

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 IPR2025-00031
Patent No. 10,655,435

DECLARATION OF DR. ROBERT A. DURHAM

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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. 10,655,435, which I may abbreviate as “the ’435 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 ’435 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 these proceedings.

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 U.S. Pat. No. 10,655,435 (“the ’435 Patent”), which I describe below in Section VI (“Overview of the ’435 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 includes 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 ’435 Patent and have been an expert in this field since before the ’435 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 ’435 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. 10,655,435 to Oehring <i>et. al.</i> (filed October 25, 2018, and issued May 19, 2020) (“’435 Patent” or “Challenged Patent”)
1002	File History of U.S Patent No. 10,655,435 (App. No. 16/170,695) (“’435 Patent File History”)
1004	PCT International Patent Publication No. 2017/040921 to Norris <i>et al.</i> , “Pump Synchronization and Method” (“Norris”), filed September 2, 2016, and published on March 9, 2017.

1005	PCT International Patent Publication No. WO 2016/019219 to Omont <i>et al.</i> , “Monitoring Health of Additive Systems” (“ <i>Omont</i> ”), filed July 31, 2015, published February 4, 2016.
1006	U.S. Patent Publication No. 2009/0053072 to Borgstadt <i>et al.</i> , “Integrated ‘One Pump’ Control of Pumping Equipment” (“ <i>Borgstadt</i> ”), filed on August 21, 2007, and published on February 26, 2009.
1007	U.S. Patent Publication No. 2008/0236818 to Dykstra, “Method and Apparatus for Controlling the Manufacture of Well Treatment Fluid” (“ <i>Dykstra</i> ”), filed March 27, 2007, published October 11, 2012.
1008	U.S. Provisional Patent Application 62/577,056, Jared Oehring et al., “Automated Fracturing Pump System”, filed October 25, 2017.
1009	Intentionally Omitted
1010	Intentionally Omitted
1011	Intentionally Omitted
1012	Intentionally Omitted
1013	Intentionally Omitted
1014	Claim Listing for Claims of U.S. Patent No. 10,655,435, Jared Oehring et al., “Smart Fracturing System and Method” (the “’435 Patent”), filed October 25, 2018, issued on May 19, 2020.
1015	Michael Morton, “Unlocking the Earth: A Short History of Hydraulic Fracturing,” GEO ExPro, Vol. 10, No. 6, December 2013 (https://geoexpro.com/unlocking-the-earth-a-short-history-of-hydraulic-fracturing/) (last accessed November 30, 2023)
1016	B.A. Wells and K.L. Wells. “Shooters – A ‘Fracking’ History.” American Oil & Gas Historical Society, (https://aoghs.org/technology/hydraulic-fracturing) (last accessed November 30, 2023)

1017	Carl T. Montgomery and Michael B. Smith, “Hydraulic Fracturing: History of an Enduring Technology,” <i>Journal of Petroleum Technology</i> , Vol. 62, Issue 12 (Dec. 2010)
1018	Bourgoyne, A. T., Jr., K. K. Millheim, M. E. Chenevert and F. S. Young, Jr. (1986). <u>Applied Drilling Engineering</u> , Society of Petroleum Engineers,
1019	Vassiliou, M. S. (2018), <u>Historical Dictionary of the Petroleum Industry</u> , Rowman & Littlefield,
1020	U.S. Patent Application Publication No. 2013/0306322 to Sanborn <i>et al.</i> entitled “System and Process for Extracting Oil and Gas by Hydraulic Fracturing” (“ <i>Sanborn</i> ”),
1021	U.S. Patent Publication No. 2012/0255734 to Coli <i>et al.</i> entitled “Mobile, Modular, Electrically Powered System for Use in Fracturing Underground Formations” (“ <i>Coli</i> ”),
1022	Tomlinson, Hl, Ac Byrd, And Cf Vanberg. 1988. Spe 17315 "Fracturing Process Control and Automation." In Permian Basin Oil and Gas Recovery Conference, Onepetro.
1023	Stephenson, SV, EL Woodall, CD Donaghe, and RE Dant. 1993. "Fracturing process control and automation: Phase 2." In Petroleum Computer Conference. OnePetro.
1024	U.S. Patent Application Publication No. 2008/0236818 to Dykstra <i>et al.</i> entitled “Method and Apparatus for Controlling the Manufacture of Well Treatment Fluid.” (“ <i>Dykstra 818</i> ”)
1025	U.S. Patent Application Publication No. 2008/0183415 to Dykstra <i>et al.</i> entitled “Methods to Monitor System Sensor and Actuator Health and Performance.” (“ <i>Dykstra 415</i> ”)
1026	<i>Modbus over Serial Line Specification and Implementation Guide V1.02</i> , Dec. 20, 2006, available at https://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf
1027	<i>IEEE Standard for Ethernet</i> , IEEE Std 802.3™-2018, IEEE Computer Society, approved June 14, 2018.

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 '435 Patent would have been obvious to a person of ordinary skill in the art, based on the following grounds.

Ground	'435 Claims	Basis for Challenge
1 & 2	1-5, 7, 13-14 & 16-17	Anticipated or rendered obvious by <i>Norris</i>
3	1-7, 10-17	Obvious over <i>Norris</i> in view of <i>Omont</i>
4	1-5, 7-19	Obvious over <i>Norris</i> in view of <i>Borgstadt</i>
5	1-7, 13-17	Obvious over <i>Norris</i> in view of <i>Dykstra</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 ‘435 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 ‘435 Patent claims priority to Provisional application No. 62/577,056 filed on October 25, 2017.¹

A. THE SUBJECT MATTER OF THE CHALLENGED PATENT

41. The ‘435 Patent generally relates to a “smart fracturing system” “for assessing flow rates in hydraulic fracturing systems.”² Per the background of the ‘435 Patent, “hydraulic fracturing usually includes pumps that inject fracturing fluid

¹ Ex. 1001 Cover.

² Ex. 1001 Title, 1:40-43.

down the wellbore, blenders that mix proppant into the fluid, cranes, wireline units, and many other components.”³

42. The ‘435 system includes multiple “pumps” configured to pressurize a fracturing fluid.⁴ The multiple “pumps” receive fracturing fluid from a blender.⁵

43. The system also includes a “distribution system,” or “missile,” “fluidly coupled to receive and consolidate fracturing fluid” from the pumps “for injection into a wellhead.”⁶ The distribution system includes suction lines coupled to the pumps, for example via a “common manifold for distribution of fluid to the pumps,” as well as one or more discharge lines coupled to the wellhead.⁷

44. The ‘435 Patent states that components in prior art fracturing systems were “generally independent systems” and “individually controlled by operators.”⁸ These independent systems purportedly required “a large amount of operator intervention” “for taking measurements,” collecting data, and “control[ling] operating conditions of the various components.”⁹

³ Ex. 1001, 1:23-28.

⁴ Ex. 1001, 1:44-46, 3:29-33, Fig. 1 (illustrating “pump trucks 14”).

⁵ Ex. 1001, 3:36-40, Fig. 1.

⁶ Ex. 1001, 1:46-48, 3:46-55, Fig. 1 (illustrating “distribution system 30”).

⁷ Ex. 1001, 3:46-55, Fig. 1.

⁸ Ex. 1001, 1:29-36.

⁹ Ex. 1001, 1:29-36.

45. To address these problems, the '435 fracturing system also includes “a control system.”¹⁰ The control system has one or more “sensing devices” to measure “parameters” of the system as well as “processing devices” that “generate control instructions” based on the measured parameters.¹¹ One or more “control devices” receive the control instructions and control aspects of the system, including aspects of the pumps, the distribution system, or other system components, based on the “control instructions.”¹²

B. THE CHALLENGED CLAIMS OF THE '435 PATENT

46. The Challenged Claims of the '435 Patent, which are Claims 1-19, 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, comprising:
1[a]	a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;
1[b]	a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and
1[c]	a control system comprising:

¹⁰ Ex. 1001, 1:48-60.

¹¹ Ex. 1001, 1:52-56.

¹² Ex. 1001, 1:56-60.

1[d]	a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;
1[e][i]	one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and
1[e][ii]	detect that the first parameter is outside of an acceptable threshold; and
1[e][iii]	generate automated control instructions at the second device based at least in part on the first parameter; and
1[f]	one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.
2	2. The system of claim 1, wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and selected from a group including flow sensors, accelerometers, pressure transducer, and tachometers.
3	3. The system of claim 1, wherein the plurality of pumps or the distribution system includes at least one device selected from a group include ¹³ a gate, valve, actuator, motor, suction pipe, discharge pipe, engine, transmission, and temperature regulation device, controllable via the one or more control devices.
4	4. The system of claim 1, further comprising: a suction line through which fracturing fluid is supplied; and a discharge line through which fracturing fluid is discharged, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line.
5[a]	5. The system of claim 1, further comprising: one or more blenders configured to mix together one or more materials to form the fracturing fluid,

¹³ This appears to be a typo in the issued claims.

5[b]	wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold,
5[c]	wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow conditions at the one or more blenders, the manifold, the plurality of pumps, or the distribution system.
6	6. The system of claim 5, wherein the one or more control device is configured to control the one or more blenders, the manifold, the plurality of pumps and the distribution system based on the flow and/or pressure conditions.
7[p]	A hydraulic fracturing method, comprising:
7[a]	providing a fracturing fluid to a plurality of pumps;
7[b]	pumping the fracturing fluid into a distribution system;
7[c]	injecting the fracturing fluid into a wellhead;
7[d]	measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;
7[e]	detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;
7[f]	generating automated instructions for one or more control devices based at least in part on the one or more parameters;
7[g]	automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions;
7[h]	transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of pumps, the distribution system, or the wellhead;
7[i]	generating the automated instructions at the second device based at least in part on the first parameter; and

7[j]	automatically adjusting one or more functions of the second device based on the automated instructions.
8[a]	The method of claim 7, further comprising: detecting that a first pump of the plurality of pumps is underperforming; and
8[b]	adjusting one or more of the pumps in the plurality of pumps to compensate for the first pump.
9	9. The method of claim 8, further comprising: selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters.
10	10. The method of claim 7, further comprising: determining that the one or more parameters are indicative of a potential failure condition; and determining a source of the potential failure condition.
11	11. The method of claim 10, further comprising: generating an alert or notification indicative of the potential failure condition and the source.
12	12. The method of claim 7, further comprising: logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and determining a maintenance schedule based at least in part on the operation data.
13[p]	A hydraulic fracturing method, comprising:
13[a]	performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;
13[b]	measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;
13[c]	transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the

	wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;
13[d]	detecting that the first parameter is outside of an acceptable threshold;
13[e]	generating automated instructions at the second device based at least in part on the first parameter; and
13[f]	automatically adjusting one or more functions of the second device based on the automated instructions.
14	14. The method of claim 13, wherein the distribution system receives and consolidates the fracturing fluid from the plurality of pumps for injection into a wellhead.
15	15. The method of claim 14, further comprising: controlling one or more functions of the distribution system based on the automated instructions.
16	16. The method of claim 13, wherein the first parameter includes measurements of one or more of the plurality of pumps.
17	17. The method of claim 16, further comprising: controlling one or more of the plurality of pumps individually based on the automated instructions.
18[a]	18. The method of claim 17, further comprising: detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold; and
18[b]	automatically taking the first pump offline in response to the detection.
19	19. The method of claim 18, further comprising: adjusting one or more of the other pumps in the plurality of pumps to compensate for taking the first pump offline.

C. PROSECUTION HISTORY OF THE ‘435 PATENT

47. Application 16/170,695 leading to the ‘435 Patent was filed October 25, 2018. The Patent Office issued a first Non-Final Office Action February 12, 2019, rejecting claims 1-7, 11, 12, and 14-18 as being anticipated by PCT Patent Publication 2017/0226842 (“*Omont*”) and rejecting claims 8-10, 19, and 20 as obvious based on *Omont* in view of PCT Patent Publication No. 2014/0379300 (“*Devine*”).¹⁴ In response, Applicant amended independent claims 1, 7, and 14 to include additional limitations: e.g., “detecting that a first parameter of the one or more parameters is outside of an acceptable threshold” and “automatically adjusting” functions of system components.¹⁵ Applicant canceled claim 8 and added new claim 21.¹⁶

48. The Patent Office issued a first Final Office Action on June 7, 2019, rejecting claims 1-12 and 14-20 as obvious over PCT Patent Publication 2017/0226842 (“*Omont*”) in view of PCT Patent Publication No. 2014/0379300 (“*Devine*”) and rejecting claim 13 as obvious based on *Omont*, *Devine*, and U.S. Patent Publication No. 2014/0095114 (“*Thom*”).¹⁷ The Final Office Action allowed claim 21.¹⁸ In response, Applicant amended the independent claims to include the subject matter of “allowable” dependent claim 21, including “transmitting the first parameter from

¹⁴ Ex. 1002, 1426-1434; Ex. 1013.

¹⁵ Ex. 1002, 1312-1317.

¹⁶ Ex. 1002, 1309.

¹⁷ Ex. 1002, 1130-1139.

¹⁸ Ex. 1002 1140.

a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of pumps, the distribution system, or the wellhead”;
“generating the automated instructions at the second device; and automatically adjusting one or more functions of the second device based on the automated instructions.”¹⁹

49. The Patent Office issued a second Non-Final Office Action September 25, 2019, allowing claims 1-7 and 9-13 and objecting to claims 14-20 for antecedent basis errors.²⁰ Following Applicant’s amendment to address antecedent basis, the Patent Office issued a notice of allowance January 13, 2020.²¹

D. PRIORITY DATE OF THE ‘435 PATENT

50. The ‘435 Patent (EX1001) claims priority to provisional application 62/577,056 (EX1008) filed October 25, 2017. The prior art discussed herein pre-dates that provisional application.

VII. LEVEL OF ORDINARY SKILL IN THE ART

51. 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)

¹⁹ Ex. 1002, 991-999, 1317.

²⁰ Ex. 1002, 969.

²¹ Ex. 1002, 912, 943.

at least four years of industry experience in the oil and gas industry including well drilling, completion, or production.

VIII. CLAIM CONSTRUCTION

52. It is my opinion that a POSITA would have understood 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 '435 Patent, for all claim terms.

IX. TECHNOLOGY BACKGROUND AND STATE OF THE ART

53. In the subsections below, I describe some of the basic principles of engineering that would be 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. GENERAL ENGINEERING KNOWLEDGE

54. Exhibit 1015 is a true and correct copy of the article by Michael Morton, "Unlocking the Earth: A Short History of Hydraulic Fracturing," GEO ExPro, Vol. 10, No. 6, December 2013. I obtained the article by accessing the website <https://www.academia.edu/> at least by November 21, 2023. Because Exhibit 1015 was published by GEO ExPro in December 2013, Exhibit 1015 was publicly available prior to October 25, 2017.

55. Exhibit 1016 is a true and correct copy of the article by B.A. Wells and K.L. Wells, "Shooters – a 'Fracking' History," American Oil & Gas Historical

Society, (<https://aoghs.org/technology/hydraulic-fracturing>). I obtained the article by accessing the above website at least by August 2, 2024. Because Exhibit 1016 was published by the American Oil & Gas Historical Society September 1, 2007, Exhibit 1016 was publicly available prior to October 25, 2017

56. Exhibit 1017 is a true and correct copy of the article by Carl T. Montgomery and Michael B. Smith, “Hydraulic Fracturing: History of an Enduring Technology,” Journal of Petroleum Technology, Vol. 62, Issue 12 (Dec. 2010). Because Exhibit 1017 was published by the Journal of Petroleum Technology in 2010, Exhibit 1017 was publicly available prior to October 25, 2017. The Journal of Petroleum Technology is “the Society of Petroleum Engineers’ flagship magazine.” SPE began in the early 1900s and “has grown into an independent, nonprofit global society with more than 119,000 members in 138 countries. SPE provides unparalleled insights, shared expertise, life-long learning and community strength to fuel the success of our members and the future of the [petroleum] industry.” I have been a member of the SPE since 2000. SPE Maintains a library of articles it publishes, as well as articles covering key areas of the oil and gas E&P Industry, known as “OnePetro.” I have regularly used OnePetro in my practice to both advance my knowledge of Oil & Gas technologies as well as research specific Oil and Gas related topics. I obtained the article by accessing OnePetro.

57. Exhibit 1018 is a true and correct copy of pages extracted from Chapter 8, “Directional Drilling and Deviation Control,” of the textbook by Adam T. Bourgoyne, Jr. *et al.*, “Applied Drilling Engineering,” Society of Petroleum Engineers. Because Exhibit 1018 was published by the Society of Petroleum Engineers in 1986, Exhibit 1018 was publicly available prior to October 25, 2017. I obtained the article by accessing OnePetro.

58. Exhibit 1019 is a true and correct copy of pages extracted from the dictionary “Historical Dictionary of the Petroleum Industry” (2nd Ed.), authored by Marius S. Vassiliou. Exhibit 1019 has been in my personal library at least since 2021 and I have accessed it regularly when researching historical information about the Oil and Gas industry.

59. Exhibit 1020 is a true and correct copy of U.S. Patent Application Publication No. 2013/0306322 to Sanborn *et al.* entitled “System and Process for Extracting Oil and Gas by Hydraulic Fracturing” (“*Sanborn*”). Because Exhibit 1020 was published by the USPTO November 21, 2013, Exhibit 1020 was publicly available prior to October 25, 2017.

60. Exhibit 1021 is a true and correct copy of U.S. Patent Publication No. 2012/0255734 to Coli *et al.* (“*Coli*”) entitled “Mobile, Modular, Electrically Powered System for Use in Fracturing Underground Formations.” Because Exhibit

1021 was published by the USPTO October 11, 2012, Exhibit 1021 was publicly available prior to October 25, 2017.

61. Exhibit 1022 is a true and correct copy of the article by H.L. Tomlinson, A.C. Byrd, and C.F. VanBerg, “Fracturing Process Control and Automation,” Society of Petroleum Engineers, Permian Basin Oil and Gas Recovery Conference (1988). Because Exhibit 1022 was presented and published by the Society of Petroleum Engineers on or around March 10-11, 1988, Exhibit 1022 was publicly available prior to October 25, 2017. I obtained the article by accessing OnePetro.

62. Exhibit 1023 is a true and correct copy of is a true and correct copy of the article by S.V. Stephenson, E.L. Woodall, C.D. Donaghe, and R.E. Dant, “Fracturing process control and automation: Phase 2,” Society of Petroleum Engineers, Petroleum Computer Conference (1993). Because Exhibit 1023 was presented and published by the Society of Petroleum Engineers on or around July 11-14, 1993, Exhibit 1023 was publicly available prior to October 25, 2017. I obtained the article by accessing OnePetro.

63. Exhibit 1024 is a true and correct copy of U.S. Patent Application Publication No. 2008/0236818 to Dykstra *et al.* entitled “Method and Apparatus for Controlling the Manufacture of Well Treatment Fluid” (“*Dykstra 818*”). Because Exhibit 1024 was published by the USPTO November 23, 2011, Exhibit 1020 was publicly available prior to October 25, 2017.

64. Exhibit 1025 is a true and correct copy of U.S. Patent Application Publication No. 2008/0183415 to Dykstra *et al.* entitled “Methods to Monitor System Sensor and Actuator Health and Performance” (“*Dykstra 415*”). Because Exhibit 1025 was published by the USPTO August 11, 2009, Exhibit 1025 was publicly available prior to October 25, 2017.

65. Exhibit 1026 is a true and correct copy of the specification “MODBUS over Serial Line Specification and Implementation Guide, V1.02.” Because Exhibit 1026 was published December 20, 2006, Exhibit 1026 was publicly available prior to October 25, 2017 I have used the Modbus protocol when designing, installing or operating industrial control systems since at least the early 1990s. Modbus is an industry standard communication protocol for communicating with field devices including sensors, VFDs, and valve actuators. Modbus is still regularly used today for communicating not only sensed data but other information including transmitter health, measured parameters in drives, and malfunction flags (such as a failed valve actuation).

66. Exhibit 1027 is a true and correct copy of the standard “IEEE Standard for Ethernet,” IEEE Computer Society, LAN/MAN Standards Committee (IEEE Std 802.3TM-2018). As would be known to anyone working with communications, ethernet is ubiquitous in applications such as local area networks to couple together all sorts of devices. Although ethernet was used for intra-computer communications

during my education in the late 1980s, my first experience with ethernet in industrial applications was in the early 1990s when we used ethernet to communicate between PLCs (for failover redundancy) and to communicate between the PLCs and the human machine interface (HMI) panels. Around the same time, I used ethernet to communicate setpoints and otherdata between large variable frequency drives (VFDs) and a central control system. Since then I can easily say that I have seen thousands of installations of ethernet technology in residential, commercial and industrial settings.

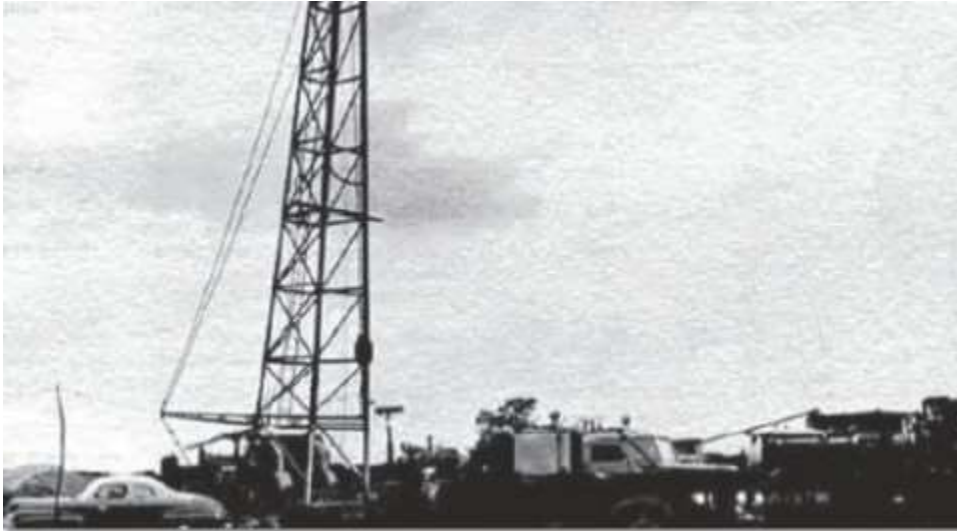
B. HISTORY OF HYDRAULIC FRACTURING

67. 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."²² 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 mid-continent region.²³ Early hydraulic fracturing in the 1940s and 1950s used frac pumps that could operate at around 1500 Hp.²⁴

²² Ex. 1015 (*Morton*).

²³ Ex. 1016 (*Wells*).

²⁴ Ex. 1017 (*Montgomery*) pg. 26.



68. The expansion of directional and horizontal drilling extended the use of hydraulic fracturing into previously underdeveloped “tight” formations, including shale.²⁵ 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 a land-based drilling pad. Like most oil and gas industry developments “the early drilling of directional wells was clearly motivated by economics.”²⁶ The offshore

²⁵ Ex. 1015 (*Morton*).

²⁶ Ex. 1018 (*Bourgoyne*) pg 351.

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.

69. 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.”²⁷ 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 “fractures” in the formation from multiple locations to allow the hydrocarbons to “leak” out of the formation into the wellbore.

²⁷ Ex. 1019 (*Vassiliou*) xliii.

70. 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.²⁸



71. 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 Sanborn, pumping systems of 32,000 hp were typically used as early as 2012.²⁹ Other references, such as *Coli*, suggest systems of pumps as large as 2,500 hp each,

²⁸ Ex. 1016 (*Wells*) at 9 (showing a 2011 map from the Energy Information Administration showing shale plays where hydraulic fracturing is common).

²⁹ Ex. 1020 (*Sanborn*) [0005].

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).³⁰ These pumps are typically triplex or quintuplex positive displacement (plunger) type pumps.³¹ Although some fracturing systems had been converted to electric-driven pump motors, most hydraulic pumping systems at the time “are typically mobilized on skids or tractor-trailers and powered using diesel motors.”³² These diesel engines require large amounts of diesel fuel and the requisite extra safeguards to address potential safety concerns.³³

C. TYPES OF PUMPS – FRACTURING PUMP CHAIN

72. The basics of hydraulic fracturing have not changed significantly since 1949 when Halliburton first commercialized the “hydrafrack” process. 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

³⁰ [0049], FIG. 2 (Ex. 1021).

³¹ *Sanborn* (Ex. 1020), at [0005]; *Coli* (Ex. 1021), at [0011].

³² Ex. 1021 (*Coli*), [0005]; *see also*, [0007] (“standard fluid pumps require large volumes of diesel fuel and extensive equipment maintenance programs”).

³³ Ex. 1020 (*Sanborn*), [0007].

changed are the pressures and flow rate of the fracturing jobs, the sizes of equipment and the particular proppants, chemicals, and liquids used.

73. A modern fracturing process requires multiple pumps operating together as a system to provide fracturing fluid with the suitable composition at the right flow rate³⁴, 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.

74. 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.

75. Once the fracturing slurry is blended to the proper makeup and consistency, it is transferred to the fracturing pumps using a blender discharge pump.

³⁴ “Flowrate,” “flow rate,” and “flow-rate” are used interchangeably in the industry and herein.

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 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.

76. A fracturing piston (or plunger) pump works similarly to a car engine without the step of igniting the fuel to provide energy to the shaft. In a piston (plunger) 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 piston (plunger) moves away from the head, creating suction which draws the slurry into the piston chamber. As the piston (plunger) moves toward the head, pressure is created which drives the fluid out of the chamber and down the line to and into the wellbore. A key characteristic of these fracturing pumps is that the same amount of liquid is discharged from the pump with every stroke, largely independent of the pressure downstream. The result is that flow 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.

77. Because the pistons (plungers) are so large (~5" in diameter with ~8" stroke), a large amount of fluid must flow into the piston on each stroke. This tends to lower the suction pressure, as the void of the piston (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).

D. PUMPING AND CAVITATION

78. 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.”³⁵ Cavitation has at least three negative effects on a pumping system:³⁶

- i. The collapsing cavitation bubbles can erode the vane surface, especially when pumping water-based liquids.
- ii. Noise and vibration are increased, with possible shortened seal and bearing life.
- iii. 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.

79. *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

³⁵ Ex. 1036 (*Tutterow*) pg 20; see also Ex. 1037 (Marks) pg. 14-2.

³⁶ Ex. 1036 (*Tutterow*) pg 20

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).”³⁷

80. Further, NPSHR “varies approximately with the square of speed in the same way as pump head.”³⁸ Accordingly, a 10% reduction in pump speed would 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.

81. 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.”³⁹ PD pumps also have an additional problem outlined by *Tutterow*:⁴⁰

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

³⁷ Ex. 1036 (*Tutterow*) pg 20

³⁸ Ex. 1036 (*Tutterow*) pg. 21.

³⁹ Ex. 1036 (*Tutterow*) pg. 30.

⁴⁰ Ex. 1036 (*Tutterow*) pg. 30.

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.

82. *Langewis* describes the 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 to 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.”⁴¹ *Langewis* further describes NPSH required mathematically:

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

83. 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.”⁴²

⁴¹ Ex. 1049 (*Langewis*) pg. 2.

⁴² Ex. 1049 (*Langewis*) pg. 2-3

84. 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.

E. CONTROL SYSTEMS FOR HYDRAULIC FRACTURING

85. Computer-based control systems have been commonplace in hydraulic fracturing operations for decades before the '435 Patent. For example, *Tomlinson* describes Phase 1 of a project to “automate and remotely control the fracturing processes” as early as 1988.⁴³ *Tomlinson* described the goals of the project:⁴⁴

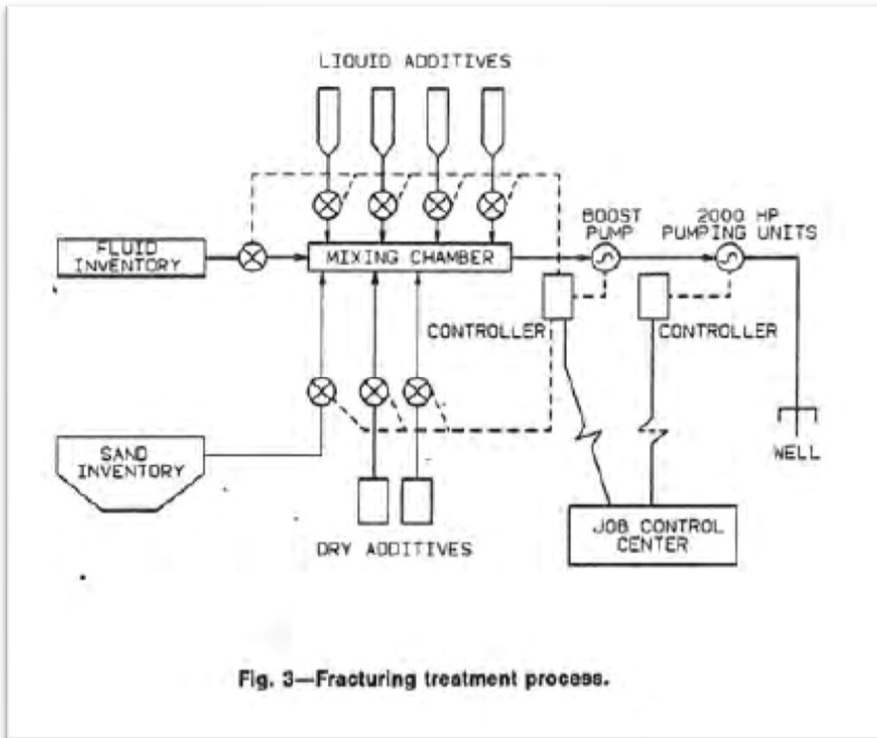
to automate and remotely control the fracturing process were to (1) improve execution of complex job design, (2) significantly improve quality control of chemical blends, (3) reduce operational cost, (4) improve safety, (5) provide for changes in job design during progress of the operation, and (6) improve documentation of the processes.

Fig. 3 of *Tomlinson* shows the fracturing system *Tomlinson* was applied to:⁴⁵

⁴³ Ex. 1022 (*Tomlinson*) pg 371.

⁴⁴ Ex. 1022 (*Tomlinson*) pg 371.

⁴⁵ Ex. 1022 (*Tomlinson*) pg 375.



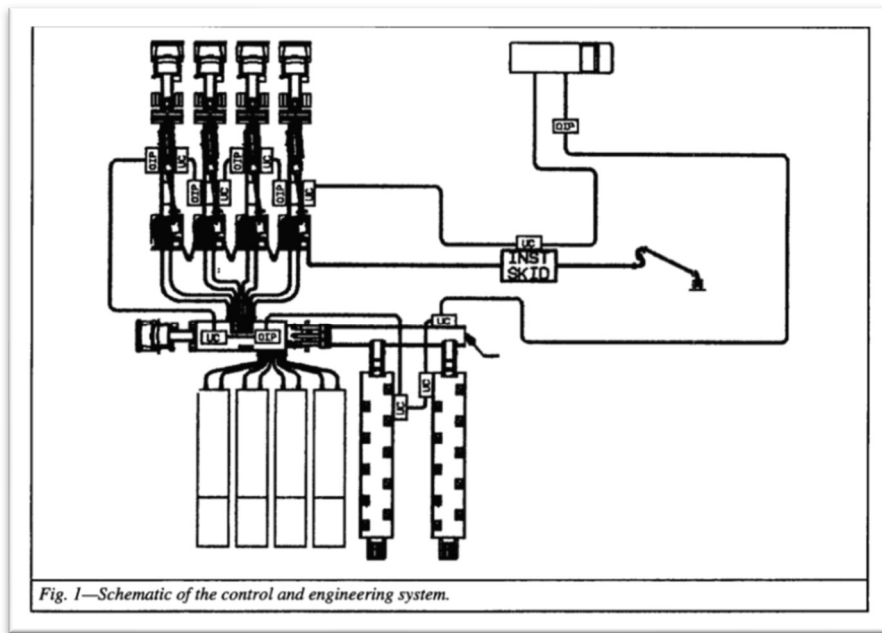
Tomlinson further discloses a blender with control loops to “monitor and adjust liquid additives, proppant [e.g., sand] delivery, engine control, dry additives, and mixing tub level.”⁴⁶ As *Tomlinson* was published more than three decades prior to the ‘435 Patent, the sensing of output rates from a sand system, water system, pumping system, and blender while controlling the rates with a controller was well-known and commonly used in the oil and gas industry for hydraulic fracturing as well as other oilfield operations.

86. Phase 2 of the *Tomlinson* project is outlined in *Stephenson*, published in 1993.⁴⁷ *Stephenson* describes that “the entire automated and remote controlled

⁴⁶ Ex. 1022 (*Tomlinson*) pg 372.

⁴⁷ Ex. 1023 (*Stephenson*) generally.

fracturing stimulation system has been placed into production globally with hundreds of jobs successfully accomplished and documented.”⁴⁸ *Stephenson* describes that Phase 2 of the control system involved ““(1) a new design concept for a slurry processor, (2) creating software for the central computer in the control and engineering center, and (3) improving the proppant handling equipment. In addition, fluid monitoring systems were developed.”⁴⁹ Fig. 1 of *Stephenson* shows the control and engineering system described.⁵⁰



Stephenson describes that the “control and engineering center monitors over 1,200 surface treatment parameters through the communications network” and that these

⁴⁸ Ex. 1023 (*Stephenson*) pg. 43.

⁴⁹ Ex. 1023 (*Stephenson*) pg 43.

⁵⁰ Ex. 1023 (*Stephenson*) Fig. 1.

“parameters consist of rates, pressures, temperatures, densities, material inventories, and equipment status.”⁵¹

87. *Coli*, for example, describes “[a] control system can be provided for regulating various equipment and systems within the electric powered fractioning [sic, fracturing] operation.”⁵² *Dykstra* and *Sanborn* describe similar control systems.⁵³ Further it was well-known long before the ‘435 Patent to use field devices to monitor the health status of fracturing equipment. For example, *Dykstra 415* allows operators “to determine failure, or likelihood of failure” of equipment, which “provides an improved view of system health and performance, and also permits signaling to operators so that failures are prevented or caught more quickly, reducing operator error.”⁵⁴ Further, *Dykstra 415* teaches its system “include[s] a plurality of subsystems (such as sensors or actuators, or combinations of parts) that can signal operation or state information. This information is used to determine if one or more

⁵¹ Ex. 1023 (*Stephenson*) pg. 47.

⁵² Ex. 1021 (*Coli*) [0065], *see also* [0072] (“Suitable controls and computer monitoring for the entire fracturing operation can take place at a single central location, which facilitates adherence to pre-set safety parameters.”)

⁵³ See, Ex. 1020 (*Sanborn*) [0030] (disclosing “an operations and control unit, usually computer-based, and containing monitoring, data-recording, and communication equipment, as well as remote pumper controls to monitor and control each stage of the fracturing process, and to record data for each phase.”, *see also* [0050]. *See* Ex. 1024 (*Dykstra*) [0021], (disclosing a “central control system” that may be an “electronic computer system” for monitoring, coordinating, and controlling the “operations of the chemical storage system, proppant storage system, blending unit, pumping grid, power unit, and manifolds”).

⁵⁴ Ex. 1025 (*Dykstra 415*) [0055].

subsystems are in or near failure mode.”⁵⁵ *Dykstra 415* further teaches the “ability to switch control modes depending on sensor or actuator health.”⁵⁶

F. COMMUNICATION PROTOCOLS

88. Control systems, including control systems for fracturing applications, have used a variety of communication protocols to allow sensors to communicate with control and monitoring systems. Many of these protocols require the use of a processor located between the physical sensor and the monitoring / control system to enable the protocol to work. For example, a common communication protocol is Modbus. Modbus is a “de facto standard” communication protocol first introduced into industrial markets in 1979.⁵⁷ Modbus is used “in innumerable gas and oil and substation applications.”⁵⁸ Modbus is “an application layer messaging protocol, positioned at level 7 of the OSI model that provides "client/server" communications between devices connected on different types of buses or networks.”⁵⁹

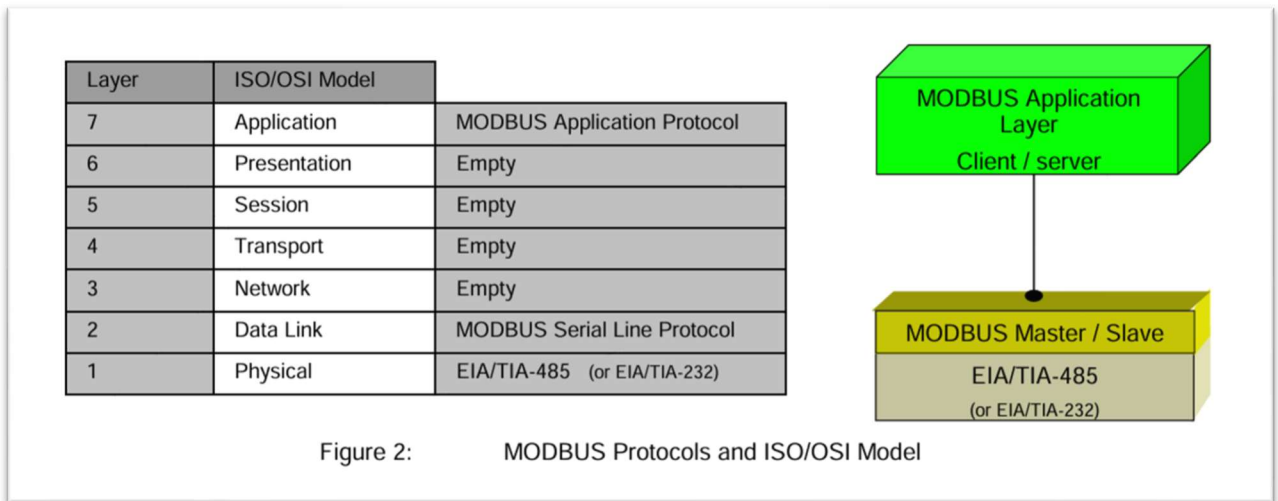
⁵⁵ Ex. 1025 (*Dykstra 415*) [0007].

⁵⁶ Ex. 1025 (*Dykstra 415*) [0016].

⁵⁷ *Modbus FAQ: About The Modbus Organization*, available at <https://web.archive.org/web/20170209120841/https://www.modbus.org/faq.php>

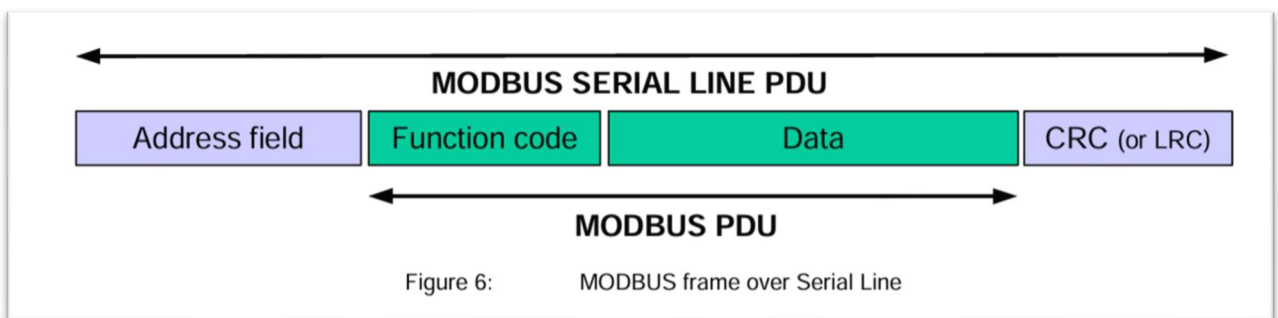
⁵⁸ *Modbus FAQ: About The Modbus Organization*, available at <https://web.archive.org/web/20170209120841/https://www.modbus.org/faq.php>

⁵⁹ Ex. 1026 (Modbus).



Ex. 1026 Figure 2

89. The Modbus specification provides definition of a “Protocol Data Unit” (PDU) which is a packet of information sent from, for example, a sensor to a controller. The PDU contains fields designating, for example, the address (destination) of the data.



Ex. 1026 Figure 6

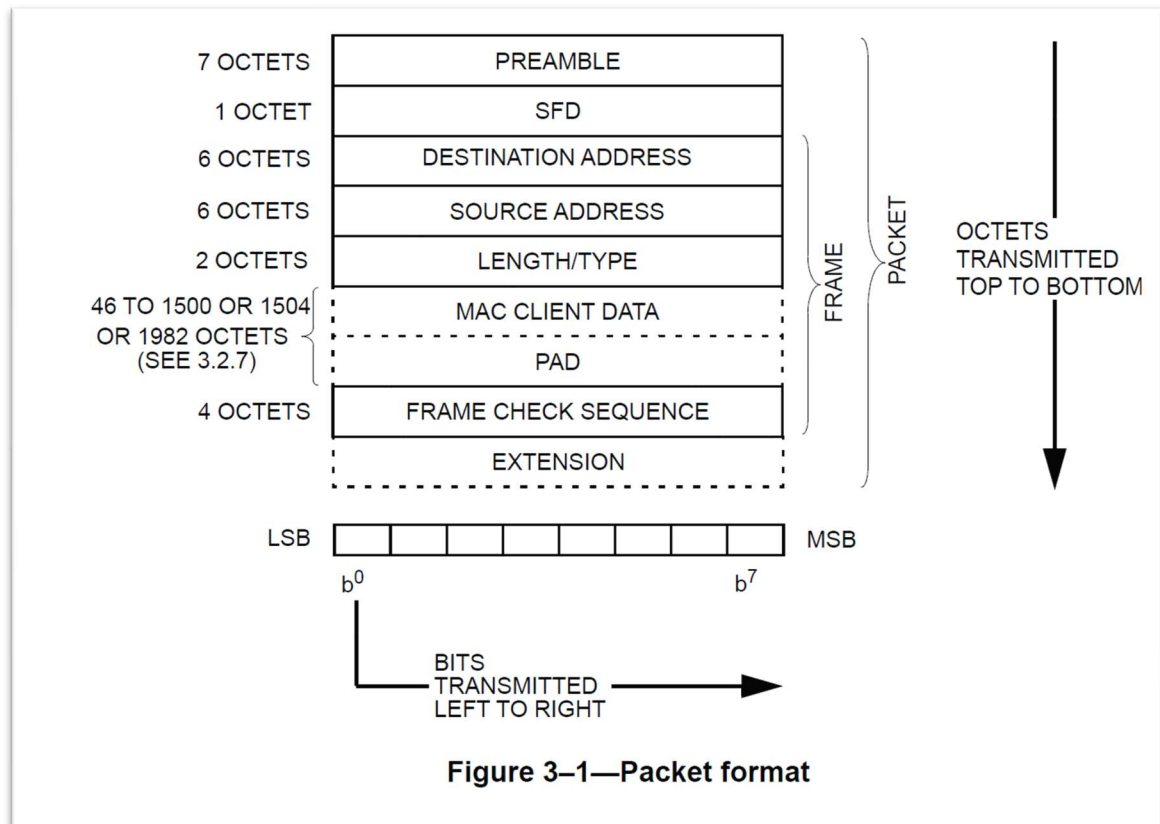
90. A POSITA would have understood that a sensor communicating with a controller using Modbus protocol would inherently have a processor located between the sensor (e.g. flow, pressure, temperature, etc.) and the controller. The

processor would read the sensor, convert it into digital data (Data in the PDU), affix additional fields, such as the address, and then transmit the PDU onto the communications bus. There would be no way to use the Modbus protocol absent a processor to build the PDU and transmit it onto the bus.

91. Similarly, Ethernet is a common communications protocol that would require a processor between the sensor and the controller. “Ethernet” is a term used to describe a protocol following the IEEE 802.3 Standard “IEEE Standard for Ethernet”, first published in 1985.⁶⁰ Ethernet operates on a local area network at speeds from “1 Mb/s to 400 Gb/s using a common media access control (MAC) specification and management information base (MIB).”⁶¹ Similar to the Modbus protocol, Ethernet defines a “packet” of information which includes the data being communicated. The packet also contains information about the destination and source addresses, delimiters and check data, as shown in the figure below.

⁶⁰ Ex. 1027 (IEEE 802.3) pg. 22.

⁶¹ Ex. 1027



Ex 1027 Figure 3-1

92. In order to use Ethernet protocol to transmit sensor data to, for example, a controller, a processing device would be required to read the sensor data, translate it into digital format (MAC client data) and add the additional information that comprises the packet.

93. Other protocols that follow the same general format (data packaged together with additional information to form a data packet or unit) are Profibus,⁶² CANbus⁶³ and USB.⁶⁴

X. OVERVIEW OF THE PRIOR ART

A. NORRIS(Ex. 1004)

1. Status of Norris

94. “*Norris*” is an PCT International Patent Publication No. 2017/040921. *Norris* is entitled, “Pump Synchronization System and Method.” *Norris* was filed September 2, 2016, and published March 9, 2017. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ’435 Patent.

2. Overview of the Disclosure of Norris

95. Like the ’435 Patent, *Norris* relates to a “pump management system” for controlling operation of multiple pumps in a “wellbore servicing system.”⁶⁵ *Norris*’s “wellbore servicing system” performs “fracturing operations” using a “pump management system” and a “fluid delivery system.”⁶⁶ *Norris*’s “pump management system” is intended to manage and improve operation of “multiple positive displacement pumps [] used in combination to provide desired flow rates

⁶² Process Field Bus

⁶³ Controller Area Network Bus

⁶⁴ Universal Serial Bus.

⁶⁵ Ex. 1004 (*Norris*) Title, [0007]- [0008], [0034].

⁶⁶ Ex. 1004 (*Norris*) [0021]- [0022].

and operational pressures.”⁶⁷ Thus, *Norris* is clearly from the same field of art as the ‘435 Patent, control and monitoring of multiple pump systems, describes a multiple-pump fracturing system similar to the system described in the ‘435 Patent, and addresses deficiencies in operating and controlling the same multiple-pump prior art systems that the ‘435 Patent purportedly improves upon.

96. *Norris* describes and illustrates the “pump management system” and “fluid delivery system” containing multiple pumps, a “supply side manifold,” and a “pressure side manifold” delivering fluid to a wellhead.⁶⁸ A blender delivers fluid to the supply side manifold.⁶⁹ The fluid delivery system has multiple “pump trucks” or “pump units,” each including a positive-displacement pump and a drivetrain.⁷⁰ *Norris* explains that operation of multiple pumps and varying pumping demands produce “dynamic variations of pressure within a downstream conduit” that must be controlled, otherwise system components “experience extremes of high and low pressure stresses” leading to fatigue and failure.⁷¹

97. *Norris* further describes how its “pump management system” coordinates operation of multiple pumps to “reduce stress and fatigue” on system components and “provide[] overall operational control” for the system as well as

⁶⁷ Ex. 1004 (*Norris*)Abstract, [0002].

⁶⁸ Ex. 1004 (*Norris*) [0021], Fig. 2.

⁶⁹ Ex. 1004 (*Norris*) [0021], Fig. 2.

⁷⁰ Ex. 1004 (*Norris*) [0024].

⁷¹ Ex. 1004 (*Norris*) [0027]

“local control” of each individual pump.⁷² *Norris* discloses an “application controller” that receives data “from sensors and data processors” and “provides overall control of pumping operations.”⁷³ The sensors and data processors—which may be “associated with pump trucks [], pressure-side manifold [] and other monitored operations”—monitor and process data on fluid pressure, flow rates, RPM, piston position, and other engine parameters.⁷⁴

98. *Norris* explains that the application controller—via its “multiple pump controller,” “multiple drivetrain controller,” or “centralized controller”—can both receive sensor data from a “local pump system control” and communicate control data to local pump system control.⁷⁵ Local pump system control may include both a “local pump controller” and a “local drivetrain controller” that implement instructions from the application controller at each pump.⁷⁶ For example, “each local pump controller [] provides data to multiple pump controller [],” the application controller accordingly “controls the operation of each local pump control system,” and the “multiple drivetrain controller” may “signal each local drive train controller [] to increase or decrease pumping operations.”⁷⁷ A POSITA would have understood

⁷² Ex. 1004 (*Norris*) [0028].

⁷³ Ex. 1004 (*Norris*) [0035].

⁷⁴ Ex. 1004 (*Norris*) [0029-0030], [0032], Fig. 3B.

⁷⁵ Ex. 1004 (*Norris*) [0034]- [0036], Figs. 3-4.

⁷⁶ Ex. 1004 (*Norris*) [0034]- [0036], Figs. 3-4.

⁷⁷ Ex. 1004 (*Norris*) [0034]- [0037].

that *Norris* discloses a multiple-pump fracturing system—similar to the multi-pump system described in the ‘435 Patent—configured for measurement and control of local components as well as the fracturing system as a whole.

B. OMONT(Ex. 1005)

1. Status of *Omont*

99. “*Omont*” is an PCT International Patent Publication No. 2016/019219. *Norris* is entitled, “Monitoring Health of Additive Systems.” *Omont* was filed July 31, 2015, and published February 4, 2016. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ‘435 Patent.

2. Overview of the Disclosure of *Omont*

100. *Omont* discloses a system for “monitoring health of additive systems” in “oilfield operations.”⁷⁸ The additive systems of *Omont* may include “several pumps ... connected in parallel” for “inject[ing] additives or other material into a wellbore.”⁷⁹ *Omont* describes problems in prior art oilfield systems, including “high frequency of use, high pressures, and abrasive properties of certain materials,” all of which may cause “systems to wear out and fail,” leading to “operation stoppages and severe damage” to other components.⁸⁰

⁷⁸ Ex. 1005 (*Omont*) Title, [0002].

⁷⁹ Ex. 1005 (*Omont*) Title, [0002].

⁸⁰ Ex. 1005 (*Omont*), [0003].

101. In response to these problems, *Omont* describes a “control and monitoring system” that enables estimating functional life of oilfield components and facilitates maintenance.⁸¹ *Omont*’s “control and monitoring system” may also “receive information generated” by sensors and “control operational parameters” associated with system components.⁸² *Omont* is thus from the same field of art as the ‘435 Patent, control and monitoring of multiple pump systems, describes a multiple-pump fracturing system similar to the system described in the ‘435 Patent, and provides for monitoring and controlling the same multiple-pump prior art systems that the ‘435 Patent purportedly improves upon.

102. The oilfield components of *Omont*’s “additive system” include one or more mixers supplying a mixture of “fracturing fluid” to “a common manifold.”⁸³ The common manifold (or “missile”), “may distribute the mixture ... to multiple pump assemblies” via a “suction line.”⁸⁴ The pump assemblies “discharge the mixture under pressure to the discharge line [] of the common manifold” for delivery into the wellbore.⁸⁵

⁸¹ Ex. 1005 (*Omont*) Figs. 1-3, [00139]- [00140], [00168]- [00169].

⁸² Ex. 1005 (*Omont*) [0026], [0038], Figs. 2-3.

⁸³ Ex. 1005 (*Omont*) [0017]- [0023].

⁸⁴ Ex. 1005 (*Omont*) [0023].

⁸⁵ Ex. 1005 (*Omont*) [0023]- [0025].

103. *Omont* also describes monitoring and control of these oilfield components.⁸⁶ *Omont*'s system includes sensors associated with oilfield components that are "operable to generate information related to an operational parameter" of each component.⁸⁷ *Omont*'s system includes "control hardware" implemented at each component and in a "system control/monitoring device."⁸⁸ The control hardware may include "processors" and "receive information generated by the sensors" associated with oilfield components.⁸⁹ Control hardware may further execute "coded instructions ... for controlling the controllable devices [] and/or for monitoring the sensors [] and/or other operation aspects of the additive system."⁹⁰

104. *Omont* also details how "operational parameters" are used to monitor and control oilfield components. For example, *Omont* describes "sensors" "for generating information related to operation parameters" of a pump.⁹¹ Sensed operational parameters (e.g., "temperature, pressure," among others) may be "communicated to the CAM [control and monitoring] system."⁹² Additionally, the CAM system, via a "system control/monitoring device," may "receive information

⁸⁶ Ex. 1005 (*Omont*) Figs. 2-4, [0026], [0029]- [0075].

⁸⁷ Ex. 1005 (*Omont*) Abstract, [0030].

⁸⁸ Ex. 1005 (*Omont*) [0061], Figs. 3-4.

⁸⁹ Ex. 1005 (*Omont*) [0062], [0065], Fig. 4.

⁹⁰ Ex. 1005 (*Omont*) [0065]

⁹¹ Ex. 1005 (*Omont*) [0051]- [0052], Fig. 3.

⁹² Ex. 1005 (*Omont*) [0051]- [0052], Fig. 3.

generated by the sensors [] and, based at least in part on such information, generate and send control signals to the controllable devices.”⁹³

105. *Omont* also describes “diagnostic tools” enabled by the systems described above.⁹⁴ *Omont*’s diagnostic tool performs hardware and sensor diagnostics, and the tool may generate an alarm when a monitored “output signal is outside a selected threshold.”⁹⁵ The diagnostic tool also provides “early warning” and “error codes” to operators that facilitate identifying problems and root causes.⁹⁶ The diagnostic tool further includes a “logging tool” that logs “operational parameters associated with various components” and a “predictive maintenance tool” that “inform[s] human operators of a predetermined maintenance schedule.”⁹⁷

106. Thus, a POSITA would have understood that *Omont* discloses a multiple-pump fracturing system that includes monitoring, control, and diagnostics of system components, including pumps, mixers/blenders, and distribution systems.

C. *BORGSTADT*(EX. 1006)

1. Status of *Borgstadt*

107. “*Borgstadt*” is a publication of a United States patent application, U.S. Patent Publication No. 2009/0053072. *Borgstadt* is entitled, “Integrated “One

⁹³ Ex. 1005 (*Omont*) [0038]

⁹⁴ Ex. 1005 (*Omont*) [0076], Fig. 5.

⁹⁵ Ex. 1005 (*Omont*) [0090]- [0094].

⁹⁶ Ex. 1005 (*Omont*) [00102]- [00104], [00107].

⁹⁷ Ex. 1005 (*Omont*) [00114]- [00119].

Pump” Control of Pumping Equipment.” *Borgstadt* was filed August 21, 2007, and published February 26, 2009. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ’435 Patent.

2. Overview of the Disclosure of *Borgstadt*

108. *Borgstadt* discloses “controlling a pumping process” having multiple pumps.⁹⁸ *Borgstadt* explains prior art pumping systems used for “subterranean operations,” in which “multiple pumps are commonly used with the pumping load distributed among them” to deliver the requisite amount of “stimulation fluids, drilling fluids or other fluids at a desired pressure or flow rate.”⁹⁹ *Borgstadt* identifies several challenges in the art and disadvantages of then-available methods of controlling multiple pumps.¹⁰⁰ *Borgstadt* states that “pumps are manually adjusted” and lack an “intelligent control system.”¹⁰¹ this caused pumps to be under- or over-utilized and resulted in “wear and tear,” “shortened life span,” and “pump failure” requiring repair or replacement.¹⁰² When taking a pump offline, operators also had “no idea which pump or pumps would be able to compensate for the dropped pump or load.”¹⁰³

⁹⁸ Ex. 1006 (*Borgstadt*) [0001]- [0002].

⁹⁹ Ex. 1006 (*Borgstadt*) [0002].

¹⁰⁰ Ex. 1006 (*Borgstadt*) [0003]- [0008].

¹⁰¹ Ex. 1006 (*Borgstadt*) [0003].

¹⁰² Ex. 1006 (*Borgstadt*) [0004].

¹⁰³ Ex. 1006 (*Borgstadt*) [0008].

109. To address these challenges, *Borgstadt* proposed a system for “controlling the operation of the pumps involved based on certain parameters characterizing the pump.”¹⁰⁴ Thus, *Borgstadt* is in a field of art—multiple-pump systems for drilling operations and associated sensing and control—that is highly relevant to the ‘435 Patent, which describes a control system for multiple-pump fracturing systems.

110. *Borgstadt* discloses a control system that includes a “master controller,” a “pump modulator,” and a local “pump controller” at each pump.¹⁰⁵ Local pump controllers “may use different measured parameters ... to adjust the performance of the pump unit.”¹⁰⁶ Similarly, the pump modulator receives information “regarding the performance of each pumping unit” and “[e]ach pump unit’s current level of operation.”¹⁰⁷ The pump modulator decides “how to best distribute the load among the individual pumps and assigns pumps” flow rates and pressures.¹⁰⁸ “In case of a problem,” the pump modulator “can also determine which pump or pumps can pick up the load.”¹⁰⁹ *Borgstadt*’s “master controller” receives “current wellhead parameters,” for example current pressure [] or current flow rate,” and uses

¹⁰⁴ Ex. 1006 (*Borgstadt*) [0009].

¹⁰⁵ Ex. 1006 (*Borgstadt*) Fig. 1.

¹⁰⁶ Ex. 1006 (*Borgstadt*) [0024].

¹⁰⁷ Ex. 1006 (*Borgstadt*) Fig. 2.

¹⁰⁸ Ex. 1006 (*Borgstadt*) [0025].

¹⁰⁹ Ex. 1006 (*Borgstadt*) [0025].

“measured value[s]” to control the pump system as a whole to achieve desired output.¹¹⁰

111. *Borgstadt* also describes using a pump modulator as a “diagnostic tool” for “diagnosing a pump unit [] failure” and for improving pump efficiency.¹¹¹ *Borgstadt*’s pump modulatory may “receive a pump unit’s current efficiency value” (or other pump parameter), compare that value to a “threshold efficiency value,” and issue a “pump warning condition” if the value falls outside the threshold.¹¹² The pump modulator can also “completely take a pump unit [] offline” in response to a “pump failure” and “redistribute the load among the remaining pump units.”¹¹³

112. Thus, a POSITA would have understood that *Borgstadt* discloses a multiple-pump control system that performs monitoring, diagnostics, and control to manage operation of multiple pumps, compensate for pump failure, and distribute pumping load.

D. DYKSTRA (EX. 1007)

1. Status of Dykstra

113. “Dykstra” is a publication of a United States patent application, U.S. Patent Publication No. 2008/0236818. Dykstra is entitled, “Method and Apparatus

¹¹⁰ Ex. 1006 (*Borgstadt*) [0027].

¹¹¹ Ex. 1006 (*Borgstadt*) Fig. 3, [0033].

¹¹² Ex. 1006 (*Borgstadt*) Fig. 3, [0033].

¹¹³ Ex. 1006 (*Borgstadt*) [0034].

for Controlling the Manufacture of Well Treatment Fluid.” Dykstra was filed March 27, 2007, and published October 2, 2008. Each of these dates is before the earliest possible priority date of all Challenged Claims of the ’435 Patent.

2. Overview of the Disclosure of Dykstra

114. *Dykstra* describes “a method for controlling the production of well treatment fluid.”¹¹⁴ *Dykstra* explains that “current well treatment subsystems often operate independently” and that “individually controlled” systems “may be running ahead or behind of other systems.”¹¹⁵ This individual operation can result in generation of a “well treatment fluid that does not comply with the needs of a well formation.”¹¹⁶

115. *Dykstra*’s well treatment operation includes “a pumping grid,” a “central manifold,” a “proppant storage system,” a “chemical storage system,” and “a blending unit.”¹¹⁷ The pumping grid may include multiple pumps.¹¹⁸ The blending unit “prepare[s] a fracturing fluid,” “according to the needs of well formation,” using chemical additives and proppant received from the proppant storage system and chemical storage system.¹¹⁹ The blending unit mixes and delivers a “final fracturing

¹¹⁴ Ex. 1007 (*Dykstra*) [0005].

¹¹⁵ Ex. 1007 (*Dykstra*) [0003]- [0004].

¹¹⁶ Ex. 1007 (*Dykstra*) [0004].

¹¹⁷ Ex. 1007 (*Dykstra*) [0014], Figs. 1-2.

¹¹⁸ Ex. 1007 (*Dykstra*) [0020], [0026].

¹¹⁹ Ex. 1007 (*Dykstra*) [0018].

fluid” “at downhole pump rates” to the pumping grid, which directs the fluid to the well via the central manifold.¹²⁰

116. To address the challenges in the art, *Dykstra* introduces a control system that “coordinates the various subsystems in a well treatment operation” and “monitor[s] the production of a well treatment fluid.”¹²¹ “[T]he operations of the chemical storage system, proppant storage system, pumping grid [] and manifolds are controlled, coordinated, and monitored by a central control system.”¹²² The control system “may use all of the sensor data from all units” and “signals from their individual subcontrollers” to control the blending process, including “control over the manufacture, pumping, gelling, blending, and resin coating” of the fracturing fluid.¹²³

117. Thus, a POSITA would have understood that *Dykstra* discloses a control system that performs both local and system-wide monitoring and control of blending and fluid delivery in multiple-pump well treatment systems.

XI. GROUNDS 1 & 2: ANTICIPATED OR RENDERED OBVIOUS BY NORRIS

118. It is my opinion that *Norris* anticipates, or at least renders obvious, Claims 1-5, 7, 13-14 & 16-17 of the ‘435 patent.

¹²⁰ Ex. 1007 (*Dykstra*) [0018].

¹²¹ Ex. 1007 (*Dykstra*) [0006].

¹²² Ex. 1007 (*Dykstra*) [0021].

¹²³ Ex. 1007 (*Dykstra*) [0021].

A. INDEPENDENT CLAIM 1

119. It is my opinion that *Norris* anticipates Claim 1 or at least renders Claim 1 obvious. As discussed in the following subsections, *Norris* discloses, or renders obvious, each and every element of Claim 1.

1. 1[p]: “1. A hydraulic fracturing system, comprising:”

120. *Norris* discloses a hydraulic fracturing system.¹²⁴ *Norris* discloses a “wellbore servicing tool 150” configured to perform “fracturing formation 130”.¹²⁵ Further, *Norris* discloses that “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 forces the wellbore service fluid into a pressure-side manifold 250b via pressure flow lines 290 and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”¹²⁶ *Norris* further describes, “In fracturing operations, wellbore servicing fluids, such as particle (e.g., proppant) laden fluids, are pumped at a relatively high-pressure into the wellbore 120. [] Proppant (e.g., grains of sand, glass beads, shells, ceramic particles, etc.) may be mixed with the wellbore servicing fluid to keep the fractures open so that hydrocarbons may be produced from the subterranean formation 130 and flow into the wellbore 120.”¹²⁷

¹²⁴ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 1 out of an abundance of caution.

¹²⁵ Ex. 1004 (*Norris*) [0020].

¹²⁶ Ex. 1004 (*Norris*) [0022].

¹²⁷ Ex. 1004 (*Norris*) [0023].

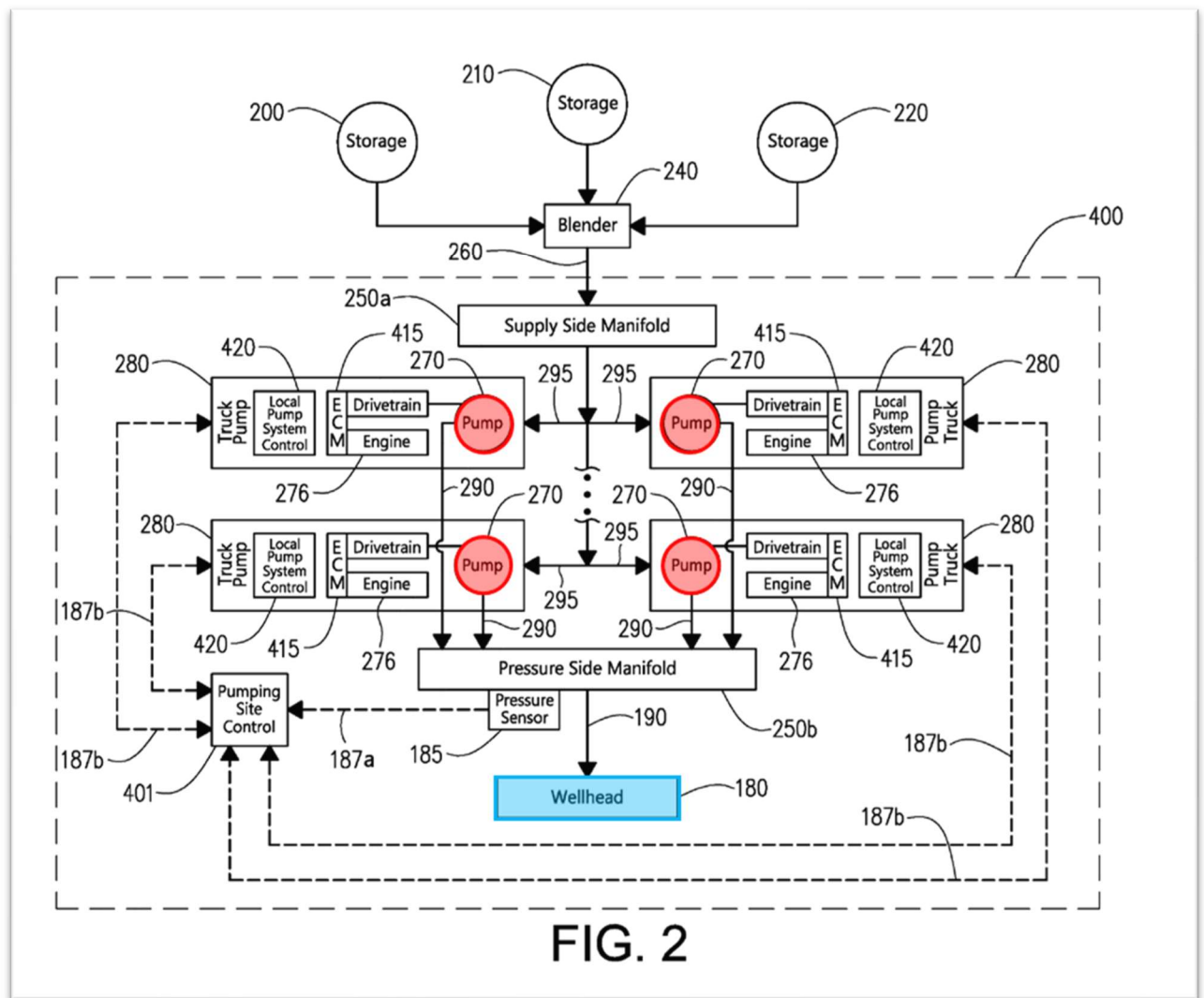
121. Accordingly, *Norris* discloses the preamble.

2. 1[a]: “a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;”

122. *Norris* discloses a plurality of pumps at a wellsite that are configured to pressurize a fracturing fluid. *Norris* discloses “[m]ultiple positive displacement pumps (PD pumps) are frequently used in combination to provide desired flow rates and operational pressures.”¹²⁸ *Norris* further discloses that, “[d]uring fracturing operations and other downhole operations PD pumps 270 operate at a rate such that the pressure within pressure-side manifold 250b and subsequent downstream lines via conduit 190 is at a significantly higher pressure.”¹²⁹ FIG. 2 of *Norris* shows that the pumps are positioned at a wellsite as pumps 270 (annotated in red) are shown in proximity to the wellhead 180 (annotated in blue).

¹²⁸ Ex. 1004 (*Norris*) [0002].

¹²⁹ Ex. 1004 (*Norris*) [0022]; *see also, e.g.*, [0026].

Ex. 1004 (*Norris*) FIG. 2

123. Accordingly, *Norris* discloses element 1[a].

3. **1[b]: “a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and”**

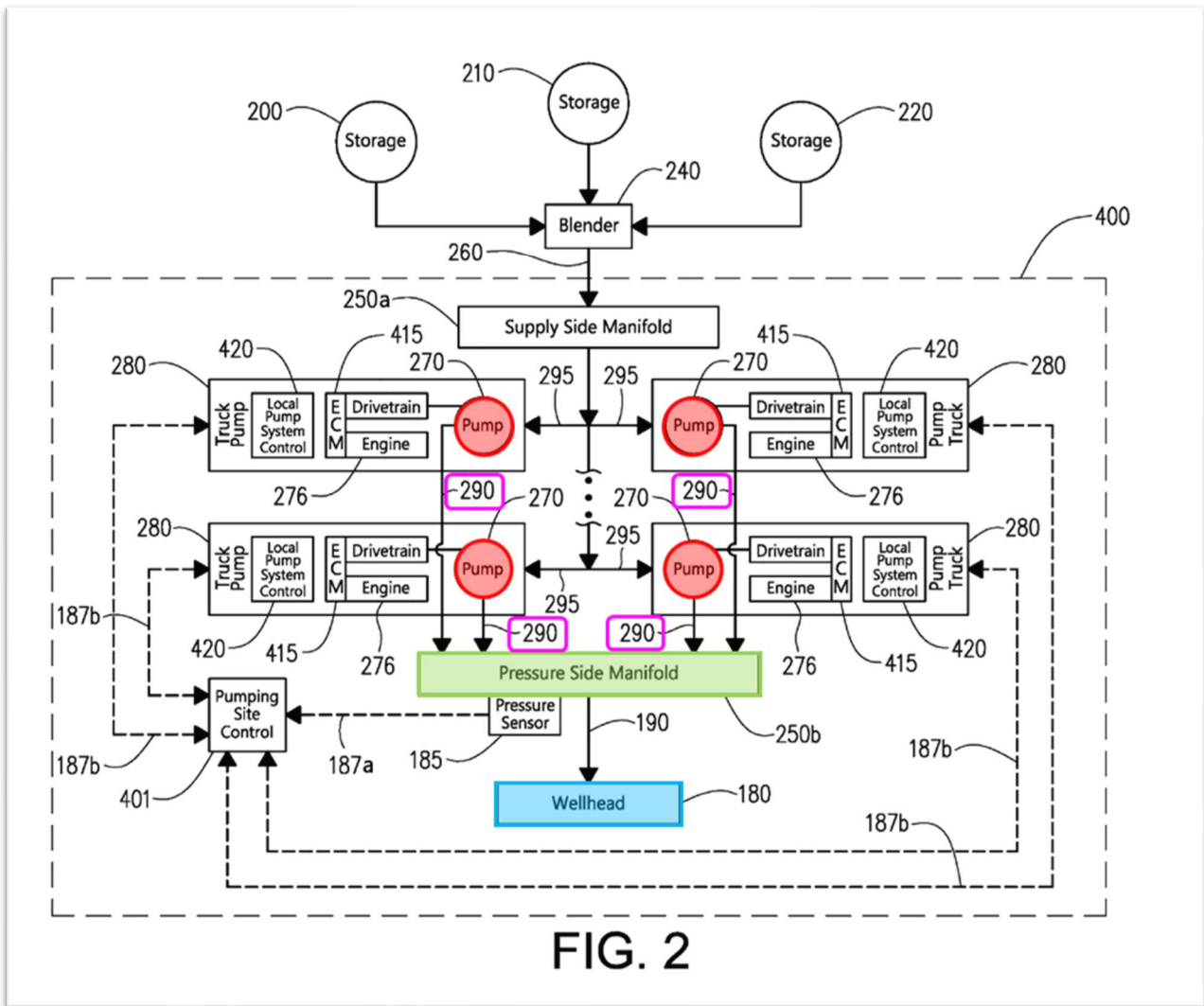
124. *Norris* discloses this limitation. *Norris* discloses a combination of manifolds and flowlines that consolidate the fracturing fluid from the pumps and carries it to the wellhead for injection into the well. For example, *Norris* discloses

that “[p]ressure flowlines 290 from PD pumps 270 communicate the highly pressurized wellbore servicing fluid to the pressure-side manifold 250b.”¹³⁰ *Norris* further teaches “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 [annotated in red] forces the wellbore service fluid into a pressure-side manifold 250b [annotated in green] via pressure flow lines 290 [annotated in magenta] and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”¹³¹

125. Fig. 2 of *Norris* further shows a distribution system of pipes and manifolds that consolidate fluid from the various pumps and deliver fluid for injection to the wellhead.

¹³⁰ Ex. 1004 (Norris) [0026].

¹³¹ Ex. 1004 (Norris) [0022].



126. Accordingly, *Norris* discloses limitation 1[b].

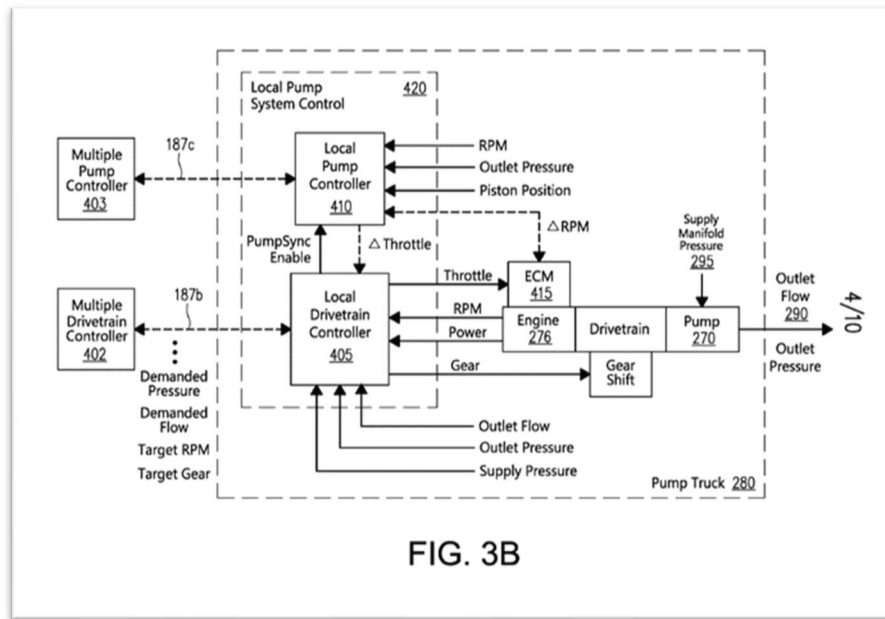
4. 1[c]: “a control system comprising:”

127. *Norris* discloses a control system. *Norris* teaches “pump management system 400 includes an application controller 401. Application controller 401 manages the overall pumping operation.”¹³² FIGS 3A and 3B of *Norris* “provide a

¹³² Ex. 1004 (*Norris*) [0029].

FIG. 3A

¹³⁴ Norris teaches two different names for the same structure 401: “application controller 401” primarily in the specification and “Pumping site control 401” primarily in the figures. For example, [0029] states “With reference to FIGS. 2-4B, pump management system 400 includes an application controller 401.” However, in each of Figs. 2-4B structure 401 is named “Pumping Site Control” or “Pumping Side Control”. I understand that both names for structure 401 refer to the same structure and use the names interchangeably, as does *Norris*.

Ex. 1004 (*Norris*) Figs. 3A & 3B

128. *Norris* teaches that “[a]pplication controller 401 receives real time data (analog or digital) via data links from sensors and data processors monitoring fluid pressure and pump operations.”¹³⁵ Further, according to *Norris*, “[a]pplication controller 401 utilizes all of the data received to manage operation of all pumping operations to minimize and preferably eliminate coincidental operation of pumps 270.”¹³⁶

129. The pump management system further includes “local pump control system 420” that controls local pump operation.¹³⁷ Local pump control may include

¹³⁵ Ex. 1004 (*Norris*) [0029].

¹³⁶ Ex. 1004 (*Norris*) [0030].

¹³⁷ Ex. 1004 (*Norris*) [0032], Figs. 2-4.

a “local pump controller” and “local drivetrain controller” for monitoring, communicating, and controlling pump operating parameters.¹³⁸

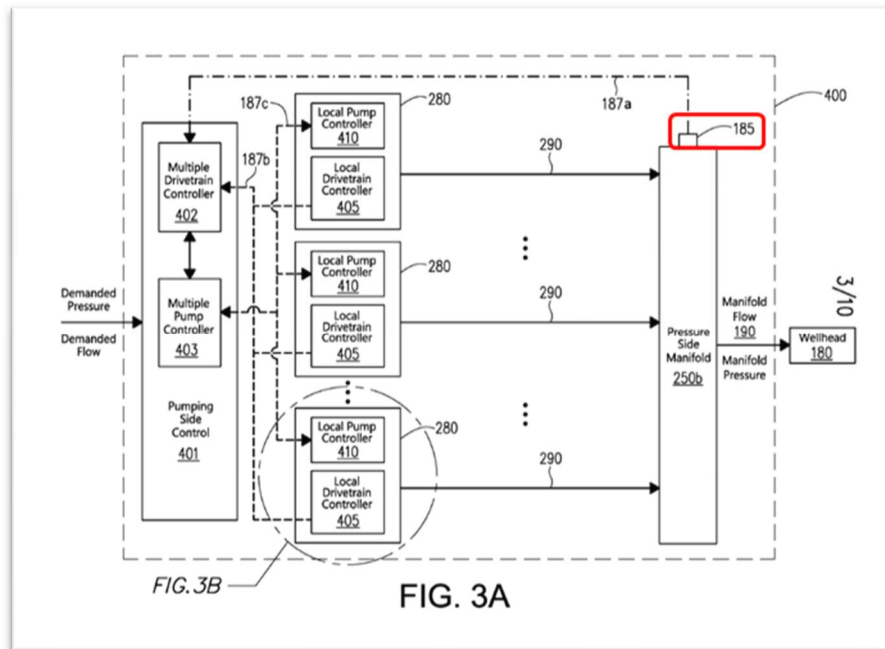
130. Accordingly, *Norris* discloses a control system for local and global control. As discussed in the subsections below, *Norris* discloses, or at least renders obvious, each of the limitations of the control system. Thus, *Norris* discloses limitation 1[c].

5. 1[d]: “a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;”

131. *Norris* discloses a plurality of sensors configured to measure one or more parameters of the plurality of pumps and the distribution system. *Norris* teaches, for example, “a pressure sensor 185 [annotated in red] monitors fluid pressure within pressure-side manifold 250b. [] Additionally, fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b. Sensors, not shown, monitor both static pressure and dynamic pressure fluctuations within the common fluid conduits and pressure-side manifold 250b.”¹³⁹

¹³⁸ Ex. 1004 (*Norris*) [0032]- [0037], Figs. 3-4.

¹³⁹ Ex. 1004 (*Norris*) [0030]

Ex. 1004 (*Norris*) Fig. 3A (annotated)

132. As another example, *Norris* teaches “PD pump 270 may include an optional piston monitoring sensor.”¹⁴⁰ Further, “a signal indicative of top dead center for the pistons in PD pump 270 will be provided to application controller 401 to maintain non-coincidental operation of PD pumps 270. That signal is provided by using ECM 415, local pump truck controller 420 or a piston position sensor associated with PD pump 270. For example, the piston position sensor outputs a signal once with each revolution of the PD pump's 270 crankshaft. [] In FIG. 3B, the piston position sensor provides either digital or analog data reflecting the position of the pistons in PD pump 270 to local pump controller 410 via a datalink 187c.”¹⁴¹

¹⁴⁰ Ex. 1004 (*Norris*) [0032].

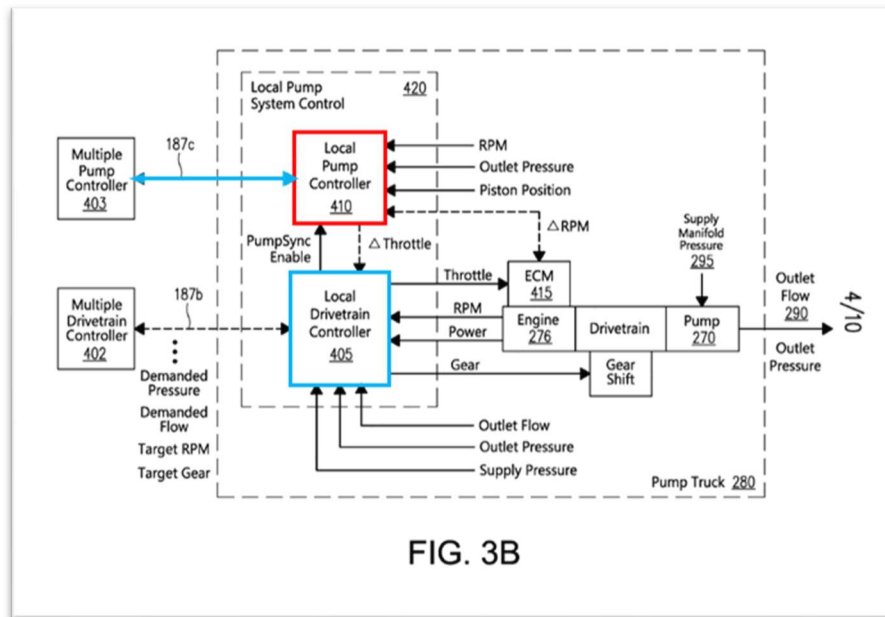
¹⁴¹ Ex. 1004 (*Norris*) [0033].

Further still, “[l]ocal pump controller 410 receives data input from ECM 415, including but not limited to engine RPM piston position and PD pump 270 outlet pressure.”¹⁴²

133. Further, *Norris* discloses that “fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b.”¹⁴³ Fig. 3B shows that, in addition to pump outlet pressure and flowrate, discussed above, sensors monitor RPM, Piston Position, and supply pressure. These parameters are sent to at least Local Drivetrain Controller 405 (annotated in blue) and Local Pump Controller 410 (annotated in red).

¹⁴² Ex. 1004 (*Norris*) [0035].

¹⁴³ Ex. 1004 (*Norris*) [0030].

Ex. 1004 (*Norris*) Fig. 3B (annotated)

134. Further examples of sensors measuring parameters of the pump include sensors to monitor “engine piston position, spark management, [and] throttle position.”¹⁴⁴ Accordingly, *Norris* discloses limitation 1[d].

6. 1[e][i]: “one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and

135. *Norris* provides numerous examples of one or more processing devices configured to receive a first parameter from a first device and transmit the first parameter to a second device. *Norris* discloses a group of data links: 187a, 187b,

¹⁴⁴ Ex. 1004 (*Norris*) [0032].

187c, each of which “provide data from sensors and other data processor associated with pump trucks 280, pressure manifold 250b, and other monitored operations” to various destinations including “application controller 401 and [] pump system control 420.”¹⁴⁵ *Norris* further teaches that “[a]ll data links discussed herein may be hard-wired connections such as a connection between serial ports, Ethernet ports, USB ports, fieldbus networks and industrial networks (e.g. CANbus, Modbus, etc.) or combinations thereof. Alternatively, the data links may be wireless connections.”¹⁴⁶ A POSITA, based on the general knowledge of basic communication protocols, would have understood that at least Ethernet, USB, Fieldbus, CANbus, Modbus and wireless protocols require a processing device on each end of the data link in order to translate the data (e.g. sensor data) into the appropriate protocol. Therefore, *Norris* discloses, or at least it would have been obvious to a POSITA, that any communication between sensors and controllers, or between controllers and controllers, using the data links and containing “a first parameter” would have included one or more processing devices (i.e. protocol translators) configured to receive a first parameter from a first device and transmit the first parameter to a second device. A POSITA would also have understood, as

¹⁴⁵ Ex. 1004 (*Norris*) [0031].

¹⁴⁶ Ex. 1004 (*Norris*) [0029]

discussed above with regard to 1[d], that a “first parameter” would have included any of the parameters measured by the sensing devices.

136. A POSITA would also have known, based on the teachings of *Norris* to use common communication protocols, to establish communications interfaces or networks containing “one or more processing devices” to receive communications from sensors or pumping operations and transmit those communications (including measured parameters) to control devices. For example, communications interfaces or networked processing devices may perform various functions, such as providing redundant data links, cleaning up raw data, storing or backing up data, or monitoring sensor or network function.

137. Other examples of “processing devices” are abundant in *Norris*. For example, *Norris* discloses that “[a]pplication controller 401 receives real time data (analog or digital) via data links from sensors and data processors monitoring fluid pressure and pump operations,” and also “manages the overall pumping operation.”¹⁴⁷ Application controller 401 manages the pumping process by using processors to implement algorithms (e.g. adaptive filter algorithms, least mean squared adaptive filter), perform communications (e.g. receive sensor information and transmit commands), and exercise control.¹⁴⁸

¹⁴⁷ Ex. 1004 (*Norris*) [0029].

¹⁴⁸ Ex. 1004 (*Norris*) [0040] – [0043].

138. Similarly, local pump control systems 420 contains processors that “manages the operation of the drivetrain 276 to drive pump 270 at the desired rate”, including communications, calculations and control.

139. The ECM is another processing device that receives operating parameters from pumping components or sensors. For example, ECM 415 receives “engine parameters” from the engine or drivetrain such as “engine piston position, spark management, throttle position, ... and other common engine management operations.”¹⁴⁹ Specific examples of combinations of equipment in *Norris* that teach one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and generate automated control instructions at the second device based at least in part on the first parameter are contained below in Section XI.A.10.

140. Accordingly, *Norris* discloses limitation 1[e][i], or at least it would have been obvious to a POSITA based on the teachings of *Norris*.

¹⁴⁹ Ex. 1004 (*Norris*) [0032], Figs. 3-4.

7. 1[e][iii]: “detect that the first parameter is outside of an acceptable threshold; and”

141. There is nothing inventive about detecting that a first parameter is outside an acceptable threshold, and then taking action based on the comparison. For example, HVAC¹⁵⁰ thermostats located in many homes, commercial buildings and automobiles compare the ambient temperature (measured parameter) to a threshold (temperature setting) and then take action (turn on or increase cooling or heating) to correct the measured parameter. As another example which would have been well known to a POSITA, an automobile cruise control detects that a first parameter (e.g. vehicle speed) is outside of an acceptable threshold (speed setting) and then takes action (increase or decrease throttle) in order to correct the parameter. As another example, many industrial and even commercial installations use compressed air to, for example, operate valves or air driven tools. In order to have an available air supply when needed, tanks are maintained at a specific air pressure. The control system for the air compressors (even those as simple as a pressure switch) sense the air pressure and detect that the air pressure is outside of an acceptable threshold (i.e. too low) and then signals the air compressor to turn on and compress air into the tank(s). Each of these examples, and many more, would have been known to a POSITA at the time of the ‘435 Patent.

¹⁵⁰ Heating, Ventilation and Air Conditioning

142. *Norris* also discloses detecting that the first parameter is outside of an acceptable threshold. *Norris* discloses that operational parameters, including for example piston position, RPM, pump output pressure and “pressure data from common downstream fluid conduits including pressure-side manifold 250b”¹⁵¹ *are* “input into application controller 401 determine the desired pressure and flow rates at pressure side manifold 250b and wellhead 180. *Upon variation from the desired settings*, multiple drivetrain controller 402 will signal each local drivetrain controller 405 to increase or decrease pumping operations.”¹⁵²

143. To the extent that *Norris* does not explicitly disclose the use of a “threshold”, it would have been obvious to a POSITA to use a “threshold”, such as a specific size of “error”¹⁵³ to determine when to issue control components, based at least on the knowledge of a POSITA regarding the common use of “thresholds” in control applications for decades prior to the ‘435 Patent. For example, I used thresholds in control applications, for example to turn on or off pumps or compressors, at least by the early 1990s.

144. Accordingly, *Norris* discloses detect[ing] that the first parameter is outside of an acceptable threshold.

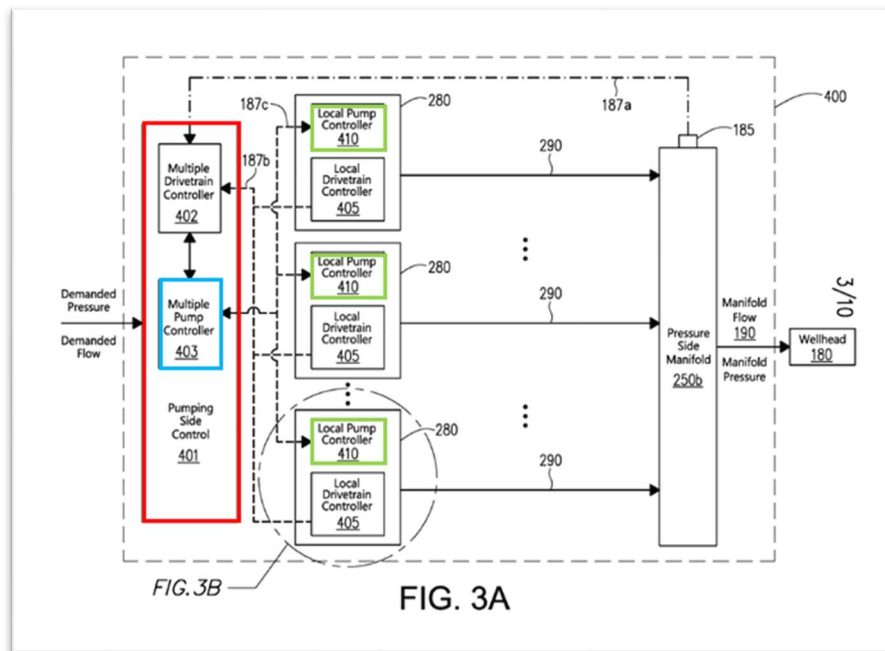
¹⁵¹ Ex. 1004 (*Norris*) [0034].

¹⁵² Ex. 1004 (*Norris*) [0037], emphasis added.

¹⁵³ In control systems, “error” is the difference between a desired parameter being controlled and the measurement of the parameter.

8. 1[e][iii]: “generate automated control instructions at the second device based at least in part on the first parameter; and”

145. As discussed above example, *Norris* teaches “[u]tilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 [part of application controller 401, annotated in blue] will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations. Upon selection of the adjustment needed, multiple pump controller 403 will direct local pump controller 410 [annotated in green] to signal the necessary changes in throttle position to control pump RPM and piston position.”¹⁵⁴



Ex. 1004 (*Norris*) Fig. 3A (annotated)

¹⁵⁴ Ex. 1004 (*Norris*) [0039].

146. *Norris* further teaches that once the application controller 401 determines the adjusted pumping operations (e.g. speed or throttle adjustment), “local pump system control 420 provides two paths to achieve a change in throttle position necessary for producing a change in engine RPM. [] In the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 [annotated in green above] and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta above]. In the second path, local pump controller 410 transmits an RPM change command to ECM 415. In this path, ECM 415 changes engine RPM in response to the change in RPM signal from ECM 415. The change in RPM directs a change in drivetrain 276 operation (e.g., such as a change in the throttle or engine operation).”¹⁵⁵ Thus, *Norris* discloses that the local pump controller 410 generates automated control instructions and sends to either the local drivetrain controller 405 or ECM 415 of the pump truck 280.

147. Because these automated control instructions are based on the adjustment to pumping operations that was determined by the multiple pump controller 403 based, in part, on the data from pressure manifold 250b (e.g. pressure from sensor 185), from the wellhead, or from the data initially received from local pump controller 410 (e.g. piston position, pressure, flowrate) as discussed above in Section XI.A.6 regarding limitation 1[e][i], the automated control instructions from

¹⁵⁵ Ex. 1004 (*Norris*) [0038]

the local pump system control 420 are based, at least in part, on those data from pressure sensor 185, the first pump, and/or the wellhead.

148. In the “alternate arrangement” taught by *Norris*, described more fully below in Section XI.A.10, the local pump controller 410 of one pump (e.g. pump 1) acts as the multiple pump controller 403. Pump 1 local pump controller 410 (acting as multiple pump controller 403) generates the instructions based, at least in part, on the data received from the other pumps (e.g. pump 2 piston position, pressure, flowrate).

149. Accordingly, *Norris* discloses generating automated control instructions (e.g., increased throttle command to drivetrain controller 405 or ECM 415) at the second device (pump 2) based at least in part on the first parameter (e.g. pressure from sensor 185 and/or the wellhead). Further *Norris* discloses generating automated control instructions (e.g. change in pumping operations) at the second device (e.g. pump 1) based at least in part on the first parameter (e.g. pump 2 piston position, pressure, flowrate).

150. Thus, *Norris* discloses limitation 1[e][iii].

9. **1[f]: “one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.”**

151. *Norris* discloses this limitation. As discussed above, once local pump control 420 receives instructions to change pumping operation, it then “transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415. In the second path, local pump controller 410 transmits an RPM change command to ECM 415.”¹⁵⁶ *Norris* teaches that “electronic control module (ECM) 415 [is] suitable for monitoring and managing engine operations. ECM 415 monitors engine parameters such as, but not limited to, engine piston position, spark management, throttle position and management and other common engine management operations typically managed or monitored by an ECM.”¹⁵⁷ Accordingly, each of local drivetrain controller 405 and ECM 415 are examples of a control device configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.

152. Accordingly, *Norris* discloses one or more control devices (local drivetrain controller 405 or ECM 415) configured to receive the automated control instructions (adjusted throttle command from local pump control 420) and

¹⁵⁶ Ex. 1004 (*Norris*) [0038].

¹⁵⁷ Ex. 1004 (*Norris*) [0032].

automatically adjust one or more aspects of the second device (pump truck 280). Accordingly, *Norris* discloses limitation 1[f].

10.Examples of *Norris*' disclosure of limitations 1[e] – 1[f]

153. As discussed above, each of the examples below is drawn from the embodiment of *Norris* shown in Figs. 3A – 3B, and thus are each compatible with each other. They are merely separated here for clarity.

a) Example 1A

154. In Example 1A, the first device is “Pressure Side Manifold 250b”, the application controller is the “one or more processing devices” and the second device(s) are the pump truck(s) 280. The “control device” is the local drivetrain controller 405 or ECM 415 of the pump trucks 280.

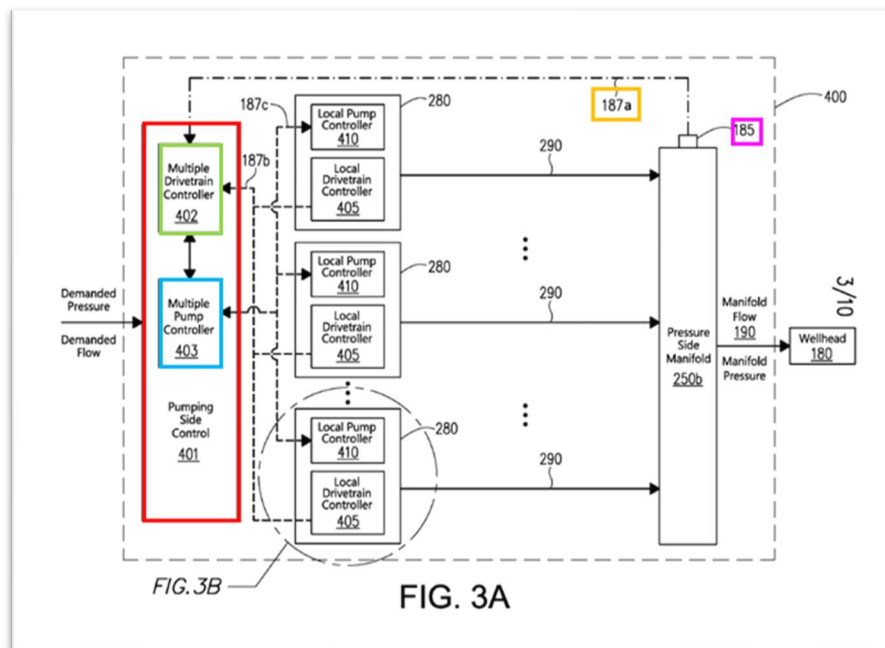
Limitation 1[e][i]

155. *Norris* discloses that “pressure sensor 185 monitors fluid pressure within pressure-side manifold 250b. Data from pressure sensor 185 [annotated in magenta below] is transmitted via data link 187a [annotated in orange below] to application controller 401[annotated in red below].”¹⁵⁸ Further, *Norris* teaches that “[a]pplication controller 401 may also receive data directly or indirectly from sensors monitoring wellhead 180.”¹⁵⁹ *Norris* further teaches that “[a]pplication controller 401 utilizes all of the data received to manage operation of all pumping

¹⁵⁸ Ex. 1004 (*Norris*) [0030].

¹⁵⁹ Ex. 1004 (*Norris*) [0030].

operations to minimize and preferably eliminate coincidental operation of pumps 270.”¹⁶⁰ As shown below in Fig. 3A of *Norris*, application controller 401 (sometimes referred to in the figures as pump site control 401 or pump side control 401) comprises Multiple Drivetrain Controller 402 [annotated in green below] and Multiple Pump Controller 403 [annotated in blue below].



Ex. 1004 (*Norris*) Fig. 3A (annotated)

156. A POSITA would have understood that application controller 401 was a “processing device” in that it processes data received, either directly or indirectly, in order to “manage operation of all pumping operations and preferably eliminate coincidental operation of pumps 270”. As an example of the data processing, *Norris*

¹⁶⁰ Ex. 1004 (*Norris*) [0030].

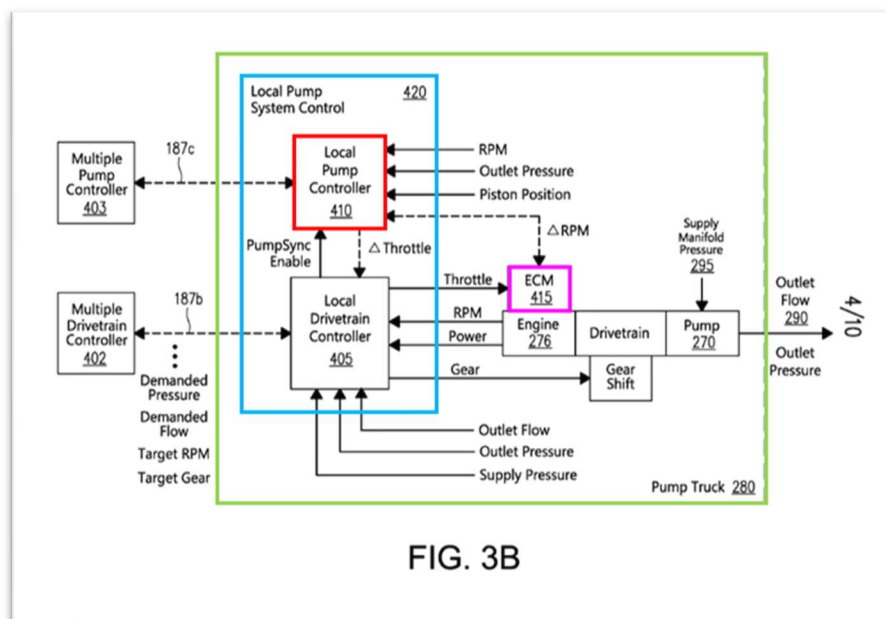
teaches that “multiple pump controller 403 [part of application controller 401] will execute instructions that include the steps necessary to determine an average pressure within common fluid conduits as reported by well head pressure sensor(s) 185. Additionally, multiple pump controller 403 will determine dynamic pressure within pressure side manifold 250b, conduit 190 and wellhead 180. Utilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations.”¹⁶¹ Further, *Norris* teaches that the manifold 250b pressure can be included in this calculation: “If desired, wellhead pressure from sensor 185 may be included in the average pressure determination.”¹⁶² A POSITA would have understood that functions such as determining an “average pressure” would have been performed by a processing device and that application controller 401 was an example of “one or more processing device”.

157. Accordingly, *Norris* discloses one or more processing devices (e.g. application controller 401) configured to receive a first parameter (e.g. pressure) from a first device of the plurality of pumps, the distribution system or the wellhead (e.g. pressure side manifold 250b via pressure sensor 185, wellhead 180).

¹⁶¹ Ex. 1004 (*Norris*) [0039].

¹⁶² Ex. 1004 (*Norris*) [0040].

158. Not only does application controller 401 use the data in its own calculations and processing, but it also forwards the data to other controllers in the system, such as local pump controller 410 (annotated in red below) and local drivetrain control 405, which are part of local pump system control 420 (annotated in blue below), which in turn is part of the plurality of pumps 280 (annotated in green below), which in turn is part of the plurality of pumps 280 (annotated in green below).¹⁶³

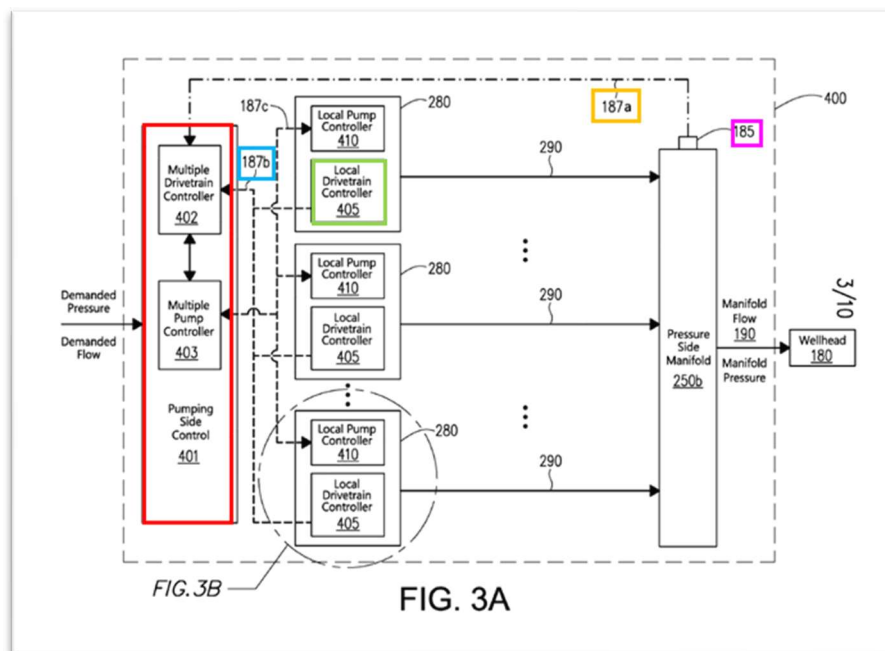


Ex. 1004 (*Norris*) Fig. 3B (annotated)

159. For example, *Norris* teaches that “local drivetrain controller 405 receives data via data links 187b from pressure side manifold 250b and/or wellhead 180 as well as data from multiple drivetrain controller 405 via data link 187b.[]

¹⁶³ See, e.g., Ex. 1004 (*Norris*) [0032] (“Each pump truck 280 also includes a local pump system control 420. Local pump system control 420 includes a local pump controller 410 and a local drivetrain controller 405.”), [0035].

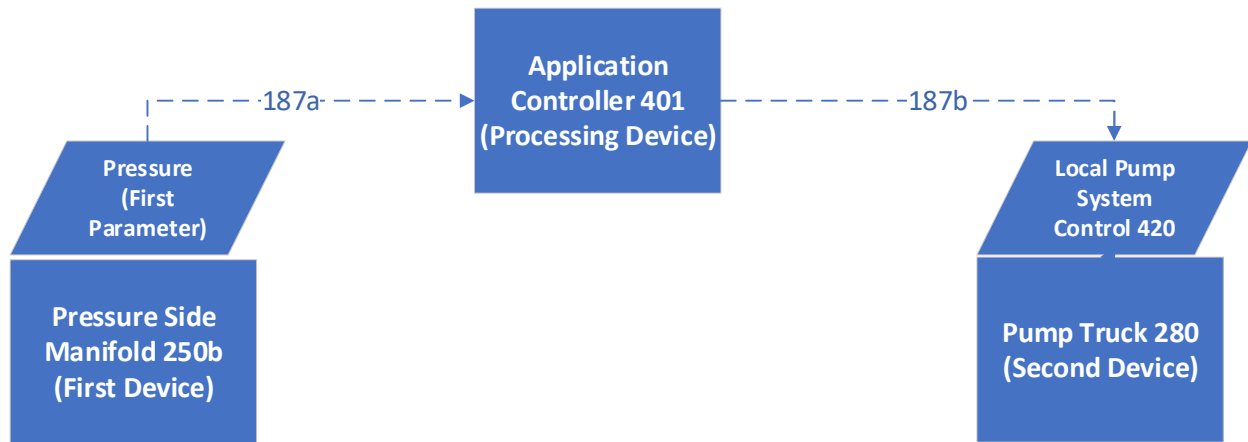
Typically, the data from pressure side manifold 250b and/or wellhead 180 includes outlet flow rates, outlet pressure at the outlet of pressure side manifold 250b and supply pressure at wellhead 180.”¹⁶⁴ As discussed above, data link 187a (annotated in orange) delivers data, such as from pressure sensor 185 on pressure side manifold 250b, to application controller 401. As shown in Fig. 3A, data link 187b (annotated in blue) connects application controller 401 to local drivetrain controller 405 (annotated in green) and delivers data such as the pressure from pressure side manifold 250b and/or wellhead 180.



Ex. 1004 (Norris) Fig. 3A (annotated)

160. Accordingly, the data flow follows the diagram below.

¹⁶⁴ Ex. 1004 (Norris) [0035]- [0036].



161. Thus, *Norris* discloses that the one or more processing devices (e.g. application controller 401) also transmits the first parameter (e.g. pressure) to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead (e.g. the pump truck via the local pump system control).

Limitation 1[e][ii]

162. *Norris* discloses that operational parameters, including for example piston position, RPM, pump output pressure and “pressure data from common downstream fluid conduits including pressure-side manifold 250b”¹⁶⁵ are “input into application controller 401 determine the desired pressure and flow rates at pressure side manifold 250b and wellhead 180. *Upon variation from the desired settings*, multiple drivetrain controller 402 will signal each local drivetrain controller 405 to increase or decrease pumping operations.”¹⁶⁶ This list includes “pressure data from downstream fluid conduits including pressure-side manifold 250b”, which would

¹⁶⁵ Ex. 1004 (*Norris*) [0034].

¹⁶⁶ Ex. 1004 (*Norris*) [0037], emphasis added.

include the pressure data from sensor 185, as discussed above. Further, *Norris* teaches “the step of determining the pressure deviation (e.g., a fluctuation from an average pressure) for each pump may include the step of calculating the difference between the pressure at each pump (e.g., as represented by the signal from each of the pump pressure sensors 430) and the average pressure. The result of the calculation is the pressure deviation (e.g., error) at each pump with respect to time (e.g., in the time domain).”¹⁶⁷ If this pressure deviation is great enough, *Norris* takes steps to modify the pumping speeds in order to maintain non-coincidental pump operation.¹⁶⁸ Accordingly, by determining variation from the desired settings, the second processing device detects that the first parameter (e.g. pressure) is outside of an acceptable threshold.

Limitation 1[e][iii]

163. As discussed above regarding limitation 1[e][ii], *Norris* teaches “[u]tilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 [part of application controller 401, annotated in blue] will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations. Upon selection of the adjustment needed, multiple pump controller 403 will direct

¹⁶⁷ Ex. 1002 (*Norris*) [0040].

¹⁶⁸ Ex. 1002 (*Norris*) [0002], [0006], [0037].

throttle position to control pump RPM and piston position.”¹⁶⁹

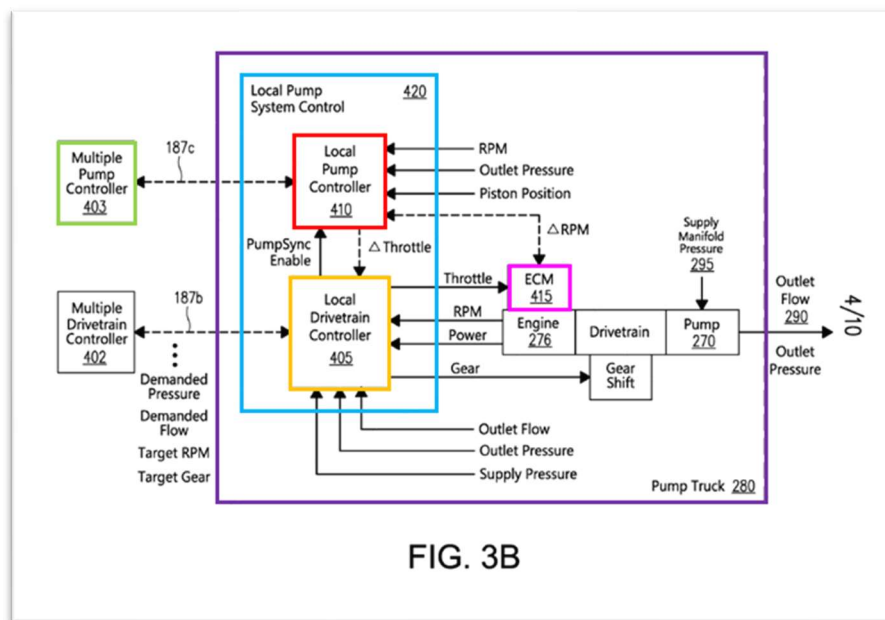


Ex. 1004 (*Norris*) Fig. 3A (annotated)

164. *Norris* further teaches that once the application controller 401 determines the adjusted pumping operations (e.g. speed or throttle adjustment), “local pump system control 420 provides two paths to achieve a change in throttle position necessary for producing a change in engine RPM. [] In the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 [annotated in orange below] and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta below]. In the second path,

¹⁶⁹ Ex. 1004 (*Norris*) [0039].

local pump controller 410 [annotated in red below] transmits an RPM change command to ECM 415. In this path, ECM 415 changes engine RPM in response to the change in RPM signal from ECM 415. The change in RPM directs a change in drivetrain 276 operation (e.g., such as a change in the throttle or engine operation).”¹⁷⁰ Thus, *Norris* discloses that the local pump controller 410 generates automated control instructions and sends to either the local drivetrain controller 405 (annotated in orange below) or ECM 415 of the pump truck 280 (annotated in purple below).



Ex. 1004 (*Norris*) Fig. 3B (annotated)

165. Because these automated control instructions are based on the adjustment to pumping operations that was determined by the multiple pump

¹⁷⁰ Ex. 1004 (*Norris*) [0038]

controller 403 based, in part, on the data from pressure manifold 250b (e.g. pressure from sensor 185), from the wellhead, or from the data initially received from local pump controller 410 (e.g. piston position, pressure, flowrate) as discussed above in Section XI.A.8 regarding limitation 1[e][i], the automated control instructions from the local pump system control 420 are based, at least in part, on those data from pressure sensor 185, the first pump, and/or the wellhead.

166. Therefore, Example 1A demonstrates that *Norris* discloses the limitations of 1[e], or at least they would have been obvious to a POSITA.

Limitation 1[f]

167. As discussed above, once local pump control 420 receives instructions to change pumping operation, it then “transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415. In the second path, local pump controller 410 transmits an RPM change command to ECM 415.”¹⁷¹ *Norris* teaches that “electronic control module (ECM) 415 [is] suitable for monitoring and managing engine operations. ECM 415 monitors engine parameters such as, but not limited to, engine piston position, spark management, throttle position and management and other common engine management operations typically managed or monitored by an ECM.”¹⁷²

¹⁷¹ Ex. 1004 (*Norris*) [0038].

¹⁷² Ex. 1004 (*Norris*) [0032].

Accordingly, each of local drivetrain controller 405 and ECM 415 are examples of a control device configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.

168. Accordingly, *Norris* discloses one or more control devices (local drivetrain controller 405 or ECM 415) configured to receive the automated control instructions (adjusted throttle command from local pump control 420) and automatically adjust one or more aspects of the second device (pump truck 280). Accordingly, Example 1A is an example of *Norris disclosing* the limitations of 1[f].

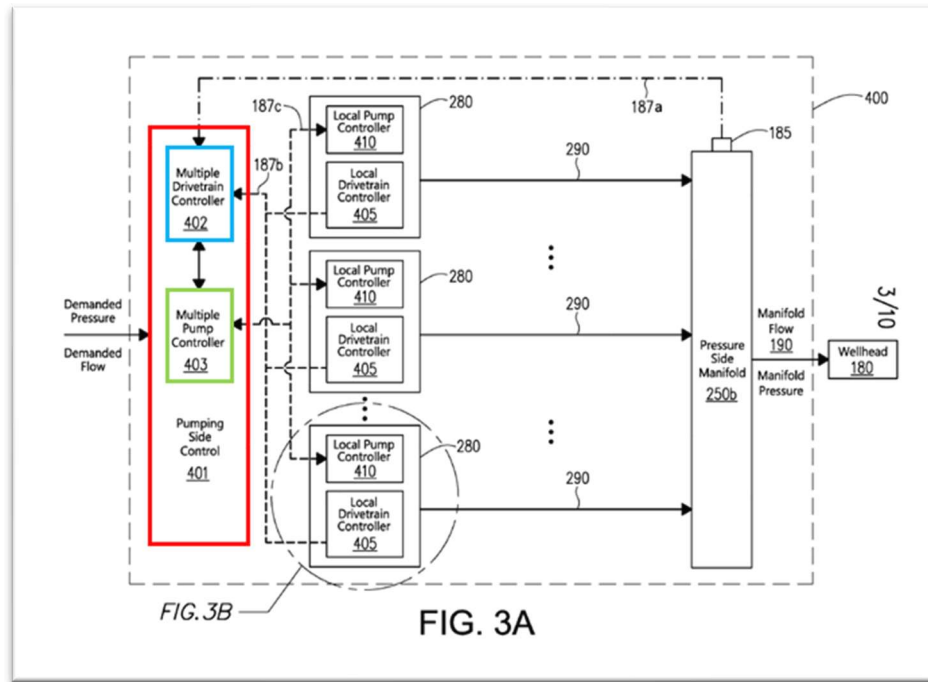
b) Example 1B

169. In example 1B, the first device is one of the pump trucks (e.g. pump truck 2), the second device is another of the pump trucks (e.g. pump truck 1) and the processing device is the local controller of pump truck 1, which is acting as the multiple pump controller 403 in an alternative arrangement taught by *Norris*. The “control device” is the local drivetrain controller 405 or ECM 415 of pump truck 1.

Limitation 1[e][i]

170. As discussed above regarding limitation 1[c], *Norris* teaches that “application controller 401 [annotated in red] includes a multiple drive train

controller 402 [annotated in blue] and a multiple pump controller 403 [annotated in green].”¹⁷³



Ex. 1004 (*Norris*) Fig. 3A (annotated)

171. *Norris* discloses that “[a]s depicted in Fig. 3B, each local pump controller 410 [annotated in orange] provides data to multiple pump controller 403 [annotated in green]. The data exchanged includes but is not limited to: PD pump 270 piston position, engine RPM, and pressure data from common downstream fluid conduits including pressure-side manifold 250b.”¹⁷⁴ As further shown below, Local

¹⁷³ Ex. 1004 (*Norris*) Fig. 3A.

¹⁷⁴ Ex. 1004 (*Norris*) [0034].

Pump Controller 410 is part of Local Pump System control 420 [annotated in blue], which is part of Pump Truck 280 [annotated in dark purple].

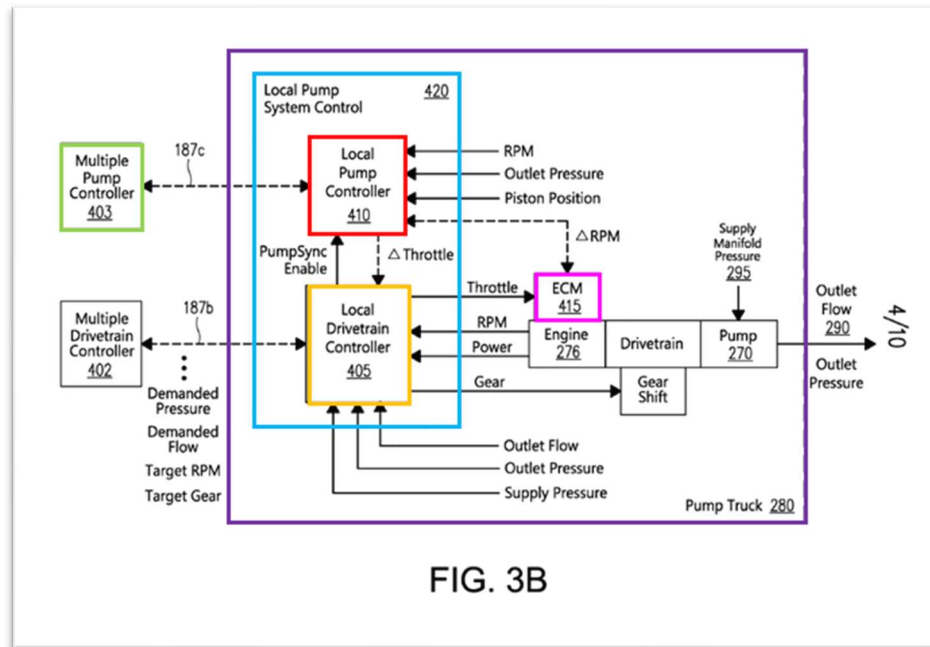


FIG. 3B

Ex. 1004 (*Norris*) Fig. 3B

172. *Norris* discloses that during normal operation, “application controller 401, through multiple drivetrain controller 402 and multiple pump controller 403, controls the operation of each local pump control system 420.”¹⁷⁵ Further, *Norris* teaches that “local drivetrain controller 405 communicates via data link 187b with multiple drivetrain controller 402 and local pump controller 410 communicates with multiple pump controller 403 via data link 187c.”¹⁷⁶ *Norris* teaches further that multiple pump controller 403 uses data obtained from local pump controller 410

¹⁷⁵ Ex. 1004 (*Norris*) [0036].

¹⁷⁶ Ex. 1004 (*Norris*) [0035].

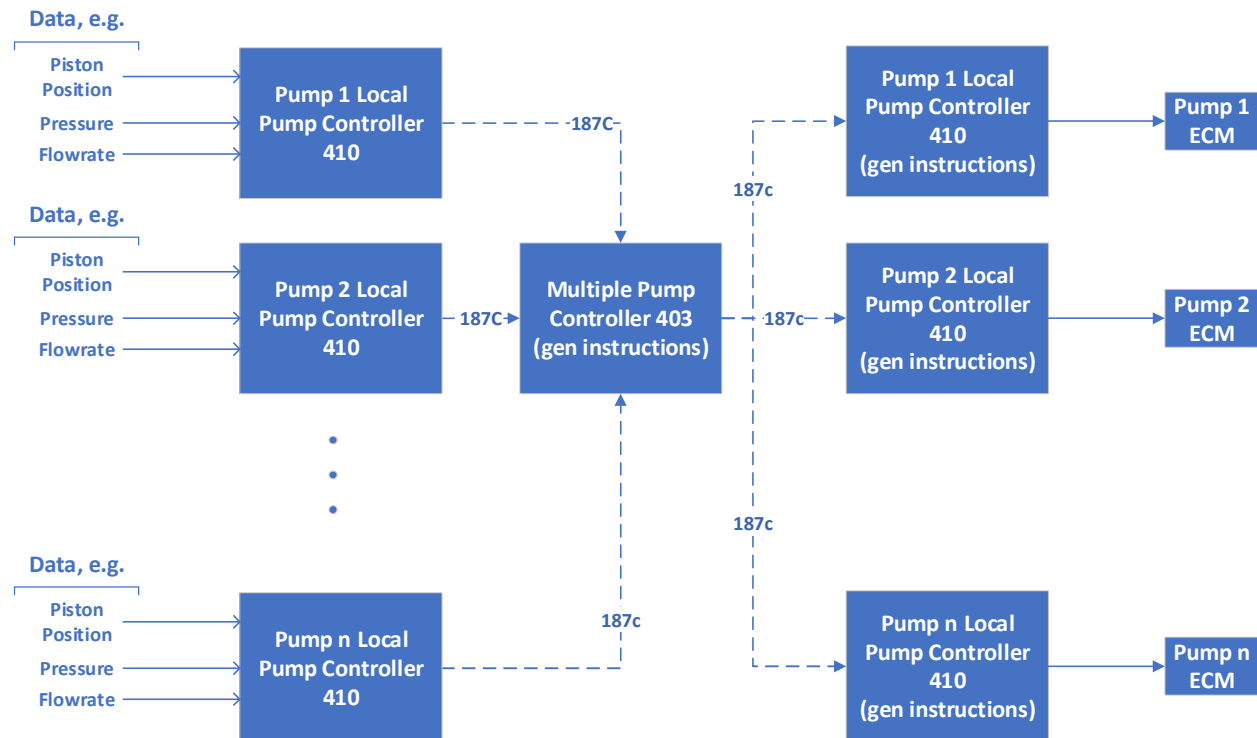
(e.g. piston position, output pressure) to determine whether changes need to be made to the operation of the pumps. For example, *Norris* discloses that “[m]ultiple pump controller 403 uses at least one of: the pressure data, piston position data or other data input, e.g. pump flow rate, in a least mean squared finite impulse response adaptive filter algorithm, as depicted in FIG. 5, to determine when to signal an individual local pump control system 420 to make adjustments in order to preclude coincidental PD pump 270 operation.” Accordingly, multiple pump controller 403 receives data from each local pump controller 410 and uses those data to determine when to signal pump(s), through the “local pump control system 420” to make adjustments to operation of the pumps.

173. Further, once the instructions are received from multiple pump controller 403, “local pump system control 420 provides two paths to achieve a change in throttle position necessary for producing a change in engine RPM. [] In the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta above]. In the second path, local pump controller 410 transmits an RPM change command to ECM 415. In this path, ECM 415 changes engine RPM in response to the change in RPM signal from ECM 415.”¹⁷⁷ Accordingly, local pump controller 420 generates instructions, such as a throttle

¹⁷⁷ Ex. 1004 (*Norris*) [0038].

change command or throttle position, and sends the instructions to the ECM through at least one of the two paths.

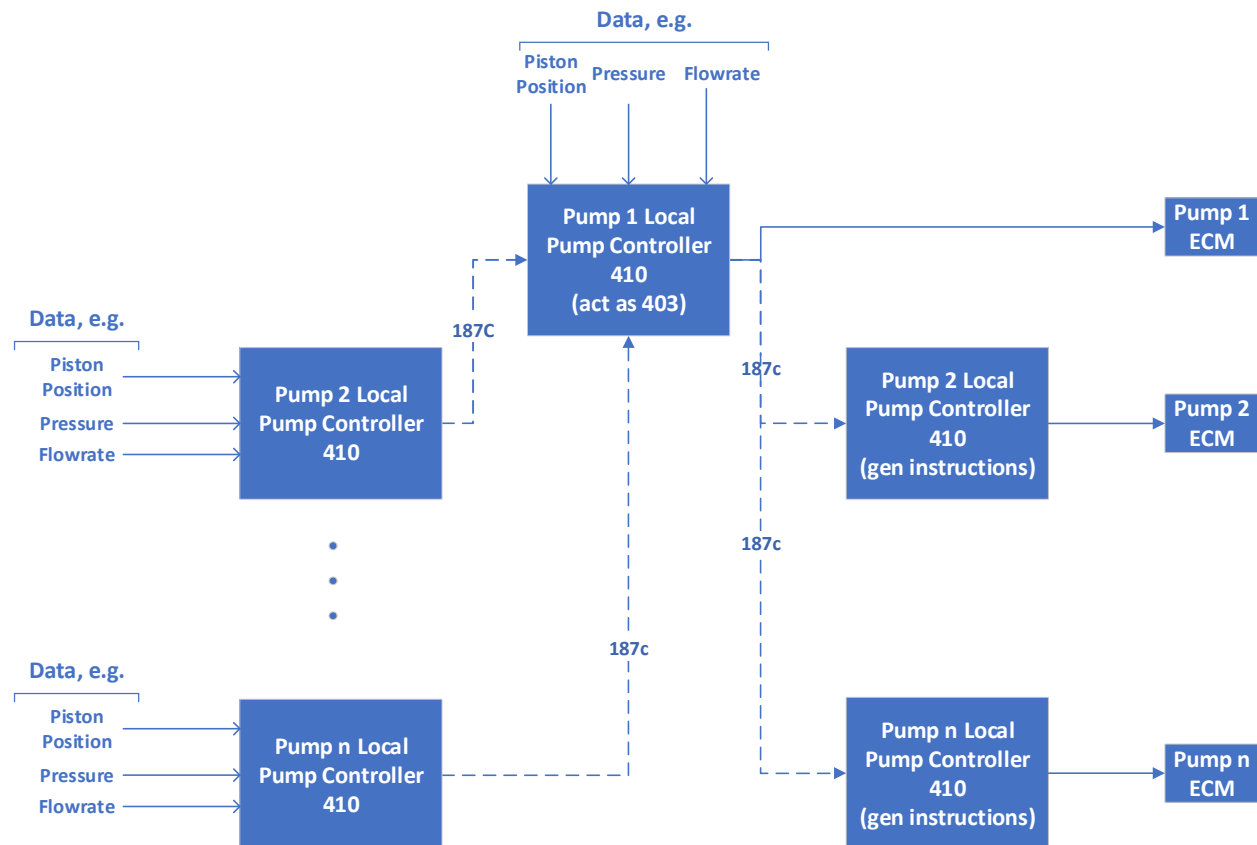
174. Based on the above disclosures of *Norris*, data flow and control instructions are developed and flow according to the diagram below.



175. However, in an alternative arrangement, *Norris* teaches that “each local pump controller 410 may also be capable of operating as multiple pump controller 403. Therefore, in the event of the failure of multiple pump controller 403, or a failure of data link 187c, a previously designated local pump controller 410 may assume overall control of multiple pump controller 403 of the pump management

system 400 as each local pump controller 410 is also in data communication with all other local pump controllers 410 via data link 187c.”¹⁷⁸

176. Accordingly, in such an alternative arrangement, data flow (and instruction generation) would follow the diagram below.



177. Accordingly, *Norris* discloses one or more processing devices (e.g. pump 1 local pump controller 410) configured to receive a first parameter (e.g. pump 2 piston position, pressure, or flowrate) from a first device of the plurality of pumps

¹⁷⁸ Ex. 1004 (*Norris*) [0044].

(e.g. pump truck 2)¹⁷⁹ and transmit the first parameter to a second device (e.g. pump truck 1 via local pump controller 410) of the plurality of pumps.

Limitation 1[e][ii]

178. *Norris* discloses that operational parameters, including for example piston position, RPM, “pump output pressure” and “pressure data from common downstream fluid conduits including pressure-side manifold 250b”¹⁸⁰ are “input into application controller 401 determine the desired pressure and flow rates at pressure side manifold 250b and wellhead 180. *Upon variation from the desired settings*, multiple drivetrain controller 402 will signal each local drivetrain controller 405 to increase or decrease pumping operations.”¹⁸¹ This list includes “pressure data from downstream fluid conduits including pressure-side manifold 250b”, which would include the pressure data from sensor 185, as discussed above. Further, *Norris* teaches “the step of determining the pressure deviation (e.g., a fluctuation from an average pressure) for each pump may include the step of calculating the difference between the pressure at each pump (e.g., as represented by the signal from each of the pump pressure sensors 430) and the average pressure. The result of the

¹⁷⁹ A POSITA would also have known that the local pump controller of pump 2 may receive a first parameter from a pump sensor on pump truck 2 or a communication device implementing a data link. See Section XI.A.6 above. Accordingly, these devices could also be the “first device” of claim 1.

¹⁸⁰ Ex. 1004 (*Norris*) [0034].

¹⁸¹ Ex. 1004 (*Norris*) [0037], emphasis added.

calculation is the pressure deviation (e.g., error) at each pump with respect to time (e.g., in the time domain).”¹⁸²

179. Though *Norris* discloses the specific implementation of determining “variations from the desired settings” taking place in multiple drivetrain controller 402, it would have been obvious to a POSITA to perform the same function (compare to an acceptable threshold) at the local pump control 410 performing the functions of multiple pump controller 403 with a reasonable expectation of success. For example, a POSITA would have understood that the local pump controller 410 (acting in place of multiple pump controller 403) compares parameters to an acceptable threshold in *Norris*’s alternate embodiment of Figure 4, in which “multiple pump controller 403 and multiple drivetrain controller 402” are combined into “a single centralized controller 404.”¹⁸³ As discussed above in Section XI.A.7, the use of thresholds and detecting that a parameter is outside of an acceptable threshold was well-known to a POSITA long before the ‘435 Patent.

180. Accordingly, by determining variation from the desired settings, it would have been obvious that a processing device (local pump controller acting as multiple pump controller 403) detects that the first parameter (e.g. pressure, piston position) is outside of an acceptable threshold.

¹⁸² Ex. 1002 (*Norris*) [0040].

¹⁸³ EX1004, [0046]- [0047], Fig. 4.

Limitation 1[e][iii]

181. In the “alternate arrangement” described above, the local pump controller 410 of one pump truck (e.g. pump truck 1) acts as the multiple pump controller 403. Pump 1 local pump controller 410 (acting as multiple pump controller 403) generates the instructions based, at least in part, on the data received from the other pumps (e.g. pump 2 piston position, pressure, flowrate).

182. Accordingly, *Norris* discloses generating automated control instructions (e.g., increased throttle command to drivetrain controller 405 or ECM 415) at the second device (pump truck 280) based at least in part on the first parameter (e.g. pressure from sensor 185 and/or the wellhead). Further *Norris* discloses generating automated control instructions (e.g. change in pumping operations) at the second device (e.g. pump truck 1) based at least in part on the first parameter (e.g. pump 2 piston position, pressure, flowrate).

183. Therefore, Example 1B demonstrates that *Norris* discloses the limitations of 1[e], or at least they would have been obvious to a POSITA.

Limitation 1[f]

184. Once local pump control 420 of pump truck 1 receives instructions to change pumping operation from local pump control 410 (acting as multiple pump controller 403), it then “transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415. In the second path, local pump controller 410 transmits an RPM change

command to ECM 415.”¹⁸⁴ *Norris* teaches that “electronic control module (ECM) 415 [is] suitable for monitoring and managing engine operations. ECM 415 monitors engine parameters such as, but not limited to, engine piston position, spark management, throttle position and management and other common engine management operations typically managed or monitored by an ECM.”¹⁸⁵ Accordingly, each of local drivetrain controller 405 and ECM 415 are examples of a control device configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.

185. Accordingly, *Norris* discloses one or more control devices (local drivetrain controller 405 or ECM 415 of pump truck 1) configured to receive the automated control instructions (adjusted throttle command from local pump control 420) and automatically adjust one or more aspects of the second device (pump truck 1). Accordingly, *Norris* discloses limitation 1[f].

c) Example 1C

186. In example 1C, the first device is the pump truck 280. The processing device is the communications processor (for data link 187c), and the second device is local pump system control of pump truck 280. The control device is the ECM.

¹⁸⁴ Ex. 1004 (*Norris*) [0038].

¹⁸⁵ Ex. 1004 (*Norris*) [0032].

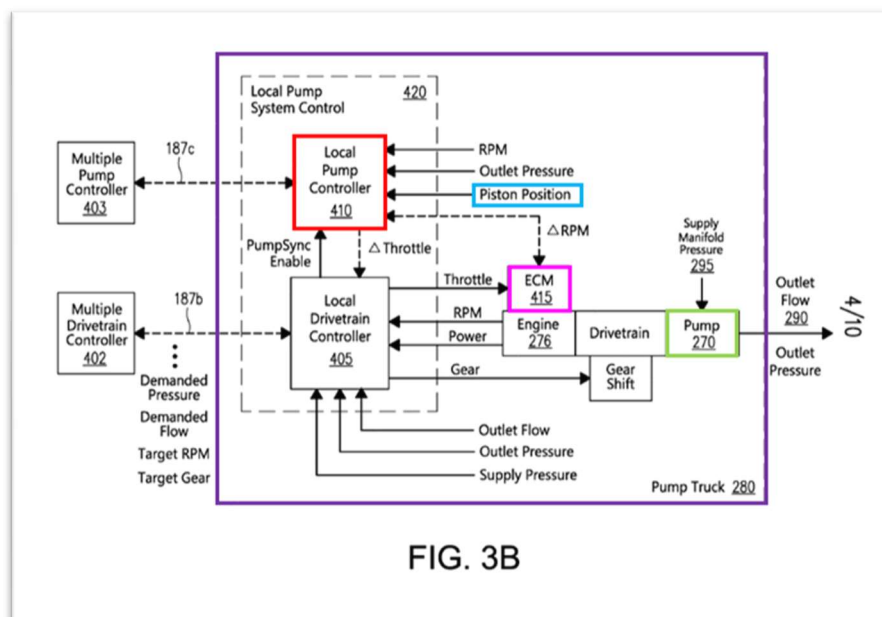
Limitation 1[e][i]

187. As discussed above regarding Limitation 1[d], *Norris* teaches “PD pump 270 may include an optional piston monitoring sensor.” Further, “a signal indicative of top dead center for the pistons in PD pump 270 will be provided to application controller 401 to maintain non-coincidental operation of PD pumps 270. That signal is provided by using ECM 415, local pump truck controller 420 or a piston position sensor associated with PD pump 270. For example, the piston position sensor outputs a signal once with each revolution of the PD pump's 270 crankshaft. [] In FIG. 3B, the piston position sensor provides either digital or analog data reflecting the position of the pistons in PD pump 270 to local pump controller 410 via a datalink 187c.”¹⁸⁶

188. As further discussed above regarding limitation 1[e] in Section XI.A.6, and incorporated herein by reference, it would have been obvious to a POSITA, based on the teachings of *Norris* regarding using protocols requiring a processor on each end of data link 187c (such as Ethernet, USB, Fieldbus, CANbus, Modbus and Wireless) that one or more processing devices (i.e. protocol translators of link 187c) configured to receive a first parameter (i.e. piston position annotated in blue) from a

¹⁸⁶ Ex. 1004 (*Norris*) [0033].

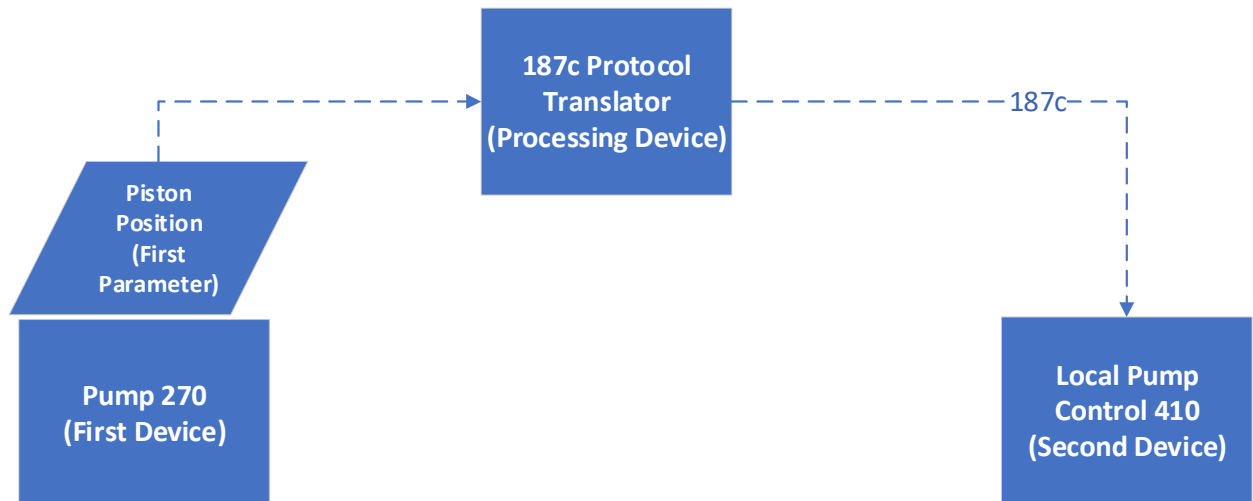
first device (pump 270, annotated in green)¹⁸⁷ and transmit the first parameter to a second device (local pump controller 410 annotated in red) of the plurality of pumps. The local pump controller is “of the plurality of pumps, the distribution system, or the wellhead” because the local pump controller is located at the pump, controls the pump, is directly associated with the pump, and is part of pump truck 280 (annotated in purple) as shown in Fig. 3B.



Ex. 1004 (*Norris*) Fig. 3B (annotated)

189. Based on the disclosures of *Norris* discussed above, data flow of the first parameter follows the diagram below.

¹⁸⁷ A POSITA would also have known that a pump sensor may send piston position to a processing device for transmission over a data link. See Section XI.A.6 above. Accordingly, the pump sensor could also be the “first device” of claim 1.



Limitation 1[e][ii]

190. *Norris* teaches detecting that the first parameter (piston position) is outside an acceptable threshold, or at least it would have been obvious to a POSITA to do so. For example, *Norris* discloses that “a signal indicative of top dead center for the pistons in PD pump 270 will be provided to application controller 401 to maintain non-coincidental operation of PD pumps 270. That signal is provided by using ECM 415, local pump truck controller 420 or a piston position sensor associated with PD pump 270.”¹⁸⁸ *Norris* teaches that “each local pump controller 410 provides data to multiple pump controller 403. The data exchanged includes but is not limited to: PD pump 270 piston position, engine RPM.”¹⁸⁹ *Norris* teaches that multiple pump controller 403 uses these data to provide “provides control over PD

¹⁸⁸ Ex. 1004 (*Norris*) [0033]

¹⁸⁹ Ex. 1004 (*Norris*) [0034]

pump 270 speed through change in engine RPM. Application controller maintains the new engine RPM until pressure signals from sensor 185 and other downstream sensors *or the piston position sensor* no longer reflect coincidental pump operation.”¹⁹⁰

191. Accordingly, *Norris* teaches, using this example, detecting that the first parameter (piston position) is outside an acceptable threshold (non-coincidental pump operation). Further, it would have been obvious to a POSITA to use a “threshold”, such as a particular time difference or piston angle difference, to determine when the pumps are in non-coincidental pump operation, based on the first parameter (piston position), as the use of thresholds in control applications were well known to a POSITA long before the ‘435 Patent.

192. To the extent that Patent Owner argues that the detecting step is not performed by the “processing device” in this example (i.e. protocol translators of link 187c), the limitation claims “one or more processing devices”, such that a network of processing devices (such as the protocol translator, local pump control 410¹⁹¹ and application controller 401) can perform the functions of the limitation.

¹⁹⁰ Ex. 1004 (*Norris*) [0038].

¹⁹¹ For example, local pump system control compares measured and “desired rate[s]” to manage pump operation. Ex. 1004 (*Norris*), [0035], [0038], Fig. 3B.

Limitation 1[e][iii]

193. *Norris* teaches that local pump system control (including local pump controller 410) “manages the operation of the drivetrain 276 to drive pump 270 at the desired rate.”¹⁹² As described above, multiple pump controller 403 directs the overall pumping system to maintain non-coincidental operation of the pumps by comparing, for example, piston position of the pumps (first parameter). *Norris* further teaches that “the primary adjustment to preclude coincidental operation of PD pumps 270 is a momentary change in drivetrain 276 operation, e.g. a change in engine (prime mover) RPM.”¹⁹³ *Norris* discloses multiple ways to cause this change in operation including “[i]n the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415. In the second path, local pump controller 410 transmits an RPM change command to ECM 415. In this path, ECM 415 changes engine RPM in response to the change in RPM signal from ECM 415.”¹⁹⁴ The change in engine RPM command generated by the local pump controller 410 is at least in part based on the first parameter (piston position) as piston position was the primary data provided to multiple pump controller 403 which determined a change in RPM was necessary.

¹⁹² Ex. 1004 (*Norris*) [0035]

¹⁹³ Ex. 1004 (*Norris*) [0038].

¹⁹⁴ Ex. 1004 (*Norris*) [0038].

194. Accordingly, *Norris* discloses generating automated control instructions (RPM change command) at the second device (local pump controller 410)¹⁹⁵ based at least in part on the first parameter (piston position).

Limitation 1[f]

195. *Norris* teaches that “electronic control module (ECM) 415 [is] suitable for monitoring and managing engine operations. ECM 415 monitors engine parameters such as, but not limited to, engine piston position, spark management, throttle position and management and other common engine management operations typically managed or monitored by an ECM.”¹⁹⁶ Further, *Norris* teaches that the second device (Local pump controller 410) “receives data input from ECM 415, including but not limited to engine RPM, piston position and PD pump 270 outlet pressure.”¹⁹⁷ As the ECM executes the change in RPM command, it will, accordingly, transmit the current engine RPM to the second device (local pump controller 410) which automatically adjusts one or more aspects of the second device (i.e. modify the change in RPM command). Accordingly, ECM 415 is an example

¹⁹⁵ A POSITA would have understood that the local drivetrain controller may also generate automated control instructions for the ECM to implement, and thus may be an alternate “second device.” Ex. 1004 (*Norris*), [0038], Fig. 3. Alternatively, with reference to claim element 1[f] below, a POSITA would have understood that the local drive train controller may receive automated control instructions from the local pump controller, and thus may be an alternate “control device.”

¹⁹⁶ Ex. 1004 (*Norris*) [0032].

¹⁹⁷ Ex. 1004 (*Norris*) [0035].

of a control device configured to receive the automated control instructions and automatically adjust one or more aspects of the second device (local pump control 410) based on the control instruction.

B. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF SENSING DEVICES ARE INSTALLED ON THE PLURALITY OF PUMPS AND THE DISTRIBUTION SYSTEM, AND SELECTED FROM A GROUP INCLUDING FLOW SENSORS, ACCELEROMETERS, PRESSURE TRANSDUCER, AND TACHOMETERS.”

196. Dependent Claim 2 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 2. *Norris* discloses “[a]s depicted in FIG. 3B, each local pump controller 410 provides data to multiple pump controller 403. The data exchanged includes but is not limited to: PD pump 270 piston position, engine RPM [i.e. from a tachometer], and pressure data [i.e. from pressure transducer 185 on pressure side manifold 250b)” from common downstream fluid conduits including pressure-side manifold 250b.”¹⁹⁸ Further, *Norris* specifically discloses “a pressure sensor 185 [i.e. pressure transducer] monitors fluid pressure within pressure-side manifold 250b.”¹⁹⁹ Further still, *Norris* discloses “fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b.”²⁰⁰

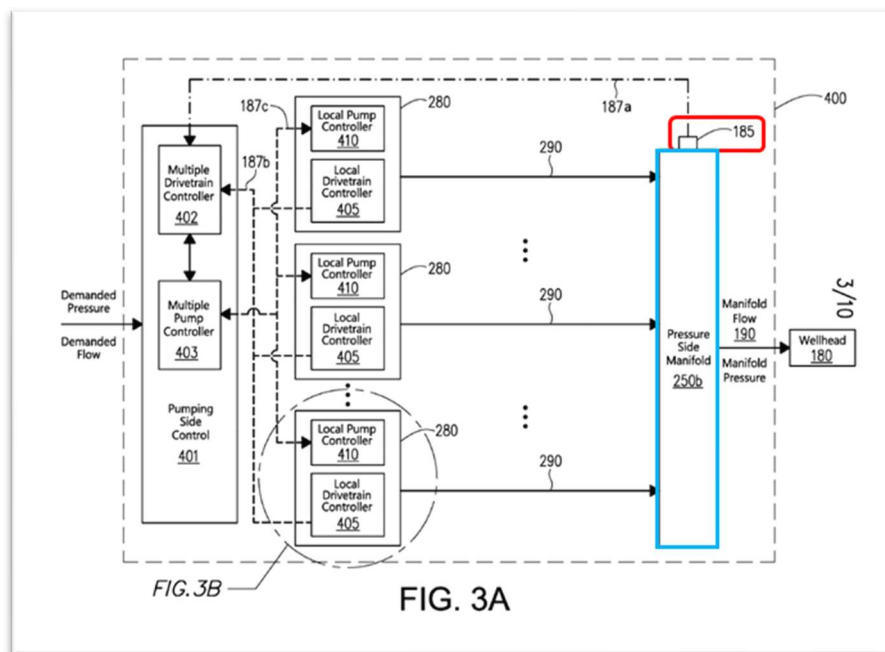
¹⁹⁸ Ex. 1004 (*Norris*) [0033].

¹⁹⁹ Ex. 1004 (*Norris*) [0030].

²⁰⁰ Ex. 1004 (*Norris*) [0030].

197. To the extent that *Norris* does not explicitly disclose a “tachometer”, it would have been obvious to a POSITA that the RPM derived from the piston position sensor, at least suggests the use of a tachometer (e.g., “the piston position sensor outputs a signal once with each revolution of the PD pump's 270 crankshaft,”²⁰¹ coupled with the internal clock of local pump truck controller 420 to derive RPM)

198. *Norris* illustrates and describes that these sensors are installed on the monitored components. For example, as shown in Fig. 3A, pressure sensor 185 (annotated in red) is mounted to pressure-side manifold 250b (annotated in blue).



Ex. 1004 (*Norris*) Fig. 3A (annotated)

²⁰¹ Ex. 1004 (*Norris*) [0033].

199. As another example, *Norris* teaches that “PD pump 270 may include an optional piston monitoring sensor, not shown.”²⁰² Further, *Norris* teaches that “the piston position sensor is a rotary encoder-type sensor (e.g., a shaft encoder), such as an absolute rotary encoder or an incremental rotary encoder.”²⁰³ A POSITA would have understood that a “shaft encoder” would be mounted to the shaft of the pump to encode the rotation of the shaft.

200. Accordingly, *Norris* discloses, or at least renders obvious, Claim 2.

C. DEPENDENT CLAIM 3: “3. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF PUMPS OR THE DISTRIBUTION SYSTEM INCLUDES AT LEAST ONE DEVICE SELECTED FROM A GROUP INCLUDE A GATE, VALVE, ACTUATOR, MOTOR, SUCTION PIPE, DISCHARGE PIPE, ENGINE, TRANSMISSION, AND TEMPERATURE REGULATION DEVICE, CONTROLLABLE VIA THE ONE OR MORE CONTROL DEVICES.”

201. Dependent Claim 3 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 3. *Norris* discloses that “[e]ach of the PD pumps 270 is driven by drivetrain 276 which may include a prime mover such as an *electric motor*, a hydrocarbon powered *engine*, a variable frequency drive or any other motive means suitable for driving a positive displacement pump. Drivetrain 276 may incorporate a *transmission* to provide maximum efficiency for driving the positive displacement pump. Thus, the combination of a PD pump 270 with drivetrain 276 is

²⁰² Ex. 1004 (*Norris*) [0032].

²⁰³ Ex. 1004 (*Norris*) [0033].

a positive displacement pump/drivetrain assembly.”²⁰⁴ As discussed above regarding Claim 1, *Norris* discloses that the engine, motor and transmission are controllable via, for example, Local Drivetrain Controller 405, Local Pump Controller 410, Local Pump System Control 420, and ECM 415).²⁰⁵

202. A POSITA would also understand *Norris*’s disclosure of a “supply-side manifold” and “pressure-side manifold” to contain Claim 3’s “suction pipe,” and “discharge pipe,” as those devices are required to deliver fluid to and consolidate fluid from the pumps.²⁰⁶

203. Accordingly, *Norris* discloses Claim 3.

²⁰⁴ Ex. 1004 (*Norris*) [0024].

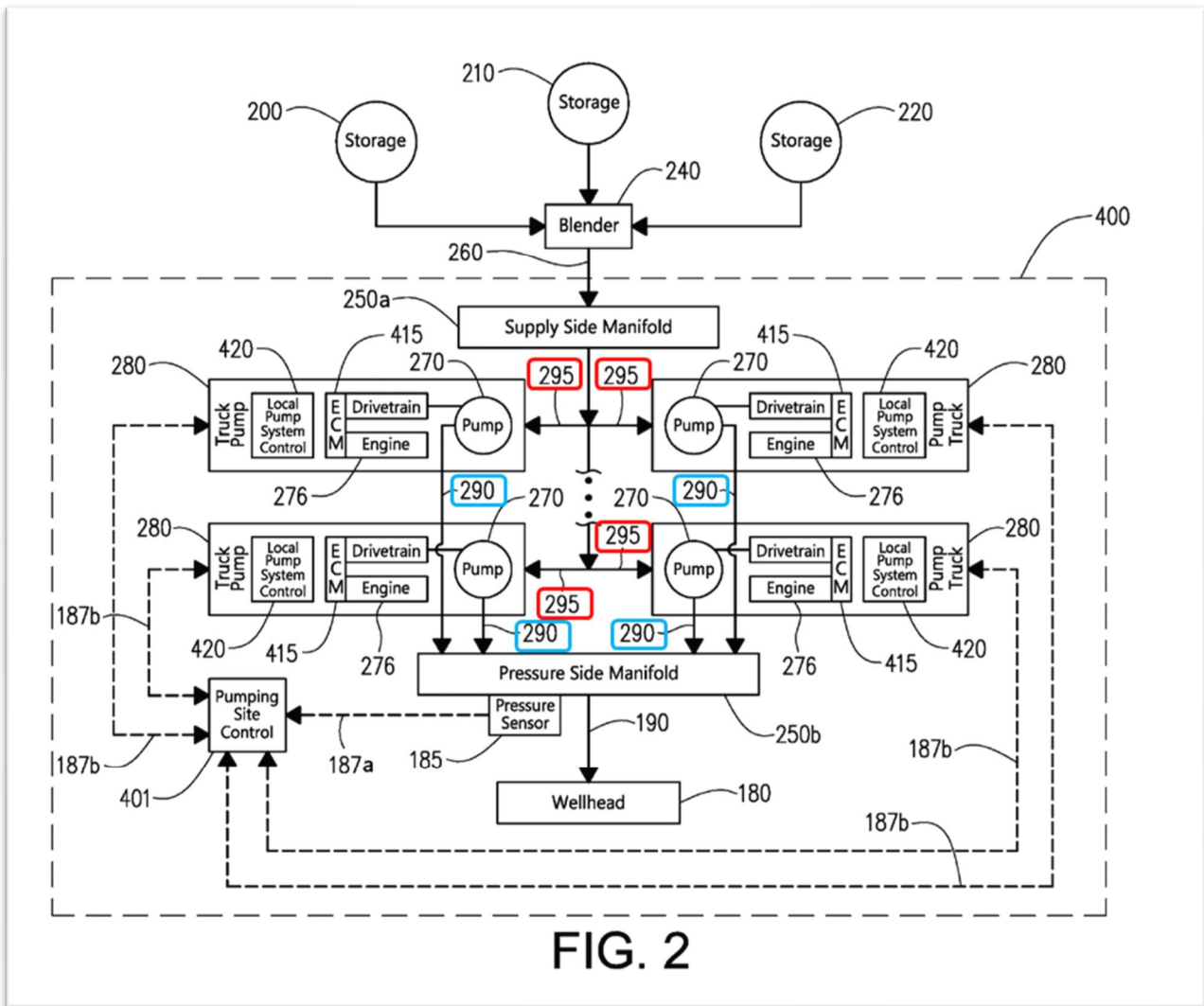
²⁰⁵ See, e.g., Ex. 1004 (*Norris*) [0024], (“Each engine of drivetrain 276 includes an associated electronic control module (ECM) 415 suitable for monitoring and managing engine operations. ECM 415 monitors engine parameters such as, but not limited to, engine piston position, spark management, throttle position and management and other common engine management operations typically managed or monitored by an ECM. Each pump truck 280 also includes a local pump system control 420. Local pump system control 420 includes a local pump controller 410 and a local drivetrain controller 405.”)

D. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: A SUCTION LINE THROUGH WHICH FRACTURING FLUID IS SUPPLIED; AND A DISCHARGE LINE THROUGH WHICH FRACTURING FLUID IS DISCHARGED, WHEREIN THE PLURALITY OF SENSING DEVICES INCLUDES ONE OR MORE FLOW SENSORS CONFIGURED TO MEASURE FLOW THROUGH THE SUCTION LINE AND THE DISCHARGE LINE.”

204. Dependent Claim 4 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 4. *Norris* discloses a suction line and a discharge line. For example, *Norris* discloses that “[e]ach of the positive displacement pumps has a fluid input and a fluid output. The fluid input of each positive displacement pump is in fluid communication with the supply flowline. [] In fluid communication with the fluid output of each positive displacement pump is at least one pressure flowline.”²⁰⁷ Further, *Norris* discloses “supply-side manifold 250a is coupled to any number of high-pressure PD pumps 270 via supply flow lines 295 [annotated in red] and pressure flow lines 290 [annotated in blue]. FIG. 2 depicts four PD pumps 270; however, in alternative embodiments, the number of PD pumps 270 used will vary depending upon the operation served by PD pumps 270. Supply flowlines 295 supply fluid to PD pumps 270 from the low-pressure side of the supply-side manifold 250a. Pressure flowlines 290 from PD pumps 270 communicate the highly pressurized wellbore servicing fluid to the pressure-side manifold 250b.”²⁰⁸

²⁰⁷ Ex. 1004 (*Norris*) [0004].

²⁰⁸ Ex. 1004 (*Norris*) [0026].



205. *Norris* further describes one or more flow sensors configured to measure flow through the suction line and the discharge line. For example, *Norris* discloses “fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b.”²⁰⁹

²⁰⁹ Ex. 1004 (*Norris*) [0030]. See also, e.g., Claim 2.

206. A POSITA would have understood that, using a positive displacement pump, such as taught by *Norris* the flow rate through the discharge line for each pump is the same or essentially the same as the flow rate through the suction line. Accordingly, by measuring flowrate “downstream of each PD pump 270”, *Norris* describes sensing the flowrate through the suction line and the discharge line. Claim 4 recognizes this, as it claims “one or more sensors” for measuring flowrate “through the suction line and the discharge line, describing, at least, one sensor for measuring flowrate through the suction line and the discharge line. Further, the claim language includes using a single sensor to measure flow “through the suction line and discharge line” as it claims “one or more sensors” to perform the measurement.

207. To the extent that the Board finds that Claim 4 requires a distinct flowrate sensor on both the suction (supply) line and the discharge line, such a configuration would have been obvious to a POSITA, based on the teaching of *Norris* to measure flow of the pump. A flow rate sensor on the suction (supply) side would have the same basic configuration and would have provided the same functionality as the flowrate sensor on the discharge side. A POSITA would have been motivated to add flowrate sensors on both the suction and discharge side to, for example, enable the system to detect leaks in the pump, such as through a worn seal. A POSITA would have recognized that, if the flow going into the pump exceeds the flow exiting the pump, then a leak has developed in the pump itself. Depending on

the size of the leak, the pump should be shut down and/or scheduled for maintenance / replacement.

208. Accordingly, *Norris* discloses, or at least renders obvious, Claim 4.

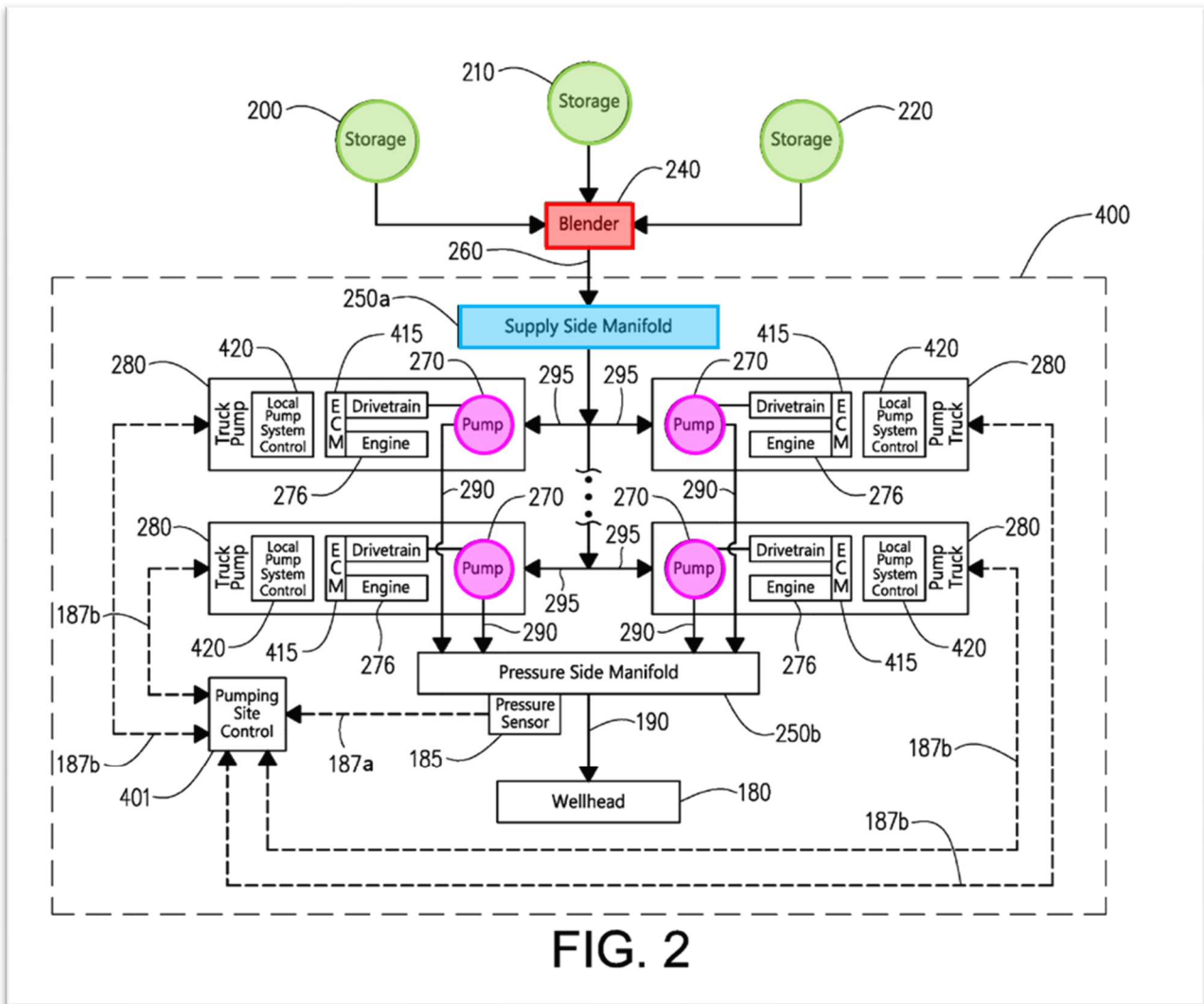
E. DEPENDENT CLAIM 5

209. Dependent Claim 5 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 5, as further described in the subsections below.

1. 5[a]: “The system of claim 1, further comprising: one or more blenders configured to mix together one or more materials to form the fracturing fluid,”

210. *Norris* discloses that “fluid delivery system 205 generally comprises one or more storage vessels (for example, storage vessels 200, 210, and 220, annotated in green) *a blender 240*, [annotated in red], a supply-side manifold 250a [annotated in blue] , a pressure-side manifold 250b, and one or more PD pumps 270 [annotated in magenta]. In FIG. 2, water from storage vessel 200 is introduced, either directly or indirectly, into the blender 240 *where the water is mixed with various other components and/or additives from storage vessels 210 and 220 to form a wellbore servicing fluid* [i.e. fracturing fluid]. The wellbore servicing fluid passes from the blender 240 into a low-pressure side of the supply-side manifold 250a via

flowline 260 and from the supply-side manifold 250a to the PD pumps 270 via supply flowlines 295.”²¹⁰



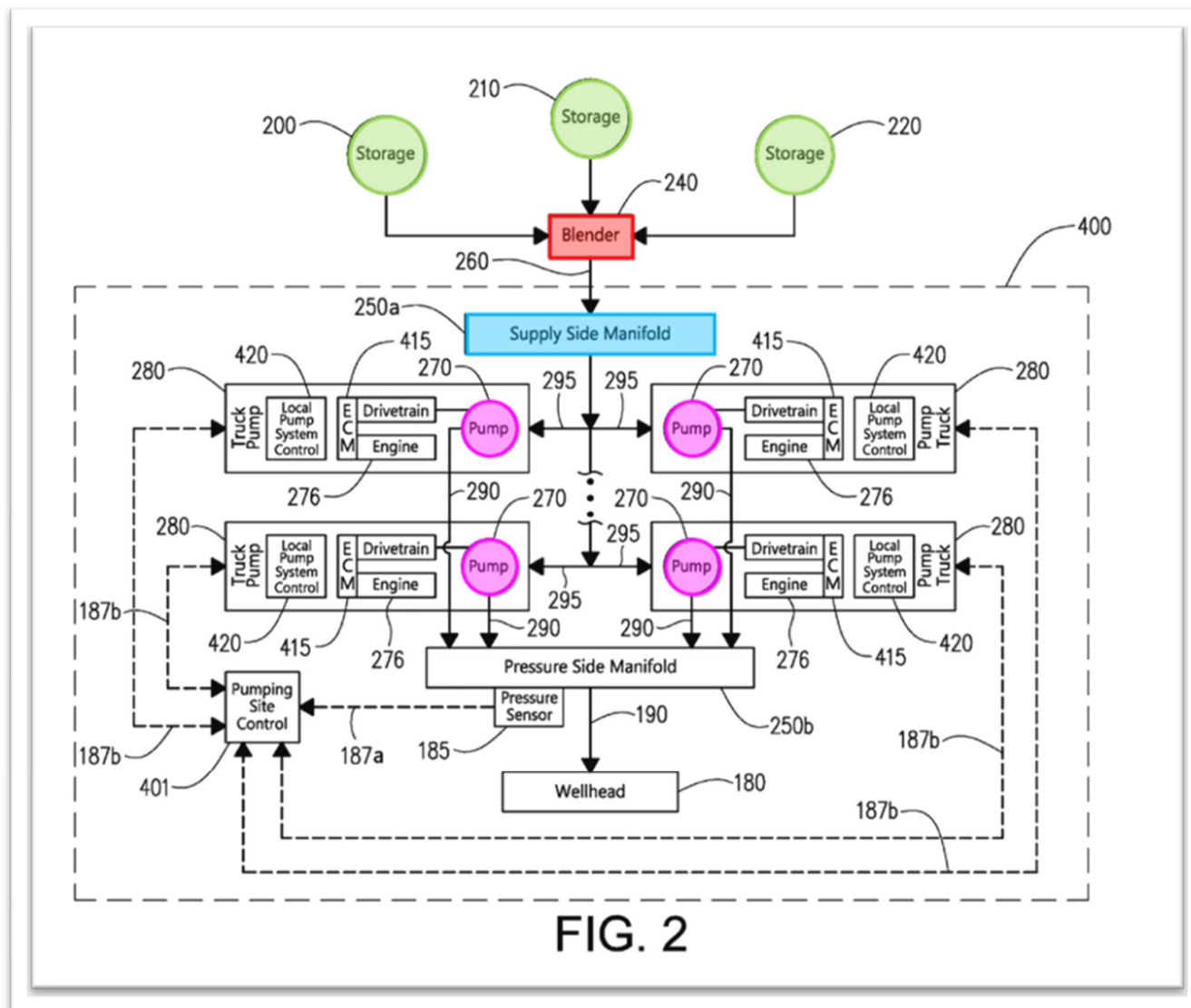
211. Accordingly, *Norris* discloses limitation 5[a].

²¹⁰ Ex. 1002 (*Norris*) [0021].

2. 5[b]: “wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold,”

212. As discussed above regarding limitation 5[a], *Norris* discloses “The wellbore servicing fluid passes from the blender 240 [annotated in red] into *a low-pressure side of the supply-side manifold 250a* [annotated in blue] via flowline 260 and *from the supply-side manifold 250a to the PD pumps 270* [annotated in magenta] via supply flowlines 295.”²¹¹

²¹¹ Ex. 1002 (*Norris*) [0021] emphasis added.

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

213. Accordingly, *Norris* discloses limitation 5[b].

3. **5[c]: “wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow conditions at the one or more blenders, the manifold, the plurality of pumps, or the distribution system.”**

214. As described above regarding limitation Claims 1, 2 and 4, and incorporated herein by reference, *Norris* discloses both pressure and flow sensors

for measuring flow conditions at the manifold, the plurality of pumps and the distribution systems.

F. INDEPENDENT CLAIM 7

215. It is my opinion that *Norris* anticipates Claim 7 or at least renders Claim 7 obvious. As discussed in the following subsections, *Norris* discloses, or renders obvious, each and every element of Claim 7.

1. 7[p]: “A hydraulic fracturing method, comprising:”

216. *Norris* discloses a hydraulic fracturing method. *Norris* discloses “wellbore servicing tool 150 is configured to perform one or more servicing operations, for example, fracturing formation 130.”²¹² Further, “In fracturing operations, wellbore servicing fluids, such as particle (e.g., proppant) laden fluids, are pumped at a relatively high pressure into the wellbore 120.”²¹³ Accordingly, *Norris* discloses the preamble.

2. 7[a]: “providing a fracturing fluid to a plurality of pumps;”

217. *Norris* discloses this limitation.²¹⁴ *Norris* discloses “[m]ultiple positive displacement pumps (PD pumps) are frequently used in combination to provide desired flow rates and operational pressures.”²¹⁵ Further, *Norris* discloses that “[t]o

²¹² Ex. 1004 (*Norris*) [0020].

²¹³ Ex. 1004 (*Norris*) [0023].

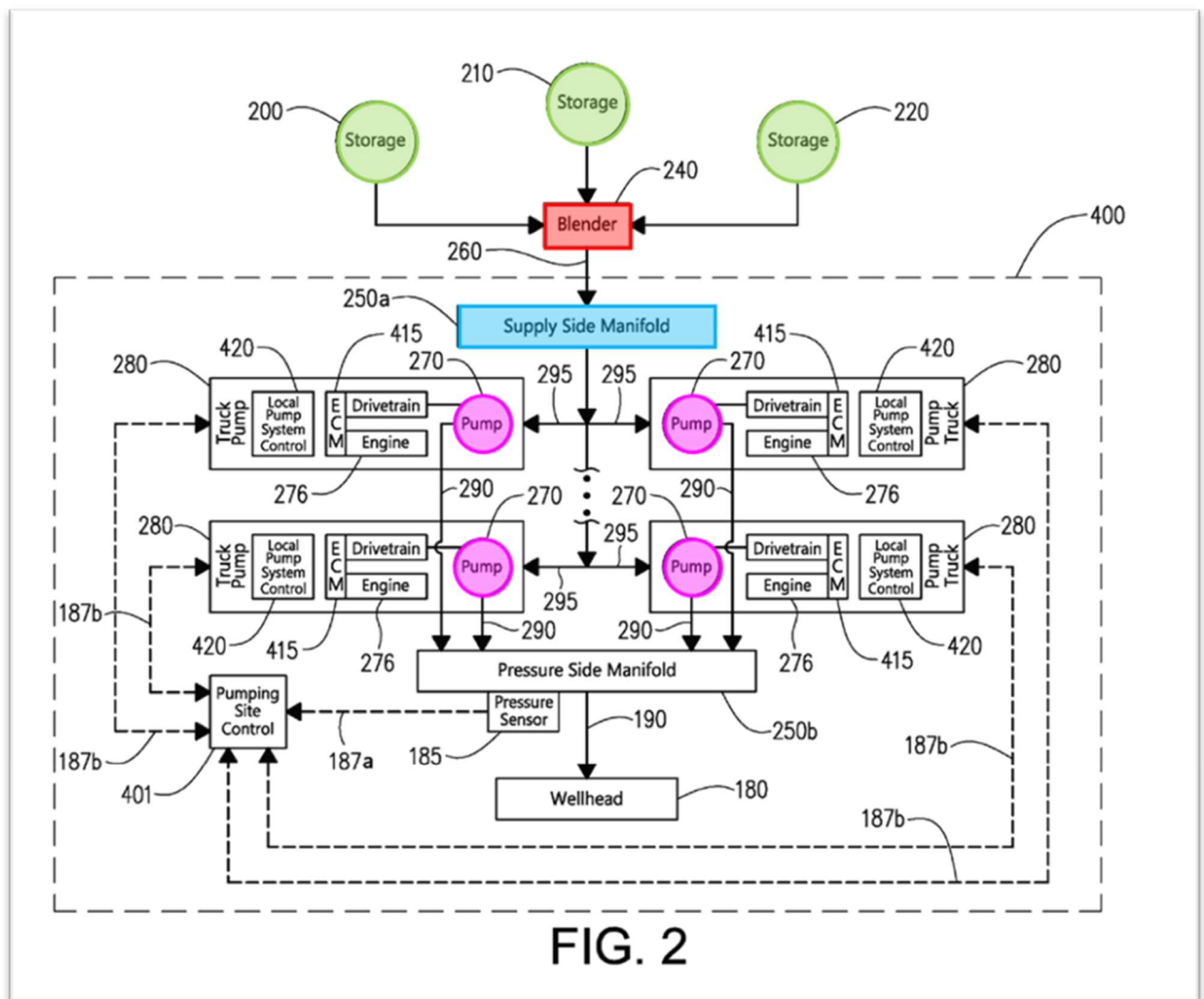
²¹⁴ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 1 out of an abundance of caution.

²¹⁵ Ex. 1004 (*Norris*) [0002].

provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 forces the wellbore service fluid into a pressure-side manifold 250b via pressure flow lines 290 and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”²¹⁶ *Norris* further discloses a fracturing fluid provided from the blender to the plurality of pumps. *Norris* teaches “water from storage vessel 200 [annotated in green] is introduced, either directly or indirectly, into the blender 240 [annotated in red] where the water is mixed with various other components and/or additives from storage vessels 210 and 220 (annotated in green) to form a wellbore servicing fluid [i.e. fracturing fluid]. The wellbore servicing fluid passes from the blender 240 into a low-pressure side of the supply-side manifold 250a [annotated in blue] via flowline 260 and from the supply-side manifold 250a to the PD pumps 270 [annotated in magenta] via supply flowlines 295.”²¹⁷

²¹⁶ Ex. 1004 (*Norris*) [0022].

²¹⁷ Ex. 1002 (*Norris*) [0021].

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

218. Accordingly, *Norris* discloses limitation 7[a].

3. 7[b]: “pumping the fracturing fluid into a distribution system;”

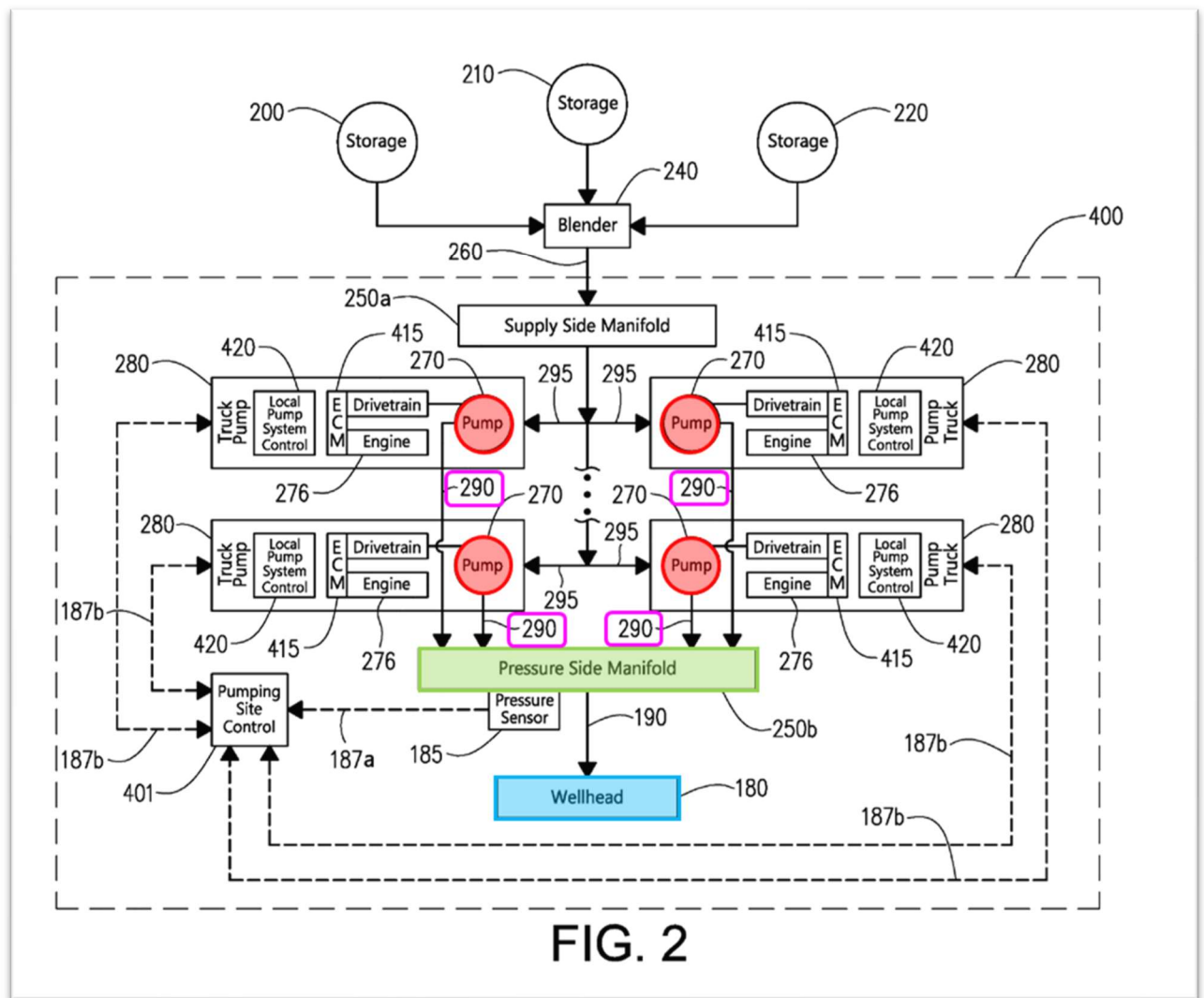
219. *Norris* discloses this limitation. *Norris* discloses a combination of manifolds and flowlines that consolidate the fracturing fluid from the pumps and carries it to the wellhead for injection into the well, which are together a distribution

system. For example, *Norris* discloses “Pressure flowlines 290 from PD pumps 270 communicate the highly pressurized wellbore servicing fluid to the pressure-side manifold 250b.”²¹⁸ *Norris* further discloses “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 [annotated in red] forces the wellbore service fluid into a pressure-side manifold 250b [annotated in green] via pressure flow lines 290 [annotated in magenta] and subsequently from pressure-side manifold 250b to wellhead 180 [annotated in blue] via conduit 190.”²¹⁹

220. Fig. 2 of *Norris* further shows a distribution system of pipes and manifolds that consolidate fluid from the various pumps and deliver fluid for injection to the wellhead.

²¹⁸ Ex. 1004 (*Norris*) [0026].

²¹⁹ Ex. 1004 (*Norris*) [0022].

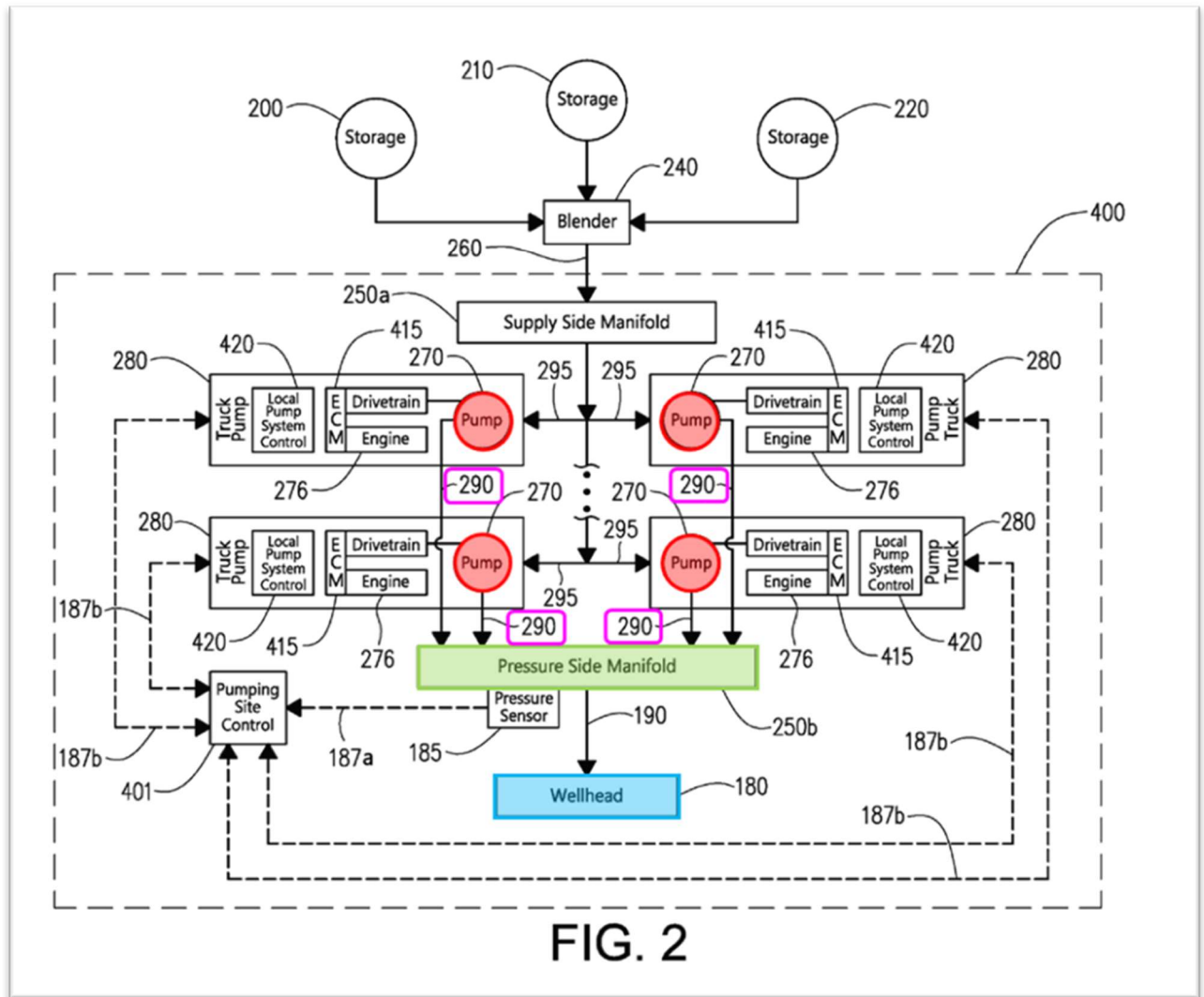
Ex. 1004 (*Norris*) FIG.2 (annotated)

221. Accordingly, *Norris* discloses limitation 7[b].

4. 7[c]: “injecting the fracturing fluid into a wellhead;

222. *Norris* discloses “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 [annotated in red] forces the wellbore service fluid into a pressure-side manifold 250b [annotated in green]

via pressure flow lines 290 [annotated in magenta] and subsequently from pressure-side manifold 250b to wellhead 180 [annotated in blue] via conduit 190.”²²⁰



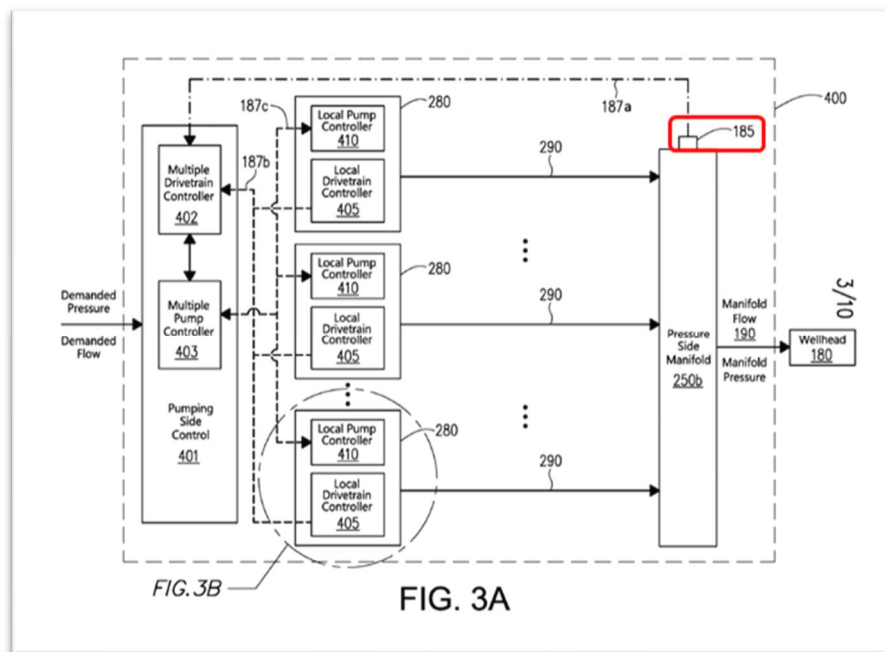
Ex. 1004 (*Norris*) FIG.2 (annotated)

223. Accordingly, *Norris* discloses limitation 7[c].

²²⁰ Ex. 1004 (*Norris*) [0022].

5. 7[d]: “measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;”

224. *Norris* discloses a plurality of sensors measuring one or more parameters of the plurality of pumps and the distribution system. *Norris* teaches, for example, “a pressure sensor 185 [annotated in red] monitors fluid pressure within pressure-side manifold 250b. [] Additionally, fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b. Sensors, not shown, monitor both static pressure and dynamic pressure fluctuations within the common fluid conduits and pressure-side manifold 250b.”²²¹



²²¹ Ex. 1004 (*Norris*) [0030]

Ex. 1004 (*Norris*) Fig. 3A (annotated)

225. As another example, *Norris* teaches “PD pump 270 may include an optional piston monitoring sensor.”²²² Further, “a signal indicative of top dead center for the pistons in PD pump 270 will be provided to application controller 401 to maintain non-coincidental operation of PD pumps 270. That signal is provided by using ECM 415, local pump truck controller 420 or a piston position sensor associated with PD pump 270. For example, the piston position sensor outputs a signal once with each revolution of the PD pump's 270 crankshaft. Because the pistons/plungers are coupled to the crankshaft in a fixed relationship, the position of the crankshaft can be used to derive the position of each piston/plunger associated therewith. In an embodiment, the piston position sensor is a rotary encoder-type sensor (e.g., a shaft encoder), such as an absolute rotary encoder or an incremental rotary encoder. In FIG. 3B, the piston position sensor provides either digital or analog data reflecting the position of the pistons in PD pump 270 to local pump controller 410 via a datalink 187c.”²²³ Further still, “Local pump controller 410 receives data input from ECM 415, including but not limited to engine RPM, piston position and PD pump 270 outlet pressure.”²²⁴ Further still, *Norris* describes that “fluid pressure and flow rates downstream of each PD pump 270 are monitored by

²²² Ex. 1004 (*Norris*) [0032].

²²³ Ex. 1004 (*Norris*) [0033].

²²⁴ Ex. 1004 (*Norris*) [0035].

sensors associated with the common fluid conduits and pressure-side manifold 250b. Sensors, not shown, monitor both static pressure and dynamic pressure fluctuations within the common fluid conduits and pressure-side manifold 250b.”²²⁵ As discussed above regarding Claim 2, and incorporated herein by reference, the sensors are mounted to the components, such as the pump, and are thus “instrumented thereon” as claimed.

226. Further examples of sensors measuring parameters of the pump include sensors to monitor “engine piston position, spark management, [and] throttle position.”²²⁶

227. Accordingly, *Norris* discloses limitation 7[d].

6. 7[e]: “detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;”

228. Except for being rewritten as a method claim. Claim 7[e] is substantially similar to Limitation 1[e][ii] and is disclosed, or rendered obvious, by *Norris* for the same reasons as those discussed above in Section XI.A.8.

7. 7[f]: “generating automated instructions for one or more control devices based at least in part on the one or more parameters;”

229. *Norris* discloses this limitation. As discussed above, *Norris* teaches “[t]he operational parameters input into application controller 401 [annotated in red]

²²⁵ Ex. 1004 (*Norris*) [0030].

²²⁶ Ex. 1004 (*Norris*) [0032].

determine the desired pressure and flow rates at pressure side manifold 250b and wellhead 180. Upon variation from the desired settings, multiple drivetrain controller 402 [part of application controller 401, annotated in blue] will signal each local drivetrain controller 405 [part of local pump control 420, annotated in green] to increase or decrease pumping operations. The resulting change in pumping operations will restore the desired pressure and flow rates at pressure side manifold 250b and wellhead 180.”²²⁷

230. Accordingly, *Norris* discloses generating automated control instructions for one or more control devices (e.g., signal each local pump control 420 to increase or decrease pumping operations) based at least on the first parameter (e.g. pressure at manifold 250b / wellhead).

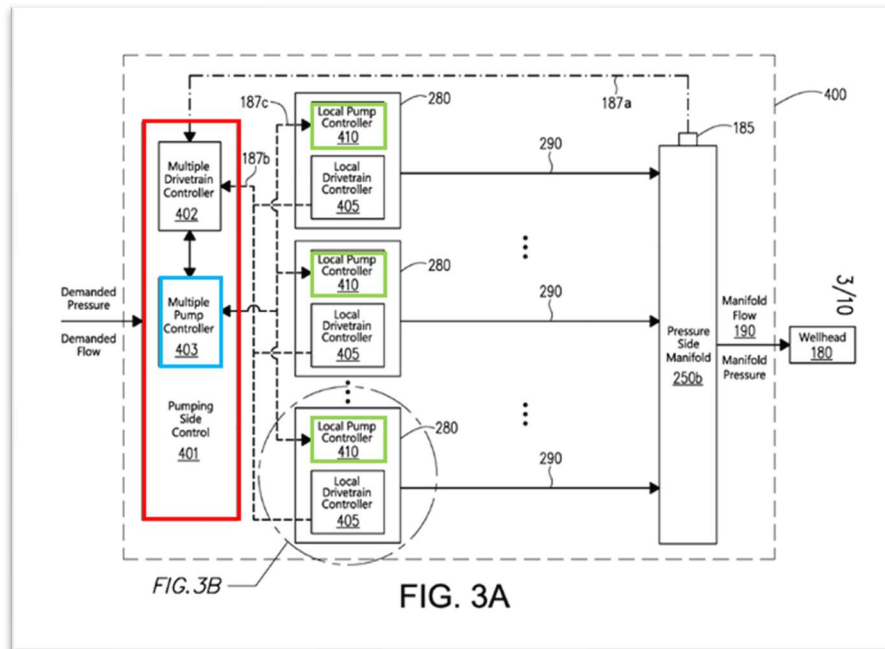
²²⁷ Ex. 1004 (*Norris*) [0037]



231. As another example, *Norris* teaches “[u]tilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 [part of application controller 401, annotated in blue] will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations. Upon selection of the adjustment needed, multiple pump controller 403 will direct local pump controller 410 [annotated in green] to signal the necessary changes in throttle position to control pump RPM and piston position.”²²⁸ Accordingly *Norris* discloses generating

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automated instructions for one or more control devices (local pump controller 410) based at least on or more parameters (data from piston position sensors).



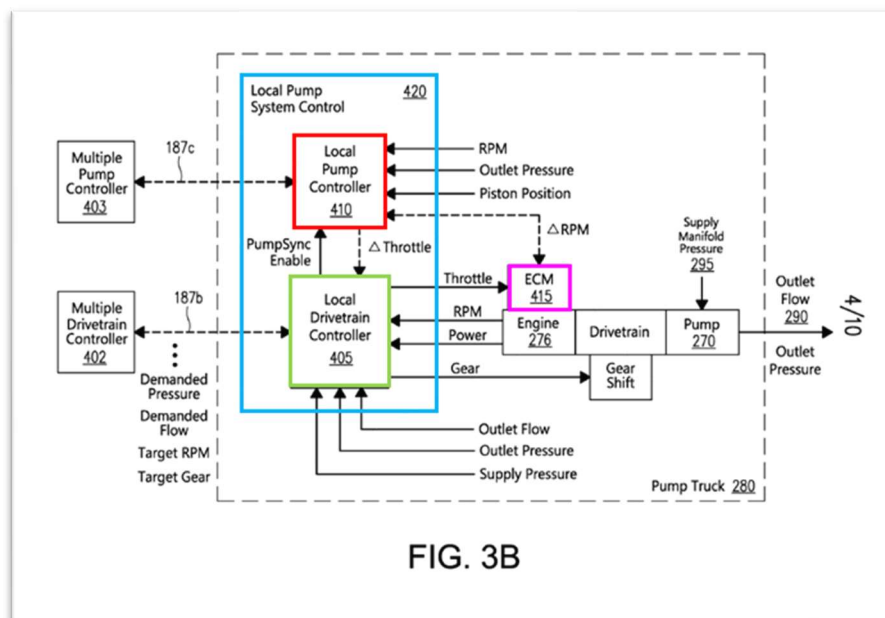
Ex. 1004 (*Norris*) Fig. 3A (annotated)

232. Thus, *Norris* discloses limitation 7[f].

8. 7[g]: “automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions;”

233. *Norris* discloses this limitation. As discussed above, *Norris* discloses one or more control devices (e.g. local pump control 410) are configured to receive the automated control instructions. Further, *Norris* discloses “[u]pon variation from the desired settings, multiple drivetrain controller 402 will signal each local drivetrain controller 405 [part of local control 420] to increase or decrease pumping

operations.”²²⁹ Once the signal to adjust pumping operations is received, “local pump system control 420 [annotated in blue] provides two paths to achieve a change in throttle position necessary for producing a change in engine RPM. In the first path, local pump controller 410 [annotated in red] transmits a throttle change command to local drivetrain controller 405 [annotated in green] and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta]. In the second path, local pump controller 410 transmits an RPM change command to ECM 415.”²³⁰



Ex. 1004 (Norris) FIG.3B (annotated)

²²⁹ Ex. 1004 (Norris) [0037].

²³⁰ Ex. 1004 (Norris) [0038].

234. Accordingly, *Norris* teaches automatically adjusting one or more functions of the plurality of pumps (e.g. RPM, throttle) based at least in part on the instructions. Thus, *Norris* discloses limitation 7[g].

9. 7[h]: “transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;”

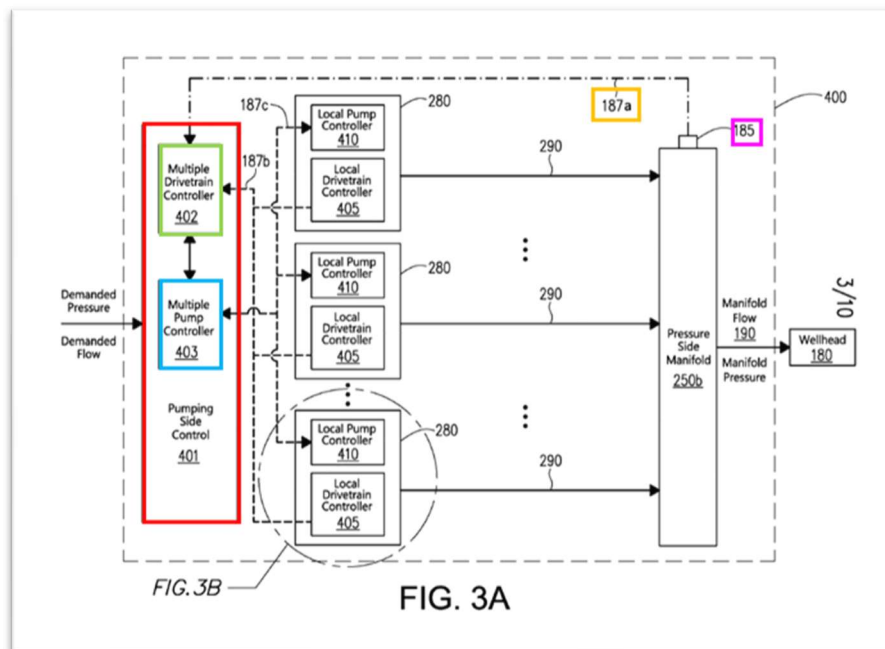
235. *Norris* discloses this limitation. As one example, as described in Section XI.A. 8 regarding limitation 1[e][i], and Section XI.A. 10 discussing examples in *Norris*, and incorporated herein by reference, *Norris* describes transmitting a first parameter (e.g. piston position, pressure, flowrates) from a first device (e.g. pump 2) to a second device (e.g. pump 1) when pump 1’s local pump controller is functioning as multiple pump controller 403.

236. As another example, *Norris* discloses that “pressure sensor 185 monitors fluid pressure within pressure-side manifold 250b. Data from pressure sensor 185 [annotated in magenta below] is transmitted via data link 187a [annotated in orange below] to application controller 401[annotated in red below].”²³¹ Further, *Norris* teaches that “[a]pplication controller 401 may also receive data directly or indirectly from sensors monitoring wellhead 180.”²³² *Norris* further teaches that

²³¹ Ex. 1004 (*Norris*) [0030].

²³² Ex. 1004 (*Norris*) [0030].

“[a]pplication controller 401 utilizes all of the data received to manage operation of all pumping operations to minimize and preferably eliminate coincidental operation of pumps 270.”²³³ As shown below in Fig. 3A of *Norris*, application controller 401 (sometimes referred to in the figures as pump site control 401 or pump side control 401) comprises Multiple Drivetrain Controller 402 [annotated in green below] and Multiple Pump Controller 403 [annotated in blue below].



Ex. 1004 (*Norris*) Fig. 3A (annotated)

237. A POSITA would have understood that application controller 401 was a “processing device” in that it processes data received, either directly or indirectly, in order to “manage operation of all pumping operations and preferably eliminate

²³³ Ex. 1004 (*Norris*) [0030].

coincidental operation of pumps 270”. As an example of the data processing, *Norris* teaches that “multiple pump controller 403 [part of application controller 401] will execute instructions that include the steps necessary to determine an average pressure within common fluid conduits as reported by well head pressure sensor(s) 185. Additionally, multiple pump controller 403 will determine dynamic pressure within pressure side manifold 250b, conduit 190 and wellhead 180. Utilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations.”²³⁴ Further, *Norris* teaches that the manifold 250b pressure can be included in this calculation: “If desired, wellhead pressure from sensor 185 may be included in the average pressure determination.”²³⁵ A POSITA would have understood that functions such as determining an “average pressure” would have been performed by a processing device and that application controller 401 was an example of “one or more processing device”.

238. Accordingly, *Norris* discloses one or more processing devices (e.g. application controller 401) that receives the first parameter (e.g. pressure) from a

²³⁴ Ex. 1004 (*Norris*) [0039].

²³⁵ Ex. 1004 (*Norris*) [0040].

first device of the plurality of pumps, the distribution system or the wellhead (e.g. pressure side manifold 250b via pressure sensor 185, wellhead 180).

239. Not only does application controller 401 use the data in its own calculations and processing, but it also forwards the data to other controllers in the system, such as local drivetrain controller 405 (annotated in red below), which is part of local pump system control 420(annotated in blue below), which in turn is part of the plurality of pumps 280 (annotated in green below).²³⁶

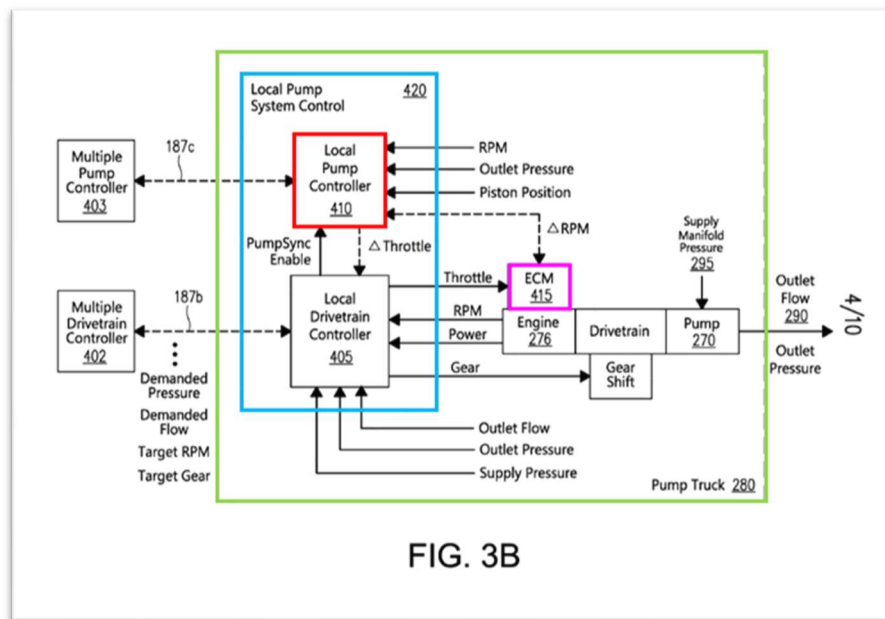


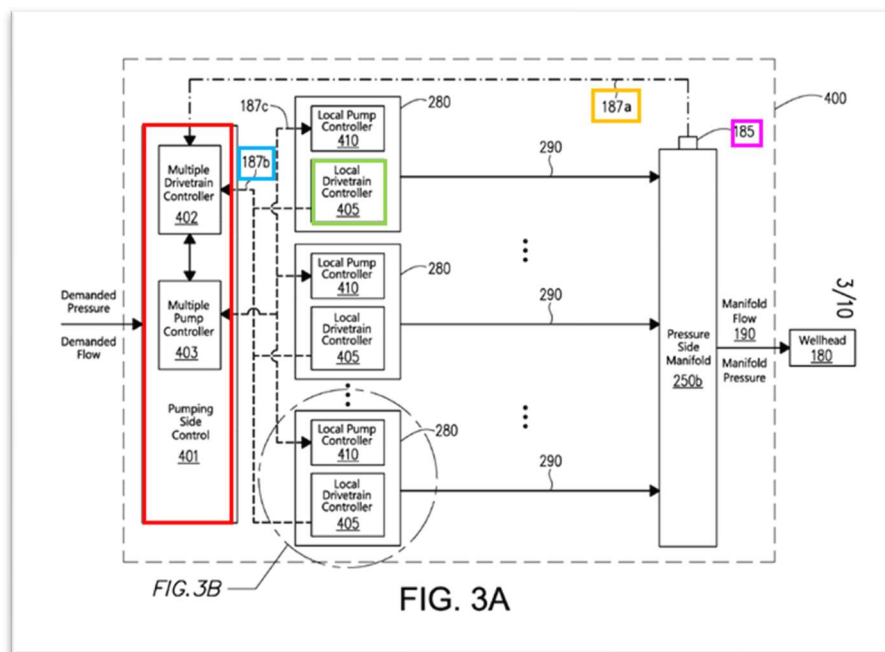
FIG. 3B

Ex. 1004 (*Norris*) Fig. 3B (annotated)

240. For example, *Norris* teaches that “local drivetrain controller 405 receives data via data links 187b from pressure side manifold 250b and/or wellhead

²³⁶ See, e.g., Ex. 1004 (*Norris*) [0032] (“Each pump truck 280 also includes a local pump system control 420. Local pump system control 420 includes a local pump controller 410 and a local drivetrain controller 405.”)

180 as well as data from multiple drivetrain controller 402 via data link 187b.[] Typically, the data from pressure side manifold 250b and/or wellhead 180 includes outlet flow rates, outlet pressure at the outlet of pressure side manifold 250b and supply pressure at wellhead 180.”²³⁷ As discussed above, data link 187a (annotated in orange) delivers data, such as from pressure sensor 185 on pressure side manifold 250b, to application controller 401. As shown in Fig. 3A, data link 187b (annotated in blue) connects application controller 401 to local drivetrain controller 405 (annotated in green) and delivers data such as the pressure from pressure side manifold 250b and/or wellhead 180.



Ex. 1004 (Norris) Fig. 3A (annotated)

²³⁷ Ex. 1004 (Norris) [0035].

241. Thus, *Norris* discloses that the one or more processing devices (e.g. application controller 401) also transmits the first parameter (e.g. manifold pressure) to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead (e.g. the local pump controller of the plurality of pumps).

242. Accordingly, *Norris* discloses limitation 7[h].

10.7[i]: “generating the automated instructions at the second device based at least in part on the first parameter; and”

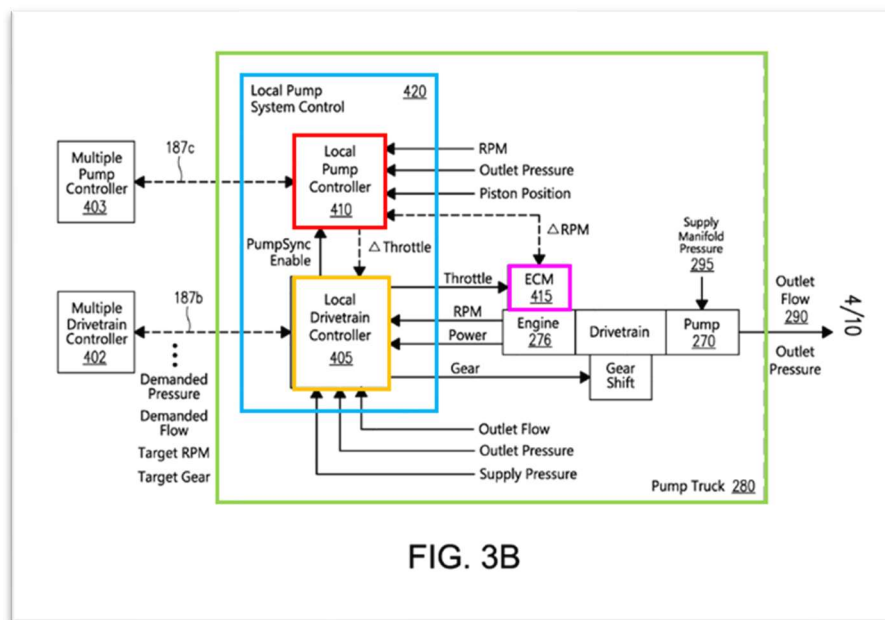
243. Except for being rewritten as a method claim. Claim 7[i] is substantially similar to Limitation 1[e][iii] and is disclosed by *Norris* for the same reasons as those discussed above in Section XI.A.10.

11.7[j]: “automatically adjusting one or more functions of the second device based on the automated instructions.”

244. *Norris* discloses this limitation. *Norris* teaches “[t]he operational parameters input into application controller 401 [annotated in red] determine the desired pressure and flow rates at pressure side manifold 250b and wellhead 180. Upon variation from the desired settings, multiple drivetrain controller 402 [part of application controller 401, annotated in blue] will signal each local drivetrain controller 405 [annotated in green] to increase or decrease pumping operations. The resulting change in pumping operations will restore the desired pressure and flow rates at pressure side manifold 250b and wellhead 180.”²³⁸

²³⁸ Ex. 1004 (*Norris*) [0037]

245. As another example, *Norris* teaches “[u]tilizing the determined average pressure, inputted desired average pressure, dynamic pressure, data from piston position sensors, multiple pump controller 403 [part of application controller 401, annotated in blue] will determine the appropriate adjustment in operations necessary to minimize dynamic pressure fluctuations. Upon selection of the adjustment needed, multiple pump controller 403 will direct local pump controller 410 [annotated in green] to signal the necessary changes in throttle position to control pump RPM and piston position.”²³⁹



Ex. 1004 (*Norris*) Fig. 3A (annotated)

246. *Norris* further teaches that once the application controller 401 determines the adjusted pumping operations (e.g. speed or throttle adjustment),

²³⁹ Ex. 1004 (*Norris*) [0039].

“local pump system control 420 provides two paths to achieve a change in throttle position necessary for producing a change in engine RPM. [] In the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 [annotated in orange above] and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta above]. In the second path, local pump controller 410 transmits an RPM change command to ECM 415. In this path, ECM 415 changes engine RPM in response to the change in RPM signal from ECM 415. The change in RPM directs a change in drivetrain 276 operation (e.g., such as a change in the throttle or engine operation).”²⁴⁰ Thus, *Norris* discloses that the local pump system control generates automated control instructions to either the drivetrain controller 405 or ECM 415 of the pump truck 280. Because these automated control instructions are based on the adjustment to pumping operations that was determined by the application controller based, in part, on the data from pressure manifold 250b (e.g. pressure from sensor 185) or from the wellhead, as discussed above in Section XI.A.8 regarding limitation 1[e][i], the automated control instructions from the local pump system control 420 are based, at least in part, on those data from pressure sensor 185 and/or the wellhead.

247. Accordingly, *Norris* discloses generating automated control instructions (e.g., increased throttle command to drivetrain controller 405 or ECM

²⁴⁰ Ex. 1004 (*Norris*) [0038]

415) at the second device (pump 280) based at least in part on the first parameter (e.g. pressure from sensor 185 and/or the wellhead).

248. Accordingly, *Norris* discloses limitation 7[j].

G. INDEPENDENT CLAIM 13

249. It is my opinion that *Norris* anticipates Claim 13 or at least renders Claim 13 obvious. As discussed in the following subsections, *Norris* discloses, or renders obvious, each and every element of Claim 13.

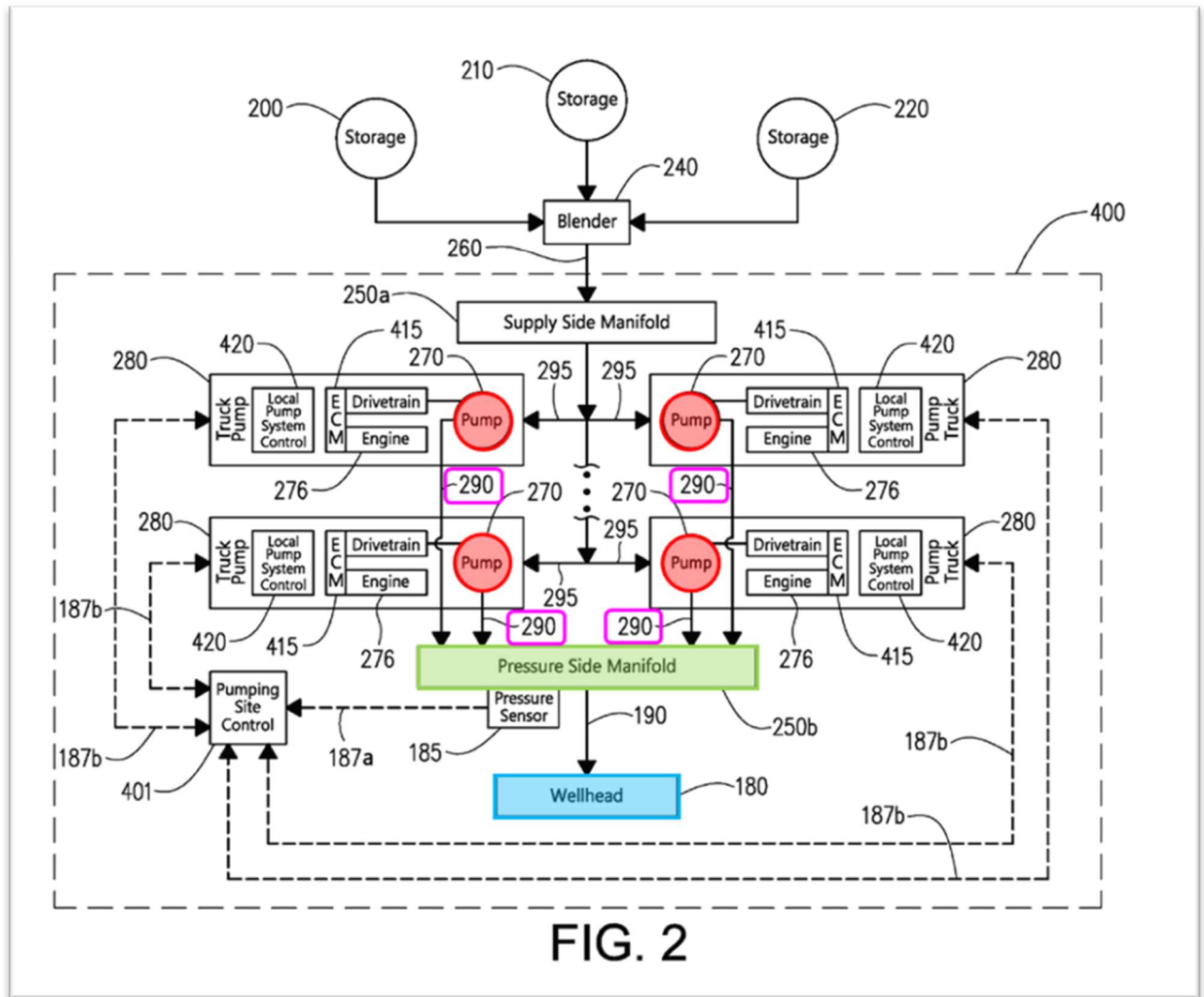
1. 13[p]: “A hydraulic fracturing method, comprising:”

250. As discussed above regarding 7[p], and incorporated herein by reference, *Norris* discloses a hydraulic fracturing method.

2. 13[a]: “performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;”

251. As discussed above regarding Limitation 7[a] – 7[c], and incorporated herein by reference, *Norris* describes performing a fracturing operation at a hydraulic fracturing system. Further, as described above regarding 1[a], and incorporated herein by reference, the fracturing system comprises a plurality of pumps (annotated in red below). Further still, as discussed above regarding limitation 1[b], and incorporate herein by reference, the hydraulic fracturing system comprises a distribution system comprising a Pressure Side Manifold (annotated in green) and flowlines 290 (annotated in magenta). Finally, as shown in Fig. 2 of

Norris, the hydraulic fracturing system comprises a wellhead 180 (annotated in blue).



Ex. 1004 (*Norris*) FIG. 2 (annotated)

252. Accordingly, *Norris* discloses limitation 13[a].

3. **13[b]: “measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;”**

253. As described above regarding limitation 7[d], and incorporated herein by reference, *Norris* discloses measuring one or more operational parameters of the plurality of pumps, the distribution system or the wellhead. Accordingly, *Norris* discloses Limitation 13[b].

4. **13[c]: “transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;”**

254. As described above regarding limitation 7[h] and incorporated herein by reference, *Norris* discloses limitation 13[c].

5. **13[d]: “detecting that the first parameter is outside of an acceptable threshold;”**

255. As described above regarding limitation 7[e] and incorporated herein by reference, *Norris* discloses, or at least renders obvious, detecting that the first parameter is outside of an acceptable threshold. Accordingly, *Norris* discloses Limitation 13[d], or at least renders it obvious.

6. **13[e]: “generating automated instructions at the second device based at least in part on the first parameter; and”**

256. As described above regarding limitation 7[i], and incorporated herein by reference, *Norris* discloses generating automated instructions at the second

device based at least in part on the first parameter. Accordingly, *Norris* discloses limitation 13[e].

7. 13[f]: “automatically adjusting one or more functions of the second device based on the automated instructions.”

257. As described above regarding limitation 7[j], and incorporated herein by reference, *Norris* discloses generating automated instructions at the second device based at least in part on the first parameter. Accordingly, *Norris* discloses limitation 13[f].

H. DEPENDENT CLAIM 14: “THE METHOD OF CLAIM 13, WHEREIN THE DISTRIBUTION SYSTEM RECEIVES AND CONSOLIDATES THE FRACTURING FLUID FROM THE PLURALITY OF PUMPS FOR INJECTION INTO A WELLHEAD.”

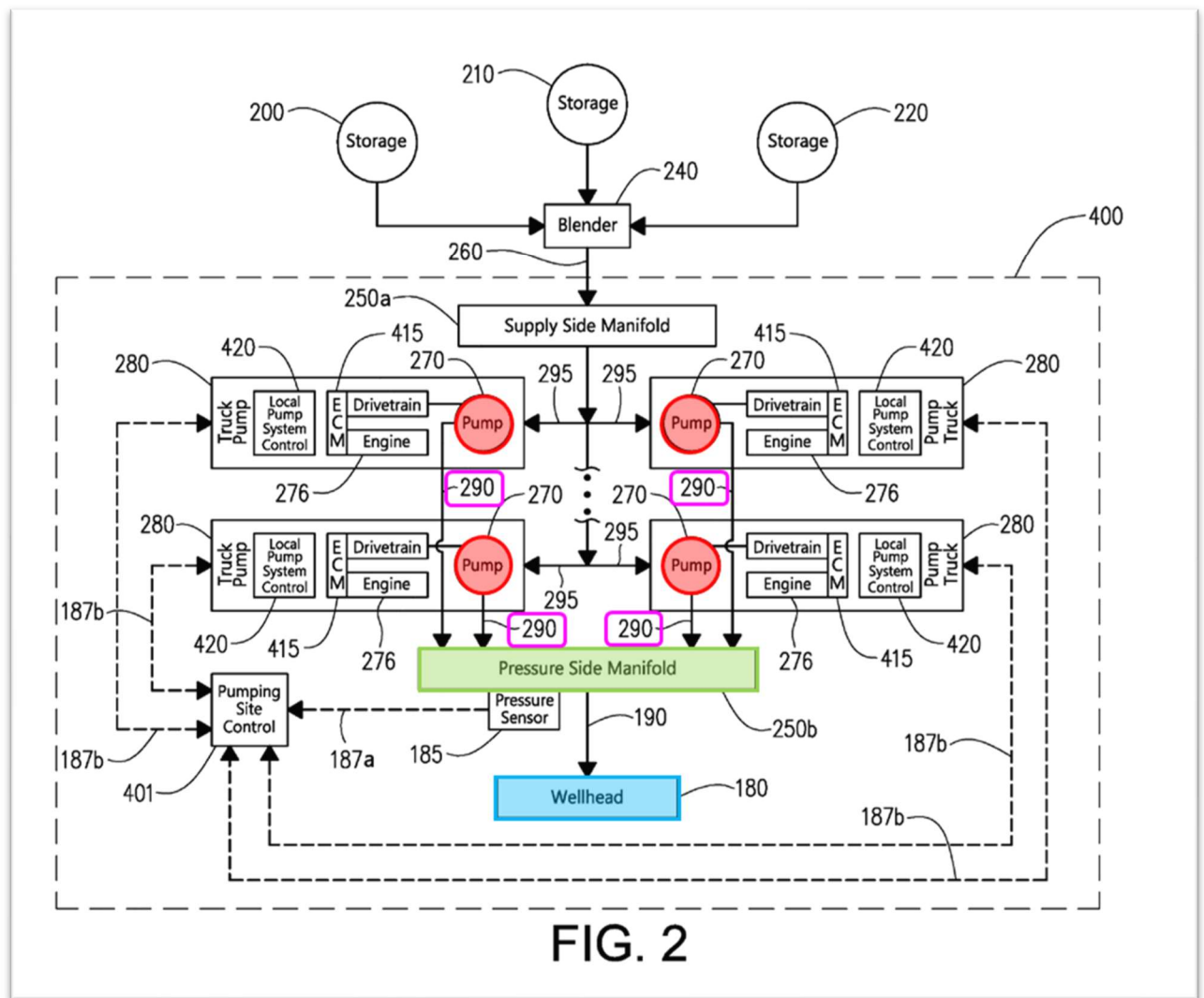
258. Dependent Claim 14 depends from Claim 13. In addition to the disclosure or teachings regarding Claim 13, as discussed above, *Norris* further discloses the additional limitations of Claim 14. *Norris* discloses a combination of manifolds and flowlines that consolidate the fracturing fluid from the pumps and carries it to the wellhead for injection into the well. For example, *Norris* discloses “Pressure flowlines 290 from PD pumps 270 communicate the highly pressurized wellbore servicing fluid to the pressure-side manifold 250b.”²⁴¹ *Norris* further discloses “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 [annotated in red] forces the wellbore service

²⁴¹ Ex. 1004 (*Norris*) [0026].

fluid into a pressure-side manifold 250b [annotated in green] via pressure flow lines 290 [annotated in magenta] and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”²⁴²

259. Fig. 2 of *Norris* further shows a distribution system of pipes and manifolds that consolidate fluid from the various pumps and deliver fluid for injection to the wellhead.

²⁴² Ex. 1004 (Norris) [0022].



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

260. Accordingly, *Norris* discloses Claim 14.

I. DEPENDENT CLAIM 16: “THE METHOD OF CLAIM 13, WHEREIN THE FIRST PARAMETER INCLUDES MEASUREMENTS OF ONE OR MORE OF THE PLURALITY OF PUMPS.”

261. Dependent Claim 16 depends from Claim 13. In addition to the disclosure or teachings regarding Claim 13, as discussed above, *Norris* further discloses the additional limitations of Claim 16. *Norris* discloses a plurality of

sensors configured to measure one or more parameters of the plurality of pumps.

Norris

262. As an example, *Norris* teaches “PD pump 270 may include an optional piston monitoring sensor.”²⁴³ Further, “a signal indicative of top dead center for the pistons in PD pump 270 will be provided to application controller 401 to maintain non-coincidental operation of PD pumps 270. That signal is provided by using ECM 415, local pump truck controller 420 or a piston position sensor associated with PD pump 270. For example, the piston position sensor outputs a signal once with each revolution of the PD pump's 270 crankshaft. Because the pistons/plungers are coupled to the crankshaft in a fixed relationship, the position of the crankshaft can be used to derive the position of each piston/plunger associated therewith. In an embodiment, the piston position sensor is a rotary encoder-type sensor (e.g., a shaft encoder), such as an absolute rotary encoder or an incremental rotary encoder. In FIG. 3B, the piston position sensor provides either digital or analog data reflecting the position of the pistons in PD pump 270 to local pump controller 410 via a datalink 187c.”²⁴⁴ Further still, “Local pump controller 410 receives data input from ECM 415, including but not limited to engine RPM, piston position and PD pump 270 outlet pressure.”²⁴⁵

²⁴³ Ex. 1004 (*Norris*) [0032].

²⁴⁴ Ex. 1004 (*Norris*) [0033].

²⁴⁵ Ex. 1004 (*Norris*) [0035].

263. Further examples of sensors measuring parameters of the pump include sensors to monitor “engine piston position, spark management, [and] throttle position.”²⁴⁶ Accordingly, *Norris* discloses Claim 16.

J. DEPENDENT CLAIM 17: “THE METHOD OF CLAIM 16, FURTHER COMPRISING: CONTROLLING ONE OR MORE OF THE PLURALITY OF PUMPS INDIVIDUALLY BASED ON THE AUTOMATED INSTRUCTIONS.”

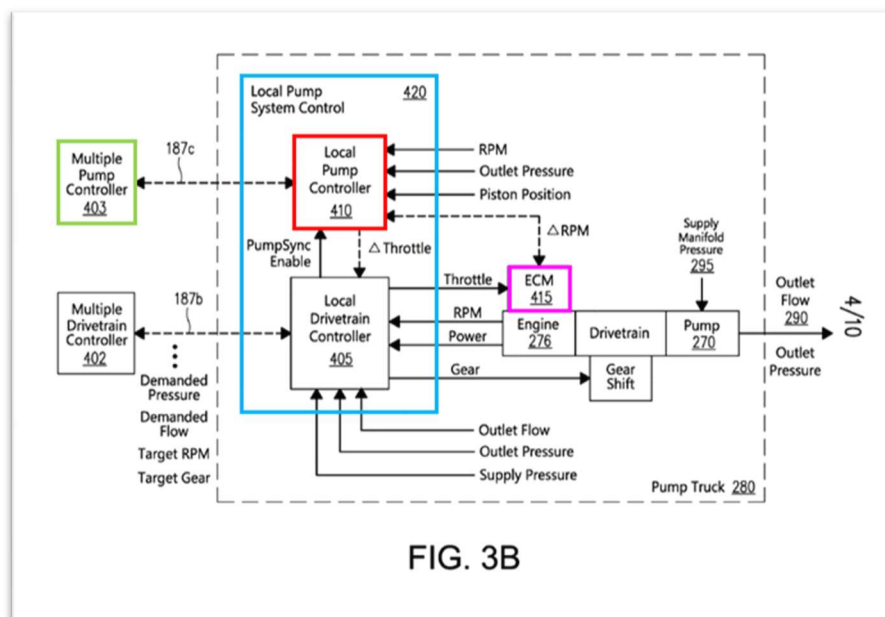
264. Dependent Claim 17 depends from Claim 16. In addition to the disclosure or teachings regarding Claim 16, as discussed above, *Norris* further discloses the additional limitations of Claim 17. As discussed above regarding Claim 1, *Norris* discloses control devices which control each pump individually. For example, *Norris* discloses one or more local control devices (e.g. Local Drivetrain Controller 405, Local Pump Controller 410) are configured to receive the automated control instructions. Further, *Norris* discloses “[u]pon variation from the desired settings, multiple drivetrain controller 402 will signal *each local drivetrain controller* 405 to increase or decrease pumping operations.”²⁴⁷ Accordingly, local drive train controller automatically adjusts one or more aspects of the pump individually based on the control instructions.

265. As another example, *Norris* discloses “As depicted in FIG. 3B, local pump system control 420 [annotated in blue] provides two paths to achieve a change

²⁴⁶ Ex. 1004 (*Norris*) [0032].

²⁴⁷ Ex. 1004 (*Norris*) [0037].

in throttle position necessary for producing a change in engine RPM. Both paths proceed from application controller 401 not shown via multiple pump controller 403 [annotated in green] to local pump controller 410 [annotated in red]. In the first path, local pump controller 410 transmits a throttle change command to local drivetrain controller 405 and local drivetrain controller 405 signals a throttle change to ECM 415 [annotated in magenta].”²⁴⁸



Ex. 1004 (*Norris*) FIG.3B (annotated)

Accordingly, the local pump controller and the ECM for each individual pump control the pump individually.

266. Thus, *Norris* discloses Claim 17.

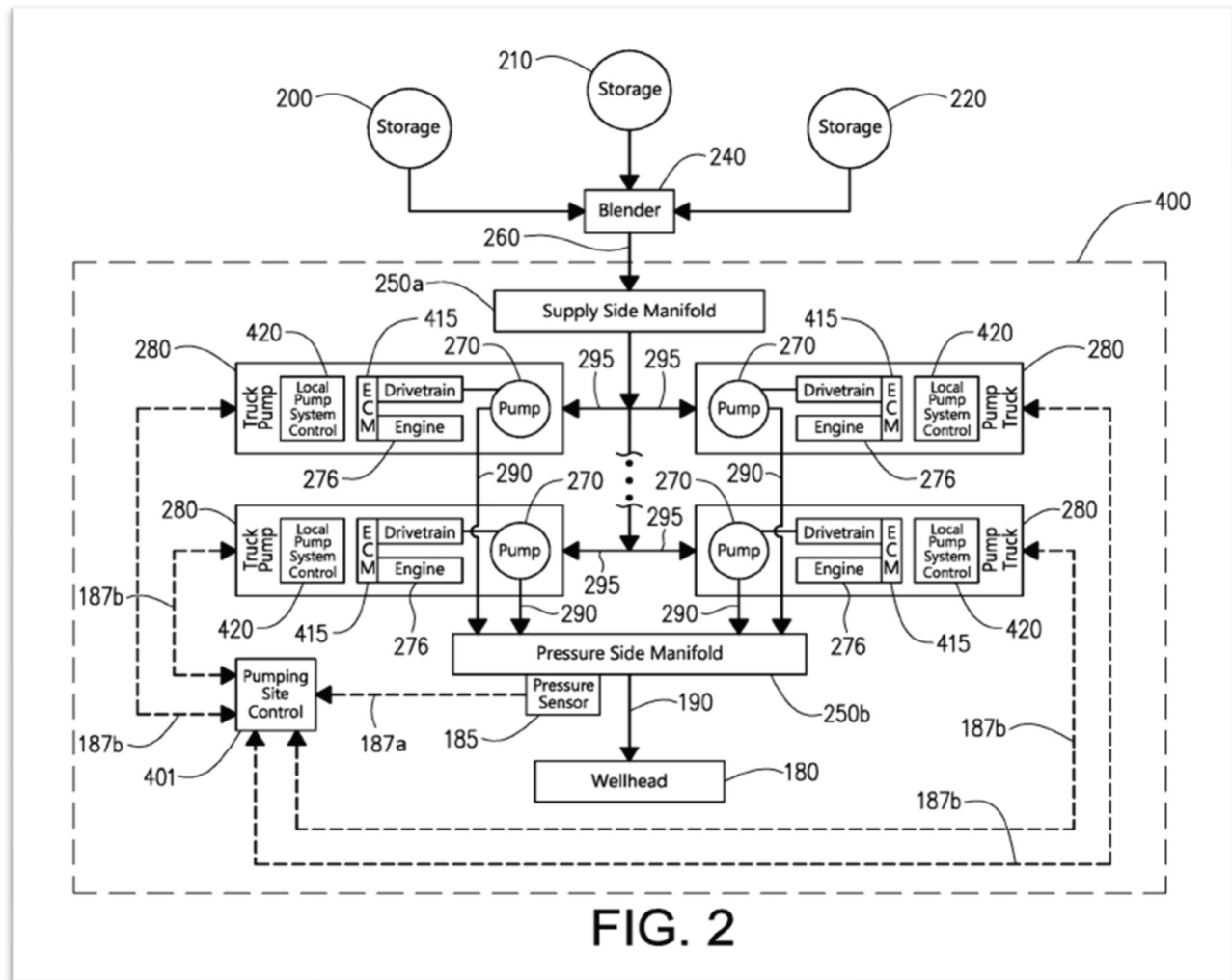
²⁴⁸ Ex. 1004 (*Norris*) [0038].

XII. GROUND 3 OBVIOUS OVER *NORRIS* IN VIEW OF *OMONT*

267. It is my opinion that the combination of *Norris* and *Omont* renders Claims 1-7 and 10-17 of the '435 patent obvious.

A. MOTIVATION TO COMBINE

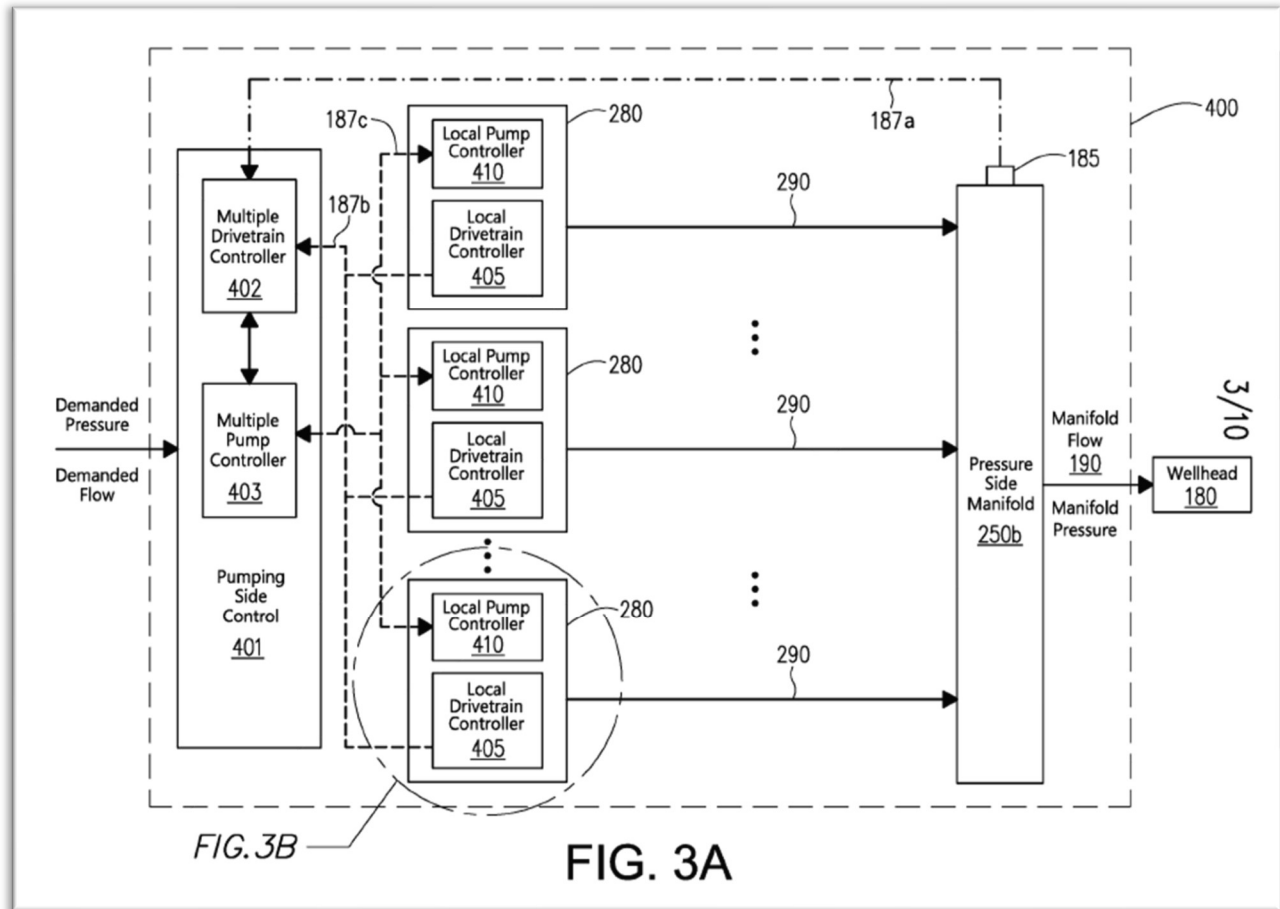
268. A POSITA would have been motivated to combine *Norris* and the teachings of *Omont* with a reasonable expectation of success in the combination. As discussed above in Section X.A.2, *Norris* discloses a multi-pump fracturing system shown in Figure 2:

Ex. 1004 (*Norris*) Fig. 2

269. *Norris* further teaches that “coincidental operation” of multiple pumps can cause “pressure spikes” that lead to “high and low pressure stresses resulting in “metal fatigue and failure of components.”²⁴⁹ *Norris* also discloses a “pump management system” to eliminate coincidental operation, as well as to control

²⁴⁹ Ex.1004 (*Norris*) [0002], [0027].

overall operation of the fracturing pumping system. Figure 3A illustrates an example:



Ex, 1004 (Norris) Fig. 3A

270. Norris's "pump management system" contains both sensors and controllers for controlling fracturing operations.²⁵⁰ Norris also uses this sensed data

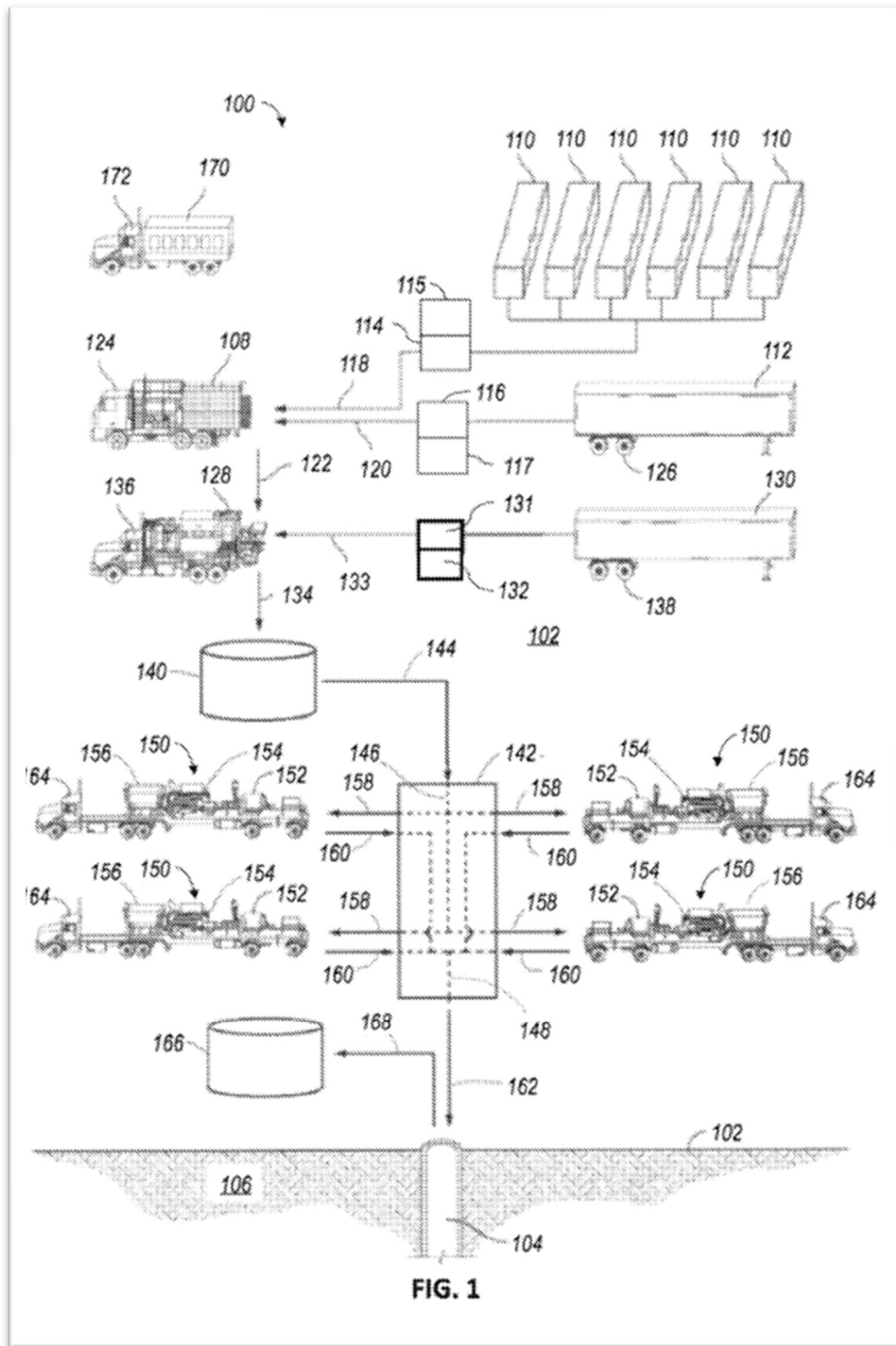
²⁵⁰ Ex. 1004 (Norris) [0035].

to manage pump operation and “reduce stress and fatigue”²⁵¹ on the pumps and pumping equipment.²⁵²

271. *Omont* similarly discloses a multi-pump fracturing system, shown in Figure 1:

²⁵¹ Ex. 1004 (*Norris*) [0035].

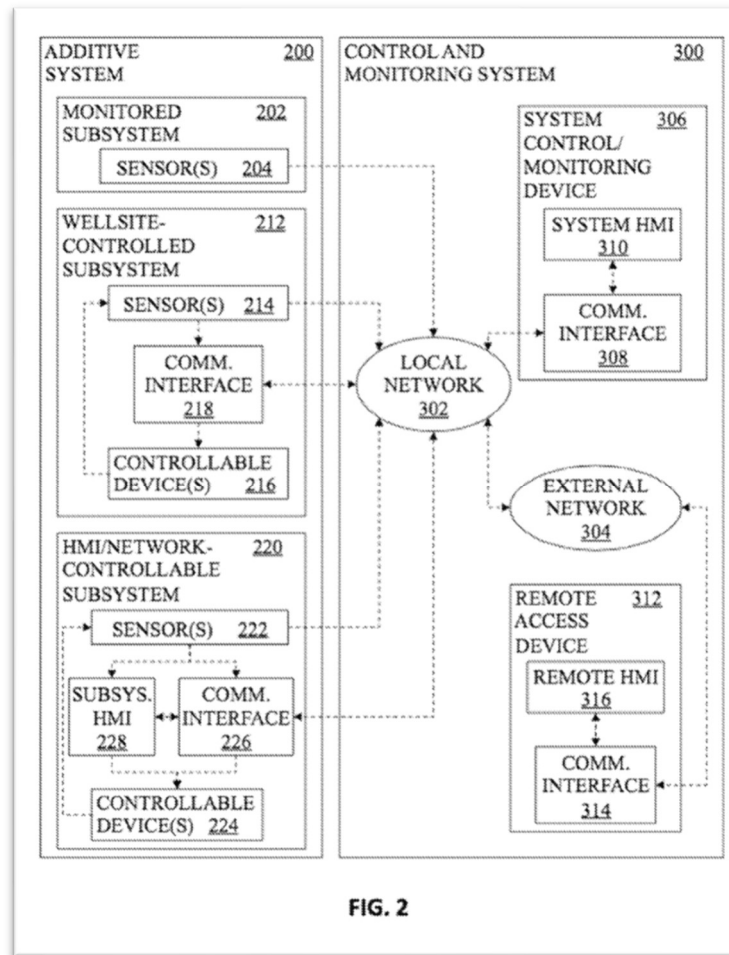
²⁵² Ex. 1004 (*Norris*) [0028], [0035].

Ex. 1005 (*Omont*) Fig. 1

272. Like *Norris*, *Omont*'s fracturing system contains “mixers,” (i.e. blenders) multiple pumps, manifolds distributing fluid, and valves to control and direct fluid.²⁵³ *Omont* identifies wear and tear, resulting in “operation stoppages and severe damage to other components,” as a challenge in oilfield operations.²⁵⁴ *Omont* discloses “control and monitoring” of fracturing operations based on sensor data, such as that shown for example in Fig. 2:

²⁵³ Ex. 1005 (*Omont*) Fig. 1, [0023] – [0025].

²⁵⁴ Ex. 1005 (*Omont*) [0002]- [0003].

Ex. 1005 (*Omont*) Fig. 2

273. *Norris* and *Omont* are thus from the same field of endeavor (i.e. multiple-pump fracturing), identify similar problems (component fatigue, stress, and failure), and address problems with similar solutions (sensing, monitoring, and control). A POSITA would have considered whether known solutions from one reference (i.e. monitoring, alarming and logging from *Omont*) could be applied in the other (*Norris*) and would have determined that the combination of features and

solutions would reasonably have resulted in a successful implementation of control features.

274. Moreover, a POSITA would reasonably expect monitoring and control techniques taught by *Omont* to improve the control system of *Norris*. A POSITA would have understood that applying elements of *Omont* (e.g., *Omont*'s diagnostic tool) to *Norris* would enable logging and storing operational parameters, generating alerts for predictive maintenance, and extending control to blenders and material-handling systems, all while maintaining *Norris*'s approach to avoiding coincidental pump operation.

275. The systems and techniques in *Norris* and *Omont* are compatible and combining elements of *Norris* and *Omont* leads toward the same system configuration as in *Norris* with desirable operating results. For example, *Omont* teaches that control devices may be deployed locally with components or separately²⁵⁵, and *Norris* similarly discloses both local and system-wide control.²⁵⁶ A POSITA would have understood that features of *Omont*'s local pump control could be implemented in *Norris*'s local pump control, that features of *Omont*'s central control could be implemented in *Norris*'s central control, or vice versa. *Norris* teaches that non-coincidental pump operation reduces stress and fatigue,²⁵⁷

²⁵⁵ See Ex.1007 (*Omont*), [0061], Figs. 2-3

²⁵⁶ See Ex. 1004 (*Norris*) Figs. 3 – 4.

²⁵⁷ Ex. 1004 (*Omont*), [0028], [0049].

and *Omont* further describes predictive maintenance techniques, compatible with *Norris*, which extend component lifetime and avoid costly failures. For example, *Omont* discloses a “predictive maintenance tool 565 [that] performs predictive maintenance operations, such as for providing remaining functional life estimates. Predictive maintenance operations may facilitate greater reliability of the additive system 200 by utilizing the logged information associated with various components of the additive system 200 to generate functional life profiles for predicting or otherwise determining remaining functional life of the components. Predicting remaining functional life of components may permit in-time servicing and maintenance of the components, such as to avoid costly failures or extend the lifetime of these components.”²⁵⁸

276. *Omont* also identifies known techniques to improve similar devices in the same way that *Norris* proposed to improve fracturing operations. For example, *Norris* describes pump sensing and control: “[a]pplication controller 401 receives real time data (analog or digital) via data links from sensors and data processors monitoring fluid pressure and pump operations.”²⁵⁹ As does *Omont*: “the control center 170 may be operable to monitor and/or control operational parameters associated with the containers 110, 112, 130, 140, 166, the first and second mixers

²⁵⁸ Ex. 1005 (*Omont*) [00118].

²⁵⁹ Ex. 1004, (*Norris*) [0029].

108, 128, the material transfer assemblies 114, 116, 130, and/or the pump assemblies 150.”²⁶⁰ Accordingly, a POSITA aware of *Norris* and *Omont* would reasonably apply *Omont*’s monitoring and control techniques—highly similar to those in *Norris*—to *Norris*’s control system, pumps, blender and flowlines.

277. A POSITA would also have been motivated to combine *Norris* and *Omont* according to known methods to yield predictable results. For example, *Norris* discloses sensors that measure “operational parameters.”²⁶¹ *Omont* discloses logging sensor data—including the same types of operational data measured in *Norris*—for use in monitoring, diagnostics, alarms and predictive maintenance.²⁶² A POSITA would have known that sensor types in *Omont* could also be used, with predictable results, with components in *Norris*. The sensors identified in *Norris* and *Omont* are of a similar nature and to monitor similar parameters.²⁶³ A POSITA would also have known that data obtained from *Norris*’s sensors could be predictably logged and used for predictive maintenance, as taught in *Omont*, particularly so since the sensors monitor the same or similar parameters in both references.

²⁶⁰ Ex. 1005 (*Omont*), [0026], see also [0027 – 0029], [0051]- [0054], [0059], Fig. 2

²⁶¹ Ex. 1004 (*Norris*), [0032], [0037], [0041].

²⁶² Ex. 1005 (*Omont*), [0005], [0052], [0094], [000114]- [00117].

²⁶³ Ex. 1004 (*Norris*) [0041], [0044], claim 2; Ex. 1005 (*Omont*) [00142], [00154], [00165], [00176].

278. Finally, design incentives and market forces in multi-pump fracturing operations would have led a POSITA to combine *Norris* and *Omont*. *Norris* teaches that coincidental pump operation causes fatigue and failure.²⁶⁴ *Omont* teaches that “operation stoppages” and “severe damage” to components introduce “monetary costs and loss of production time.”²⁶⁵ A POSITA seeking to extend component life, maximize production time, or reduce expensive manual interventions in operations would naturally look to the teachings of *Norris* and *Omont* together. *Omont*’s teachings require little variation for use with *Norris*, and variations in sensing, monitoring, and control techniques would have been predictable to a POSITA, particularly as both references teach similar pump and system control, as well as the use of sensors to monitor the same or similar data regarding the pumps and system of both references.

B. INDEPENDENT CLAIM 1

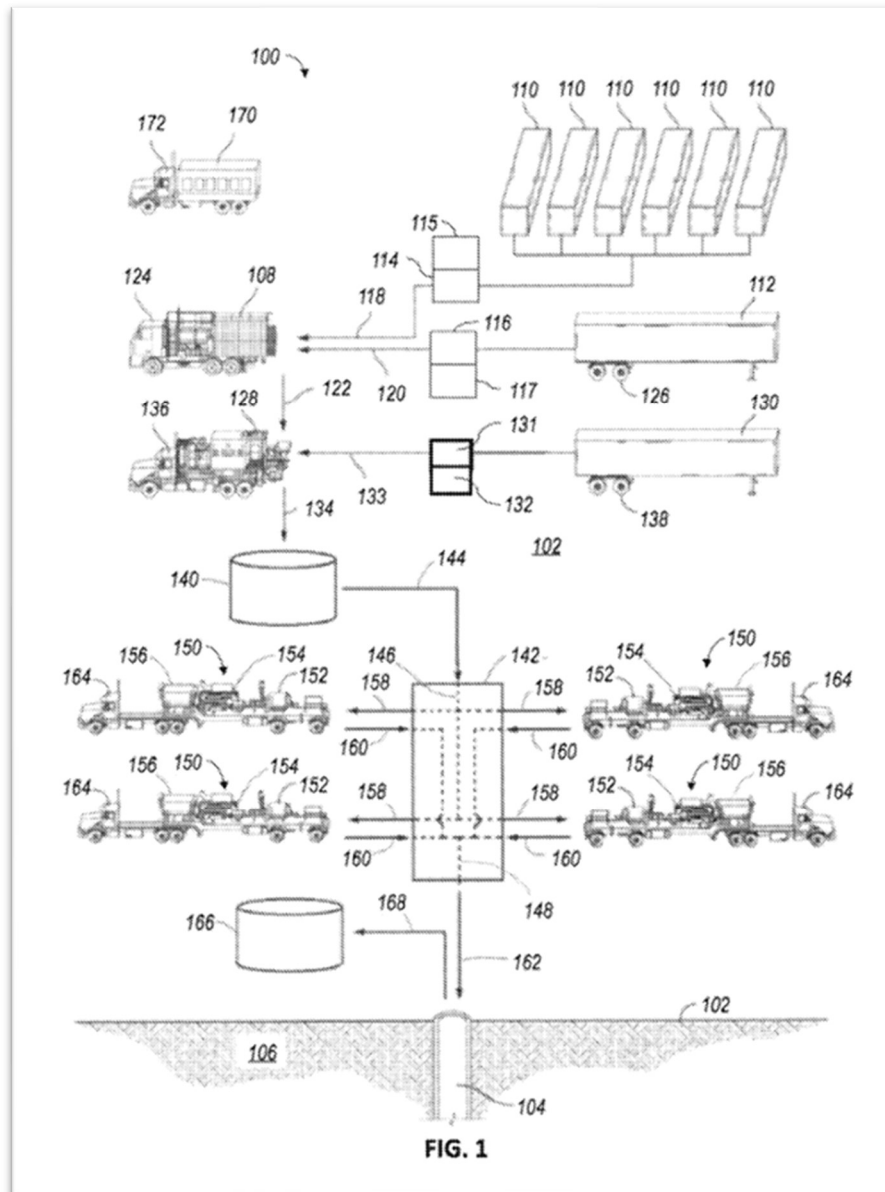
1. 1[p] – 1[b]

279. Limitations 1[p] – 1[b] are disclosed or rendered obvious by *Norris* as discussed above in Sections X.A.1 – X.A.3 and incorporated herein by reference. As discussed in the subsections below, *Omont* also discloses each limitation of 1[p] –

²⁶⁴ Ex. 1004 (*Norris*) [0002]- [0003].

²⁶⁵ Ex. 1005 (*Omont*) [0003].

1[b] and the combination of *Norris* and *Omont* renders limitations 1[p] – 1[b] obvious.²⁶⁶



Ex. 1005 (*Omont*) Fig. 1

²⁶⁶ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 1 out of an abundance of caution.

a) 1[p]: ““1. A hydraulic fracturing system, comprising:”

280. *Omont* discloses that “Fig. 1 is a schematic view of at least a portion of an example additive system 100.”²⁶⁷ *Omont* discloses that “additive system 100 is operable as a fracturing system”.²⁶⁸ Accordingly, *Omont* discloses the limitations of 1[p], and the preamble would have been obvious to a POSITA based on the combination of teachings of *Norris* and *Omont*.

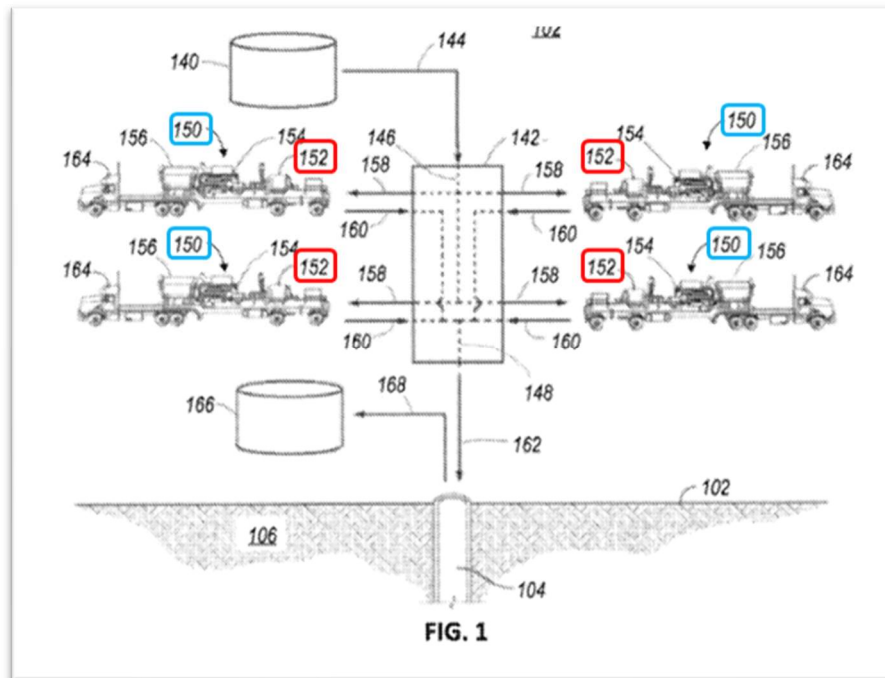
b) 1[a]: “a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;”

281. *Omont* discloses that the additive system 100 comprises a “pump fleet” and that “[t]he pump fleet may comprise multiple pump assemblies 150 [annotated in blue] each comprising a pump 152 [annotated in red], a prime mover 154, and a heat exchanger 156.”²⁶⁹ Accordingly, *Omont* discloses the limitations of 1[a] and 1[a] would have been obvious to a POSITA based on the combination of teachings of *Norris* and *Omont*.

²⁶⁷ Ex. 1005 (*Omont*) [0017].

²⁶⁸ Ex. 1005 (*Omont*) [0017], see also [0020], [0021].

²⁶⁹ Ex. 1005 (*Omont*) [0023].



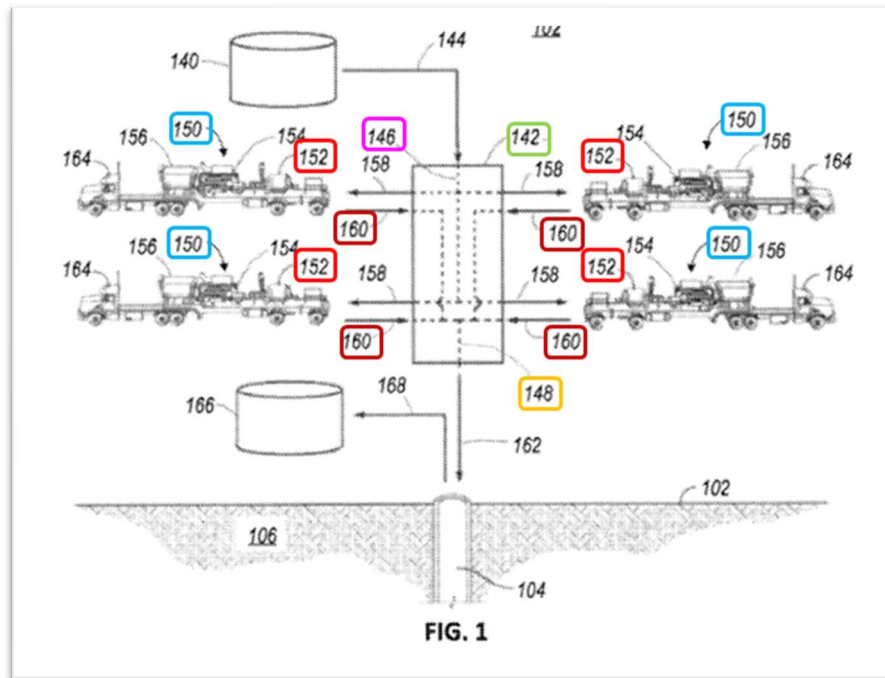
Ex. 1005 (*Omont*) Fig. 1 (annotated and excerpted)

c) 1[b]: “a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and”

282. *Omont* discloses a combination of flowlines and manifolds which, together “receives and consolidates the fracturing fluid from the plurality of pumps for injection into a wellhead”. *Omont* discloses a “common manifold 142 [annotated in green] [that] may comprise a combination of valves and/or diverters, as well as a suction line 146 [annotated in magenta] and a discharge line 148 [annotated in orange], such as may be collectively operable to direct flow of the mixture in a selected or predetermined manner.”²⁷⁰ Further, *Omont* discloses that the pumps

²⁷⁰ Ex. 1005 (*Omont*) [0023].

“discharge the mixture under pressure to the discharge line 148 of the common manifold 142, via one or more conduits 160 [annotated in dark red].”²⁷¹ *Omont* teaches that “[t]he mixture may comprise a fracturing fluid when the additive system 100 is operable as the fracturing system.”²⁷²



Ex. 1005 (*Omont*) (annotated and excerpted)

283. Further, *Omont* teaches that “[t]he mixture may then be discharged from the common manifold 142 into the wellbore 104 via one or more conduits 162.”²⁷³

²⁷¹ Ex. 1005 (*Omont*) [0023].

²⁷² Ex. 1005 (*Omont*) [0021].

²⁷³ Ex. 1005 (*Omont*) [0025].

284. Accordingly, *Omont* teaches a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead. Therefore, the combination of *Norris* and *Omont* renders limitation 1[b] obvious.

2. 1[c]: “a control system comprising:”

285. As discussed above in Section XI.A.4, and incorporated herein by reference, *Norris* discloses a control system. *Omont* also discloses a control system, as discussed below. *Omont* teaches “a control and monitoring (CAM) system 300”²⁷⁴ CAM system 300 controls various controllable devices 216, 224 to control overall operation of the additive system.²⁷⁵

286. *Omont* further discloses “control hardware 400” which is an example of an implementation of CAM system 300.²⁷⁶ *Norris* teaches control hardware 400 can be used to implement any of the control of components throughout additive system 200 and CAM system 300.²⁷⁷ Further, *Omont* teaches that “[e]ach instance of the control hardware 400 may be or comprise one or more processors, special-purpose computing devices, servers, personal computers, personal digital assistant (PDA) devices, smartphones, Internet appliances, and/or other types of computing

²⁷⁴ Ex. 1005 (*Omont*) [0029].

²⁷⁵ *see* Ex. 1005 (*Omont*) [0032] – [0040].

²⁷⁶ Ex. 1005 (*Omont*) [0060].

²⁷⁷ Ex. 1005 (*Omont*) [0061].

devices,”²⁷⁸ including common components of these processing devices including memory, I/O storage, etc. Accordingly, *Omont* discloses a control system.²⁷⁹ A POSITA would have understood that, since the CAM system and control hardware of *Omont* and the various controllers of *Norris* are both implemented using processors (including generic computers) that communicate, execute algorithms, and control devices of their related physical systems, that the teachings of *Omont* and *Norris* are compatible and functions disclosed in one reference could easily be programmed into and performed by the hardware of the other reference. Accordingly, a POSITA would have been motivated to implement the functions of *Omont* into *Norris*’ control system, or vice versa. Further, since the teachings are compatible, a POSITA would have had a reasonable expectation of success in the combination.

3. 1[d]: “a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;”

287. As discussed above in Section XI.A.5, and incorporated herein by reference, *Norris* discloses a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system. *Omont*

²⁷⁸ Ex. 1005 (*Omont*) [0062].

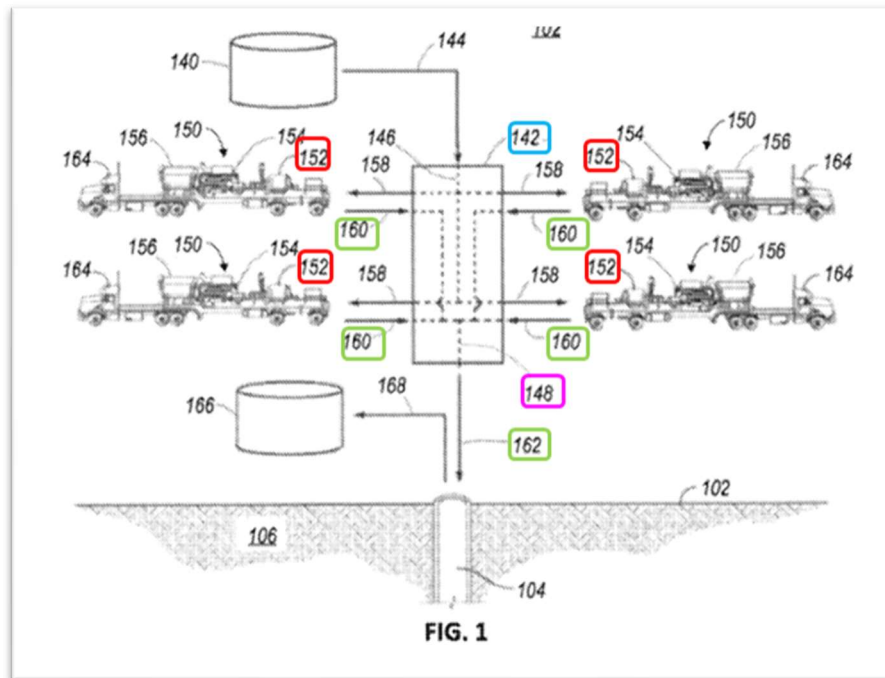
²⁷⁹ Ex. 1005 (*Omont*) [0060] – [0065].

also discloses a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system as discussed below.

288. *Omont* teaches that “the additive system 200 may comprise one or more monitored subsystems 202. Examples of the monitored subsystem 202 depicted in FIG. 2 may include the containers 110, 112, 130, 140 and/or other components and/or subsystems of the additive system 100 shown in FIG. 1 that may be monitored but not controlled via operation of the CAM system 300. Each monitored subsystem 202 comprises one or more sensors 204 each operable to monitor one or more parameters associated with that monitored subsystem 202. Each sensor 204 is operable to generate a signal or information related to operational parameters of the monitored subsystem 202, which may then be communicated to the CAM system 300.”²⁸⁰ As shown in Fig. 1, the “other components and or subsystems of the additive system 100” include pumps 152 [annotated in red], common manifold 142 (annotated in blue), and other components of the distribution system including conduits 160, 162 (annotated in green) and discharge line 148 (annotated in magenta).²⁸¹

²⁸⁰ Ex. 1005 (*Omont*) [0030]., see also [0031] – [0035].

²⁸¹ See Ex. 1005 (*Omont*) [0023].



Ex 1007 (*Omont*) (annotated and excerpted)

289. *Omont* further discloses that the sensors gathering “operational parameters” of valves, actuators, material transfer devices, and prime movers “may be operable to generate information related to temperature, pressure, electrical current, power consumption, proximity, linear position, rotational position, operating speed, operating frequency, torque, elapsed operating time, and/or other operational parameter[s]” of the various subsystems and equipment shown in Fig. 1.²⁸² *Omont* further describes a “material sensor” monitoring a “subsystem” including “pumps” or measuring “flow rate of material being transferred via ...

²⁸² See Ex. 1005 (*Omont*) [0050] – [0052], Figs. 1,3.

material conduits,” such as those in the suction and discharge manifolds.²⁸³ Other examples of “one or more parameters of the plurality of pumps” include “power end oil pressure on a pump 152” and “air pressure of the pump 152”.²⁸⁴

290. A POSITA would also have known that the sensors of *Omont* and *Norris* contain processors for monitoring parameters and communicating with control devices. *Omont*, for example, teaches that its sensors, for example of subsystems 202, 212 and 220, may be implemented as an “instance of the control hardware,” which contains a processor.²⁸⁵ A POSITA would have found it obvious to implement sensors with the control hardware of *Omont*.

291. As the sensors of *Omont* and *Norris* are similar, and measure similar parameters of similar equipment, a POSITA would have recognized that the sensors of *Omont* would have been obvious to implement into the teachings of *Norris* with a reasonable expectation of success in the implementation.

292. Accordingly, *Omont* discloses a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system as claimed. Therefore, the combination of *Norris* and *Omont* renders limitation 1[d] obvious.

²⁸³ Ex. 1005 (*Omont*) [0051], [0054], Fig. 3.

²⁸⁴ Ex. 1005 (*Omont*) [0094].

²⁸⁵ Ex. 1005 (*Omont*) [0061]- [0063], Fig. 4.

4. 1[e][i]: “one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and

293. As discussed above in Sections XI.A.6 and XI.A.10, and incorporated herein by reference, *Norris* discloses limitation 1[e][i], or at least it would have been obvious to a POSITA. As discussed below, *Omont* discloses limitation 1[e][i] as well, or it would have been obvious to a POSITA based on the teachings of *Omont*.

294. *Omont* states that “components of each subsystem 202, 212, 220” (including sensors) and “components of the SCM device” (or “system control/monitoring device”) may be “implemented as ... control hardware” having “one or more processors.”²⁸⁶ A POSITA would have known, based on the teaching of *Omont* to implement sensors, data processors, and controllers in *Norris* using *Omont*’s control hardware.²⁸⁷ Both references also teach use standard industrial communication protocols, such as Modbus, ethernet, etc., that require processing devices to send and receive operating parameters.²⁸⁸ Similarly, a POSITA would have implemented aspects of *Omont*’s SCM device in *Norris*’s application controller

²⁸⁶ Ex. 1005 (*Omont*) [0060]- [0062], Figs. 2-4.

²⁸⁷ See sections XII.B.2-3 above; Ex. 1004 (*Norris*) [0029]; Ex. 1005 (*Omont*), [0062]- [0063].

²⁸⁸ See sections XII.B.2-3 above; Ex. 1004 (*Norris*) [0029]; Ex. 1005 (*Omont*), [0062]- [0063].

(e.g., *Omont*'s diagnostic tool and associated methods), and *Omont* teaches that the SCM may be “implemented as ... control hardware.”²⁸⁹

295. *Omont* also teaches control hardware implemented in communication interfaces between sensors (in subsystems 202, 212, 220) and controllers and between sensors and other subsystem components, and a POSITA would have accordingly implemented communication between sensors, controllers, and subsystem components in *Norris*—claimed “first device[s]” and “second device[s]”—via a communication interface containing “processing devices.”²⁹⁰

296. *Omont* further teaches that processors transmit and receive operational parameters. For example, “control hardware 400 may receive information generated by the sensors.”²⁹¹ *Omont*'s sensors also transmit operational parameters “to the CAM system” via a local network or communication interface.²⁹²

297. A POSITA would have known, from the teachings of *Omont*, that a sensor (a “first device”) transmits measured parameters to *Omont*'s SCM,²⁹³ and in light of *Norris*'s teaching that the application controller receives operational parameters,²⁹⁴ would have implemented similar data links in the system of *Norris*.

²⁸⁹ Ex. 1005 (*Omont*) [0060]- [0061].

²⁹⁰ See Ex. 1005 (*Omont*) [0032], [0061], Fig. 2.

²⁹¹ Ex. 1005 (*Omont*) [0065].

²⁹² Ex. 1005 (*Omont*) [0038], [0050], Figs. 2-3.

²⁹³ Ex. 1005 (*Omont*) [0038], [0065].

²⁹⁴ Ex. 1004 (*Norris*) [0029]- [0030]

A POSITA would also have known, from the teachings of *Omont*, that a sensor (a “first device”) transmits measured parameters to *Omont*’s control hardware (located in *Omont*’s subsystems, a “second device”),²⁹⁵ and would have implemented similar data links in the system of *Norris* to facilitate communications between sensors and controllers.

298. Accordingly, the combination of *Norris* and *Omont* renders limitation 1[e][i] obvious.

5. 1[e][ii]: “detect that the first parameter is outside of an acceptable threshold; and”

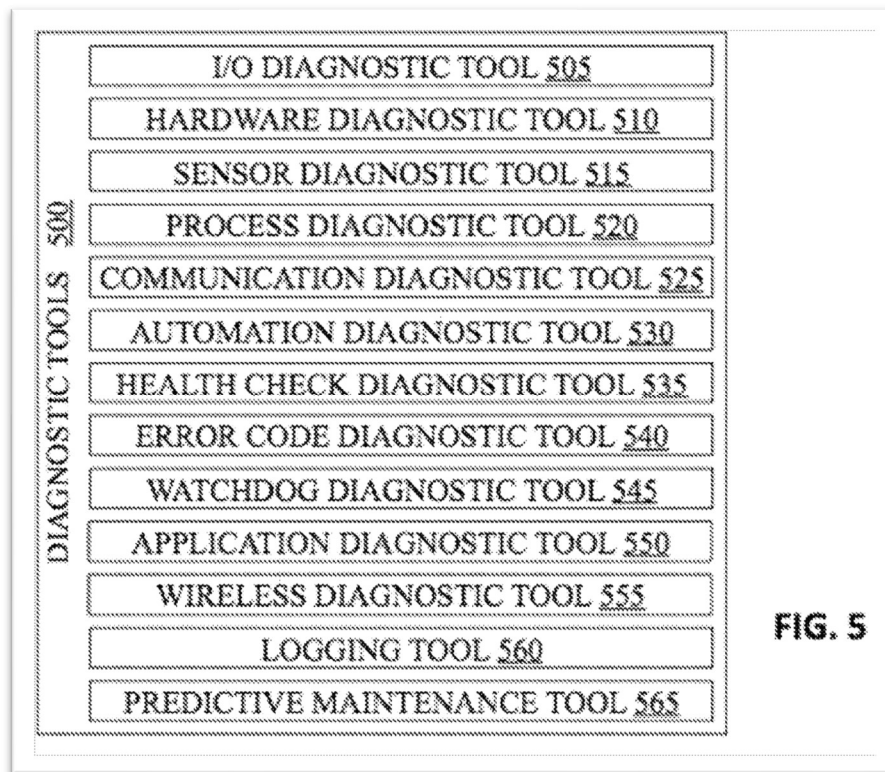
299. As discussed above in Sections XI.A.7 and XI.A.10, and incorporated herein by reference, *Norris* discloses limitation 1[e][i], or at least it would have been obvious to a POSITA. To the extent that *Norris* does not explicitly use the term “threshold”, *Omont* teaches detecting that the first parameter (any measured parameter) is outside of an acceptable threshold.

300. For example, *Omont* discloses that “portion[s] of the CAM system 300 may include instructions or program code for implementing several layers of diagnostic tools operable to perform diagnostics of the additive system 200 and/or the CAM system 300.”²⁹⁶ These “diagnostic tools” are shown in Fig. 5. A POSITA would have recognized that the diagnostic methods implemented by *Omont*’s

²⁹⁵ Ex. 1005 (*Omont*) [0065].

²⁹⁶ Ex. 1005 (*Omont*) [0075].

diagnostic tool could improve *Norris*'s control systems—for monitoring pumps, comparing operating and desired parameters, and mitigating component fatigue—and implemented them accordingly.



Ex. 1005 (*Omont*) Fig. 5

301. *Omont* further teaches, as part of the diagnostic system shown in Fig. 5, “may also include monitoring a fracturing pump suction pressure sensor, such as to compare an amperage or other parameter associated with the sensor to a predetermined threshold.”²⁹⁷ Further, *Omont* teaches, as part of the diagnostic tools, to “monitor[] raw sensor data and/or other process parameters values to, for example,

²⁹⁷ Ex. 1005 (*Omont*) [0093].

confirm that such values meet predetermined thresholds or are within predetermined ranges.”²⁹⁸ Accordingly, *Omont* teaches multiple other uses of thresholds and detecting when a measured parameter is outside an acceptable threshold that a POSITA would have implemented throughout the fracturing system.²⁹⁹

6. 1[e][iii]: “generate automated control instructions at the second device based at least in part on the first parameter; and”

302. As discussed above in Sections XI.A.8 and XI.A.10, and incorporated herein by reference, *Norris* discloses limitation 1[e][iii], or at least it would have been obvious to a POSITA. *Omont* also teaches generating automated control instructions at a second device (e.g., at the SCM or subsystems in *Omont*) based on measured parameters.

303. The SCM in *Omont* generates automated control instructions based on the first parameter.³⁰⁰ *Omont* teaches that the “SCM device” may “receive information generated by the sensors” and based “on such information, generate and send control signals.”³⁰¹ The “SCM device” uses “information generated by the sensors” to “execute coded machine-readable instructions” to perform methods and processes disclosed in *Omont* (e.g. *Omont*’s “diagnostic tool”).³⁰² The SCM

²⁹⁸ Ex. 1005 (*Omont*) [0094].

²⁹⁹ See, e.g., Ex. 1005 (*Omont*) [0090], [0094], [00119], [00140], [00148], [00158], [00169].

³⁰⁰ Ex. 1005 (*Omont*), [0038].

³⁰¹ Ex. 1005 (*Omont*), [0038].

³⁰² Ex. 1005 (*Omont*), [0038].

generates control instructions “at the second device” because instructions are contained at the SCM and the SCM itself generates and sends instructions.³⁰³

304. The control hardware in *Omont* also generates automated control instructions at a controlled subsystem based on the first parameter.³⁰⁴ “[c]ontrol hardware may receive information generated by the sensors” and “execute programs, routines, and/or other coded instructions based on such information,” resulting “in the generation of output information [] for controlling the controllable devices.”³⁰⁵ And control hardware implements methods described in *Omont* for controlling components based on operational parameters.³⁰⁶ Control hardware generates instructions “at a second device” because the control hardware may be in or at the controlled subsystem (a “second device”).³⁰⁷

305. Accordingly, the combination of *Norris* and *Omont* renders this limitation obvious.

³⁰³ Ex. 1005 (*Omont*), [0038].

³⁰⁴ See Ex. 1005 (*Omont*) [0065].

³⁰⁵ See Ex. 1005 (*Omont*) [0065]- [0067].

³⁰⁶ See Ex. 1005 (*Omont*) [0065], [00137]- [00143].

³⁰⁷ See Ex. 1005 (*Omont*), [0061]- [0065], Figs. 2-3.

7. **1[f]: “one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.”**

306. As discussed above in Sections XI.A.9 and XI.A.10, and incorporated herein by reference, *Norris* discloses limitation 1[e][iii], or at least it would have been obvious to a POSITA. *Omont* also teaches “controllable devices” that receive instructions from control hardware and/or the SCM—that is, from local and global control.

307. For example, “[t]he SCM” may “generate and send control signals to the controllable devices.”³⁰⁸ As examples, a “common manifold,” “valve,” “actuator,” “material transfer device,” (pump) or “prime mover” (motor) “may be implementations of the controllable devices.”³⁰⁹

308. Similarly, “executed instructions and/or generated output information” from control hardware “may be for controlling the controllable devices,” including “by another instance of the control hardware.”³¹⁰

309. A POSITA would have combined features and functions of *Omont*’s controllers into *Norris*’s controllers.³¹¹ And a POSITA would have controlled similar controllable devices in *Omont* and *Norris*—multiple pumps, manifolds, lines and

³⁰⁸ Ex. 1005 (*Omont*) [0038].

³⁰⁹ Ex. 1005 (*Omont*) [0050]- [0052], [0059].

³¹⁰ Ex. 1005 (*Omont*) [0065], Fig. 2.

³¹¹ See Section XII.B.2 above.

conduits, blenders, and wellheads—in a similar manner. For example, *Omont* and *Norris* each teach sensing and controlling similar parameters (e.g., “throttle,” “flow rate,” and “pressure”) at similar controllable devices.³¹²

310. Accordingly, the combination of *Norris* and *Omont* renders this limitation obvious.

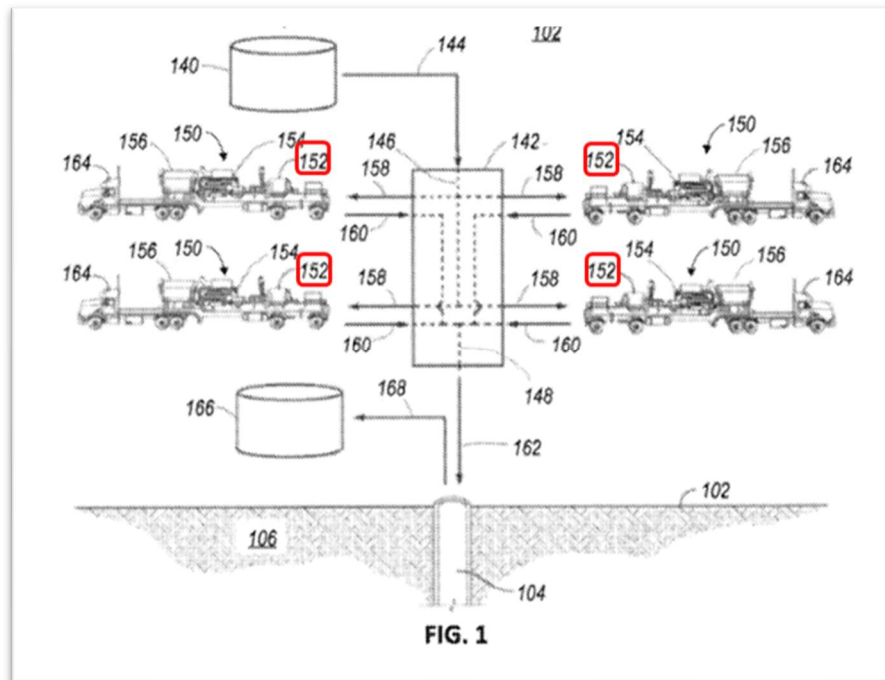
C. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF SENSING DEVICES ARE INSTALLED ON THE PLURALITY OF PUMPS AND THE DISTRIBUTION SYSTEM, AND SELECTED FROM A GROUP INCLUDING FLOW SENSORS, ACCELEROMETERS, PRESSURE TRANSDUCER, AND TACHOMETERS.”

311. Dependent Claim 2 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 2. As discussed above in Section XI.B, and incorporated herein by reference, *Norris* discloses the additional limitations of Claim 2. *Omont* also discloses these additional limitations, as discussed below.

312. *Omont* teaches the use of a “material transfer device 254” which “may be [] pumps 152” shown in Fig. 1 (annotated in red below).³¹³

³¹² Ex. 1005 (*Omont*) [0051]- [0059], [0094].

³¹³ Ex. 1005 (*Omont*) [0051].



Ex. 1005 (*Omont*) Fig. 1 (annotated and excerpted)

313. *Omont* further teaches that “sensors 214, 222 may be disposed or otherwise utilized in association with the material transfer device 254 and/or the prime mover 256, such as for generating information related to operational parameters of the material transfer device 254 and/or the prime mover 256. For example, the one or more sensors 214, 222 may be operable to generate information related to temperature, pressure, electrical current, power consumption, proximity, linear position, rotational position, operating speed, operating frequency, torque, elapsed operating time, and/or other operational parameter associated with the material transfer device 254.”³¹⁴ A POSITA would have understood that a sensor for

³¹⁴ Ex. 1005 (*Omont*) [0052].

monitoring “pressure” would have been a pressure transducer. Further, a sensor for measuring “operating speed” would have been a tachometer.

314. Further, *Omont* teaches that other parameters of the material transfer device 254 that are measured and logged “may also be temperature, pressure, flow rate, electrical current, power consumption, operating speed, operating frequency, torque, position, elapsed operating time, and/or other operational parameters.”³¹⁵ A POSITA would have understood that measuring “flow rate” would have been accomplished using “flow sensors”.

315. A POSITA would have understood that, at least the tachometer measuring “operating speed” would have necessitated being installed “on” the pumps. Further, a POSITA would have understood that sensors measuring fluid parameters of the pumps, such as pressure transducers and flow sensors, would have needed to be installed on some portion of the fluid handling system, such as the pump or distribution system, to measure those flow parameters.

316. *Omont* further illustrates and describes these sensors as installed on the monitored components.³¹⁶

317. Accordingly, *Omont* discloses the additional limitations of Claim 2, and the combination of *Norris* and *Omont* would have rendered Claim 2 obvious.

³¹⁵ Ex. 1007 (*Omont*) [00142].

³¹⁶ Ex. 1005 (*Omont*) [0051]- [0052], Figs. 2-3.

D. DEPENDENT CLAIM 3: “DEPENDENT CLAIM 3: “3. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF PUMPS OR THE DISTRIBUTION SYSTEM INCLUDES AT LEAST ONE DEVICE SELECTED FROM A GROUP INCLUDE A GATE, VALVE, ACTUATOR, MOTOR, SUCTION PIPE, DISCHARGE PIPE, ENGINE, TRANSMISSION, AND TEMPERATURE REGULATION DEVICE, CONTROLLABLE VIA THE ONE OR MORE CONTROL DEVICES.”

318. Dependent Claim 3 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 3. As discussed above in Section XI.C, and incorporated herein by reference, *Norris* discloses the additional limitations of Claim 3. *Omont* also discloses these additional limitations, as discussed below.

319. *Omont* discloses that “material transfer device 254 may be or comprise one of the material transfer devices 114, 116, 131 or pumps 152 shown in FIG. 1. Thus, the subsystem 252 may also comprise a prime mover 256 operable to drive the material transfer device 254.”³¹⁷ Accordingly, *Omont* discloses a “pump”. Further, *Omont* discloses that the pump system “may also comprise a prime mover control device (not shown), such as may power and/or control the prime mover 256. For example, in implementations in which the prime mover 256 comprises an *electric motor*, the prime mover control device may be a drive.”³¹⁸ Accordingly, *Omont* also discloses a motor. Further, *Omont* discloses that the motor may be

³¹⁷ Ex. 1005 (*Omont*) [0051] emphasis added.

³¹⁸ Ex. 1005 (*Omont*) [0051] emphasis added.

controlled by a control device (i.e. a drive). A POSITA would have understood that by controlling the motor using a “drive” to control, for example, speed and torque of the motor, the drive is also controlling the pump.

320. Accordingly, *Omont* discloses the additional limitations of Claim 3, and the combination of *Norris* and *Omont* renders Claim 3 obvious.

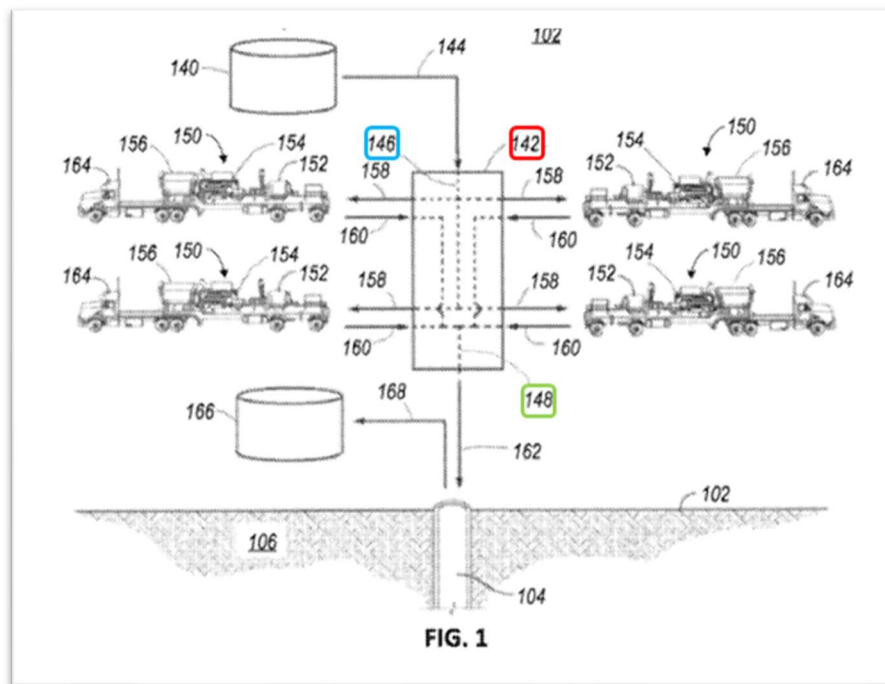
E. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: A SUCTION LINE THROUGH WHICH FRACTURING FLUID IS SUPPLIED; AND A DISCHARGE LINE THROUGH WHICH FRACTURING FLUID IS DISCHARGED, WHEREIN THE PLURALITY OF SENSING DEVICES INCLUDES ONE OR MORE FLOW SENSORS CONFIGURED TO MEASURE FLOW THROUGH THE SUCTION LINE AND THE DISCHARGE LINE”

321. Dependent Claim 4 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* further discloses the additional limitations of Claim 4. As discussed above in Section XI.D, and incorporated herein by reference, *Norris* discloses, or at least renders obvious, the additional limitations of Claim 4. *Omont* also discloses these additional limitations, or at least they would have been obvious to a POSITA, as discussed below.

322. *Omont* teaches both a suction line and a discharge line, both of which comprise at least part of a common manifold 142. *Omont* discloses that “[t]he common manifold 142 may comprise a combination of valves and/or diverters, as well as a suction line 146 and a discharge line 148.”³¹⁹ *Omont* further teaches that he

³¹⁹ Ex. 1005 (*Omont*) [0023].

pump fleet may comprise multiple pump assemblies 150 each comprising a pump 152, a prime mover 154, and a heat exchanger 156. Each pump assembly 150 may receive the mixture from the suction line 146 of the common manifold 142, via one or more conduits 158, and discharge the mixture under pressure to the discharge line 148 of the common manifold 142, via one or more conduits 160.”³²⁰ The common manifold 142 (annotated in red), along with suction line 146 (annotated in blue) and discharge line 148 (annotated in green) are each shown in the excerpt of Fig. 1 below.



Ex. 1005 (*Omont*) Fig. 1 (annotated and excerpted)

323. Further, *Omont* teaches that “[t]he common manifold 142 may also comprise one or more sensors (not shown) operable to generate a signal or

³²⁰ Ex. 1005 (*Omont*) [0023].

information related to operational parameters of or associated with the common manifold 142 and communicate such signal or information to the CAM system 300.”³²¹ *Omont* teaches the use of these sensors “to control or otherwise operate flow through the common manifold 142” by operating “actuators [] operable to receive control signals from the CAM [control and monitoring] system 300.”³²² It would at least have been obvious to a POSITA to use flow sensors configured to measure flow through the suction line and the discharge line in order to control flow through the common manifold. A POSITA would also have understood that absent leaks on the pump trailer(s), the flow through the suction manifold would be the same as the flow through the discharge manifold, due to the laws of thermodynamics and mass balance.

324. It would have been further obvious to add such sensors, as *Omont* teaches using sensors to measure “temperature, pressure, flow rate, electrical current, power consumption, operating speed, operating frequency, torque, position, elapsed operating time, and/or other operational parameters”³²³ of, at least, the pumps. A POSITA would have understood that measuring “flow rate” of the pumps would be equal to (absent leaks or other failures) measuring flowrate of the suction lines and discharge lines. To the extent the board finds that separate sensors are needed to

³²¹ Ex. 1005 (*Omont*) [0059].

³²² Ex. 1005 (*Omont*) [0059].

³²³ Ex. 1007 (*Omont*) [00142].

render the claim obvious, adding sensors to measure flow through the suction line and separate sensors to measure flow through the discharge line would have been well within the skill of a POSITA, as the use of flow sensors to measure flowrate was well known when handling fluid.

325. Accordingly, *Omont* discloses the additional limitation of Claim 4, or at least the additional limitations would have been obvious to a POSITA based on the teachings of *Omont* and the general engineering knowledge of a POSITA.

F. DEPENDENT CLAIM 5: “DEPENDENT CLAIM 5

326. Dependent Claim 5 depends from Claim 1. In addition to the disclosure or teachings regarding Claim 1, as discussed above, *Norris* and/or *Omont* further disclose the additional limitations of Claim 5. As discussed above in Section XI.E, and incorporated herein by reference, *Norris* discloses the additional limitations of Claim 3. *Omont* also discloses these additional limitations, or at least they would have been obvious to a POSITA, as discussed below.

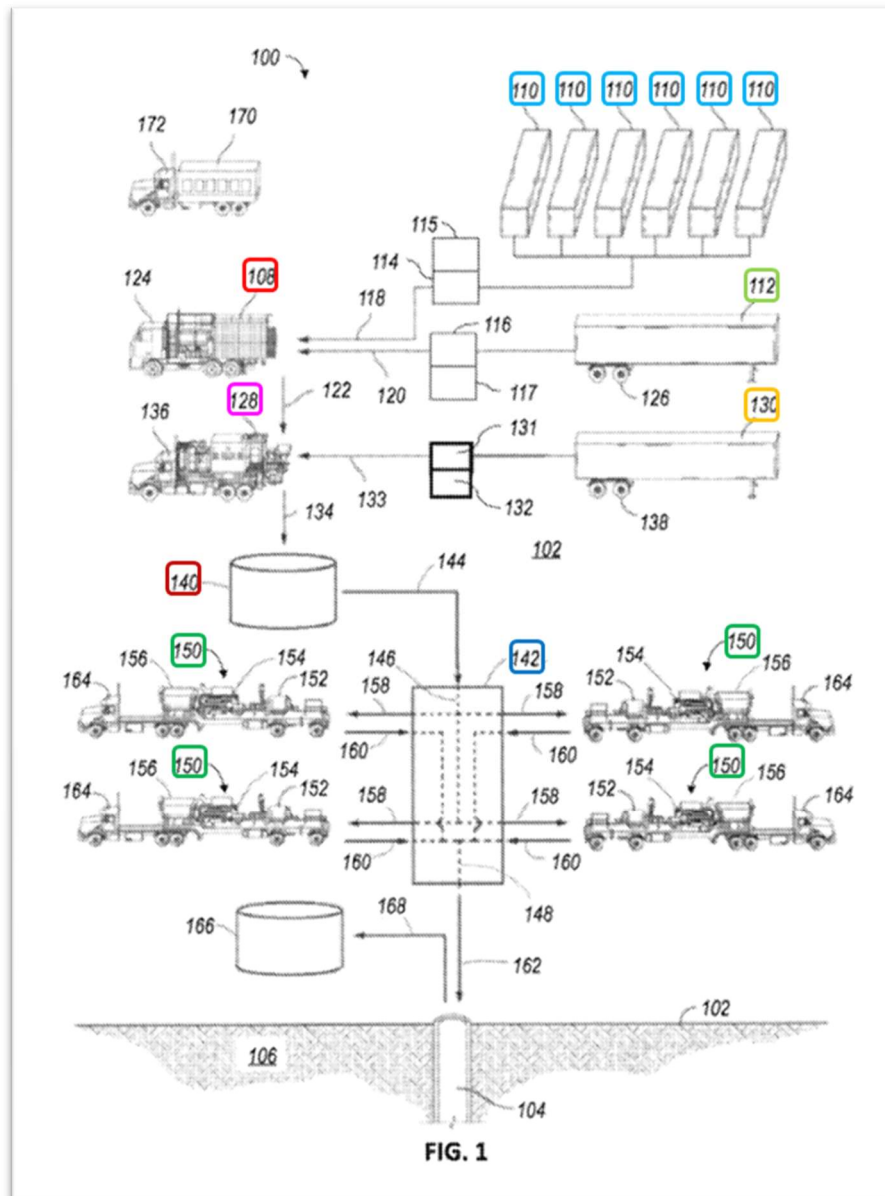
1. 5[a]: “The system of claim 1, further comprising: one or more blenders configured to mix together one or more materials to form the fracturing fluid,”

327. *Omont* discloses the use of mixers (blenders) to mix together one or more materials to form the fracturing fluid. As one example, *Omont* discloses the use of “first mixer 108 [that is] connected with one or more first containers 110 [annotated in blue] and a second container 112 [annotated in green]. The second

container 112 may contain a first additive and the first containers 110 may contain water or another liquid comprising water.”³²⁴Further, *Omont* teaches that the liquid (e.g. water) and first additive are sent to first mixer 108 which “mix[es] or otherwise combine[s] the first additive and the liquid to form a base fluid.”³²⁵

³²⁴ Ex. 1005 (*Omont*) [0017].

³²⁵ Ex. 1005 (*Omont*) [0018].



Ex. 1005 (*Omont*) Fig. 1 (annotated)

328. Further, *Omont* teaches that the system may comprise a “second mixer 128 [annotated in magenta above] fluidly connected with the first mixer 108 and a third container 130 [annotated in orange above].”³²⁶ *Omont* teaches that the “third

³²⁶ Ex. 1005 (*Omont*) [0020].

container 130 may contain a second additive that may be substantially different than the first additive.”³²⁷ When applied to a fracturing system, one of the example applications of the disclosures of *Omont*, “the second additive may be or comprise a proppant material, such as sand, sand-like particles, silica, quartz, and/or propping agents, among other examples.”³²⁸ Further still, *Omont* teaches that this mixture mixed in the second mixer (blender) “may comprise a fracturing fluid when the additive system 100 is operable as the fracturing system”.³²⁹

329. Accordingly, *Omont* discloses the elements of limitation 5[a].

2. 5[b]: “wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold,”

330. *Omont* discloses that the fracturing fluid is provided from the blender to the plurality of pumps via a manifold. *Omont* teaches that the fracturing fluid “may be communicated from the second mixer 128 to a fourth container 140 [annotated in dark red above], which may be or comprise a mixing, displacement, or storage tank for the mixture prior to being injected into the wellbore 104. The mixture may be communicated from the fourth container 140 to a common manifold 142 [annotated in dark blue above] via the one or more conduits 144.”³³⁰ Further, as discussed above regarding Claim 4, *Omont* teaches that “[e]ach pump assembly 150

³²⁷ Ex. 1005 (*Omont*) [0020].

³²⁸ Ex. 1005 (*Omont*) [0020].

³²⁹ Ex. 1005 (*Omont*) [0021].

³³⁰ Ex. 1005 (*Omont*) [0023].

[annotated in dark green] may receive the mixture from the suction line 146 of the common manifold 142, via one or more conduits 158, and discharge the mixture under pressure to the discharge line 148 of the common manifold 142, via one or more conduits 160.”³³¹

331. Accordingly, *Omont* discloses that the fracturing fluid is provided from the blender (mixers 108, 128) to the pumps (pump assembly 150) via a manifold (common manifold 142). Thus, *Omont* discloses the elements of limitation 5[b].

332. Therefore, *Omont* discloses each additional limitation of Claim 5 and the combination of *Norris* and *Omont* render Claim 5 obvious.

G. DEPENDENT CLAIM 6: “. THE SYSTEM OF CLAIM 5, WHEREIN THE ONE OR MORE CONTROL DEVICE IS CONFIGURED TO CONTROL THE ONE OR MORE BLENDERS, THE MANIFOLD, THE PLURALITY OF PUMPS AND THE DISTRIBUTION SYSTEM BASED ON THE FLOW AND/OR PRESSURE CONDITIONS.”

333. Dependent Claim 6 depends from Claim 5. In addition to the discussion regarding the disclosure of the limitations of Claim 5 described above, *Omont* discloses, or renders obvious, the additional limitations of Claim 6

334. As discussed above regarding Limitation 1[f] in Section XII.B.2, *Omont* discloses “one or more control devices” in the form “of a control and monitoring (CAM) system 300.”³³² *Omont* teaches that the CAM system 300

³³¹ Ex. 1005 (*Omont*) [0023].

³³² Ex. 1005 (*Omont*) [0029].

controls each of the systems that are claimed in Claim 6.³³³ For example, *Omont* discloses that “the control center 170 may be operable to monitor and/or control operational parameters associated with the containers 110, 112, 130, 140, 166, *the first and second mixers 108, 128*, the material transfer assemblies 114, 116, 130, and/or the *pump assemblies 150*.”³³⁴ Thus, a POSITA would have understood *Omont* to teach control of the blenders and pumps. *Omont* further teaches” the common manifold 142 may comprise one or more actuators (not shown) operable to receive control signals from the CAM system 300, such as to control or otherwise operate flow through the common manifold 142.”³³⁵ By controlling the “actuators”³³⁶ of the common manifold, *Omont* teaches control of the manifold and the distribution system.

335. *Omont* states that “FIG. 2 is a schematic view of at least a portion of an example implementation of the additive system 100 shown in FIG. 1 designated in FIG. 2 by reference numeral 200, according to one or more aspects of the present disclosure.”³³⁷ Based on this disclosure and similar disclosure for Fig. 3, a POSITA would have been motivated to combine the teachings of Figs. 2-3, and systems 200

³³³ Ex. 1005 (*Omont*) [0029]- [0038], [0046]- [0059], Figs. 2-3.

³³⁴ Ex. 1005 (*Omont*) [0026], see also [0050]- [0052],

³³⁵ Ex. 1005(*Omont*) [0059].

³³⁶ An “actuator” is a device connected to, for example, a valve to control the position of the valve.

³³⁷ Ex. 1005 (*Omont*) [0029]; *see also* [0046].

or 300, with those regarding Fig. 1, and system 100. Further, a POSITA would have understood that Fig. 2 and Fig. 3 each comprises “control and monitoring system 300”, which is a more detailed implementation of “control center 170” disclosed in Fig. 1 and the supporting textual description.

H. INDEPENDENT CLAIM 7

336. It is my opinion that the combination of *Norris* and *Omont* renders Claim 7 obvious. As discussed in the following subsections, *Norris* and/or *Omont* discloses, or renders obvious, each and every element of Claim 7.

1. 7[p]: “A hydraulic fracturing method, comprising:”

337. As discussed above in Section XI.F.1, and incorporated herein by reference, *Norris* discloses the limitations of 7[p]. Further, other than being rewritten as a method claim, 7[p] is substantially similar to 1[p] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.1 and XII.B.1.

2. 7[a]: “providing a fracturing fluid to a plurality of pumps;”

338. As discussed above in Section XI.F.2, and incorporated herein by reference, *Norris* discloses the limitations of 7[a]. Further, other than being rewritten as a method claim, 7[a] is substantially similar to 1[a] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.2 and XII.B.1.

3. 7[b]: “pumping the fracturing fluid into a distribution system;”

339. As discussed above in Section XI.F.3, and incorporated herein by reference, *Norris* discloses the limitations of 7[b]. Further, other than being rewritten as a method claim, 7[b] is contained within the limitations of 1[b] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.3 and XII.B.1.

4. 7[c]: “injecting the fracturing fluid into a wellhead;”

340. As discussed above in Section XI.F.4, and incorporated herein by reference, *Norris* discloses the limitations of 7[c]. Further, other than being rewritten as a method claim, 7[c] is contained within the limitations of 1[b] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.3 and XII.B.1.

5. 7[d]: “measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;”

341. As discussed above in Section XI.F.5, and incorporated herein by reference, *Norris* discloses the limitations of 7[d]. Further, other than being rewritten as a method claim, 7[d] is substantially similar to 1[d] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.5 and XII.B.3.

6. 7[e]: “detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;”

342. As discussed above in Section XI.F.6, and incorporated herein by reference, *Norris* discloses the limitations of 7[e]. Further, other than being rewritten as a method claim, 7[e] is substantially similar to 1[e][ii] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.7 and XII.B.5.

7. 7[f]: “generating automated instructions for one or more control devices based at least in part on the one or more parameters;”

343. As discussed above in Section XI.F.7, and incorporated herein by reference, *Norris* discloses the limitations of 7[f]. Further, other than being rewritten as a method claim, 7[f] is substantially similar to 1[e][iii] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.8 and XII.B.6.

8. 7[g]: “automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions;”

344. As discussed above in Section XI.F.8, and incorporated herein by reference, *Norris* discloses the limitations of 7[g]. Further, other than being rewritten as a method claim, 7[g] is contained within the limitations of 1[f] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.9 and XII.B.7.

9. 7[h]: “transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;”

345. As discussed above in Section XI.F.9, and incorporated herein by reference, *Norris* discloses the limitations of 7[h]. Further, other than being rewritten as a method claim, 7[h] is contained within the limitations of 1[e][i] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.6 and XII.B.4.

10.7[i]: “generating the automated instructions at the second device based at least in part on the first parameter; and”

346. As discussed above in Section XI.F.10, and incorporated herein by reference, *Norris* discloses the limitations of 7[i]. Further, other than being rewritten as a method claim, 7[h] is contained within the limitations of 1[e][iii] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.8 and XII.B.6.

11.7[j]: “automatically adjusting one or more functions of the second device based on the automated instructions.”

347. As discussed above in Section XI.F.10, and incorporated herein by reference, *Norris* discloses the limitations of 7[j]. Further, other than being rewritten as a method claim, 7[j] is contained within the limitations of 1[f] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.A.9 and XII.B.7.

I. DEPENDENT CLAIM 10: “10. THE METHOD OF CLAIM 7, FURTHER COMPRISING: DETERMINING THAT THE ONE OR MORE PARAMETERS ARE INDICATIVE OF A POTENTIAL FAILURE CONDITION; AND DETERMINING A SOURCE OF THE POTENTIAL FAILURE CONDITION.”

348. Dependent Claim 10 depends from Claim 7. In addition to the discussion regarding the disclosure of the limitations of Claim 7 described above, *Omont* discloses, or renders obvious, the additional limitations of Claim 10.

349. *Omont* discloses a “process diagnostic tool 520” that “performs process diagnostics for monitoring raw sensor data and/or other process parameters values” and to, for example, confirm that such values meet predetermined thresholds or are within predetermined ranges.”³³⁸ *Omont* teaches that this comparison “may facilitate identification of problems [i.e. potential failure condition] associated with the wellsite operation process.”³³⁹ Further, still, *Omont* discloses that “[s]uch alarms may be enhanced by adding a troubleshooting guide or a list of suggestions related to *potential root causes* of each alarm.”³⁴⁰

350. *Omont* provides examples that the “sensor data” which is compared and used to identify “potential root causes” of the potential failure condition are the sensors “measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead” as claimed. For example, *Omont* teaches that

³³⁸ Ex. 1005 (*Omont*) [0094].

³³⁹ Ex. 1005 (*Omont*) [0094].

³⁴⁰ Ex. 1005 (*Omont*) [0094] emphases added.

“[o]ne example of process diagnostics includes comparing the power end oil pressure *on a pump 152* to a threshold value while the associated prime mover 154 is driving the pump 152.”³⁴¹ *Omont* then teaches that the comparison, if outside of an acceptable range, would result in “a low power end oil pressure warning” for the particular pump being compared. As another example, *Omont* teaches a comparison of “an air pressure of the pump 152 to a threshold value”, which may result in a low air pressure warning and display a list of potential resolutions, such as checking the air supply, compressor, filter, or hoses (e.g., for leaks) of the pump 152.”³⁴²

351. Accordingly, *Omont* discloses determining that the one or more parameters (e.g. oil pressure of the pump 152, air pressure of the pump 152) are indicative of a potential failure condition (e.g. low power end oil pressure, air pressure problem); and determining a source of the potential failure condition (e.g. the “potential root cause” of the failure and identifying problems on the particular pump 152 being monitored).

352. A POSITA would have implemented *Omont*’s techniques, for example in *Omont*’s diagnostic tool, for identifying and troubleshooting potential failure conditions to prevent equipment failures and facilitate preventative maintenance into

³⁴¹ Ex. 1005 (*Omont*) [0094] emphasis added.

³⁴² Ex. 1004 (*Omont*) [0094].

the system of *Omont* to take advantage of the benefits of the diagnostic tool taught by *Omont*, as discussed above.

353. Accordingly, *Omont* discloses the additional limitations of Claim 10, and the combination of *Norris* and *Omont* renders Claim 10 obvious.

J. DEPENDENT CLAIM 11: “11. THE METHOD OF CLAIM 10, FURTHER COMPRISING: GENERATING AN ALERT OR NOTIFICATION INDICATIVE OF THE POTENTIAL FAILURE CONDITION AND THE SOURCE.”

354. Dependent Claim 11 depends from Claim 10. In addition to the discussion regarding the disclosure of the limitations of Claim 10 described above, *Omont* discloses, or renders obvious, the additional limitations of Claim 11.

355. *Omont* discloses that, when a potential failure condition is identified “[s]uch information may be displayed via one or more of the HMIs 228, 310, 316.”³⁴³ Further, *Omont* teaches that “[s]uch alarms may be enhanced by adding a troubleshooting guide or a list of suggestions related to potential root causes of each alarm.”³⁴⁴ *Omont* provides examples of such alarms (i.e. alerts or notifications) including a “low power end oil pressure warning” and “low air pressure warning and display a list of potential resolutions, such as checking the air supply, compressor, filter, or hoses (e.g., for leaks) of the pump 152.”³⁴⁵ As *Omont* teaches that the alarm is for a specific pump 152, and identifies “potential root causes” and specific

³⁴³ Ex. 1004 (*Omont*) [0094].

³⁴⁴ Ex. 1005 (*Omont*) [0094].

³⁴⁵ Ex. 1005 (*Omont*) [0094].

examples of things to check (e.g. air supply, compressor, etc.), *Omont* teaches that the alarm (i.e. alert or notification) is indicative of the potential failure condition and its source.

356. Accordingly, *Omont* discloses the additional limitations of Claim 11, and the combination of *Norris* and *Omont* renders Claim 11 obvious.

K. DEPENDENT CLAIM 12: “12. THE METHOD OF CLAIM 7, FURTHER COMPRISING: LOGGING OPERATION DATA INCLUDING A NUMBER OF STROKES AND PUMPING HOURS PERFORMED BY A PUMP OF THE PLURALITY OF PUMPS; AND DETERMINING A MAINTENANCE SCHEDULE BASED AT LEAST IN PART ON THE OPERATION DATA.”

357. Dependent Claim 12 depends from Claim 7. In addition to the disclosure or teachings regarding Claim 7, as discussed above, *Omont* further discloses the additional limitations of Claim 12, as further described below. Accordingly, the combination of *Norris* and *Omont* renders Claim 12 obvious.

358. *Omont* discloses this limitation, or at least renders it obvious. *Omont* teaches a “[a] monitoring system operable to monitor an oilfield additive system having multiple components.”³⁴⁶ *Omont* further discloses “The monitoring system also includes a monitoring device in communication with the sensors and operable to record the information generated by the sensors to generate a database. The database includes information indicative of maintenance aspects of the oilfield

³⁴⁶ Ex. 1005 (*Omont*) Abstract.

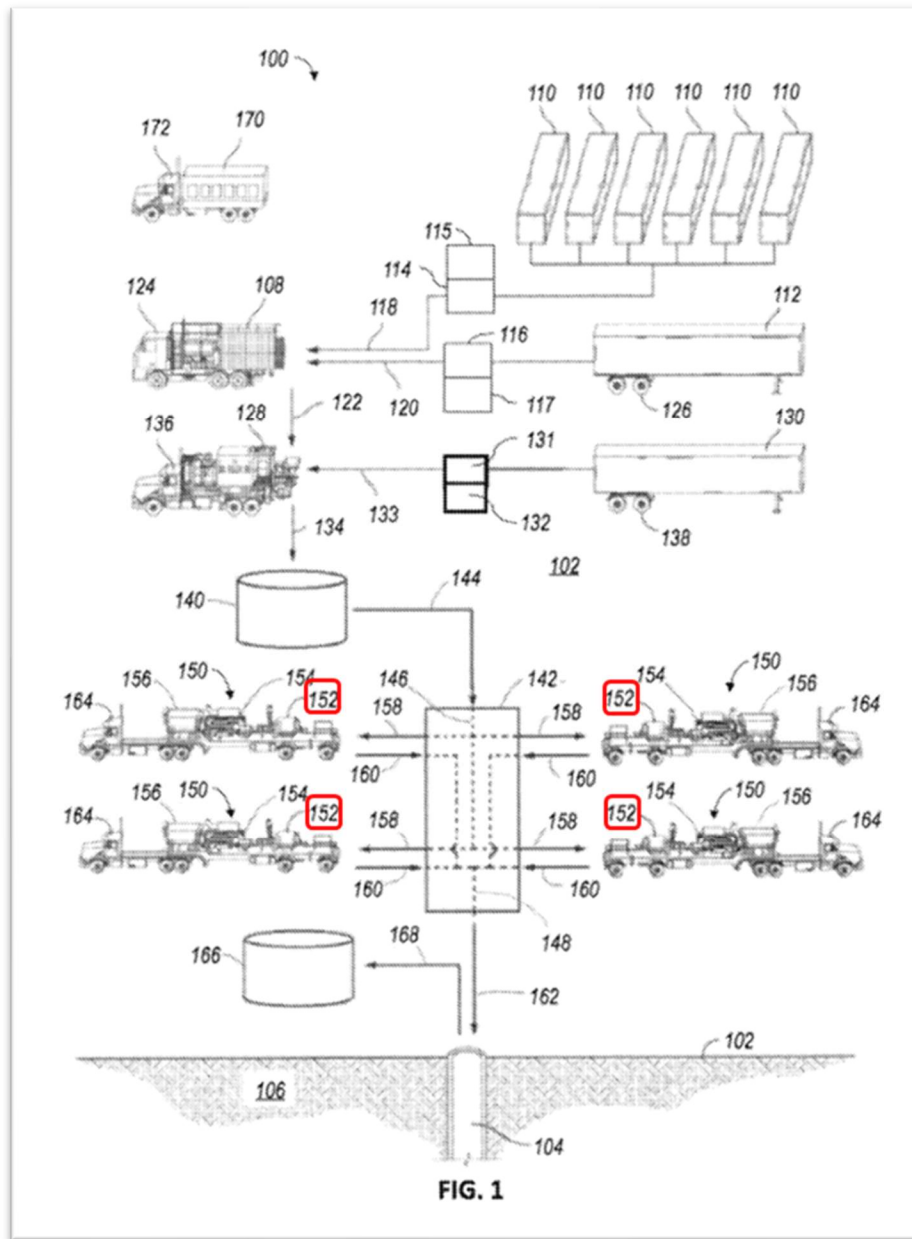
additive system and/or the oilfield additive system components.”³⁴⁷ *Omont* further describes the system as comprised of “sensors and a monitoring device. Each sensor is associated with, and generates information related to the operational parameter of, a corresponding one of the oilfield additive system components. The monitoring device is in communication with each of the sensors, and records the information generated by the sensors to generate a database indicative of a maintenance aspect of the oilfield additive system and/or one or more of the oilfield additive system components.”³⁴⁸

359. *Omont* further teaches the use of “material transfer device 254” which comprises “pumps 152 shown in Fig. 1”. *Omont* explains that “the material transfer device 254 may be or comprise one of the material transfer devices 114, 116, 131 or pumps 152 [annotated in red] shown in FIG. 1. [] subsystem 252 may also comprise a prime mover 256 operable to drive the material transfer device 254.”³⁴⁹

³⁴⁷ Ex. 1005 (*Omont*) Abstract.

³⁴⁸ Ex. 1005 (*Omont*) [00005]. *See also, e.g.*, [00006], [00007], [00139], [00140].

³⁴⁹ Ex. 1005 (*Omont*) [0051].



Ex. 1005 (*Omont*) Fig. 1 (annotated)

360. Further, *Omont* teaches using sensors to measure parameters of the pumps (material transfer device) including “temperature, pressure, electrical current, power consumption, proximity, linear position, rotational position, **operating speed**, operating frequency, torque, **elapsed operating time**, and/or other operational

parameter associated with the material transfer device 254, [] The information generated by the sensors 214, 222 may then be communicated to the CAM system 300 via the local network 302.”³⁵⁰ By measuring the “operating speed” and “elapsed operating time” of the pumps, *Omont* teaches measuring the number of strokes (operating speed or a function of operating speed and pumping hours) and pumping hours of the pump.

361. *Omont* further describes the use of a “logging tool 560 [that] performs logging activities of various operational parameters associated with various components of the additive system 100 and the CAM system 300.”³⁵¹ A POSITA would have understood that sensor data, such as that described above including operating speed and elapsed operating time, would be included in the “various operational parameters” of the components of the system. Further, *Omont* goes on to teach this explicitly, stating that the logs generated by the logging tool 560 may include “modes (e.g., manual, automatic, remote), settings (e.g., what type of component, engine, transmission, gate type), ***process/sensor readings***, process/control set points, firmware/software versions, and/or other information generated by the diagnostic tools.”³⁵² *Omont* further explains the reasons for retaining information such as sensor readings, teaching “if some of such information

³⁵⁰ Ex. 1005 (*Omont*) [0052].

³⁵¹ Ex. 1005 (*Omont*) [00114].

³⁵² Ex. 1005 (*Omont*) [00114].

is not logged, subsequent issues may be unresolvable, which may lead to repeated job incidents and lost time.”³⁵³ These logged data, then, would include the number of strokes and operating hours that *Omont* discloses measuring.

362. Further, *Omont* specifically discloses that “[o]ther logged parameters associated with the material transfer devices may include temperature, pressure, power consumption, proximity, linear position, rotational position, ***operating rate or frequency***, material transfer rate, total material transferred, torque, acceleration, and ***operating time***. However, other examples of such parameters are also within the scope of the present disclosure.”³⁵⁴

363. *Omont* further teaches using the logged data to generate a maintenance schedule, at least in part on the logged data including number of strokes and operating hours. *Omont* teaches that a “predictive maintenance tool 565 performs predictive maintenance operations, such as for providing remaining functional life estimates. Predictive maintenance operations may facilitate greater reliability of the additive system 200 ***by utilizing the logged information associated with various components of the additive system 200 to generate functional life profiles for predicting or otherwise determining remaining functional life of the components.*** Predicting remaining functional life of components may permit in-time servicing

³⁵³ Ex. 1005 (*Omont*) [00114] emphasis added.

³⁵⁴ Ex. 1005 (*Omont*) [00129].

and maintenance of the components, such as to avoid costly failures or extend the lifetime of these components.”³⁵⁵ By “predicting remaining functional life of components” and performing “in-time service and maintenance of the components”, the predictive maintenance teaching of *Omont* disclose generating a maintenance schedule at least in part on the logged data.

364. Further, *Omont* specifically ties the “maintenance” of the component to the predicted remaining functional life of the components (including the pumps). For example, *Omont* discloses that “[t]he maintenance aspect may be, or may be indicative of, an estimated remaining functional life of the item. As described above, the estimated remaining functional life may be an estimate of remaining operational time until failure of the item and/or an estimate of remaining operational time until operational efficiency of the item falls below a predetermined threshold. The maintenance aspect may also be, or be indicative of, the health of the item.”

365. *Omont* provides several examples of the types of components that the predictive maintenance tool would generate a maintenance schedule for including “the material transferring devices described above, such as pumps, conveyers, bucket elevators, feeding screws, and other material transfer devices.” This disclosure would include the “plurality of pumps” claimed, as discussed above.³⁵⁶

³⁵⁵ Ex. 1005 (*Omont*) [00118] emphasis added.

³⁵⁶ See, e.g., Ex. 1005 (*Omont*) [0051], Fig. 1

366. Accordingly, *Omont* discloses, logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and determining a maintenance schedule based at least on the operation data. To the extent the Board finds the *Omont* does not explicitly disclose a “determining a maintenance schedule”, it would have at least been obvious to a POSITA to determine a maintenance schedule based at least in part on the operational data based on the teachings of *Omont* regarding logging data and using the logged data to predict a remaining useful life and generate a “maintenance aspect” for the components of the system, including the pumps.

367. A POSITA would have implemented *Omont*’s logging techniques, for example in *Omont*’s diagnostic tool, to assess functional life of components and determine a maintenance schedule that prevents equipment failures and facilitates preventative maintenance.

368. Thus, the combination of *Norris* and *Omont* renders Claim 12 obvious.

L. INDEPENDENT CLAIM 13

369. It is my opinion that the combination of *Norris* and *Omont* renders Claim 13 obvious. As discussed in the following subsections, *Norris* and/or *Omont* discloses, or renders obvious, each and every element of Claim 13.

1. 13[p]: “A hydraulic fracturing method, comprising:”

370. As discussed above in Section XI.G.1, and incorporated herein by reference, *Norris* discloses the limitations of 13[p]. Further, other than being rewritten as a method claim, 13[p] is substantially similar to 1[p] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.1 and XII.B.1.

2. 13[a]: “performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;”

371. As discussed above in Section XI.G.2, and incorporated herein by reference, *Norris* discloses the limitations of 13[a]. Further 13[a] is substantially similar to 7[a] – 7[c] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.2 – XI.F.4 and XII.G.2 – XII.G.4.

3. 13[b]: “measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;”

372. As discussed above in Section XI.G.3, and incorporated herein by reference, *Norris* discloses the limitations of 13[b]. Further, 13[b] is substantially similar to 7[d] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.5 and XII.G.5

4. **13[c]: “transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;”**

373. As discussed above in Section XI.G.4, and incorporated herein by reference, *Norris* discloses the limitations of 13[c]. Further, 13[c] is substantially similar to 7[h] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.10 and XII.G.10.

5. **13[d]: “detecting that the first parameter is outside of an acceptable threshold;”**

374. As discussed above in Section XI.G.5, and incorporated herein by reference, *Norris* discloses the limitations of 13[d]. Further, 13[d] is substantially similar to 7[e] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.6 and XII.G.6.

6. **13[e]: “generating automated instructions at the second device based at least in part on the first parameter; and”**

375. As discussed above in Section XI.G.6, and incorporated herein by reference, *Norris* discloses the limitations of 13[e]. Further, 13[e] is substantially similar to 7[f] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.7 and XII.G.7.

7. 13[f]: “automatically adjusting one or more functions of the second device based on the automated instructions.”

376. As discussed above in Section XI.G.7, and incorporated herein by reference, *Norris* discloses the limitations of 13[f]. Further, 13[f] is substantially similar to 7[g] and is rendered obvious by the combination of *Norris* and *Omont* for the same reasons as those discussed in Sections XI.F.8 and XII.G.8.

M. CLAIM 14: “14. THE METHOD OF CLAIM 13, WHEREIN THE DISTRIBUTION SYSTEM RECEIVES AND CONSOLIDATES THE FRACTURING FLUID FROM THE PLURALITY OF PUMPS FOR INJECTION INTO A WELLHEAD.”

377. As discussed above in Section XI.H, and incorporated herein by reference, *Norris* discloses Claim 14. Further, Claim 14 is substantially similar to limitation 1[b] and is disclosed by *Omont* for the same reasons as those discussed in Section XIII.B.1. Accordingly, the Claim 14 would have been obvious to a POSITA in light of the teachings of *Norris* and *Omont*.

N. CLAIM 15: “15. THE METHOD OF CLAIM 14, FURTHER COMPRISING: CONTROLLING ONE OR MORE FUNCTIONS OF THE DISTRIBUTION SYSTEM BASED ON THE AUTOMATED INSTRUCTIONS.”

378. Claim 15 is contained in the limitations of Claim 6 and is disclosed by *Omont* for the same reasons as those discussed in Section XII.F. Accordingly, the Claim 15 would have been obvious to a POSITA in light of the teachings of *Norris* and *Omont*.

**O. CLAIM 16: “16. THE METHOD OF CLAIM 13, WHEREIN THE FIRST
PARAMETER INCLUDES MEASUREMENTS OF ONE OR MORE OF THE
PLURALITY OF PUMPS.”**

379. Claim 16 depends from Claim 13. In addition to the teachings of Claim 13 discussed above, the combination of *Norris* and *Omont* renders Claim 16 obvious. Claim 16 is disclosed or rendered obvious by *Norris* as discussed above in Sections XI.I and incorporated herein by reference. *Omont* also teaches that “sensors 214, 222 may be disposed or otherwise utilized in association with the material transfer device 254 [i.e. pump] and/or the prime mover 256, such as for generating information related to operational parameters of the material transfer device 254 and/or the prime mover 256. For example, the one or more sensors 214, 222 may be operable to generate information related to temperature, pressure, electrical current, power consumption, proximity, linear position, rotational position, operating speed, operating frequency, torque, elapsed operating time, and/or other operational parameter associated with the material transfer device 254, the prime mover 256, and/or other monitored and/or controlled components of the subsystem 252. The information generated by the sensors 214,222 may then be communicated to the CAM system 300 via the local network 302.”³⁵⁷ *Omont* further teaches that “[t]he material transfer device 254 may be or comprise one of the material transfer devices 114, 116, 131 or pumps 152 shown in FIG. 1. Thus, *Omont* teaches that the sensors

³⁵⁷ Ex. 1005 (*Omont*) [0052].

measure a “first parameter” (one of the parameters listed above) of the “transfer device 254” (pump).

380. Accordingly, Claim 16 would have been obvious to a POSITA in light of the teachings of *Norris* and *Omont*.

**P. CLAIM 17: “17. THE METHOD OF CLAIM 16, FURTHER COMPRISING:
CONTROLLING ONE OR MORE OF THE PLURALITY OF PUMPS
INDIVIDUALLY BASED ON THE AUTOMATED INSTRUCTIONS.”**

381. Claim 17 depends from Claim 16, which further depends from Claim 13. In addition to the teachings of Claims 13 and 16 discussed above, the combination of *Norris* and *Omont* renders Claim 17 obvious. Claim 17 is disclosed or rendered obvious by *Norris* as discussed above in Sections XI.J and incorporated herein by reference. *Omont* also teaches that “subsystem 220” contains “controllable device 224,” which may control an individual “material transfer device” or “prime mover.”³⁵⁸ The controllable device 224 receives “control signals” “based at least in part on” “information generated by the sensors,”³⁵⁹ A POSITA would have recognized the benefits of controlling each pump individually, particularly as pumps operate differently, for example due to age.³⁶⁰

382. Accordingly, the Claim 17 would have been obvious to a POSITA in light of the teachings of *Norris* and *Omont*.

³⁵⁸ Ex. 1005 (*Omont*) [0037]- [0038], [0051]- [0052], Fig. 2.

³⁵⁹ Ex. 1005 (*Omont*) [0037]- [0038], [0051]- [0052], Fig. 2.

³⁶⁰ See, e.g., Ex. 1005 (*Omont*) [00128].

XIII. GROUND 4: OBVIOUS OVER *NORRIS* IN VIEW OF *BORGSTADT*

383. It is my opinion that the combination of *Norris* and *Borgstadt* renders Claims 1-5 and 7-19 of the '435 patent obvious.

A. MOTIVATION TO COMBINE

384. In my opinion, a POSITA would have been motivated to combine *Borgstadt* with the teachings of *Norris* at least for the reasons below.

385. As discussed above regarding Section VI.A, the '435 Patent is directed to a “hydraulic fracturing system includes a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid , a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead.”³⁶¹

386. Similarly, *Norris* is directed to “manag[ing] operation of a plurality of positive displacement pumps”³⁶² such as those used for “fracturing operation of PD pumps”.³⁶³ *Norris* further teaches “[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 forces the wellbore service fluid into a pressure-side manifold 250b via pressure flow lines 290 and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”³⁶⁴

³⁶¹ Ex. 1001 ('435 Patent) Abstract.

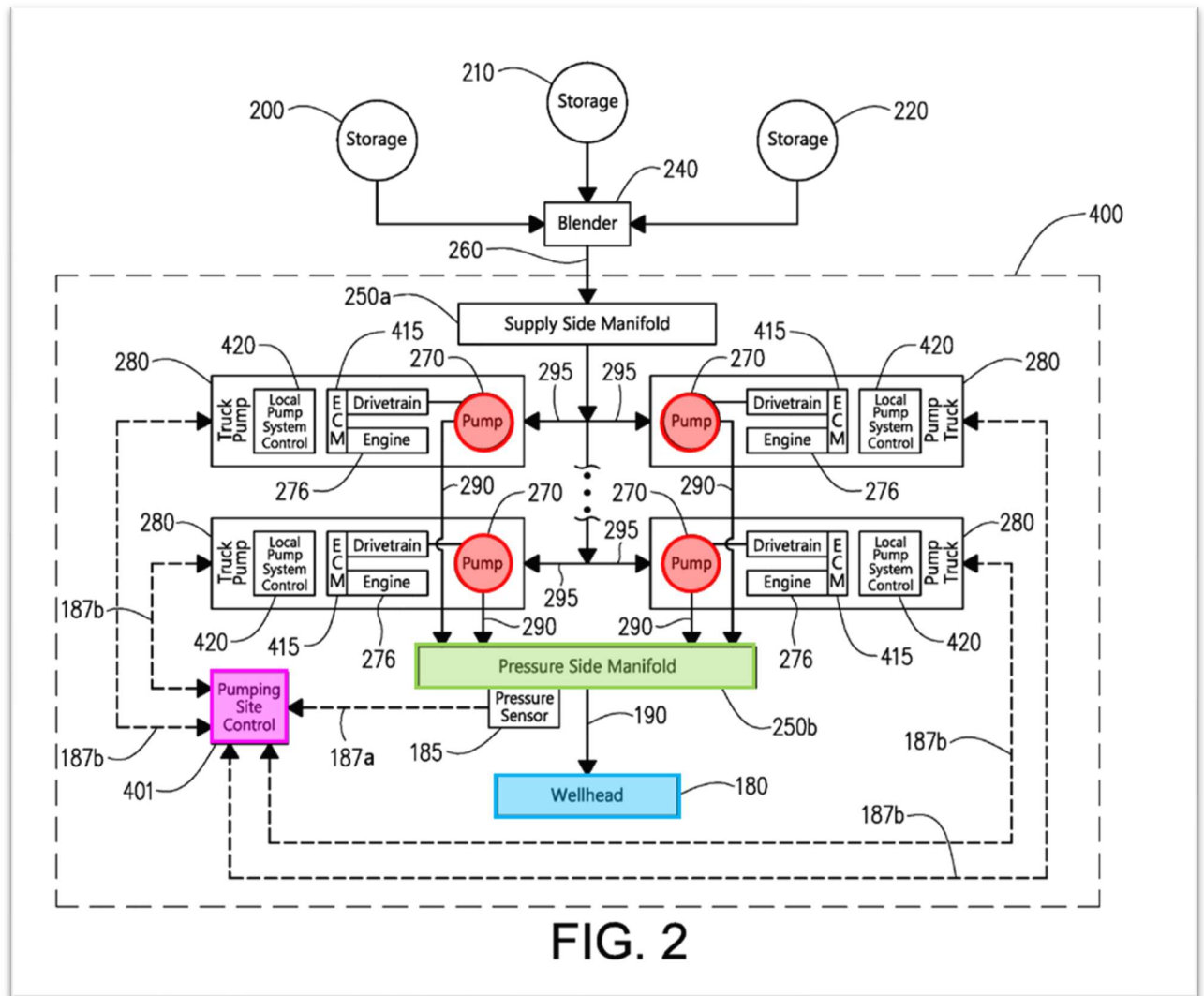
³⁶² Ex. 1004 (*Norris*) Abstract.

³⁶³ Ex. 1004 (*Norris*) [0022].

³⁶⁴ Ex. 1004 (*Norris*) [0022].

As shown in Fig. 2 of *Norris*, the fluid from the discharge of the pumps (annotated in red) is collected by the pressure side manifold (annotated in green) and delivered to a single destination, the wellhead (annotated in blue). Accordingly, the pumps in *Norris* work together to provide the fluid to the wellhead at the appropriate pressure and flowrate. *Norris*' pumps are managed by "application controller 401 [annotated in magenta that] provides overall control of pumping operations."³⁶⁵

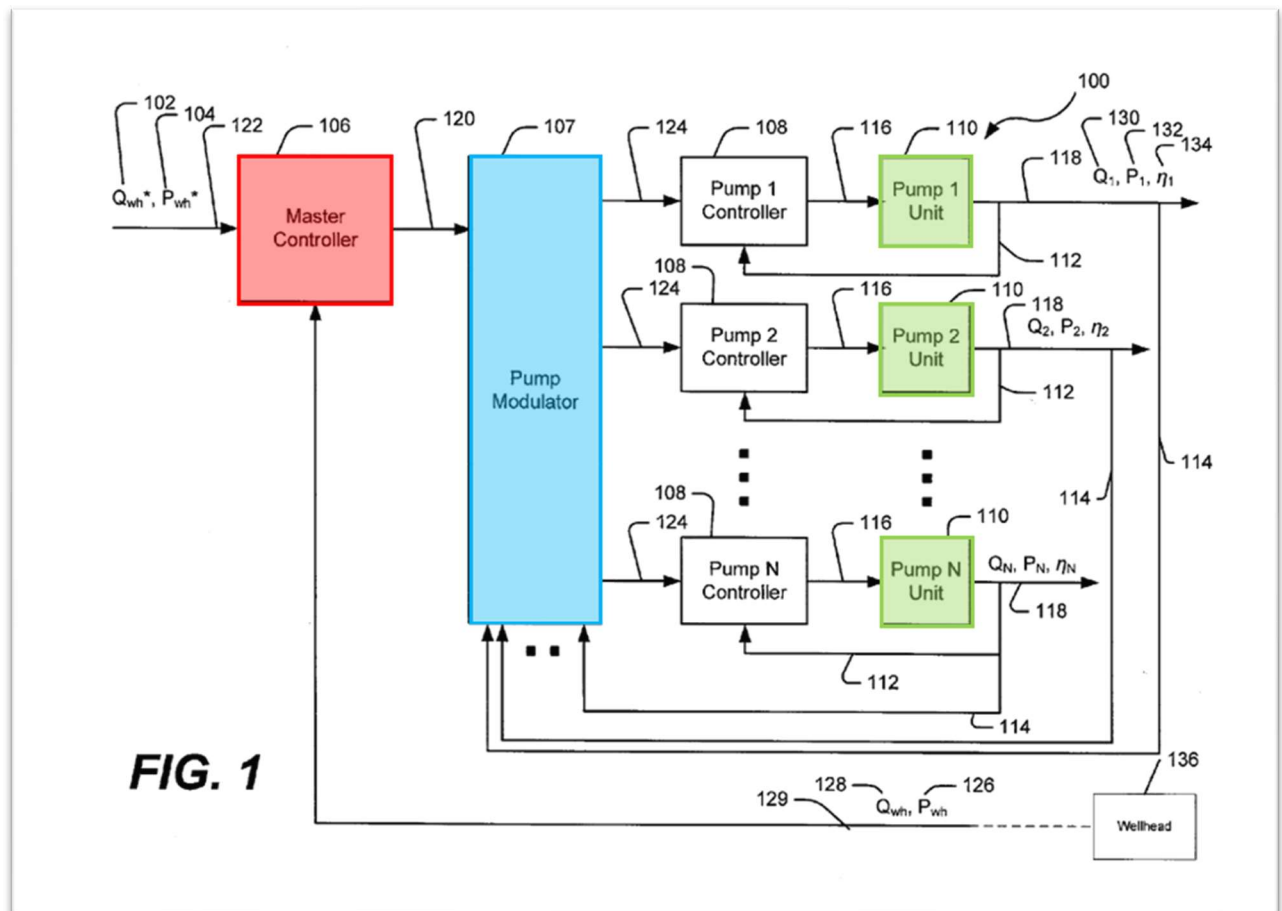
³⁶⁵ Ex. 1004 (*Norris*) [0035]. I note that application controller 401 is sometimes referred to in the figures as pump site control 401 or pump side control 401.

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

387. Like *Norris*, *Borgstadt* also contains a plurality of pumps useful in a fracturing operation controlled by a central controller. As shown in Fig. 1, *Borgstadt* teaches “a plurality of pump units 110 labeled Pump 1 Unit through Pump N Unit [annotated in green].”³⁶⁶ Like *Norris*, these pumps are controlled by an overall pump

³⁶⁶ Ex. 1006 (*Borgstadt*) [0022].

control system comprising master controller 106 (annotated in red) and pump modulator 107 (annotated in blue).



Ex. 1006 (*Borgstadt*) Fig. 1 (annotated)

388. *Borgstadt* teaches that “master controller 106 of the present invention is responsible for comparing the desired wellhead pressure or rate to the corresponding measured wellhead pressure or rate and driving the pumping process to the desired wellhead pressure or rate.”³⁶⁷ Further, *Borgstadt* teaches that the pump

³⁶⁷ Ex. 1006 (*Borgstadt*) [0022].

modulator receives output parameters of the pump, including pressure, flowrate and efficiency. Based on these parameters, “the pump modulator 107 makes an intelligent decision on how to best distribute the load among the individual pumps and assigns pumps their flow rates and or pressures. In case of a problem, it can also determine which pump or pumps can pickup the load and still operate effectively, safely and efficiently.”³⁶⁸ Further, like *Norris*, *Borgstadt*’s plurality of pumps and control system is useful in a fracturing application.³⁶⁹ Accordingly, a POSITA would have been motivated to combine the teachings of *Borgstadt* and *Norris* at least because of their similarities.

389. Additionally, *Borgstadt* teaches that its system of controlling pumps allows the system of pumps “to achieve optimal performance.”³⁷⁰ Further, *Borgstadt* discloses that its “intelligent” pump control system “will increase the life of the pumps between maintenance thereby lowering costs and improving job efficiency,” and has the “capability to develop a pattern on how long each part in a pumping unit can last [] an potentially replace them right before they fail.”³⁷¹ Further still, *Borgstadt* teaches that its intelligent system “allows monitoring for pump cavitations to prevent damage and make the operations safer”.³⁷² This is particularly important

³⁶⁸ Ex. 1006 (*Borgstadt*) [0025].

³⁶⁹ Ex. 1006 (*Borgstadt*) [0006].

³⁷⁰ Ex. 1006 (*Borgstadt*) Abstract.

³⁷¹ Ex. 1006 (*Borgstadt*) [0013].

³⁷² Ex. 1006 (*Borgstadt*) [0013].

in a fracturing application where, according to *Borgstadt*, and as would have been known to a POSITA, there is the risk that “a pump may not get enough pressure and flow rate and be starved. [i.e. cavitate] When a pump is starved, it will suffer wear and tear.”³⁷³ A POSITA would have been motivated to apply the teachings of *Borgstadt* to the system of *Norris* at least in order to take advantage of the benefits taught by *Borgstadt* including optimal performance of the pumping system, pump operation within capacity, increased job efficiency and preventative maintenance, longer life of pumps between maintenance, and protection from the wear and tear of cavitation.

390. *Norris* and *Borgstadt* also suggests combining the references for distributing pumping load. *Borgstadt* describes methods for compensating for “dropped pump load”: intelligently redistributing the load among remaining pumps.³⁷⁴ *Norris* describes “backup operational modes”—including taking a pump truck “off-line” and having “pumping operations handled by the remaining pump trucks”—to account for component failures.³⁷⁵ A POSITA would have known, as disclosed in *Norris*, to maintain system pumping capacity when taking a pump off-line and would naturally apply *Borgstadt*’s solution, intelligently redistributing pumping load to maintain overall pumping capacity.

³⁷³ Ex. 1006 (*Borgstadt*) [0006].

³⁷⁴ Ex. 1006 (*Borgstadt*) [0008], [0031]- [0034].

³⁷⁵ Ex. 1004 (*Borgstadt*) [0044], [0048].

391. A POSITA would have had a reasonable expectation of success in combining the teachings of *Borgstadt* and *Norris*. Both *Norris* and *Borgstadt* teach an overall and local control system that controls the operation of the pumps. A POSITA would have understood based on the teachings of *Norris* and *Borgstadt* that both systems teach electronic controls, and applying the teachings of *Borgstadt* to *Norris* would be simply implementing the functions of *Borgstadt* into *Norris*' electronic control system. Such electronic control systems for fracturing applications have been known for decades before *Norris*, *Borgstadt* or the '435 Patent.³⁷⁶ Combining the teachings would be simply combining prior art elements (the functions of *Norris*' control system and the functions of *Borgstadt*'s control system) to yield predictable results (increased efficiency and preventative maintenance, longer life, protection from cavitation, and operation within available capacity as taught by *Borgstadt*). Further, such a combination would be the use of known techniques (the functions of *Borgstadt*'s control system) to improve similar devices (*Norris*' control system) in the same way, to gain the advantages taught by *Borgstadt*.

B. INDEPENDENT CLAIM 1

392. It is my opinion that the combination of *Norris* and *Borgstadt* anticipates renders Claim 1 obvious. As discussed in the following subsections, the

³⁷⁶ See, e.g., Section IX.E above.

combination of *Norris* and *Borgstadt* discloses, or renders obvious, each and every element of Claim 1.

1. Limitations 1[p] – 1[b]

A hydraulic fracturing system, comprising:

a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;

a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and

393. Limitations 1[p] - 1[b] are disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.A.1 – XI.A.3. *Borgstadt* also teaches a hydraulic fracturing system having a plurality of pumps and a distribution system consolidating fluid from the pumps for injection into a wellhead.³⁷⁷ In light of the similarity between *Borgstadt*'s and *Norris*'s systems (among other reasons), a POSITA would have been motivated to combine elements and functions of *Borgstadt*'s fracturing system (and associated control system) with *Norris*'s fracturing system (and associated control system).³⁷⁸

394. Accordingly, the combination of *Norris* and *Borgstadt* renders limitations 1[p]-1[b] obvious.

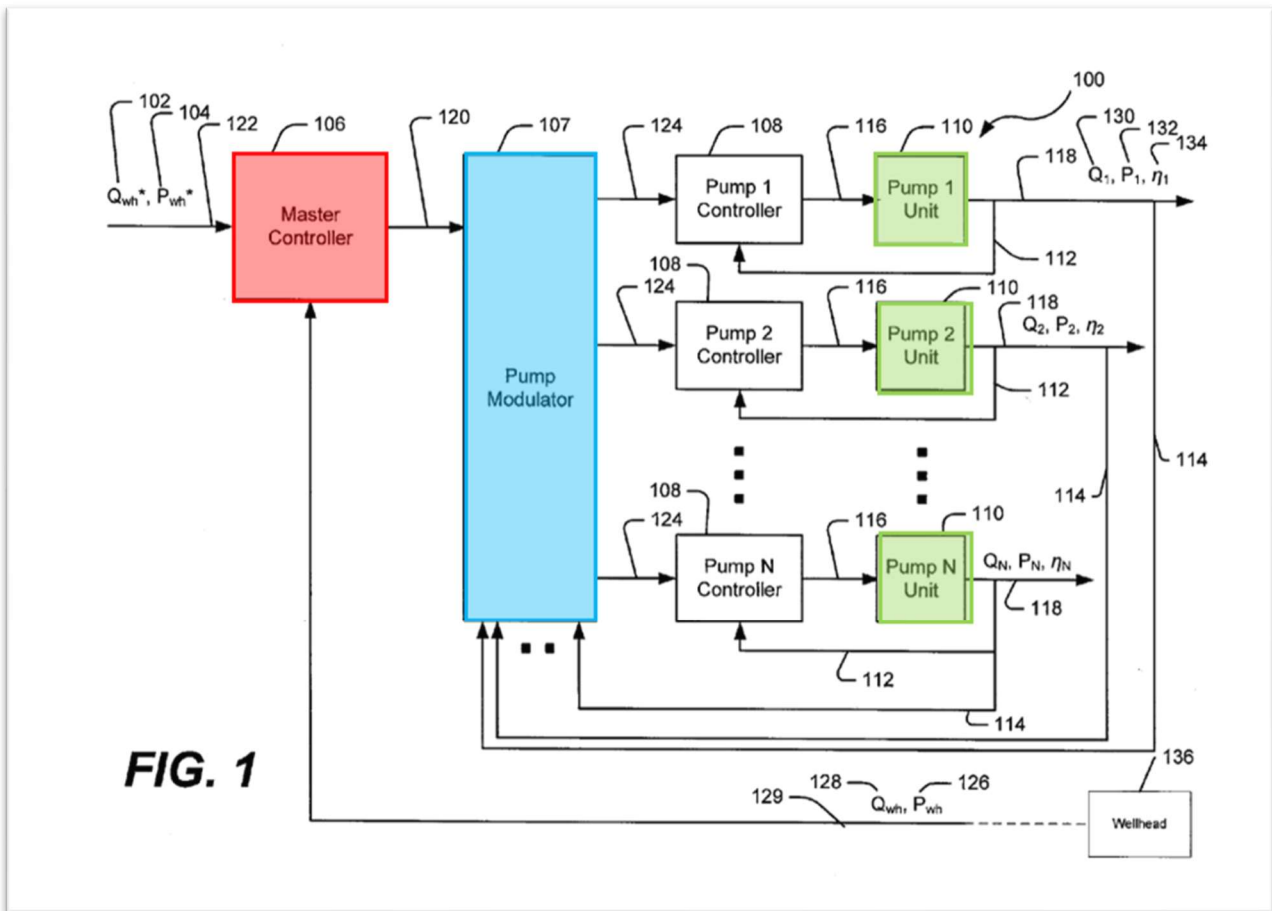
³⁷⁷ See section X.C above; *see, e.g.*, Ex. 1006 (*Borgstadt*) [0027], [0037], Figs. 1,4.

³⁷⁸ See section XIII.A above.

2. Limitations 1[c]: “a control system comprising:”

395. As discussed above in Section XI.A.4, *Norris* discloses a control system. *Borgstadt* also discloses a control system, as discussed in greater detail below. For example, *Borgstadt* teaches a “master controller 106 (annotated in red),” “pump modulator 107 (annotated in blue),” and local “pump controller[s] 110 (annotated in green)” at pump units.³⁷⁹ *Borgstadt* teaches local and system-wide control of a fracturing system like *Norris*, and a POSITA would have been motivated to combine elements and functions of *Borgstadt*’s control system with *Norris*’s control system.

³⁷⁹ Ex. 1006 (Borgstadt) Fig. 1, [0021]- [0029].

Ex. 1006 (*Borgstadt*) Fig. 1 (annotated)

396. A POSITA would have understood that, since the controllers of *Borgstadt* and the various controllers of *Norris* are both implemented using processors (including generic computers) that communicate, execute algorithms, and control devices of their related physical systems, that the teachings of *Borgstadt* and *Norris* are compatible and functions disclosed in one reference could easily be programmed into and performed by the hardware of the other reference. Accordingly, a POSITA would have been motivated to implement the functions of *Borgstadt* into *Norris*' control system, or vice versa. Further, since the teachings are

compatible, a POSITA would have had a reasonable expectation of success in the combination.

397. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[c] obvious.

3. Limitations 1[d]: “a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;”

398. As discussed above in Section XI.A.5, *Norris* discloses multiple sensing devices measuring parameters of the pumps and distribution system. *Borgstadt* also teaches sensors measuring parameters of the pump and distribution system, as discussed below.

399. For example, in *Borgstadt* “individual pump controllers ... measure information regarding the performance of the pump,” including “flow rate,” “output pressure,” and “output efficiency.”³⁸⁰ Sensors providing these parameters to the controllers are located at measured components: pump units, the distribution system, and the wellhead.³⁸¹ A POSITA would have understood that the well-known sensors types in *Borgstadt* could be used in *Norris*, or vice versa.

400. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[d] obvious.

³⁸⁰ Ex. 1006 (*Borgstadt*) [0023], Fig. 1.

³⁸¹ Ex. 1006 (*Borgstadt*) [0023]- [0024], [0043], Fig. 1.

4. **Limitation 1[e][i]: “one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and”**

401. Limitation 1[e][i] is disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Sections XI.A.6 and XI.A.10. *Borgstadt* also teaches numerous processing devices that receive and transmit operational parameters of the pumps, the distribution system, and the wellhead.

402. *Borgstadt*’s “master controller,” “pump modulator,” and “local controllers” contain processors that implement algorithms, communications, and control.³⁸² Controllers and sensors in *Borgstadt* also signal each other over data links, and a POSITA would have understood that processing devices implement these data links.³⁸³

403. *Borgstadt* Figure 1 illustrates measured parameters—pressure, flow rate, efficiency—transmitted from “pump unit[s]” (each a “first device”) to “pump controller[s]” and a “pump modulator” (each a “second device”). EX1006, Fig. 1. *Borgstadt* teaches that “output 118 parameters of each pump unit” are “fed into the

³⁸² See, e.g., Ex. 1006 (*Borgstadt*) [0023]- [0025], [0037]- [0038], Figs. 2-3, 5; see section XIII.B.2 above.

³⁸³ Ex. 1006 (*Borgstadt*) [0011], [0026]- [0027], Figs. 1, 4; see section XI.A.6 above.

pump modulator.”³⁸⁴ *Borgstadt* also describes a pump modulator “receiv[ing] a pump unit’s current efficiency value” or “other pump parameters” for diagnostics.³⁸⁵

404. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[e][i] obvious.

5. Limitation 1[e][ii]: “detect that the first parameter is outside of an acceptable threshold; and”

405. As discussed above in Sections XI.A.7 and XI.A.10, it is my opinion that detecting that a parameter is outside an acceptable threshold is at least obvious over *Norris* alone. To the extent the Board finds that detecting that a parameter is outside an acceptable threshold is not obvious based solely on the teachings of *Norris*, using a threshold in this manner is disclosed by *Borgstadt*. *Borgstadt* teaches the pump unit’s efficiency may be used for diagnosing a pump failure.”³⁸⁶ Further, *Borgstadt* teaches that “the pump modulator 107 will compare the pump unit’s current efficiency value with the threshold value provided. If the pump unit 110 is operating at an efficiency lower than the threshold value, the pump modulator 107 recognizes that the pump unit has encountered an abnormal operating condition and a warning is issued at step 308.”³⁸⁷ *Borgstadt* teaches that this process (comparing efficiency to a threshold) is not limited to only efficiency, but that “the performance

³⁸⁴ Ex. 1006 (*Borgstadt*) [0025].

³⁸⁵ Ex. 1006 (*Borgstadt*) [0033], Fig. 3.

³⁸⁶ Ex. 1006 (*Borgstadt*) [0033].

³⁸⁷ Ex. 1006 (*Borgstadt*) [0033].

of a pump at 118 may include, but is not limited to, the output flow rate 130, the output pressure 132 or the output efficiency 134.”³⁸⁸

406. A POSITA would have understood from the teachings of *Borgstadt* and *Norris* that this threshold comparison would be implemented at local controllers, global controllers, or both to facilitate control of the fracturing system in *Norris*.³⁸⁹

407. Based on this teaching, it would have been obvious to use a threshold in the system of *Norris*, particularly when determining whether a parameter has varied from the desired settings, as taught by *Norris*.³⁹⁰

408. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[e][ii] obvious.

6. Limitation 1[e][iii]: “generate automated control instructions at the second device based at least in part on the first parameter; and”

409. Limitation 1[e][iii] is disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Sections XI.A.8 and XI.A.10. *Borgstadt* also teaches generating automated control instructions at a second device based on received parameters.

410. In *Borgstadt*, each local pump controller, the pump modulator, and the master controller all generate automated control instructions based on receiving

³⁸⁸ Ex. 1006 (*Borgstadt*) [0023].

³⁸⁹ Ex. 1004 (*Norris*), [0037]; Ex. 1006 (*Borgstadt*), [0033], [0042], Fig. 1.

³⁹⁰ See Section XI.A.7 above, see also, e.g., Ex. 1004 (*Norris*) [0037]

measured parameters such as pressure, flow rate, and pump efficiency.³⁹¹ A POSITA would have known that *Borgstadt*'s system generates automated control instructions at the master controller for execution at the pump modulator and local pump controller, and at the pump modulator for execution at local pump controllers.

411. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[e][iii] obvious.

7. Limitation 1[f]: “one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instruction.”

412. Limitation 1[f] is disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.A.9. *Borgstadt* also teaches a control device receiving automated control instructions and adjusting operation of a second device. For example, *Borgstadt*'s local pump units, pump modulator, and master controller are all control devices.³⁹²

413. As a detailed example, *Borgstadt*'s local pump units (each a “control device”) receive control instructions from local pump controllers (each a “second device” that receives measured parameters). *Borgstadt* teaches that local pump controllers “may use different measured parameters ... to adjust the performance of

³⁹¹ See, e.g., EX1006, [0010], [0022]- [0026], Fig. 1.

³⁹² See section XIII.B.2 above.

the pump unit.”³⁹³ The “pump controller 108 may use a measured parameter ... to adjust the driving signal 116 sent to the pump unit.”³⁹⁴

414. The “pump unit” may “run at a particular level of operation” based on signals received from the “pump controller.”³⁹⁵ The “pump unit” may adjust a level of operation by controlling “output pressure, output flow rate, and the gear RPM” of the pump.³⁹⁶ Pump unit operating parameters feed back to the local pump controller to adjust its operation.³⁹⁷ The pump unit thus receives control instructions from the local pump controller and adjusts aspects of both the local pump controller and its own operation.³⁹⁸

415. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 1[f] obvious.

³⁹³ Ex. 1006 (*Borgstadt*) [0024], Fig. 1.

³⁹⁴ Ex. 1006 (*Borgstadt*) [0024], Fig. 1.

³⁹⁵ Ex. 1006 (*Borgstadt*) [0022], Figs. 1.

³⁹⁶ Ex. 1006 (*Borgstadt*) [0022], Figs. 1; *see also* EX1004, Fig. 3B (illustrating ECM in a pump unit adjusting RPM and throttle). And as taught in *Norris*, a POSITA would have known that the local pump unit may control operation via a local drivetrain control or an ECM. See section XI.A.9 above.

³⁹⁷ Ex. 1006 (*Borgstadt*) [0023]- [0024], Fig. 1.

³⁹⁸ Ex. 1006 (*Borgstadt*) [0022]- [0024], Fig. 1.

C. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF SENSING DEVICES ARE INSTALLED ON THE PLURALITY OF PUMPS AND THE DISTRIBUTION SYSTEM, AND SELECTED FROM A GROUP INCLUDING FLOW SENSORS, ACCELEROMETERS, PRESSURE TRANSDUCER, AND TACHOMETERS.”

416. Dependent Claim 2 depends from Claim 1. In addition to the discussion regarding Claim 1 in Section XIII.B 1 above, *Norris* discloses the additional additional limitations of Claim 2 for the same reasons as those discussed above regarding Ground 1. The combination of *Norris* and *Borgstadt* also renders obvious installing pressure and flow sensors on monitored devices, and a POSITA would have known this was common in the art.³⁹⁹

417. Accordingly, the combination of *Norris* and *Borgstadt* renders the additional limitations of Claim 2 obvious.

D. DEPENDENT CLAIM 3: “3. THE SYSTEM OF CLAIM 1, WHEREIN THE PLURALITY OF PUMPS OR THE DISTRIBUTION SYSTEM INCLUDES AT LEAST ONE DEVICE SELECTED FROM A GROUP INCLUDE A GATE, VALVE, ACTUATOR, MOTOR, SUCTION PIPE, DISCHARGE PIPE, ENGINE, TRANSMISSION, AND TEMPERATURE REGULATION DEVICE, CONTROLLABLE VIA THE ONE OR MORE CONTROL DEVICES.”

418. Dependent Claim 2 depends from Claim 1. In addition to the discussion regarding Claim 1 in Section XIII.B above, *Norris* discloses the additional limitations of Claim 3 for the same reasons as those discussed above regarding Ground 1. *Borgstadt* also teaches that controllable “pump units” operate an engine

³⁹⁹ See sections IX.E, XIII.B.3 above.

or motor having “gear RPM” and “horsepower.”⁴⁰⁰ *Borgstadt* also teaches a controllable “manifold” that a POSITA would have known has valves, suction pipe(s), and discharge pipe(s).⁴⁰¹

419. Accordingly, the combination of *Norris* and *Borgstadt* renders the additional limitations of Claim 3 obvious.

E. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: A SUCTION LINE THROUGH WHICH FRACTURING FLUID IS SUPPLIED; AND A DISCHARGE LINE THROUGH WHICH FRACTURING FLUID IS DISCHARGED, WHEREIN THE PLURALITY OF SENSING DEVICES INCLUDES ONE OR MORE FLOW SENSORS CONFIGURED TO MEASURE FLOW THROUGH THE SUCTION LINE AND THE DISCHARGE LINE.”

420. Dependent Claim 4 depends from Claim 1. In addition to the discussion regarding Claim 1 in Section XIII.B above, *Norris* discloses the additional limitations of Claim 4 for the same reasons as those discussed above regarding Ground 1. *Borgstadt* teaches a “manifold observer 500” that uses “measured flow rate 128”⁴⁰² to improve “the performance of the master controller 106”.⁴⁰³ *Borgstadt* also teaches that “the manifold observer may be used at any point in a system to provide an estimate of the output parameters at that point based on the measured value of a parameter and the desired value of a parameter at that point in the

⁴⁰⁰ Ex. 1006 (*Borgstadt*) [0022], [0031]- [0032], Fig. 1.

⁴⁰¹ Ex. 1006 (*Borgstadt*) [0037], [0043], Figs. 4-5.

⁴⁰² Ex. 1006 (*Borgstadt*) [0037], [0042].

⁴⁰³ Ex. 1006 (*Borgstadt*) [0037].

system.”⁴⁰⁴ As would have been appreciated by a POSITA “any point in a system” would include in suction lines and discharge lines.

421. Accordingly, the combination of *Norris* and *Borgstadt* renders the additional limitations of Claim 4 obvious.

F. DEPENDENT CLAIM 5: “THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: ONE OR MORE BLENTERS CONFIGURED TO MIX TOGETHER ONE OR MORE MATERIALS TO FORM THE FRACTURING FLUID, WHEREIN THE FRACTURING FLUID IS PROVIDED FROM THE BLENDER TO THE PLURALITY OF PUMPS VIA A MANIFOLD, WHEREIN THE PLURALITY OF SENSING DEVICES INCLUDES ONE OR MORE PRESSURE OR FLOW SENSORS FOR MEASURING FLOW CONDITIONS AT THE ONE OR MORE BLENTERS, THE MANIFOLD, THE PLURALITY OF PUMPS, OR THE DISTRIBUTION SYSTEM.”

422. Dependent Claim 5 depends from Claim 1. In addition to the discussion regarding Claim 1 in Section XIII.B 1 above, *Norris* discloses the additional limitations of Claim 5 for the same reasons as those discussed above regarding Ground 1.

G. INDEPENDENT CLAIM 7

423. It is my opinion that the combination of *Norris* and *Borgstadt* anticipates renders Claim 7 obvious. As discussed in the following subsections, the combination of *Norris* and *Borgstadt* discloses, or renders obvious, each and every element of Claim 7.

⁴⁰⁴ Ex. 1006 (*Borgstadt*) [0043].

1. Limitations 7[p] – 7[d]

A hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps;
pumping the fracturing fluid into a distribution system;
injecting the fracturing fluid into a wellhead;
measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;

424. Limitations 7[p] - 7[d] are disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.F.1 – XI.F.5.

2. Limitation 7[e]: “detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;”

425. Except for being rewritten as a method claim. Claim 7[e] is substantially similar to Limitation 1[e][ii] and is rendered obvious, by the combination of *Norris* and *Borgstadt* for the same reasons as those discussed above in Section XIII.B.2.

3. Limitations 7[f] – 7[j]

426. Limitations 7[f] - 7[j] are disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.F.7 – XI.F.11.

H. DEPENDENT CLAIM 8

427. Claim 8 depends from Claim 7. In addition to the discussion regarding the disclosure of the limitations of Claim 7 described above, as discussed in the following subsections, *Borgstadt* discloses, or renders obvious, each and every element of Claim 8. It is my opinion that the combination of *Norris* and *Borgstadt* renders dependent Claim 8 obvious.

1. 8[a]: “The method of claim 7, further comprising: detecting that a first pump of the plurality of pumps is underperforming; and”

428. *Borgstadt* discloses this limitation. As discussed above, *Borgstadt* discloses “methods and systems for improving the efficiency of a pumping process by controlling the operation of the pumps involved based on certain parameters characterizing the pump.”⁴⁰⁵ One of the “parameters” that *Borgstadt* teaches using to characterize the pump is pump efficiency. For example, *Borgstadt* teaches that “the performance of a pump at 118 may include, but is not limited to, the output flow rate 130, the output pressure 132 or the output efficiency 134.”⁴⁰⁶ Further *Borgstadt* discloses that “[b]ased on this information the pump modulator 107 makes an intelligent decision on how to best distribute the load among the individual pumps and assigns pumps their flow rates and or pressures. In case of a problem, it can also determine which pump or pumps can pickup the load and still operate effectively,

⁴⁰⁵ Ex. 1006 (*Borgstadt*) [0001].

⁴⁰⁶ Ex. 1006 (*Borgstadt*) [0023].

safely and efficiently.”⁴⁰⁷ *Borgstadt* discloses that “[t]he pump modulator 107 is an intelligent component which uses its knowledge about the system to integrate the operation of the various pump units 110 in the system.”⁴⁰⁸

429. Part of the system and method that *Borgstadt* teaches is determining when a pump is performing badly and using the pump modulator 107 to adjust the rest of the pumps to supplement or even replace the poorly performing pump. For example, *Borgstadt* discloses that “the pump modulator 107 may also act as a diagnostic tool.”⁴⁰⁹ As part of the diagnostics “the pump unit’s efficiency may be used for diagnosing a pump failure.”⁴¹⁰ Further explaining the diagnostic elements of the pump modulator, *Borgstadt* teaches that “the pump modulator 107 will compare the pump unit’s current efficiency value with the threshold value provided. If the pump unit 110 is operating at an efficiency lower than the threshold value, the pump modulator 107 recognizes that the pump unit has encountered an abnormal operating condition and a warning is issued at step 308.”⁴¹¹ Once *Borgstadt* has determined whether or not a particular pump is underperforming, it issues a warning

⁴⁰⁷ Ex. 1006 (*Borgstadt*) [0025].

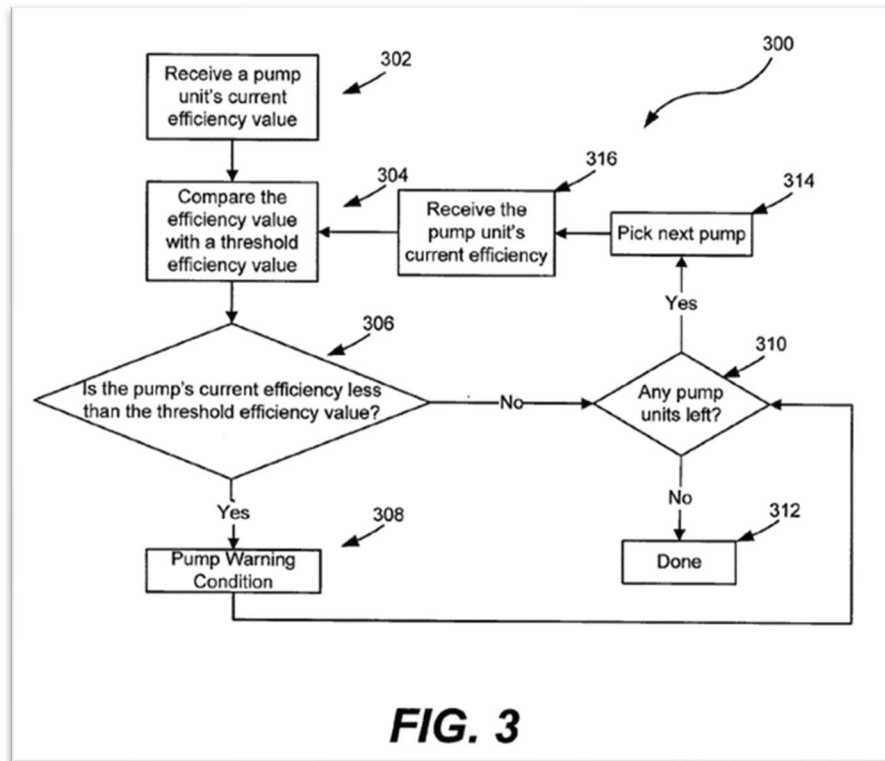
⁴⁰⁸ Ex. 1006 (*Borgstadt*) [0025].

⁴⁰⁹ Ex. 1006 (*Borgstadt*) [0033].

⁴¹⁰ Ex. 1006 (*Borgstadt*) [0033].

⁴¹¹ Ex. 1006 (*Borgstadt*) [0033].

and then goes on to check the rest of the pumps.⁴¹² Fig. 3 of *Borgstadt* summarizes these steps.



Ex. 1006 (*Borgstadt*) Fig. 3

430. Accordingly, *Borgstadt* discloses detecting that a first pump of the plurality of pumps is underperforming and as a result discloses limitation 8[a].

2. 8[b]: “adjusting one or more of the pumps in the plurality of pumps to compensate for the first pump.”

431. Further, once *Borgstadt* has determined that a pump is underperforming (performing poorly in the words of *Borgstadt*), *Borgstadt* adjusts the rest of the

⁴¹² See, e.g., Ex. 1006 (*Borgstadt*) [0036].

pumps to compensate, and in some cases takes the underperforming pump completely offline. For example, *Borgstadt* teaches that “the pump modulator 107 may shift the load away from a pump unit 110 which is performing poorly in order to improve the system performance. In some preferred embodiments the pump modulator 107 may completely take a pump unit 110 offline if it determines that the pump unit 110 has suffered a pump failure. In such instances, the pump modulator 107 can redistribute the load among the remaining pump units 110.”⁴¹³

432. Moreover, it would have been obvious to a POSITA to take an underperforming pump offline and redistribute its pumping capacity to the remaining pumps. This would maintain pumping operations, enable maintenance, and prevent damages to pumps or other components.⁴¹⁴ A POSITA would have been motivated to use *Borgstadt*’s intelligent redistribution system for “adjusting one or more of the pumps,” based on *Borgstadt*’s teachings⁴¹⁵ and the common use of control systems in fracturing operations since the 1980s.⁴¹⁶

433. Accordingly, *Borgstadt* discloses adjusting one or more pumps in the plurality of pumps to compensate for the first pump which is underperforming, and thus discloses limitation 8[b]. A POSITA would have implemented *Borgstadt*’s

⁴¹³ Ex. 1006 (*Borgstadt*) [0034].

⁴¹⁴ See Sections IX.B-C, XIII.A above.

⁴¹⁵ See Ex. 1006 (*Borgstadt*) [0025].

⁴¹⁶ See Section IX.E above.

methods for detecting underperforming pumps and redistributing pumping capacity in the system of *Norris* to enable the system to continue to operating at desired flowrates even with one pump underperforming (or failed).⁴¹⁷ Accordingly, the combination of *Norris* and *Borgstadt* renders claim 8 obvious.

I. DEPENDENT CLAIM 9: “9. THE METHOD OF CLAIM 8, FURTHER COMPRISING: SELECTING THE ONE OR MORE OF THE OTHER PUMPS TO ADJUST BASED AT LEAST IN PART ON THE CONDITIONS OF THE OTHER PUMPS AS INDICATED BY ONE OR MORE OF THE ONE OR MORE PARAMETERS.”

434. Dependent Claim 9 depends from Claim 8. In addition to the discussion regarding the disclosure of the limitations of Claim 8 described above, *Borgstadt* discloses, or renders obvious, the additional limitations of Claim 9. *Borgstadt* discloses that “the pump modulator 107 receives information 204 regarding each pump unit’s 110 current level of operation through the feedback loop 114. In an exemplary embodiment this information may include the pump unit’s 110 current operating efficiency 134, flow rate 130 and/or differential pressure 132.”⁴¹⁸ Further, *Borgstadt* describes using this information, “the pump modulator 107 optimizes and distributes the drive signals 124 sent to each individual pump controller 108 such that no single pump is operated beyond its normal operating range and that the overall system is operating at maximum efficiency.”⁴¹⁹ *Borgstadt* further teaches

⁴¹⁷ See Section XIII.A above.

⁴¹⁸ Ex. 1006 (*Borgstadt*) [0031].

⁴¹⁹ Ex. 1006 (*Borgstadt*) [0031].

that “the pump modulator 107 may completely take a pump unit 110 offline if it determines that the pump unit 110 has suffered a pump failure. In such instances, the pump modulator 107 can redistribute the load among the remaining pump units 110. As a result, the pump units control parameters such as gear rpm, flow rate and pressure are set according to the specified system pumping requirements, individual pump specifications *and existing operating conditions of the pump units*.”⁴²⁰

435. These measured parameters are precisely the type of parameters that *Norris* discloses are measured by its system. For example, *Norris* describes that “fluid pressure and flow rates downstream of each PD pump 270 are monitored by sensors associated with the common fluid conduits and pressure-side manifold 250b. Sensors, not shown, monitor both static pressure and dynamic pressure fluctuations within the common fluid conduits and pressure-side manifold 250b.”⁴²¹

436. A POSITA would also have known that shifting pumping load from an underperforming (or failed) pump to another pump verging on underperformance or failure would allow the underperforming pump to be taken off-line for repair or maintenance, while still maintaining pumping rates and normal operations, and would have been motivated to distribute pumping load based on pump conditions to control pump operation within normal operating ranges.⁴²²

⁴²⁰ Ex. 1006 (*Borgstadt*) [0034].

⁴²¹ Ex. 1004 (*Norris*) [0030].

⁴²² See, e.g., Section IX.D-E.

437. Accordingly, *Borgstadt* discloses selecting one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters as claimed. Therefore, *Borgstadt* discloses the additional limitations of Claim 9, and the combination of *Norris* and *Borgstadt* renders Claim 9 obvious.

J. CLAIM 10

438. Dependent Claim 10 depends from Claim 7. In addition to the disclosure or teachings regarding Claim 7, as discussed above, *Borgstadt* further discloses, or at least renders obvious, the additional limitations of Claim 10, as further described in the subsections below. Accordingly, the combination of *Norris* and *Borgstadt* renders Claim 10 obvious.

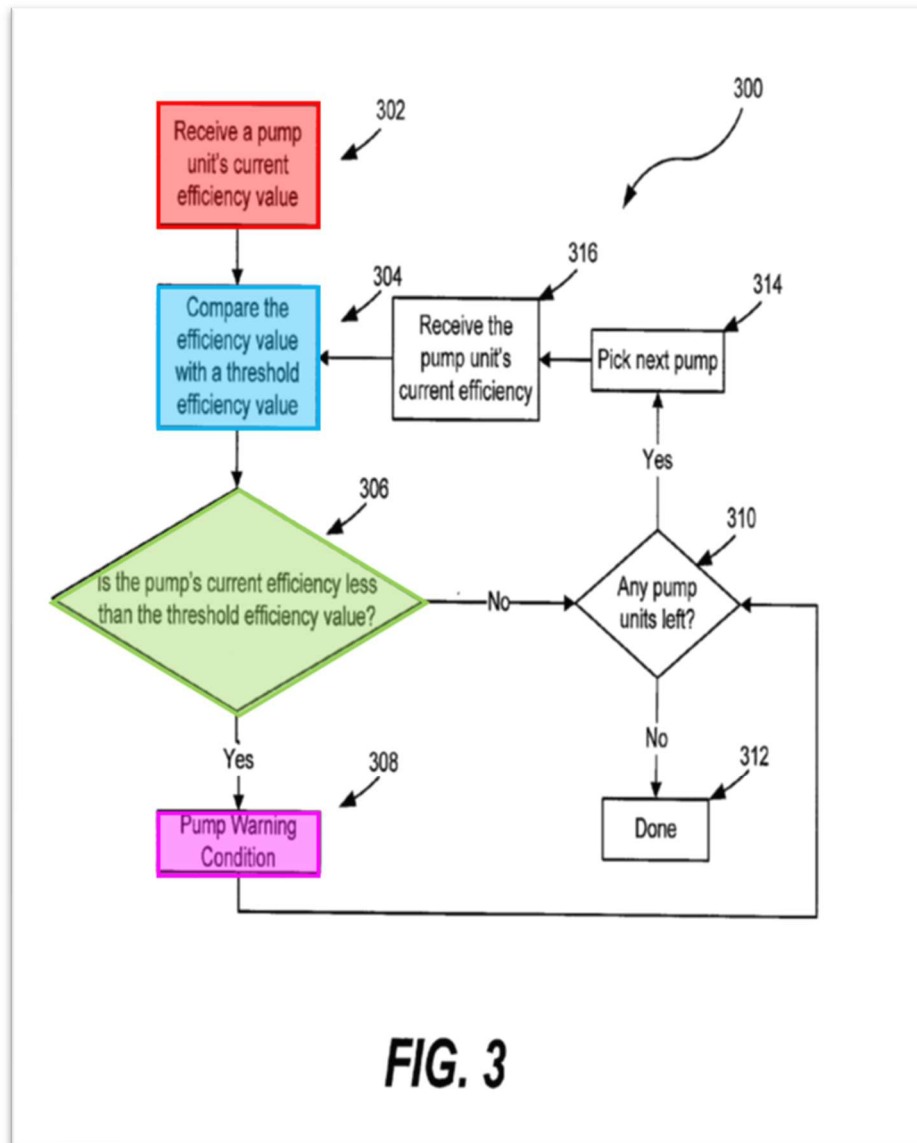
1. 10[a]: “The method of claim 7, further comprising: determining that the one or more parameters are indicative of a potential failure condition; and”

439. The combination of *Norris* and *Borgstadt* discloses this limitation, or at least renders it obvious. As discussed above regarding Claim 8, and incorporated herein by reference, *Borgstadt* discloses detecting pump underperformance, and a POSITA would have known that underperformance is indicative of a potential failure condition.⁴²³

⁴²³ See section XIII.H above.

440. According to *Borgstadt*, “[t]he pump modulator 107 may also act as a diagnostic tool. Shown in FIG. 3 is a flow diagram of the pump modulator 107 process for diagnosing a pump unit 110 failure in accordance with an embodiment of the present invention. Although the pump unit's efficiency is used as a parameter in this example, as would be appreciated by those of ordinary skill in the art, with the benefit of this disclosure, other pump parameters may be used during the diagnosing process. In one embodiment, the pump unit's efficiency may be used for diagnosing a pump failure. In the exemplary embodiment, at step 302 [annotated in red], the pump modulator 107 receives information regarding a pump unit's 110 current efficiency value through the feedback path 114. Next, at step 304 [annotated in blue], the pump modulator compares the current efficiency value of the particular pump unit 110 with a threshold efficiency value that may be provided by the system operator. At step 306 [annotated in green], the pump modulator 107 will compare the pump unit's current efficiency value with the threshold value provided. If the pump unit 110 is operating at an efficiency lower than the threshold value, the pump modulator 107 recognizes that the pump unit has encountered an abnormal operating condition and a warning is issued at Step 308 [annotated in magenta].”⁴²⁴

⁴²⁴ Ex. 1006 (*Borgstadt*) [0033].

Ex. 1006 (*Borgstadt*) FIG.3 (annotated)

441. As disclosed by *Borgstadt*, “the pump unit's efficiency [or other pump parameter] may be used for diagnosing a pump failure.”

442. To the extent that the Board determines that *Borgstadt* does not explicitly teach determining a “potential” pump failure, such a configuration of the system would have been obvious to a POSITA based on the teachings of *Borgstadt*.

First a POSITA would have recognized that using a pump's efficiency (or other parameter) to identify a pump failure is, in fact, identifying a potential failure. There could be other reasons for the measured parameter to be lower than the threshold, such as a dirty or faulty sensor. Accordingly, the load is redistributed, or the pump is taken offline, per the teachings of *Borgstadt*. It would have been obvious to a POSITA that, if the pump is actually found to be operating properly, and there was another reason for the indicated failure, that the pump could be placed back into service.

443. Further, a POSITA would have recognized that the system of *Borgstadt* could be modified, using normal creativity, to indicate impending (i.e. potential) failures before they occur. Using, for example, the pumps efficiency to identify a pump failure, a POSITA would have recognized based on general engineering knowledge and the teachings of *Borgstadt* that a pump's efficiency can be used to indicate a pump is failing. *Borgstadt* teaches that a pump efficiency that falls below a given threshold is indicative of a pump failure. A POSITA would have recognized that a pump's efficiency that is just above the threshold would be indicative of a potential pump failure, i.e. a pump that has begun to fail but has not yet reached the threshold for complete failure.

444. Further, *Borgstadt* also teaches identifying potential failure conditions prior to a complete pump failure. *Borgstadt* teaches "capability to develop a pattern

on how long each part in a pumping unit can last if they are run at their maximum efficiency, and potentially replace them right before they fail.”⁴²⁵ Accordingly, a POSITA would have understood that by adjusting the threshold value a pump could be identified before failure and “replace them [in the pumping operation] right before they fail.”

445. Accordingly, *Borgstadt* discloses, or at least renders obvious, determining that the one or more parameters are indicative of a potential failure condition. Thus, *Borgstadt* discloses or renders obvious Limitation 10[a].

2. 10[b]: “determining a source of the potential failure condition.”

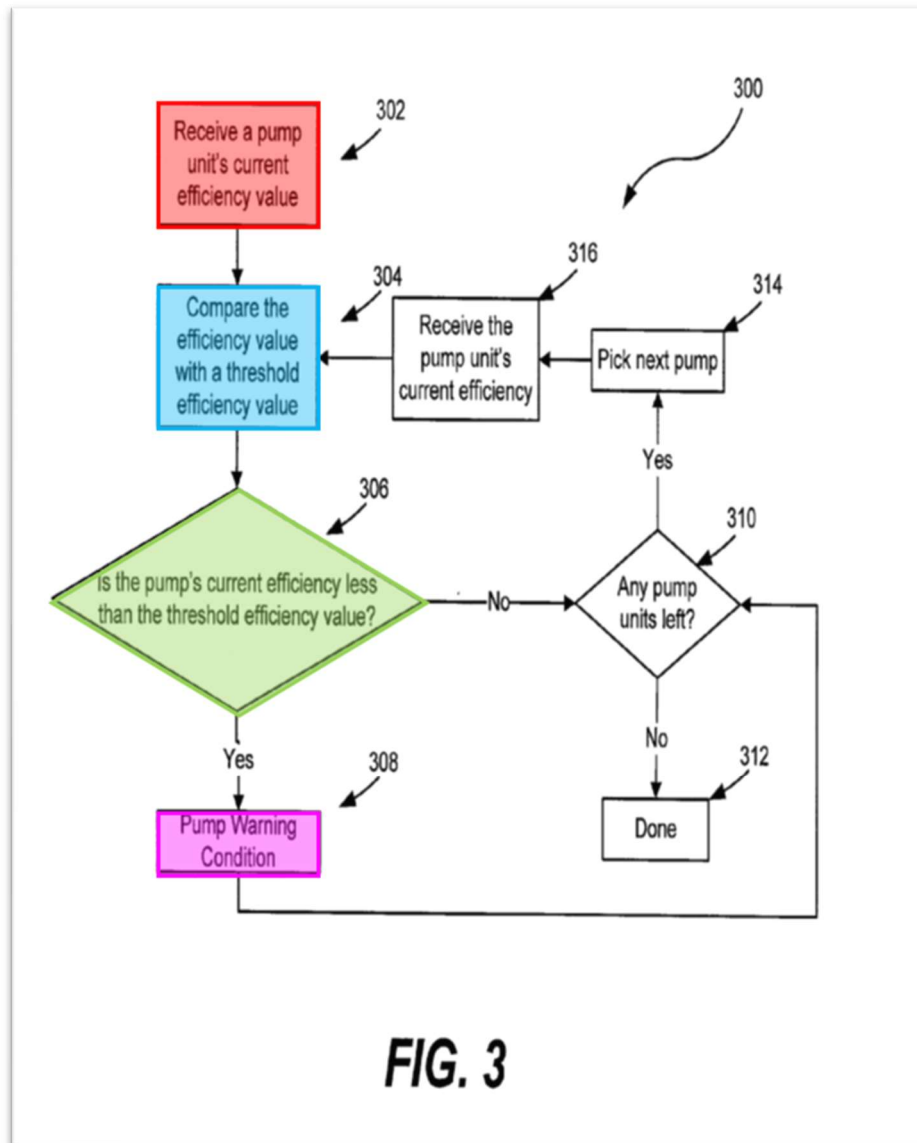
446. *Borgstad* discloses this limitation, or at the least it would have been obvious to a POSITA based on the teachings of *Borgstadt*. As discussed above regarding 10[a], *Borgstadt* teaches a series of steps for diagnosing, for example, a potential pump failure. Further, *Borgstadt* teaches determining which particular pump has potentially failed. *Borgstatdt* teaches “at step 304 [annotated in blue], the pump modulator compares the current efficiency value *of the particular pump unit 110* with a threshold efficiency value that may be provided by the system operator. At step 306 [annotated in green], the pump modulator 107 will compare *the pump unit’s* current efficiency value with the threshold value provided. If *the pump unit 110* is operating at an efficiency lower than the threshold value, the pump modulator

⁴²⁵ Ex. 1006 (*Borgstadt*) 0013.

107 recognizes that *the pump unit* has encountered an abnormal operating condition and a warning is issued at Step 308 [annotated in magenta].”⁴²⁶ at step 304 [annotated in blue], the pump modulator compares the current efficiency value *of the particular pump unit 110* with a threshold efficiency value that may be provided by the system operator. At step 306 [annotated in green], the pump modulator 107 will compare *the pump unit’s* current efficiency value with the threshold value provided. If *the pump unit 110* is operating at an efficiency lower than the threshold value, the pump modulator 107 recognizes that *the pump unit* has encountered an abnormal operating condition and a warning is issued at Step 308 [annotated in magenta].”⁴²⁷

⁴²⁶ Ex. 1006 (*Borgstadt*) [0033].

⁴²⁷ Ex. 1006 (*Borgstadt*) [0033] emphasis added.

Ex. 1006 (*Borgstadt*) FIG.3 (annotated)

447. Accordingly, by recognizing that “the pump unit 110” is in a failure or potential failure mode, *Borgstadt* teaches identifying the particular pump that is the source of the potential failure. A POSITA would have understood that “a pump warning condition,” or a diagnosis of “sensor or pump controller failure,” would indicate the pump at issue, particularly in light of *Borgstadt*’s teaching that the

determination of an alarm condition is performed on a pump-by-pump basis. Thus, *Borgstadt* discloses Limitation 10[b]. A POSITA would have implemented *Borgstadt*'s methods for detecting and diagnosing potential pump failure in the system of *Norris*.⁴²⁸ Accordingly, the combination of *Norris* and *Borgstadt* renders claim 10 obvious.

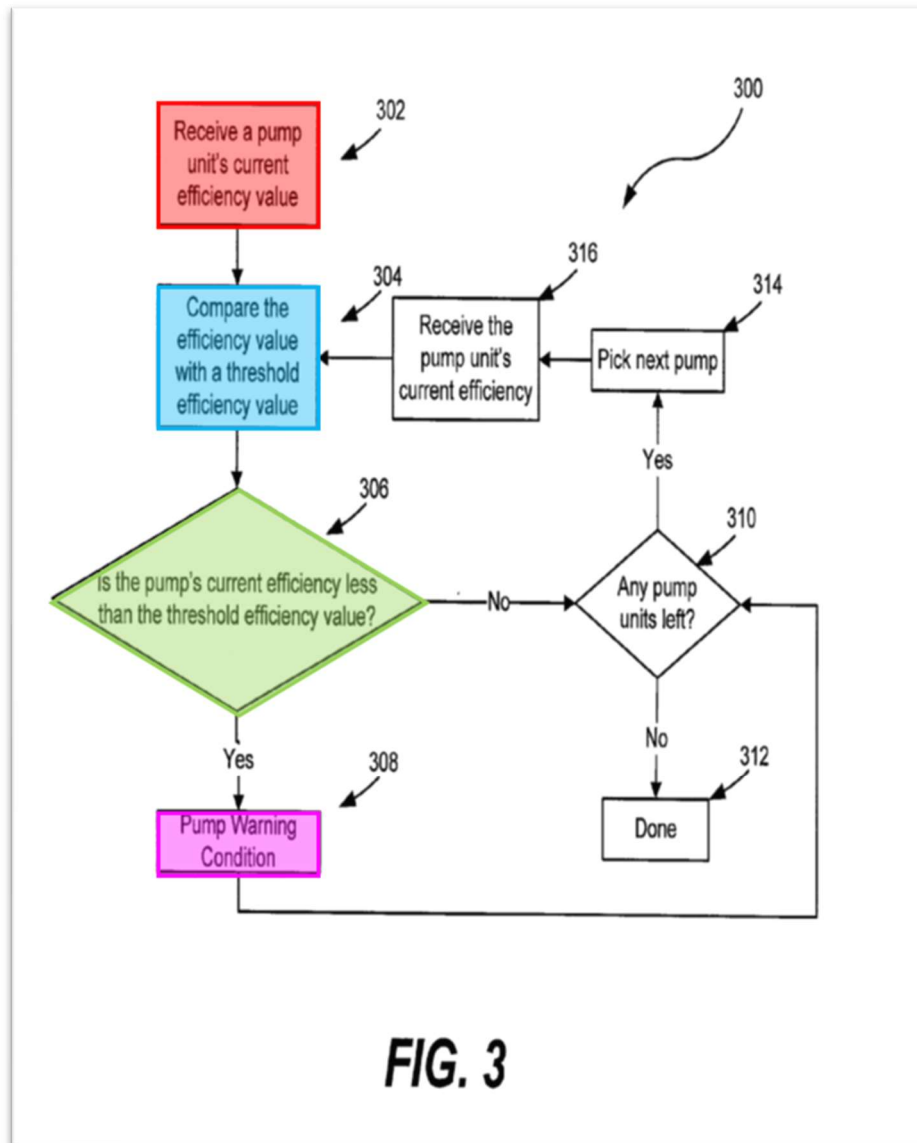
**K. CLAIM 11: “11. THE METHOD OF CLAIM 10, FURTHER COMPRISING:
GENERATING AN ALERT OR NOTIFICATION INDICATIVE OF THE
POTENTIAL FAILURE CONDITION AND THE SOURCE.”**

448. Dependent Claim 11 depends from Claim 10 which further depends from Claim 7. In addition to the disclosure or teachings regarding Claims 7 & 10, as discussed above, *Borgstadt* further discloses, or at least renders obvious, the additional limitations of Claim 11. Accordingly, the combination of *Norris* and *Borgstadt* renders Claim 10 obvious.

449. As discussed above regarding Claim 10, and incorporated herein by reference, *Borgstadt* describes or at east suggests a system for diagnosing potential pump failures. As part of that description, *Borgstadt* discloses “If *the pump unit 110* is operating at an efficiency lower than the threshold value, the pump modulator 107 recognizes that *the pump unit* has encountered an abnormal operating condition and a warning is issued at Step 308 [annotated in magenta].”⁴²⁹

⁴²⁸ See Section XIII.A above.

⁴²⁹ Ex. 1006 (*Borgstadt*) [0033] emphasis added.

Ex. 1006 (*Borgstadt*) FIG.3 (annotated)

450. Accordingly, *Borgstadt* discloses generating a warning (i.e. an alert or notification) indicative of the potential failure condition and the source.

451. To the extent that *Borgstadt* does not explicitly disclose the warning includes the potential failure condition *and the source*, such a notification would have been obvious in light of the teachings of *Borgstadt*. As discussed above

regarding Claim 10, and incorporated herein by reference, *Borgstadt's* system already identifies the specific pump that is in the warning condition, and the specific parameter that is below a threshold indicative of the failure. *Borgstadt* at least suggests providing both pieces of information. *Borgstadt* issues a “pump warning condition”, which at least suggests identifying the “pump” and the “condition”. A POSITA would have understood that supplying both pieces of information to the operator as part of the warning would provide the most complete information about the operation of the system and would have allowed the operator to make decisions appropriately.

452. Accordingly, the combination of *Norris* and *Borgstadt* renders Claim 11 obvious.

L. CLAIM 12

453. Dependent Claim 12 depends from Claim 7. In addition to the disclosure or teachings regarding Claim 7, as discussed above, *Borgstadt* teaches, or at least suggests the additional limitations of Claim 12, as further described in the subsections below. Accordingly, the combination of *Norris* and *Borgstadt* renders Claim 12 obvious.

1. 12[a]: “The method of claim 7, further comprising: logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and”

454. The combination of *Norris* and *Borgstadt* renders this limitation obvious. As discussed above regarding Claim 7, and incorporated herein by reference, *Norris* teaches that, among the data passed to the “control system 400” includes “RPM” or revolutions (strokes) per minute. *Norris* discloses “[t]he data exchanged includes but is not limited to: PD pump 270 piston position, engine RPM, and pressure data from common downstream fluid conduits including pressure-side manifold 250b.”⁴³⁰

455. In addition to the disclosure of *Norris*, *Borgstadt* teaches the “capability to develop a pattern on how long each part in a pumping unit can last if they are run at their maximum efficiency, and potentially replace them right before they fail.”⁴³¹ This disclosure of *Borgstadt* teaches, or at least suggests logging pumping hours so that the system can determine when to replace the part so they can be replaced “right before they fail”. In the combination of *Norris* and *Borgstadt* it would have been at least obvious to combine the time run (i.e. hours) with the RPM data and maintain a log of the number of strokes a pump is run, along with the hours, so an operator can more completely determine when a particular part is about to fail and replace the

⁴³⁰ Ex. 1004 (*Norris*) [0034].

⁴³¹ Ex. 1006 (*Borgstadt*) [0013].

part “right before they fail”. A POSITA would have understood that a pump part would wear out based not only on how long the part had operated, but also how hard the pump was run (i.e. how many strokes the part had endured). It would have been obvious to a POSITA that a part run in a pump running at idle for a period of time would experience less wear than a part run in a pump running at full speed for the same period of time. *Borgstadt* confirms this well understood concept when it teaches “those pumps that are operating at their maximum capacity will be subject to wear and tear and have a shortened life span while other pumps are being under utilized.”⁴³² Further, *Borgstadt* teaches “one pump may run well under its maximum horse power and be underused, while another pump is running close to its maximum horse power thus shortening its life span.”⁴³³ Accordingly, it would have been obvious to a POSITA to record (i.e. log) not only the number of hours run, taught or at least suggested by *Borgstadt*, but also the speed at which the pump was run, the combination of which provides the number of strokes. This allows an operator to more easily determine which parts need to be replaced prior to failure.

456. Accordingly, the combination of *Norris* and *Borgstadt* renders limitation 12[a] obvious.

⁴³² Ex. 1006 (*Borgstadt*) [0004].

⁴³³ Ex. 1006 (*Borgstadt*) [0005].

2. 12[b]: “determining a maintenance schedule based at least in part on the operation data.”

457. *Borgstadt* discloses this limitation, or at least renders it obvious. As discussed above, *Borgstadt* discloses “capability to develop a pattern on how long each part in a pumping unit can last if they are run at their maximum efficiency, and potentially replace them right before they fail.”⁴³⁴ A POSITA would have recognized this to be determining a maintenance schedule (i.e. replacing parts before they fail) based at least in part on the operational data (i.e. how long each part has run). To the extent the Board finds that *Borgstadt* does not explicitly disclose this limitation, it would have been obvious to a POSITA to determine a maintenance schedule based at least in part on the operation data, such as time run and RPM. As discussed above regarding Limitation 12[a], *Borgstadt* teaches that pumps wear based at least on how hard they are run (e.g., pumps operated close to maximum capacity are subjected to more wear and tear). Accordingly, a POSITA would have understood, based on the teaching of *Borgstadt* to replace parts before they fail, that a maintenance schedule (i.e. replacement of parts) would take into account both time run and how “hard” the pump had been run (e.g., how many strokes the part had encountered).

458. Accordingly, the combination of *Norris* and *Borgstadt* renders Limitation 12[b] obvious.

⁴³⁴ Ex. 1006 (*Borgstadt*) 0013.

M. INDEPENDENT CLAIM 13

459. It is my opinion that the combination of *Norris* and *Borgstadt* anticipates renders Claim 13 obvious. As discussed in the following subsections, the combination of *Norris* and *Borgstadt* discloses, or renders obvious, each and every element of Claim 13.

1. Limitations 13[p] – 13[c]

A hydraulic fracturing method, comprising:

performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;

measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;

transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

460. Limitations 13[p] - 13[c] are disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.F.1 – XI.F.4.

2. Limitation 13[d]: “detecting that the first parameter is outside of an acceptable threshold;”

461. Except for being rewritten as a method claim. Claim 13[e] is substantially similar to Limitation 1[e][ii] and is rendered obvious, by the combination of *Norris* and *Borgstadt* for the same reasons as those discussed above in Section XIII.B.2.

3. Limitations 13[e] – 13[f]

generating automated instructions at the second device based at least in part on the first parameter; and

automatically adjusting one or more functions of the second device based on the automated instructions.

462. Limitations 13[e] - 13[f] are disclosed and/or rendered obvious by *Norris* alone for the same reasons as those discussed above in Section XI.F.6 – XI.F.7.

N. DEPENDENT CLAIM 14: “THE METHOD OF CLAIM 13, WHEREIN THE DISTRIBUTION SYSTEM RECEIVES AND CONSOLIDATES THE FRACTURING FLUID FROM THE PLURALITY OF PUMPS FOR INJECTION INTO A WELLHEAD.”

463. Dependent Claim 14 depends from Claim 13. In addition to the discussion regarding Claim 13 in Section XIII.M above, *Norris* discloses the additional limitations of Claim 14 for the same reasons as those discussed above regarding Ground 1.

O. DEPENDENT CLAIM 15: “THE METHOD OF CLAIM 14, FURTHER COMPRISING: CONTROLLING ONE OR MORE FUNCTIONS OF THE DISTRIBUTION SYSTEM BASED ON THE AUTOMATED INSTRUCTIONS.”

464. Dependent Claim 15 depends from Claim 14. In addition to the discussion regarding Claim 14 in Section XIII.N above, the combination of *Borgstadt* and *Norris* renders obvious the additional limitations of Claim 15. *Borgstadt* teaches a “manifold observer” for sensing “at any point in a system” and operating at a “desired value of a parameter at that point in the system.”⁴³⁵ A POSITA would have understood to monitor and control operating parameters throughout the fracturing system (including in the distribution system) based on the teachings of *Norris* and *Borgstadt*.

P. DEPENDENT CLAIM 16: “THE METHOD OF CLAIM 13, WHEREIN THE FIRST PARAMETER INCLUDES MEASUREMENTS OF ONE OR MORE OF THE PLURALITY OF PUMPS.”

465. Dependent Claim 16 depends from Claim 13. In addition to the discussion regarding Claim 13 in Section XIII.M above, *Norris* discloses the additional limitations of Claim 16 for the same reasons as those discussed above regarding Ground 1.

⁴³⁵ Ex. 1006 (*Borgstadt*) [0042]- [0043], Fig. 4.

Q. DEPENDENT CLAIM 17: “THE METHOD OF CLAIM 16, FURTHER COMPRISING: CONTROLLING ONE OR MORE OF THE PLURALITY OF PUMPS INDIVIDUALLY BASED ON THE AUTOMATED INSTRUCTIONS.”

466. Dependent Claim 16 depends from Claim 16, which further depends from Claim 13. In addition to the discussion regarding Claims 13 & 16 in Section XIII.M & XIII.P above, *Norris* discloses the additional limitations of Claim 17 for the same reasons as those discussed above regarding Ground 1.

R. DEPENDENT CLAIM 18

467. Claim 18 depends from Claim 17. In addition to the discussion regarding the disclosure of the limitations of Claim 17 described above, as discussed in the following subsections, *Borgstadt* discloses, or renders obvious, each and every element of Claim 18. It is my opinion that the combination of *Norris* and *Borgstadt* renders Dependent Claim 18 obvious.

1. 18[a]: “18. The method of claim 17, further comprising: detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold; and”

468. *Borgstadt* discloses this limitation. As discussed above, *Borgstadt* discloses “methods and systems for improving the efficiency of a pumping process by controlling the operation of the pumps involved based on certain parameters characterizing the pump.”⁴³⁶ One of the “parameters” that *Borgstadt* teaches using to characterize the pump is pump efficiency. For example, *Borgstadt* teaches that

⁴³⁶ Ex. 1006 (*Borgstadt*) [0001].

“the performance of a pump at 118 may include, but is not limited to, the output flow rate 130, the output pressure 132 or the output efficiency 134.”⁴³⁷ Further *Borgstadt* discloses that “Based on this information the pump modulator 107 makes an intelligent decision on how to best distribute the load among the individual pumps and assigns pumps their flow rates and or pressures. In case of a problem, it can also determine which pump or pumps can pickup the load and still operate effectively, safely and efficiently.”⁴³⁸ *Borgstadt* discloses that “[t]he pump modulator 107 is an intelligent component which uses its knowledge about the system to integrate the operation of the various pump units 110 in the system.”⁴³⁹

469. Part of the system and method that *Borgstadt* teaches is determining when a pump is performing badly and using the pump modulator 107 to adjust the rest of the pumps to supplement or even replace the poorly performing pump. For example, *Borgstadt* discloses “In one embodiment, the pump modulator 107 may also act as a diagnostic tool.”⁴⁴⁰ As part of the diagnostics “the pump unit’s efficiency may be used for diagnosing a pump failure.”⁴⁴¹ Further explaining the diagnostic elements of the pump modulator, *Borgstadt* teaches that “the pump modulator 107 will compare the pump unit’s current efficiency value with the

⁴³⁷ Ex. 1006 (*Borgstadt*) [0023].

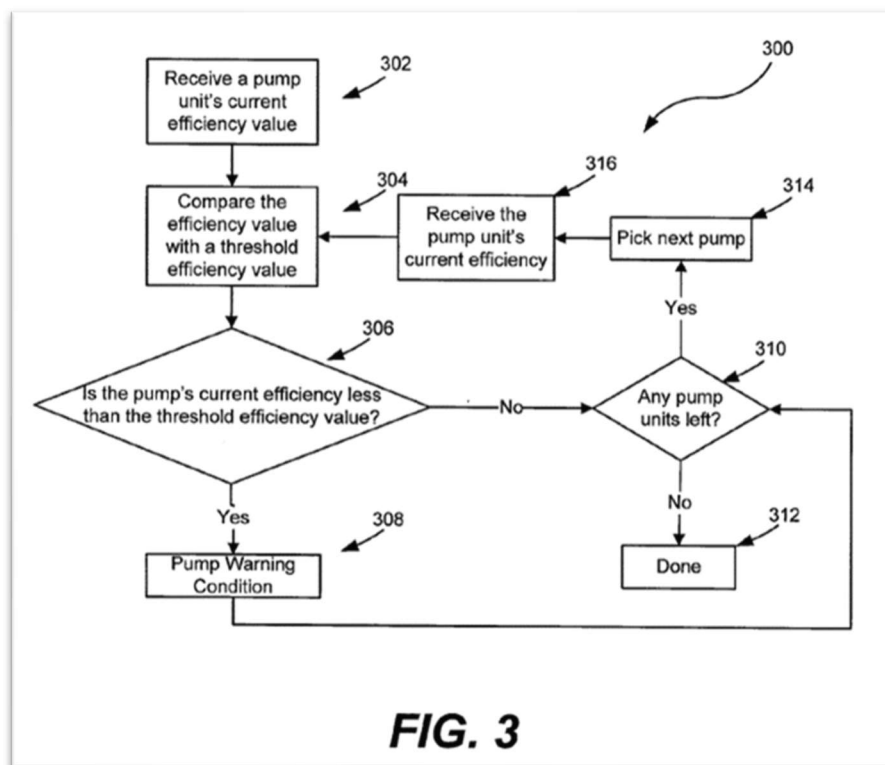
⁴³⁸ Ex. 1006 (*Borgstadt*) [0025].

⁴³⁹ Ex. 1006 (*Borgstadt*) [0025].

⁴⁴⁰ Ex. 1006 (*Borgstadt*) [0033].

⁴⁴¹ Ex. 1006 (*Borgstadt*) [0033].

threshold value provided. *If the pump unit 110 is operating at an efficiency lower than the threshold value*, the pump modulator 107 recognizes that the pump unit has encountered an abnormal operating condition and a warning is issued at step 308.”⁴⁴² Once *Borgstadt* has determined whether or not a particular pump is underperforming, it issues a warning and then goes on to check the rest of the pumps.⁴⁴³ Fig. 3 of *Borgstadt* summarizes these steps.



Ex. 1006 (*Borgstadt*) Fig. 3

⁴⁴² Ex. 1006 (*Borgstadt*) [0033].

⁴⁴³ See, e.g., Ex. 1006 (*Borgstadt*) [0036].

470. Also, to the extent the Board determines that Claim 18 requires a second “detecting [] of an acceptable threshold,” in addition to Claim 13’s “detecting of an acceptable threshold,” it would have been obvious to a POSITA to compare each of multiple parameters to various thresholds. *Borgstadt*, for example, teaches comparing pressure, efficiency, and flow rate to separate thresholds during diagnostics.⁴⁴⁴

471. Accordingly, *Borgstadt* discloses detecting that a that a measurement associated with a first pump (e.g. efficiency) of the plurality pumps is outside an acceptable threshold and as a result discloses limitation 18[a].

2. 18[b]: “automatically taking the first pump offline in response to the detection.”

472. *Borgstadt* discloses this limitation as well. As discussed above regarding limitation 8[] and incorporated herein by reference, *Borgstadt* teaches detecting that a pump is underperforming by comparing measurements, such as pump efficiency, are outside of an acceptable threshold. after a warning is issued, as described above regarding Claim 8, *Borgstadt* teaches “after the pump modulator 107 determines there is a pump warning condition 308, it will act to correct the

⁴⁴⁴ Ex. 1006, (*Borgstadt*), [0031] (“[T]his information [received by the pump modulator] may include the pump unit's 110 current operating efficiency 134, flow rate 130 and/or differential pressure 132”), [0033] (“Although the pump unit's efficiency is used as a parameter in this example, as would be appreciated by those of ordinary skill in the art, with the benefit of this disclosure, other pump parameters may be used during the diagnosing process”)

problem or minimizes the impact of the abnormal condition on the system (this step is not shown).”⁴⁴⁵ If after attempting to correct the problem, the measured parameter is still not above the threshold the unit is taken offline. *Borgstadt* gives at least one example: “For example, if a pump unit is cavitating, the pump modulator 107 may unload that pump unit, for example, by reducing pump unit's speed, which could potentially eliminate the cavitation. If a reduction in the pump unit's operating speed does not improve the efficiency, this may be an indication that the pump unit's seals need to be replaced or that the pump unit should be taken offline and inspected for damages.”⁴⁴⁶ *Borgstadt* further teaches that the pump is taken offline automatically “the pump modulator 107 may completely take a pump unit 110 offline if it determines that the pump unit 110 has suffered a pump failure. In such instances, the pump modulator 107 can redistribute the load among the remaining pump units 110.”⁴⁴⁷

473. Accordingly, *Borgstadt* teaches automatically taking the first pump offline in response to the detection that a measured parameter is outside an acceptable threshold as claimed in limitation 18[b].

⁴⁴⁵ Ex. 1006 (*Borgstadt*) [0034].

⁴⁴⁶ Ex. 1006 [0034].

⁴⁴⁷ Ex. 1006 (*Borgstadt*) [0034].

**S. CLAIM 19: “19. THE METHOD OF CLAIM 18, FURTHER COMPRISING:
ADJUSTING ONE OR MORE OF THE OTHER PUMPS IN THE PLURALITY OF
PUMPS TO COMPENSATE FOR TAKING THE FIRST PUMP OFFLINE.”**

474. Dependent Claim 19 depends from Claim 18. In addition to the discussion regarding the disclosure of the limitations of Claim 18 described above, *Borgstadt* discloses, or renders obvious, the additional limitations of Claim 19. As discussed above regarding Claim 18, *Borgstadt* teaches “the pump modulator 107 may completely take a pump unit 110 offline if it determines that the pump unit 110 has suffered a pump failure. In such instances, the pump modulator 107 can redistribute the load among the remaining pump units 110.”

475. Moreover, it would have been obvious to a POSITA to take a failed pump offline and redistribute its pumping capacity to the remaining pumps. This would maintain pumping operations, enable maintenance, and prevent damage to pumps or other components.⁴⁴⁸ A POSITA would have been motivated to use *Borgstadt*’s intelligent redistribution system for “adjusting one or more of the pumps,” based on *Borgstadt*’s teachings⁴⁴⁹ and the common use of control systems in fracturing operations since the 1980s.⁴⁵⁰

476. Accordingly, *Borgstadt* discloses the additional limitations of Claim 19 and the combination of *Borgstadt* and *Norris* render Claim 19 obvious.

⁴⁴⁸ See Sections IX.B-C, XIII.A above.

⁴⁴⁹ See Ex. 1006 (*Borgstadt*) [0025].

⁴⁵⁰ See Section IX.E above.

XIV. GROUND 5: OBVIOUS OVER *NORRIS* IN VIEW OF DYKSTRA

477. As described in Grounds 1 and 2, it is my opinion that *Norris* anticipates or at least renders obvious claims 1-5, 7, 13-14, and 16-17. Ground 5 relies on *Norris*'s teaching, described in Grounds 1-2, of these claims.

478. It is my opinion that the combination of *Norris* and *Dykstra* also renders Claims 5, 6 & 15 of the '435 patent obvious.

A. MOTIVATION TO COMBINE

479. In my opinion, a POSITA would have been motivated to combine *Dykstra* with the teachings of *Norris* at least for the reasons below.

480. As discussed above regarding Section VI.A, the '435 Patent is directed to a "hydraulic fracturing system includes a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid, a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead."⁴⁵¹

481. Similarly, *Norris* is directed to "manag[ing] operation of a plurality of positive displacement pumps"⁴⁵² such as those used for "fracturing operation of PD pumps".⁴⁵³ *Norris* further teaches "[t]o provide the necessary pressure for downhole operations such as fracturing, operation of PD pumps 270 forces the wellbore service

⁴⁵¹ Ex. 1001 ('435 Patent) Abstract.

⁴⁵² Ex. 1004 (*Norris*) Abstract.

⁴⁵³ Ex. 1004 (*Norris*) [0022].

fluid into a pressure-side manifold 250b via pressure flow lines 290 and subsequently from pressure-side manifold 250b to wellhead 180 via conduit 190.”⁴⁵⁴

Further, *Norris* describes “In fracturing operations, wellbore servicing fluids, such as particle (e.g., proppant) laden fluids, are pumped at a relatively high-pressure into the wellbore 120. The particle laden fluids may then be introduced into a portion of the subterranean formation 130 at a pressure and velocity sufficient to cut and/or abrade a casing and/or initiate, create, or extend perforation tunnels and/or fractures within the subterranean formation 130. Proppant (e.g., grains of sand, glass beads, shells, ceramic particles, etc.,) may be mixed with the wellbore servicing fluid to keep the fractures open so that hydrocarbons may be produced from the subterranean formation 130 and flow into the wellbore 120.”⁴⁵⁵ *Norris* further teaches the use of “blender 240 where the water is mixed with various other components and/or additives from storage vessels 210 and 220 to form a wellbore servicing fluid [i.e. fracturing fluid]. The wellbore servicing fluid passes from the blender 240 into a low-pressure side of the supply-side manifold 250a via flowline 260 and from the supply-side manifold 250a to the PD pumps 270 via supply flowlines 295.”⁴⁵⁶

⁴⁵⁴ Ex. 1004 (*Norris*) [0022].

⁴⁵⁵ Ex. 1004 (*Norris*) [0023].

⁴⁵⁶ Ex. 1004 (*Norris*) [0021].

Further still, *Norris* teaches the use of a “centralized controller 404” to “direct[] an individual local pump system control to make necessary throttle changes”.⁴⁵⁷

482. Similarly, *Dykstra* is directed towards “[a] method and apparatus for controlling the production of well treatment fluid is disclosed.”⁴⁵⁸ *Dykstra*’s teachings include the use of a “well treatment operations factory” which includes “a centralized power unit 103; a pumping grid 111; a central manifold 107; a proppant storage system 106; a chemical storage system 112; and a blending unit 105.”⁴⁵⁹ Like *Norris*, *Dykstra*’s pumping grid comprises “one or more pumps that can be electric, gas, diesel, or natural gas powered.”⁴⁶⁰ Further, *Dykstra*, like *Norris*, teaches the use of a blender to mix “sand from the sand system and water from the water system.”⁴⁶¹ Also like *Norris*, *Dykstra* teaches the use of manifolds to direct flow of the fracturing fluid.⁴⁶² Accordingly, *Dykstra* and *Norris* are analogous art to each other and to the ‘435 Patent.

483. Further, both *Norris* and *Dykstra* are concerned with effective control of the fracturing pumps. *Norris* describes “configurations and methods designed to preclude coincidental operation of PD pumps. Thus, these configurations lead to out

⁴⁵⁷ Ex. 1004 (*Norris*) [0047].

⁴⁵⁸ Ex. 1007 (*Dykstra*) Abstract.

⁴⁵⁹ Ex. 1007 (*Dykstra*) [0014].

⁴⁶⁰ Ex. 1007 (*Dykstra*) [0020].

⁴⁶¹ Ex. 1007 (*Dykstra*) [0005].

⁴⁶² See e.g., Ex. 1007 (*Dykstra*) [0014], [0018], [0020] – [0021], Fig. 2.

of phase operation, i.e. non-coincidental operation, of the PD pumps.”⁴⁶³ *Dykstra* teaches an overall control system that “includes the steps of determining an output rate from a sand system sensing an output rate from a water system; sensing an output rate from a pumping system; sensing the height within a blender tub of a mixture of sand from the sand system and water from the water system; providing a virtual rate control system; and producing a drive signal to the pumping system using the virtual rate control system using a desired rate of well treatment fluid to be delivered to a well, the output rate of the sand system, the output rate of the water system, and the output rate of the pumping system.”⁴⁶⁴ Further, *Dykstra* teaches a central control system that “use[s] all of the sensor data from all units and the drive signals from their individual subcontrollers to determine subsystem trajectories.”⁴⁶⁵ A POSITA would have been motivated to combine the teachings of *Norris* and *Dykstra* at least because of their similarities.

484. A POSITA would have been motivated to take advantage of *Dykstra*’s “virtual rate control system” so that “consistent performance be maintained according to a desired output rate or output property.”⁴⁶⁶ *Dykstra* teaches that without its virtual rate control system, “much of the [fracturing] equipment is

⁴⁶³ Ex. 1003 (*Norris*) [0003].

⁴⁶⁴ Ex. 1007 (*Dykstra*) [0005].

⁴⁶⁵ Ex. 1007 (*Dykstra*) [0021].

⁴⁶⁶ Ex. 1007 (*Dykstra*) [0005].

controlled independently with passed setpoint data and with no direct consideration of the subsystem physical dynamics.”⁴⁶⁷ *Dykstra* further discloses “this can lead to well treatment fluid that does not comply with the needs of a well formation.”⁴⁶⁸ *Dykstra* teaches that “the operations of the chemical storage system, proppant storage system, blending unit, pumping grid, power unit, and manifolds are controlled, coordinated, and monitored by a central control system.”⁴⁶⁹ This allows for “the ability to change a desired property of a well treatment fluid and to automatically propagate the change throughout the well treatment fluid production process.”⁴⁷⁰ Accordingly, “the operation of a well treatment operation can be coordinated and consistent performance can be maintained across the various subsystems.”⁴⁷¹ This consistency would have been recognized as highly advantageous to the operation of a fracturing system, and a POSITA would have been motivated to integrate the teachings of *Dykstra* with *Norris* in order to take advantage of this consistency in operations.

485. A POSITA would have understood that, since the various controllers of *Dykstra* and *Norris* are both implemented using similar processors (including generic computers) that communicate, execute algorithms, and control devices of

⁴⁶⁷ Ex. 1007 (*Dykstra*) [0004].

⁴⁶⁸ Ex. 1007 (*Dykstra*) [0004].

⁴⁶⁹ Ex. 1007 (*Dykstra*) [0021].

⁴⁷⁰ Ex. 1007 (*Dykstra*) [0006].

⁴⁷¹ Ex. 1007 (*Dykstra*) [0031].

their related physical systems, that the teachings of *Dykstra* and *Norris* are compatible and functions disclosed in one reference could easily be programmed into and performed by the hardware of the other reference. Accordingly, a POSITA would have been motivated to implement the functions of *Dykstra* into *Norris*' control system, or vice versa. Further, since the teachings are compatible, a POSITA would have had a reasonable expectation of success in the combination. For example, a POSITA would have understood that features of *Dykstra*'s central control would be implemented in or alongside *Norris*' application controller without affecting *Norris*' pump management system or *Norris*' methods for avoiding coincidental operation.

486. *Dykstra* also identifies known control techniques, similar to those in *Norris*, to improve similar devices in the same way. For example, *Norris* describes pump sensing and control,⁴⁷² while *Dykstra* extends similar sensing and control to blenders and fluid delivery.⁴⁷³ A POSITA would have applied *Dykstra*'s monitoring and control techniques, which are similar to those in *Norris*, to the fracturing system's blender, manifolds, and fluid-delivery systems.

487. A POSITA would have had a reasonable expectation of success in combining the teachings of *Norris* and *Dykstra*. The combination is merely

⁴⁷² EX1004 (*Norris*) [0029].

⁴⁷³ EX1007 (*Dykstra*) [0021], Fig. 3.

combining prior art elements (*Norris* and *Dykstra*'s overall monitoring and control systems) according to known methods to yield predictable results (coordinated control of fracturing subsystems to maintain consistent performance of the fracturing system). Further, the combination would have been the use of a known technique (*Dykstra*'s coordinated central control system) to improve similar methods (*Norris*' control system).

B. DEPENDENT CLAIM 5: “THE SYSTEM OF CLAIM 1, FURTHER COMPRISING: ONE OR MORE BLENDERS CONFIGURED TO MIX TOGETHER ONE OR MORE MATERIALS TO FORM THE FRACTURING FLUID, WHEREIN THE FRACTURING FLUID IS PROVIDED FROM THE BLENDER TO THE PLURALITY OF PUMPS VIA A MANIFOLD, WHEREIN THE PLURALITY OF SENSING DEVICES INCLUDES ONE OR MORE PRESSURE OR FLOW SENSORS FOR MEASURING FLOW CONDITIONS AT THE ONE OR MORE BLENDERS, THE MANIFOLD, THE PLURALITY OF PUMPS, OR THE DISTRIBUTION SYSTEM.”

488. *Norris* discloses the additional limitations of Claim 5 for the same reasons as those discussed above regarding Ground 1. *Dykstra* also states that the “final fracturing fluid” prepared by the “mixer” is “directed to a pumping grid.”⁴⁷⁴ *Dykstra* teaches “pressure sensors or pump sensors at the well pump or pumps” and flow sensors that “indicate the rate of water entering the blender tub.”⁴⁷⁵ A POSITA would have measured pressure and flow at *Norris*'s pumps, blenders, manifold, and distribution system based on *Dykstra*'s teaching that monitoring and controlling

⁴⁷⁴ Ex. 1007 (*Dykstra*) [0018].

⁴⁷⁵ Ex. 1007 (*Dykstra*) [0028]

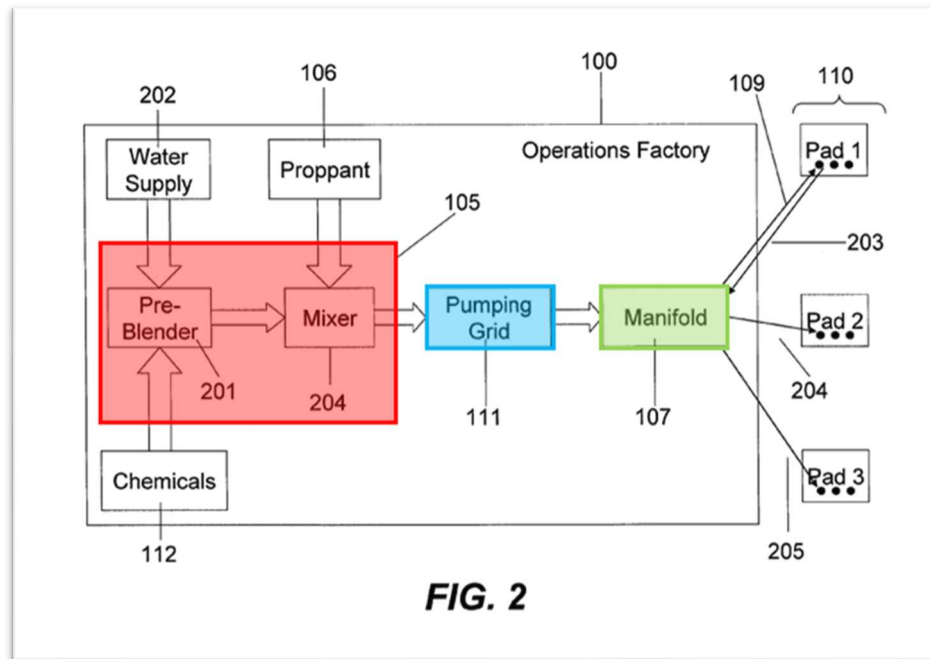
pressure and flow for both fluid-delivery and pumping systems improves well-treatment operations.⁴⁷⁶

489. Accordingly, the combination of *Norris* and *Dykstra* renders Claim 5 obvious.

C. DEPENDENT CLAIM 6: “6. THE SYSTEM OF CLAIM 5, WHEREIN THE ONE OR MORE CONTROL DEVICES IS CONFIGURED TO CONTROL THE ONE OR MORE BLENDERS, THE MANIFOLD, THE PLURALITY OF PUMPS AND THE DISTRIBUTION SYSTEM BASED ON THE FLOW AND/OR PRESSURE CONDITIONS.”

490. Dependent Claim 6 depends from Claim 5, which further depends from Claim 1. In addition to the disclosures of the limitations of Claim 5 discussed above, and the disclosures of the limitations of Claim 1 described regarding Ground 1, *Dykstra* discloses the additional limitations of Claim 6. As discussed above in Section XII.A, *Dykstra* discloses a central control system. *Dykstra* further teaches “In some embodiments, the operations of the chemical storage system, proppant storage system, *blending unit* [annotated in red], *pumping grid* [annotated in blue], power unit, and *manifolds* [annotated in green] are controlled, coordinated, and monitored by a central control system.[] The central control system may use all of the sensor data from all units and the drive signals from their individual subcontrollers to determine subsystem trajectories.”⁴⁷⁷

⁴⁷⁶ Ex. 1007 (*Dykstra*) [0021]- [0022], [0025].



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

491. *Dykstra* teaches that the “blending unit” comprises a blender: “the blending unit 105 is connected to the chemical storage system 112, the proppant storage system 106, a water source 202, and a pumping grid 111 and may prepare a fracturing fluid, complete with proppant and chemical additives or modifiers, by mixing and blending fluids and chemicals at continuous rates according to the needs of a well formation.”⁴⁷⁸

492. *Dykstra* teaches that the “pumping grid” comprises pumps for pressurizing fracturing fluid: “the pumping grid 111, [] comprises one or more

⁴⁷⁸ Ex. 1007 (*Dykstra*) [0018].

pumps that can be electric, gas, diesel, or natural gas powered.”⁴⁷⁹ And that “fluid can be directed to a pumping grid 111 and subsequently directed to a central manifold 107, which can connect and direct the fluid via connection 109, 204, or 205 to multiple wells 110 simultaneously.”⁴⁸⁰

493. The ‘435 patent teaches that “the manifold” is part of the distribution system. Generally, the ‘435 Patent teaches that the distribution system is “fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead.”⁴⁸¹ Further, when describing Fig. 1, the ‘435 Patent teaches “a distribution system 30 [annotated in red], such as a missile [a manifold] , receives the fracturing fluid solution for injection into the wellhead 18. The distribution system 30 consolidates the fracturing fluid solution from each of the pump trucks 14 (for example, via common manifold for distribution of fluid to [*sic* from] the pumps) includes discharge piping 32 (which may be a series of discharge lines or a single discharge line) coupled to the wellhead 18.”⁴⁸² Accordingly, a POSITA would have understood the distribution system of the ’453 Patent to comprise a manifold, just like in the disclosure of *Dykstra*, and that by controlling the manifold, the control

⁴⁷⁹ Ex. 1007 (*Dykstra*) [0020].

⁴⁸⁰ Ex. 1007 (*Dykstra*) [0018]

⁴⁸¹ Ex. 1001 1:46 – 48.

⁴⁸² Ex. 1001 3:49 – 54.

system is also controlling the distribution system. There is no teaching in the ‘435 Patent specification that the manifold is separate from the distribution system.

494. In combination with *Norris*, a POSITA would have combined *Dykstra*’s teachings of a central control system to control “the chemical storage system, proppant storage system, blending unit, pumping grid, power unit, and manifolds” into the “site control 401” of *Norris* so that so that “consistent performance be maintained according to a desired output rate or output property.”⁴⁸³ Alternatively, a POSITA would have incorporated *Norris*’ teaching of pump control to avoid “coincidental operation of PD pumps [that] can lead to significant periodic pressure spikes”⁴⁸⁴ into the central control of *Dykstra* in order to “reduce or eliminate pressure deviations in fluid components and conduits”⁴⁸⁵ as taught by *Norris*.

495. Accordingly, *Dykstra* discloses all of the additional elements of Claim 6 and the combination of *Norris* and *Dykstra* renders Claim 6 obvious.

D. DEPENDENT CLAIM 15: “15. THE METHOD OF CLAIM 14, FURTHER COMPRISING: CONTROLLING ONE OR MORE FUNCTIONS OF THE DISTRIBUTION SYSTEM BASED ON THE AUTOMATED INSTRUCTIONS.”

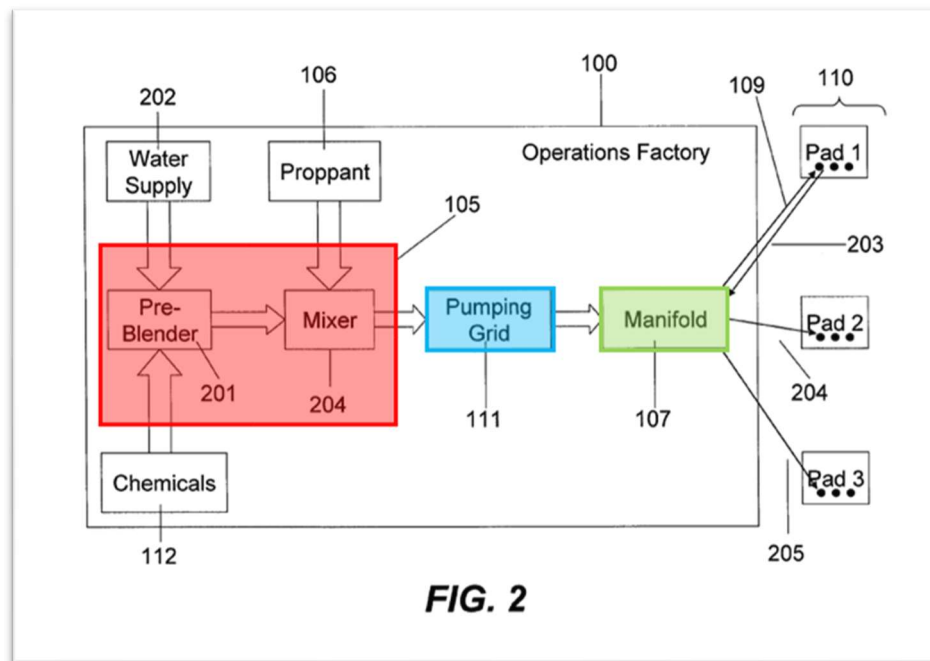
496. Dependent Claim 6 depends from Claim 14, which further depends from Claim 13. In addition to the disclosures of the limitations of Claims 13 & 14 discussed above, *Dykstra* discloses the additional limitations of Claim 15. As

⁴⁸³ Ex. 1007 (*Dykstra*) [0005].

⁴⁸⁴ Ex. 1004 (*Norris*) [0002]

⁴⁸⁵ Ex. 1004 (*Norris*) [0002].

discussed above in Section XII.A, *Dykstra* discloses a central control system. *Dykstra* further teaches “[i]n some embodiments, the operations of the chemical storage system, proppant storage system, **blending unit** [annotated in red], **pumping grid** [annotated in blue], power unit, and **manifolds** [annotated in green] are controlled, coordinated, and monitored by a central control system.[] The central control system may use all of the sensor data from all units and the drive signals from their individual subcontrollers to determine subsystem trajectories.”⁴⁸⁶



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

497. As discussed above in Section XIV.C, and incorporated herein by reference, the manifold is part of the distribution system, as the term is used in the

⁴⁸⁶ Ex. 1007 (*Dykstra*), [0021]

'435 Patent. Therefore, by controlling the manifold, *Dykstra's* control system is controlling one or more functions of the distribution system.

498. Accordingly, *Dykstra* discloses the additional limitations of Claim 15 and the combination of *Norris* and *Dykstra* render Claim 15 obvious.

XV. SECONDARY CONSIDERATIONS

499. I am not aware of any evidence of secondary considerations that would support a finding of nonobviousness of the '435 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 '435 Patent, and to update my analysis.

XVI. CONCLUSION

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 11, 2024.



Dr. Robert A. Durham