHALLENGED PATENT

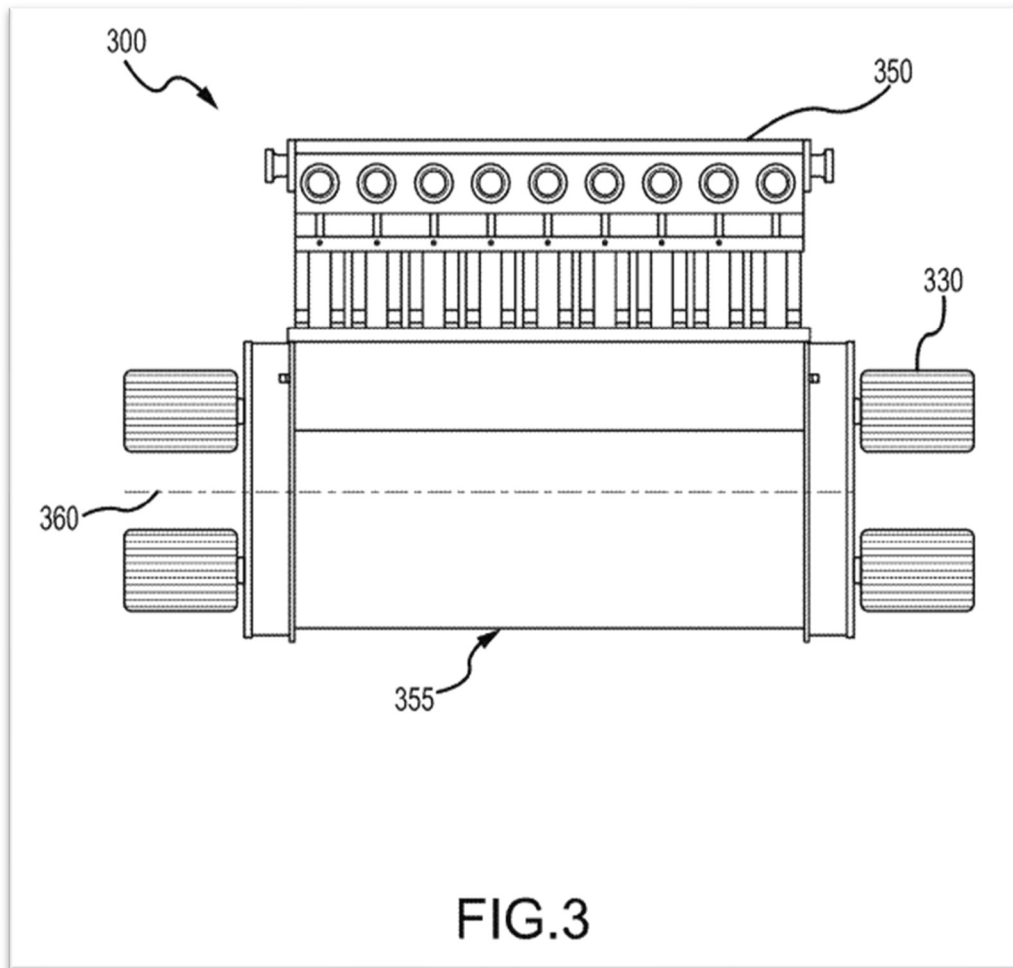
41. The '258 Patent generally relates to “drive systems for reciprocating plunger-style pumps used in hydraulic fracturing operations, and more particularly to multi-plunger hydraulic fracturing pumps and associated drive systems.”²

42. The system taught by the '258 Patent includes a “multi-plunger hydraulic pump” that is powered by a “plurality of motors,” which may be electric motors or hydraulic motors.³ Figure 3 of the '258 Patent depicts this configuration:⁴

² Ex. 1001, 1:16-19.

³ Ex. 1001, 2:46-67.

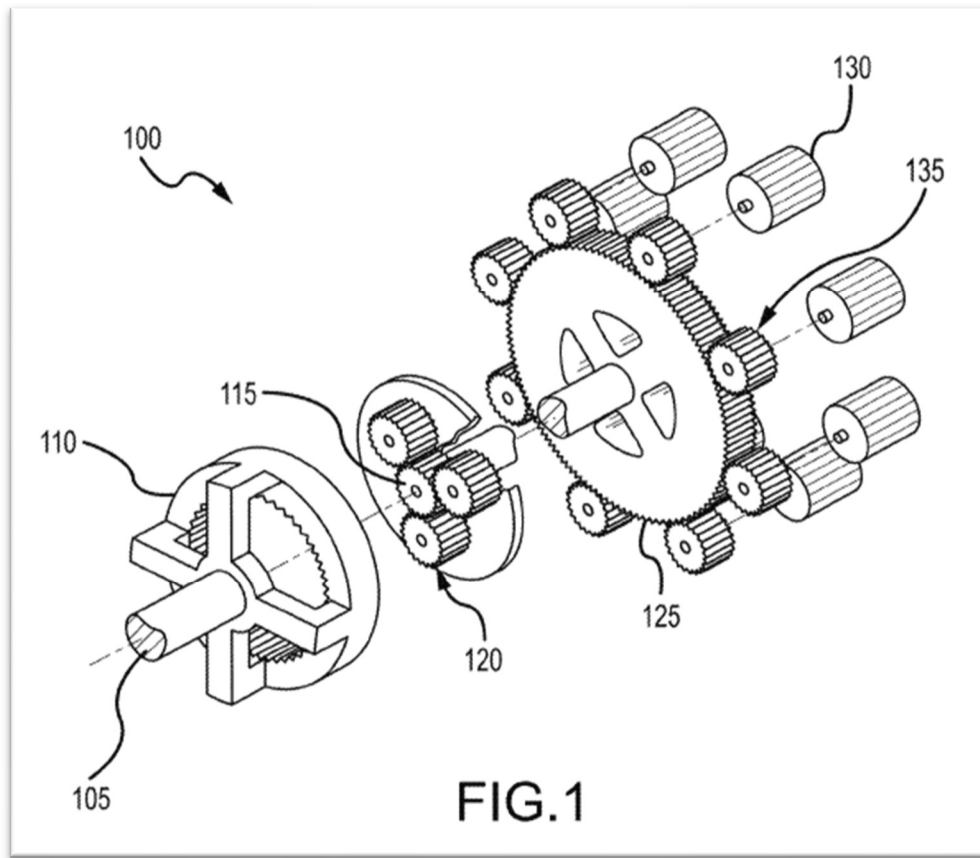
⁴ Ex. 1001 ('258 Patent), Fig. 3 (showing pump 300, multi-plunger fluid end 350, motors 330, and crankshaft centerline 360, *id.*, 8:33-46).



43. The system further includes a “planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors.”⁵ An example of this planetary gear train is depicted in Figure 1 below:⁶

⁵ Ex. 1001, 2:53-57.

⁶ Ex. 1001, Fig. 1.



44. The system may further include “a plurality of speed reduction gearboxes positioned between the plurality of input pinion gears and the plurality of motors.”⁷ Further, the electric motors may be connected to a “variable frequency drive (VFD)” that “control[s] the speed of the plurality of motors.”⁸ The VFD may “be configured to automatically shut off in the event of an overpressure event.”⁹

⁷ Ex. 1001 2:61 – 63.

⁸ Ex. 1001 3:16 – 18.

⁹ Ex. 1001 3:25 - 27.

B. THE CHALLENGED CLAIMS OF THE '258 PATENT

45. The Challenged Claims of the '258 Patent, which are Claims 1-20, are set forth below. Some of the claim elements have been further sub-divided for ease of reference.

Ex.	Description
1[p]	1. A hydraulic fracturing system for fracturing a subterranean formation comprising:
1[a]	a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;
1[b]	a plurality of motors positioned to simultaneously power the multi-plunger pump; and
1[c]	a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors,
1[d]	wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.
2	2. The system of claim 1, the system further comprising a plurality of speed reduction gearboxes positioned between the plurality of input pinion gears and the plurality of motors so as to achieve a desired pump rate.
3	3. The system of claim 1, wherein the plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors.
4	4. The system of claim 1, wherein the maximum pump speed correlates to a critical plunger speed associated with the multi-plunger hydraulic fracturing pump.

5	5. The system of claim 1, wherein the maximum pump speed is 5% or less over a critical plunger speed associated with the multi-plunger hydraulic fracturing pump.
6	6. The system of claim 1, wherein the multi-plunger hydraulic fracturing pump comprises an odd number of plungers greater than or equal to five plungers.
7	7. The system of claim 6, wherein a stroke length of each of the plungers associated with the multi-plunger hydraulic fracturing pump is selected to inversely relate to a pump speed associated with the multi-plunger hydraulic fracturing pump so as to achieve a predetermined flow rate.
8	8. The system of claim 1, further comprising: a variable frequency drive (VFD) connected to the plurality of motors to control the speed of the plurality of motors, wherein the VFD is positioned to accelerate or decelerate pump rotational speeds associated with the multi-plunger hydraulic fracturing pump.
9	9. The system of claim 8, wherein the VFD comprises a plurality of VFDs and wherein the plurality of VFDs are configured to share a load required to power the multi-plunger hydraulic fracturing pump.
10	10. The system of claim 9, wherein the plurality of VFDs are configured to automatically shut off in the event of an overpressure event with respect to the multi-plunger hydraulic fracturing pump.
11[p]	11. A hydraulic fracturing system for fracturing a subterranean formation comprising:
11[a]	a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;

11[b]	a plurality of motors positioned to simultaneously power the multi-plunger pump;
11[c]	a variable frequency drive connected to the plurality of motors to control the speeds of the plurality of motors; and
11[d]	a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors,
11[e].	wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.
12	12. The system of claim 11, the system further comprising a plurality of speed reduction gearboxes positioned between the plurality of input pinion gears and the plurality of motors so as to achieve a desired pump rate.
13	13. The system of claim 11, wherein the plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors.
14	14. The system of claim 11, wherein the maximum pump speed correlates to a critical plunger speed associated with the multi-plunger hydraulic fracturing pump.
15[p]	15. A method for pumping fluid into a wellbore associated with a subterranean formation, the method comprising:
15[a]	fluidly connecting a multi-plunger hydraulic fracturing pump to a well associated with the subterranean formation such that the multi-plunger pump pumps fluid into the wellbore at a high pressure so that fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;
15[b]	simultaneously powering the multi-plunger pump with a plurality of motors;
15[c]	providing a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors so as to translate power from the plurality of motors into a desired pump rate of the multi-plunger pump.

16	16. The method of claim 15, further comprising: positioning a plurality of speed reduction gearboxes between the plurality of input pinion gears and the plurality of motors so as to achieve the desired pump rate.
17	17. The method of claim 15, wherein the plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors.
18	18. The method of claim 15, wherein the maximum pump speed correlates to a critical plunger speed associated with the multi-plunger hydraulic fracturing pump.
19	19. The method of claim 15, further comprising: connecting a variable frequency drive (VFD) to the plurality of motors so as to control the speed of the plurality of motors, wherein the VFD is positioned to accelerate or decelerate pump rotational speeds associated with the multi-plunger hydraulic fracturing pump
20	20. The method of claim 19, the method further comprising: detecting an overpressure event with respect to the multi-plunger hydraulic fracturing pump; and automatically shutting off the VFD.

C. PROSECUTION HISTORY OF THE '258 PATENT

46. The Patent Office issued a first Non-Final Office Action on July 3, 2019, rejecting claims 1-3, 6, 7, and 15-17 as being obvious over U.S. Patent Publication 2017/0051732 (“*Hernandez*”) in view of U.S. Patent No. 4,100,822 (“*Rosman*”), rejecting claims 4, 5, and 18 as being obvious over *Hernandez* in view of *Rosman* and U.S. Patent No. 8,851,860 (“*Mail*”), rejecting claims 8-13 and 19-20 as obvious over *Hernandez* in view of *Rosman* and U.S. Patent Publication 2016/0258267 (“*Payne*”), and rejecting claim 14 as obvious over *Hernandez* in view

of *Rosman and Payne*.¹⁰ In response, the Applicant amended independent claims 1, 11, and 15 to recite that the claimed “plurality of motors [are] positioned to simultaneously power the multi-plunger pump.”¹¹

D. PRIORITY DATE OF THE '258 PATENT

47. The application leading to the '258 Patent was filed on December 5, 2018 as Application 16/210,807 and claimed priority to provisional application No. 62/594,912, which was filed on December 5, 2017.¹² For purposes of this Declaration, I assume that the priority date of the '258 Patent is December 5, 2017, the effective filing date of the 62/594,912 Provisional Application.

VII. LEVEL OF ORDINARY SKILL IN THE ART

48. A person of ordinary skill in the art would have either (1) a Bachelor of Science in Mechanical Engineering, Electrical Engineering, Petroleum Engineering or an equivalent field as well as at least 2 years of academic or industry experience in the oil and gas industry, including well drilling, completion, or production, or (2) at least four years of industry experience in the oil and gas industry including well drilling, completion, or production.

¹⁰ Ex. 1002, 115-127.

¹¹ Ex. 1002, 99-102.

¹² Ex. 1001 Cover.

VIII. CLAIM CONSTRUCTION

49. It is my opinion that a POSITA would understand all the claim terms to have their plain and ordinary meaning, and I have applied the plain and ordinary meaning, in the context of the '258 Patent, for all claim terms.

IX. TECHNOLOGY BACKGROUND AND STATE OF THE ART

50. In the subsections below, I describe some of the basic principles of engineering that would have been used, or at least considered for use, on a hydraulic fracturing site. The principles discussed in the subsections below would have been well-known to a POSITA in the 2018 timeframe, and long before.

A. HISTORY OF HYDRAULIC FRACTURING

51. Fracturing the hydrocarbon-bearing formations is a technique that has been used to increase or speed up oil and gas production for nearly as long as oil and gas production has existed. As early as the 1850's fracturing methods used explosives such as gunpowder ignited by red-hot iron or nitroglycerin "torpedoes."¹³ Hydraulic fracturing, in its modern form of pumping using pumps and valves to control fluids and proppants (*e.g.*, sand) pumped into the formation, began in the 1940s using a process developed by Stanolind Oil and used by Halliburton in the

¹³ Ex. 1017 (*Morton*).

mid-continent region.¹⁴ Early hydraulic fracturing in the 1940s and 1950s used frac pumps that could operate at around 1500 Hp.¹⁵



52. The expansion of directional and horizontal drilling extended the use of hydraulic fracturing into previously underdeveloped “tight” formations, including shale.¹⁶ In oil and gas exploration, directional drilling is a technique for accessing hydrocarbon-bearing formations (oil and gas formations) that are not located immediately beneath the surface location or to increase the amount of formation exposed to the wellbore. In directional drilling, some tool or process is used to cause the wellbore to deviate from the vertical to reach previously inaccessible formation locations, to expose more of the hydrocarbon-bearing formation to the wellbore, or to drill several wells from a single surface location, such as an offshore platform or

¹⁴ Ex. 1043 (*Wells*).

¹⁵ Ex. 1044 (*Montgomery*) pg 26.

¹⁶ Ex. 1017 (*Morton*).

a land-based drilling pad. Like most oil and gas industry developments “the early drilling of directional wells was clearly motivated by economics.”¹⁷ The offshore fields of California spawned the technology that led to modern directional and horizontal drilling. In the 1930s, directional drilling was used in the Huntington Beach, California field to reach an offshore oil-bearing formation from a well initiated on an onshore pad.

53. Throughout the 1980s, directional drilling increased, particularly on offshore pads and in the Austin Chalk trend of central Texas. Horizontally deviated wells were drilled into the chalk to intersect several of the natural fractures, allowing for transport of the hydrocarbons into the wellbore. This was combined with artificial fracturing to increase the flowrate of hydrocarbons. By at least 1986, horizontal drilling techniques were well-known and heavily developed. In 1986, the “first successful multifracture horizontal well is drilled in Wayne County, West Virginia.”¹⁸ This well used directional drilling to cause the wellbore to enter a more or less horizontal orientation (parallel to the surface of the earth) and combined it with advanced hydraulic fracturing techniques to not only expose large lengths of the hydrocarbon formation to the wellbore, but also to create artificial cracks or

¹⁷ Ex. 1045 (*Bourgoyne*) pg 351.

¹⁸ Ex. 1046 (*Vassiliou*) xliii.

“fractures” in the formation from multiple locations to allow the hydrocarbons to “leak” out of the formation into the wellbore.

54. The use of horizontal drilling and fracturing systems in shale formations led to the United States vastly increasing its oil and especially natural gas production—starting in the 1980s and continuing to the present day.¹⁹



55. As more formation is exposed to be fractured, horizontal wells use much higher volumes of fracturing fluid and proppant than vertical wells. This requires the use of more and bigger blending and pumping systems. As discussed by

¹⁹ Ex. 1043 (*Wells*) at 9 (showing a 2011 map from the Energy Information Administration showing shale plays where hydraulic fracturing is common).

Sanborn, pumping systems of 32,000 hp were typically used as early as 2012 with the pumps being driven by electric motors and VFDs.²⁰ Other references, such as *Coli*, suggest systems of pumps as large as 2,500 hp each, being driven by electric motors with VFDs, with total system power as high as 40,000 hp were used in the same period (four trailers, each with four 2500 hp pumps operating in parallel).²¹ These pumps are typically triplex or quintuplex positive displacement (plunger) type pumps.²²

B. TYPES OF PUMPS – FRACTURING PUMP CHAIN

56. The basics of hydraulic fracturing have not changed significantly since 1949 when Halliburton first commercialized the “hydrafrack” process.²³ Hydraulic fracturing still involves pumping water (or another fluid) blended with a proppant (*e.g.*, sand) and other chemicals into the downhole reservoir at a sufficient pressure to crack (fracture) the downhole rock. The sand-water mixture is then forced into the cracks, where the sand keeps the cracks (fractures) open to allow hydrocarbons, such as oil and natural gas, to flow out of the formation into the well bore. What has changed are the pressures and flow rate of the fracturing jobs, the sizes of equipment and the particular proppants, chemicals, and liquids used.

²⁰ Ex. 1047 (*Sanborn*) [0005], [0009], [0012], [0017] – [0018], [0038], [0040].

²¹ Ex. 1048 (*Coli*) [0009], [0011], [0013], [0014], [0016] - [0018], [0049], [0065] – [0066], FIG. 2

²² Ex. 1047 (*Sanborn*), at [0005]; Ex. 1021 (*Coli*), at [0011].

²³ Ex. 1017 (Morton), 87.

57. A modern fracturing process requires multiple pumps operating together as a system to provide fracturing fluid with the suitable composition at the right flow rate²⁴, and at a pressure sufficient to fracture the formation. At the beginning of the pumping chain are the water transfer pumps. These pumps operate at a relatively low pressure to move water from storage (e.g., ponds, tanks) to the blender or the hydration unit.

58. In the blender, the water is mixed with a proppant, such as sand, resin-coated sand, or ceramics, to form the fracturing slurry. Other chemicals, such as acids, gels, friction reducers, biocides, and the like, are added to the slurry. Dry products, such as sand, are transported into the blender tub using gravity, conveyors, or augers. Liquid products, such as acids, are transported into the blender tub using various sizes and types of pumps. These are typically relatively small horsepower pumps operating at lower pressures, as the blender tub operates at more or less ambient pressures.

59. Once the fracturing slurry is blended to the proper makeup and consistency, it is transferred to the fracturing pumps using a blender discharge pump. This pump typically operates at a higher pressure than the water or chemical transfer pumps for several reasons. First, the viscosity of the slurry is typically higher than

²⁴ “Flowrate,” “flow rate,” “flow-rate,” and “pump rate” are used interchangeably in the industry and herein.

that of water, which requires higher pressures to move the same volume of slurry. Second, the slurry is heavier than plain water, requiring additional horsepower to move the slurry (as compared to plain water). Finally, the large fracturing pumps are piston (or plunger) positive displacement pumps, requiring a higher suction (input) pressure to ensure flow sufficient to prevent cavitation, as explained below.

60. A common type of pump used in fracturing operations is a plunger (piston) pump. A fracturing plunger (or piston) pump works similarly to a car engine without the step of igniting the fuel to provide energy to the shaft. In a plunger (piston) pump, the shaft is rotated by an external power source, such as an engine or electric motor. Pistons (plungers), typically 3-5, are arranged along the shaft and connected so that the rotational motion of the shaft is translated into the linear motion of the pistons. As the shaft rotates, the plunger (piston) moves away from the head, creating suction which draws the slurry into the piston chamber. As the plunger (piston) moves toward the head, pressure is created which drives the fluid out of the chamber and down the line to and into the wellbore.

61. One example of a plunger pump commonly used in fracturing is a Gardner Denver “GD-2500Q Quintuplex Well Servicing Pump.” Gardner Denver describes the GD-2500Q as a “high horsepower, high rod load multi-purpose pump for various applications such as oil and gas well fracturing and acidizing.”²⁵ Gardner

²⁵ Ex. 1016 (Gardner) pg 9.

describes that “[t]he GD-2500Q quintuplex pump uses only two major assemblies: power end and fluid end.”²⁶ A “quintuplex”²⁷ pump has 5 cylinders. In the case of the GD-2500Q Gardner provides Figure 2.1 which shows the dimensions and key components of the GD02500Q.

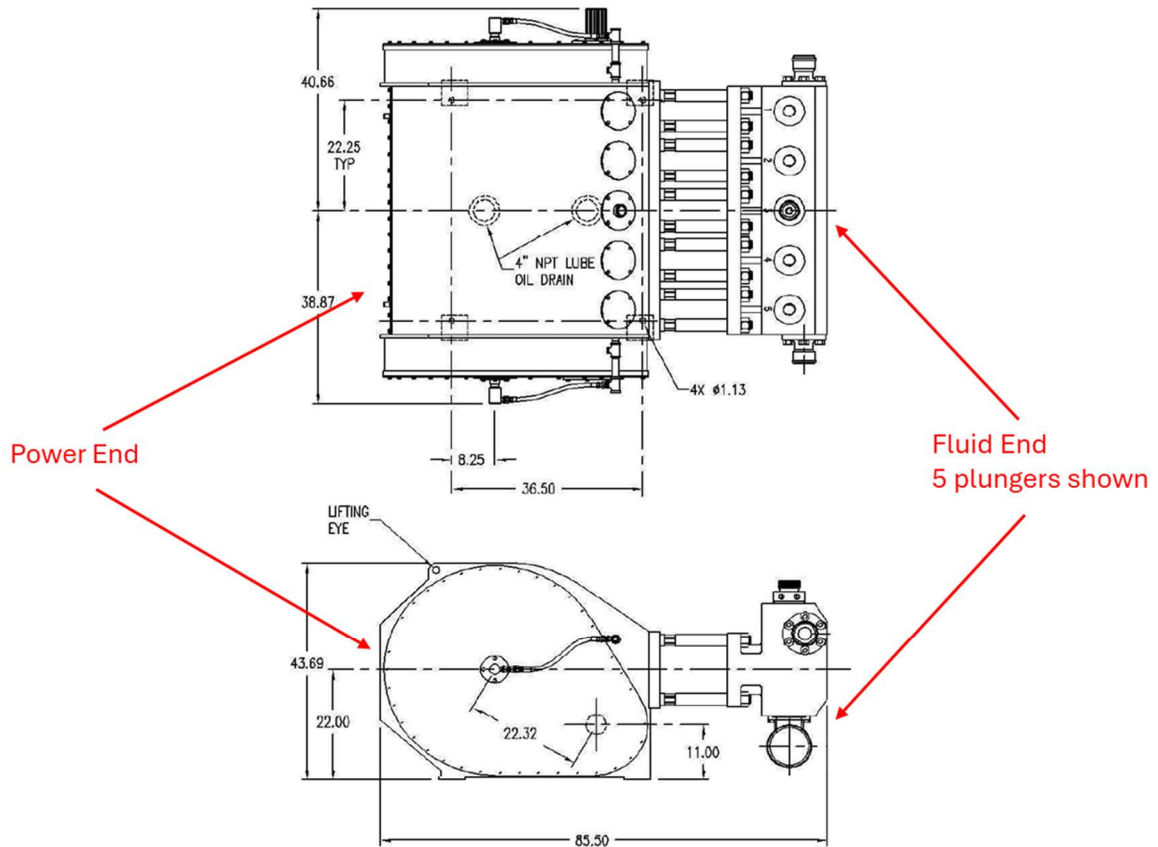


FIGURE 2-1: GD-2500Q Pump

Ex. 1016 (Gardner) Figure 2.1

²⁶ Ex. 1016 (Gardner) pg. 10.

²⁷ See, e.g., Ex. 1018 (Merriam-Webster online dictionary definition of “quintuple”: “having five units or members”).

Figure 2-5 Provides further detail of the fluid end, showing the front suction covers for 5 plunger cylinders.

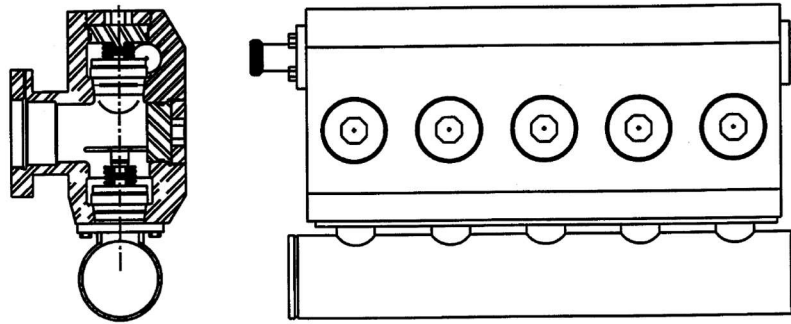


FIGURE 2-5: GD-2500Q Fluid End

62. A key characteristic of these type of fracturing pumps is that the same amount of liquid is discharged from the pump with every stroke, largely independent of the pressure downstream. For example, *Marks* (Ex. 1019) teaches that “[a] displacement pump (also called positive-displacement or just p-d) is a pump which imparts energy to the pumpage (the material pumped) by trapping a fixed volume at suction (inlet) conditions, compressing it to discharge pressure, then pushing it into the discharge (outlet) line.”²⁸ Further, *Marks*’ teaches reciprocating pump is a displacement pump which reciprocates the pumping element (piston, plunger or diaphragm). The capacity of a reciprocating pump is proportional to its speed and is relatively independent of discharge pressure.”²⁹

²⁸ Ex. 1019 (*Marks*) pg 14-2.

²⁹ Ex. 1019 (*Marks*) pg 14-2.

63. Accordingly, the flow rate of a positive displacement pump is a function of the “fixed volume” trapped in the cylinder and the number of times that the cylinder is emptied in a given period of time. The “fixed volume” of the cylinder is a function of the cylinder cross sectional area (CSA) and the stroke length. The CSA is a function of the cylinder diameter (d).³⁰

$$CSA = \frac{\pi d^2}{4}$$

$$volume = \frac{\pi d^2}{4} \times stroke length$$

The number of times the cylinder is emptied is a function of the pump speed. For a given pump arrangement, as speed goes up, the number of times the cylinder is emptied increases and flowrate increases and vice versa. Similarly, at a given speed if stroke length or cylinder diameter increase, the fixed volume goes up and flowrate increases. For a fixed flowrate, the required pump speed is inversely related to both stroke length and cylinder diameter. In other words, if the fixed volume increases, the number of times the cylinder must be emptied would decrease, assuming volume does not change.

64. As one example, Gardner provides specifications of the GD-2500Q Quintuplex well servicing pump. Specifications of the pump indicate a stroke length

³⁰ Ex. 1014 (*Nesbitt*), 140 (showing “displacement” of a single-cylinder pump to be the CSA of the cylinder multiplied by the stroke length).

of 8.0 inches.³¹ As shown below, the GD-2500Q is available with plunger size (diameters) between 3.75 and 6.75 inches. The table provides flowrates for pump speeds between 100 and 330 RPM.

Plunger Size	Displacement per Revolution	Displacement at Pump RPM - Well Stimulation Application							
		100		150		250		330	
in.	gal/rev.	GPM	PSI	GPM	PSI	GPM	PSI	GPM	PSI
3.75	1.91	191	17800	287	13500	478	8100	631	6100
4	2.17	217	15600	326	11800	544	7100	718	5400
4.5	2.75	275	12400	413	9300	688	5600	908	4200
5	3.40	340	10000	510	7600	850	4500	1121	3400
5.5	4.11	411	8300	617	6300	1028	3800	1357	2800
5.75	4.49	449	7600	674	5700	1124	3400	1483	2600
6	4.89	489	6900	734	5300	1223	3200	1615	2400
6.5	5.74	574	5900	861	4500	1436	2700	1895	2000
6.75	6.19	619	5500	929	4200	1548	2500	2044	1900
Input Power	BHP	2200		2500		2500		2500	

Ex. 1016 (Gardner) pg 14

65. Since in the GD-2500Q the stroke length is fixed, the relationship between speed, plunger size and flowrate is shown in the table. For example, for a flow of ~620 GPM, a POSITA could select: a 6.75" plunger size and operate just above 100 RPM; a 5.5" plunger size and operate a little above 150 RPM; a 4.5" plunger size and operate below 250 RPM; or a 3.75" plunger size and operate at a

³¹ Ex. 1016 (Gardner) pg 14.

little below 330 RPM. Thus, there is an inverse relationship between volume (stroke length and plunger size) and flowrate.

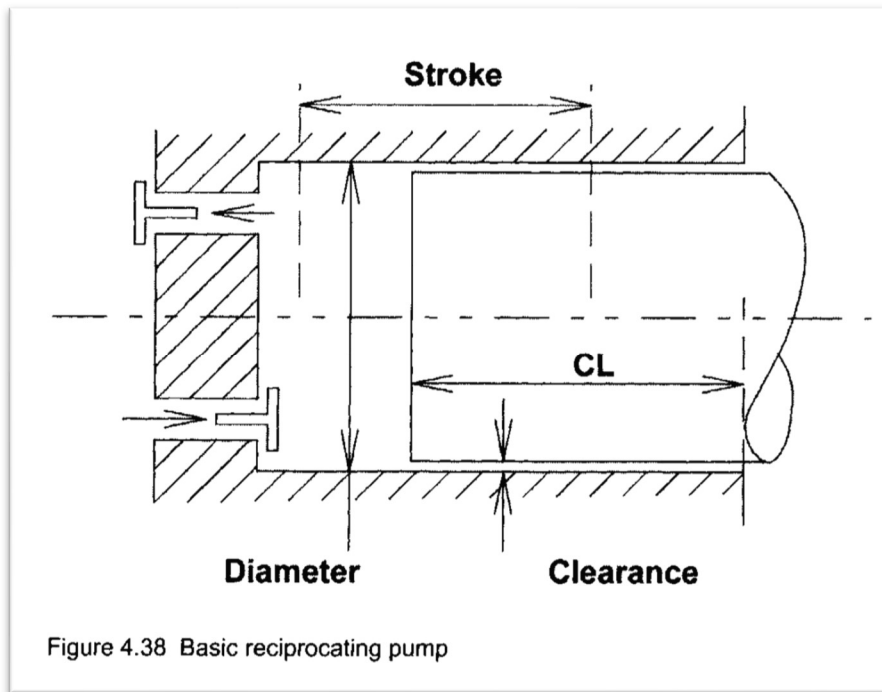
66. As another example, *Nesbitt* teaches in a “basic” “single cylinder reciprocating pump shown in Figure 4.38 [] the ideal flow is delivered is calculated from”³² the following equation:

$$Q_{th} = 0.001 \times s \times \frac{\pi d^2}{4} \times n/60 \quad (\text{Equ 4.25})$$

where:

- Q_{th} = theoretical flow (cc/s)
- n = strokes per minute (1/minute)
- d = piston [plunger] diameter (mm)
- s = stroke (mm)

³² Ex. 1014 (*Nesbitt*) pg 140.



67. By mathematically rearranging Equation 4.25, to calculate pump speed with a fixed flowrate and stroke length yields the following equation:

$$n = \frac{Q_{th} \times 60 \times 4}{0.001 \times s \times \pi d^2}$$

In order to calculate stroke length with a fixed flowrate and pump speed, equ 4.25 would be arranged as follows:

$$s = \frac{Q_{th} \times 60 \times 4}{0.001 \times n \times \pi d^2}$$

As can be seen from each of the above equations, there is an inverse relationship between stroke length (and piston/plunger diameter) and pump speed for a fixed flowrate. This is an inherent characteristic of plunger pumps. For a pump with more than one cylinder (e.g. quintuplex pump with 5 cylinders), the above equation would

be simply multiplied by the number of cylinders in order to obtain the total flowrate from the pump.

68. The result of the above is that flow for a given pump at a particular pump speed is relatively constant, while pressure changes as downstream conditions change. Accordingly, as fracturing begins, reducing the downstream impedance of the fluid flow system, pressure tends to drop as flow rate stays relatively constant. Conversely, pressure rises with a relatively stable flow rate as downstream impedance increases. As a boundary condition, if a valve is closed downstream of a fracturing pump, flow rate through the pump will remain relatively constant while pressure rises extremely fast. Pressure will continue to rise until some condition reduces the downstream impedance. This is typically equipment failure, such as pump seals, piping failure, or rupturing of valve bodies.

69. As shown by *Gardner*, the flowrate of a plunger pump is a function of the speed of the pump, the diameter of the plunger and the length of the stroke.

70. Because the plungers are so large (~5" in diameter with ~8" stroke), a large amount of fluid must flow into the cylinder on each stroke. This tends to lower the suction pressure, as the void of the plunger must be filled by the incoming slurry. If the suction pressure gets too low, then cavitation occurs. Cavitation is the condition where bubbles form in the liquid because the vapor pressure of the liquid is higher than the suction pressure. When the bubbles collapse, such as when the

piston reaches the bottom of its stroke, noise, vibration and damaging forces are created. To avoid cavitation and the associated problems, the suction pressure must be maintained higher than the fluid's vapor pressure of the fluid (e.g., slurry), even during the intake phase of the piston. This is called maintaining a Net Positive Suction Head (NPSH). The amount of NPSH necessary to avoid cavitation is dependent on many factors, including the suction line design, pump speed, suction valve spring strength, and temperature and viscosity of the fluid. Gardner teaches several methods to reduce or eliminate cavitation. These techniques include, for example, using a suction stabilizer or pulsation damper, changing the supply line design, and reducing pump speed.³³

³³ Ex. 1016 (Gardner) pg 30.

Cavitation, Fluid Knock or Hammer.	1. Improper suction system layout.	1. See recommended system layout in manual.
	2. Low suction pressure.	2. See Low Suction Pressure problem.
	3. Suction stabilizer and pulsation damper not used.	3. Install suction stabilizer and pulsation damper.
	4. Defective stabilizer or damper.	4. Repair and recharge or replace.
	5. High fluid temperature or viscosity.	5. Reduce pump speed.
	6. High fluid vapor pressure.	6. Increase NPSH.
	7. High acceleration head.	7. Increase supply line size. Decrease supply line length.
	8. Suction valve spring too stiff. with low NPSH.	8. Use weaker spring.
	9. Air/Gas in pumped fluid.	9. Allow more settling time in supply tank. Reduce pump speed.
	10. Air entering suction line.	10. Repair suction line.
	11. Air entering charging pump.	11. Tighten or replace shaft packing or seal.
	12. Air entering or charge gas escaping from suction stabilizer.	12. Repair and recharge stabilizer
	13. Multiple pumps operating in phase.	13. Use a suction stabilizer on each pump. Separate lines may also be needed.

C. PUMPING AND CAVITATION

71. Cavitation in pumping, including in positive displacement (e.g. plunger) pumps, has been a well known problem. Cavitation is described when “the incoming liquid [into a pump] is at a pressure with insufficient margin above the vapour pressure, then vapour cavities or bubbles appear [] [t]his phenomenon is

known as cavitation.”³⁴ Cavitation has at least three negative effects on a pumping system:³⁵

1. The collapsing cavitation bubbles can erode the vane surface, especially when pumping water-based liquids.
2. Noise and vibration are increased, with possible shortened seal and bearing life.
3. The cavity areas will initially partially choke the impeller passages and reduce the pump performance. In extreme cases, total loss of pump-developed head occurs.

Accordingly, it was known to avoid cavitation in pumping systems.

72. *Tutterow* further teaches that “[t]he amount by which the pressure in the pump inlet exceeds the liquid vapour pressure is expressed as a head of liquid and referred to as Net Positive Suction Head Available (NPSHA). This is a characteristic of the system design. The value of NPSH needed at the pump suction to prevent the pump from cavitating is known as NPSH Required (NPSHR).”³⁶

73. Further, NPSHR “varies approximately with the square of speed in the same way as pump head.”³⁷ Accordingly, a 10% reduction in pump speed would

³⁴ Ex. 1013 (*Tutterow*) pg 20; see also Ex. 1019 (Marks) pg 14-2.

³⁵ Ex. 1013 (*Tutterow*) pg 20

³⁶ Ex. 1013 (*Tutterow*) pg 20

³⁷ Ex. 1013 (*Tutterow*) pg. 21.

result in a 19% reduction in NPSHR and an 10% increase in speed would require a 21% increase in NPSHR. In any given system, a reduction in pump speed would reduce the risk of cavitation. It follows then that there is a specific speed that would eliminate cavitation for any given pump system. It further follows that as speed increases, cavitation increases.

74. With specific regard to PD pumps, “a PD pump needs the incoming liquid to have a pressure margin above liquid vapour pressure to prevent cavitation within the suction passages or pumping chamber.”³⁸ PD pumps also have an additional problem outlined by *Tutterow*:³⁹

The cavities [cylinders] on a positive displacement pump open and close as the pump operates and the liquid must flow quickly enough at the pump suction to fill the cavities completely with liquid. If the cavities do not fill with liquid, there will be a void, and apparent cavitation, resulting in a loss of both flow and pressure performance. If the speed is increased, this filling process becomes more problematical, limiting the maximum speed. With viscous liquids, [such as fracturing fluid] the effect is more severe.

³⁸ Ex. 1013 (*Tutterow*) pg. 30.

³⁹ Ex. 1013 (*Tutterow*) pg. 30.

75. *Langewis* describes use of positive displacement pumps used to inject produced water into the formation in a waterflood oil & gas operation. The pumps described in *Langewis* are very similar in design and function as those used in hydraulic fracturing. *Langewis* describes “Net positive suction head (NPSH) is defined as the head, in feet of liquid above vapor pressure, required at the suction inlet of the pump to completely fill each cylinder on the suction stroke.”⁴⁰ *Langewis* further describes NPSH required mathematically:

$$NPSH_{required} = H_a + H_g - H_{vp}$$

76. H_g represents “minimum pressure required for acceptable pump performance”. Further, *Langewis* teaches that “[t]he value of H_g should be obtained from the pump manufacturer. This term is a function of the diameter of the plunger, *speed of the pump*, type of valve used, valve-spring load and tolerance of the equipment. therefore, all pump manufacturers should have this value for their pumps.”⁴¹

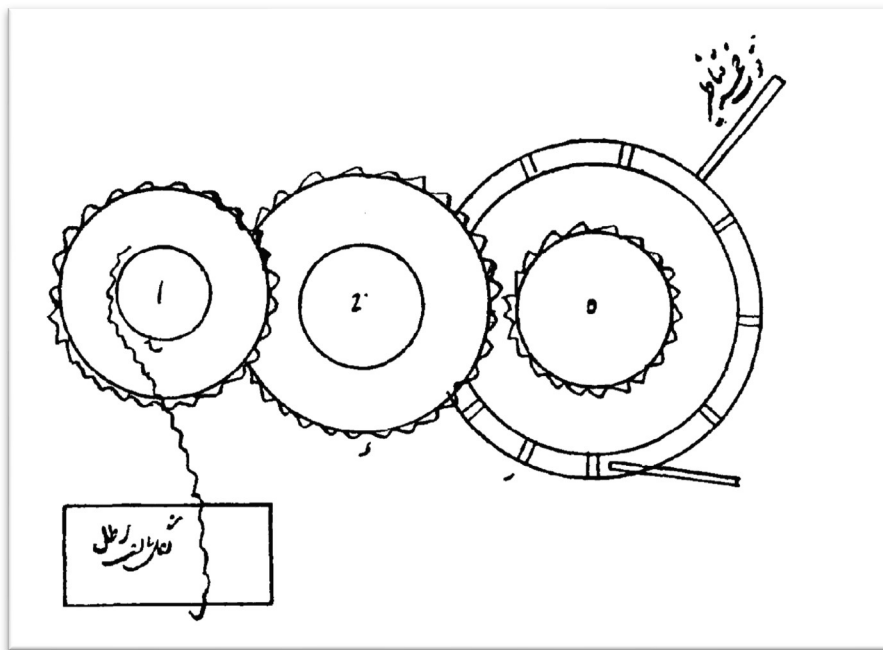
77. The maximum speed of operation of a positive displacement pump to prevent cavitation is the lower of the speed that keeps NPSHR below NPSHA and that speed which allows sufficient time for the cylinders to completely fill based on the NPSHA.

⁴⁰ Ex. 1020 (*Langewis*) pg. 174.

⁴¹ Ex. 1020 (*Langewis*) pg. 174-175.

D. GEARING MECHANISMS

78. Gearing mechanisms to drive loads (e.g. pumps) at a different speed than their drive mechanisms (i.e. motors) have been known for centuries. Gears have been known in the art since at least the 3rd century B.C.⁴² Geared mechanisms were developed in Alexandria, Egypt by Greek mechanics, under the Greek Ptolemies in the Alexandrian “Museum”. Hero describes gears which mesh in the same plane and multiplies force by meshing gears with different numbers of teeth.⁴³

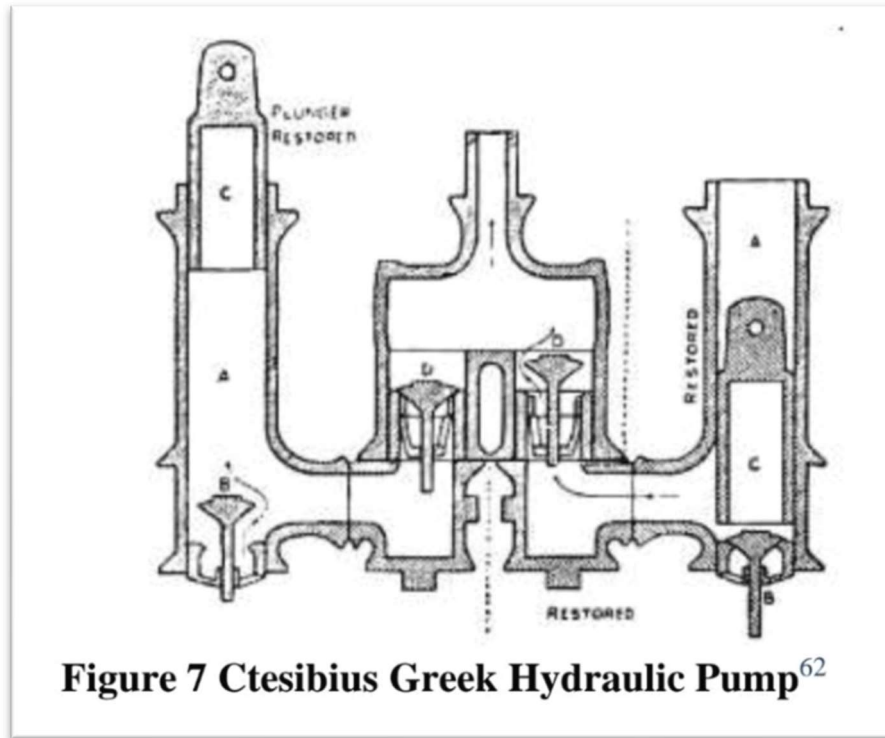


79. Interestingly, it was in this same period and location that hydraulic pumps were developed by Ctesibius, also a member of the Musaeum.⁴⁴

⁴² Ex. 1021 (*Lewis*) pg 110.

⁴³ Ex. 1021 (*Lewis*) pg 110.

⁴⁵ Ex. 1021 (*Lewis*) pg 111.

EX. 1050 (*Johns*) Figure 7

80. The oldest physical artifact containing gears is the Antikythera mechanism, which dates to the first century B.C. The Antikythera mechanism contained “at least 30 gear wheels” and was used to calculate the positions of, at least, the sun and the moon based on a date input.⁴⁵

81. As discussed above, it was known for several gears to be used together, known as a “gear train”. Further it was known that gear trains can change the speed and direction of the input power. As described in *Mabie*, “given the input angular velocity to a gear train, it is important to be able to determine easily the angular

⁴⁵ Ex. 1021 (*Lewis*) pg 111.

velocity of the output gear and is direction of rotation.”⁴⁶ When a gear train is driven by a driving force such as a motor “the angular velocity [i.e. speed] of the driver will be known from the speed of the motor, and it is necessary only to multiply the speed of the drive by a factor to find the speed of the last gear in the train [i.e. speed of the load].”⁴⁷ Accordingly, by knowing the ratio of the gear train and the speed of the motor, the speed of the output of the gear train, connected to the load, can be calculated by simple multiplication. Further, if the desired speed of the driven load is known, that speed can be controlled by proper selection of the gear ratio and/or the speed of the motor. *Nesbitt* describes gearboxes applied to drive pumps and teaches that “[g]earboxes can be applied to any shaft speed and any ratio is popular.”⁴⁸

82. There are two fundamental concepts when dealing with gear drives (gearboxes). The first is *efficiency*. Efficiency is “unproductive power expenditure”.⁴⁹ The second is a *transmission ratio* which is the ratio of the speeds of the input and the output. In order to explain these concept, *Jelaska* teaches “The mechanical drive driving shaft receives power P_1 at speed of rotation n_1 from the prime mover driven shaft, and the mechanical drive driven shaft supplies power P_2

⁴⁶ Ex. 1022 (Mabie) pg 245.

⁴⁷ Ex. 1022 (Mabie) pg 246.

⁴⁸ Ex. 1014 (*Nesbitt*) pg 281.

⁴⁹ Ex. 1012 (*Jelaska*) pg 3.

< P_1 at speed of rotation n_2 to the operational machine driving shaft [e.g. load or pump].”⁵⁰ Efficiency η is the ratio between power out and power in (always less than 100%).

$$\eta = \frac{p_2}{p_1} = \frac{p_1 - \text{losses}}{p_1} = 1 - \text{losses}/p_1$$

83. Transmission ratio i is the ratio of the driving shaft speed (n_1 below) and driven shaft speed (n_2 below). It is also the ratio of the angular velocity ω of the input shaft (ω_1 below) and the output shaft (ω_2 below).⁵¹

$$i = \frac{n_1}{n_2} = \frac{\omega_1}{\omega_2}.$$

Accordingly any combination of input speed (driving speed) and transmission ratio (i) defines the output speed of the gear train.

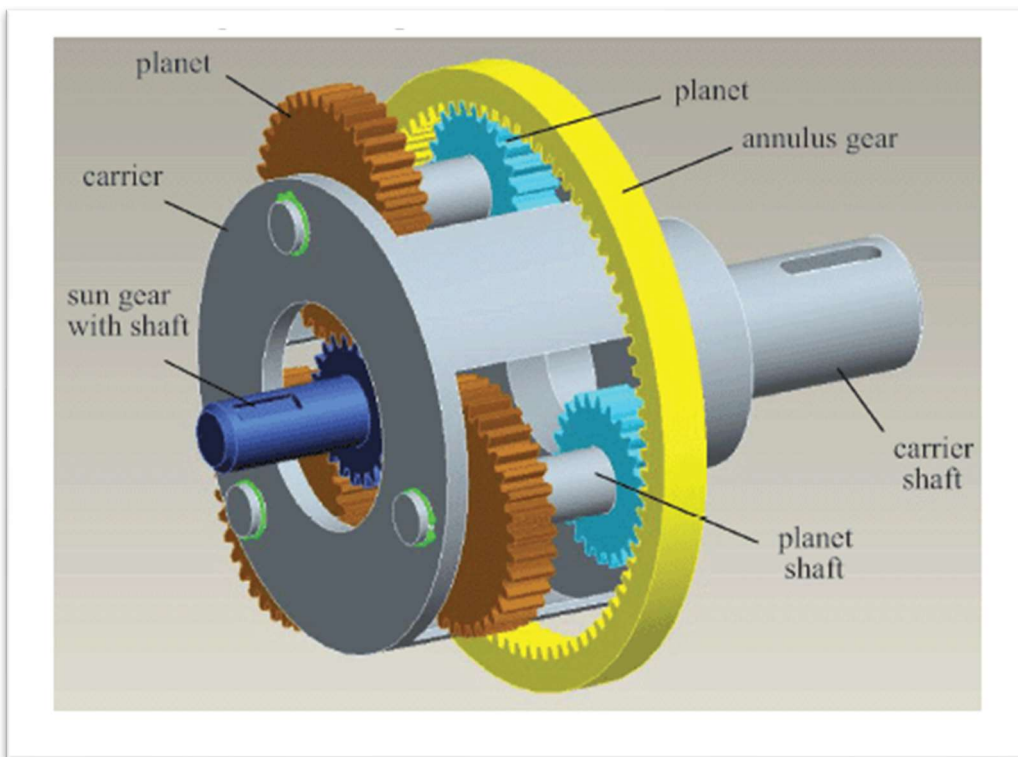
84. *Mabie* teaches that “[t]o obtain a desired gear ratio it is often advantageous to design a gear train so that one of the gears will have a planetary motion. With this motion, a gear will be so driven that it not only rotates about its own center but at the same time its center rotates about another center.”⁵² Such an arrangement is known as a “planetary gear train”. Because of the motion of the various gears “a planetary gear train is referred to as an epicyclic, or cyclic, gear

⁵⁰ Ex. 1012 (*Jelaska*) pg 2-3.

⁵¹ Ex. 1012 (*Jelaska*) pg. 3.

⁵² Ex. 1022 (*Mabie*) pg 248.

train.”⁵³ These arrangements “find many applications in machine tools, hoists, aircraft propellor reduction drives, automobile transmissions, aircraft servo-drives and many others.”⁵⁴ *Nesbitt* teaches that “[e]picycle gearboxes are popular for larger and high speed applications[] Epicyclic gearboxes can be used as a variable ratio transmission by adding a small control drive.”⁵⁵ *Jelaska* provides an image of a planetary gear train.



Ex. 1030 (*Jelaska*) Plate 2

⁵³ Ex. 1022 (Mabie) pg. 248.

⁵⁴ Ex. 1022 (Mabie) pg 258.

⁵⁵ Ex. 1014 (*Nesbitt*) pg. 282.

85. Not only were planetary gear trains known for changing the speed of a single motor to a single load (e.g. pump), such gear trains were known for combining several motors to drive a single load. For example, *Jelaska* describes that “[planetary] differential trains having two or more degrees of freedom are used for dividing the single rotary motion into two or more, or *for joining several rotary motions into one*. A common simple differential train having one sun gear, one annulus gear and a carrier with three planets is demonstrated in Figure 6.4 [Plate 2 above].”⁵⁶ As an example, *Jelaska* describes a planetary gear train “with two inputs of power [] and one output.”⁵⁷

86. Planetary gear trains are commonly used in applications where there is a need for “high torque in compact (a high torque/volume) and light (a high torque/weight ratio) package.”⁵⁸ Further, a planetary gear train has advantage in lubrication as the lubrication “is continuously redistribute, “*pushed and pulled*” or “*mixed*” into the gear contacts, ensuring lubrication practically in any mounting position and at any speed”.⁵⁹ Overall, planetary gear trains “have a high torque density, [are] compact, [have] low inertia and can be grease lubricated for life,”⁶⁰ which are all advantageous in an industrial application.

⁵⁶ Ex. 1012 (*Jelaska*) pg. 333.

⁵⁷ Ex. 1012 (*Jelaska*) pg. 361.

⁵⁸ Ex. 1023 (Pawar) pg. 150.

⁵⁹ Ex. 1023 (Pawar) pg. 151.

⁶⁰ Ex. 1023 (Pawar) pg. 151.

E. ALTERNATING CURRENT (AC) SYSTEMS

87. It was general engineering knowledge that Alternating Current (AC or a.c.) power systems are those in which “Alternating waveforms have currents and voltages that vary with time in a symmetrical manner ... for the most part, the variations are sinusoidal in time.”⁶¹ The use of the term alternating current indicates “that the current is produced by the application of a sinusoidal voltage. This means that the flow of electrons changes directions, unlike DC circuits where the flow of electrons is unidirectional”⁶²

88. Single-phase AC systems are those in which there is a single voltage source driving the current. For single-phase systems, at least two connections to the load are needed in order for current to flow. These are generally referred to as “hot” and “neutral” connections, or “L1” and “L2” when used with motor connections. A separate ground wire is often used to provide personnel and equipment protection and to allow protective devices to operate effectively.

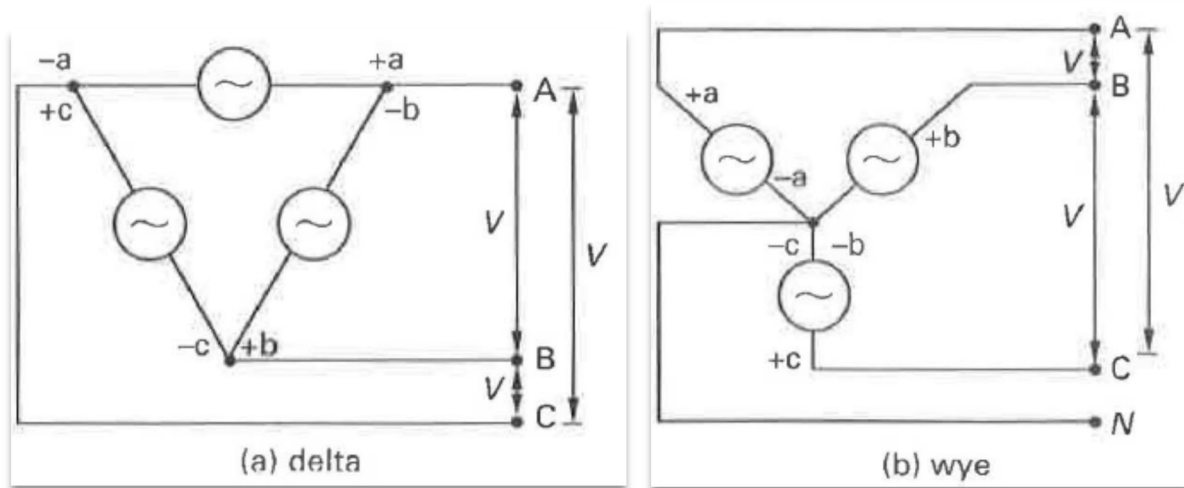
89. Three-phase AC systems are those in which there are three voltage sources driving current. Those three sources can be provided by a single physical structure such as an “AC generator that produces three equal sinusoidal voltages,” which “are 120° apart in phase.”⁶³ As described in EE-Reference, “a six conductor

⁶¹ Ex. 1015 (EE-Reference) p. 27-1.

⁶² Ex. 1015 (EE-Reference) pg. 27-1.

⁶³ Ex. 1015 (EE-Reference) pg. 34-1

transmission line could be used to transmit the three voltages” by treating them as three separate single phase voltages, but “it is more efficient to interconnect the windings.”⁶⁴ Two connection types are delta and wye, as shown in Figure 34.2 from *EE Reference*.



Ex. 1015 (EE-Reference) p. 34-2.

90. Delta connected power systems require three phase-wires (plus a ground if required). Wye connected power systems require three phase-wires plus a neutral (plus a ground if required)⁶⁵. The neutral wire carries any imbalance from the loads back to the source.

⁶⁴ Ex. 1015 (EE-Reference) pg. 34-2.

⁶⁵ Certain balanced three phase wye connected system are operated with only three wires, though this is limited in application primarily to single loads, such as a three-phase motor.

91. It was general engineering knowledge that there are several benefits to using three-phase systems over single-phase systems, particularly in the context of large electrical loads such as large electric motors.⁶⁶

Three-phase energy distribution systems use fewer and smaller conductors and, therefore are more efficient than multiple single-phase systems providing the same power. Three-phase motors provide a uniform torque, not a pulsating torque as do single-phase motor. Three-phase induction motors do not require additional starting windings or associated switches. When rectified [converted to DC], three-phase voltage has a smoother waveform and less ripple to be filtered out.

This is due to the difference in power relationships between single-phase and three-phase systems. The power relationship for single-phase systems is:

$$P = V \cdot I$$

while the power relationship for three-phase systems is:

$$P = \sqrt{3} \cdot V \cdot I^*$$

Thus, for a three-phase system, current is reduced by a factor of $\sqrt{3}$ (~1.73) as compared to a single-phase system. This allows for smaller conductors, decreased losses and increased efficiency. As a result, nearly all larger power systems are configured as three-phase systems.

⁶⁶ Ex. 1015 (EE-Reference) pg. 34-1.

F. ELECTRIC MOTORS

92. It was general engineering knowledge that electric motors are a subset of rotating electric machinery (rotating machines) in which electric power is converted to rotational mechanical energy.

Rotating machines are broadly categorized as AC and DC machines. Both categories include machines that use [electric] power (i.e. motors) and those that generate [electric] power (alternators and generators). Most machines can be constructed in either single-phase or polyphase [three-phase] configurations, although single-phase machines may be outclassed in terms of economics and efficiency. . . . Large AC motors are almost always three-phase.

Ex. 1015 (EE-Reference) p. 40-1.

93. Electric motors have been manufactured to one or more standards, depending on the application and size. As an example, motors up to 500 horsepower (Hp) are manufactured at least to the specifications of National Electrical Manufacturer's Association (NEMA) Standard MG-1.⁶⁷ Severe duty motors larger than 500 Hp used in oil & gas applications are manufactured to the specifications of American Petroleum Institute (API) standard 541.

94. The National Electrical Manufacturer's Association (NEMA) was founded in the 1920s and is an ANSI- (American National Standards Institute) accredited Standards Developing Organization (SDO) made up of business leaders,

⁶⁷ Severe duty motors smaller than 500 Hp used in oil & gas applications are manufactured to the specifications of IEEE 841, one of the IEEE standards for which I am responsible.

electrical experts, engineers, scientists, and technicians. NEMA convenes a neutral forum for Members to discuss industry-wide concerns and objectives under a legal umbrella by trained NEMA Staff.

95. It is inherent that electric motors have a plurality of connections to the power source in order to operate. As in all electric circuits, there must be a complete path between the power source (e.g., generator) and the load (motor) in order for current to flow and for the electric equipment (motor) to operate. The complete path requires a minimum of two connections for each load, generally designated as L1 and L2 for single phase or DC motors and L1, L2 and L3 for three phase motors.

G. ADJUSTABLE SPEED DRIVES / VARIABLE FREQUENCY DRIVES

96. By way of background, a Variable Frequency Drive (VFD) is another term for and type of Adjustable Speed Drive (ASD). ASD is the preferred term. Nevertheless, based on my experience, the term VFD has been commonly used, so I also use the terms interchangeably in this declaration.

97. Standard industrial motors have a fixed speed tied to the frequency of the alternating current (AC) electric power being supplied to them. The “synchronous speed” of the motor is determined using the following equation:⁶⁸

$$n_s = f(2/p)60 = \frac{120f}{p}$$

⁶⁸ Ex. 1015 (EE-Reference) pg. 40-4.

Where:

n_s = synchronous speed of the motor (rpm)

f = frequency (hertz)

p = # of poles in the motor (a function of design and construction)

For example, a 4 pole motor supplied with 60 Hz AC power (US standard) would have a synchronous speed of 1800 RPM, as shown below.

$$n_s = 60 \left(\frac{2}{4} \right) 60 = 1800$$

98. “Synchronous” motors run exactly at the synchronous speed. “Induction” motors run at a somewhat slower speed because of the interaction of the electrical field inside the motor with the conductors of the rotor, which is a function of the construction of the motor. The difference between an induction motor’s rated speed and the synchronous speed of a motor of the same construction is referred to as “slip” and is calculated as follows:⁶⁹

$$s = \frac{(N_s - N_r)}{N_s} \times 100\%$$

Where

s = slip(%)

N_s = synchronous speed of the motor (rpm)

⁶⁹ Ex. 1015 (EE-Reference) pg. 40-7

N_r = rated speed of the motor (rpm)

For example, a 4 pole induction motor operating at 1% slip would have a rated speed of 1782 rpm ($1800 - 1\% \cdot 1800$).

99. In order to control the speed of these motors at other than their rated speed, the frequency of the power being supplied to the motor must change. As discussed below, an ASD (VFD) performs this function.

100. *Standard Handbook for Electrical Engineers* from 1993 describes the basic operation of an ASD (VFD) as follows:⁷⁰

In order to supply an adjustable frequency to an ac motor, the incoming constant-frequency [fixed frequency] voltage or current must first be rectified to a dc current or voltage. This dc voltage or current is then inverted to an adjustable frequency output. This is accomplished by power semi-conductor devices.

These devices allow current to flow in only one direction. They act as electronic switches. Various types can be fired on and off at certain times in the cycle. This selected firing allows control of the resultant voltage or current.

Exhibit 1024 contains true and correct copies of pages from the Fink reference. As an additional example, Horikoshi (filed in 2011) describes that such an ASD (VFD) was known for three-phase AC power as well:⁷¹

Providing a motor driving apparatus, which is connected to a three-phase AC power supply and which comprises an AC/DC converter for converting three-phase AC power supplied from the three-phase AC power supply into DC power and a DC/AC converter for converting the

⁷⁰ Ex. 1024 (Fink) p 20-85.

⁷¹ Ex. 1025 (Horikoshi) [0004].

DC power output from the AC/DC converter into three-phase AC power for supply to a motor, is known.

101. The outgoing DC-AC converter modifies the frequency and/or voltage of the waveform in order to control the speed and torque delivered by the motor.

102. One of the more common ASD topologies, particularly for larger motors is a “pulse-width modulated (PWM)” drive topology. PWM drives have a number of advantages over other drive topologies including “high line-side power factor (near unity),” and the “distortion seen by the electrical network is ... reduced.”⁷² Additionally, “high dynamic performance can also be realized. Full torque can be maintained and controlled throughout the speed range – even at zero speed.”⁷³

103. One of the methods of determining the power of a rotating piece of equipment (e.g. a motor) is the well-known relationship: Power = (Torque) x (rotational speed). This formula is expressed as: $P = \tau \cdot \omega$. As can be seen by this relationship, torque and rotational speed of an object are inversely related for a given power, such that for a given power, torque is increased by reducing rotational speed (and vice versa). Thus, by controlling the speed and torque (inherently a function of PWM drives), the drive is also controlling the power of a motor, and maintaining that power within the operating range of the motor.

⁷² Ex. 1024 (Fink) pg. 20-89.

⁷³ Ex. 1024 (Fink) pg. 20-89.

104. The history of Adjustable Speed Drives (ASDs, sometimes referred to as Variable Frequency Drives or VFDs) began in 1958 with the advent of silicon controlled rectifiers (SCRs), a type of power electronics that could be turned on or off in order to allow power flow. The first motor drives using this new SCR technology were DC motor drives, and by the early 1960s “DC SCR drives [were] readily available for industrial applications”⁷⁴

105. By 1960, SCRs were being used in oil and gas operations, albeit on a relatively small scale, as evidenced by Exhibit 1027, US patent 3,186,222 which was filed on July 28, 1960.

106. By at least August, 1961, pulse width modulated (PWM) drives were being used for motor drives. Jones (General Electric) developed “Variable Pulse Width Parallel Inverters” and filed US Patent 3,075,136 on August 31, 1961. “[B]y employing a rectified alternating voltage input, the inverter can be readily adapted for use as a frequency changer...in a power supply system for the operations of motors at various speeds”⁷⁵

107. By 1962 a “Means for Smoothly Varying the Speed of a Star-Connected Polyphase [3 phase] Induction Motor” had been developed.⁷⁶

⁷⁴ Ex. 1026 (Roethemeyer) pg. 543.

⁷⁵ Ex. 1028 (“Jones”), 1:20-30.

⁷⁶ Ex. 1029 (“Clarke”), US Patent 3,262,036.

108. By 1965 it was known in industry that “a 3-phase induction motor can be controlled, in this manner [by using SCRs], in order to give a range of torque-speed characteristics suitable for fan control.”⁷⁷ The motor Shepherd was controlling with his VFD was a 3 horsepower motor. However, over the next 20 years, the technology of ASDs rapidly improved. By 1985, SCRs and GTOs (Gate TurnOff Thyristors) were being used for large motor ASDs.⁷⁸ These devices were “large, bulky and expensive” and had “marginal acceptance” throughout industry as a whole.⁷⁹ However “certain industries like petro/chem and textile” showed larger acceptance, largely because of the very large motors used in those industries.⁸⁰

109. One of the main benefits of an ASD, other than the means to control the speed of the motor in order to control the output of the driven equipment (e.g. pumps), is the energy savings from reducing speed of the motor. Historically, with direct coupled AC motor driven equipment, a pump or fan was run at a constant speed and the pressure and flowrate of the process fluid was controlled by control valves, dampers, or other control devices that would open or close depending on the needs of the system. Other devices, such as the eddy current and magnetic drives varied the speed of the driven equipment while maintaining a constant speed on the

⁷⁷ Ex. 1030 (“Shepherd”), Introduction.

⁷⁸ Ex. 1026 (“Roethemeyer”) pg 543.

⁷⁹ Ex. 1026 (“Roethemeyer”) pg 543.

⁸⁰ Ex. 1026 (“Roethemeyer”) pg 543.

motor. As the energy consumption of a motor is directly proportional to the speed of the motor (at a constant delivered torque), then as the speed of the motor is decreased, the energy consumption, and operational cost, of the motor also decreases. Since, in the 1980s, large drives were “large, bulky and expensive” they were applied first to large motors, such as those in the petrochemical industry and the textile industry, where the amount of savings could justify the expense and space of ASD installation.⁸¹

110. Between 1985 and 1989, bi-polar PWM technology had been developed, and drives became “smaller and more economical” which lead to “A greater acceptance among users”.⁸² In this time frame as well, Insulated Gate Bipolar Transistors (IGBTs) were in use and “smaller drives packages with micro drives for smaller hp motors” had gained “A much larger acceptance. Micro drives have actually become commodities.”⁸³ As would make sense with any electronic technology, continued development led to smaller, less expensive devices that could be used where the energy savings would not justify larger, more expensive installations. This is analogous to the computer industry. The first digital computers were very large, requiring dedicated buildings, very expensive and could only be afforded by governments and very large corporations. As electronics progressed,

⁸¹ See Ex. 1031 (Hickok) generally.

⁸² Ex. 1026 (“Roethemeyer”) pg 543-544.

⁸³ Ex. 1026 (“Roethemeyer”) pg 544.

they have come down to the point where a small, handheld device contains “More computing power than NASA” during the Apollo missions.

111. By at least 1988, very large VFD drives were in operation in petrochemical facilities. Frank DeWinter’s paper “The Application of a 3500-hp Variable Frequency Drive for Pipeline Pump Control” was presented to the IEEE Petroleum and Chemical Industry Conference in Dallas, TX in September 1988.⁸⁴ In this peer-reviewed publication, DeWinter discusses the expansion of a Canadian pipeline “from 130,000 barrels / day (bpd) to 185,000 bpd utilizing a 3500-hp adjustable speed drive. The unit is a variable frequency induction motor drive (VFD) supplied by GE Canada employing gate turn-off thyristors (GTOs).”⁸⁵ As DeWinter states “based on wide general industry acceptance of VFD’s, the technology was considered to be well established and accepted, and not of a ‘prototype’ nature. The VFD had to perform at least with the same degree of reliability as a control valve so as not to reduce the pipeline service factor.”⁸⁶ According to DeWinter, the installation would cost \$800,000 (Canadian) in 1986 dollars, but would generate approximately \$129,000 (Canadian) in overall operating cost savings in the first year alone. That is a good investment.⁸⁷

⁸⁴ Ex. 1032 (“DeWinter”), 1019.

⁸⁵ Ex. 1032 (“DeWinter”) at Abstract.

⁸⁶ Ex. 1032 (“DeWinter”) pg 1020.

⁸⁷ Ex. 1032 (“DeWinter”) pg 1019.

112. It is around this time that I gained my first exposure to ASDs. In 1990-1992, while employed by Public Service Company of Oklahoma, I was responsible for overseeing field installation of multiple ABB 4,500+ Hp VFDs for fans and pumps. These systems were, as Roethemeyer described them, “large, bulky and expensive,” requiring individual drive buildings for each pair of drives. However, the operational cost savings for these large motors more than justified the capital investment. As my career progressed I continued to design and oversee installation of smaller and smaller ASDs for various applications in power generation, petrochemical, and commercial environments. ASD technology has progressed now that even small, integer horsepower motors in residential applications, such as HVAC blowers and pool pumps, have become to be controlled by ASDs. ASDs were first applied to very large, several thousand horsepower motors, where the cost savings would justify their installation.

113. By at least 1997, “The use of variable frequency drives (VFD) is becoming increasingly popular with induction motor driven gas compressors.”⁸⁸ To the motor and drive system, there is no significant difference between driving a reciprocating compressor or a reciprocating pump. Perrin’s paper describes applications of VFDs (ASDs) on 1500 – 3000 Hp installations.⁸⁹

⁸⁸ Ex. 1033 (“Perrin”) at Abstract.

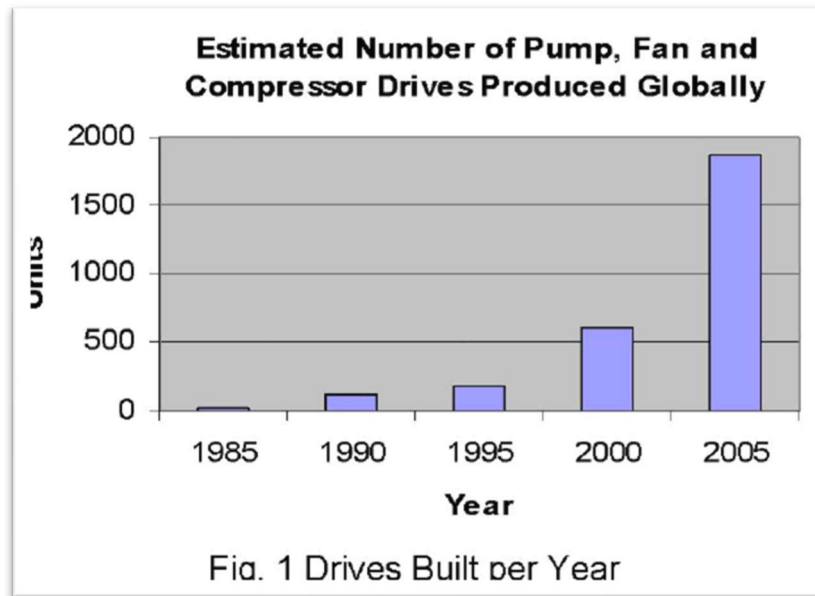
⁸⁹ Ex. 1033, pg. 3.

114. Installation of large ASDs in petroleum and chemical operations continued to increase. By the early 2000s, installations were so ubiquitous that industry, particularly the petroleum and chemical industry, recognized the need for standardization. This need led to the development of IEEE 1566 *Standard for Performance of Adjustable Speed Drives Rated 375 kW and Larger*. This standard was sponsored by Standards Subcommittee the Petroleum and Chemical Industry Committee of the IEEE. As discussed in the background section of my Declaration, I served as Chair of the Standards Subcommittee of the PCIC from 2013 – 2022. In that role I was responsible for maintenance, update and oversight of IEEE 1566. IEEE 1566 continues as an Active standard today.⁹⁰

115. “Lockley”, published in 2006, contains a description of the need for and development of IEEE 1566. “Adjustable Speed Drives have been used in process application for some time on applications into many tens of MWs [MegaWatts, ~1,000 Hp] and from below 300 rpm up to about 20 000 rpm.”⁹¹ Fig. 1 from Lockley showed the number of “pump fan and compressor” ASDs built annually between 1985 and 2005.

⁹⁰ See Ex. 1034 (Lockley) generally

⁹¹ Ex. 1034 (Lockley) pg. 1.



Ex 1034 “Lockley” Fig. 1.

116. “Work stated in 2000 on an IEEE standard for large ASDs...the standard was approved in late 2005 and published in 2006”.⁹² So, by 2006 large ASD installations had become so ubiquitous, particularly in the Petroleum and Chemical Industry, that the drives themselves had become standardized. As described by *Tutterow* by 2004, “Variable speed drives [VFDs] in pump systems are now a mature technology which can generate large benefits to the user in cost savings and reliability improvements.”⁹³

117. Using a single ASD to control the speed/torque of multiple motors has also been well-known. For example, in 1993 *Manz* described differences in

⁹² Ex. 1034 (Lockley) pg. 2

⁹³ Ex. 1013 (*Tutterow*) pg. 1.

applications of ASDs to various kinds of motors. As part of this description, *Manz* describes “load sharing where multiple motors are used with a single ASD” when describing ASD use with high starting torque NEMA D motors.⁹⁴ Reciprocating pumps are an application known to have high starting torque. As another example, in 2009 *Baseer* described one of the advantages of using ASD is “[a] single ASD ca[n] control more [than] one motors at once, so ASD can be known as multi-motor control.”⁹⁵

118. ASDs (VFDs) were also known to be used to control motors in hydraulic fracturing operations. By at least 2012, Coli “an electrically powered fracturing system”⁹⁶ that used variable frequency drives to control the speed of the fracturing pumps. Coli discloses how the electrification of the fracturing operation can improve costs,⁹⁷ efficiency,⁹⁸, safety,⁹⁹ and environmental impact.¹⁰⁰ Regarding safety, Coli discloses that “[e]lectric motors controlled via variable frequency drive are far safer and easier to control than conventional diesel powered equipment.”¹⁰¹ Coli explains that because “electric motors are controlled by variable frequency

⁹⁴ Ex. 1035 (Manz) pg. 18.

⁹⁵ Ex. 1036 (Baseer) pg 134.

⁹⁶ Ex. 1048 (Coli) at Abstract.

⁹⁷ Ex. 1048 (Coli) at [0075].

⁹⁸ Ex. 1048 (Coli) at [0077].

⁹⁹ Ex. 1048 (Coli) at [0066].

¹⁰⁰ Ex. 1048 (Coli) at [0080].

¹⁰¹ Ex. 1048 (Coli) at [0066].

drives [] the control software and variable frequency drives [“VFD”] calculate a maximum current available to the motors.”¹⁰²

119. Similarly, by 2012, *Broussard* taught “[a] system for hydraulically fracturing an underground formation” that “includes a plurality of electric pumps fluidly connected to the well, and configures to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the [formation] and fractures the formation.”¹⁰³ *Broussard* further teaches that the “electric pumps” comprises “pumps 10 [that] are powered by electric motors 14.”¹⁰⁴ “In addition,” *Broussard* teaches “each electric motor 14 can be equipped with a variable frequency drive (VFD) [] that controls the speed of the electric motor 14, and hence the speed of the pump 10.”¹⁰⁵

X. OVERVIEW OF THE PRIOR ART

A. BUCKLEY(Ex. 1004)

1. Status of Buckley

120. “*Buckley*” is a publication of a United States Patent Application, U.S. Patent Publication No. 2020/0256429. *Buckley* is entitled, “Electric Drive Pump for Well Stimulation.” *Buckley* was filed at the PCT on September 25, 2018, and published on August 13, 2020. *Buckley* claims priority to U.S. Provisional

¹⁰² Ex. 1048 (Coli) [0065].

¹⁰³ Ex. 1049 (Broussard at Abstract.

¹⁰⁴ Ex. 1049 (Broussard) 3:23.

¹⁰⁵ Ex. 1049 (Broussard) 3:39 – 42.

Application No. 62,562,943 filed September 25, 2017 (Ex. 1005, “*Buckley Provisional*”). The filing date of the *Buckley Provisional* is before the earliest possible priority date of all challenged claims of the ’258 Patent, and the portions of *Buckley* on which I rely are supported by the *Buckley Provisional*.

2. Overview of the Disclosure of *Buckley* and *Buckley Provisional*

121. Like the ’258 Patent, *Buckley* describes a pumping system that “relates generally to hydraulic fracturing in oil and gas wells, and in particular to an electric drive pump used to drive a fluid end for the pumping of a fracturing fluid into a well.”¹⁰⁶ Thus, *Buckley* is clearly from the same field of art as the ’258 Patent, and describes a fracturing pump that is similar to the pump described in the ’258 Patent.

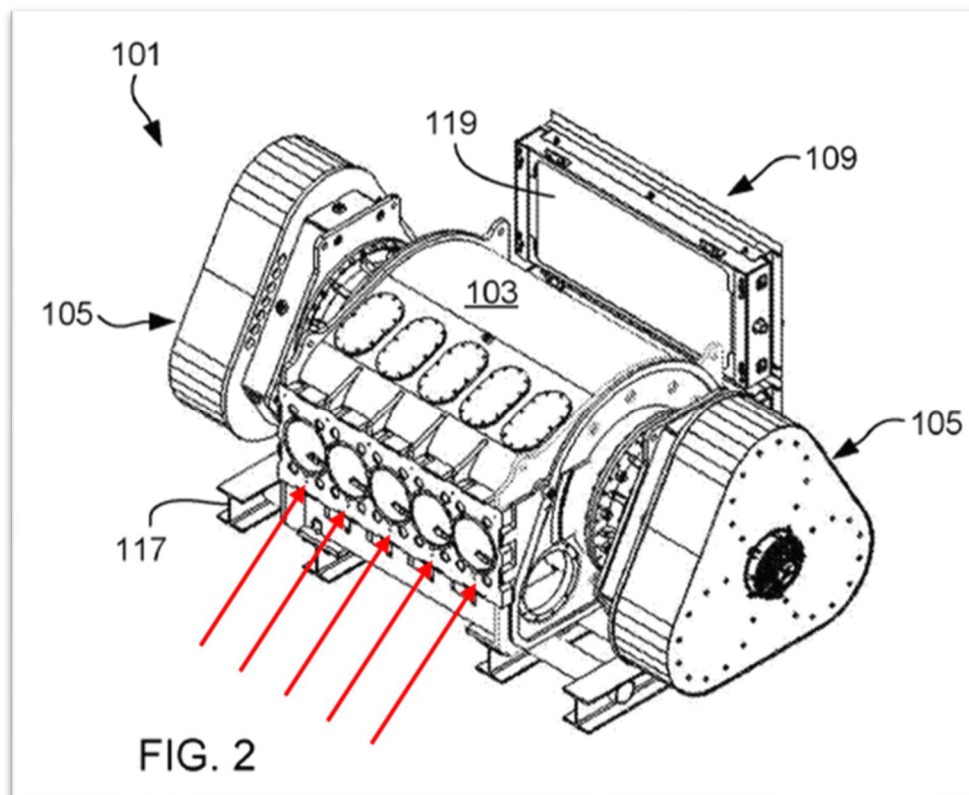
122. *Buckley* discloses that its electric drive pump system includes “a plurality of individual motors in selective configurations that work together to provide power to a power end,” and that the motors “are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid end” of the electric drive pump.¹⁰⁷ *Buckley* describes several scenarios where multiple motors are turned on at the same time to meet the output needs of the drive pump (e.g., when a “50% output is required, []

¹⁰⁶ Ex. 1004 (*Buckley*) [0001]; Ex. 1005 (*Buckley Provisional*) 2.

¹⁰⁷ EX1004, [0009]; see also EX1005, 4 (“This system includes a series of electric motors of sufficient number needed to give the required output to operate the one or more fluid ends.”)

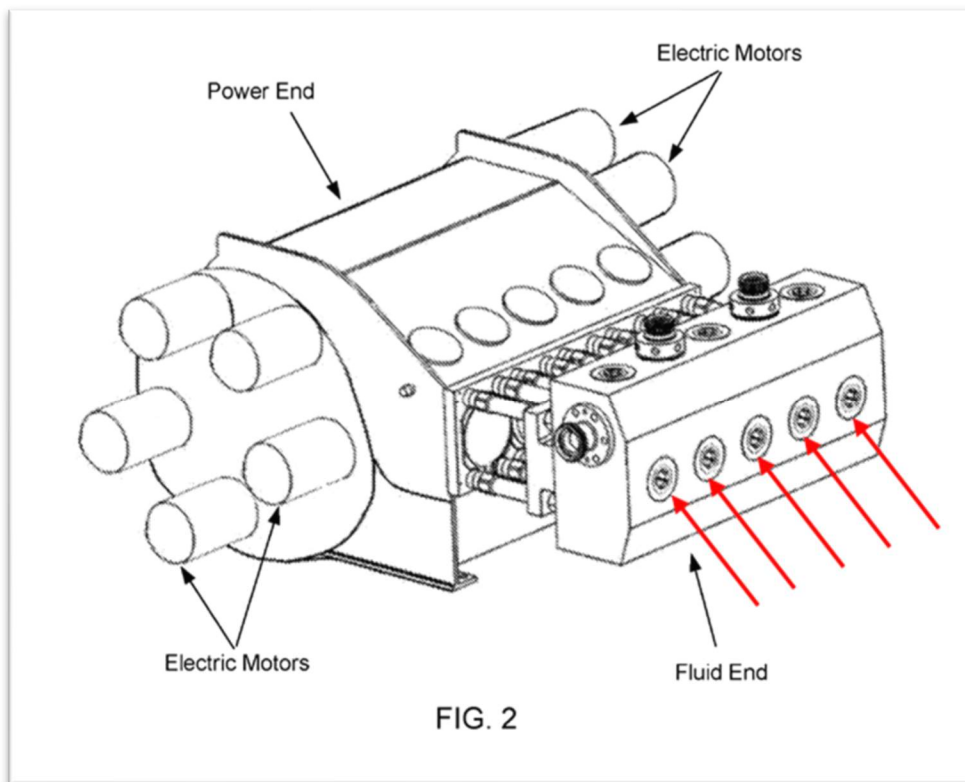
the even numbered motors 111 are operative while the odd numbered motors 111 are deactivated or turned off.”).¹⁰⁸

123. Further, *Buckley* discloses five-plunger pumps, as depicted by annotated Figure 2 of *Buckley* and annotated Figure 2 of *Buckley Provisional*:



Ex. 1004 (*Buckley*), Fig. 2 (annotated).

¹⁰⁸ See EX1004, [0057], Figs. 16-18; EX1005, 6, Figs. 4-6.



EX1005 (*Buckley Provisional*), Fig. 2.

124. Thus, a POSITA would understand that *Buckley* discloses a multi-plunger fracturing pump that is simultaneously driven by multiple electric motors, similar to the pump described in the '258 Patent.

B. BERGAN(Ex. 1006)

1. Status of Bergan

125. “*Bergan*” is a publication of a United States patent application, U.S. Patent Publication No. 2015/0361736. *Bergan* is entitled, “Heave Compensation Winches.” *Bergan* was filed June 13, 2014, and published December 17, 2015. Each of these dates is before the earliest possible priority date of all Challenged Claims of the '258 Patent.

2. Overview of the Disclosure of *Bergan*

126. *Bergan* discloses a hoisting system for use in oil and gas drilling that includes a rotatable drum driven by multiple electric motors.¹⁰⁹ *Bergan* further describes a “planetary gear system” that is used to couple the multiple electric motors to the load so the motors can drive the rotation of the load.¹¹⁰

127. Thus, *Bergan* is in a field of art—using multiple motors and a planetary gear system for driving a load in oil and gas drilling—that is highly relevant to the ’258 Patent, which describes using multiple motors and a planetary gear system for driving a fracturing pump, and a POSITA would understand that *Bergan* addresses the potential problem of coupling multiple electric motors to a load.

C. *ROSMAN*(EX. 1007)

1. Status of *Rosman*

128. “*Rosman*” is United States Patent No. 4,100,822. *Rosman* is entitled, “Drive System for a Moving Mechanism.” *Rosman* was filed April 19, 1976, and granted July 18, 1978. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ’258 Patent.

¹⁰⁹ Ex. 1006 (*Bergan*), Abstract, [0003]-[0005], [0030].

¹¹⁰ Ex. 1006 (*Bergan*), [0032], Figs. 5, 6.

2. Overview of the Disclosure of *Rosman*

129. *Rosman* teaches the use of multiple smaller motors which combine power outputs through gearing to drive a larger, higher torque load.¹¹¹ *Rosman* describes the use of “[p]lanetary transmission and gear boxes 22,” which are used “to develop the amount of torque necessary” to drive high-torque loads from “off-the-shelf” motors that “are known as fast rotating and hav[ing] lower torque output.”¹¹² Thus, *Rosman* is highly relevant to the ’258 Patent, as it describes a gearing configuration for using multiple electric motors to drive a load, as is taught by the ’258 Patent.

D. *PAYNE* (EX. 1008)

1. Status of *Payne*

130. “*Payne*” is a publication of a United States patent application, U.S. Patent Publication No. 2016/0258267. *Payne* is entitled, “Well Fracturing Systems with Electrical Motors and Methods of Use.” *Payne* was filed March 3, 2016, and Published September 8, 2016. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ’258 Patent.

2. Overview of the Disclosure of *Payne*

131. *Payne* describes a “system for stimulating oil or gas production from a wellbore [that] includes a hydraulic fracturing pump unit having one or more

¹¹¹ See, e.g., Ex. 1007 (*Rosman*), 2:15-24, Figs. 1-4.

¹¹² Ex. 1007 (*Rosman*), 4:54-62.

hydraulic fracturing pumps driven by one or more electrical fracturing motors, [and] a variable frequency drive (VFD) controlling the electrical fracturing motors.”¹¹³ *Payne* further discloses a programmable automation controller that can automatically shut off a VFD upon detecting an overpressure event in an associated fracturing pump.¹¹⁴ Thus, *Payne* is in a field of art—VFD-controlled electric motors for use with fracturing pumps—that is highly relevant to the ’258 Patent, which describes VFD-controlled, electric motor drive fracturing pumps.

E. Yi (Ex. 1009)

1. Status of Yi

132. “*Yi*” is a Chinese patent application publication entitled “Fracturing Pump Transmission System and Fracturing Pump” and published April 23, 2014. *Yi* was therefore publicly available before the earliest possible priority date of all Challenged Claims of the ’258 Patent. Petitioner has provided an English translation of *Yi* and a supporting translator affidavit (Ex. 1010).

2. Overview of the Disclosure of Yi

133. *Yi* discloses a “fracturing pump transmission system” wherein “multiple motors are used to drive the fracturing pump.”¹¹⁵ *Yi* teaches that “fracturing pump 5 is a crankshaft-type plunger pump,” and at the ends of the

¹¹³ Ex. 1008 (*Payne*), Abstract.

¹¹⁴ Ex. 1008 (*Payne*), [0039].

¹¹⁵ Ex. 1010 (*Yi* Translation), Abstract.

crankshaft are “power input gears 51, and each motor 4 engages at least with the power input gears 51 at one of end of the crankshaft-type plunger pump through a power output gear 41 (whose pitch circle diameter is smaller than that of the power input gear.”¹¹⁶ Thus, POSITA would understand that *Yi* discloses a fracturing pump that is driven by multiple motors, similar to the pump described in the ’258 Patent.

F. JELAKSA (EX. 1012)

1. Status of Jelaska

134. “*Jelaska*” is a selection from the book titled *Gears and Gear Drives* by Damir Jelaska and was publicly available no later than May 16, 2013.¹¹⁷ *Jelaska* was therefore publicly available before the earliest possible priority date of all Challenged Claims of the ’258 Patent.

2. Overview of the Disclosure of Jelaska

135. *Jelaska* is a textbook that describes various gearing systems, their underlying mathematical principles, and their applications.¹¹⁸ In particular, *Jelaska* describes the equation for the transmission ratio of a mechanical drive, which is defined as the ratio of the drive’s driving and driven shaft speeds of rotation.¹¹⁹

¹¹⁶ Ex. 1010 (*Yi* Translation), [0044].

¹¹⁷ Ex. 1037 (Hall-Ellis Declaration), ¶¶ 34-40, 55.

¹¹⁸ See generally Ex. 1012 (*Jelaska*).

¹¹⁹ Ex. 1012 (*Jelaska*), pg. 3.

G. TUTTEROW (EX. 1013)**1. Status of Tutterow**

136. “Tutterow” is a book titled *Variable Speed Pumping: A Guide to Successful Applications* prepared at the Europump and Hydraulic Institute. *Tutterow* was publicly available no later than August 24, 2004.¹²⁰ *Tutterow* was therefore publicly available before the earliest possible priority date of all Challenged Claims of the ’258 Patent.

2. Overview of the Disclosure of Tutterow

137. *Tutterow* is a textbook that describes fundamental pumping principles, types of pumps, and techniques for controlling the speed of those pumps.¹²¹ In particular, *Tutterow* describes the well-known phenomenon called “cavitation” and cavitation’s effects on pumping systems, as well as the reasons to avoid cavitation.¹²²

H. NESBITT (EX. 1014)**1. Status of Nesbitt**

138. “Nesbitt” is a book titled *Handbook of Pumps and Pumping* edited by Brian Nesbitt and was publicly available no later than November 14, 2008.¹²³ *Nesbitt* was therefore publicly available before the earliest possible priority date of all Challenged Claims of the ’258 Patent.

¹²⁰ Ex. 1037 (Hall-Ellis Declaration), ¶¶ 41-47, 55.

¹²¹ See generally Ex. 1013 (*Tutterow*).

¹²² Ex. 1013 (*Tutterow*), 20, 30.

¹²³ Ex. 1037 (Hall-Ellis Declaration), ¶¶ 48-55.

2. Overview of the Disclosure of *Nesbitt*

139. *Nesbitt* is a textbook that describes fundamental pump and pumping principles.¹²⁴ In particular, *Nesbitt* provides the equation for calculating the flow rate of a plunger-style pump.¹²⁵

XI. GROUND 1A: OBVIOUS OVER *BUCKLEY* AND *BERGAN* IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA*

140. It is my opinion that *Buckley* in view of *Bergan* discloses, suggests, and renders obvious Claims 1, 3, and 6 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska*.

A. MOTIVATION TO COMBINE

1. *Buckley* and *Bergan*

141. A POSITA would have been motivated to combine the teachings of *Buckley* and *Bergan* to take advantage of *Bergan*'s teachings regarding how to connect multiple motors to drive a single rotary load.

142. Initially, both *Buckley* and *Bergan* teach using multiple motors driving a single load in an oil and gas application. *Buckley* teaches using multiple motors to drive a single rotary load such as a fluid end of a fracturing pump. *Buckley* discloses that "[t]he electric drive pump system is configured to provide a plurality of individual motors in selective configurations that work together to provide power to

¹²⁴ See generally Ex. 1014 (*Nesbitt*).

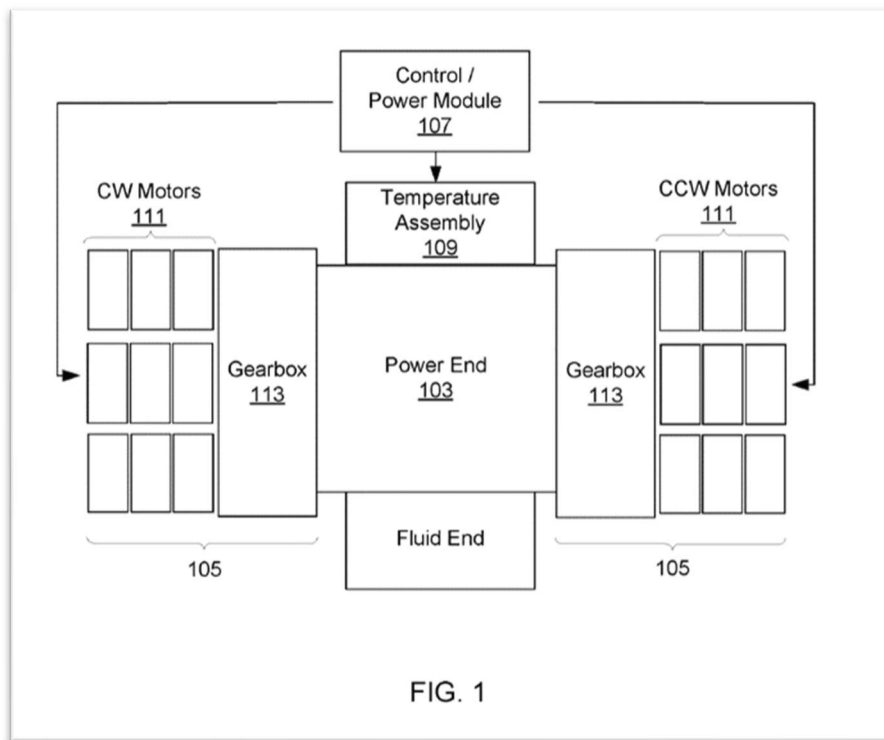
¹²⁵ Ex. 1014 (*Nesbitt*), 140.

a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid ends.”¹²⁶ *Buckley* teaches that the electric drive pump system is intended as an improvement of pumps used for “hydraulic fracturing procedure or “frac job,”¹²⁷ and that “[t]he present application relates generally to hydraulic fracturing in oil and gas well, and in particular to an electric drive pump used to drive a fluid end for the pumping of a fracturing fluid into a well.”¹²⁸ Fig. 1 of *Buckley* displays the plurality of motors arranged around a gearbox and providing power to the “power end” of a pump.

¹²⁶ Ex. 1004 (*Buckley*) [0009]; see also Ex. 1005 (*Buckley* Provisional) pg 4, 5 (“Selected gearing may be used to assist in mating the electric motors to the power end. ... Also a transfer gear system can be used if required.”)

¹²⁷ Ex. 1004 (*Buckley*) [0001]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

¹²⁸ Ex. 1004 (*Buckley*) [0009]; see also Ex. 1005 (*Buckley* Provisional) pg. 2



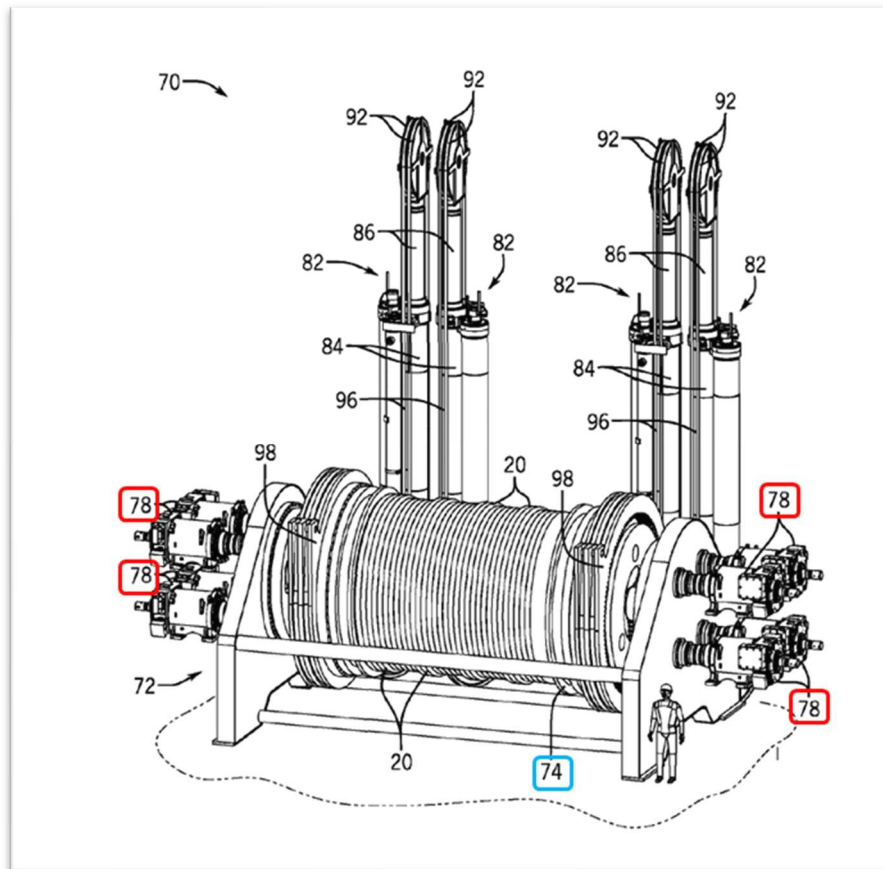
Ex. 1004 (*Buckley*) Fig. 1¹²⁹

143. A POSITA would have been motivated to look to other references, such as *Bergan* to understand gearing configurations useful to connect multiple motors to drive a single load and would have understood that *Bergan* provides one such solution.

144. Like *Buckley*, *Bergan* teaches the use of a plurality of motors located axially with the shaft of the load (i.e. drum) and connected to the shaft via gearing systems and used in oil and gas drilling, which is at least a closely related field to hydraulic fracturing. For example, when describing Fig. 3, *Bergan* discloses that

¹²⁹ See also Ex. 1005 (*Buckley Provisional*) Fig. 1, Fig. 2.

“[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹³⁰

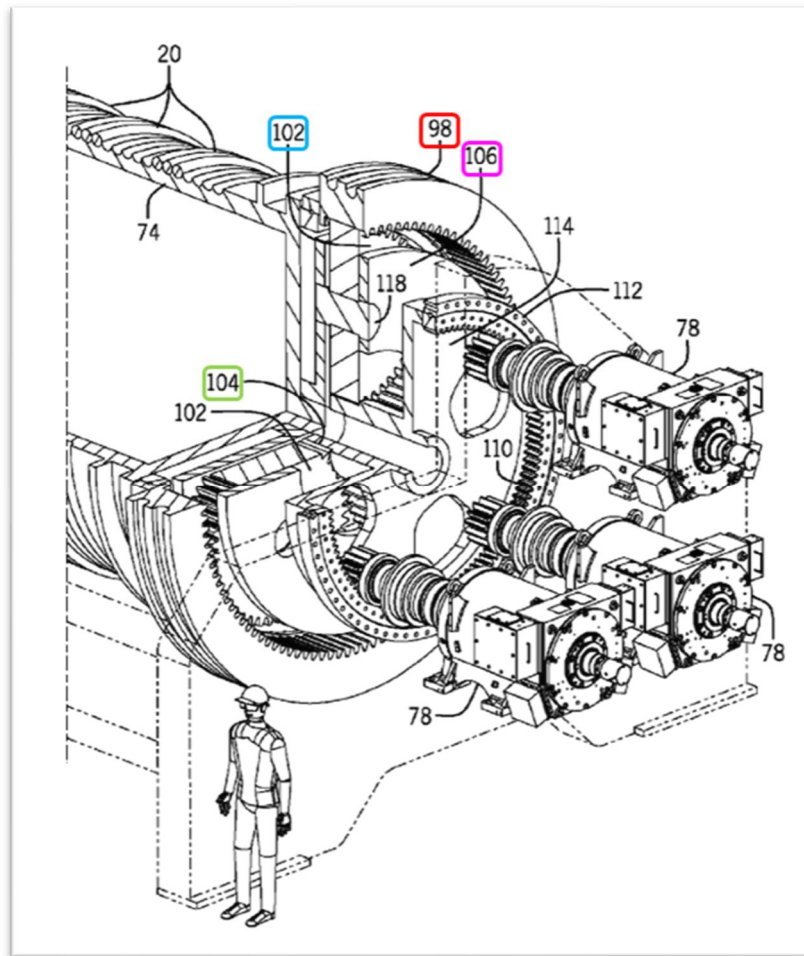


Ex. 1006 (*Bergan*) Fig. 3 (annotated)

145. *Bergan* further teaches the use of a planetary gear system to couple motors to the shaft. *Bergan* discloses “As generally shown in FIG. 4 and more specifically shown in FIGS. 5 and 6, the planetary gear system includes the ring gear

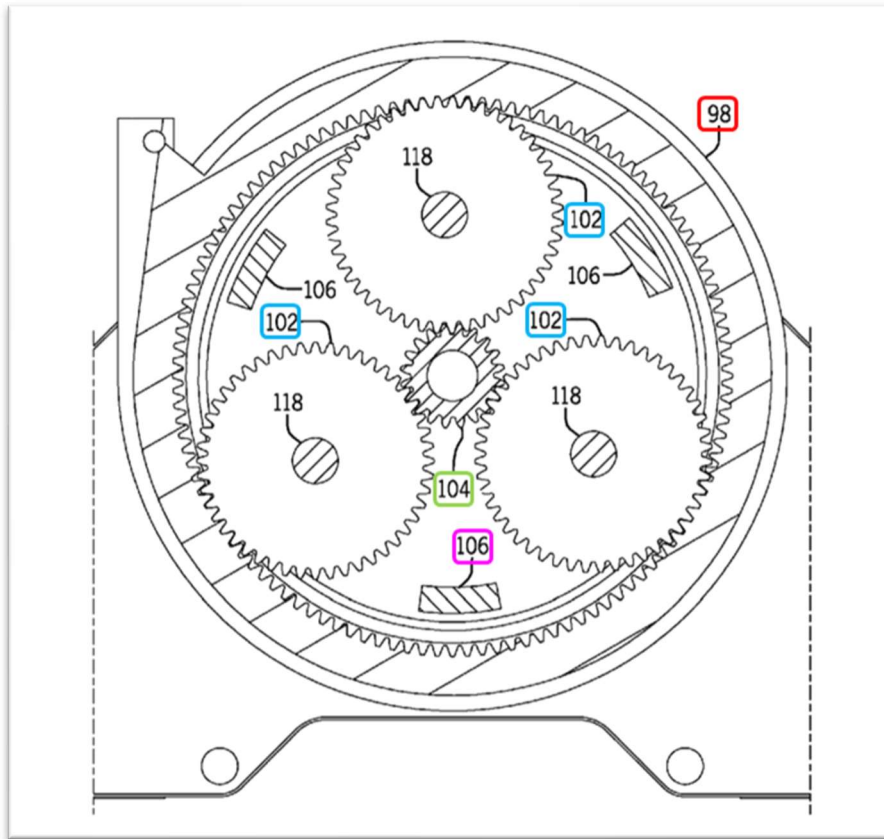
¹³⁰ Ex. 1006 (*Bergan*) [0030].

98 [annotated in red], planetary gears 102 [annotated in blue], and a sun gear 104 [annotated in green]. A carrier 106 [annotated in magenta] is coupled to rotate with the planetary gears 102 as they orbit the sun gear 104 in operation.”¹³¹



Ex. 1006 (*Bergan*) Fig. 5 (annotated)

¹³¹ Ex. 1006 (*Bergan*) [0032].



Ex. 1006 (*Bergan*) Fig. 6 (annotated)

146. A POSITA would have recognized that the planetary gear system of *Bergan* would have been useful in connecting the multiple motors of *Buckley* to *Buckley*'s rotating load (i.e. the pump crankshaft) as planetary gear trains were known to be more compact, have a higher torque rating and have better lubrication than other gearing systems (e.g., fixed, parallel shaft gearboxes), and would have been motivated to incorporate a planetary gear train in the system of *Buckley* to gain these advantages from such a configuration.¹³²

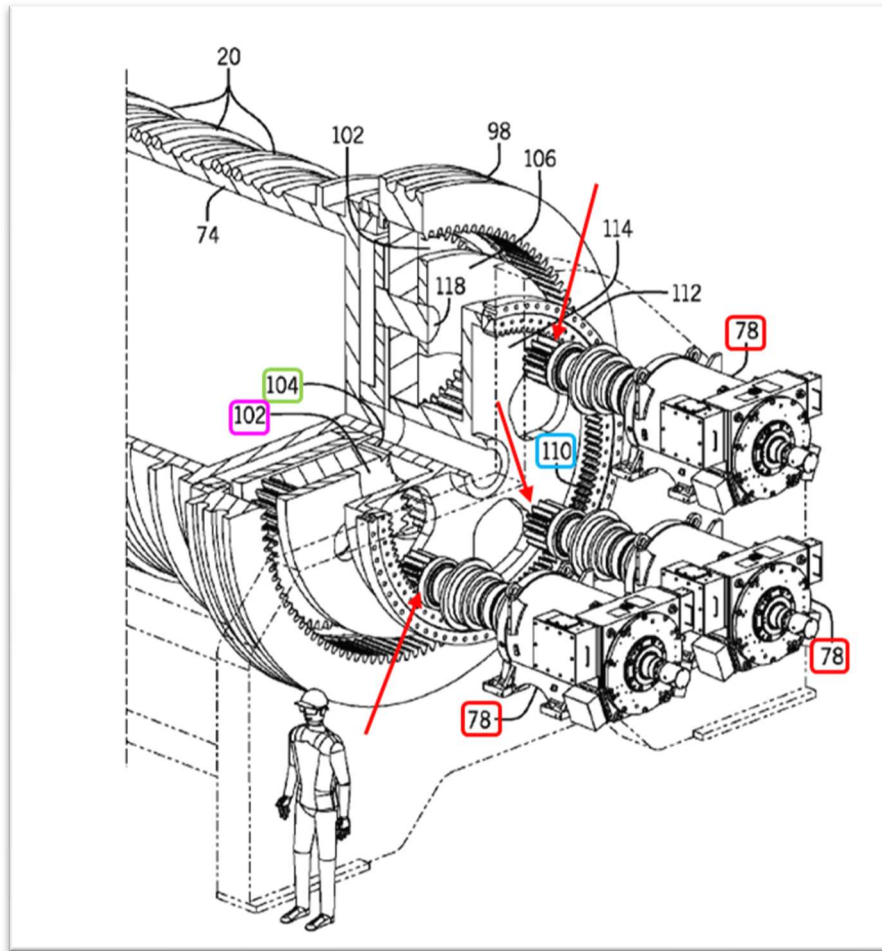
¹³² See section IX.C above

147. Further, *Bergan* shows a specific configuration of gearing that would have been used to connect *Buckley*'s plurality of motors to a single rotary load. For example, *Bergan* discloses "the motors 78 [annotated in red below] are connected to drive rotation of a gear 110 [annotated in blue below] of a slew bearing 112. The gear 110 is coupled to a sun wheel 114 having the sun gear 104 [annotated in green below] such that the motors 78 rotate the sun gear 104 via the wheel 114 and the gear 110. The planetary gears 102 [annotated in magenta] are mounted on axles 118 coupled to the carrier 106, which is coupled to drive the drum 74. This allows the orbit of the planetary gears 102 to drive rotation of both the carrier 106 and the drum 74."¹³³

148. Figure 5 shows a perspective view of *Bergan*'s gearing mechanism. *Buckley* Figure 5 further shows the motors 78 each rotationally coupled to an "input pinion" (not numbered, annotated with red arrows) allowing the motors to drive the gearing system. A "pinion" was known to be "a gear with a small number of teeth designed to mesh with a larger wheel or rack."¹³⁴ The pinions annotated with red arrows mesh with the larger gear (wheel) 110.

¹³³ Ex. 1006 (*Bergan*) [0032]; *see also, e.g.*, [0014], [0035], [0041], Claims 4-6, 10, 16-18.

¹³⁴ Ex. 1011.



Ex. 1006 (*Bergan*) Fig. 5 (annotated)

149. In combination, a POSITA would have understood that *Buckley's* motors would couple to *Bergan's* planetary gearing system via *Bergan's* input pinions (consistent with *Bergan's* teaching of coupling multiple motors to the planetary gearing system via the input pinions) and that *Bergan's* planetary gearing system would couple to *Buckley's* pump crankshaft via *Bergan's* carrier 106 (consistent with *Bergan's* teaching of coupling carrier 106 to a rotating load), such that *Buckley's* motors would drive the rotation of *Buckley's* pump crankshaft via

Bergan's planetary gearing system. Such a combination would involve scaling *Bergan's* gears to sizes appropriate to *Buckley's* pumping system, which would have been obvious and common-sense changes for a POSITA using basic engineering principles.

150. A POSITA would have had a reasonable expectation of success in combining the teachings of *Buckley* and *Bergan*. Incorporating *Bergan's* teachings of a planetary gear train and the use of “pinions” to connect the motors to the load is applying a known technique (planetary gear trains and motors with pinions) to improve similar devices (*Buckley's* gearbox) in the same way. The results of the combination would have been predictable – transfer of rotational energy from *Buckley's* motors to *Buckley's* pump with straightforward, predictable changes in gear ratios and corresponding changes in speed and torque available. And, *Bergan's* teachings of planetary gear systems and motors with pinions was known in one field of endeavor (oil and gas drilling) and would have prompted a POSITA to use it in either the same field or a different one (oil and gas fracturing) based on design incentives (ability to connect multiple motors to a single load and the advantages of a planetary gear train described in Section IX.D) because the variations used for a pump—such as using appropriately-sized gears in a manner obvious to a POSITA—would have been predictable to one of ordinary skill in the art. As discussed above, the results of the combination would have been predictable – transfer of rotational

energy from *Buckley*'s motors to *Buckley*'s pump with straightforward, predictable changes in gear ratios and corresponding changes in speed and torque available. Similarly, modifying *Buckley*'s pumping system to use *Bergan*'s planetary gearing system requires a simple substitution of one known element (*Bergan*'s planetary gearing system with obvious changes to gear sizes) for another (*Buckley*'s gearing system) to obtain the predictable result of transferring rotational energy from *Buckley*'s motors to *Buckley*'s pump. Thus, a POSITA would have been motivated to combine the teachings of *Buckley* and *Bergan* and would have had a reasonable expectation of success in doing so.¹³⁵

2. *Buckley, Bergan, and Jelaska*

151. As discussed above, the *Buckley-Bergan* combination teaches a multi-plunger pump powered by multiple electric motors via a planetary gearing configuration. A POSITA would have searched for other references to better understand details of gearing configurations that are not described in *Buckley* and/or *Bergan*. One such reference is *Jelaska*, which is a publication that provides granular details about gearing configurations that would have been invaluable to a POSITA

¹³⁵ I also understand that the U.S. Patent Office combined *Buckley* and *Bergan* in a similar manner during the prosecution of U.S. Patent Application No. 18/357,271, which was filed as a continuation of, and contained claims similar to, the '258 Patent. See Ex. 1042, 443-444 (IDS accompanying Application No. 18/357,271, claiming priority to U.S. Application 16/210,807, which issued as the '258 Patent (see Ex. 1001, Cover)), 157-162 (Office Action analysis of *Buckley-Bergan* combination).

looking to apply the teachings of *Bergan* to a practical system. In particular, *Jelaska*'s description of transmission ratio and its effect on the speed of a driven component would aid a POSITA's design of a gearing configuration when implementing *Bergan*'s planetary gearing configuration to result in a particular pump speed.¹³⁶

152. Further, combining *Jelaska*'s teachings regarding transmission ratio to the *Buckley-Bergan* combination's pumping configuration is merely combining prior art elements (designing a transmission system to produce a desired output speed and the planetary gearset of *Bergan*) to known methods (*Bergan*'s planetary gearset) to yield predictable results (producing a desired pump speed as the output of the planetary gearset). Accordingly, a POSITA would have been motivated to combine *Jelaska*'s teachings of fundamental gearing system operations with the *Buckley-Bergan* combination's pumping configuration, and would have reasonably expected success in doing so.

B. INDEPENDENT CLAIM 1

153. As discussed in the following subsections, it is my opinion that the combination of *Buckley* and *Bergan* discloses, suggests, and renders obvious Claim 1 of the '258 Patent. As discussed in the following subsections, *Buckley* and/or

¹³⁶ See Ex. 1012 (*Jelaska*), 3.

Bergan, along with the general knowledge of a POSITA and, in the alternative, in view of *Jelaska*, discloses, or renders obvious, each and every element of Claim 1.

1. 1[p]: “1. A hydraulic fracturing system for fracturing a subterranean formation comprising:”

154. *Buckley* discloses a hydraulic fracturing system.¹³⁷ *Buckley* discloses that “[t]he present application relates generally to hydraulic fracturing in oil and gas wells, and in particular to an electric drive pump used to drive a fluid end for the pumping of a fracturing fluid into a well.”¹³⁸ Further, *Buckley* teaches that “[h]ydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells,” that the process includes pumping fluid into a (downhole) formation, and that “[w]hen the fluid enters the formation, it fractures, or creates fissures, in the formation.”¹³⁹ As discussed above in Section IX.A, this is a typical and well-known part of hydraulic fracturing dating back to the 1940s.

155. Accordingly, *Buckley* discloses, and the combination of *Buckley* with *Bergan* and the knowledge of a POSITA renders the preamble obvious.

¹³⁷ I understand that the preamble may not be limiting. I include analysis of the preamble out of an abundance of caution.

¹³⁸ Ex. 1004 (*Buckley*) [0001]; see also Ex. 1005 (*Buckley Provisional*) pg. 2

¹³⁹ Ex. 1004 (*Buckley*) [0002]; see also Ex. 1005 (*Buckley Provisional*) pg. 2

2. **1[a]: “a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”**

a) *“a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well”*

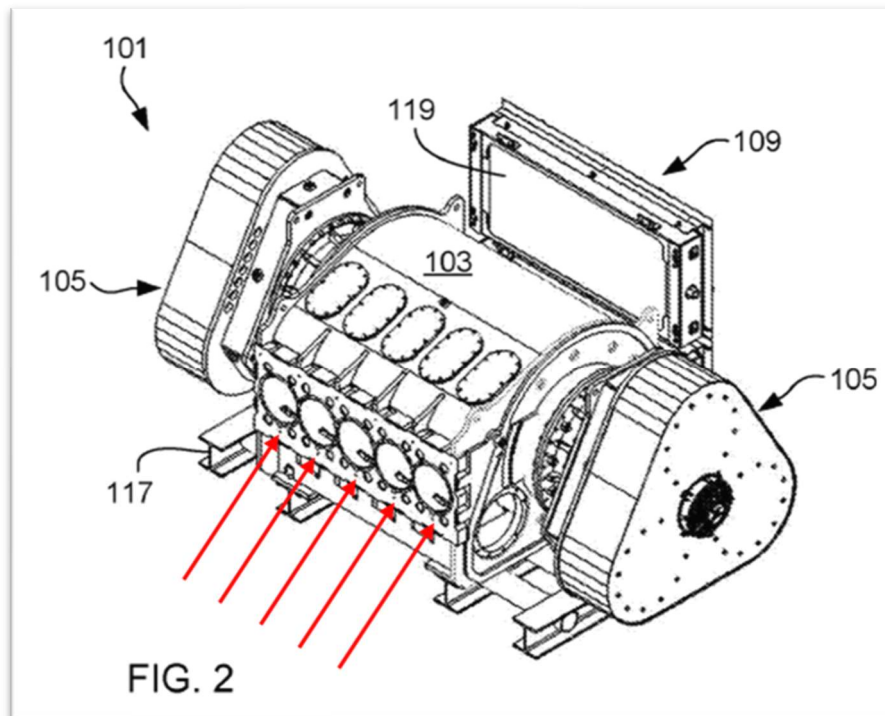
156. *Buckley* discloses a multi-plunger hydraulic pump that is both connected to a well associated with the subterranean formation and configured to pump fluid into a wellbore associated with the well. Initially, the '258 Patent admits that multi-plunger hydraulic fracturing pumps were known: “Multi-plunger hydraulic fracturing pumps, though known in the art, are typically limited to either triplex (three plungers) or quintuplex (five plungers) arrangements.”¹⁴⁰ Further, *Buckley* discloses “an electric drive pump used to drive a fluid end for the pumping of a fracturing fluid into a well.”¹⁴¹ Further, *Buckley* describes “hydraulic fracturing [] consists of pumping fluid into a wellbore at high pressure (sometimes as high as 50,000 PSI).”¹⁴² Because *Buckley* teaches pumping fluid into the well and wellbore, the pump must be connected to the well.

¹⁴⁰ Ex. 1001 5:1-3.

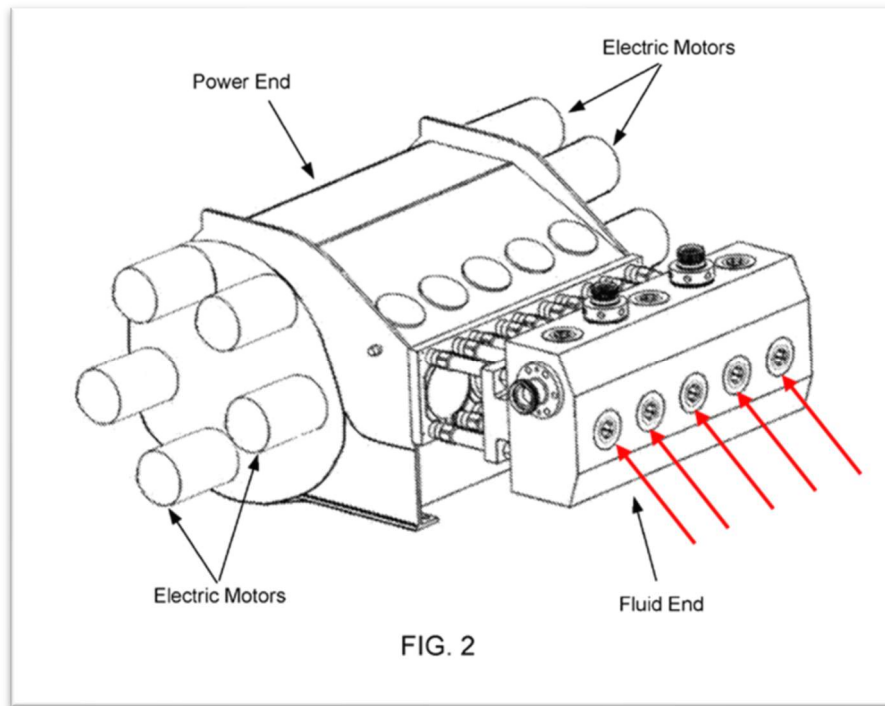
¹⁴¹ Ex. 1004 (*Buckley*) [0001]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

¹⁴² Ex. 1004 (*Buckley*) [0002]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

157. *Buckley*'s configuration contains "a plurality of individual motors in selective configurations that work together to provide power to a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid ends."¹⁴³ As discussed above in Section IX.B, the use of multiple plungers in a pump fluid end was well known long before the '258 Patent. Both *Buckley* and the *Buckley* provisional provide figures that show the use of a quintuplex (5 plungers) fluid end. In each figure, the 5 cylinders (annotated in red) are evident from the arrangement of the fluid end.



¹⁴³ Ex. 1004 (*Buckley*) [0009];

Ex. 1004 (*Buckley*) Fig. 2Ex. 1005 (*Buckley* Provisional) Fig. 2

158. Accordingly, as *Buckley* discloses the use of a 5-plunger pump, *Buckley* discloses the use of a “multi-plunger” pump. To the extent that *Buckley* does not explicitly use the term “multi-plunger” when describing the pump, the use of a “multi-plunger” fracturing pump would have been obvious to a POSITA based on the general knowledge of a POSITA that such pumps were commonly used in fracturing operations (see section IX.A), the disclosure of *Buckley* including showing a multi-plunger fracturing pump in the figure(s), and the ’258 Patent’s admission that multi-plunger pumps are known in the art.

b) “at a high pressure”

159. *Buckley* teaches pumping fluid into the wellbore at high pressures.¹⁴⁴

Buckley discloses “Hydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells. The practice consists of pumping fluid into a wellbore at high pressure (sometimes as high as 50,000 PSI).”¹⁴⁵ Accordingly, *Buckley* discloses pumping fluid into the wellbore “at a high pressure”.

c) ***“so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation”***

160. *Buckley* discloses this limitation as well. *Buckley* teaches “[h]ydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells. The practice consists of pumping fluid into a wellbore at high pressure (sometimes as high as 50,000 PSI). Inside the wellbore, large quantities of proppants are carried in suspension by the fracture fluid into the fractures. When the fluid enters the formation, it fractures, or creates fissures, in the formation. Water, as well as other fluids, and some solid proppants, are then pumped into the fissures to stimulate the release of oil and gas from the formation”¹⁴⁶ Accordingly, *Buckley* discloses the

¹⁴⁴ I understand that the term “high pressure” has been found to be indefinite when used in a similar way in other US Wells Patents. I match the terms “high pressure” from both the ‘258 Patent and *Buckley*. The fact that the prior art teaches pumping “at high pressure” does not mean the term is definite as used in the ‘258 Patent. I reserve the right to opine about the use of the term “high pressure” in the claims and specification of the ‘258 Patent should the issue arise in any proceeding.

¹⁴⁵ Ex. 1004 (*Buckley*) [0002], [0003], [0036]; see also Ex. 1005 (*Buckley* Provisional) pg. 2, pg. 4;

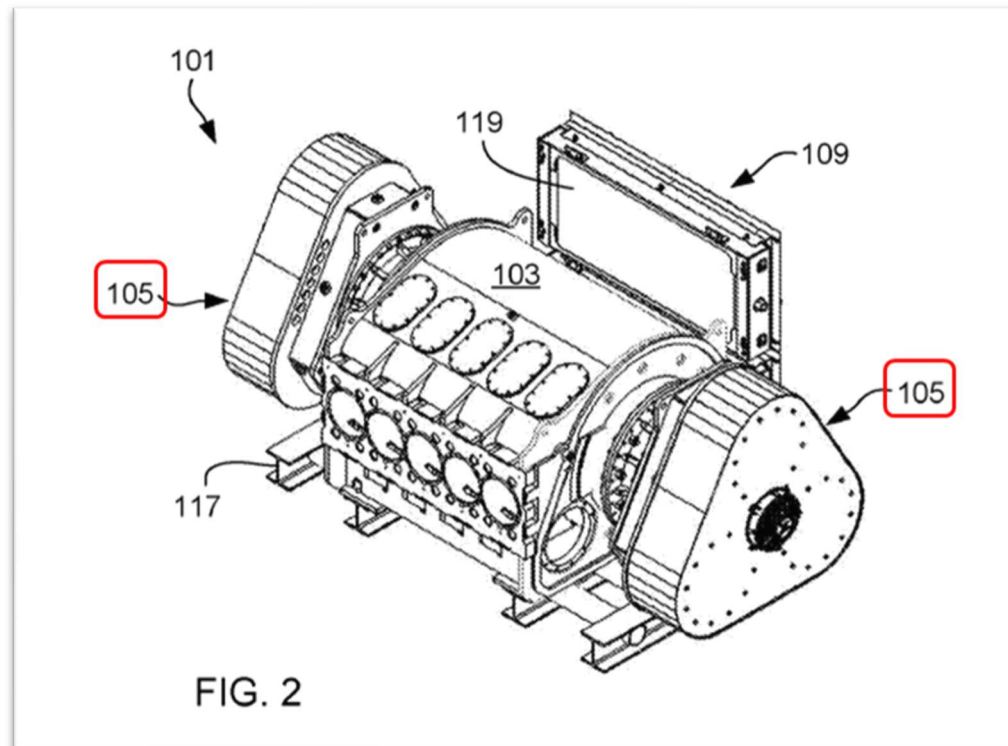
¹⁴⁶ Ex. 1004 (*Buckley*) [0002]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation.

3. 1[b]: “a plurality of motors positioned to simultaneously power the multi-plunger pump; and”

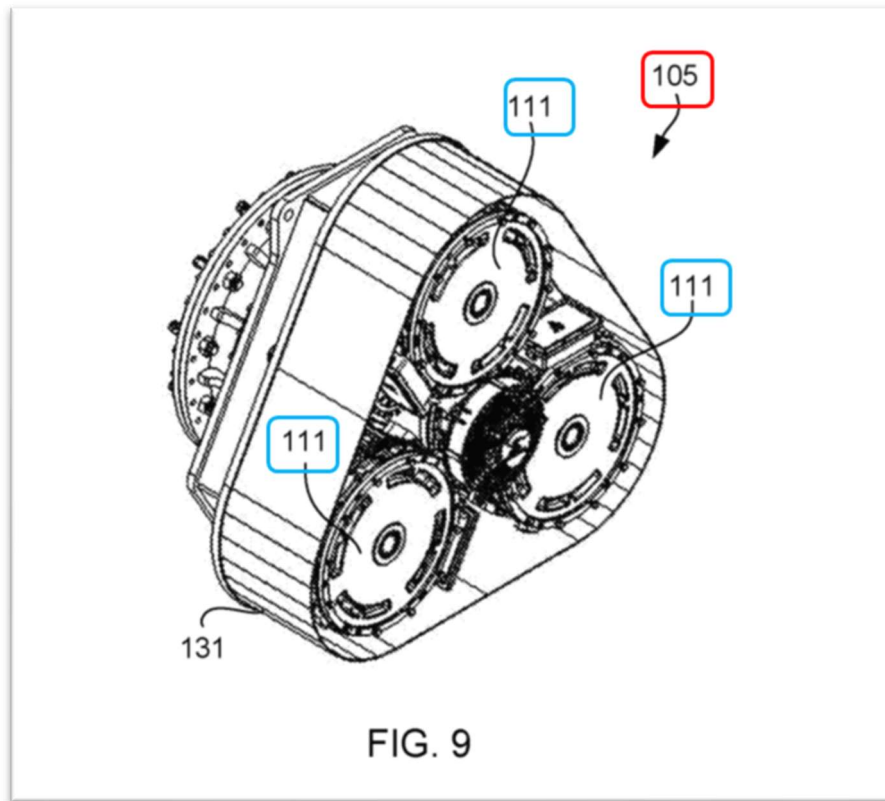
161. *Buckley* discloses this limitation as well. *Buckley* discloses “[t]he electric drive pump system is configured to provide a plurality of individual motors in selective configurations that work together to provide power to a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid ends.”¹⁴⁷ The plurality of motors is shown in the figures of both *Buckley* and its Provisional Application. Fig.2 of *Buckley* shows “transmission assembly 105” (annotated in red) mounted to drive the pump.

¹⁴⁷ Ex. 1004 (*Buckley*) [0009]; see also Ex. 1005 (*Buckley* Provisional) p. 4 (“Referring now to Figures 1 and 2 in the drawings, a side view of a schematic of a power end in communication with a plurality of electric motors and a representative perspective view is illustrated. The power end includes a pump that is used to operate one or more fluid ends. [] This system includes a series of electric motors of sufficient number needed to give the required output to operate the one or more fluid ends. The precise number is dependent upon design constraints and engineering parameters. It is understood that more than one may be used. In Figure 1,[sic. Figure 2] a total of 10 are shown or implied, with 5 being located on either side of the power end.”)



Ex. 1004 (*Buckley*) Fig. 2 (annotated)

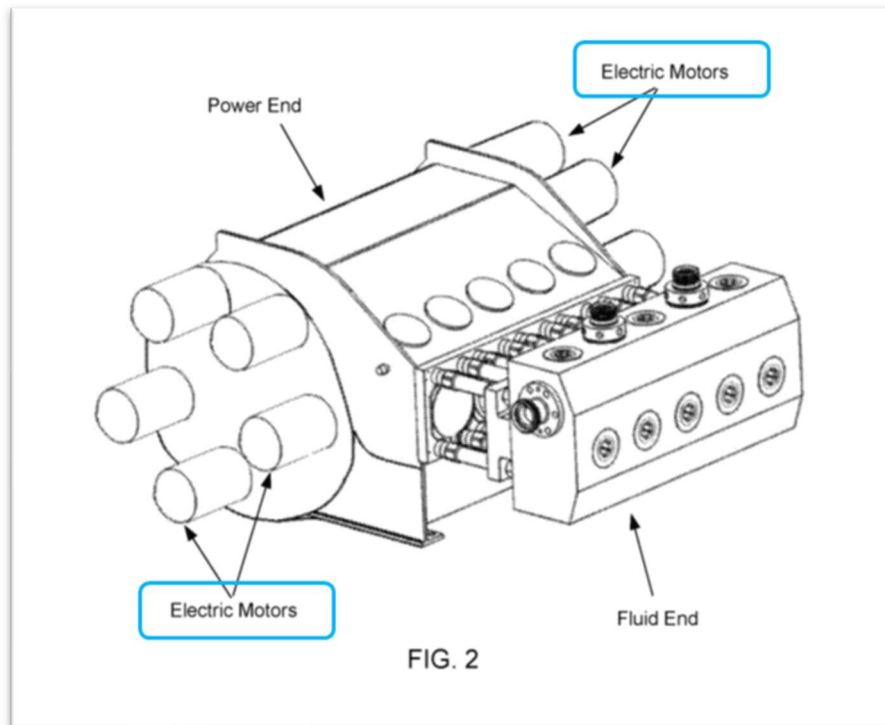
Fig. 9 of *Buckley* shows that transmission assembly 105 (annotated in red) comprises a plurality of “motors 111” (annotated in blue).



Ex. 1004 (*Buckley*) Fig. 9 (annotated)

162. Similarly, *Buckley Provisional* Fig. 2 shows a “series of electric motors of sufficient number needed to give the required output to operate the one or more fluid ends [] a total of 10 [motors] are shown or implied [annotated in blue], with 5 being located on either side of the power end.”¹⁴⁸

¹⁴⁸ Ex. 1005 (*Buckley Provisional*) pg. 4.



Ex. 1005 (*Buckley Provisional*) Fig. 2 (annotated)

163. *Buckley* teaches “motors 111 may operate *as a collective whole* or independent of one another. Motors 111 can be used *in a continuous duty cycle* or as a sequenced duty cycle to meet the requirement of the pumps output.”¹⁴⁹ Similarly, the *Buckley Provisional* teaches “each electric motor is configured to produce a set amount of power (power max). The sizing of the plurality of motors can be such that they output equal or different amounts of power individually. *Collectively*, to some degree, *a sufficient amount of power needs to be output from some number of the plurality of electric motors as is necessary to achieve the pumps*

¹⁴⁹ Ex. 1004 (*Buckley*) [0056] emphasis added.

output. It is understood that if each of the motors are independently operable, *some motors may be on while others are off*.”¹⁵⁰

164. Indeed, *Buckley* discloses various examples of operating multiple motors at the same time based on the output requirements of the drive pump. For example, when a “50% output is required, [] the even numbered motors 111 are operative while the odd numbered motors 111 are deactivated or turned off”; when “100% power is required...all motors 111 are turned on”; and when “70% power is required...motors 1, 5, 9, and 13 are off while the others are on.”¹⁵¹

165. Accordingly, *Buckley* discloses a plurality of motors positioned to simultaneously power the multi-plunger pump.

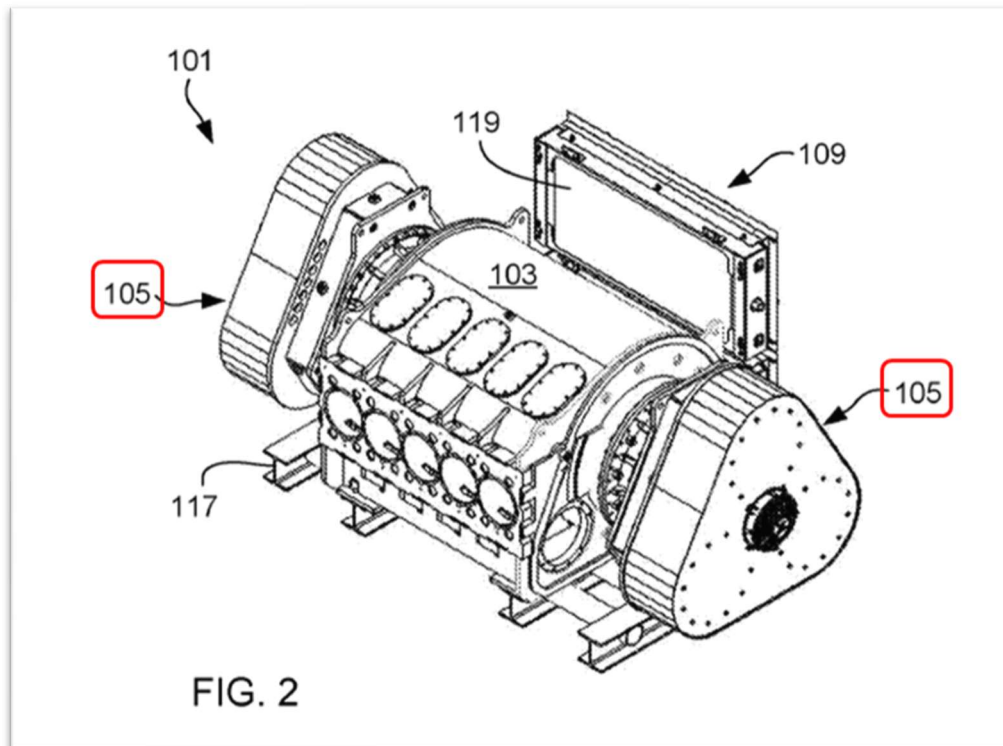
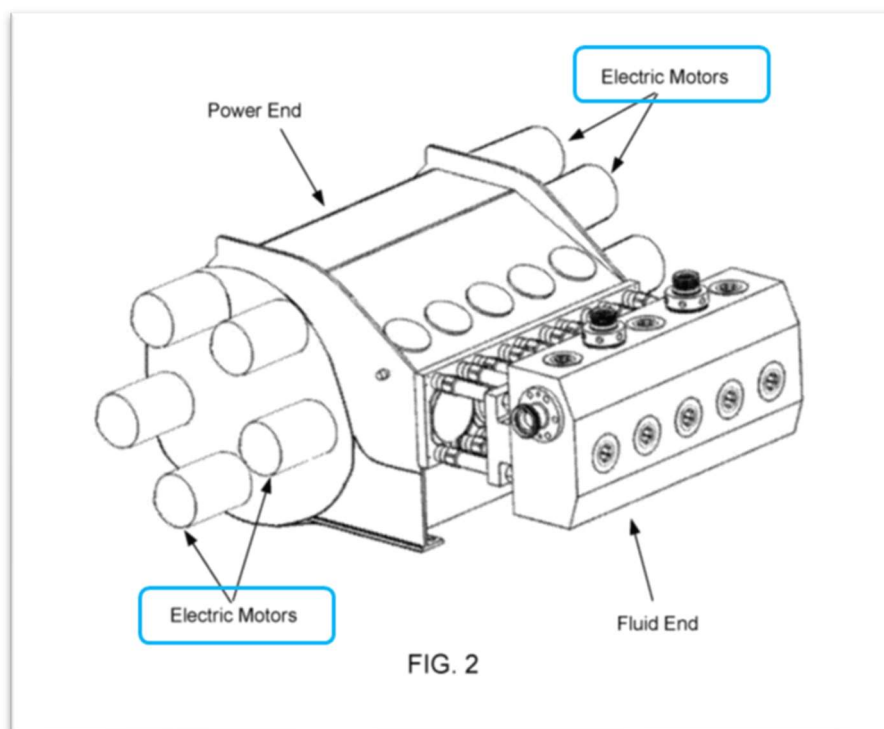
4. 1[c]: “a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors,

a) “a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors”

166. The combination of *Buckley* and *Bergan*, renders this limitation obvious. As discussed above, *Buckley* teaches a plurality of motors positioned to simultaneously power the multi-plunger pump. In *Buckley*, figures show the motors located axially with the shaft of the pump fluid end.

¹⁵⁰ Ex. 1005 (*Buckley Provisional*) pg. 5 emphasis added.

¹⁵¹ Ex. 1004 (*Buckley*), [0057]; Figs. 16-18; Ex. 1005 (*Buckley Provisional*), pg. 6, Figs. 4-6.

Ex. 1004 (*Buckley*) Fig. 2 (annotated)

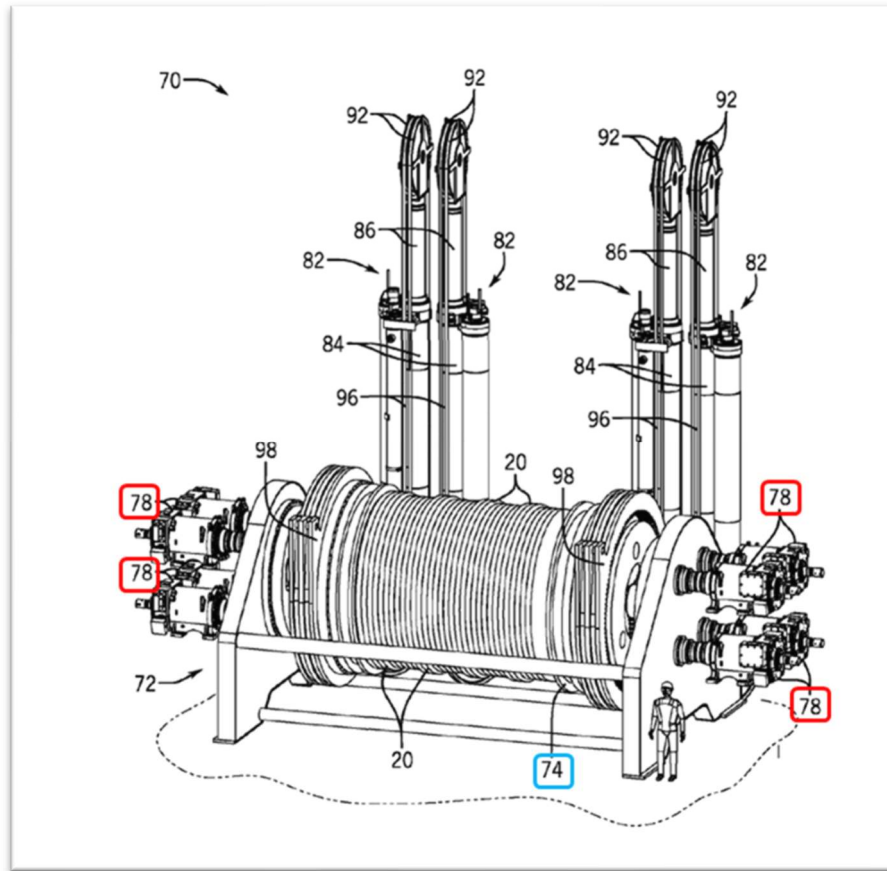
Ex. 1005 (*Buckley* Provisional) Fig. 2 (annotated)

167. *Buckley* further teaches “[t]he motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid ends.”¹⁵²

168. Like *Buckley*, *Bergan* teaches the use of a plurality of motors located axially with the shaft of the load (i.e. drum) and connected to the shaft via gearing systems. For example, when describing Fig. 3, *Bergan* discloses that “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁵³

¹⁵² Ex. 1004 (*Buckley*) [0009]; see Ex. 1005 (*Buckley* Provisional) pg. 5 (“Selected gearing may be used to assist in mating the electric motors to the power end. As seen from Figure 1, these can be mounted at both ends of the pump, which apply the drive by means of any of the following: a gear/gears, chain or belt drive, or a combination of some or all. [] Also a transfer gear system can be used if required. This may depend on the orientation of the axis of the motor to the axis of the pump.”)

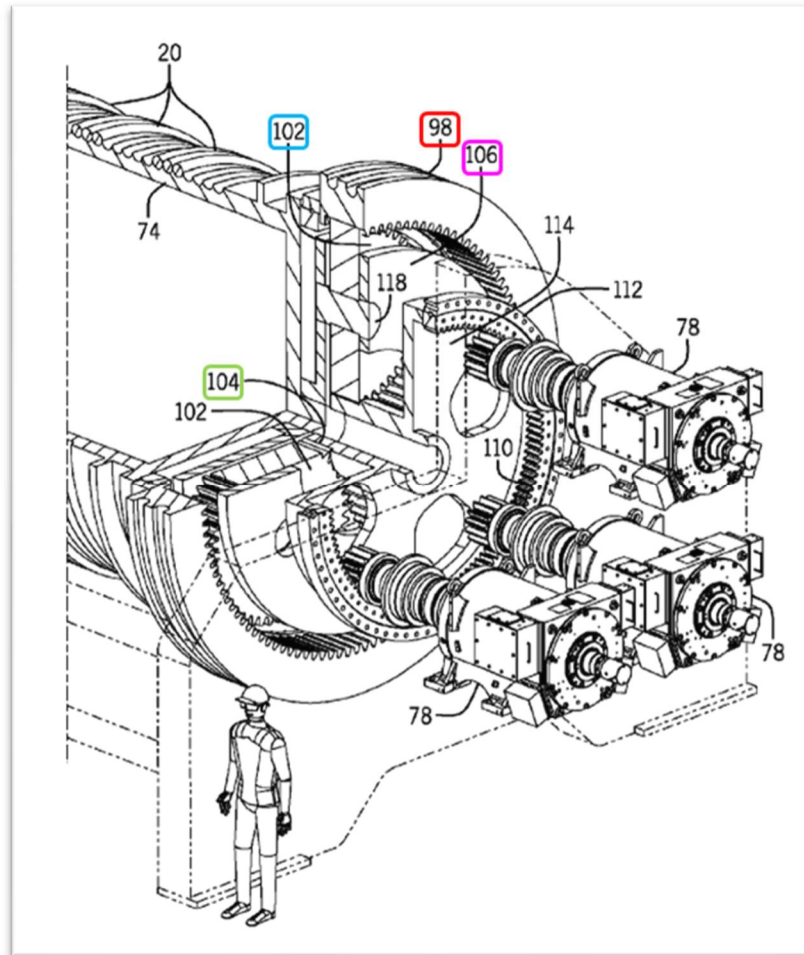
¹⁵³ Ex. 1006 (*Bergan* [0030])



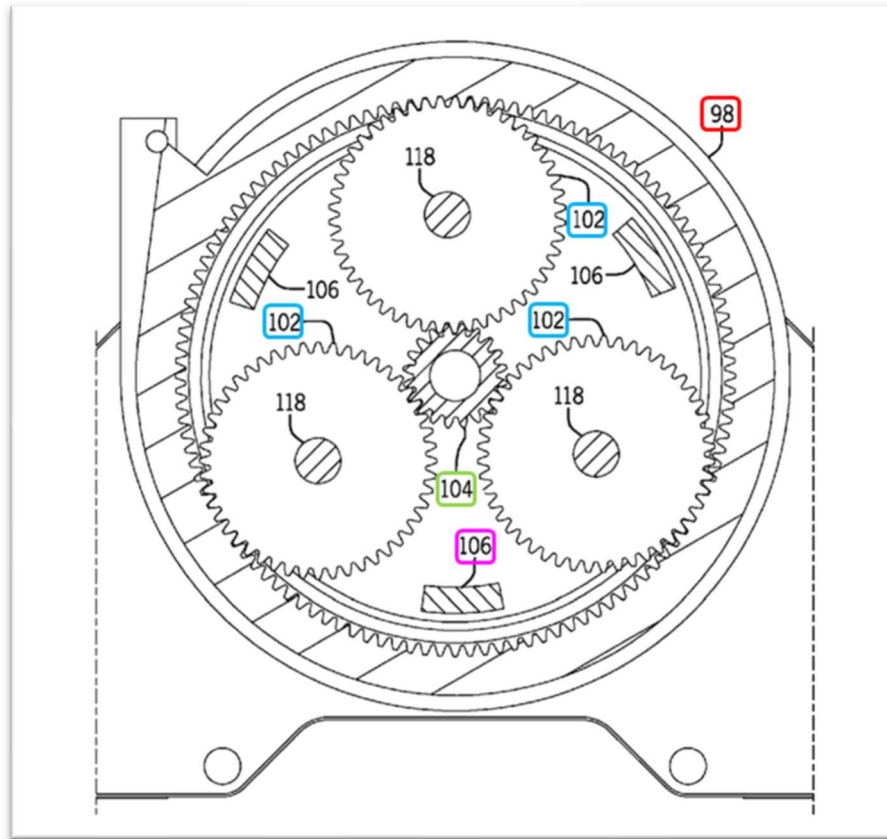
Ex. 1006 (*Bergan*) Fig. 3 (annotated)

169. *Bergan* further teaches the use of a planetary gear system to couple motors to the shaft. *Bergan* discloses “As generally shown in FIG. 4 and more specifically shown in FIGS. 5 and 6, the planetary gear system includes the ring gear 98 [annotated in red], planetary gears 102 [annotated in blue], and a sun gear 104 [annotated in green]. A carrier 106 [annotated in magenta] is coupled to rotate with the planetary gears 102 as they orbit the sun gear 104 in operation.”¹⁵⁴

¹⁵⁴ Ex. 1006 (*Bergan*) [0032].



Ex. 1006 (*Bergan*) Fig. 5 (annotated)



Ex. 1006 (*Bergan*) Fig. 6 (annotated)

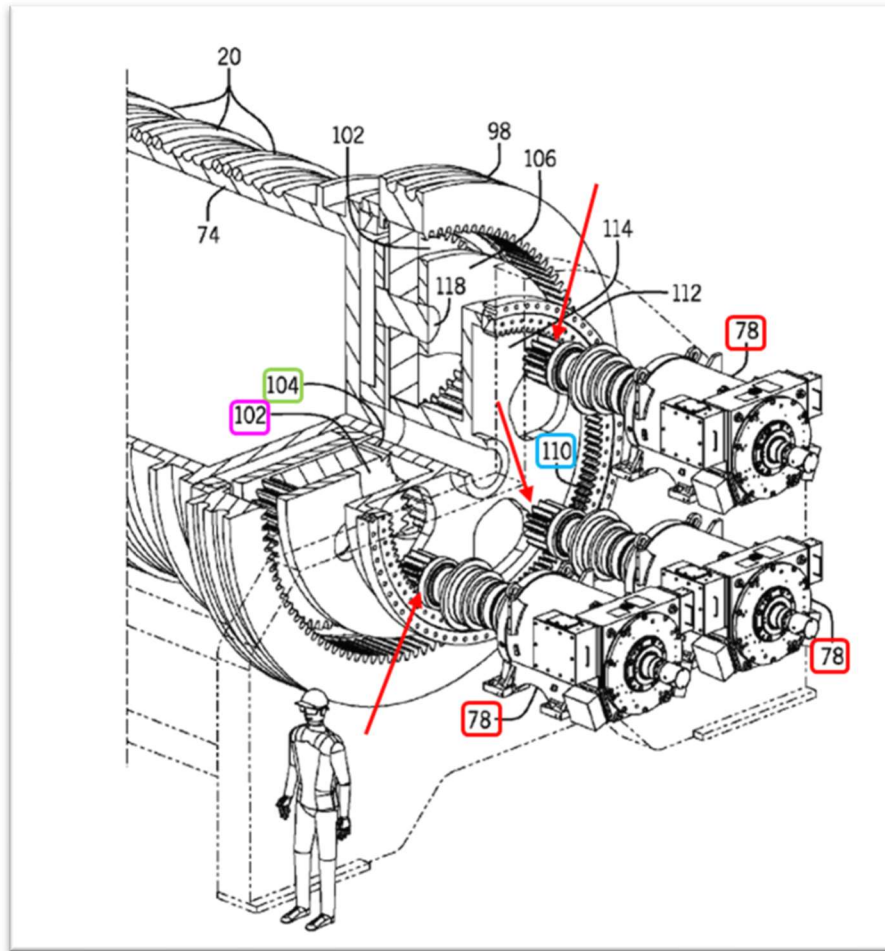
170. *Bergan* further discloses driving the planetary gear train with multiple motors. *Bergan* teaches that “the motors 78 [annotated in red] are connected to drive rotation of a gear 110 [annotated in blue] of a slew bearing 112. The gear 110 is coupled to a sun wheel 114 having the sun gear 104 [annotated in green] such that the motors 78 rotate the sun gear 104 via the wheel 114 and the gear 110. The planetary gears 102 [annotated in magenta] are mounted on axles 118 coupled to the

carrier 106, which is coupled to drive the drum 74. This allows the orbit of the planetary gears 102 to drive rotation of both the carrier 106 and the drum 74.”¹⁵⁵

171. Figure 5 shows a perspective view of *Bergan*’s gearing mechanism. A POSITA would have understood that *Bergan*’s motors 78 drive sun gear 104 as a result of motors 78 driving the rotation of a respective “input pinion” (not numbered, annotated with red arrows). A “pinion” was known to be “a gear with a small number of teeth designed to mesh with a larger wheel or rack.”¹⁵⁶ The pinions annotated with red arrows mesh with the larger gear (wheel) 110. I understand that the Patent Owner asserts that input pinion gears directly connected to a motor driving the rotation satisfies this limitation, and *Bergan* discloses this.

¹⁵⁵ Ex. 1006 (*Bergan*) [0032]; *see also, e.g.*, [0014], [0035], [0041], Claims 4-6, 10, 16-18.

¹⁵⁶ Ex. 1011.



Ex. 1006 (*Bergan*) Fig. 5 (annotated)

172. Accordingly, *Bergan* discloses a planetary gear train having a plurality of input pinion in rotational contact with each of the plurality of motors.

173. As discussed above in Section XI.A, a POSITA would have been motivated to combine *Buckley* and *Bergan* such that *Bergan*'s planetary gear system would couple *Buckley*'s motors to its drive pump and would have a reasonable expectation of success in doing so. Accordingly, *Bergan* discloses, and the combination of *Buckley* and *Bergan* renders Limitation 1[c] obvious.

5. 1[d]: “wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.”

174. As discussed above in Section IX.C, it was well known long before the '258 Patent that the speed of the drive (i.e. motors) and the gear ratio of the gear train dictate the speed of the driven mechanism (i.e. pump) according to the equation

$$i = \frac{n_1}{n_2} = \frac{\omega_1}{\omega_2},$$

where i is the gear ratio, n_1 is the driving shaft speed, n_2 is the driven shaft speed, ω_1 is the angular speed of the driving shaft, and ω_2 is the angular speed of the driven shaft.¹⁵⁷ This was known to the ancient Greeks, and is a well understood fundamental of gear train operation and would have been included in the general knowledge of a POSITA. Indeed, the fact that the gear ratio and the driving speed dictate the speed of the driven shaft (e.g. pump) would have been known to anyone who has ridden a multi-speed bicycle with gears, or anyone who has operated a manual transmission. To “limit a maximum pump speed associated with the multi-plunger pump” a POSITA would simply choose a maximum speed of the pump desired and coordinate the speed of *Buckley*’s motors with the gear ratio of *Bergan*’s planetary gear train (which operates as the transmission that links *Buckley*’s motors with its drive pump) so that the maximum speed of *Buckley*’s pump is not exceeded. The output speed of

¹⁵⁷ Ex. 1012 (*Jelaska*), pg. 3.

a gear train is predictable based on the input speed of the prime mover (*e.g.*, motor) and the gear ratio of the drive train. Accordingly, the combination of *Buckley* and *Bergan* in view of the general knowledge of a POSITA renders this limitation obvious. In the alternative, this limitation is rendered obvious by the combination of *Buckley*, *Bergan*, and *Jelaska* for the same reasons just discussed, as *Jelaska* describes basic operations of gear trains.

C. DEPENDENT CLAIM 3: “3. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

175. Dependent Claim 3 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, both *Buckley* and *Bergan*, alone or in combination, disclose the additional limitations of Claim 3. As discussed above regarding limitation 1[b], and incorporated herein by reference, *Buckley* discloses that “[t]he *electric drive pump system* is configured to provide a plurality of individual motors in selective configurations that work together to provide power to a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the *electric motors* into linear motion for operation of the plungers in the fluid ends.”¹⁵⁸ Accordingly, *Buckley* discloses using a plurality of electric motors to drive the hydraulic fracturing pump.

¹⁵⁸ Ex. 1004 (*Buckley*) [0009] emphasis added; see also [0007], [00032] Figs 15-18, [0036], [0041] – [0042], Claims 1-15, 19, 20, 23, 24; see also Ex. 1005 (*Buckley* Provisional) p. 4 (“Referring now to Figures 1 and 2 in the drawings, a

176. *Bergan* also teaches the use of electric motors. As discussed above regarding limitation 1[c], and incorporated herein by reference, *Bergan* teaches “motors 78” to drive the planetary gear system claimed. *Bergan* further discloses, for example, “[m]otors 78 can be operated to drive rotation of the drum 74 to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁵⁹ Accordingly, not only are electric motors explicitly disclosed by *Bergan*, but hydraulic motors would have been obvious (“any suitable motors 78 could be used”).

177. Further still, the general knowledge of a POSITA would have rendered Claim 3 obvious. As discussed above in section IX, electric motors with VFDs driving fracturing pumps would have been well known to a POSITA by the time of the '258 Patent.

Accordingly, both *Buckley* and *Bergan*, alone or in combination, disclose the additional limitations of Claim 3 and render Claim 3 obvious. In the alternative,

side view of a schematic of a power end in communication with a plurality of electric motors and a representative perspective view is illustrated. The power end includes a pump that is used to operate one or more fluid ends. [] This system includes a series of electric motors of sufficient number needed to give the required output to operate the one or more fluid ends. The precise number is dependent upon design constraints and engineering parameters. It is understood that more than one may be used. In Figure 1,[sic. Figure 2] a total of 10 are shown or implied, with 5 being located on either side of the power end.”)

¹⁵⁹ Ex. 1006 (*Bergan*) [0030]

Claim 3 is rendered obvious by the combination of *Buckley*, *Bergan*, and *Jelaska* for the same reasons just discussed, as *Jelaska* describes basic operations of gear trains.

D. DEPENDENT CLAIM 6: “6. THE SYSTEM OF CLAIM 1, WHEREIN THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP COMPRISES AN ODD NUMBER OF PLUNGERS GREATER THAN OR EQUAL TO FIVE PLUNGERS.”

178. Dependent Claim 6 depends from Claim 1. In addition to the disclosures regarding Claim 1 discussed above, *Buckley* discloses the additional limitations of Claim 6. Initially, the '258 Patent admits that multi-plunger hydraulic fracturing pumps that meet the limitations of Claim 6 were known: “Multi-plunger hydraulic fracturing pumps, though known in the art, are typically limited to either triplex (three plungers) or quintuplex (five plungers) arrangements.”¹⁶⁰

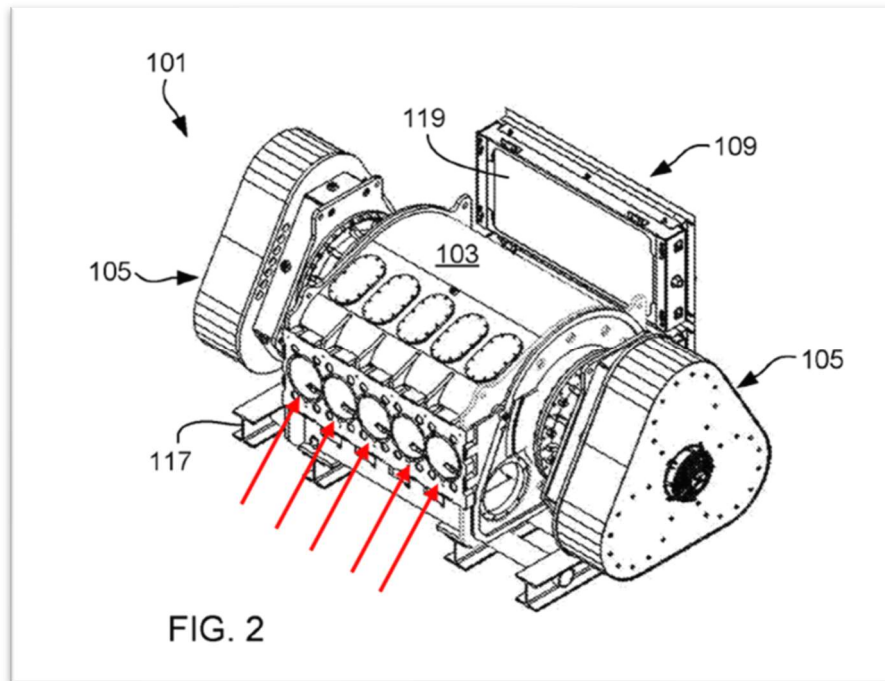
179. Further, as discussed above regarding limitation 1[a], and incorporated herein by reference, Fig. 2 of *Buckley* shows “a front perspective view of an electric drive pump” Fig. 2 shows “power end 103 [that] operate[s] with any number of fluid ends.”¹⁶¹ Fig. 2 what a POSITA would have recognized to be a “quintuplex” pump, with 5 locations (annotated with red arrows) for the linear motion generated by the power end to transfer to the fluid end.¹⁶² Fig. 2 of the *Buckley Provisional* has a

¹⁶⁰ Ex. 1001 5:1-3.

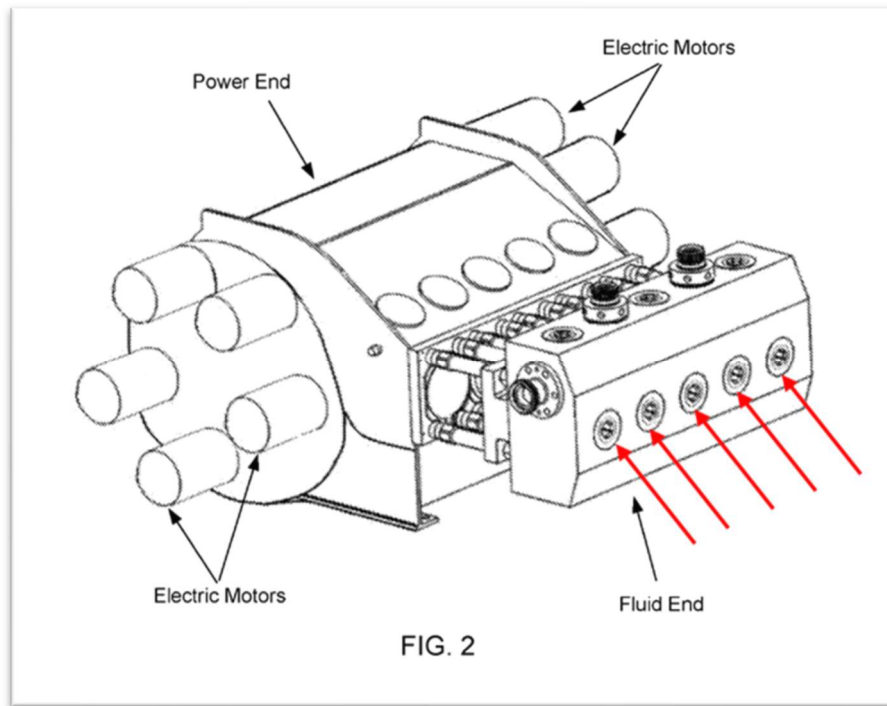
¹⁶¹ Ex. 1004 (*Buckley*) [0040]; Ex. 1005 (*Buckley Provisional*) pg 3.

¹⁶² See, e.g., Ex. 1018 (Merriam-Webster online dictionary definition of “quintuple”: “having five units or members”).

similar disclosure but shows the fluid end connected to the power end, with the 5 plunger suction covers visible (annotated with red arrows).



Ex, 1004 (*Buckley*) Fig. 2 (annotated)



Ex. 1005 (*Buckley Provisional*) Fig. 2 (annotated)

Accordingly, *Buckley* discloses that the multi-plunger hydraulic fracturing pump comprises an odd number of plungers equal to five plungers. Thus, *Buckley* discloses the additional limitations of Claim 6, and the combination of *Buckley* and *Bergan* in view of the general knowledge of POSITA renders Claim 6 obvious. In the alternative, Claim 6 is rendered obvious by the combination of *Buckley*, *Bergan*, and *Jelaska* for the same reasons just discussed, as *Jelaska* describes basic operations of gear trains.

XII. GROUND 1B: OBVIOUS OVER *YI* AND *BERGAN* IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA*

A. MOTIVATION TO COMBINE

1. *Yi* and *Bergan*

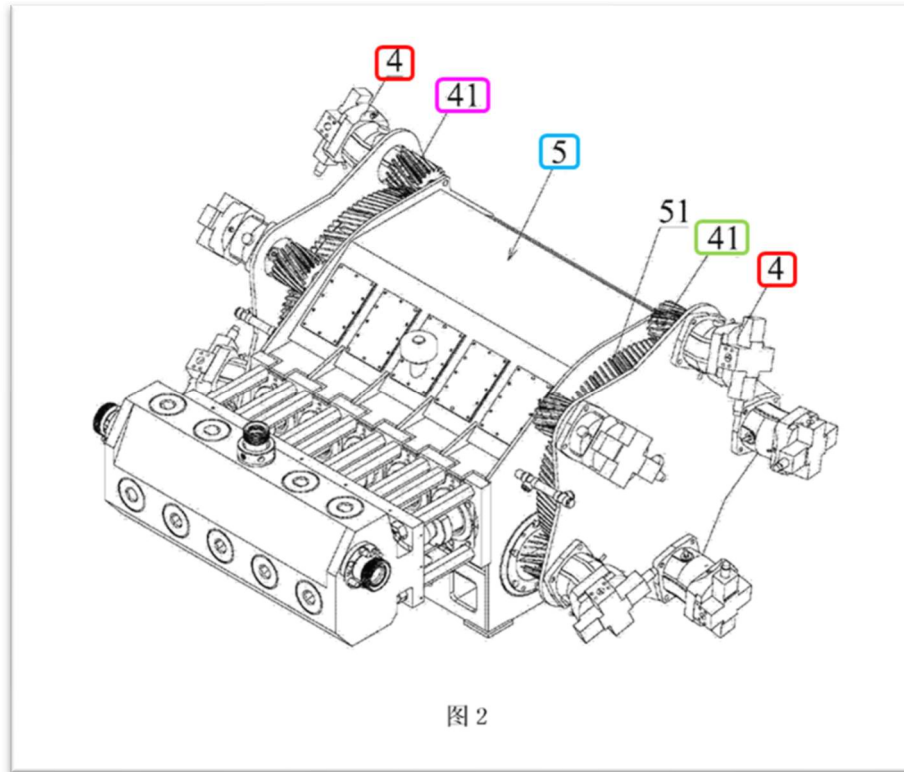
180. A POSITA would have been motivated to combine the teachings of *Yi* and *Bergan* to take advantage of *Bergan*'s teachings regarding how to connect multiple motors to drive a single rotary load.

181. Initially, both *Yi* and *Bergan* teach using multiple motors driving a single load in an oil and gas application. *Yi* teaches using multiple motors to drive a single rotary load such as a fracturing pump. *Yi* discloses that “the fracturing pump transmission system includes one or more engines, multiple oil pumps, ***and multiple motors***. When there is one engine, the engine is used to drive multiple oil pumps. When there are multiple engines, each engine is used to drive at least one of the oil pumps. Each oil pump is connected to at least one of the motors, and ***all the multiple motors are used to drive the fracturing pump.***”¹⁶³ *Yi* further discloses that the motors are powering the pump simultaneously. *Yi* teaches that during operation “the multiple motors 4 [] rotate, the multiple motors 4 [annotated in red] drive the fracturing pump 5 [annotated in blue] to rotate.”¹⁶⁴

¹⁶³ Ex. 1010 (*Yi* Translation) [0008].

¹⁶⁴ Ex. 1010 (*Yi* Translation) [0046].

182. Fig. 2 of *Yi* displays the plurality of motors 4 arranged around a gearbox and providing power to the pump 5 through a series of pinions 41.

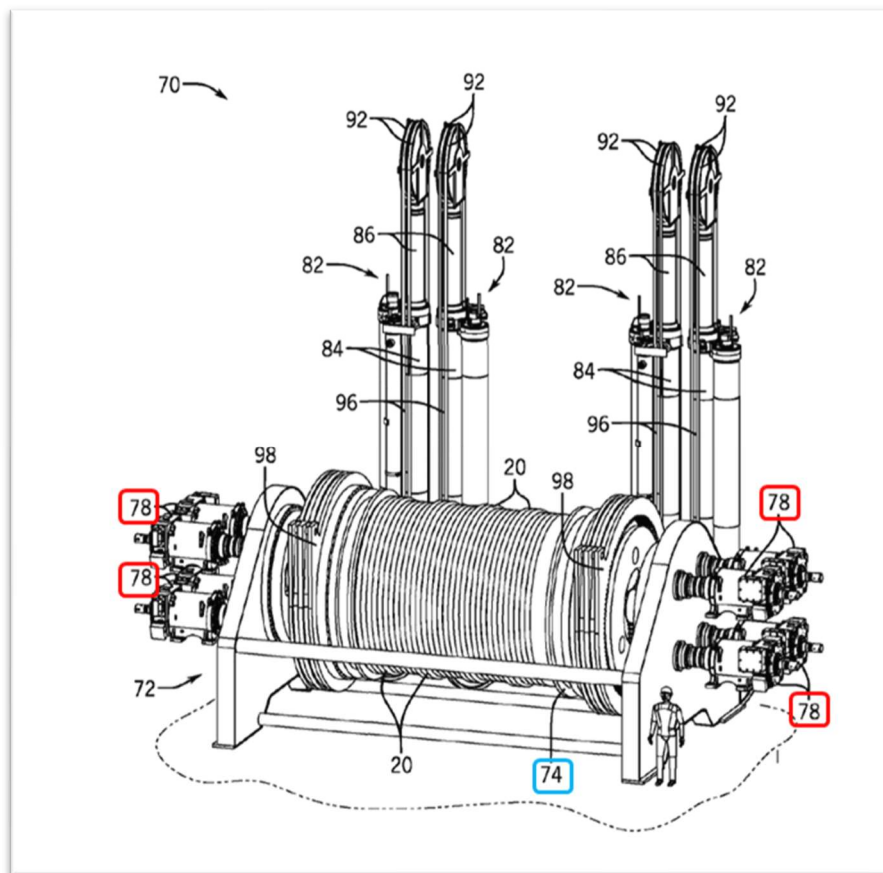


Ex. 1009 (*Yi*) Fig. 2

183. However, *Yi* provides little detail on precisely how to couple motors to the pump shaft in *Yi*. A POSITA would have been motivated to look at other references showing multiple motors driving a rotary load to gain these additional details of how to connect the motors to the gearing or transfer gear system of *Yi*. *Bergan* provides these additional details.

184. Like *Yi*, *Bergan* teaches the use of a plurality of motors located axially with the shaft of the load (i.e. drum) and connected to the shaft via gearing systems

and used in oil and gas drilling, which is at least a closely related field to hydraulic fracturing. For example, when describing Fig. 3, *Bergan* discloses that “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁶⁵

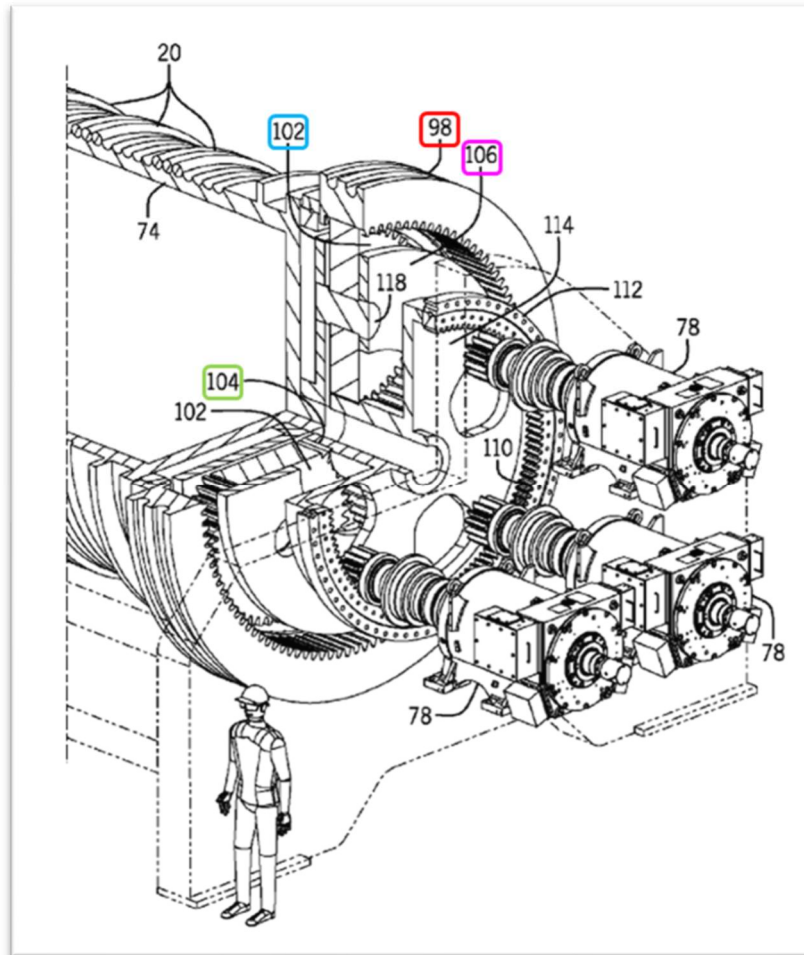


Ex. 1006 (*Bergan*) Fig. 3 (annotated)

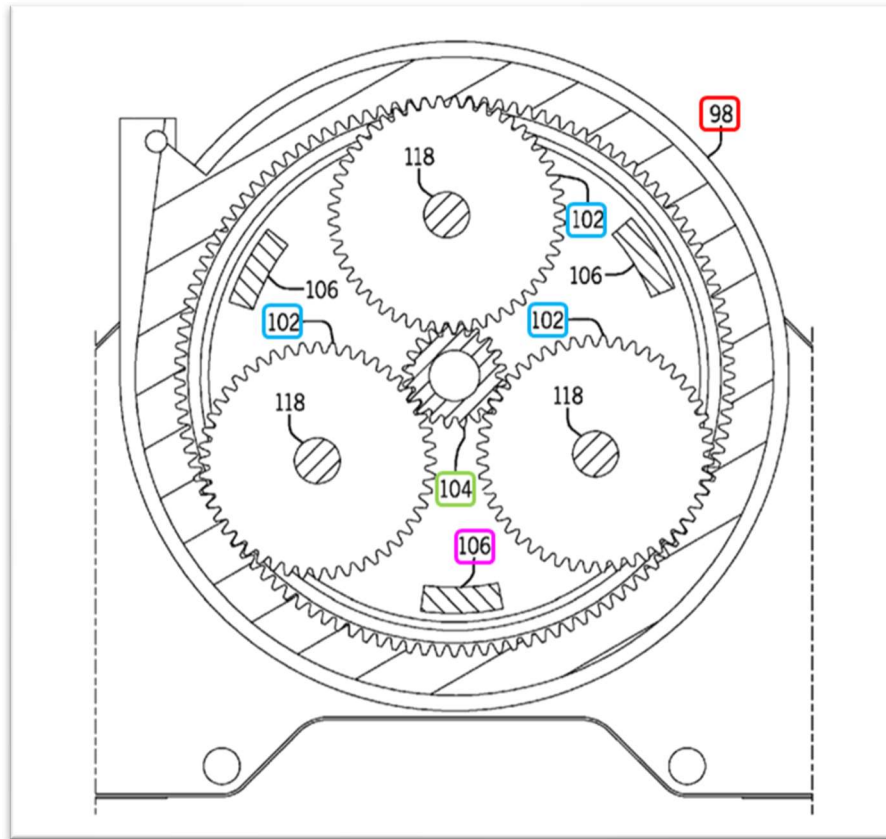
¹⁶⁵ Ex. 1006 (*Bergan*) [0030].

185. *Bergan* further teaches the use of a planetary gear system to couple motors to the shaft. *Bergan* discloses “As generally shown in FIG. 4 and more specifically shown in FIGS. 5 and 6, the planetary gear system includes the ring gear 98 [annotated in red], planetary gears 102 [annotated in blue], and a sun gear 104 [annotated in green]. A carrier 106 [annotated in magenta] is coupled to rotate with the planetary gears 102 as they orbit the sun gear 104 in operation.”¹⁶⁶

¹⁶⁶ Ex. 1006 (*Bergan*) [0032].



Ex. 1006 (*Bergan*) Fig. 5 (annotated)



Ex. 1006 (*Bergan*) Fig. 6 (annotated)

186. A POSITA would have recognized that the planetary gear system of *Bergan* would have been useful in connecting the multiple motors of *Yi* to the rotating load as planetary gear trains were known to be more compact, have a higher torque rating and have better lubrication than other types of gearboxes (e.g., fixed, parallel shaft gearboxes) and would have been motivated to incorporate a planetary gear train in the system of *Yi* to gain these advantages from such a configuration.

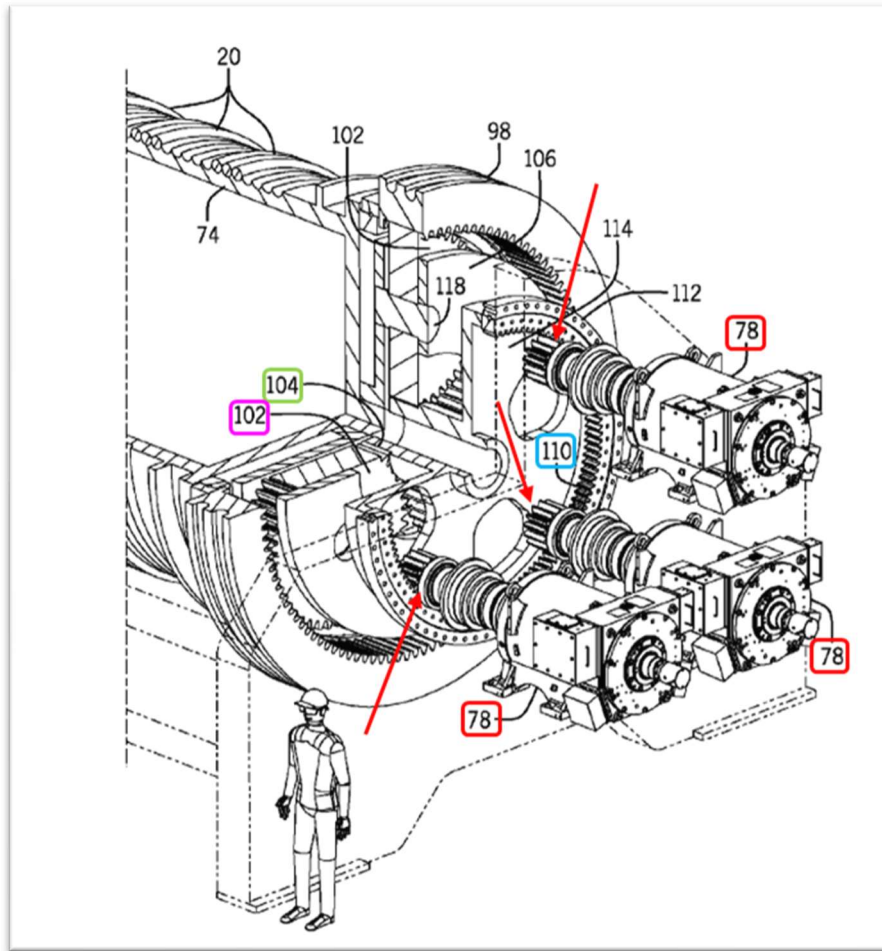
187. Further, *Bergan* fills in the blanks of *Yi* by showing the specific configuration of gearing that would have been used to connect *Yi*'s plurality of

motors to a single rotary load. For example, *Bergan* discloses “the motors 78 [annotated in red below] are connected to drive rotation of a gear 110 [annotated in blue below] of a slew bearing 112. The gear 110 is coupled to a sun wheel 114 having the sun gear 104 [annotated in green below] such that the motors 78 rotate the sun gear 104 via the wheel 114 and the gear 110. The planetary gears 102 [annotated in magenta] are mounted on axles 118 coupled to the carrier 106, which is coupled to drive the drum 74. This allows the orbit of the planetary gears 102 to drive rotation of both the carrier 106 and the drum 74.”¹⁶⁷

188. Figure 5 shows a perspective view of *Bergan*’s gearing mechanism. Figure 5 further shows the motors 78 each rotationally coupled to an “input pinion” (not numbered, annotated with red arrows) allowing the motors to drive the gearing system. A “pinion” was known to be “a gear with a small number of teeth designed to mesh with a larger wheel or rack.”¹⁶⁸ The pinions annotated with red arrows mesh with the larger gear (wheel) 110.

¹⁶⁷ Ex. 1006 (*Bergan*) [0032]; *see also, e.g.*, [0014], [0035], [0041], Claims 4-6, 10, 16-18.

¹⁶⁸ Ex. 1011, pg. 4.



Ex. 1006 (*Bergan*) Fig. 5 (annotated)

189. A POSITA would have been motivated to incorporate *Bergan's* teaching of how to connect multiple motors to a single rotary load to “fill in the blanks” left by *Yi*.

190. In combination, a POSITA would have understood that *Yi's* motors would couple to *Bergan's* planetary gearing system via *Bergan's* input pinions (consistent with *Bergan's* teaching of coupling multiple motors to the planetary gearing system via the input pinions) and that *Bergan's* planetary gearing system

would couple to *Yi*'s pump crankshaft via *Bergan*'s carrier 106 (consistent with *Bergan*'s teaching of coupling carrier 106 to a rotating load), such that *Yi*'s motors would drive the rotation of *Buckley*'s pump crankshaft via *Bergan*'s planetary gearing system. Such a combination would involve scaling *Bergan*'s gears to sizes appropriate to *Yi*'s pumping system, which would have been obvious and common-sense changes for a POSITA.

191. A POSITA would have had a reasonable expectation of success in combining the teachings of *Yi* and *Bergan*. Incorporating *Bergan*'s teachings of a planetary gear train and the use of "pinions" to connect the motors to the load is applying a known technique (planetary gear trains and motors with pinions) to improve similar devices (*Yi*'s motor–pump gearbox) in the same way. The results of the combination would have been predictable – transfer of rotational energy from *Yi*'s motors to *Yi*'s pump with straightforward, predictable changes in gear ratios and corresponding changes in speed and torque available. Further, *Bergan*'s teachings of planetary gear systems and motors with pinions was known in one field of endeavor (oil and gas drilling) and would have prompted a POSITA to use it in either the same field or a different one (oil and gas fracturing) based on design incentives (ability to connect multiple motors to a single load and the advantages of a planetary gear train described in Section IX.D) because the variations used for a pump would have been predictable to one of ordinary skill in the art. As discussed above, the

results of the combination would have been predictable – transfer of rotational energy from *Yi*'s motors to *Yi*'s pump with straightforward, predictable changes in gear ratios and corresponding changes in speed and torque available.¹⁶⁹

2. *Yi, Bergan, and Jelaska*

192. As discussed above, the *Yi-Bergan* combination teaches a multi-plunger pump powered by multiple motors via a planetary gearing configuration. A POSITA would have searched for other references to better understand details of gearing configurations that are not described in *Yi* and/or *Bergan*. One such reference is *Jelaska*, which is a well-known publication that provides granular details about gearing configurations that would have been invaluable to a POSITA looking to apply the teachings of *Bergan* to a practical system. In particular, *Jelaska*'s description of transmission ratio and its effect on the speed of a driven component would aid a POSITA's design of a gearing configuration when implementing *Bergan*'s planetary gearing configuration to result in a particular pump speed.¹⁷⁰

193. Further, combining *Jelaska*'s teachings regarding transmission ratio to the *Yi-Bergan* combination's pumping configuration is merely combining prior art

¹⁶⁹ As noted above, the U.S. Patent Office combined *Bergan* with a pumping system similar to *Yi* during the prosecution of U.S. Patent Application No. 18/357,271, which was filed as a continuation of, and contained claims similar to, the '258 Patent. See Ex. 1042, 443-444 (IDS accompanying Application No. 18/357,271, claiming priority to U.S. Application 16/210,807, which issued as the '258 Patent (see Ex. 1001, Cover)), 157-162 (Office Action analysis of *Buckley-Bergan* combination).

¹⁷⁰ See Ex. 1012 (*Jelaska*), 3.

elements (designing a transmission system to produce a desired output speed and the planetary gearset of *Bergan*) to known methods (*Bergan*'s planetary gearset) to yield predictable results (producing a desired pump speed as the output of the planetary gearset). Accordingly, a POSITA would have been motivated to combine *Jelaska*'s teachings of fundamental gearing system operations with the *Yi-Bergan* combination's pumping configuration and would have reasonably expected success in doing so.

B. INDEPENDENT CLAIM 1

194. It is my opinion that the combination of *Yi* and *Bergan* discloses, suggests, and renders Claim 1 of the '258 Patent obvious. As discussed in the following subsections, *Yi* and/or *Bergan*, along with the general knowledge of a POSITA and, in the alternative, in view of *Jelaska* discloses, or renders obvious, each and every element of Claim 1.

1. 1[p]: "A hydraulic fracturing system for fracturing a subterranean formation comprising:"

195. *Yi* discloses the preamble.¹⁷¹ *Yi* teaches "The invention relates to the technical field of fracturing trucks and discloses a fracturing pump transmission

¹⁷¹ I understand that the preamble may not be limiting. I provide analysis of the preamble out of an abundance of caution.

system and a fracturing truck.”¹⁷² Further, *Yi* describes “fracturing” to be “hydraulic fracturing for fracturing a subterranean formation”:

“Fracturing operations are one of the most important methods for modifying oil and gas reservoirs. For low-permeability oil and gas wells, fracturing is generally necessary to achieve stable production and increase output. A fracturing truck is the primary equipment used in fracturing operations. Its function is to inject high-pressure, large-volume fracturing fluid into the formation, causing it to crack open and injecting proppants (such as fracturing sand) into the fractures to enhance the permeability of the formation, increase the fluidity of oil and gas, and improve the recovery rate of oil and gas.”¹⁷³

A POSITA would have understood that the “formations” that are fractured are “subterranean formations” that contain oil and gas (hydrocarbon) reserves.

196. *Yi* describes the purpose of the invention as “provide a fracturing pump transmission system to effectively reduce the selection difficulty and cost of relevant components for the fracturing pump transmission system while also effectively improving the safety redundancy of the fracturing pump transmission system.”¹⁷⁴

197. Accordingly, *Yi* discloses the preamble.

¹⁷² Ex. 1010 (*Yi* Translation) Abstract.

¹⁷³ Ex. 1010 (*Yi* Translation) [0002].

¹⁷⁴ Ex. 1010 (*Yi* Translation) [0007].

2. 1[a]: “a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”

b) *“a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well”*

198. *Yi* discloses a multi-plunger hydraulic pump that is both connected to a well associated with the subterranean formation and configured to pump fluid into a wellbore associated with the well. Initially, the 9258 Patent admits that multi-plunger hydraulic fracturing pumps were known: “Multi-plunger hydraulic fracturing pumps, though known in the art, are typically limited to either triplex (three plungers) or quintuplex (five plungers) arrangements.”¹⁷⁵ *Yi* discloses “a fracturing pump transmission system and a fracturing truck.” *Yi* further teaches “A fracturing truck is the primary equipment used in fracturing operations. Its function is to inject high-pressure, large-volume fracturing fluid into the formation, causing it to crack open and injecting proppants (such as fracturing sand) into the fractures to enhance the permeability of the formation, increase the fluidity of oil and gas, and improve the recovery rate of oil and gas.”¹⁷⁶ Further, *Yi* teaches “the fracturing pump

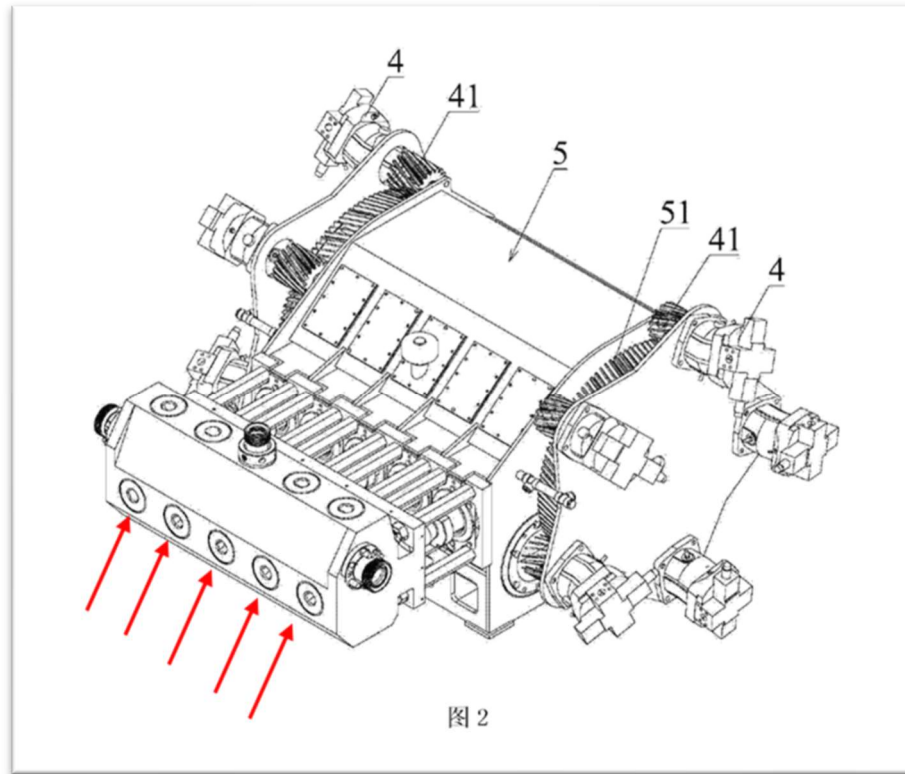
¹⁷⁵ Ex. 1001 ('258 Patent) 5:1-3.

¹⁷⁶ Ex. 1010 (*Yi* Translation) [0002].

5 is a crankshaft-type plunger pump,” and that at “both ends of the crankshaft-type plunger pump, there are power input gears 51, and each motor 4 engages at least with the power input gears 51 at one end of the crankshaft-type plunger pump through a power output gear 41.”¹⁷⁷ Because *Yi* teaches pumping fluid into the formation, *Yi*’s pump would have been connected to the well. To the extent that *Yi* does not explicitly disclose a “wellbore associated with a well,” it would have been obvious to a POSITA that access to the “formation” would have been via a well with a wellbore, as that arrangement has been known to oil and gas operations for over 100 years.

199. As discussed above in Section IX.B, the use of multiple plungers in a pump fluid end was known long before the ’258 Patent. *Yi* further provides Fig. 2 which shows the use of a quintuplex (5 plungers) fluid end. In the figure, the 5 cylinders (identified with red arrows) are evident from the arrangement of the fluid end.

¹⁷⁷ Ex. 1010 (*Yi* Translation) [0044].



Ex. 1009 (Yi) Fig. 2 (annotated)

Accordingly, as *Yi* discloses the use of a 5-plunger pump, *Yi* discloses the use of a “multi-plunger” pump. To the extent that *Yi* does not explicitly use the term “multi-plunger” when describing the pump, the use of a “multi-plunger” fracturing pump would have been obvious to a POSITA based on the general knowledge of a POSITA that such pumps were commonly used in fracturing operations (see section IX.B) and the disclosure of *Yi* including showing a multi-plunger fracturing pump in the figure(s).

c) “at a high pressure”

200. *Yi* teaches pumping fluid into the wellbore at high pressures.¹⁷⁸ *Yi* discloses that “[a] fracturing truck is the primary equipment used in fracturing operations. ***Its function is to inject high-pressure, large-volume fracturing fluid into the formation***, causing it to crack open and injecting proppants (such as fracturing sand) into the fractures to enhance the permeability of the formation, increase the fluidity of oil and gas, and improve the recovery rate of oil and gas.”¹⁷⁹ Accordingly, *Yi* discloses pumping fluid into the wellbore “at a high pressure.”

d) ***“so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation”***

201. *Yi* discloses this limitation as well. As discussed above, *Yi* teaches that “[a] fracturing truck is the primary equipment used in fracturing operations. Its function is to inject high-pressure, large-volume fracturing fluid into the formation, causing it to crack open and injecting proppants (such as fracturing sand) into the fractures to enhance the permeability of the formation, increase the fluidity of oil and gas, and improve the recovery rate of oil and gas.”¹⁸⁰ A POSITA would have

¹⁷⁸ I understand that the term “high pressure” has been found to be indefinite when used in a similar way in other US Wells Patents. I match the terms “high pressure” from both the ’258 Patent and *Yi*. The fact that the prior art teaches pumping “at high pressure” does not mean the term is definite as used in the ’258 Patent. I reserve the right to opine about the use of the term “high pressure” in the claims and specification of the ’258 Patent should the issue arise in any proceeding.

¹⁷⁹ Ex. 1010 (*Yi* Translation) [0002] (emphasis added).

¹⁸⁰ Ex. 1010 (*Yi* Translation) [0002].

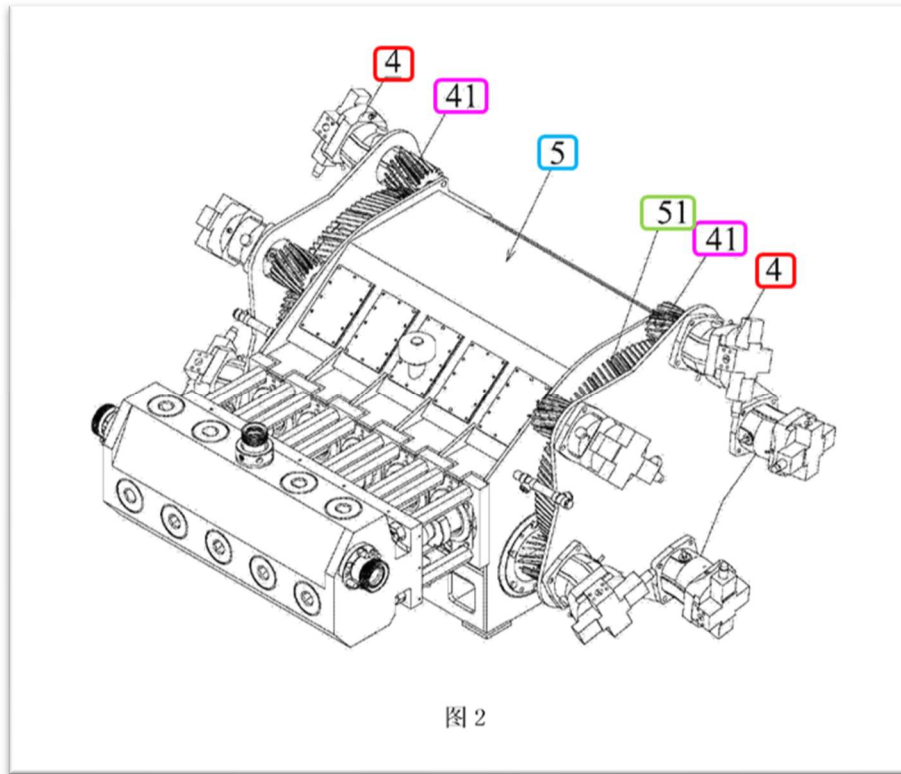
understood that, for the fracturing fluid to go “into the formation,” the fluid would pass into the wellbore and from the wellbore *into the formation*. To the extent that *Yi* does not explicitly disclose fluid passing “from the wellbore into the formation,” it would have been obvious to a POSITA that access to the “formation” would have been via a well with a wellbore, as that arrangement has been known to oil and gas operations for over 100 years.

3. 1[b]: “a plurality of motors positioned to simultaneously power the multi-plunger pump; and”

202. *Yi* discloses this limitation. *Yi* teaches that “the fracturing pump transmission system includes one or more engines, multiple oil pumps, *and multiple motors*. When there is one engine, the engine is used to drive multiple oil pumps. When there are multiple engines, each engine is used to drive at least one of the oil pumps. Each oil pump is connected to at least one of the motors, and *all the multiple motors are used to drive the fracturing pump*.”¹⁸¹ *Yi* further discloses that the motors are powering the pump simultaneously. *Yi* teaches that during operation “the multiple motors 4 [] rotate, the multiple motors 4 [annotated in red] drive the fracturing pump 5 [annotated in blue] to rotate.”¹⁸² Figure 2 of *Yi*, copied below, depicts this configuration:

¹⁸¹ Ex. 1010 (*Yi* Translation) [0008].

¹⁸² Ex. 1010 (*Yi* Translation) [0046].



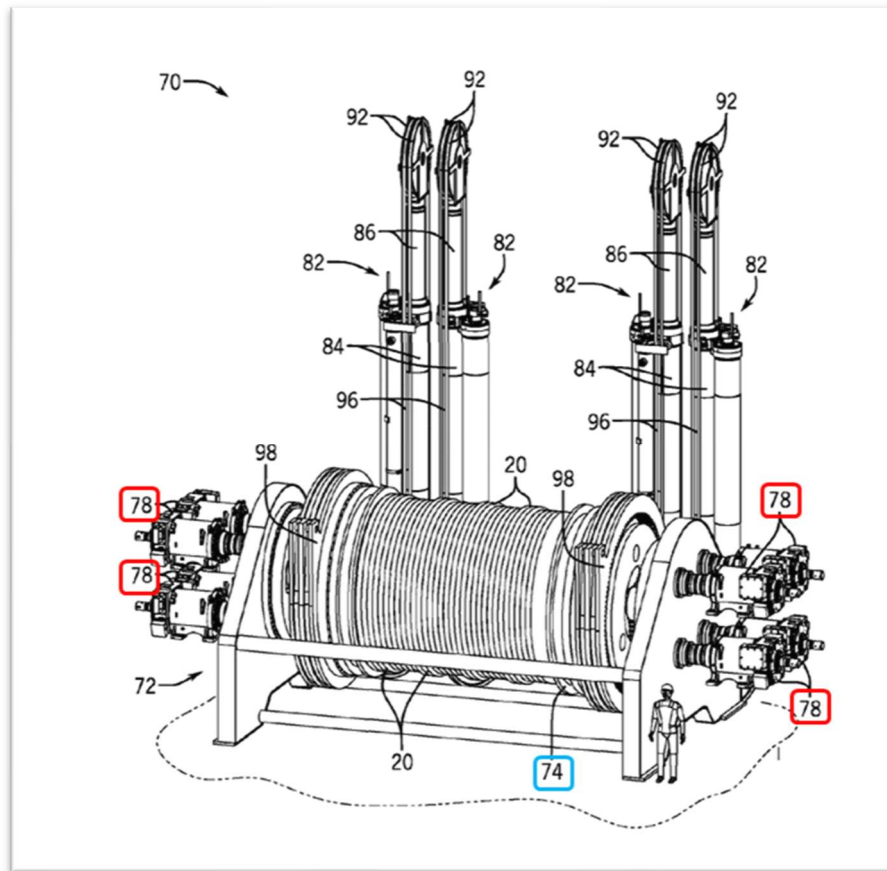
Ex. 1009 (Yi), Fig. 2.

203. *Yi* further discloses that the motors are connected through power input gears on both ends of the pump. *Yi* teaches “both ends of the crankshaft-type plunger pump, there are power input gears 51 [annotated in green], and each motor 4 [annotated in red] engages at least with the power input gears 51 at one end of the crankshaft-type plunger pump through a power output gear 41 [pinion, annotated in magenta].”¹⁸³

204. *Bergan* also teaches the use of a plurality of motors located axially with the shaft of the load (i.e. drum) and connected to the shaft via gearing systems. For

¹⁸³ Ex. 1010 (*Yi* Translation) [0044].

example, when describing Fig. 3, *Bergan* discloses that “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁸⁴



Ex. 1006 (*Bergan*) Fig. 3 (annotated)

¹⁸⁴ Ex. 1006 (*Bergan* [0030])

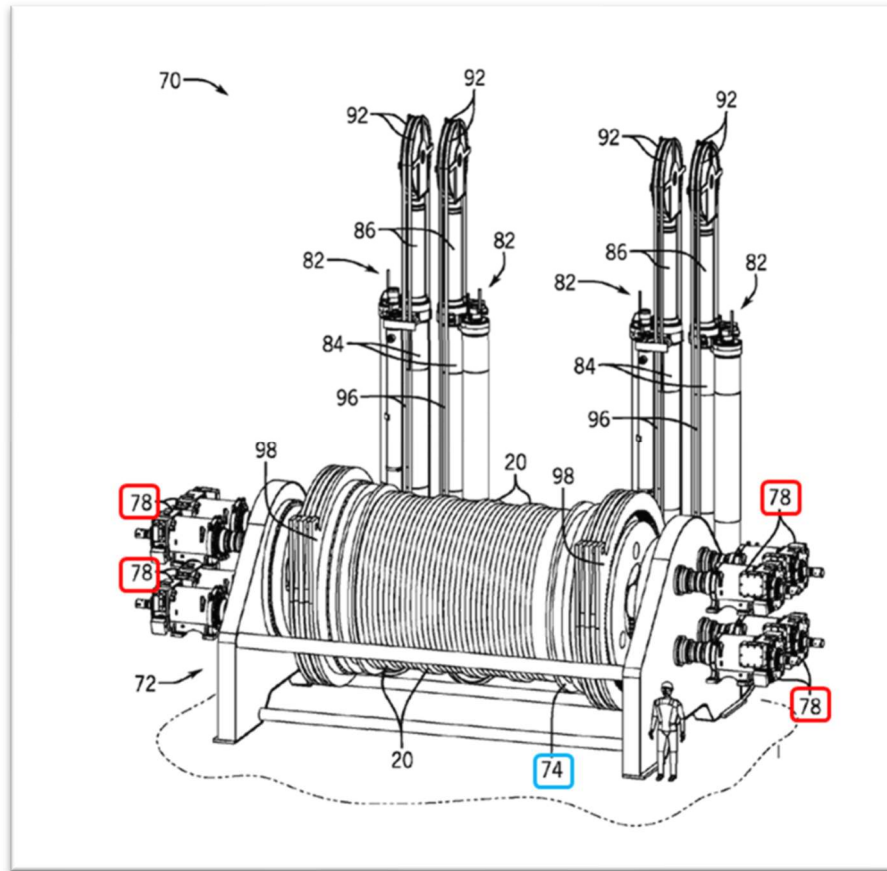
205. Accordingly, *Yi* discloses limitation 1[b] and the combination of *Yi* and *Bergan* renders limitation 1[b] obvious.

4. 1[c]: “a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors,”

206. The combination of *Yi* and *Bergan* renders this limitation obvious. As discussed above, *Yi* teaches a plurality of motors positioned to simultaneously power its multi-plunger pump.¹⁸⁵ And as discussed above, *Bergan* teaches the use of a plurality of motors located axially with the shaft of the load (i.e. drum) and connected to the shaft via gearing systems. For example, when describing Fig. 3, *Bergan* discloses “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁸⁶

¹⁸⁵ See Section XII.V.3 above.

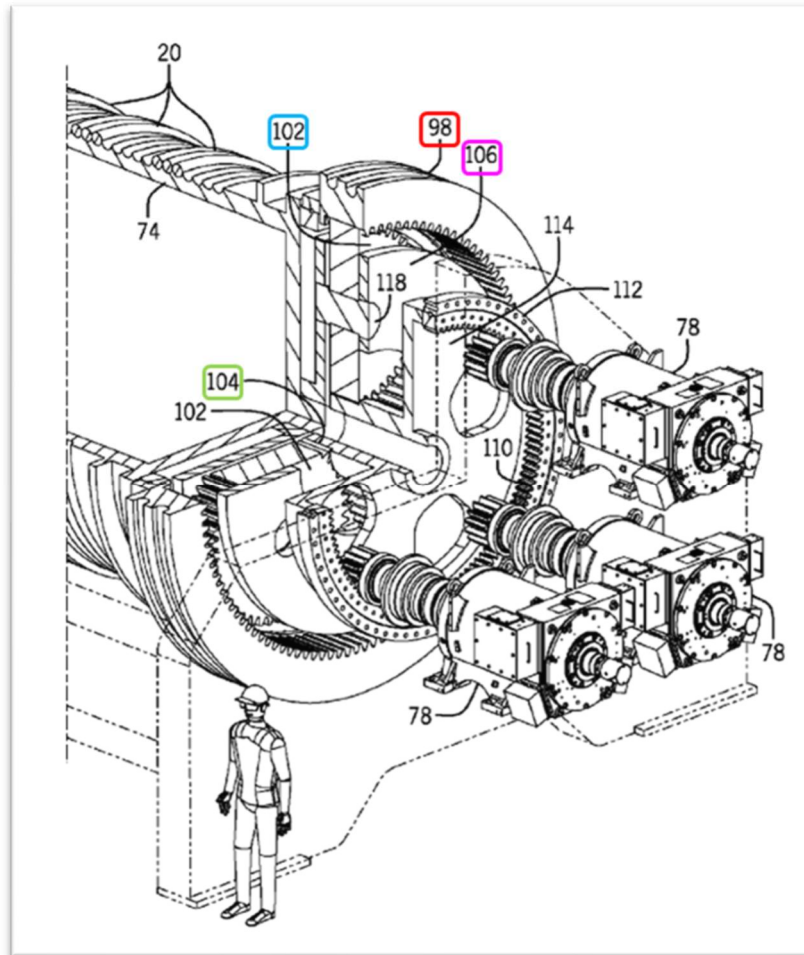
¹⁸⁶ Ex. 1006 (*Bergan* [0030])



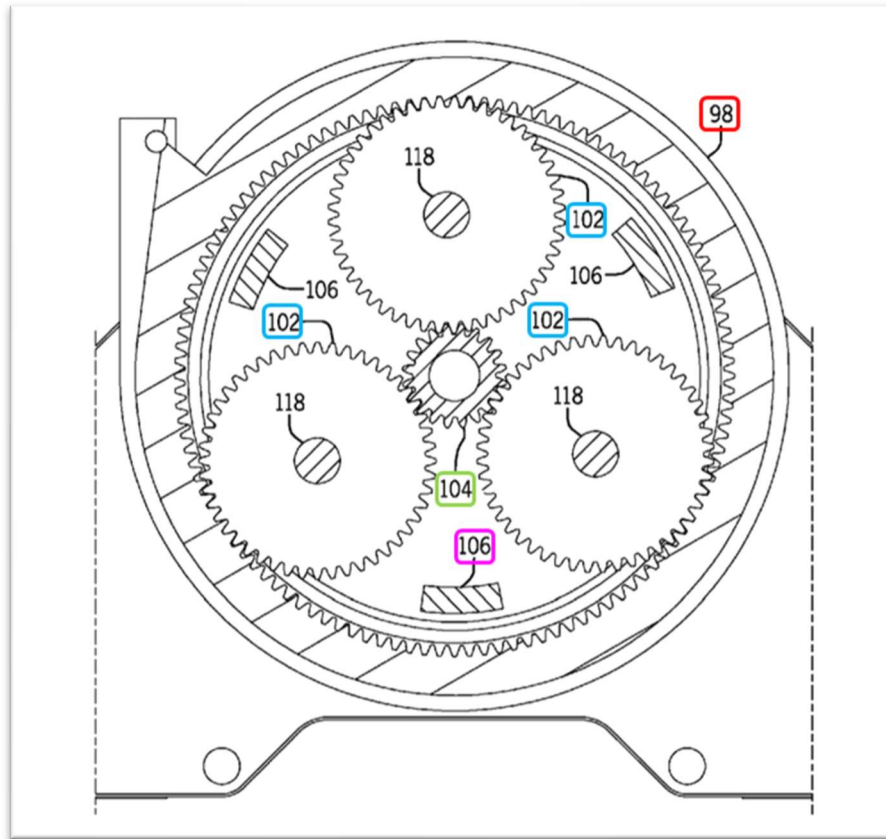
Ex. 1006 (*Bergan*) Fig. 3 (annotated)

207. *Bergan* further teaches the use of a planetary gear system to couple the motors to the shaft. *Bergan* discloses “As generally shown in FIG. 4 and more specifically shown in FIGS. 5 and 6, the planetary gear system includes the ring gear 98 [annotated in red], planetary gears 102 [annotated in blue], and a sun gear 104 [annotated in green]. A carrier 106 [annotated in magenta] is coupled to rotate with the planetary gears 102 as they orbit the sun gear 104 in operation.”¹⁸⁷

¹⁸⁷ Ex. 1006 (*Bergan*) [0032].



Ex. 1006 (*Bergan*) Fig. 5 (annotated)



Ex. 1006 (*Bergan*) Fig. 6 (annotated)

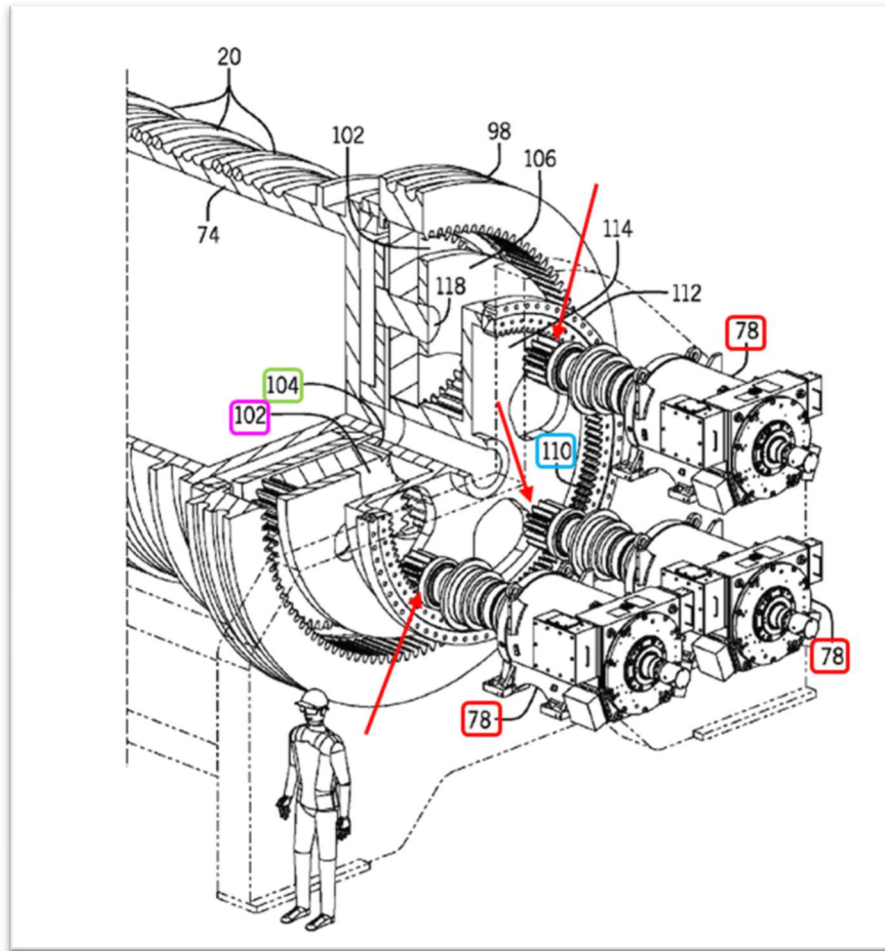
208. *Bergan* further discloses driving the planetary gear train with multiple motors. *Bergan* teaches “the motors 78 [annotated in red] are connected to drive rotation of a gear 110 [annotated in blue] of a slew bearing 112. The gear 110 is coupled to a sun wheel 114 having the sun gear 104 [annotated in green] such that the motors 78 rotate the sun gear 104 via the wheel 114 and the gear 110. The planetary gears 102 [annotated in magenta] are mounted on axles 118 coupled to the

carrier 106, which is coupled to drive the drum 74. This allows the orbit of the planetary gears 102 to drive rotation of both the carrier 106 and the drum 74.”¹⁸⁸

209. Figure 5 shows a perspective view of *Bergan*’s gearing mechanism. A POSITA would have understood that *Bergan*’s motors 78 drive sun gear 104 as a result of motors 78 driving the rotation of a respective “input pinion” (not numbered, annotated with red arrows), allowing the motors to drive the gearing system. A “pinion” was known to be “a gear with a small number of teeth designed to mesh with a larger wheel or rack.”¹⁸⁹ The pinions annotated with red arrows mesh with the larger gear (wheel) 110. I understand that the Patent Owner asserts that input pinion gears directly connected to a motor driving the rotation satisfies this limitation, and *Bergan* discloses this.

¹⁸⁸ Ex. 1006 (*Bergan*) [0032]; *see also, e.g.*, [0014], [0035], [0041], Claims 4-6, 10, 16-18.

¹⁸⁹ Ex. 1011.



Ex. 1006 (*Bergan*) Fig. 5 (annotated)

210. Accordingly, *Bergan* discloses a planetary gear train having a plurality of input pinions in rotational contact with each of the plurality of motors.

211. As discussed above in Section XII.A, a POSITA would have been motivated to combine *Yi* and *Bergan* such that *Bergan*'s planetary gear system would couple *Yi*'s motors to its drive pump and would have a reasonable expectation of success in doing so. Accordingly, *Bergan* discloses, and the combination of *Yi* and *Bergan* renders Limitation 1[c] obvious.

5. 1[d]: “wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.”

212. As discussed above in Section IX.D, it was well known long before the '258 Patent that the speed of the drive (i.e. motors) and the gear ratio of the gear train dictate the speed of the driven mechanism (i.e. pump) according to the equation

$$i = \frac{n_1}{n_2} = \frac{\omega_1}{\omega_2},$$

Where i is the gear ratio, n_1 is the driving shaft speed, n_2 is the driven shaft speed, ω_1 is the angular speed of the driving shaft, and ω_2 is the angular speed of the driven shaft.¹⁹⁰ This was known to the ancient Greeks and is a well-understood fundamental of gear train operation and would have been included in the general knowledge of a POSITA. Indeed, the fact that the gear ratio and the driving speed dictate the speed of the driven shaft (i.e. pump) would have been known to anyone who has ridden a multi-speed bicycle with gears or anyone who has operated a manual transmission. To “limit a maximum pump speed associated with the multi-plunger pump” a POSITA would simply choose the maximum speed of the pump desired and coordinate the speed of *Yi*’s motors with the gear ratio of *Bergan*’s planetary gear train (which operates as the transmission that links *Yi*’s motors with its drive pump) so that the maximum speed of *Yi*’s pump is not exceeded. The output speed of a gear

¹⁹⁰ Ex. 1012 (*Jelaska*), pg. 3.

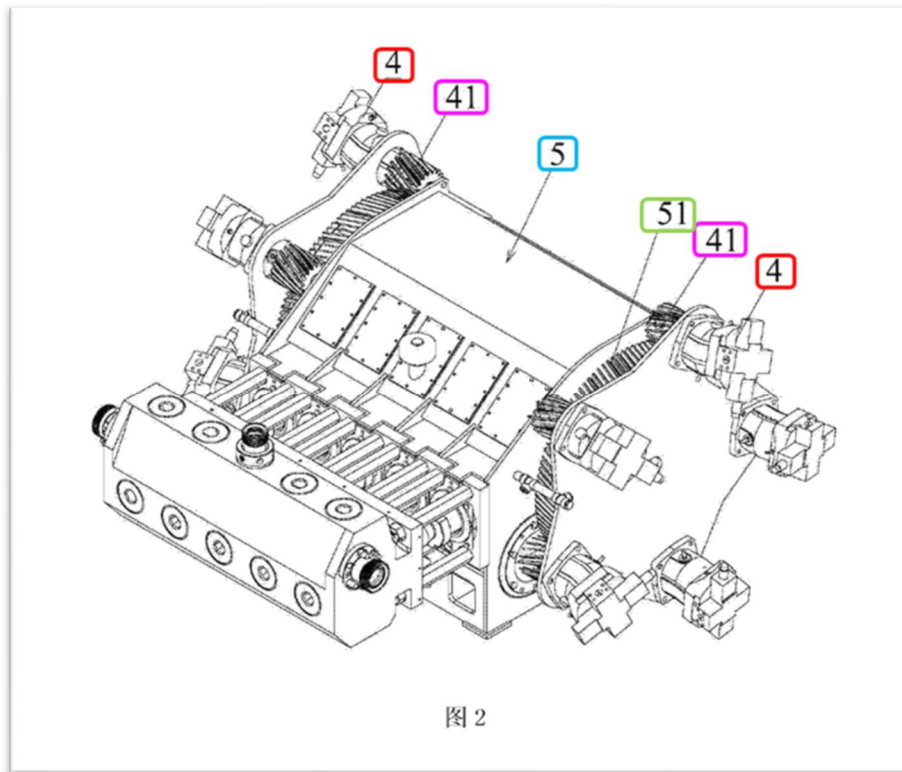
train is predictable based on the input speed of the motor and the gear ratio of the drive train. Accordingly, the combination of *Yi* and *Bergan* in view of the general knowledge of a POSITA renders this limitation obvious. In the alternative, this limitation is rendered obvious by the combination of *Yi*, *Bergan*, and *Jelaska* for the same reasons just discussed, as *Jelaska* describes basic operations of gear trains.

C. DEPENDENT CLAIM 3: “3. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

213. Dependent Claim 3 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, both *Yi* and *Bergan*, alone or in combination, disclose the additional limitations of Claim 3. *Yi* teaches the use of a plurality of hydraulic motors. As discussed above regarding limitation 1[b], with regard to Fig. 2, *Yi* teaches “[e]ach engine 1 is used to drive at least one oil pump 2, multiple oil pumps 2 are used to supply pressure oil to multiple motors 4 [annotated in red], and all the multiple motors 4 are used to drive the fracturing pump 5 [annotated in blue].”¹⁹¹ Further, *Yi* teaches, “In Figure 2, a preferred transmission connection method between motors 4 and a fracturing pump 5 is illustrated. As shown in Figure 2, the fracturing pump 5 is a crankshaft-type plunger pump. At both ends of the crankshaft-type plunger pump, there are power input gears 51 [annotated in green], and each motor 4 engages at least with the power input gears 51 at one

¹⁹¹ Ex. 1010 (*Yi* Translation) [0042].

end of the crankshaft-type plunger pump through a power output gear 41 [i.e. pinion, annotated in magenta] (whose pitch circle diameter is smaller than that of the power input gear).”¹⁹²



Ex. 1010 Fig. 2 (annotated)

214. *Yi's* teaching of “[e]ach engine 1 is used to drive at least one oil pump 2, multiple oil pumps 2 are used to supply pressure oil to multiple motors 4” and “the output of each oil pump is respectively connected through a corresponding oil line to a first oil port of at least one motor, and a second oil port of that at least one motor is connected to a hydraulic oil tank,” would have been recognized by a

¹⁹² Ex. 1010 (*Yi* Translation), [0044].

POSITA as disclosing a hydraulic motor, as it was well-known to use pressurized oil to generate rotation in a hydraulic motor.¹⁹³ *Yi* also teaches that “[a]dditionally, in specific implementation, there are various ways for multiple motors 4 to drive the fracturing pump 5, as long as the motors 4 can drive the fracturing pump 5 to rotate, which are not limited in the embodiments of the invention,” which would have made it obvious to a POSITA that electric motors sized to “drive the fracturing pump 5 to rotate” would have been used with the disclosures of *Yi*, as it was well known to use electric motors to drive fracturing pumps as discussed in Sections IX.F-G.¹⁹⁴

215. *Bergan* further teaches the use of electric motors. As discussed above regarding limitation 1[c], incorporated herein by reference, *Bergan* teaches “motors 78” to drive the planetary gear system claimed. *Bergan* further discloses, for example, “[m]otors 78 can be operated to drive rotation of the drum 74 to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”¹⁹⁵ Accordingly, not only are electric motors explicitly disclosed by *Bergan*, but hydraulic motors would have been obvious based on the teachings of *Bergan* (“any suitable motors 78 could be used”).

¹⁹³ See Ex. 1010 (*Yi* Translation), [0009], [0042]

¹⁹⁴ See Ex. 1010 (*Yi* Translation), [0044].

¹⁹⁵ Ex. 1006 (*Bergan*) [0030]

216. Further still, the general knowledge of a POSITA would have rendered Claim 3 obvious. As discussed above in section IX.A, electric motors with VFDs driving fracturing pumps would have been well known to a POSITA by the time of the '258 Patent.

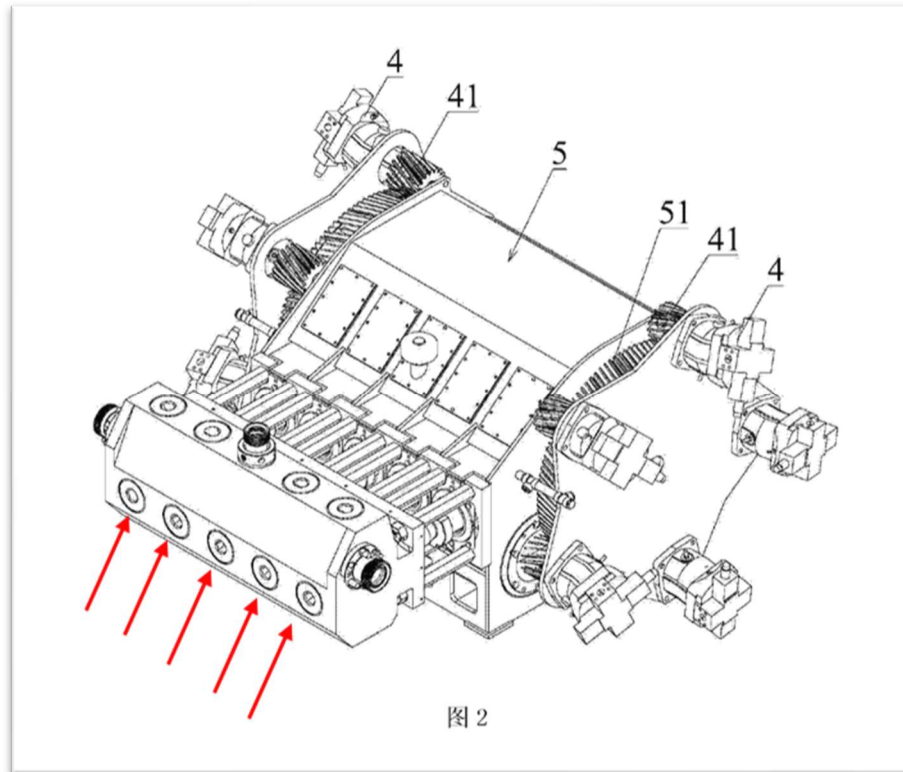
217. Accordingly, the combination of *Yi* and *Rosman*, along with the general knowledge of a POSITA and, in the alternative, in view of *Jelaska* renders Claim 3 obvious, as *Jelaska* describes basic operations of gear trains.

D. DEPENDENT CLAIM 6: “6. THE SYSTEM OF CLAIM 1, WHEREIN THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP COMPRISES AN ODD NUMBER OF PLUNGERS GREATER THAN OR EQUAL TO FIVE PLUNGERS.”

218. Dependent Claim 6 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, *Yi* discloses the additional limitations of Claim 6. Initially, the '258 Patent admits that multi-plunger hydraulic fracturing pumps which meet the limitations of Claim 6 were known: “[m]ulti-plunger hydraulic fracturing pumps, though known in the art, are typically limited to either triplex (three plungers) or quintuplex (five plungers) arrangements.”¹⁹⁶

219. Further, as discussed above regarding limitation 1[a], and incorporated herein by reference, Fig. 2 of *Yi* shows the use of a quintuplex (5 plungers) fluid end. In the figure, the 5 cylinders (annotated in red) are evident from the arrangement of the fluid end.

¹⁹⁶ Ex. 1001 5:1-3.

Ex. 1010 (*Yi*) Fig. 2 (annotated)

220. Accordingly, as *Yi* discloses the use of a 5-plunger pump, *Yi* discloses the use of a “multi-plunger” pump. To the extent that *Yi* does not explicitly use the term “multi-plunger” when describing the pump, the use of a “multi-plunger” fracturing pump would have been obvious to a POSITA based on the general knowledge of a POSITA that such pumps were commonly used in fracturing operations (see section IX.B) and the disclosure of *Yi* including showing a multi-plunger fracturing pump in the figure(s). Accordingly, *Yi* discloses that the multi-plunger hydraulic fracturing pump comprises an odd number of plungers equal to five plungers.

221. Thus, *Yi* discloses the additional limitations of Claim 6, and the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA renders Claim 6 obvious. In the alternative, Claim 6 is rendered obvious by the combination of *Yi*, *Bergan*, and *Jelaska* for the same reasons just discussed, as *Jelaska* describes basic operations of gear trains.

XIII. GROUND 2A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *TUTTEROW*

222. It is my opinion that *Buckley* in view of *Bergan* discloses, suggests, and renders obvious Claims 4 & 5 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Tutterow*.

A. MOTIVATION TO COMBINE

223. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A and incorporated herein by reference. Nothing in *Tutterow* teaches against the combination of *Buckley* and *Bergan* and *Jelaska*. A POSITA would have been motivated to combine the teachings of *Tutterow* with those of *Buckley* and *Bergan* (and *Jelaska*) as *Tutterow* is intended as “a comprehensive guide on variable speed pumps, motors and drives.”¹⁹⁷ *Tutterow* is a publication that contains “sections on pumps, systems, motors, variable speed drives and control methods, which start with the basic principles, but progress to

¹⁹⁷ Ex. 1013 (*Tutterow*) pg 1.

more advanced and detailed concepts.”¹⁹⁸ Further, *Tutterow* “concentrates on electronic variable frequency drives because they have the greatest benefits, including wide ranging applications, versatile control, energy saving and ease of retrofitting.”¹⁹⁹

224. As discussed above regarding Ground 1, Claim 8, *Buckley* teaches the use of a plurality of motors to provide power to the multi-plunger hydraulic fracturing pump. *Buckley* further teaches that the “system of the present application may permit the motors 11 to run at various speeds or power outputs.”²⁰⁰ A POSITA would have understood this to be analogous to the teachings of *Tutterow* regarding “variable speed pumps, motors and drives” used in pumping. Additionally, *Tutterow* contains basic descriptions of the operation of pumps, including plunger pumps, that would have been invaluable to a POSITA looking to apply the teachings of *Buckley* to a practical system. Accordingly, the operation of the pumps of *Buckley* would have already had the characteristics described by *Tutterow*, such as the risk of cavitation. *Tutterow* simply describes how the pumps operate, how cavitation occurs, and how and why to avoid it. A POSITA would have been motivated to avoid

¹⁹⁸ Ex. 1013 (*Tutterow*) pg 2.

¹⁹⁹ Ex. 1013 (*Tutterow*) pg. 3.

²⁰⁰ Ex. 1004 (*Buckley*) [0058]; *see also* Ex. 1005 (*Buckley* Provisional) pg 6 “It is understood that the system of the present application may permit the motors to be run at various speeds or power outputs.”

the “negative effects” of cavitation, as taught by *Tutterow*, to avoid the long-term damage or inefficiencies of pumping that cavitation creates.

225. A POSITA would have had a reasonable expectation of success in applying the teachings of *Tutterow* regarding avoiding cavitation of plunger pumps by controlling speed as such teachings were basic to the operation of positive displacement pumps, including plunger pumps. Such a combination is merely combining prior art elements (limiting pump operation speed to avoid cavitation and the pump of *Buckley/Bergan*) to known methods (the pump of *Buckley/Bergan*) to yield predictable results (avoiding the negative effects of cavitation on the pumping system).

B. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 1, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

226. Dependent Claim 4 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above in Ground 1A, the combination of *Buckley* and *Bergan*, along with the general knowledge of a POSITA, renders Claim 4 obvious. The specification of the ’258 Patent refers to the critical plunger speed as a speed that avoids cavitation. For example, the ’258 Patent teaches that “by operating transmissions such that pumps are maintained at or below critical pump speeds, such formation of vacuum bubbles and resulting pump cavitation and

damage may be avoided.”²⁰¹ Accordingly, I understand “a critical plunger speed associated with the multi-plunger hydraulic fracturing pump,” as claimed, to be the maximum speed a pump can run without cavitation, given a particular system configuration. No other definition or description of “critical plunger speed” is provided in the specification.

227. As described above in Section IX.C, it was known to avoid cavitation in pumping systems, for example, to avoid negative effects of cavitation such as erosion.²⁰² The '258 Patent admits that this was known.²⁰³ As further discussed in Section IX.C, and described in *Tutterow*, it was also well known that it is an inherent property of positive displacement pumps (e.g. plunger pumps) that, for a given pump system, operation above a certain speed (i.e. critical plunger speed) creates cavitation and that the maximum speed of such pumps is therefore commonly limited to avoid cavitation.²⁰⁴

²⁰¹ Ex. 1001 2:15 – 19.

²⁰² See, e.g., Ex. 1013 (*Tutterow*), 20.

²⁰³ See, e.g., Ex. 1001 2:4 – 14.

²⁰⁴ See, e.g., Ex. 1013 (*Tutterow*), 30 (“The cavities [cylinders] on a positive displacement pump open and close as the pump operates and the liquid must flow quickly enough at the pump suction to fill the cavities completely with liquid. If the cavities do not fill with liquid, there will be a void, and apparent cavitation, resulting in a loss of both flow and pressure performance. ***If the speed is increased, this filling process becomes more problematical, limiting the maximum speed.***”) (emphasis added)).

228. Accordingly, operating a pump speed below the speed required to create cavitation, which a POSITA would have understood to be a “critical speed” of the pump, would have been obvious based on the general knowledge of a POSITA. Accordingly, the combination of *Buckley* and *Bergan* in view of the general knowledge of POSITA renders Claim 4 obvious. In the alternative, combination of *Buckley* and *Bergan* in view of *Jelaska* and *Tutterow* renders Claim 4 obvious for the same reasons just provided, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

C. DEPENDENT CLAIM 5: “5. THE SYSTEM OF CLAIM 1, WHEREIN THE MAXIMUM PUMP SPEED IS 5% OR LESS OVER A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

229. Dependent Claim 5 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Buckley* and *Bergan*, along with the general knowledge of a POSITA, render Claim 5 obvious. Claim 5 simply claims operating the pump speed at a speed higher than the speed at which cavitation begins. The specification of the '258 Patent itself teaches that operating the pump at speeds that allow cavitation to occur was not only known, but “commonly” performed. For example, the '258 Patent discloses that “[a] heightened speed of operation creates low pressure within the pumps, creating vacuum bubbles. As the pump plungers retract, the vacuum bubbles implode, causing damage (cavitation) to the pump and engine systems. Although the risks of operating the

pumps at too great of speeds may be known, concerns about lowered pump rates and lost efficiency resulting from maintaining slower transmission speeds *commonly lead to disregard of the risks as an unavoidable consequence of maintaining pump efficiency.*”²⁰⁵

230. The ’258 Patent claims no new benefit from operating the motor above the cavitation speed other than “to achieve a desired pump rate”, as even the specification of the ’258 Patent admits was “commonly” practiced before the ’258 Patent. Indeed, the ’258 Patent specification does not exclusively teach the 5% limit but instead teaches that “any other acceptable range [of speed above the cavitation speed].”²⁰⁶ Accordingly, even the specification of the ’258 Patent teaches that there is no inventive concept involved in operating at 5% above the cavitation speed.

231. Further, operating a pump above the speed at which cavitation begins is a type of risk-reward engineering decision that is made every day in industrial processes, including pumping. As described in Section IX.C, cavitation in a pumping system leads to problems such as erosion of the pump's internal components, noise and vibration, and loss of pumping pressure (head). While these are undesirable impacts of cavitation and should be avoided, a POSITA would also understand that small amounts of cavitation would affect the life and efficiency of the pump but

²⁰⁵ Ex. 1001 2:4-14 emphasis added; see also Ex. 1001, 1:37-49, 1:56-65.

²⁰⁶ See Ex. 1001 6:1-13.

would not immediately stop the pumping process.²⁰⁷ Accordingly, there is a risk to operating with the pump cavitating (loss of life and pumping pressure), but also a reward (increased flow rate). The decision to operate in a region where cavitation occurs, particularly relatively low amounts of cavitation, is a tradeoff between the risks and the rewards. Operating to gain the benefits of higher flowrate while accepting a small reduction in the life of components or pumping pressure was well known, as the '258 Patent itself discloses, “Although the risks of operating the pumps at too great of speeds may be known, concerns about lowered pump rates and lost efficiency resulting from maintaining slower transmission speeds commonly lead to disregard of the risks as an unavoidable consequence of maintaining pump efficiency.”²⁰⁸

232. Accordingly, the combination of *Buckley* and *Bergan* in view of the general knowledge of a POSITA renders Claim 5 obvious. In the alternative, the combination of *Buckley* and *Bergan* in view of *Jelaska* and *Tutterow* renders Claim 5 obvious, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

²⁰⁷ Ex. 1013 (*Tutterow*), pg. 20 (explaining that “total loss of pump-developed head occurs” only in “extreme cases” of cavitation).

²⁰⁸ Ex. 1001 2:8 – 14.

XIV. GROUND 2B: OBVIOUS OVER YI IN VIEW OF *BERGAN* FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *TUTTEROW*

233. It is my opinion that *Yi* in view of *Bergan* discloses, suggests, and renders obvious Claims 4 & 5 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Tutterow*.

A. MOTIVATION TO COMBINE

234. The motivation to combine *Yi*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XII.A and incorporated herein by reference. Nothing in *Tutterow* teaches against the combination of *Yi* and *Bergan*. A POSITA would have been motivated to combine the teachings of *Tutterow* with those of *Yi*, *Bergan* and *Jelaska* as *Tutterow* is intended as “a comprehensive guide on variable speed pumps, motors and drives.”²⁰⁹ *Tutterow* is a publication that contains “sections on pumps, systems, motors, variable speed drives and control methods, which start with the basic principles, but progress to more advanced and detailed concepts.”²¹⁰ Further, *Tutterow* “concentrates on electronic variable frequency drives because they have the greatest benefits, including wide ranging applications, versatile control, energy saving and ease of retrofitting.”²¹¹

²⁰⁹ Ex. 1013 (*Tutterow*) pg 1.

²¹⁰ Ex. 1013 (*Tutterow*) pg 2.

²¹¹ Ex. 1013 (*Tutterow*) pg. 3.

235. *Yi* teaches the use of a plurality of motors to provide power to the multi-plunger hydraulic fracturing pump. *Yi* further teaches “control over the speed and output power of the fracturing pump.”²¹² A POSITA would have understood this to be analogous to the teachings of *Tutterow* regarding “variable speed pumps, motors and drives” used in pumping. Additionally, *Tutterow* contains basic descriptions of the operation of pumps, including plunger pumps, that would have been invaluable to a POSITA looking to apply the teachings of *Yi* to a practical system. Accordingly, the operation of the pumps of *Yi* would have already had the characteristics described by *Tutterow*, such as the risk of cavitation. *Tutterow* simply describes how the pumps operate, how cavitation occurs, and how and why to avoid it. A POSITA would have been motivated to avoid the “negative effects” of cavitation, as taught by *Tutterow*, to avoid the long-term damage or inefficiencies of pumping that cavitation creates.

236. A POSITA would have had a reasonable expectation of success in applying the teachings of *Tutterow* regarding avoiding cavitation of plunger pumps by controlling speed as such teachings were basic to the operation of positive displacement pumps, including plunger pumps. Such a combination is merely combining prior art elements (limiting pump operation speed to avoid cavitation as taught by *Tutterow* and the pump of *Yi/Bergan*) to known methods (the pump of

²¹² Ex. 1010 (*Yi* Translation), [0019].

Yi/Bergan) to yield predictable results (avoiding the negative effects of cavitation on the pumping system).

B. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 1, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

237. Dependent Claim 4 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA, renders Claim 4 obvious. The specification of the '258 Patent refers to the critical speed as a speed that avoids cavitation. For example, the '258 Patent teaches “by operating transmissions such that pumps are maintained at or below critical pump speeds, such formation of vacuum bubbles and resulting pump cavitation and damage may be avoided.”²¹³ Accordingly, I understand “a critical plunger speed associated with the multi-plunger hydraulic fracturing pump”, as claimed, to be the maximum speed a pump can run without cavitation, given a particular system configurations. No other definition or description of “critical plunger speed” is provided in the specification.

238. As described above in Section IX.C, and described in *Tutterow*, it was known to avoid cavitation in pumping systems, for example, to avoid negative effects of cavitation such as erosion.²¹⁴ The '258 Patent admits that this was

²¹³ Ex. 1001 2:15 – 19.

²¹⁴ See, e.g., Ex. 1013 (*Tutterow*), 20.

known.²¹⁵ As further discussed in Section IX.C, it was also well known that it is an inherent property of positive displacement pumps (e.g. plunger pumps) that, for a given pump system, operation above a certain speed (i.e. critical plunger speed) creates cavitation.²¹⁶

239. Accordingly, operating a pump speed below the speed required to create cavitation, which a POSITA would have understood to be a “critical speed” of the pump, would have been obvious based on the general knowledge of a POSITA. Accordingly, the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA, render Claim 4 obvious. In the alternative, combination of *Yi* and *Bergan* in view of *Jelaska* and *Tutterow* renders Claim 4 obvious for the same reasons just provided, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

²¹⁵ See, e.g., Ex. 1001 2:4 – 14.

²¹⁶ See, e.g., Ex. 1013 (*Tutterow*), 30 (“The cavities [cylinders] on a positive displacement pump open and close as the pump operates and the liquid must flow quickly enough at the pump suction to fill the cavities completely with liquid. If the cavities do not fill with liquid, there will be a void, and apparent cavitation, resulting in a loss of both flow and pressure performance. ***If the speed is increased, this filling process becomes more problematical, limiting the maximum speed.***”) (emphasis added)).

C. DEPENDENT CLAIM 5: “5. THE SYSTEM OF CLAIM 1, WHEREIN THE MAXIMUM PUMP SPEED IS 5% OR LESS OVER A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

240. Dependent Claim 5 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA, render Claim 5 obvious. Claim 5 simply claims operating the pump speed at a speed higher than the speed at which cavitation begins. The specification of the '258 Patent itself teaches that operating the pump at speeds which allow for cavitation was not only known, but “commonly” performed. For example, the '258 Patent discloses that “[a] heightened speed of operation creates low pressure within the pumps, creating vacuum bubbles. As the pump plungers retract, the vacuum bubbles implode, causing damage (cavitation) to the pump and engine systems. Although the risks of operating the pumps at too great of speeds may be known, concerns about lowered pump rates and lost efficiency resulting from maintaining slower transmission speeds *commonly lead to disregard of the risks as an unavoidable consequence of maintaining pump efficiency.*”²¹⁷

241. The '258 Patent claims no new benefit from operating the motor above the cavitation speed other than “to achieve a desired pump rate”, as even the specification of the '258 Patent admits was “commonly” practiced before the '258

²¹⁷ Ex. 1001 2:4-14 emphasis added.

Patent. Indeed, the '258 Patent specification does not exclusively teach the 5% limit but instead teaches that “any other acceptable range [of speed above the cavitation speed].”²¹⁸ Accordingly, even the specification of the '258 Patent teaches that there is no inventive concept involved in operating at 5% above the cavitation speed.

242. Further, operating a pump above the speed at which cavitation begins is a type of risk-reward engineering decision that is made every day in industrial processes, including pumping. As described in Section IX.C, cavitation in a pumping system leads to problems such as erosion of the pump's internal components, noise and vibration, and loss of pumping pressure (head). While these are undesirable impacts of cavitation and should be avoided, a POSITA would also understand that small amounts of cavitation would affect the life and efficiency of the pump but would not immediately stop the pumping process.²¹⁹ Accordingly, there is a risk to operating with the pump cavitating (loss of life and pumping pressure), but also a reward (increased flowrate). The decision to operate in a region where cavitation occurs, particularly relatively low amounts of cavitation, is a tradeoff between the risks and the rewards. Operating to gain the benefits of higher flowrate while accepting a small reduction in life of components or pumping pressure was well known, as the '258 Patent itself discloses that “[a]lthough the risks of operating the

²¹⁸ See Ex. 1001 6:1-13.

²¹⁹ Ex. 1013 (*Tutterow*), pg. 20 (explaining that “total loss of pump-developed head occurs” only in “extreme cases” of cavitation).

pumps at too great of speeds may be known, concerns about lowered pump rates and lost efficiency resulting from maintaining slower transmission speeds commonly lead to disregard of the risks as an unavoidable consequence of maintaining pump efficiency.”²²⁰

243. Accordingly, the combination of *Buckley*, *Bergan*, and the general knowledge of a POSITA renders Claim 5 obvious. In the alternative, combination of *Yi* and *Bergan* in view of *Jelaska* and *Tutterow* renders Claim 5 obvious for the same reasons just provided, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

XV. GROUND 3A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

244. It is my opinion that *Buckley* in view of *Bergan* discloses, suggests, and renders obvious Claims 7, 15 & 17 of the ’258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

245. The motivation to combine *Buckley* and *Bergan* and *Jelaska* is the same as that discussed above in Section XI.A and incorporated herein by reference. Nothing in *Nesbitt* teaches against the combination of *Buckley* and *Bergan* and *Jelaska*. A POSITA would have been motivated to combine the teachings of *Nesbitt*

²²⁰ Ex. 1001 2:8 – 14.

with those of *Buckley* and *Bergan* as *Nesbitt* is a textbook entitled “Pumping Manual International: Handbook of Pumps and Pumping” and written “as a practical reference book for pump users.”²²¹ *Nesbitt* “has been compiled with the help of and benefit from the practical experience of pump users; it is aimed at everyone who has technical problems” relating to pumps²²². Additionally, *Nesbitt* contains basic descriptions of the operation of pumps, including plunger pumps, that would have been invaluable to a POSITA looking to apply the teachings of *Buckley* to a practical system. Accordingly, the operation of the pumps of *Buckley* would have already had the characteristics described by *Nesbitt*, such as the inverse relationship between the stroke length of a plunger and the speed of the pump, at a given flowrate. *Nesbitt* merely describes and defines these characteristics and emphasizes to a POSITA how a positive displacement pump, such as a plunger pump, operates. Accordingly, *Nesbitt*’s description of the ideal flowrate formula representing plunger pumps operations would aid a POSITA’s selection of pump speed and stroke length when implementing *Buckley*’s pumping system to achieve a desired flowrate.

246. A POSITA would have had a reasonable expectation of success in combining the teachings of *Nesbitt* with those of *Buckley* and *Bergan* (and *Jelaska*) as *Nesbitt* merely describes the inherent characteristics of the plunger pump of the

²²¹ Ex. 1014 pg VII

²²² Ex. 1014 pg VII

Buckley/Bergan system. Such a combination would simply be combining prior art elements (the basic operation of a plunger pump and *Buckley/Bergan's* plunger pump) according to known methods (operating the pump) to yield predictable results (an increase in the pressure of fluid).

B. DEPENDENT CLAIM 7: “7. THE SYSTEM OF CLAIM 6, WHEREIN A STROKE LENGTH OF EACH OF THE PLUNGERS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP IS SELECTED TO INVERSELY RELATE TO A PUMP SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP SO AS TO ACHIEVE A PREDETERMINED FLOW RATE.”

247. Dependent Claim 7 depends from Claim 6. In addition to the disclosures regarding Claim 6 disclosed above in Ground 1A, the combination of *Buckley* and *Bergan* renders Claim 7 obvious. As discussed above in Section IX.B, and incorporated herein by reference, and further discussed in *Nesbitt*, the limitations of Claim 7 are an inherent part of a positive displacement (i.e. plunger) pump. To calculate pump speed for a fixed flowrate and stroke length, a positive displacement (PD) pump would adhere to the following relationship:²²³

$$n = \frac{Q_{th} \times 60 \times 4}{0.001 \times s \times \pi d^2}$$

where

Q_{th} = theoretical flow (cc/s)

n = strokes per minute (1/minute)

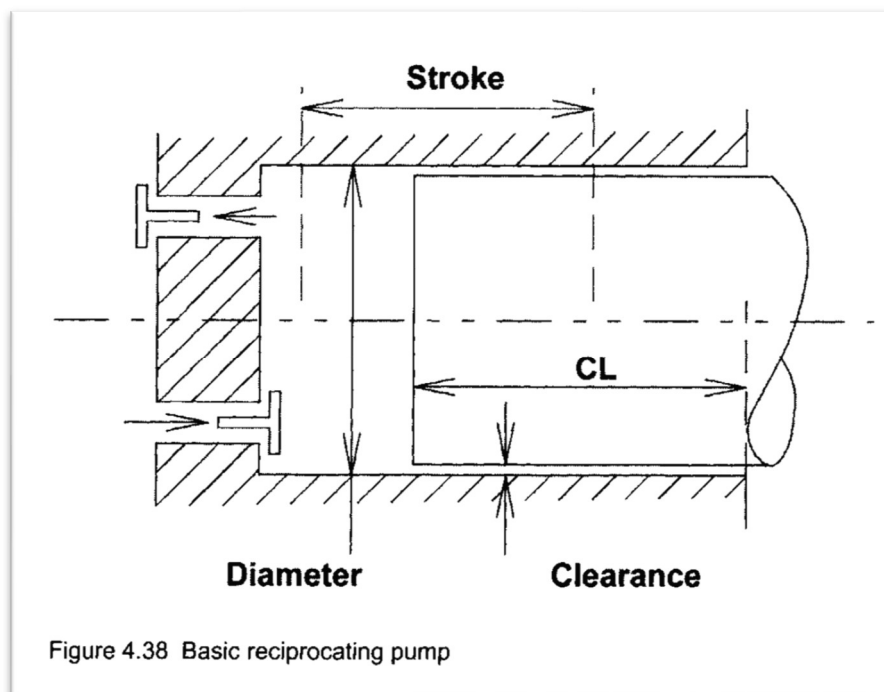
²²³ Ex. 1014 (*Nesbitt*) pg 140, Eq. 4.25.

d = piston [plunger] diameter (mm)

s = stroke length (mm)

To calculate stroke length with a fixed flowrate and pump speed, a PD pump would adhere to the following relationship:

$$s = \frac{Q_{th} \times 60 \times 4}{0.001 \times n \times \pi d^2}$$



Ex. 1014 (*Nesbitt*), 140 (Fig. 4.38).

248. To calculate flowrate with a fixed stroke length and piston diameter, a PD pump would adhere to the following relationship:

$$Q_{th} = \frac{s \times 0.001 \times n \times \pi d^2}{60 \times 4}$$

249. As can be seen from each of the above equations, there is an inverse relationship between stroke length (and piston/plunger diameter) and pump speed for a fixed flow rate. In other words, with a fixed flowrate, as stroke length (s) increases, the speed of the pump (n) must decrease to maintain the flowrate.

250. This is an inherent characteristic of plunger pumps. For a pump with more than one cylinder (e.g. quintuplex pump with 5 cylinders), the equation above would be simply multiplied by the number of cylinders in order to obtain the total flowrate from the pump. Accordingly, it would have been obvious to a POSITA to select a particular stroke length associated with *Buckley's* pump to achieve a particular flow rate and that for the particular flow rate, the stroke length would be inversely related to a pump speed (the speed of the plungers).

251. Accordingly, the combination of *Buckley* and *Bergan* in view of the general knowledge of a POSITA render Claim 7 obvious. In the alternative, the combination of *Buckley* and *Bergan* in view of *Jelaska* and *Nesbitt* renders Claim 7 obvious for the same reasons.

C. INDEPENDENT CLAIM 15

252. It is my opinion that the combination of *Buckley* and *Bergan* discloses, suggests, and renders obvious Claim 15. As discussed in the following subsections, the combination of *Buckley* and *Bergan* in view of the general knowledge of a

POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt*, discloses, or renders obvious, each and every element of Claim 15.

1. 15[p]: “15. A method for pumping fluid into a wellbore associated with a subterranean formation, the method comprising:”

253. *Buckley* discloses the preamble to Claim 15.²²⁴ *Buckley* discloses that “[t]he present application relates generally to hydraulic fracturing in oil and gas wells, and in particular to an electric drive pump used to drive a fluid end for the pumping of a fracturing fluid into a well.”²²⁵ Further, *Buckley* teaches that “[h]ydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells,” and that the process includes pumping fluid into a (downhole) formation and that “[w]hen the fluid enters the formation, it fractures, or creates fissures, in the formation.”²²⁶ *Buckley* discloses particular techniques for performing such fracturing using a multi-plunger pump.²²⁷

254. *Buckley* further teaches a method and that “those skilled in the art will appreciate that the conception, upon which this disclosure is based, may readily be

²²⁴ I understand that the preamble may not be limiting. I include analysis of the preamble out of an abundance of caution.

²²⁵ Ex. 1004 (*Buckley*) [0001]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

²²⁶ Ex. 1004 (*Buckley*) [0002]; see also Ex. 1005 (*Buckley* Provisional) pg. 2

²²⁷ Ex. 1004 (*Buckley*) [0009], Fig. 2; see also Ex. 1005 (*Buckley* Provisional) pg. 4, Fig. 2; see also Section XI.B.2 (Ground 1A, Limitation 1[a]) above.

utilized as a basis for the designing of other structures, methods and systems for carrying out the various purposes of the present system.”²²⁸

255. Accordingly, *Buckley* discloses, and the combination of *Buckley* with *Bergan* and the knowledge of a POSITA, and, in the alternative, in view of *Jelaska* and *Nesbitt*, renders the preamble obvious.

2. **15[a]: “fluidly connecting a multi-plunger hydraulic fracturing pump to a well associated with the subterranean formation such that the multi-plunger pump pumps fluid into the wellbore at a high pressure so that fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”**

256. Except for being rewritten as a method claim, limitation 15[a] is essentially similar to limitation 1[a] and is rendered obvious by the combination of *Buckley* and *Bergan* and, in the alternative, in view of *Jelaska* and *Nesbitt*, for the same reasons as those discussed above in Section XI.B.2.

3. **15[b]: “simultaneously powering the multi-plunger pump with a plurality of motors;”**

257. Except for being rewritten as a method claim, limitation 15[b] is essentially similar to limitation 1[b] and is rendered obvious by the combination of *Buckley* and *Bergan* and, in the alternative, in view of *Jelaska* and *Nesbitt*, for the same reasons as those discussed above in Section XI.B.3.

²²⁸ Ex. 1004 (*Buckley*) [0016]; see also Ex. 1005 (*Buckley Provisional*) pg. 6.

4. **15[c]: “providing a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors so as to translate power from the plurality of motors into a desired pump rate of the multi-plunger pump.”**

258. As I explain above in Sections XI.B.3-4 for limitations 1[b]-[c], the *Buckley-Bergan* combination discloses a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality motors (i.e., as taught by *Bergan*) to translate power from the plurality of motors to the crankshaft of the drive pump (as taught by *Buckley*). And as discussed above in Sections XI.B.5 and XV.B with reference to Limitation 1[d] and Claim 7, it was known in the art that (1) the flow rate (i.e., “pump rate”) of a pump is a function of the speed of its plungers²²⁹ and (2) the speed of the pump’s plungers is a function of the driving component’s (i.e., the motors’) speed and the gear ratio of the gearing systems linking the driving components (i.e., the motors) with the driven component (i.e., the pump).²³⁰ Accordingly, a POSITA would know to operate the motors at a specific speed, taking into account the gear ratio of the entire drive train (i.e., the planetary gearing system taught by *Bergan*), to achieve the desired pump speed and corresponding flow rate (i.e., “pump rate”).²³¹ Thus, the *Buckley-Bergan*

²²⁹ See section XV.B (Ground 3A, Claim 7) above.

²³⁰ See section XI.B.5 (Ground 1A, Limitation 1[d]) above.

²³¹ This argument assumes that “pump rate” means “flow rate,” as would have been understood by a POSITA. See section, IX.A above. To the extent Patent Owner argues that “pump rate” means “pump speed,” Limitation 15[c] is rendered obvious by the *Buckley-Bergan* combination in view of the knowledge of a POSITA and, in

combination renders obvious Limitation 15[c] in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for same reasons discussed above with reference to Limitations 1[b]-[d] and Claim 7.

D. DEPENDENT CLAIM 17: “THE METHOD OF CLAIM 15, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

259. Except for depending from Claim 15 and being rewritten as a method claim, Claim 17 is essentially similar to Claim 3 and is rendered obvious by the combination of *Buckley* and *Bergan* and, in the alternative, in view of *Jelaska* and *Nesbitt*, for the same reasons as those discussed above in Section XI.C.

XVI. GROUND 3B: OBVIOUS OVER YI IN VIEW OF BERGAN FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, JELASKA AND NESBITT

260. It is my opinion that *Yi* in view of *Bergan* discloses, suggests, and renders obvious Claims 7, 15 & 17 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

261. The motivation to combine *Yi* and *Bergan* and *Jelaska* is the same as that discussed above in Section XII.A and incorporated herein by reference. Nothing in *Nesbitt* teaches against the combination of *Yi* and *Bergan* and *Jelaska*. A POSITA

the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as those discussed in this section, as flow rate is directly tied to pump speed.

would have been motivated to combine the teachings of *Bergan* with those of *Yi* and *Bergan* (and *Jelaska*) as *Nesbitt* is a textbook entitled “Pumping Manual International: Handbook of Pumps and Pumping” published in 2006 and written “as a practical reference book for pump users.”²³² *Nesbitt* “has been compiled with the help of and benefit from the practical experience of pump users; it is aimed at everyone who has technical problems” relating to pumps²³³. Additionally, *Nesbitt* contains basic descriptions of the operation of pumps, including plunger pumps, that would have been invaluable to a POSITA looking to apply the teachings of *Yi/Bergan* to a practical system. Accordingly, the operation of the pumps of *Yi* would have already had the characteristics described by *Nesbitt*, such as the inverse relationship between the stroke length of a plunger and the speed of the pump, at a given flow rate. *Nesbitt* merely describes and defines these characteristics and emphasizes to a POSITA how a positive displacement pump, such as a plunger pump, operates. Accordingly, *Nesbitt*’s description of the ideal flowrate produced by plunger pumps would aid a POSITA’s selection of pump speed and stroke length when implementing *Yi*’s pumping system to achieve a desired flowrate.

262. A POSITA would have had a reasonable expectation of success in combining the teachings of *Nesbitt* with those of *Yi* and *Bergan* (and *Jelaska*) as

²³² Ex. 1014 pg VII

²³³ Ex. 1014 pg VII

Nesbitt merely describes the inherent characteristics of the plunger pump of the *Yi/ Bergan* system. Such a combination would simply be combining prior art elements (the basic operation of a plunger pump and *Yi/ Bergan/Jelaska* plunger pump) according to known methods (operating the pump) to yield predictable results (an increase in the pressure of fluid).

B. DEPENDENT CLAIM 7: “7. THE SYSTEM OF CLAIM 6, WHEREIN A STROKE LENGTH OF EACH OF THE PLUNGERS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP IS SELECTED TO INVERSELY RELATE TO A PUMP SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP SO AS TO ACHIEVE A PREDETERMINED FLOW RATE.”

263. Dependent Claim 7 depends from Claim 6. In addition to the disclosures regarding Claim 6 disclosed above in Ground 1B, the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA, render Claim 7 obvious. As discussed above in Section IX.B, and incorporated herein by reference, and further disclosed by *Nesbitt* the limitations of Claim 7 are an inherent part of a positive displacement (i.e. plunger) pump. To calculate pump speed for a fixed flowrate and stroke length, a positive displacement (PD) pump would adhere to the following relationship:²³⁴

$$n = \frac{Q_{th} \times 60 \times 4}{0.001 \times s \times \pi d^2}$$

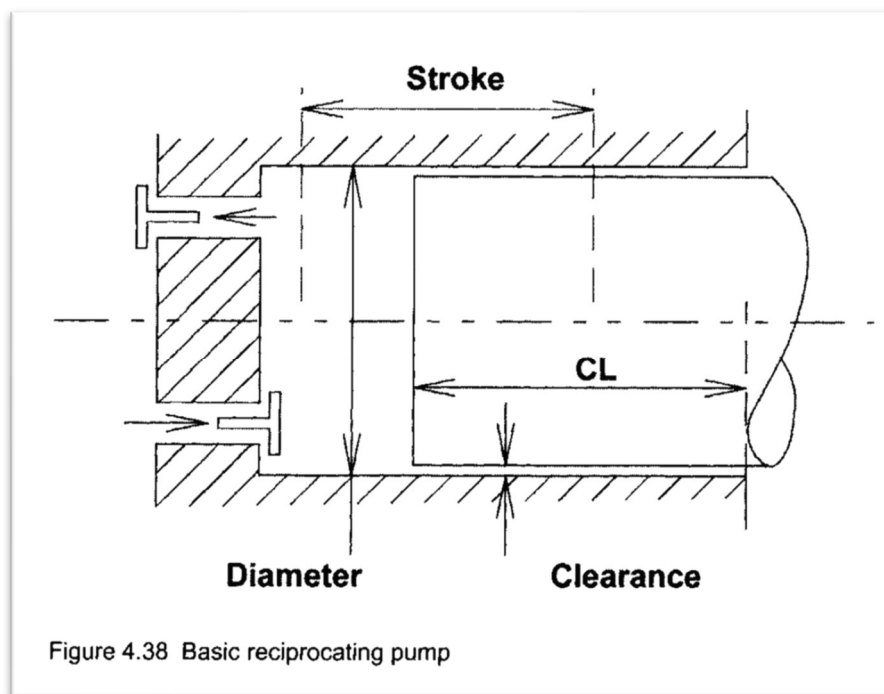
where

²³⁴ Ex. 1014 (*Nesbitt*) pg 140, Eq. 4.25.

Q_{th} = theoretical flow (cc/s)
 n = strokes per minute (1/minute)
 d = piston [plunger] diameter (mm)
 s = stroke (mm)

To calculate stroke length with a fixed flowrate and pump speed, a PD pump would adhere to the following relationship:

$$s = \frac{Q_{th} \times 60 \times 4}{0.001 \times n \times \pi d^2}$$



Ex. 1014 (*Nesbitt*), 140 (Fig. 4.38).

264. To calculate flowrate with a fixed stroke length and piston diameter, a PD pump would adhere to the following relationship:

$$Q_{th} = \frac{s \times 0.001 \times n \times \pi d^2}{60 \times 4}$$

265. As can be seen from each of the above equations, there is an inverse relationship between stroke length (and piston/plunger diameter) and pump speed for a fixed flowrate. In other words, with a fixed flowrate, as stroke length (s) increases, the speed of the pump (n) must decrease to maintain the flowrate.

This is an inherent characteristic of plunger pumps. For a pump with more than one cylinder (e.g. quintuplex pump with 5 cylinders), the above equation would be simply multiplied by the number of cylinders to obtain the total flow rate from the pump. Accordingly, it would have been obvious to a POSITA to select a particular stroke length associated with *Yi*'s pump to achieve a particular flow rate and that for the particular flow rate, the stroke length would be inversely related to a pump speed (the speed of the plungers).

266. Accordingly, the combination of *Yi* and *Bergan*, along with the general knowledge of a POSITA, renders Claim 7 obvious. In the alternative, the combination of *Yi* and *Bergan* in view of *Jelaska* and *Nesbitt* renders Claim 7 obvious as those references teach basic operations of gear trains and positive displacement pumps respectively.

C. INDEPENDENT CLAIM 15

267. It is my opinion that *Yi* in view of *Bergan* discloses, suggests, and renders obvious Claim 15 of the '258 Patent. As discussed in the following subsections, the combination of *Yi*, *Bergan*, in view of the general knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt*, discloses, or renders obvious, each and every element of Claim 15.

5. 15[p]: “A method for pumping fluid into a wellbore associated with a subterranean formation, the method comprising:”

268. *Yi* discloses the preamble.²³⁵ *Yi* teaches “[t]he invention relates to the technical field of fracturing trucks and discloses a fracturing pump transmission system and a fracturing truck.”²³⁶ Further, *Yi* describes “fracturing” to be “hydraulic fracturing for fracturing a subterranean formation”:

“Fracturing operations are one of the most important methods for modifying oil and gas reservoirs. For low-permeability oil and gas wells, fracturing is generally necessary to achieve stable production and increase output. A fracturing truck is the primary equipment used in fracturing operations. Its function is to inject high-pressure, large-volume fracturing fluid into the formation, causing it to crack open and injecting proppants (such as fracturing

²³⁵ I understand that the preamble may not be limiting. I include analysis of the preamble out of an abundance of caution.

²³⁶ Ex. 1010 (*Yi* Translation) Abstract.

sand) into the fractures to enhance the permeability of the formation, increase the fluidity of oil and gas, and improve the recovery rate of oil and gas.”²³⁷

269. *Yi* describes the purpose of the invention as “provide a fracturing pump transmission system to effectively reduce the selection difficulty and cost of relevant components for the fracturing pump transmission system while also effectively improving the safety redundancy of the fracturing pump transmission system.”²³⁸ Thus, *Yi* discloses a technique for performing hydraulic fracturing, which involves “inject[ing] high-pressure, large-volume fracturing fluid into the formation, causing it to crack open,” using a multi-plunger pump.²³⁹

270. Accordingly, *Yi* discloses the preamble.

6. 15[a]: “fluidly connecting a multi-plunger hydraulic fracturing pump to a well associated with the subterranean formation such that the multi-plunger pump pumps fluid into the wellbore at a high pressure so that fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”

271. Except for being rewritten as a method claim, limitation 15[a] is essentially similar to limitation 1[a] and is rendered obvious by the combination of

²³⁷ Ex. 1010 (*Yi* Translation) [0002].

²³⁸ Ex. 1010 (*Yi* Translation) [0007].

²³⁹ Ex. 1010 (*Yi* Translation) [0002], [0010], Fig. 2; see also Section XII.B.2 (Ground 1B, Limitation 1[a]) above.

Yi and *Bergan* and the general knowledge of a POSITA for the same reasons as those discussed above in Section XII.B.2.

7. **15[b]: “simultaneously powering the multi-plunger pump with a plurality of motors;”**

272. Except for being rewritten as a method claim, limitation 15[b] is essentially similar to limitation 1[b] and is rendered obvious by the combination of *Yi* and *Bergan* and, in the alternative, in view of *Jelaska* and *Nesbitt*, for the same reasons as those discussed above in Section XII.B.3.

8. **15[c]: “providing a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors so as to translate power from the plurality of motors into a desired pump rate of the multi-plunger pump.”**

273. As I explain above in Sections XII.B.3-4 for limitations 1[b]-[c], the *Yi-Bergan* combination discloses a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality motors (i.e., as taught by *Bergan*) to translate power from the plurality of motors to the crankshaft of the drive pump (as taught by *Yi*). And as discussed above in Sections XII.B.5 and XVI.B with reference to Limitation 1[d] and Claim 7, it was known in the art that (1) the flow rate (i.e., “pump rate”) of a pump is a function of the speed of its plungers²⁴⁰ and (2) the speed of the pump’s plungers is a function of the driving component’s (i.e., the

²⁴⁰ See section XVI.B (Ground 3B, Claim 7) above.

motors’) speed and the gear ratio of the gearing systems linking the driving components (i.e., the motors) with the driven component (i.e., the pump).²⁴¹ Accordingly, a POSITA would know to operate the motors at a specific speed, taking into account the gear ratio of the entire drive train (i.e., the planetary gearing system taught by *Bergan*), in order to achieve the desired pump speed and corresponding flow rate (i.e., “pump rate”).²⁴² Thus, the *Yi-Bergan* combination renders obvious Limitation 15[c] in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for same reasons discussed above with reference to Limitations 1[b]-[d] and Claim 7.

D. DEPENDENT CLAIM 17: “17. THE METHOD OF CLAIM 15, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

274. Except for depending from Claim 15 and being rewritten as a method claim, Claim 17 is essentially similar to Claim 3 and is rendered obvious by the combination of *Yi* and *Bergan* and, in the alternative, in view of *Jelaska* and *Nesbitt*, for the same reasons as those discussed above in Section XII.C.

²⁴¹ See section XI.B.5 (Ground 1B, Limitation 1[d]) above.

²⁴² This argument assumes that “pump rate” means “flow rate,” as would have been understood by a POSITA. See section IX.B above. To the extent Patent Owner argues that “pump rate” means “pump speed,” Limitation 15[c] is rendered obvious by the *Yi-Bergan* combination in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons, as flow rate is directly related to pump speed.

XVII. GROUND 4A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* FURTHER IN VIEW OF *ROSMAN* AND THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

275. It is my opinion that *Buckley* in view of *Bergan* and *Rosman* discloses, suggests, and renders obvious Claims 2 & 16 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

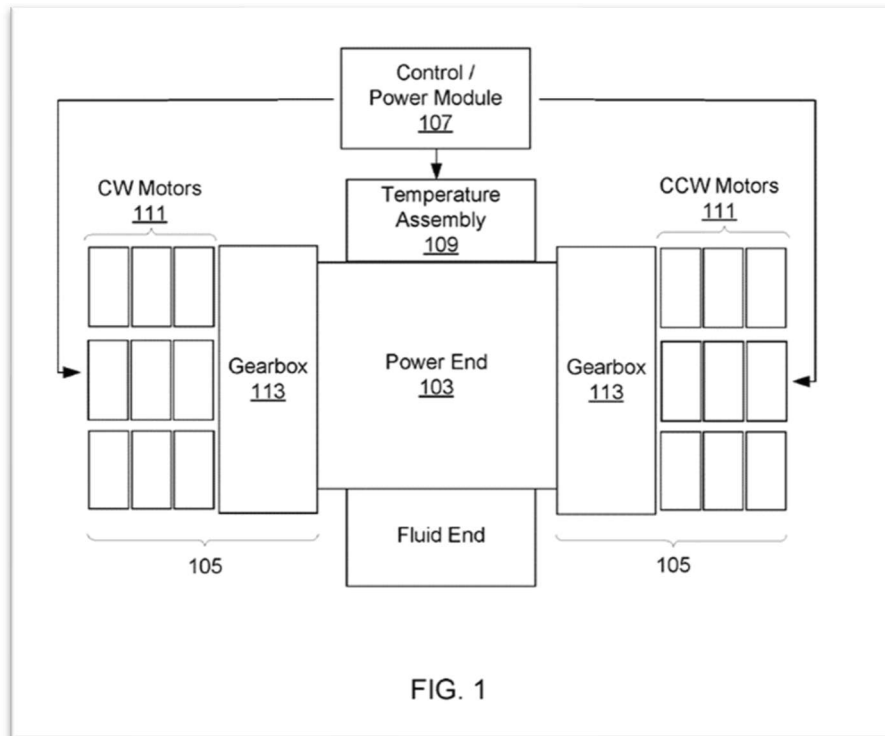
A. MOTIVATION TO COMBINE

276. The motivation to combine *Buckley*, *Bergan*, *Jelaska*, and *Nesbitt* is the same as that discussed above in Sections XI.A and XV.A incorporated herein by reference. Nothing in *Rosman* teaches against the combination of *Buckley*, *Bergan*, *Jelaska*, and *Nesbitt*. A POSITA would have been motivated to further combine *Buckley*, *Bergan*, *Jelaska* and *Nesbitt* with *Rosman* to gain the benefits of *Rosman*'s specific gear teachings such as the ability to exchange speed for torque in order to drive a higher torque load. As *Rosman* discloses, this allows the use of “smaller motors” and “there is an advantage that the system is less expensive with respect to initial capitalization and maintenance.”²⁴³

277. Initially, *Rosman* is like both *Buckley* and *Bergan* in that it teaches using a plurality of motors operating simultaneously to power a single rotating load. As discussed above with regard to Ground 1, *Buckley* discloses that “[t]he electric drive pump system is configured to provide a plurality of individual motors in

²⁴³ Ex. 1007 (*Rosman*) 4:54-59.

selective configurations that work together to provide power to a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear motion for operation of the plungers in the fluid ends.”²⁴⁴



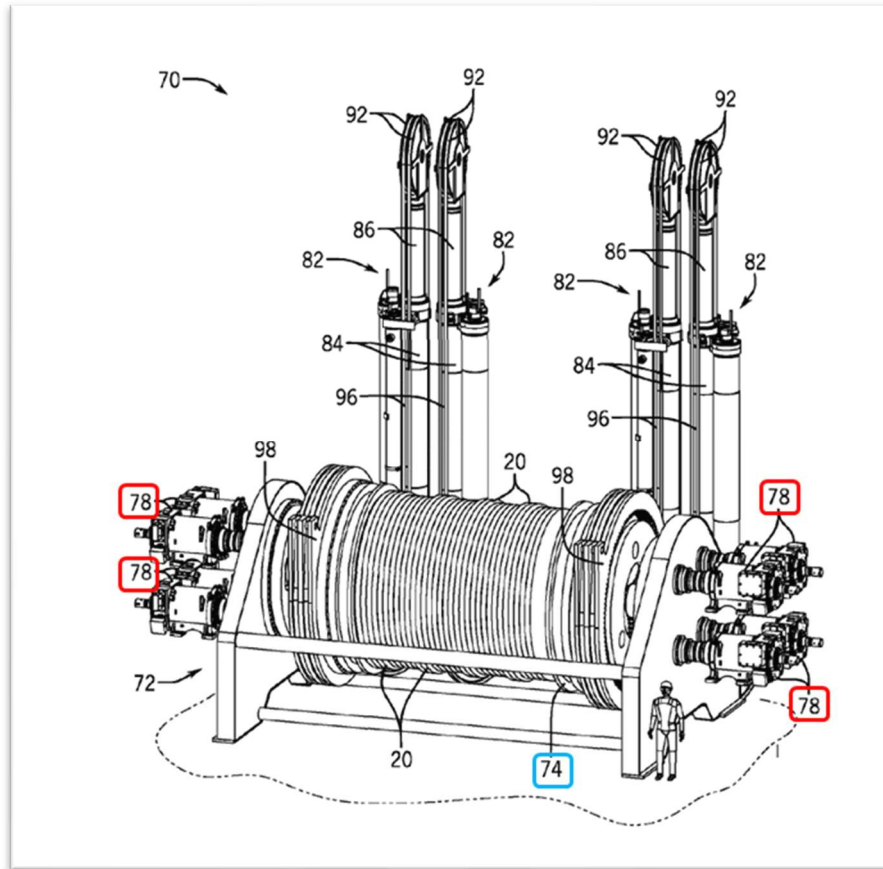
Ex. 10044 (*Buckley*) Fig. 1²⁴⁵

278. Similarly, *Bergan* teaches, when describing Fig. 3, “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load

²⁴⁴ Ex. 1004 (*Buckley*) [0009]; see also Ex. 1005 (*Buckley* Provisional) pg 4, 5 (“selected gearing may be used to assist in mating the electric motors to the power end. [] also a transfer gear system can be used if required.”)

²⁴⁵ See also Ex. 1005 (*Buckley* Provisional) Fig. 1, Fig. 2.

30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”²⁴⁶



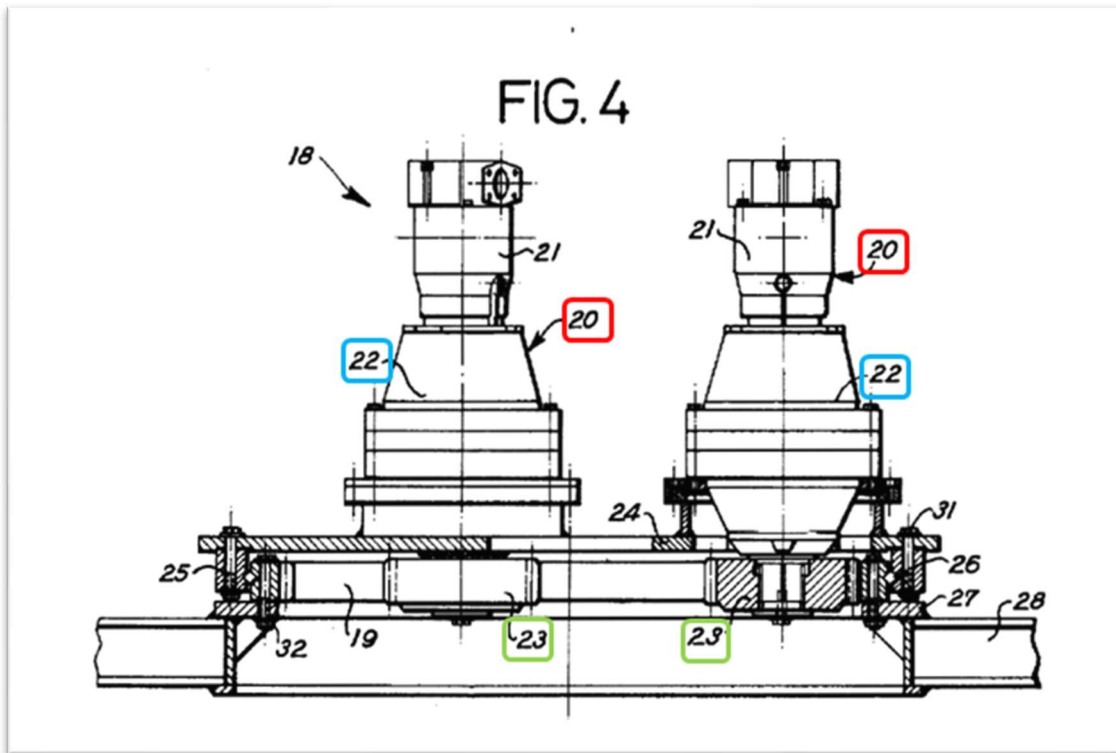
Ex. 1006 (*Bergan*) Fig. 3 (annotated)

279. Like both *Buckley* and *Bergan*, *Rosman* teaches the use of multiple smaller motors which combine power outputs through gearing to drive a larger, higher torque load.²⁴⁷ As shown in Figure 4 of *Rosman*, “[e]ach drive motor

²⁴⁶ Ex. 1006 (*Bergan* [0030])

²⁴⁷ See, e.g., Ex. 1007 (*Rosman*), 2:15-24 (“The invention as disclosed herein is directed to a drive system comprising an annular member carrying first engagement means and being rotatably mounted. A plurality of driver motor means is disposed in spaced relationship with respect to each other along the

assembly 20 [annotated in red] includes a planetary gear mechanism 22 [annotated in blue] and a pinion member 23 [annotated in green].”²⁴⁸ Like the system of *Bergan*, *Rosman*’s pinions mesh with a common gear that drives the load.



Ex. 1007 (*Rosman*) Fig. 4 (annotated)

280. Further, *Rosman* discloses “In the embodiment as shown, the motors 21 are known as fast rotating and have lower torque output. [] Planetary transmission and gear boxes 22 are used in combination to develop the amount of torque necessary

circumference of the annular member. Second engagement means located on the drive motor means couple with the first engagement means. All of the drive motor means are operated simultaneously to rotate the annular member about an axis of rotation.”), Figs. 1-4.

²⁴⁸ Ex. 1007 (*Rosman*) 4:46-48.

to rotate ring members moving up to 300-ton loads.”²⁴⁹ This allows the use of “standard off-the shelf [] motors 21 [that] are known as fast rotating and have lower torque output.”²⁵⁰ This leads directly to the “less expensive” capital and maintenance costs taught by *Rosman*.²⁵¹

281. As a POSITA would have known, and as discussed above in Section IX.F, incorporated herein by reference, the speed of an AC electric motor is a function of the frequency of the power supplied to the motor and the construction of the motor, in particular the number of magnetic “poles” in the motor. The “synchronous speed” of the motor is determined using the following equation:²⁵²

$$n_s = f(2/p)60$$

Where:

n_s = synchronous speed of the motor (rpm)

f = frequency (hertz)

p = # of poles in the motor (a function of design and construction).²⁵³

²⁴⁹ Ex. 1007 (*Rosman*) 4:55-62

²⁵⁰ Ex. 1007 (*Rosman*) 4:54 – 56.

²⁵¹ Ex. 1007 (*Rosman*) 4:57-59.

²⁵² Synchronous motors run at exactly the synchronous speed. Induction motors run near synchronous speed, but with some small loss of speed due to the “slip” of the motor.

²⁵³ Ex. 1015 (EE-Reference) pg. 40-4.

For example, a 4 pole motor supplied with 60 Hz AC power (US standard) would have a synchronous speed of 1800 RPM, as shown below.

$$n_s = 60(2/4)60 = 1800$$

282. To build a motor that operates slower, a motor designer would increase the number of poles in a machine. For example, in order to directly operate the Gardner Denver pump discussed in Section IX.B at its recommended speeds (between 100 and 330 RPM), and, as an example, at 60 Hz, the motor would need to have at least 22 poles (327 RPM) and maybe as many as 60 poles (120 RPM).²⁵⁴ As the size of the motor and the amount of copper, magnetic steel and other components increase substantially as poles are added, such a machine would have been very costly and would likely have to be custom-built, which adds even more to the cost.

283. In contrast, the use of *Rosman's* planetary gearbox located between motors 21 and pinions 23 allow a POSITA to use “off-the shelf” motors with “fast rotating [higher speed] and have lower torque output” and use the planetary gearbox mechanism to slow down the rotational speed and gain the accompanying increase in torque. This allows the “lower torque” motors, in combination, to drive a high

²⁵⁴ Ex. 1016 (Gardner) pg. 14.

torque load, for example the “300 tons” of *Rosman*.²⁵⁵ The application of *Rosman*’s planetary gear system into the motor / gear trains of *Buckley* / *Bergan* would have predictable results – a reduction in speed and increase in available torque.

284. A POSITA would have been motivated to combine teachings that allow for lower capital and maintenance costs, as taught by *Rosman* to take advantage of the lower costs. Further, a POSITA would have been motivated to apply a teaching that allowed the use of “off the shelf” components as such components have higher availability than custom components and are typically much less expensive, as taught by *Rosman* and would have been known to a POSITA. That is, the above design incentives and market forces would have motivated POSITA to incorporate *Rosman*’s planetary transmission and gear box into *Buckley*’s electric motor and pump configuration to make the implementation of the system simpler and less expensive (e.g., through the use of less expensive and smaller electric motors) as taught by *Rosman*.

285. Further, a POSITA would have known that planetary gear systems, such as the ones taught by *Rosman* have advantages over parallel shaft gear trains in that planetary gear trains “have a high torque density, [are] compact, [have] low

²⁵⁵ As a POSITA would have known, in a gearing system for a particular power available, as speed goes down, available torque goes up. See, for example, Section IX.C above discussing the relationship between power, torque and speed.

inertia and can be grease lubricated for life,” all of which are advantageous in an industrial application as discussed above in Section IX.D.

286. A POSITA would have had a reasonable expectation of success in *Rosman's* teaching of a gearbox (e.g. a planetary gear system) between the motor and pinion of the *Buckley / Bergan* combination. As discussed above in Section IX.D, planetary gear systems were well known and applying a planetary gearbox between the motors and pinions of the *Buckley/Bergan* combination to lower speed and increase available torque would have been a routine engineering decision. Further, such a combination would have been merely the use of a known technique (*Rosman's* planetary gear trains) to improve similar devices (the motor / gear trains of the *Buckley/Bergan* combination) in the same way (to lower speed and increase available torque). Further still, the combination would have been merely applying a known technique (*Rosman's* planetary gear trains) to a known device (the motor / gear trains of the *Buckley/Bergan* combination) ready for improvement (lower capital and maintenance costs and the use of off the shelf components) to yield predictable results (to lower speed and increase available torque while lowering capital and maintenance costs).

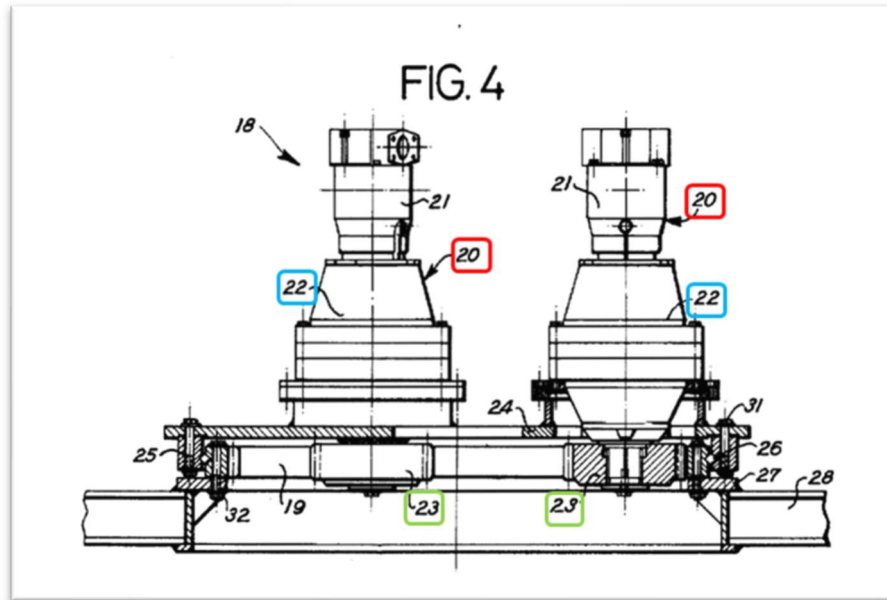
B. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, THE SYSTEM FURTHER COMPRISING A PLURALITY OF SPEED REDUCTION GEARBOXES POSITIONED BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE A DESIRED PUMP RATE.”

287. Dependent Claim 2 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Buckley*, *Bergan*, and *Rosman* renders Claim 2 obvious. As discussed above in Section XVII.A, *Rosman*, like *Buckley* and *Bergan* teaches a system which uses multiple motors arranged around a gearing mechanism to move a rotating load. As *Rosman* discloses this allows the use of “smaller motors” and “there is an advantage that the system is less expensive with respect to initial capitalization and maintenance.”²⁵⁶

288. Further, like *Bergan*, and consistent with *Buckley*, *Rosman* teaches the that “[e]ach drive motor assembly 20 [annotated in red] includes a planetary gear mechanism 22 [annotated in blue] and a pinion member 23 [annotated in green].”²⁵⁷ Like the system of *Bergan*, *Rosman*’s pinions mesh with a common gear which drives the load.

²⁵⁶ Ex. 1007 (*Rosman*) 4:54-59.

²⁵⁷ Ex. 1007 (*Rosman*) 4:46-48.

Ex. 1007 (*Rosman*) Fig. 4 (annotated)

289. Further, *Rosman* discloses that “the motors 21 are known as fast rotating and have lower torque output. [] Planetary transmission and gear boxes 22 are used in combination to develop the amount of torque necessary to rotate ring members moving up to 300-ton loads.”²⁵⁸ As can be seen from Fig. 4, *Rosman* teaches that gearboxes 22 (annotated in blue) are positioned between the plurality of input pinion gears 23 (annotated in green) and the plurality of motors 20 (annotated in red). In combination with the *Buckley-Bergan* combination, it would have been obvious to implement *Rosman*’s planetary gearboxes such that the each of *Buckley*’s electric motors are coupled with *Bergan*’s pinion gears by a respective gearbox, as taught by *Rosman*, such that the gearboxes are “positioned between the plurality of

²⁵⁸ Ex.1007 (*Rosman*) 4:55-62

input pinion gears and the plurality of motors.”²⁵⁹ Further, a POSITA would have understood that *Rosman*’s planetary gearboxes are “speed reduction” gear boxes because they increase torque by lowering speed.²⁶⁰

290. Further, it would have been obvious to a POSITA that implementing the gearboxes taught by *Rosman* with a particular gear ratio would result in the combined pumping “achiev[ing] a desired pump rate.” It was well known in the art that the ideal flow rate of a single cylinder reciprocating pump is given by the following equation:

$$Q_{th} = 0.001 \times s \times \frac{\pi d^2}{4} \times n / 60,$$

where Q_{th} = theoretical flow (cc/s), n = strokes per minute (1/minute), d = piston (*i.e.*, plunger) diameter (mm), and s = stroke length (mm).²⁶¹ As shown, it was known in the art that the flow rate (*i.e.*, “pump rate”) of a pump is a function of the speed of its plungers (as indicated by the term n in the above equation). This is an inherent characteristic of plunger pumps. For a pump with more than one cylinder (e.g. quintuplex pump with 5 cylinders), Equation 4.25 of *Nesbitt* would be simply multiplied by the number of cylinders to obtain the total flowrate from the pump.

²⁵⁹ Ex. 1007 (*Rosman*), 2:15-24, Fig. 4.

²⁶⁰ See discussion in Section IX.G above regarding inverse relationship between rotational speed and torque.

²⁶¹ Ex. 1014 (*Nesbitt*), 140 (Equation 4.25).

291. Further, as discussed above regarding limitation 1[d], a POSITA would simply choose the speed of the pump desired and coordinate the speed of the motors with the gear ratio of the gear train in order to achieve the desired speed of the pump.²⁶² So, in order to achieve a desired pump rate, a POSITA would know to operate the motors at a specific speed, taking into account the gear ratio of the entire drive train, in order to achieve the desired pump speed and corresponding pump rate.²⁶³

292. Accordingly, *Rosman* discloses the additional limitations of Claim 2 and the combination of *Buckley*, *Bergan* and *Rosman* render Claim 2 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

²⁶² See, e.g., Ex. 1012 (*Jelaska*), pg. 3.

²⁶³ This argument assumes that “pump rate” means “flow rate,” as would have been understood by a POSITA. *See supra*, § IX.B. To the extent Patent Owner argues that “pump rate” means “pump speed,” Claim 2 is rendered obvious by the *Buckley-Bergan-Rosman* combination in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as a pump’s flow rate is directly related to the pump speed.

C. DEPENDENT CLAIM 16: “THE METHOD OF CLAIM 15, FURTHER COMPRISING: POSITIONING A PLURALITY OF SPEED REDUCTION GEARBOXES BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE THE DESIRED PUMP RATE.”

293. Except for depending from Claim 15, and being rewritten as a method claim, the limitations of Claim 16 are essentially similar to those of Claim 2 and are rendered obvious by the combination of *Buckley*, *Bergan* and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as those disclosed in Section XVII.B above.

XVIII. GROUND 4B: OBVIOUS OVER *YI* IN VIEW OF *BERGAN* FURTHER IN VIEW OF *ROSMAN* AND THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

294. It is my opinion that *Yi* in view of *Bergan* and *Rosman* discloses, suggests, and renders obvious Claims 2 & 16 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska*.

A. MOTIVATION TO COMBINE

295. The motivation to combine *Yi*, *Bergan*, *Jelaska*, and *Nesbitt* is the same as that discussed above in Sections XII.A and XVI.A, and incorporated herein by reference. Nothing in *Rosman* teaches against the combination of *Yi*, *Bergan*, *Jelaska*, and *Nesbitt*. A POSITA would have been motivated to further combine *Yi* and *Bergan* (and *Jelaska* and *Nesbitt*) with *Rosman* in order to gain the benefits of *Rosman*'s specific gear teachings such as the ability to exchange speed for torque in order to drive a higher torque load. As *Rosman* discloses, this allows the use of

“smaller motors” and “there is an advantage that the system is less expensive with respect to initial capitalization and maintenance.”²⁶⁴

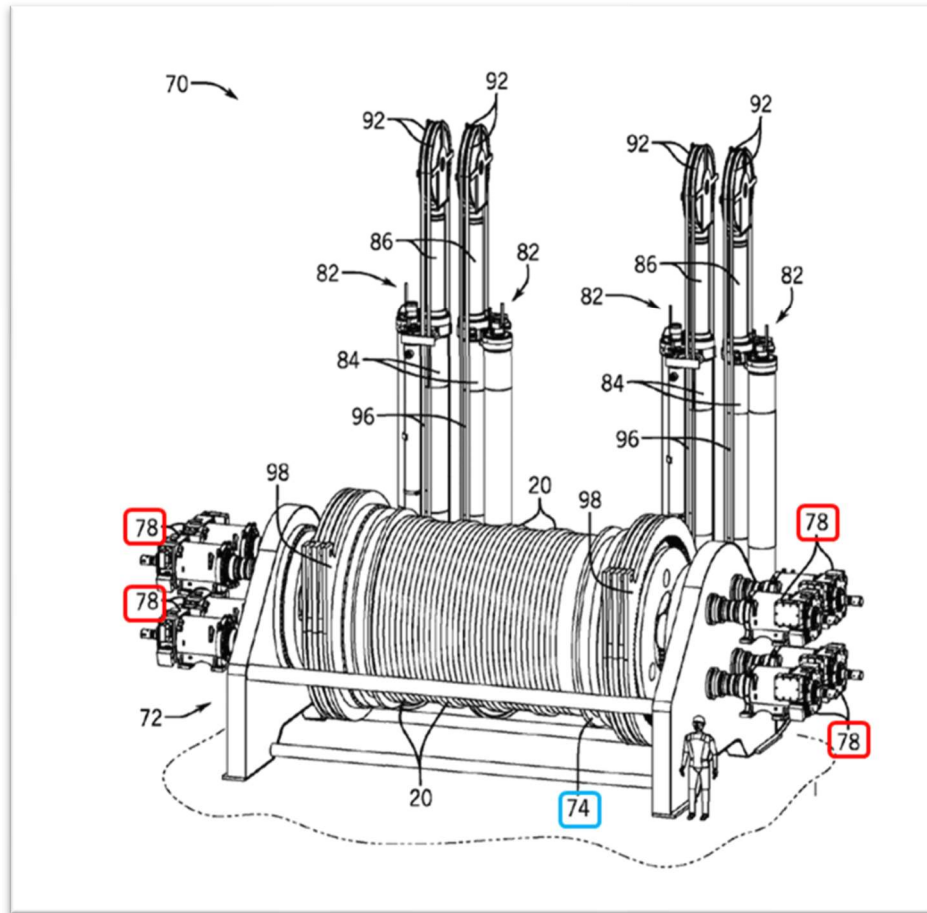
296. Initially, *Rosman* is similar to both *Yi* and *Bergan* in that it teaches using a plurality of motors operating simultaneously to power a single rotating load. As discussed above regarding Ground 1B, *Yi* teaches “the fracturing pump 5 is a crankshaft-type plunger pump,” and that at “both ends of the crankshaft-type plunger pump, there are power input gears 51, and each motor 4 engages at least with the power input gears 51 at one end of the crankshaft-type plunger pump through a power output gear 41.”²⁶⁵

297. Similarly, *Bergan* teaches, when describing Fig. 3, “[m]otors 78 [annotated in red] can be operated to drive rotation of the drum 74 [annotated in blue] to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”²⁶⁶

²⁶⁴ Ex. 1007 (*Rosman*) 4:54-59.

²⁶⁵ Ex. 1010 (*Yi* Translation) [0044].

²⁶⁶ Ex. 1006 (*Bergan* [0030])

Ex. 1006 (*Bergan*) Fig. 3 (annotated)

298. A POSITA would have been motivated to modify the combined *Yi-Bergan* pumping configuration, including its fracturing pump and plurality of motors, to include *Rosman*'s "planetary transmission and gear boxes," based at least on design incentives or market forces. A POSITA would have recognized that an objective of *Yi* is to provide a fracturing pump system that offers improved sourcing of components and reduced cost when compared to traditional systems that utilize a

single, high-power diesel motor to power fracturing pumps.²⁶⁷ Accordingly, a POSITA would have been motivated to modify *Yi*'s pumping system to include *Rosman*'s speed-reduction gearbox based on design incentives and market forces, namely, to further improve the cost-efficiency of *Yi*'s pumping system. A POSITA would have recognized that instead of using costly high-torque motors to drive a fracturing pump, *Rosman*'s speed reduction gearbox would have been used to lower the rotational speeds delivered from higher-speed motors to the pump at a lower cost (e.g., due to lower capital and maintenance costs, as taught by *Rosman*).²⁶⁸ A POSITA would have also recognized that implementing speed reduction gear boxes would allow for the use of common "off-the-shelf" motors (as taught by *Rosman*), which would simplify the implementation of *Yi*'s pumping system as such motors have higher availability (and lower cost) than custom components.²⁶⁹

299. A POSITA would have had a reasonable expectation of success in combining *Rosman*'s gearbox between the motors and power output gears of the *Yi* pumping system for several reasons. First, this combination represents the application of a known technique (*i.e.*, *Rosman*'s planetary gearboxes) to improve similar devices (*i.e.*, the motor and gear trains of the *Yi* pumping system) in the same

²⁶⁷ Ex. 1010 (*Yi* Translation), [0003] (describing drawbacks of traditional diesel engine fracking systems, including expensive, low-availability components).

²⁶⁸ Ex. 1007 (*Rosman*), 4:57-59.

²⁶⁹ Ex. 1007 (*Rosman*), 4:54-55.

way (*i.e.*, by lowering speed and increasing available torque delivered to the pump). Second, the combination would have been merely applying a known technique (*i.e.*, *Rosman*'s planetary gear trains) to a known device (*i.e.*, the motor and gear trains of the *Yi* pumping system) ready for improvement (*e.g.*, lower capital and maintenance costs and the use of off-the-shelf components) to yield predictable results (*e.g.*, to lower speed and increase available torque while lowering capital and maintenance costs).

B. DEPENDENT CLAIM 2: “THE SYSTEM OF CLAIM 1, THE SYSTEM FURTHER COMPRISING A PLURALITY OF SPEED REDUCTION GEARBOXES POSITIONED BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE A DESIRED PUMP RATE.”

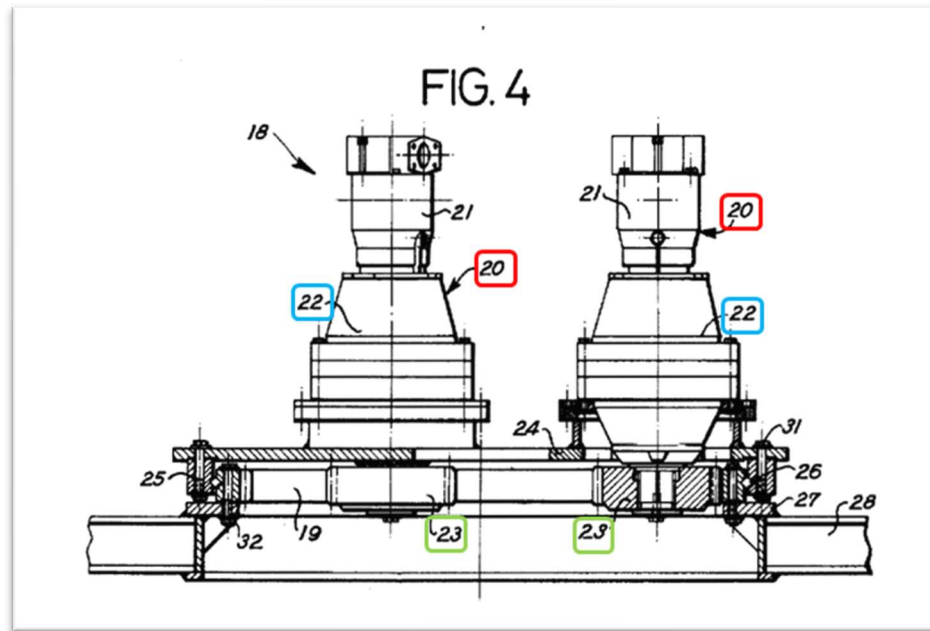
300. Dependent Claim 2 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Yi*, *Bergan*, and *Rosman* renders Claim 2 obvious. As discussed above in Section XVIII.A, *Rosman*, like *Yi* and *Bergan* teaches a system which uses multiple motors arranged around a gearing mechanism to move a load. As *Rosman* discloses, this allows the use of “smaller motors” and “there is an advantage that the system is less expensive with respect to initial capitalization and maintenance.”²⁷⁰

301. Further, like *Bergan*, and consistent with *Yi*, *Rosman* teaches that “[e]ach drive motor assembly 20 [annotated in red] includes a planetary gear

²⁷⁰ Ex. 1007 (*Rosman*) 4:54-59.

mechanism 22 [annotated in blue] and a pinion member 23 [annotated in green].”²⁷¹

Like the system of *Bergan*, *Rosman*’s pinions mesh with a common gear which drives the load.



Ex. 1007 (*Rosman*) Fig. 4 (annotated)

302. Further, *Rosman* discloses “the motors 21 are known as fast rotating and have lower torque output. [] Planetary transmission and gear boxes 22 are used in combination to develop the amount of torque necessary to rotate ring members moving up to 300-ton loads.”²⁷² As can be seen from Fig. 4, *Rosman* teaches that gearboxes 22 (annotated in blue) are positioned between the plurality of input pinion gears 23 (annotated in green) and the plurality of motors 20 (annotated in red). In

²⁷¹ Ex. 1007 (*Rosman*) 4:46-48.

²⁷² Ex.1007 (*Rosman*) 4:55-62

combination with the *Yi-Bergan* combination, it would have been obvious to implement *Rosman*'s planetary gearboxes such that the each of *Yi*'s motors are coupled with *Bergan*'s pinion gears by a respective gearbox, as taught by *Rosman*, such that the gearboxes are "positioned between the plurality of input pinion gears and the plurality of motors."²⁷³ Further, a POSITA would have understood that *Rosman*'s planetary gearboxes are "speed reduction" gear boxes because they increase torque by lowering speed.²⁷⁴

303. As discussed above in Section IX.B and for Claim 2 in Ground 4A, the pump rate (flowrate) of a plunger pump is directly proportional to the speed of the pump (i.e., the speed of pump's plungers).²⁷⁵

304. Further, as discussed above in Section XII.B.5 regarding limitation 1[d], a POSITA would simply choose the speed of the pump desired and coordinate the speed of the motors with the gear ratio of the gear train in order to achieve the desired speed of the pump.²⁷⁶ So, in order to achieve a desired pump rate, a POSITA would know to operate the motors at a specific speed, taking into account the gear

²⁷³ Ex. 1007 (*Rosman*), 2:15-24, Fig. 4.

²⁷⁴ See discussion in Section IX.G above regarding inverse relationship between rotational speed and torque.

²⁷⁵ See, e.g., Ex. 1014 (*Nesbitt*), pg. 140 (Equation 4.25).

²⁷⁶ See, e.g., Ex. 1012 (*Jelaska*), pg. 3.

ratio of the entire drive train, in order to achieve the desired pump speed and corresponding pump rate.²⁷⁷

305. Accordingly, *Rosman* discloses the additional limitations of Claim 2 and the combination of *Yi*, *Bergan* and *Rosman* render Claim 2 obvious in view of the knowledge of a POSITA, and, in the alternative, in view of *Jelaska* and *Nesbitt*, as those references describe the basic operations of gear trains and positive displacement pumps respectively.

C. DEPENDENT CLAIM 16: “THE METHOD OF CLAIM 15, FURTHER COMPRISING: POSITIONING A PLURALITY OF SPEED REDUCTION GEARBOXES BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE THE DESIRED PUMP RATE.”

306. Except for depending from Claim 15, and being rewritten as a method claim, the limitations of Claim 16 are essentially similar to those of Claim 2 and are rendered obvious by the combination of *Yi*, *Bergan* and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as those disclosed in Section XIV.B above.

²⁷⁷ This argument assumes that “pump rate” means “flow rate,” as would have been understood by a POSITA. See section IX.A above. To the extent Patent Owner argues that “pump rate” means “pump speed,” Claim 2 is rendered obvious by the *Yi-Bergan-Rosman* combination in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as a pump’s flow rate is directly related to the pump speed.

XIX. GROUND 5A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* FURTHER IN VIEW OF *PAYNE* AND THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA*

307. It is my opinion that *Buckley* in view of *Bergan* and *Payne* discloses, suggests, and renders obvious Claims 8-11 & 13 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

308. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A and incorporated herein by reference. Nothing in *Payne* teaches against the combination of *Buckley* and *Bergan* and *Jelaska*. A POSITA would have been motivated to combine the teachings of *Buckley* and *Bergan* (and *Jelaska*) with those of *Payne* to take advantage of the speed control benefits of *Payne*'s AC motors and VFDs to control the speed and torque of the electric motors.

309. Initially, both *Buckley* and *Payne* teach the use of electric motors to drive hydraulic fracturing pumps. *Buckley* teaches "[t]he electric drive pump system is configured to provide a plurality of individual motors in selective configurations that work together to provide power to a power end. The motors are arranged around a gearbox which is used to convert the rotary motion of the electric motors into linear

motion for operation of the plungers in the fluid ends.”²⁷⁸ *Payne* describes “[a] system for stimulating oil or gas production from a well bore includes a hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.”²⁷⁹

310. *Buckley* further contains an express motivation to combine. *Buckley* discloses that “system of the present application may permit the motors 11 to run at various speeds or power outputs,”²⁸⁰ but provides little to no detail on *how* to construct a system that permits motors to run at various speeds or power outputs. A POSITA would have understood that standard industrial motors (AC induction motors or AC synchronous motors) operate at a fixed speed based on the construction of the motor and the frequency of power supplied to them.²⁸¹ Although *Buckley* provides little detail on how to run the motors at various speeds or power

²⁷⁸ Ex. 1004 (*Buckley*) [0009]; see also Ex. 1005 (*Buckley* Provisional) p. 4 (“Referring now to Figures 1 and 2 in the drawings, a side view of a schematic of a power end in communication with a plurality of electric motors and a representative perspective view is illustrated. The power end includes a pump that is used to operate one or more fluid ends. [] This system includes a series of electric motors of sufficient number needed to give the required output to operate the one or more fluid ends. The precise number is dependent upon design constraints and engineering parameters. It is understood that more than one may be used. In Figure 1,[sic. Figure 2] a total of 10 are shown or implied, with 5 being located on either side of the power end.”)

²⁷⁹ Ex. 1008 (*Payne*) Abstract

²⁸⁰ Ex. 1004 (*Buckley*) [0058]; see also Ex. 1005 (*Buckley* Provisional) pg 6 “It is understood that the system of the present application may permit the motors to be run at various speeds or power outputs.”

²⁸¹ See Section IX.F

outputs, *Payne* fills those gaps, and a POSITA would have been motivated to apply the teachings of *Payne* in order to develop a system to allow motors to operate at various speeds and power outputs.

311. *Payne* discloses “a variable frequency drive controlling the electrical fracturing motors.”²⁸² *Payne* further discloses that the VFD is used to control speed of the pump (i.e. accelerate or decelerate pump rotational speeds). As an example, *Payne* teaches the use of a “distributed programmable automation controller (PAC) on each hydraulic fracturing unit.”²⁸³ *Payne* further teaches that “[t]he PAC relays the speed set point from the operator at the HMI to a variable frequency drive. The VFD provides ac current which turns the mechanically coupled motor and fracturing pump.”²⁸⁴ As described above in Section IX.E, controlling speed of motor(s), along with controlling torque, are the primary functions of a VFD.²⁸⁵

312. *Payne* teaches the advantages of using AC motors (i.e. induction or synchronous) and controlling speed with a VFD, particularly in “applications where the operating environment may be wet, corrosive or explosive.”²⁸⁶ A POSITA would have understood that a fracturing pump system operates by pumping water, and

²⁸² Ex. 1008 (*Payne*) Abstract

²⁸³ Ex.1008 (*Payne*) [0039].

²⁸⁴ Ex. 1008 (*Payne*) [0039]. An HMI is a human machine interface.

²⁸⁵ As power is a function of the speed and torque of the motor, controlling speed and torque also allows the drive to control power output.

²⁸⁶ Ex. 1008 (*Payne*) [0011].

operates outdoors, both environments that may be wet. Further, oftentimes produced water which has a high saline content is used for the fracturing process, along with chemicals such as PH reducers (Acid) which are corrosive. Because of the nature of the formation, which is intended to recover hydrocarbons, the environment around a fracturing pump may be explosive.

313. *Payne* discloses “AC motors are better suited for applications where the load varies greatly, and light loads may be encountered for prolonged periods.” These advantages occur because of the construction of AC motors vs. DC motors. *Payne* teaches “DC motor commutators and brushes may wear rapidly under this condition. [load varying greatly].”²⁸⁷ Further, *Payne* discloses that “AC motors offer[] lower cost operation for higher power applications. In addition, AC motors are generally smaller, lighter, more commonly available, and less expensive than equivalent DC motors. AC motors require virtually no maintenance and are preferred for applications where reliability is critical.”²⁸⁸ In addition to the lower cost of AC motors themselves, *Payne* discloses that, as of at least 2016 “VFD drive technology used with AC motors has advanced significantly in recent times to become more compact, reliable and cost effective. DC drives had a cost advantage for a number of years, but that has changed with the development of new power electronics like

²⁸⁷ Ex. 1008 (*Payne*) [0011].

²⁸⁸ Ex. 1008 (*Payne*) [0010].

IGBTs (Insulated-gate bipolar transistors).”²⁸⁹ A POSITA would have been motivated to apply the teachings of *Payne* to use AC motors, along with a VFD to control speed, to take advantage of the reliability, lower maintenance and cost savings of such a system over another type system, such as one that uses DC motors. The combination of AC motors and VFDs into the system of *Buckley/Bergan* would yield predictable results – the ability to control speed at a lower cost and more reliably than using DC motors.

314. A POSITA would have had a reasonable expectation of success in applying the teachings of *Payne* regarding using an AC motor and controlling speed with a variable frequency drive. Both AC motors and VFDs were well-known, established technologies.²⁹⁰ Further, both AC motors and VFDs were subject to industry standards before the time of the ’258 application. Further still, adding the teachings of *Payne* to fill in the gaps in *Buckley*’s teaching is simply combining prior art elements (AC motors and VFDs along with the multi-motor pump system of *Buckley/Bergan*) according to known methods (controlling speed/torque of an AC motor with a VFD) to yield predictable results (control of the plurality of motors in *Buckley/Bergan*). Further still, such a combination is using a known technique (AC motors and VFDs) to improve similar devices (*Buckley/Bergan*’s electric motor

²⁸⁹ Ex. 1008 (*Payne*) [0011].

²⁹⁰ See, e.g., Sections IX.F, G above.

driven pump compared with *Paynes* electric motor driven pump) in the same way (VFD to control speed/torque of the motors in the *Buckley/Bergan* system).

B. DEPENDENT CLAIM 8: “8.THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: A VARIABLE FREQUENCY DRIVE (VFD) CONNECTED TO THE PLURALITY OF MOTORS TO CONTROL THE SPEED OF THE PLURALITY OF MOTORS, WHEREIN THE VFD IS POSITIONED TO ACCELERATE OR DECELERATE PUMP ROTATIONAL SPEEDS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

315. Dependent Claim 8 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Buckley, Bergan*, and *Payne* renders Claim 8 obvious.

316. *Payne* describes “[a] system for stimulating oil or gas production from a well bore includes a hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.”²⁹¹ *Payne* additionally teaches that AC motors “offers lower cost operation for higher power applications. In addition, AC motors are generally smaller, lighter, more commonly available, and less expensive than equivalent DC motors. AC motors require virtually no maintenance and are preferred for applications where reliability is critical.”²⁹²

²⁹¹ Ex. 1008 (*Payne*) Abstract

²⁹² Ex. 1008 (*Payne*) [0010]

317. *Payne* further discloses “a variable frequency drive controlling the electrical fracturing motors.”²⁹³ *Payne* further discloses that the VFD is used to control speed of the pumps (i.e. accelerate or decelerate pump rotational speeds). As an example, *Payne* teaches the use of a “distributed programmable automation controller (PAC) on each hydraulic fracturing unit.”²⁹⁴ *Payne* further teaches that “[t]he PAC relays the speed set point from the operator at the HMI to a variable frequency drive. The VFD provides ac current which turns the mechanically coupled motor and fracturing pump.”²⁹⁵ A POSITA would have understood that this teaches that the VFD is “connected to the plurality of motors to control the speeds of the plurality of motors,” which, as described above in Section IX.G, is one of the primary functions of a VFD (i.e., controlling speed and torque of AC motor(s)). A POSITA would have understood that by “turn[ing] the mechanically coupled motor and fracturing pump” in response to receiving a “speed set point” from an operator, *Payne*’s VFD accelerates (or decelerates) the electric motors (and, as a result, the fracturing pump driven by the electric motors) to the operator-selected speed.

318. Accordingly, *Payne* discloses the limitations of Claim 8, and the combination of *Buckley*, *Bergan* and *Payne* renders Claim 8 obvious in view of the

²⁹³ Ex. 1008 (*Payne*) Abstract. See also [0011] , [0014], [0015], [0017], [0039], [0047] – [0048], [0053] – [0056].

²⁹⁴ Ex.1008 (*Payne*) [0039]

²⁹⁵ Ex. 1008 (*Payne*) [0039]. An HMI is a human machine interface.

knowledge of a POSITA and, in the alternative, in view of *Jelaska*, as *Jelaska* teaches the basic operations of gearing systems.

C. DEPENDENT CLAIM 9: “9. THE SYSTEM OF CLAIM 8, WHEREIN THE VFD COMPRISES A PLURALITY OF VFDs AND WHEREIN THE PLURALITY OF VFDs ARE CONFIGURED TO SHARE A LOAD REQUIRED TO POWER THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

319. Dependent Claim 9 depends from Claim 8. In addition to the disclosures regarding Claim 8 disclosed above, the combination of *Buckley*, *Bergan*, and *Payne* render Claim 9 obvious.

320. *Payne* describes “[a] system for stimulating oil or gas production from a well bore includes a hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.”²⁹⁶ *Payne* also teaches an embodiment with an individual VFD for each motor. For example, *Payne* discloses “a variable frequency drive housing that houses a first frac motor variable frequency drive (“VFD”) 410a for driving a first frac motor 411a, a second frac motor VFD 410b for operating a second frac motor 411b.”²⁹⁷ In the combination with *Buckley* and *Bergan* a POSITA would have applied this teaching to the *Buckley/Bergan* system with multiple motors driving multiple pumps and applied a VFD to each of the motors. In this arrangement, as each motor shares a portion of

²⁹⁶ Ex. 1008 (*Payne*) Abstract.

²⁹⁷ Ex. 1008 (*Payne*) [0047].

the load (as taught by *Buckley*), and each VFD (which controls a respective motor's operation, as taught by *Payne*) shares a portion of the load.

321. Accordingly, the combination of *Buckley*, *Bergan* and *Payne* render Claim 9 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska*, as *Jelaska* teaches the basic operations of gearing systems.

D. DEPENDENT CLAIM 10: “10. THE SYSTEM OF CLAIM 9, WHEREIN THE PLURALITY OF VFDs ARE CONFIGURED TO AUTOMATICALLY SHUT OFF IN THE EVENT OF AN OVERPRESSURE EVENT WITH RESPECT TO THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

322. Dependent Claim 10 depends from Claim 9. In addition to the disclosures regarding Claim 9 disclosed above, the combination of *Buckley*, *Bergan*, and *Payne* render Claim 10 obvious.

323. As discussed above regarding Claim 8, *Payne* teaches the use of a “distributed programmable automation controller (PAC) on each hydraulic fracturing unit.”²⁹⁸ Part of the function of the PAC is to “relay[] the speed set point from the operator at the HMI to a variable frequency drive.”²⁹⁹ *Payne* further discloses that “[i]f an unsafe condition is detected, for example, an over pressure event, the PAC can independently override the remote operator's command and take whatever action is appropriate, for example, shutting off the VFD.”³⁰⁰ Accordingly,

²⁹⁸ Ex.1008 (*Payne*) [0039].

²⁹⁹ Ex.1008 (*Payne*) [0039].

³⁰⁰ Ex.1008 (*Payne*) [0039] emphasis added.

the VFDs of *Payne* are configured, through the PAC, to automatically shut off in the event of an overpressure event.

324. A POSITA would have understood that the multi-plunger pump is providing pressure to the system and that an overpressure event would have been “with respect to the multi-plunger hydraulic fracturing pump.” Further, *Payne* explicitly teaches this concept. *Payne* discloses “An overpressure setpoint can be adjusted on the control system ***that is triggered by the pump discharge pressure.*** If the pump discharge pressure exceeds the overpressure setpoint, the control system stops the frac motor 411a via the RUN/STOP control to the frac VFD 410a. The control system should activate/indicate a shutdown. The Overpressure shut down is latched until the Alarm Reset switch is operated.”³⁰¹ An overpressure event “that is triggered by the pump discharge pressure” would have been an event “with respect to” the pump.

325. Accordingly, *Payne* discloses the additional limitations of Claim 10, and the combination of *Buckley*, *Bergan* and *Payne* renders Claim 10 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* as *Jelaska* teaches the basic operations of gearing systems.

³⁰¹ Ex. 1008 (*Payne*) [0062].

E. INDEPENDENT CLAIM 11:

326. It is my opinion that *Buckley* in view of *Bergan* further in view of *Payne* discloses, suggests, and renders obvious Claim 11 of the '258 Patent. As discussed in the following subsections, the combination of *Buckley*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* discloses, or renders obvious, each and every element of Claim 11.

1. 11[p]: “11. A hydraulic fracturing system for fracturing a subterranean formation comprising:”

327. The preamble to Claim 11 is identical to that of Claim 1 and is rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XI.B.1 above.³⁰²

2. 11[a]: “a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”

328. Limitation 11[a] is identical to Limitation 1[a] and is rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XI.B.2 above.

³⁰² I understand that the preamble may not be limiting. I include the analysis of the preamble out of an abundance of caution.

3. **11[b]: “a plurality of motors positioned to simultaneously power the multi-plunger pump;”**

329. Limitation 11[b] is identical to Limitation 1[b] and is rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* and, in the alternative, in view of *Jelaska e* for the same reasons as those disclosed in Section XI.B.3 above.

4. **11[c]: “a variable frequency drive connected to the plurality of motors to control the speeds of the plurality of motors; and”**

330. Limitation 11[c] is essentially similar to the limitations of Claim 8 and is rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* and, in the alternative, in view of *Jelaska* as described above in Section XIX.B.

5. **11[d]: “a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors, “**

331. Limitation 11[d] is identical to Limitation 1[c] and is rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XI.B.4 above.

6. **11[e]: “wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.”**

332. Limitation 11[e] is identical to Limitation 1[d] and is rendered obvious by the combination of *Buckley* and *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XI.B.5 above.

F. DEPENDENT CLAIM 13: “THE SYSTEM OF CLAIM 11, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

333. Except for depending from Claim 11, the limitations of Claim 13 are identical to Claim 3 and are rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XI.C above.

XX. GROUND 5B: OBVIOUS OVER YI IN VIEW OF BERGAN FURTHER IN VIEW OF PAYNE AND THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, JELASKA

334. It is my opinion that *Yi* in view of *Bergan* and *Payne* discloses, suggests, and renders obvious Claims 8-11 & 13 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska*.

A. MOTIVATION TO COMBINE

335. The motivation to combine *Yi*, *Bergan*, and *Jelaska* is the same as that disclosed above in Section XII.A above and incorporated herein by reference. Nothing in *Payne* teaches away from the combination of *Yi*, *Bergan* and *Jelaska*.

336. A POSITA would have been motivated to combine the teachings of *Yi* and *Bergan* with those of *Payne* to take advantage of the speed control benefits of *Payne*'s AC motors and VFDs to control the speed and torque of the electric motors to replace the hydraulic motors of *Yi*. *Bergan* already discloses using electric motors as one of the plurality of motors disclosed by both *Yi* and *Bergan*. For example,

Bergan teaches “motors 78” to drive the planetary gear system claimed. *Bergan* further discloses, for example, “[m]otors 78 can be operated to drive rotation of the drum 74 to reel in or reel out the hoisting lines 20 to raise and lower an attached load 30. Any suitable motors 78 could be used. The motors 78 can include electric motors, for example.”³⁰³

337. *Yi* also discloses using a plurality of motors to operate a single rotating load. Further, *Yi*’s teaching of “each engine 1 is used to drive at least one oil pump 2 for supplying pressurized oil to a plurality of motors 4” would have been recognized by a POSITA as disclosing a hydraulic motor. *Yi* also teaches “there are various ways for multiple motors 4 to drive the fracturing pump, as long as the motor 4 can drive the fracturing pump 5 to rotate, which are not limited in the embodiments of the invention,” which would have made it obvious to a POSITA that electric motors sized to “drive the fracturing pump 5 to rotate” would have been used with the disclosures of *Yi*.

338. Further, *Payne* describes the advantages of using AC electric motors in place of mechanical systems, such as the diesel driven hydraulic motor of *Yi*. *Payne* discloses that “[d]iesel engines have been used as the primary driving mechanism for fracturing pumps in the past. Using diesel engines, however, has serious disadvantages, including the relative inefficiency of the internal combustion engine

³⁰³ Ex. 1006 (*Bergan*) [0030]

and the fact that its operation is costly. In addition, off-road diesel engines of the types used for hydraulic fracturing are noisy while pumping, limiting the areas in which they may be used. Also, diesel engines have many moving parts and require continuous monitoring, maintenance, and diagnostics. Ancillary Subsystems are typically driven hydraulically in traditional diesel-driven systems, which also contribute to other operational problems.”³⁰⁴

339. As an alternative, *Payne* teaches the use of electric motors for hydraulic fracturing operations. *Payne* teaches “[i]n view of the above deficiencies [of mechanical systems], electrical motors for hydraulic fracturing operations potentially offer an attractive alternative. Electrical motors are lighter, have fewer moving parts, and can more easily be transported. Further, the control of electrical motors provides many advantages over traditional diesel-driven, variable gear ratio powertrains, for example, through more precise, continuous speed control.”³⁰⁵ Further still, *Payne* teaches benefits of using electrical motors not only on the fracturing pumps, but to replace the hydraulically driven ancillary systems. *Payne* teaches that “the use of electrical motors obviates the need for supplying diesel fuel to more traditional fracturing pumps, and reduces the footprint of the site, and its environmental impact. Other advantages of electrical motors include, but are not

³⁰⁴ Ex. 1008 (*Payne*) [0008].

³⁰⁵ Ex. 1008 (*Payne*) [0009].

limited to, the ability to independently control and operate ancillary Sub Systems.”³⁰⁶

A POSITA would have been motivated to implement the teachings of *Payne* to gain the benefits of electric motors, such as reduced footprint, reduced environmental impact and avoiding the expense of supplying diesel fuel to the site.

340. In addition to teaching the benefits of using electric motors to power the fracturing site, *Payne* teaches the benefits of using AC motors with variable frequency drives (VFDs). *Payne* teaches the advantages of using AC motors (*e.g.*, induction or synchronous) and controlling speed with a VFD, particularly in “applications where the operating environment may be wet, corrosive or explosive.”³⁰⁷ A POSITA would have understood that a fracturing pump system operates by pumping water, and operates outdoors, both environments that may be wet. Further, oftentimes produced water which has a high saline content is used for the fracturing process, along with chemicals such as PH reducers (acid) which are corrosive. Because of the nature of the formation, which is intended to recover hydrocarbons, the environment around a fracturing pump may be explosive.

341. *Payne* discloses “AC motors are better suited for applications where the load varies greatly and light loads may be encountered for prolonged periods.” These advantages occur because of the construction of AC motors vs. DC motors. *Payne*

³⁰⁶ Ex. 1008 (*Payne*) [0009].

³⁰⁷ Ex. 1008 (*Payne*) [0011].

teaches “DC motor commutators and brushes may wear rapidly under this condition. [load varying greatly].”³⁰⁸ Further, *Payne* discloses that “AC motors offer lower cost operation for higher power applications. In addition, AC motors are generally smaller, lighter, more commonly available, and less expensive than equivalent DC motors. AC motors require virtually no maintenance and are preferred for applications where reliability is critical.”³⁰⁹ In addition to the lower cost of AC motors themselves, *Payne* discloses that, as of at least 2016 “VFD drive technology used with AC motors has advanced significantly in recent times to become more compact, reliable and cost effective. DC drives had a cost advantage for a number of years, but that has changed with the development of new power electronics like IGBTs (Insulated-gate bipolar transistors).”³¹⁰ A POSITA would have been motivated to apply the teachings of *Payne* to use AC motors, along with a VFD to control speed, to take advantage of the reliability, lower maintenance and cost savings of such a system over another type system, such as one that uses DC motors. The combination of AC motors and VFDs into the system of *Yi/Bergan* would yield predictable results – the ability to control speed at a lower cost and more reliably than using DC motors.

³⁰⁸ Ex. 1008 (*Payne*) [0011].

³⁰⁹ Ex. 1998 (*Payne*) [0010].

³¹⁰ Ex. 1008 (*Payne*) [0011].

342. A POSITA would have had a reasonable expectation of success in applying the teachings of *Payne* regarding using an AC motor and controlling speed with a variable frequency drive. Both AC motors and VFDs were well known, established technologies.³¹¹ Further, Both AC motors and VFDs were subject to industry standards before the time of the '258 application. Further, adding the teachings of *Payne* to *Yi/Bergan*'s teaching of multiple motor driven loads teaching is simply combining prior art elements (AC motors and VFDs along with the multi-motor pump system of *Yi/Bergan*) according to known methods (controlling speed/torque of an AC motor with a VFD) to yield predictable results (control of the plurality of motors in *Yi/Bergan*). Further still, such a combination is using a known technique (AC motors and VFDs) to improve similar devices (*Yi/Bergan*'s hydraulic motor driven pump compared with *Payne*'s electric motor driven pump) in the same way (VFD to control speed/torque of the motors in the *Yi/Rosman* system).

B. DEPENDENT CLAIM 8: “8.THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: A VARIABLE FREQUENCY DRIVE (VFD) CONNECTED TO THE PLURALITY OF MOTORS TO CONTROL THE SPEED OF THE PLURALITY OF MOTORS, WHEREIN THE VFD IS POSITIONED TO ACCELERATE OR DECELERATE PUMP ROTATIONAL SPEEDS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

343. Dependent Claim 8 depends from Claim 1. In addition to the disclosures regarding Claim 1 disclosed above, the combination of *Yi, Bergan*, and

³¹¹ See, e.g., Sections IX.E, F above.

Payne and the knowledge of a POSITA, and in the alternative in view of *Jelaska*, renders Claim 8 obvious.

344. *Payne* describes “[a] system for stimulating oil or gas production from a well bore includes a hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.”³¹² *Payne* further discloses “a variable frequency drive controlling the electrical fracturing motors.”³¹³ *Payne* further discloses that the VFD is used to control speed of the pump (i.e. accelerate or decelerate pump rotational speeds. As an example, *Payne* teaches the use of a “distributed programmable automation controller (PAC) on each hydraulic fracturing unit.”³¹⁴ *Payne* further teaches that “[t]he PAC relays the speed set point from the operator at the HMI to a variable frequency drive. The VFD provides ac current which turns the mechanically couple motor and fracturing pump.”³¹⁵ A POSITA would have understood that this teaches that the VFD is “connected to the plurality of motors to control the speeds of the plurality of motors,” which, as described above in Section IX.G, is one of the primary functions of a VFD (i.e., controlling speed of and torque of AC motor(s)). Further, a POSITA would have understood that by “turn[ing] the mechanically coupled motor and fracturing

³¹² Ex. 1008 (*Payne*) Abstract

³¹³ Ex. 1008 (*Payne*) Abstract

³¹⁴ Ex.1008 (*Payne*) [0039]

³¹⁵ Ex. 1008 (*Payne*) [0039]. An HMI is a human machine interface.

pump” in response to receiving a “speed set point” from an operator, *Payne*’s VFD accelerates (or decelerates) the electric motors (and, as a result, the fracturing pump driven by the electric motors) to the operator-selected speed.

345. Accordingly, *Payne* discloses the limitations of Claim 8, and the combination of *Yi*, *Bergan* and *Payne* renders Claim 8 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska*.

C. DEPENDENT CLAIM 9: “9. THE SYSTEM OF CLAIM 8, WHEREIN THE VFD COMPRISES A PLURALITY OF VFDs AND WHEREIN THE PLURALITY OF VFDs ARE CONFIGURED TO SHARE A LOAD REQUIRED TO POWER THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

346. Dependent Claim 9 depends from Claim 8. In addition to the disclosures regarding Claim 8 disclosed above, the combination of *Yi*, *Bergan*, and *Payne* render Claim 9 obvious.

347. *Payne* describes “[a] system for stimulating oil or gas production from a well bore includes a hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.”³¹⁶ *Payne* also teaches an embodiment with an individual VFD for each motor. For example, *Payne* discloses “a variable frequency drive housing that houses a first frac motor variable frequency drive (“VFD”) 410a for driving a first frac motor 411a, a second frac motor VFD 410b for operating a second frac motor 411b.”³¹⁷ In the combination

³¹⁶ Ex. 1008 (*Payne*) Abstract.

³¹⁷ Ex. 1008 (*Payne*) [0047].

with *Yi* and *Bergan* a POSITA would have applied this teaching to the *Yi/Bergan* system with multiple motor driving a single pump and applied a VFD to each of the motors. In this arrangement, as each motor shares a portion of the load of the pump(as taught by *Yi*), and each VFD (which controls a respective motor's operation, as taught by *Payne*) shares a portion of the load of the pump.

348. Accordingly, the combination of *Yi*, *Bergan* and *Payne* render Claim 9 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska*.

D. DEPENDENT CLAIM 10: “10. THE SYSTEM OF CLAIM 9, WHEREIN THE PLURALITY OF VFDs ARE CONFIGURED TO AUTOMATICALLY SHUT OFF IN THE EVENT OF AN OVERPRESSURE EVENT WITH RESPECT TO THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

349. Dependent Claim 10 depends from Claim 9. In addition to the disclosures regarding Claim 9 disclosed above, the combination of *Yi*, *Bergan*, and *Payne* and the knowledge of a POSITA, and, in the alternative, in view of *Jelaska* render Claim 10 obvious.

350. As discussed above regarding Claim 8, *Payne* teaches the use of a “distributed programmable automation controller (PAC) on each hydraulic fracturing unit.”³¹⁸ Part of the function of the PAC is to “relay[] the speed set point from the operator at the HMI to a variable frequency drive.”³¹⁹ *Payne* further

³¹⁸ Ex.1008 (*Payne*) [0039].

³¹⁹ Ex.1008 (*Payne*) [0039].

discloses that “[i]f an unsafe condition is detected, for example, an over pressure event, the PAC can independently override the remote operator's command and take whatever action is appropriate, for example, shutting off the VFD.”³²⁰ Accordingly, the VFDs of *Payne* are configured, through the PAC, to automatically shut off in the event of an overpressure event.

351. A POSITA would have understood that the multi-plunger pump is providing pressure to the system and that an overpressure event would have been “with respect to the multi-plunger hydraulic fracturing pump.” Further, *Payne* explicitly teaches this concept. *Payne* discloses “An Overpressure setpoint can be adjusted on the control system ***that is triggered by the pump discharge pressure***. If the pump discharge pressure exceeds the Overpressure setpoint, the control system stops the frac motor 411a via the RUN/STOP control to the frac VFD 410a. The control system should activate/indicate a shutdown. The Overpressure shut down is latched until the Alarm Reset switch is operated.”³²¹ An overpressure event “that is triggered by the pump discharge pressure” would have been an event “with respect to” the pump.

³²⁰ Ex.1008 (*Payne*) [0039] emphasis added.

³²¹ Ex. 1008 (*Payne*) [0062].

352. Accordingly, *Payne* discloses the additional limitations of Claim 10 and the combination of *Yi*, *Bergan* and *Payne* renders Claim 10 obvious in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska*.

E. INDEPENDENT CLAIM 11:

353. It is my opinion that *Yi* in view of *Bergan* further in view of *Payne*, discloses, suggest, and renders Claim 11 of the '258 Patent obvious. As discussed in the following subsections, the combination of *Yi*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* discloses, or renders obvious, each and every element of Claim 11.

7. 11[p]: “11. A hydraulic fracturing system for fracturing a subterranean formation comprising:”

354. The preamble to Claim 11 is identical to that of Claim 1 and is rendered obvious by the combination of *Yi*, *Bergan* and *Payne* for the same reasons as those disclosed in Section XII.B.1 above.

8. 11[a]: “a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation, the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation;”

355. Limitation 11[a] is identical to Limitation 1[a] and is rendered obvious by the combination of *Yi*, *Bergan* and *Payne* for the same reasons as those disclosed in Section XII.B.2 above.

9. 11[b]: “a plurality of motors positioned to simultaneously power the multi-plunger pump;”

356. Limitation 11[b] is identical to Limitation 1[b] and is rendered obvious by the combination of *Yi, Bergan* and *Payne* for the same reasons as those disclosed in Section XII.B.3 above.

10.11[c]: “a variable frequency drive connected to the plurality of motors to control the speeds of the plurality of motors; and”

357. Limitation 11[c] is substantially similar to the limitations of Claim 8 and is rendered obvious by the combination of *Yi, Bergan* and *Payne* along with the general knowledge of a POSITA as described above in Section XX.B.

11.11[d]: “a planetary gear train having a plurality of input pinion gears in rotational contact with each of the plurality of motors, “

358. Limitation 11[d] is identical to Limitation 1[c] and is rendered obvious by the combination of *Yi, Bergan* and *Payne* for the same reasons as those disclosed in Section XII.B.4 above.

12.11[e]: “wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump.”

359. Limitation 11[e] is identical to Limitation 1[d] and is rendered obvious by the combination of *Yi, Bergan*, and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XII.B.5 above.

F. DEPENDENT CLAIM 13: “THE SYSTEM OF CLAIM 11, WHEREIN THE PLURALITY OF MOTORS COMPRISES ONE OF A PLURALITY OF ELECTRIC MOTORS OR A PLURALITY OF HYDRAULIC MOTORS.”

360. Except for depending from Claim 11, the limitations of Claim 13 are identical to Claim 3 and are rendered obvious by the combination of *Yi*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XII.C above.

XXI. GROUND 6A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN*, *ROSMAN*, AND *PAYNE* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

361. It is my opinion that *Buckley* in view of *Bergan*, *Rosman*, and *Payne* discloses, suggests, and renders obvious Claim 12 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

362. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XV.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Rosman* is the same as discussed above in Section XVII.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Payne* is the same as discussed above in Section XIX.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine

Buckley, Bergan, Rosman, Payne, Jelaska and Nesbitt for the same reasons as those discussed in Sections XI.A, XV.A, XVII.A and XIX.A.

B. DEPENDENT CLAIM 12: “12. THE SYSTEM OF CLAIM 11, THE SYSTEM FURTHER COMPRISING A PLURALITY OF SPEED REDUCTION GEARBOXES POSITIONED BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE A DESIRED PUMP RATE.”

363. Except for depending from Claim 11, the limitations of Claim 12 are identical to those of Claim 2 and are rendered obvious by the combination of *Buckley, Bergan* and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt* for the same reasons as those disclosed in Section XVII.B above which discusses how Claim 2 is obvious over the combination of *Buckley, Bergan*, and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Nesbitt*.

XXII. GROUND 6B: OBVIOUS OVER *YI* IN VIEW OF *BERGAN, ROSMAN, AND PAYNE* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

364. It is my opinion that *Yi* in view of *Bergan, Rosman*, and *Payne* discloses, suggests, and renders obvious Claim 14 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

365. The motivation to combine *Yi, Bergan*, and *Jelaska* is the same as that discussed above in Section XII.A, and incorporated herein by reference. The

motivation to combine *Yi*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XVI.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Rosman* is the same as discussed above in Section XVIII.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Payne* is the same as discussed above in Section XX.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Yi*, *Bergan*, *Rosman*, *Payne*, *Jelaska* and *Nesbitt* for the same reasons as those discussed in Sections XII.A, XVI.A, XVIII.A and XX.A.

B. DEPENDENT CLAIM 12: “12. THE SYSTEM OF CLAIM 11, THE SYSTEM FURTHER COMPRISING A PLURALITY OF SPEED REDUCTION GEARBOXES POSITIONED BETWEEN THE PLURALITY OF INPUT PINION GEARS AND THE PLURALITY OF MOTORS SO AS TO ACHIEVE A DESIRED PUMP RATE.”

366. Except for depending from Claim 11, the limitations of Claim 12 are identical to those of Claim 2 and are rendered obvious by the combination of *Yi*, *Bergan* and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* for the same reasons as those disclosed in Section XVIII.B above which discusses how Claim 2 is obvious over the combination of *Yi*, *Bergan*, and *Rosman* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska*.

XXIII. GROUND 7A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* AND *PAYNE* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *TUTTEROW*

367. It is my opinion that *Buckley* in view of *Bergan* and *Payne* discloses, suggests, and renders obvious Claim 14 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Tutterow*.

A. MOTIVATION TO COMBINE

368. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Tutterow* is the same as discussed above in Section XIII.A and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Payne* is the same as discussed above in Section XIX.A and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Buckley*, *Bergan*, *Payne*, *Jelaska* and *Tutterow* for the same reasons as those discussed in Sections XI.A, XIII.A and XIX.A.

B. DEPENDENT CLAIM 14: “14. THE SYSTEM OF CLAIM 11, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

369. Except for depending from Claim 11, the limitations of Claim 14 are identical to Claim 4 and are rendered obvious by the combination of *Buckley*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of

Jelaska and *Tutterow* for the same reasons as those disclosed in Section XIII.B above.

XXIV. GROUND 7B: OBVIOUS OVER *YI* IN VIEW OF *BERGAN* AND *PAYNE* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *TUTTEROW*

370. The motivation to combine *Yi*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XII.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Tutterow* is the same as discussed above in Section XIV.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Payne* is the same as discussed above in Section XX.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Yi*, *Bergan*, *Payne*, *Jelaska* and *Tutterow* for the same reasons as those discussed in Sections XII.A, XIV.A and XX.A.

A. DEPENDENT CLAIM 14: “14. THE SYSTEM OF CLAIM 11, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

371. Except for depending from Claim 11, the limitations of Claim 14 are identical to Claim 4 and are rendered obvious by the combination of *Yi*, *Bergan* and *Payne* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Tutterow* for the same reasons as those disclosed in Section XIV.B above.

XXV. GROUND 8A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA*, *TUTTEROW*, AND *NESBITT*

372. It is my opinion that *Buckley* in view of *Bergan* discloses, suggests, and renders obvious Claim 18 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

373. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Tutterow* is the same as discussed above in Section XIII.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XV.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Buckley*, *Bergan*, *Jelaska*, *Tutterow* and *Nesbitt* for the same reasons as those discussed in Sections XI.A, XIII.A and XV.A.

B. DEPENDENT CLAIM 18: “THE METHOD OF CLAIM 15, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

374. Except for depending from Claim 15 and being rewritten as a method claim, Claim 18 is essentially similar to Claim 4 and is rendered obvious by the combination of *Buckley* and *Bergan* in view of the knowledge of a POSITA and, in

the alternative, in view of *Jelaska* and *Tutterow* for the same reasons as those discussed above in Section XIII.B.

XXVI. GROUND 8B: OBVIOUS OVER YI IN VIEW OF *BERGAN* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA*, *TUTTEROW*, AND *NESBITT*

375. It is my opinion that *Yi* in view of *Bergan* discloses, suggests, and renders obvious Claim 18 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

376. The motivation to combine *Yi*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XII.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Tutterow* is the same as discussed above in Section XIV.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XVI.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Yi*, *Bergan*, *Jelaska*, *Tutterow* and *Nesbitt* for the same reasons as those discussed in Sections XII.A, XIV.A and XVI.A.

B. DEPENDENT CLAIM 18: “18. THE METHOD OF CLAIM 15, WHEREIN THE MAXIMUM PUMP SPEED CORRELATES TO A CRITICAL PLUNGER SPEED ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP.”

377. Except for depending from Claim 15 and being rewritten as a method claim, Claim 18 is essentially similar to Claim 4 and is rendered obvious by the combination of *Yi* and *Bergan* in view of the knowledge of a POSITA and, in the alternative, in view of *Jelaska* and *Tutterow* for the same reasons as those discussed above in Section XIV.B.

XXVII. GROUND 9A: OBVIOUS OVER *BUCKLEY* IN VIEW OF *BERGAN* AND *PAYNE* AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, *JELASKA* AND *NESBITT*

378. It is my opinion that *Buckley* in view of *Bergan* and *Payne* discloses, suggests, and renders obvious Claims 19 and 20 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

379. The motivation to combine *Buckley*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XI.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XV.A, and incorporated herein by reference. The motivation to combine *Buckley*, *Bergan*, and *Payne* is the same as discussed above in Section XIX.A, and incorporated herein by reference. Accordingly, a POSITA would have been

motivated to combine *Buckley, Bergan, Payne, Jelaska* and *Nesbitt* for the same reasons as those discussed in Sections XI.A, XV.A and XIX.A.

B. DEPENDENT CLAIM 19: “19. THE METHOD OF CLAIM 15, FURTHER COMPRISING: CONNECTING A VARIABLE FREQUENCY DRIVE (VFD) TO THE PLURALITY OF MOTORS SO AS TO CONTROL THE SPEED OF THE PLURALITY OF MOTORS, WHEREIN THE VFD IS POSITIONED TO ACCELERATE OR DECELERATE PUMP ROTATIONAL SPEEDS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP”

380. Except for depending from Claim 15 and being rewritten as a method claim, Claim 19 is essentially similar to Claim 8 and is rendered obvious by the combination of *Buckley, Bergan* and *Payne* for the same reasons as those discussed above in Section XIX.B.

C. DEPENDENT CLAIM 20: “20. THE METHOD OF CLAIM 19, THE METHOD FURTHER COMPRISING: DETECTING AN OVERPRESSURE EVENT WITH RESPECT TO THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP; AND AUTOMATICALLY SHUTTING OFF THE VFD.”

381. Except for depending from Claim 19 and being rewritten as a method claim, Claim 20 is essentially similar to Claim 10 and is rendered obvious by the combination of *Buckley, Bergan* and *Payne* for the same reasons as those discussed above in Section XIX.D.

XXVIII. GROUND 9B: OBVIOUS OVER YI IN VIEW OF BERGAN AND PAYNE AND FURTHER IN VIEW OF THE KNOWLEDGE OF A POSITA AND, IN THE ALTERNATIVE, JELASKA AND NESBITT

382. It is my opinion that *Yi* in view of *Bergan* and *Payne* discloses, suggests, and renders obvious Claims 19 and 20 of the '258 Patent in view of the knowledge of a POSITA and, in the alternative, *Jelaska* and *Nesbitt*.

A. MOTIVATION TO COMBINE

383. The motivation to combine *Yi*, *Bergan*, and *Jelaska* is the same as that discussed above in Section XII.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Nesbitt* is the same as discussed above in Section XVI.A, and incorporated herein by reference. The motivation to combine *Yi*, *Bergan*, and *Payne* is the same as discussed above in Section XX.A, and incorporated herein by reference. Accordingly, a POSITA would have been motivated to combine *Yi*, *Bergan*, *Payne*, *Jelaska* and *Nesbitt* for the same reasons as those discussed in Sections XII.A, XVI.A and XX.A.

B. DEPENDENT CLAIM 19: “19. THE METHOD OF CLAIM 15, FURTHER COMPRISING: CONNECTING A VARIABLE FREQUENCY DRIVE (VFD) TO THE PLURALITY OF MOTORS SO AS TO CONTROL THE SPEED OF THE PLURALITY OF MOTORS, WHEREIN THE VFD IS POSITIONED TO ACCELERATE OR DECELERATE PUMP ROTATIONAL SPEEDS ASSOCIATED WITH THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP”

384. Except for depending from Claim 15 and being rewritten as a method claim, Claim 19 is essentially similar to Claim 8 and is rendered obvious by the

combination of *Yi, Bergan* and *Payne* for the same reasons as those discussed above in Section XX.B.

C. DEPENDENT CLAIM 20: “20. THE METHOD OF CLAIM 19, THE METHOD FURTHER COMPRISING: DETECTING AN OVERPRESSURE EVENT WITH RESPECT TO THE MULTI-PLUNGER HYDRAULIC FRACTURING PUMP; AND AUTOMATICALLY SHUTTING OFF THE VFD.”

385. Except for depending from Claim 19 and being rewritten as a method claim, Claim 20 is essentially similar to Claim 10 and is rendered obvious by the combination of *Yi, Bergan* and *Payne* for the same reasons as those discussed above in Section XX.D.

XXIX. SECONDARY CONSIDERATIONS

386. I am not aware of any evidence of secondary considerations that would support a finding of nonobviousness of the '258 Patent. Should the Patent Owner put forth any alleged evidence of secondary considerations, I reserve the right to consider such evidence, to consider whether any such evidence has a nexus to any claims of the '258 Patent, and to update my analysis.

XXX. CONCLUSION

387. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. I further understand that willful false statements and the like are punishable by fine or imprisonment, or both under Section 1001 of Title 18 of the United States Code. I declare under penalty of perjury that the foregoing is true and correct.

Executed on October 31, 2024



Dr. Robert A. Durham

Appendix A

Dr. ROBERT A DURHAM, PhD, FIEEE

Resume
Specialization
Honors & Awards
Publications

Dr ROBERT A DURHAM, PhD, FIEEE

Robert A Durham is the Principal of D² Tech Solutions, a technology related firm concentrating on Mechanical and Electrical systems and energy conversions. He also serves as a Principal Scientist of THEWAY LABs, Tulsa, OK, an engineering and energy consulting firm that provides design and failure analysis of facilities and system installations.

Dr. Durham's work experience is broad and encompasses all areas of the energy industry. Dr. Durham spent 11 years with AEP/CSW, at the time the country's largest utility, in electrical engineering positions in the power generation and transmission planning departments. He then accepted a position as Manager of Electric Infrastructure for New Dominion, LLC., a major independent energy producer in Oklahoma. Dr. Durham then moved on to hold the position of Vice President of Engineering and Project Management for EDG Power Group, an Engineering Procurement and Construction company specializing in design and construction of small to medium size power generating facilities. Dr. Durham left EDG Power Group to accept his current positions. Dr. Durham has been accepted as an expert and offered testimony in several jurisdictions.

Dr. Durham's extensive client list includes the development of a broad spectrum of forensic, electrical and facilities projects for many companies. He has also taught University offered courses in electrical engineering review for board licensure. He has published five books, six magazine articles and over 40 other technical papers and articles. Dr. Durham's extensive work on standards and electrical systems has resulted in his elevation to Fellow of the IEEE, the highest grade of recognition in the electrical technology industry.

Dr. Durham received the B.S. in electrical engineering from the University of Tulsa in 1992 and the M.E. in Technology Management from The University of Tulsa in 1997. Tulsa, OK. In 2004, Dr. Durham received a PhD in Engineering Management from Kennedy Western University.

Degrees Earned

BSEE, with Honors, The University of Tulsa
Master of Engineering, The University of Tulsa
PhD , Kennedy Western University

Area of Specialization

lightning & grounding
failure analysis & forensic engineering
electrical power systems & safety
power generation
utility industry competition
economics & management
petroleum & chemical industry
electrical / mechanical energy conversion

Registration

Professional Engineer - Oklahoma
Professional Engineer – Texas
Professional Engineer – California
Professional Engineer – New Hampshire (Inactive)
Professional Engineer – Kansas
Professional Engineer – North Carolina (Inactive)
Professional Engineer – Missouri
Professional Engineer – Arkansas
Professional Engineer – Virginia (Inactive)
Professional Engineer – Illinois (Inactive)
Electrical Contractor - Oklahoma

Work History

D² Tech Solutions, Inc. 2002 - 2022
Principal

THEWAY Corp. 2004 - 2022
Principal Scientist

EDG Power Group, Inc. 2002 - 2004
Vice President Engineering & Project Management

New Dominion, LLC 2000 - 2002
Mgr Electric Infrastructure

Central & Southwest, Inc 1989 - 2000
Electrical Engineer

Professional Memberships

Fellow	Institute of Electrical and Electronic Engineers
Diplomate	American College of Forensic Examiners, International
Member	National Association of Fire Investigators
Voting Member	National Fire Protection Institute, Electrical Section
Executive Member	Petroleum and Chemical Industry Committee, IEEE
Diplomate,	
Past Board Member	American Board of Forensic Engineering and Technology
Member	IEEE Standards Association
Past Chair	Production Subcommittee, IEEE IAS/PCIC
CFC	American College of Forensic Examiners
Member	International Association of Arson Investigators
CFEI, CVFEI	National Association of Fire Investigators
Past Chair	Tulsa Section IEEE
Chair	IEEE RP1017.1 Working Group
Chair	IEEE RP1017.2 Working Group
Chair	IEEE RP1017.3 Working Group
Chair	IEEE RP1017.4 Working Group
Past Chair	IEEE PCIC Standards Subcommittee
Secretary	IEEE Petroleum and Chemical Industry Committee

Honors and Awards

Fellow of the IEEE

For contributions to submersible electrical equipment analysis and multi-point ground method in hazardous petroleum and chemical environments.

Honor Societies

Tau Beta Pi, national engineering honors
Eta Kappa Nu, national electrical engineering honors

Dr. Durham's publications have often successfully competed for outstanding paper awards from journals of the Institute of Electrical and Electronic Engineers (PCIC and IAS). This is an

international competitive peer review and evaluation of papers that provide a significant contribution to the advancement and understanding of electrical applications.

IEEE Industry Applications Society, New Orleans, LA: Prize Article for “Data Quality and Grounding: Considerations in a Mixed Use Facility”

PCIC, Cincinnati, OH: Prize Paper for “Grounding and Bonding Conductors: Solid, Stranded, Bare or Insulated”

PCIC, New Orleans, LA: Prize paper for "Industrial Design Application for Power Distribution over Extra-Long Distances"

PCIC, Philadelphia, PA: Prize paper for "Paradigm Shifts and Impact on Engineers and Industry"

Transactions on Industry Applications, Orlando, FL: Prize Paper for "Lightning, Grounding, and Protection for Control Systems”.

PCIC, Denver, CO: Prize Paper for “Grounding System Design for Isolated Locations and Plant Systems”

PCIC, St. Louis, MO: First place for "Lightning, Grounding, and Protection for Distributed Control and Communications Systems: A Retrofit".

Publications

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Electrical Failure Analysis for Fire and Incident Investigations, Marcus O. Durham, Robert A. Durham, Rosemary Durham, Jason Coffin, ISBN 978-1463773472, 2011

Leadership and Success in Relationships and Communication, Marcus O. Durham and Robert A Durham, ISBN 978-1463758769, 2011

Leadership and Success in Organizations, Culture & Ethics: Group or Horizontal Interactions, Marcus O. Durham and Robert A Durham, ISBN 978-1466250338, 2011

Leadership and Success in Economics, Law & Technology: Society or External Influence, Marcus O. Durham and Robert A Durham, OK, ISBN 978-1466250461, 2011

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