

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Intelligent Wellhead Systems, Inc.
Petitioner,

v.

Downing Wellhead Equipment, LLC
Patent Owner

IPR2024-00256
Patent No. 11,401,779

DECLARATION OF DR. ROBERT DURHAM

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INTRODUCTION

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. 11,401,779, which I may abbreviate as “the ’779 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 ’779 Patent. I am being compensated at my normal rate of \$305 per hour for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

I. EXPERIENCE AND QUALIFICATIONS

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 electrification of the oil and gas industry from drilling

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

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

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

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

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

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

9. After a brief stint as Vice President for EDG Power Group, responsible for Engineering and Project Management of generation and co-generation facilities across the U.S., I transitioned to the role of consulting engineer. In that role I have served as consulting engineer relating to the design, construction, 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 well versed 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)¹ and completion operations for nearly twenty years. In addition to being responsible for interfacing with drilling and fracturing operations with regards to electrical needs as an employee of New Dominion, LLC, I have been further educated about drilling, fracturing and operations as I have consulted and investigated incidents on multiple well drilling, fracturing and completion pad sites over my engineering consulting engagements.

¹ “Frac*” and “frack*” are used interchangeably in the industry and herein.

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

13. 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.

14. Therefore, based on my education, professional experience of 30 years, and scholarly books and publications, I am an expert in the relevant field of the Challenged Patent at issue here and have been an expert in this field since before the Challenged 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 ’779 Patent at the time of its filing.

II. TASK SUMMARY AND MATERIALS REVIEWED

15. 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

16. 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. 11,401,779 by Jordan Kuehn <i>et al.</i> entitled “HYDRAULIC FRACTURING PLAN AND EXECUTION OF SAME” (the “’779 Patent”)
1002	Declaration of Dr. Robert Durham
1003	U.S. Patent Publication 2022/0268141 A1 by Andrew Krupa <i>et al.</i> entitled “System and Method for an Automated and Intelligent Frac Pumping” (“Krupa”)
1004	U.S. Patent Publication 2017/0275980 by Saurabh Kajaria entitled “Systems and Methods for Fracturing a Multiple Well Pad” (“Kajaria”)

Ex.	Description
1005	U.S. Patent Publication 2007/0023184 A1 by Robert Jackson <i>et al.</i> entitled “Well Product Recovery Process” (“Jackson”)
1006	U.S. Patent Publication 2017/0315566 by Martino et al. entitled “Variable Frequency Drive for a Fluid-handling System” (“Martino”)
1007	<i>Downing Wellhead Equipment, LLC v. Intelligent Wellhead Systems, Inc., et al.</i> , No. 1:23-cv-01180 (D. Colo.) (“the Litigation”)
1008	Jacobs, Trent. “The Shale Evolution: Zipper Fracture Takes Hold,” J Pet Technol 66 (2014): 60–67. doi: https://doi.org/10.2118/1014-0060-JPT
1009	’779 Prosecution History
1010	Excerpt from Ex. 1009, Office Action dated January 5, 2022
1011	Patent Family Priority Diagram
1012	Patent Family Specification Comparisons
1013	Claim-By-Claim Priority Analysis
1014	Downing’s Objections and Responses to IWS’s First Set of Interrogatories in the Litigation
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 July 17, 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 July 17, 2023)
1017	Carl T. Montgomery and Michael B. Smith, “Hydraulic Fracturing: History of an Enduring Technology,” <i>Journal of</i>

Ex.	Description
	<i>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> (" <i>Coli</i> ") entitled "Mobile, Modular, Electrically Powered System for Use in Fracturing Underground Formations"
1022	Waters, George, Dean, Barry, Downie, Robert, Kerrihard, Ken, Austbo, Lance, and Bruce McPherson. "Simultaneous Hydraulic Fracturing of Adjacent Horizontal Wells in the Woodford Shale." Paper presented at the SPE Hydraulic Fracturing Technology Conference, The Woodlands, Texas, January 2009. doi: https://doi.org/10.2118/119635-MS (" <i>Waters</i> ")
1023	Pearson, C.M., Bond, A.J., Eck, M.E., and J.H. Schmidt. "Results of Stress-Oriented and Aligned Perforating in Fracturing Deviated Wells." J Pet Technol 44 (1992): 10–18. doi: https://doi.org/10.2118/22836-PA
1024	Mutalik, P N, and Bob Gibson. "Case History of Sequential and Simultaneous Fracturing of the Barnett Shale in Parker County." Paper presented at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA, September 2008. doi: https://doi.org/10.2118/116124-MS (" <i>Mutalik</i> ")
1025	Mayerhofer, M. J., Lolon, E. P., Warpinski, N. R., Cipolla, C. L., Walser, D., and C. M. Rightmire. "What is Stimulated Reservoir

Ex.	Description
	Volume (SRV)?" Paper presented at the SPE Shale Gas Production Conference, Fort Worth, Texas, USA, November 2008. doi: https://doi.org/10.2118/119890-MS (“Mayerhofer”)
1026	Roussel, Nicolas P., and Mukul M. Sharma. “Optimizing Fracture Spacing and Sequencing in Horizontal-Well Fracturing.” SPE Prod & Oper 26 (2011): 173–184. doi: https://doi.org/10.2118/127986-PA (“Roussel”)
1027	K. R. Webster, W. C. Goins, Jr., and S. C. Berry, "A Continuous Multistage Tracing Technique," <i>Journal of Petroleum Technology</i> , vol. 17, no. 06, pp. 619-625, 1965, doi: 10.2118/977-pa. (“Webster”)
1028	A. Casero, G. Pace, B. Malone, F. Cantaloube, L. Tealdi, H. Malonga, and R. Seale, “Continuous Pumping, Multistage, Hydraulic Fracturing in Kitina Field, Offshore Congo, West Africa,” in <i>SPE International Symposium and Exhibition on Formation Damage Control</i> , 2008, vol. All Days, SPE-112442-MS, doi: 10.2118/112442-ms. [Online]. Available: https://doi.org/10.2118/112442-MS (“Casero”).
1029	S. Rassenfoss, "A Look Into What Fractures Really Look Like," <i>Journal of Petroleum Technology</i> , vol. 70, no. 11, pp. 28-36, 2018, doi: 10.2118/1118-0028-jpt. at 6 (“Rassenfoss”).
1030	R. Oberhofer, “Application of Ball-Drop Technology to Improve Efficiency and Stimulation of Limited Entry Completion Systems,” in <i>Abu Dhabi International Petroleum Exhibition & Conference</i> , 2016, vol. Day 2 Tue, November 08, 2016, D021S052R004, doi: 10.2118/183427-ms. [Online]. Available: https://doi.org/10.2118/183427-MS (“Oberhofer”).
1031	Tolman, R. C., et al. (2009). <u>Method and Apparatus for Simultaneous Stimulation of Multi-Well Pads</u> . SPE Hydraulic Fracturing Technology Conference (“Tolman”).

Ex.	Description
1032	G. R. Holzhausen and R. P. Gooch, "Impedance of Hydraulic Fractures: Its Measurement and Use for Estimating Fracture Closure Pressure and Dimensions," in <i>SPE/DOE Low Permeability Gas Reservoirs Symposium</i> , 1985, vol. All Days, SPE-13892-MS, doi: 10.2118/13892-ms. [Online]. Available: https://doi.org/10.2118/13892-MS ("Holzhausen").
1033	R. W. Paige, L. R. Murray, and J. D. M. Roberts, "Field Application of Hydraulic Impedance Testing for Fracture Measurement," <i>SPE Production & Facilities</i> , vol. 10, no. 01, pp. 7-12, 1995, doi: 10.2118/26525-pa ("Paige").
1034	L. V. Massaras, A. Dragomir, and D. Chiriac, "Enhanced Fracture Entry Friction Analysis of the Rate Step-Down Test," in <i>SPE Hydraulic Fracturing Technology Conference</i> , 2007, vol. All Days, SPE-106058-MS, doi: 10.2118/106058-ms. [Online]. Available: https://doi.org/10.2118/106058-MS ("Massaras").
1035	S. Mondal, "Pressure transients in wellbores: Water hammer effects and implications for fracture diagnostics," 2010 ("Mondal").

17. Other than prosecution histories, Ex 1009, all citations to exhibits reference original page numbers found in the underlying document, and all emphases are added.

IV. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE

18. After reviewing the materials identified in the List of Exhibits, I have concluded that each of the Challenged Claims (Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, and 36) of the '779 Patent would have been anticipated and/or obvious to a

person of ordinary skill in the art, based on the following grounds. I explain and show below why each of the Challenged Claims are unpatentable in the detailed discussion of Grounds 1-5. I've considered each of the claims as a whole, but have addressed each subpart separately for ease of discussion.

Ground	'779 Claims	Basis for Challenge
1	1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36	Anticipated under 35 U.S.C. § 102 by Krupa
2	1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36	Obvious under 35 U.S.C. § 103 over Krupa
3	1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36	Obvious under 35 U.S.C. § 103 over Kajaria in view of Jackson
4	1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36	Obvious under 35 U.S.C. § 103 over Krupa in view of Jackson
5	1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36	Obvious under 35 U.S.C. § 103 over Kajaria in view of Jackson and Martino

V. LEGAL STANDARDS

A. LEVEL OF ORDINARY SKILL IN THE ART

19. 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.

20. 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

21. 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.

22. 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.

23. 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.

24. I understand that to determine how a person of ordinary skill would have understood 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.

25. 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.

26. 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

27. 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

28. 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).

29. 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.

30. 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.

31. 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.

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

33. 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.

34. 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

35. I understand that, subject to the next paragraph, the “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 properly claims the benefit of priority to that earlier-filed patent application.

36. 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 for purposes of Section 112 it is not enough that the claim would have been obvious from the earlier application, but that the earlier application itself must describe the claimed invention.

37. 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 or 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. 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.

F. INDEPENDENT AND DEPENDENT CLAIM ANALYSIS

38. I understand that an independent claim does not refer to any preceding claim. The '779 Patent includes numerous dependent claims that refer to the independent claims. Further, I understand that each dependent claim depends from an independent claim or from another dependent claim. I understand that, as a result, each dependent claim incorporates all of the elements of the claim(s) that it refers to. Therefore, in my analysis of the dependent claims, my analysis of the claim(s) from which they depend is also incorporated.

VI. OVERVIEW OF THE CHALLENGED PATENT

39. I have reviewed U.S. Patent No. 11,401,779 (“the ’779 Patent”), which is entitled “Hydraulic Fracturing Plan and Execution of Same.” Ex. 1001. I understand that the application for patent was filed on July 29, 2021, and that it issued on August 2, 2022. The ’779 Patent claims priority to several other patent applications/patents, but as I discuss below in the “Priority Date of the ’779 Patent” section, those earlier applications/patents do not provide support for all claim limitations of the ’779 Patent.

A. THE SUBJECT MATTER OF THE CHALLENGED PATENT

40. The ’779 Patent generally relates to hydraulic fracturing operations of subterranean formations. The ’779 Patent includes a section entitled “Background”. The Background section describes the Patent application as relating “generally to oil and gas hydraulic fracturing applications”.² The Background section does not describe the state of the art for fracturing systems at the time of the application. Further, the ’779 Patent does not describe how the systems and methods described in the Patent improve upon already known fracturing applications.

B. THE CHALLENGED CLAIMS OF THE ’779 PATENT

41. The Challenged Claims of the ’779 Patent, which are Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, and 36, are set forth below. Some of the claim elements

² Ex. 1001 2:6-10

have been further sub-divided (and labeled as part “1.1”, “1.2” or “1.1.1”, “1.1.2” or similar, where the first number indicates the claim number, and the following decimals refer to sub parts of that claim) for ease of reference.

Claim Element	Claim Language from '779 Patent
1.1.1	1. A method, comprising:
1.1.2	(a) permitting performance of a first hydraulic fracturing operation on a first well,
1.1.3	which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and
1.2	measuring a flow rate of the fluid being pumped into the first well;
1.3	(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and
1.4	has been below the flow rate threshold for a threshold amount of time;
1.5	(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;
1.6	(d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and
1.7	(e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;

Claim Element	Claim Language from '779 Patent
1.8	wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.
2.1	2. The method of claim 1, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and
2.2	wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.
3	3. The method of claim 1, wherein the second valve is opened after step (b).
6	6. The method of claim 1, wherein each of the first and second valves is a zipper valve.
8.1.1	8. An apparatus, comprising:
8.1.2	a non-transitory computer readable medium; and
8.2.1	a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors,
8.2.2	wherein, when the instructions are executed by the one or more processors, the following steps are executed:
8.3	(a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and
8.4	measuring a flow rate of the fluid being pumped into the first well; and

Claim Element	Claim Language from '779 Patent
8.5	(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and
8.6	has been below the flow rate threshold for a threshold amount of time;
8.7	(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;
8.8	(d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and
8.9	(e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;
8.10	wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.
9	9. The apparatus of claim 8, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.
10	10. The apparatus of claim 8, wherein the second valve is opened after step (b).
13	13. The apparatus of claim 8, wherein each of the first and second valves is a zipper valve.
15.1	15. A method of hydraulically fracturing at least first and second wells of a plurality of wells, the first and second wells being

Claim Element	Claim Language from '779 Patent
	associated with first and second valves, respectively, the method comprising:
15.2.1	(a) permitting hydraulic fracturing of the second well, comprising:
15.2.2	opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve;
15.3	and measuring a flow rate of the fluid being pumped into the second well;
15.4.1	(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising:
15.4.2	opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve;
15.4.3	and closing the second valve associated with the second well;
15.5	wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and
15.6	wherein: in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or
15.7	in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).
16.1	16. The method of claim 15, wherein the plurality of wells further comprises third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein the method further comprises:

Claim Element	Claim Language from '779 Patent
16.2	(c) permitting hydraulic fracturing of the fourth well; and
16.3	(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.
17	17. The method of claim 16, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.
18.1	18. The method of claim 16, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;
18.2	wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and
18.3.1	wherein step (d) comprises: opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and
18.3.2	closing the fourth valve associated with the fourth well.
25.1	An apparatus adapted to hydraulically fracture first and second wells, the first and second wells being associated with first and second valves, respectively, the apparatus comprising:
25.2	a non-transitory computer readable medium; and
25.3	a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed:

Claim Element	Claim Language from '779 Patent
25.4	(a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and
25.5	measuring a flow rate of the fluid being pumped into the second well;
25.6	(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising: opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well;
25.7	wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and wherein:
25.8	in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b);
25.9	or in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).
26.1	The apparatus of claim 25, wherein the apparatus is further adapted to hydraulically fracture third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein, when the instructions are executed by the one or more processors, the following steps are also executed:
26.2	(c) permitting hydraulic fracturing of the fourth well;

Claim Element	Claim Language from '779 Patent
26.3	(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.
27	27. The apparatus of claim 26, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.
28.1	28. The apparatus of claim 26, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;
28.2	wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and
28.3.1	wherein step (d) comprises: opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and
28.3.2	closing the fourth valve associated with the fourth well.
31.1	31. The method of claim 25, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold, or both; and
31.2	wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.
36.1	36. The method of claim 15, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow

Claim Element	Claim Language from '779 Patent
	rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold or both and
36.2	wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.

C. PROSECUTION HISTORY OF THE '779 PATENT

42. In the subsections below, I summarize the prosecution history of the '779 Patent. As can be seen, all claims of the '779 Patent were allowed because all of the independent claims recited or were amended to recite meeting “a flow rate threshold,” a “flow rate threshold for a threshold amount of time,” or “one or more flow rate conditions.” The Applicant did not dispute that the remaining limitations of the claims were disclosed in the prior art.

43. The '779 Patent was filed as U.S. Application No. 17/388,716 (“the '716 Application”) on July 29, 2021, with 30 claims and a Request for Prioritized Examination (Track II). The Application Data Sheet (ADS) filed along with the '716 Application indicated that the application claimed the benefit of U.S. Provisional Application No. 63/189,663 (“the '663 Provisional”), which was filed May 17, 2021, and also indicated that the application was a “continuation of” of U.S. Application No. 17/319,854 (“the '854 Application”), which was filed May 13,

2021. The ADS for the '716 Application also indicated the '716 Application claimed the benefit of a long family chain of the '854 Application.

44. I also note that the '854 Application listed two inventors (Ronnie B. Beason and Nicholas J. Cannon), whereas the later-filed '663 Provisional listed four inventors (Ronnie B. Beason, Nicholas J. Cannon, Jordan Kuehn, and Austin Johnson). The '716 Application lists the same four inventors as the '663 Provisional.

45. On January 5, 2022, the Office issued a non-final rejection in which claims 1-3, 5-6, 8-10, and 12-13 were indicated as allowed, claims 4, 7, 11, 14-17, 20-25, and 28-30 were rejected, and claims 18, 19, 26, and 27 were objected to. In the Office Action, claims 15, 16, 20-24, 28-30 were rejected under 35 U.S.C. § 102(a)(1) as being anticipated by U.S. Publication No. 2017/0275980 ("Kajaria"). Claims 17 and 25 were rejected under 35 U.S.C. § 103 as being obvious over Kajaria in view of U.S. Publication No. 2014/0352968 ("Pitcher").

46. In response to the Office Action, Patent Owner filed a reply on April 5, 2022, maintained allowed claims in their original form, and amended rejected claims to include subject matter that the Examiner indicated was allowable (including limitations directed to operating valves in response to determining whether a flow rate meets a flow rate threshold for a time threshold). Patent Owner also added new dependent claims.

47. The Office issued a Notice of Allowance on April 25, 2022, in which the Examiner entered further amendments to claims 15, 23, 31, and 36, including changing “met a flow rate threshold” to “satisfied one or more flow rate conditions” in claims 15 and 23, and adding definitions for satisfying or not satisfying the flow rate conditions in claims 31 and 36, and allowed the claims.

48. After prosecution closed on the merits, Patent Owner filed a corrected ADS to change the ’716 Application from a “continuation” application to a “continuation-in-part” (“CIP”) application and amended the specification to reflect the same.

49. The issue fee was paid on June 15, 2022, and the ’716 Application issued as the ’779 Patent on August 2, 2022.

D. PRIORITY DATE OF THE ’779 PATENT

50. As discussed, the ’779 Patent claims the benefit of the ’663 Provisional”, which was filed May 17, 2021, and is a CIP of the ’854 Application”, which was filed May 13, 2021. The ’854 Application purports to claim priority to seven non-provisional applications, each being related through CIP filings. The ’854 Application and the seven parent non-provisional applications are collectively referred to as the “CIP parent applications.” The ’854 Application also claims priority to nine provisional applications, collectively referred to as the “parent provisional applications.”

51. Except for some generic background language, the '779 Patent does not contain any copied portions of the CIP parent applications or the parent provisional applications. Instead, the specification of the '779 Patent contains originally drafted descriptions of fracturing systems and methods, including detailed descriptions of frac legs and associated valve operation for a plurality of wells.

52. The CIP parent applications and the parent provisional applications are not related to and do not disclose valve sequencing for continuous pumping zipper fracturing of multiple wells or determining if flow rate thresholds into the wells are met. Further, some of the CIP parent applications and parent provisional applications do not even disclose multiple well fracturing systems or operations, such as parent applications titled "Unibody valve and methods of using the valve" and "Method of operating a valve and extending an object through the valve and into a well," which are instead directed to valve assemblies for passing objects into a well, and parent applications titled "Delivering and metering grease to process valves" and "Grease system for valves used in oil and gas operations," which are directed to valve greasing systems.

53. I understand that to rely on a parent application's filing date, the parent application must disclose each element of the claim to an extent where it is clear the inventor had possession of the claimed invention at the time of the parent application. I have also been instructed that only subject matter which is actually or

inherently disclosed in a parent application is entitled to the parent application's filing date. Subject matter that is obvious over the parent application's disclosure is not entitled to the parent application's filing date.

54. Because none of the CIP parent applications or the parent provisional applications disclose all the limitations in claims of the '779 Patent, the claims are not entitled to any of the claimed earlier filing dates of the CIP parent applications or the parent provisional applications. Therefore, the earliest priority date to which any claim of the '779 Patent is entitled is that of the '663 Provisional: May 17, 2021.

E. COMPARISON OF ASSERTED REFERENCES TO PRIOR ART DISCUSSED DURING PROSECUTION

55. I have been asked to analyze the technical references that I understand Petitioner is asserting as prior art (Krupa, Kajaria, Jackson, Martino) and to compare them to the references cited by the USPTO Examiner during prosecution of the '779 Patent.

56. **Primary references:** I have relied upon Krupa and Kajaria as the base (or primary) references.

57. **Secondary references:** I have relied upon several additional references (secondary references) including Jackson and Martino, as well as the knowledge of a person of ordinary skill in the art, that are used in combination with the primary references.

58. Although the U.S. Patent Office (“the Office”) considered Kajaria during prosecution of the ’779 Patent, the Office did not consider any ground in this Petition. In fact, the Examiner found Kajaria was close prior art, disclosing most elements of the claims except for some flow/time threshold limitations, but did not consider Kajaria in combination with Jackson or Martino, which a person of ordinary skill in this art would have considered or had knowledge of these known techniques. Accordingly, the prior art grounds discussed in this declaration are different from any prior art ground considered by the examiner.

VII. LEVEL OF ORDINARY SKILL IN THE ART

59. A person of ordinary skill in the art would have a Bachelor of Science in Engineering as well as at least two years of academic or industry experience in the oil and gas industry, including well-related operations experience, such as well drilling, completion, or production. Additional education could offset experience and vice versa.

VIII. CLAIM CONSTRUCTION

60. In the sections below, I have sought to provide the ordinary and customary meaning of claim terms, using the principles I discuss above in the Legal Standards section.

61. I do not believe that any claim terms of the '779 Patent need to be construed to assess whether the prior art reads on the challenged claims.³

IX. TECHNOLOGY BACKGROUND AND STATE OF THE ART

62. 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 2019-2021 timeframe, and long before.

A. HISTORY OF HYDRAULIC FRACTURING

63. 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. Fracturing methods as early as the 1850's used explosives such as gunpowder ignited by red-hot iron or nitroglycerin "torpedoes."⁴ 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

³ I reserve the right to raise or address claim construction of the claims of the '779 Patent and other arguments in district court. For example, all challenges to the '779 Patent are not raised in the petition, including, for example, validity under 35 U.S.C. 112, and controversies may arise during litigation that require resolution through claim construction not presented here because of the similarities between the prior art and the '779 Patent.

⁴ 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) (Ex. 1015).

1940s using a process developed by Stanolind Oil and used by Halliburton in the mid-continent region.⁵ Early hydraulic fracturing in the 1940s and 1950s used frac pumps that could operate at around 1500 Hp.⁶



64. The expansion of directional and horizontal drilling extended the use of hydraulic fracturing into previously underdeveloped “tight” formations, including shale.⁷ 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

⁵ 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) (Ex. 1016).

⁶ Carl T. Montgomery and Michael B. Smith, “Hydraulic Fracturing: History of an Enduring Technology,” *Journal of Petroleum Technology*, Vol. 62, Issue 12, p. 26 (Dec. 2010) (Ex. 1017).

⁷ Ex. 1015.

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 developments in the oil and gas industry “the early drilling of directional wells was clearly motivated by economics.”⁸ It was the offshore fields of California that spawned the technology which led to modern directional and horizontal drilling. In the 1930s, directional drilling was being used in the Huntington Beach, California field to reach an offshore oil-bearing formation from a well initiated on an onshore pad.

65. Throughout the 1980s, directional drilling increased, in particular 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, the techniques of horizontal drilling were well known and heavily developed. In 1986, the “first successful multifracture horizontal well is drilled in Wayne County, West

⁸ Bourgoyne, A. T., Jr., K. K. Millheim, M. E. Chenevert and F. S. Young, Jr. (1986). Applied Drilling Engineering, Society of Petroleum Engineers, 351 (Ex. 1018).

Virginia.”⁹ 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 location in order to allow the hydrocarbons to “leak” out of the formation into the wellbore.

66. 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 present day.¹⁰

⁹ Vassiliou, M. S. (2018), Historical Dictionary of the Petroleum Industry, Rowman & Littlefield, xliii (Ex. 1019).

¹⁰ Ex. 1016, at 9 (showing a 2011 map from the Energy Information Administration showing shale plays where hydraulic fracturing is common).



67. As more formation is exposed to be fractured, horizontal wells use much higher volumes of fracturing fluid and proppant than do 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 2012.¹¹ Other references, such as *Coli*, suggest systems of pumps as large as 2,500 hp each, with total system power as high as 40,000 hp were used in the same time period (four

¹¹ 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”), [0005] (Ex. 1020).

trailers, each with four 2500 hp pumps operating in parallel).¹² These pumps are typically triplex or quintuplex positive displacement (plunger) type pumps.¹³ Although some fracturing systems had been converted to electric driven pump motors, the large majority of hydraulic pumping systems at the time “are typically mobilized on skids or tractor-trailers and powered using diesel motors.”¹⁴ These diesel engines require large amounts of diesel fuel, along with the requisite extra safeguards to address potential safety concerns.¹⁵

B. TYPES OF PUMPS – FRACTURING PUMP CHAIN

68. 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

¹² U.S. Patent Publication No. 2012/0255734 to Coli *et al.* entitled “Mobile, Modular, Electrically Powered System for Use in Fracturing Underground Formations” (“*Coli*”), [0049], FIG. 2 (Ex. 1021).

¹³ *Sanborn* (Ex. 1020), at [0005]; *Coli* (Ex. 1021), at [0011].

¹⁴ *Coli* (Ex. 1021), [0005]; *see also*, [0007] (“standard fluid pumps require large volumes of diesel fuel and extensive equipment maintenance programs”).

¹⁵ *Sanborn* (Ex. 1020), [0007].

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

69. A modern fracturing process requires multiple pumps, operating together as a system in order to provide fracturing fluid with the right composition, at the right flowrate¹⁶, 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 the storage location (e.g., ponds, tanks) to the blender or the hydration unit.

70. In the blender, the water is mixed with a proppant, such as sand, or resin-coated sand or ceramics, to form the fracturing slurry. Additionally, 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 pumps of various sizes and types. These are typically relatively small horsepower pumps operating at lower pressures, as the blender tub operates at more or less ambient pressures.

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

¹⁶ “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 in order 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 in order to ensure flow sufficient to prevent cavitation, as explained below.

72. A fracturing piston (or plunger) pump works in a similar manner 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 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) then 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 of the pump. 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 downstream impedance of the fluid flow system, pressure tends to drop as flowrate stays relatively constant. Conversely, as downstream impedance increases, pressure rises with a relatively constant flowrate. As a boundary condition, if a valve is closed downstream of a fracturing pump, flowrate 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 a failure of a piece of equipment, such as pump seals, failure of piping or rupturing of valve bodies.

73. 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, then noise, vibration and damaging forces are created. In order to avoid cavitation, and the associated problems, the suction pressure must be maintained higher than the vapor pressure of the fluid (e.g., slurry), even during the intake phase of the piston. This is referred to as maintaining a Net Positive Suction Head (NPSH).

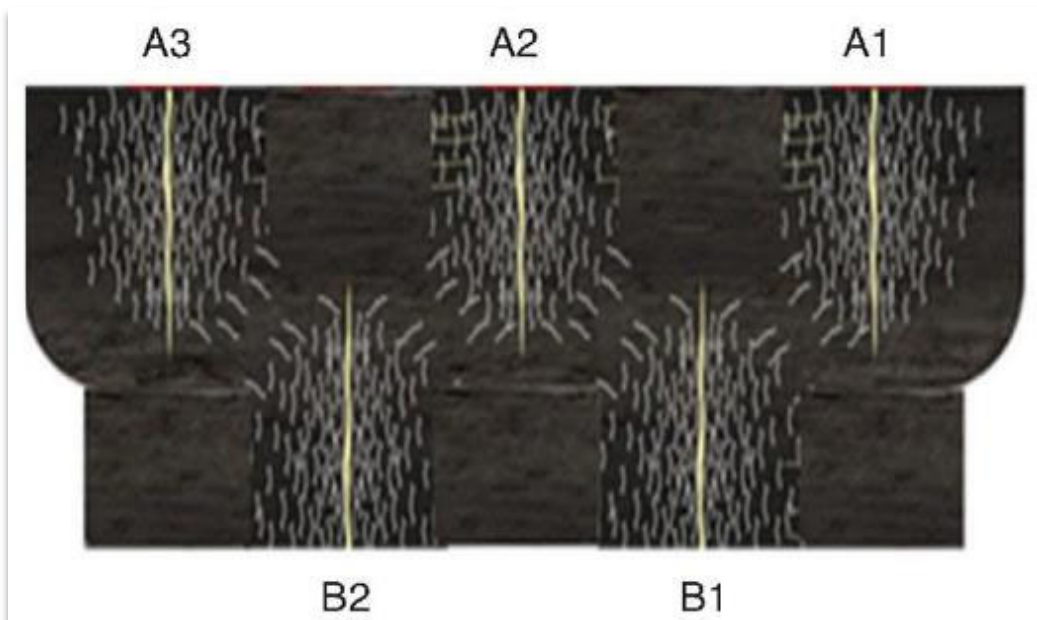
C. SIMULTANEOUS OR SEQUENTIAL FRACTURING (SIMULFRAC OR ZIPPER FRAC)

74. For most of the history of hydraulic fracturing, fracturing technology advances have largely been geared towards advancements in chemicals (such as the development of corrosion inhibitors, gels and slickwater fracking) and proppants as well as increasing flow and pressure of the fracturing operations. The goal, as always, was to create fractures that expose the hydrocarbon bearing formation to the wellbore, allowing the hydrocarbons to flow into the wellbore. For most of its history, hydraulic fracturing has been performed one well at a time, potentially with several stages (zones) being fractured in a single well. With the increased popularity of horizontal drilling in the 1990s and 2000s, the number of fracturing stages in a well increased dramatically as the “pay zone” (the hydrocarbon bearing formation), in which the well exposed increased from tens to hundreds of feet to several thousand feet.

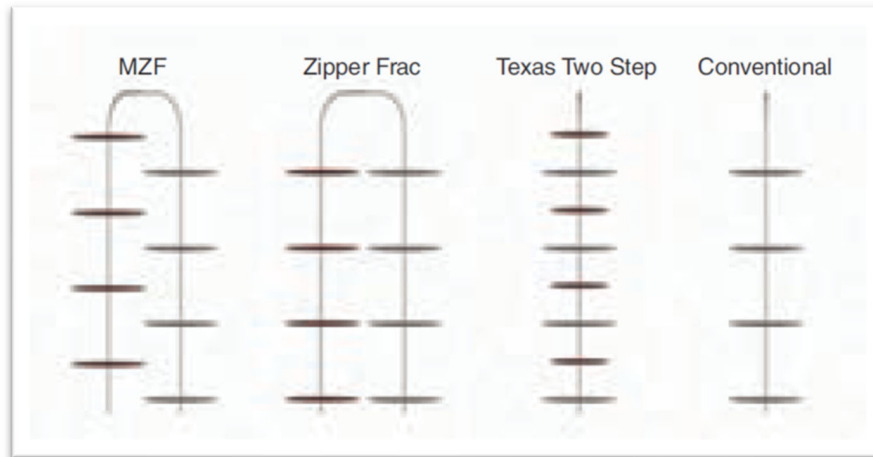
75. In the mid-2000s, operators began experimenting with, and then using a technique dubbed “zipper fracturing,” in which multiple wells, closely spaced in the formation, were fractured simultaneously, or sequentially. The result was that the fractures formed in one well were affected by the pressures and fractures in another well, leading to so called “zipper fractures” that were longer, multidirectional, and exposed more formation to the wellbores than single well fracturing produced.

76. The image below was captured from *Jacobs*¹⁷ and shows the influence that simultaneous or sequencing fracturing has on the fractures caused by wells. For the fractures nearest the wellbores, the fractures show a typical pattern of being aligned with the perforations, as shown in the below figure where A1-A3 are perforations and associated fractures from a first horizontal wellbore and B1-B2 are the perforations/fractures from a second parallel wellbore. However, for those fractures that are near other wellbores, the fracture lengthens and turns, creating a zipper-like pattern to the fracture. This exposes more of the formation to the wellbore, and allows for earlier, and more complete, recovery of hydrocarbons from the formation.

¹⁷ Ex. 1008; Jacobs, Trent. “The Shale Evolution: Zipper Fracture Takes Hold,” *J Pet Technol* 66 (2014): 60–67. doi: <https://doi.org/10.2118/1014-0060-JPT>



77. The figure below (with the wellbores represented vertically) from Jacobs shows various types of fracturing configurations beginning with conventional fracturing (to the right) and ending with modified zipper fracturing (MZF) on the left. The changes in location of the perforation and fracturing operations are intended to increase the development of zipper fractures and expand the interface with the hydrocarbon-bearing formation.



78. Zipper fracturing has had the most success in Shale regions. As discussed in *Waters*, a lower Young's Modulus allows for tighter spacing of the fractures, allowing for an easier formation of zipper fractures.¹⁸

Two conclusions are apparent:

- In order for hydraulic fractures to be very close together very high stresses are required. A fracture spacing of 1 ft requires stresses in excess of 4,000 psi for all listed moduli. This is unrealistic and will certainly lead to the truncation of most fractures and the creation of a dominant, single fracture at this spacing.
- The rock stiffness greatly influences the achievable fracture spacing. For example, at a fracture spacing of 25 ft the increase in stress is >800 psi for a rock with a Young's Modulus of 5×10^6 psi. Yet the stress increase is only 170 psi for a rock with a Young's Modulus of only 1×10^6 psi.

Waters at 5.

79. As further described by *Waters*, the process for developing zipper fractures involves maintaining pressure in the formation from one wellbore, while

¹⁸ Waters, George, Dean, Barry, Downie, Robert, Kerrihard, Ken, Austbo, Lance, and Bruce McPherson. "Simultaneous Hydraulic Fracturing of Adjacent Horizontal Wells in the Woodford Shale." Paper presented at the SPE Hydraulic Fracturing Technology Conference, The Woodlands, Texas, January 2009. doi: <https://doi.org/10.2118/119635-MS> (Ex. 1022).

initiating fractures by pressuring up a proximate wellbore. “In ultra-low permeability reservoirs such as shales, the stimulations do not necessarily have to occur concurrently. Since there is little to no fluid leak off into the rock matrix the fracture systems will remain pressurized until flown back. This pressurized system can provide the diversion [zipper fracture] desired when the adjacent lateral is stimulated subsequent to the initial stimulation.”¹⁹

80. This allows for one well stage to be pressurized and shut in (such as with a valve, plug or a ball seal), then an adjacent well stage pressurized and gains the benefits of the stress induced from the other pressurized well. This has advantages not only to the development of fractures downhole but has operational advantages as well. As *Waters* states below, one fracturing crew and one perforating crew can treat multiple wells simultaneously or in an alternating arrangement allowing for faster completion of the fracturing process.²⁰

¹⁹ *Waters* at 8.

²⁰ *Waters* at 8.

- This “Zipper-Frac” method provides some significant operational efficiencies:
 - When two wells drilled from the same pad are being stimulated only one stimulation crew and perforating crew is required. While the fracturing crew is stimulating one well, the perforating crew is setting the frac plug and perforating the adjacent wellbore. The two crews continue to work back and forth between the two wells to efficiently complete them in a timely manner.
 - If more than two wells are being stimulated at the same time then a completion sequence can be developed to most effectively create a dense fracture network throughout the acreage. For example, if four laterals are being stimulated with two crews the outer wells can be stimulated first, followed by the inner wells where a more dense fracture pattern can be created. The treatment sizes can be adjusted based on the order in which the wells are stimulated. The completion sequence utilized will be a function of the well spacing, the structural geology, surface logistics, and the desire for hydraulic fracture density versus fracture length.

81. The advantages of zipper fractures have been known for decades, as shown by *Pearson*, an article published in the Journal of Petroleum Technology in 1992.²¹ While not directly discussing the simultaneous or alternating process, *Pearson* does discuss the results of such a process. “This paper reports the first results of stress-oriented and aligned perforating of deviated wells at the Kuparuk River field, Alaska. Preferred perforation alignment and spacing are calculated for each well so the fractures from individual perforations link to produce a single ‘zipper’ fracture plane along the deviated [horizontal] wellbore.”²² *Pearson* further states that “During the past 7 years [prior to 1992], more than 600 new development wells have been fracture stimulated in the Kapurak River field. The large number of

²¹ Pearson, C.M., Bond, A.J., Eck, M.E., and J.H. Schmidt. "Results of Stress-Oriented and Aligned Perforating in Fracturing Deviated Wells." J Pet Technol 44 (1992): 10–18. doi: <https://doi.org/10.2118/22836-PA> (Ex. 1023).

²² *Id.* at Summary.

treatments has provided the opportunity for significant advances in the technical and operational aspects of hydraulically fracturing deviated wells.”²³

82. The Zipper-frac process (alternating perforations and pressurization of adjacent wells) has been well-known in the industry since at least 2008, particularly to those operators and fracturing companies operating in Shale regions such as the Barnett, Woodford, and Marcellus shale formations. This contributes to the general engineering knowledge that a fracturing designer (engineer) had when planning operations of fracturing systems. *Waters* is one example of the well-known nature of this process, and dates to 2008.

83. Another example of the well-known nature of the zipper-frac process in shale producing regions is *Mutalik*, a paper published by the SPE in 2008.²⁴ *Mutalik* discusses multiple case studies of wells using a “simo-frac” process to create more effective downhole formation fractures in the Barnett Shale. “In this paper, the case history of sequential and simultaneous fracturing of four similarly drilled and

²³ *Id.* at Introduction.

²⁴ Mutalik, P N, and Bob Gibson. "Case History of Sequential and Simultaneous Fracturing of the Barnett Shale in Parker County." Paper presented at the SPE Annual Technical Conference and Exhibition, Denver, Colorado, USA, September 2008. doi: <https://doi.org/10.2118/116124-MS> (Ex. 1024).

completed horizontal azimuth wells in Eastern Parker County is discussed.”²⁵

Mutalik further describes:²⁶

Simultaneous fracturing (simo-fracs) of paired offset wells is one of the recent trends in Barnett fracturing and is being increasingly used by many operators. In this technique, two or more adjacent wells that are roughly parallel to each other are fractured simultaneously. The goal is to expose the shale to more pressure and produce a more complex, “three-dimensional web” of fractures by increasing the density of the hydraulic fracture network and increasing the surface area created by the frac job.

Mutalik describes the operational benefits of a simultaneous frac process. “Simo-fracs [are] expensive and require[] much more coordination and logistics and a larger location. At the same time, they are cost-effective as the fracturing equipment is being utilized more efficiently and two wells are being completed in one week instead of two weeks.”²⁷ *Mutalik* further teaches that, as of 2008, “simultaneous fracturing operators are now experimenting with triple fracs (‘trifectas’) or even quad-fracs in some cases.”²⁸

²⁵ *Mutalik* at Abstract.

²⁶ *Mutalik* at Background.

²⁷ *Mutalik* at background.

²⁸ *Id.*

84. In addition to the above references, *Mayerhofer*²⁹ and *Rousell*³⁰ provide more information of the advantages and benefits of such a process. For example, *Mayerhofer* discusses “it may be more beneficial to drill laterals at closer spacing, with the chance of overlapping SRV’s” (Stimulated Reservoir Volume).³¹ “This is the reason for the so-called “simul-fracs” and “zipper-fracs” in shale reservoirs where multiple parallel wellbores are either stimulated simultaneously or in short alternating sequence from one lateral to the next.”³²

85. *Rousell* teaches that “[t]he numerical calculation of the fracture spacing required to avoid fracture deviation during propagation, for all three fracturing techniques, demonstrate the potential advantages of alternate fracture sequencing and zipper-fracs to improve the performance of stimulation treatments in horizontal wells. Simultaneous fracturing of two or more parallel adjacent wells, also

²⁹ Mayerhofer, M. J., Lolon, E. P., Warpinski, N. R., Cipolla, C. L., Walser, D., and C. M. Rightmire. "What is Stimulated Reservoir Volume (SRV)?" Paper presented at the SPE Shale Gas Production Conference, Fort Worth, Texas, USA, November 2008. doi: <https://doi.org/10.2118/119890-MS> (Ex. 1025).

³⁰ Roussel, Nicolas P., and Mukul M. Sharma. “Optimizing Fracture Spacing and Sequencing in Horizontal-Well Fracturing.” SPE Prod & Oper 26 (2011): 173–184. doi: <https://doi.org/10.2118/127986-PA> (Ex. 1026).

³¹ *Mayerhofer* at 12.

³² *Mayerhofer* at 12.

referred to as simul-fracs or zipper-fracs, aim to generate a more complex fracture network in the reservoir.”³³

86. By at least 2014 the use of the zipper-frac process was widespread in hydraulic fracturing operations. As described by *Jacobs*:³⁴

A horizontal well completion method known as zipper fracturing has been rapidly adopted over the last couple of years by companies in the Eagle Ford shale of south Texas. Instead of drilling and hydraulically fracturing one well at a time, the zipper method involves drilling multiple wells from a pad site and then hydraulically fracturing a stage in one well, while getting ready for the next, as wireline and perforation operations take place in another. The multiwell completion method earns its name from the zipper-like configuration of the fracture stages from wells drilled with relatively tight spacing.

In addition to discussing the production and operational benefits of such a process, *Jacobs* discusses the prevalence of this process by 2014. For example, by 2014 nearly half of Schlumberger’s completions in North America were completed with the zipper-fracturing method and “in less than 3 years, the proportion of zipper-fracturing completions ... in the Eagle Ford shale of Texas ... increased threefold to 85%.”³⁵

³³ *Rousell* at 1.

³⁴ *Jacobs* at 1.

³⁵ *Jacobs* at 2-3.

D. CONTINUOUS PUMPING FRACTURING

87. As hydraulic fracturing has increased in number of stages and number of wells treated, various techniques have been employed to meet the overall goal of reducing financial costs and non-productive time (NPT) at the wellsite. At the same time, techniques were developed to reduce wear and damage to the high horsepower pumps, valves, and related equipment. One technique which furthers both of these goals is the use of continuous pumping to treat multiple stages in a well or multiple wells simultaneously or sequentially.

88. Early continuous pumping techniques from at least the 1960s were directed toward treating multiple zones (stages) in a well without stopping the pumps. "Wells with multiple producing zones can be fractured one zone at a time during continuous pumping."³⁶ *Webster* further describes that continuous pumping "is less expensive than treating one zone at a time using isolating packers".³⁷ By at least 2007, continuous pumping equipment and techniques were well known and practiced internationally. In 2007, Casero describes completion of three wells in the Kitina field of west Africa using a "Continuous Pumping Multi-State System

³⁶ K. R. Webster, W. C. Goins, Jr., and S. C. Berry, "A Continuous Multistage Tracing Technique," *Journal of Petroleum Technology*, vol. 17, no. 06, pp. 619-625, 1965, doi: 10.2118/977-pa (Ex. 1027).

³⁷ *Webster* at Abstract

(CPMSS) technique” which “ha[d] been used for six years in North America.”³⁸ The CPMSS technique “allows pumping multiple hydraulic fracturing treatments without the need of intermediate operation such as bridge plugs or proppant plugs”. Casero further teaches multiple benefits of a continuous pumping system including:

- With adequate bulk capacity, all stimulation can be done in hours instead of weeks.
- Quicker fluid recovery due to the short time for the injection process.
- Reducing rig costs may encourage additional fracturing treatments for enhanced stimulation of the well.

89. By 2018, *Rassenfoss* observed that wells drilled in 2015 in the Permian were fractured using “zipper fracturing” and teaches “Zipper fracturing speed work by allowing continuous pumping and it reduces the risk of frac hits because the method only fractures rock where pressure has not been depleted by production. Now zipper fracturing is used to fracture even more wells at once.”³⁹ *Rassenfoss*

³⁸ A. Casero, G. Pace, B. Malone, F. Cantaloube, L. Tealdi, H. Malonga, and R. Seale, "Continuous Pumping, Multistage, Hydraulic Fracturing in Kitina Field, Offshore Congo, West Africa," in *SPE International Symposium and Exhibition on Formation Damage Control*, 2008, vol. All Days, SPE-112442-MS, doi: 10.2118/112442-ms. [Online]. Available: <https://doi.org/10.2118/112442-MS> (Ex. 1028).

³⁹ S. Rassenfoss, "A Look Into What Fractures Really Look Like," *Journal of Petroleum Technology*, vol. 70, no. 11, pp. 28-36, 2018, doi: 10.2118/1118-0028-jpt. at 6 (Ex. 1029).

further observes “Simultaneous fracturing is likely to create stronger connections [between wells] because the time between stages is relatively short.”⁴⁰

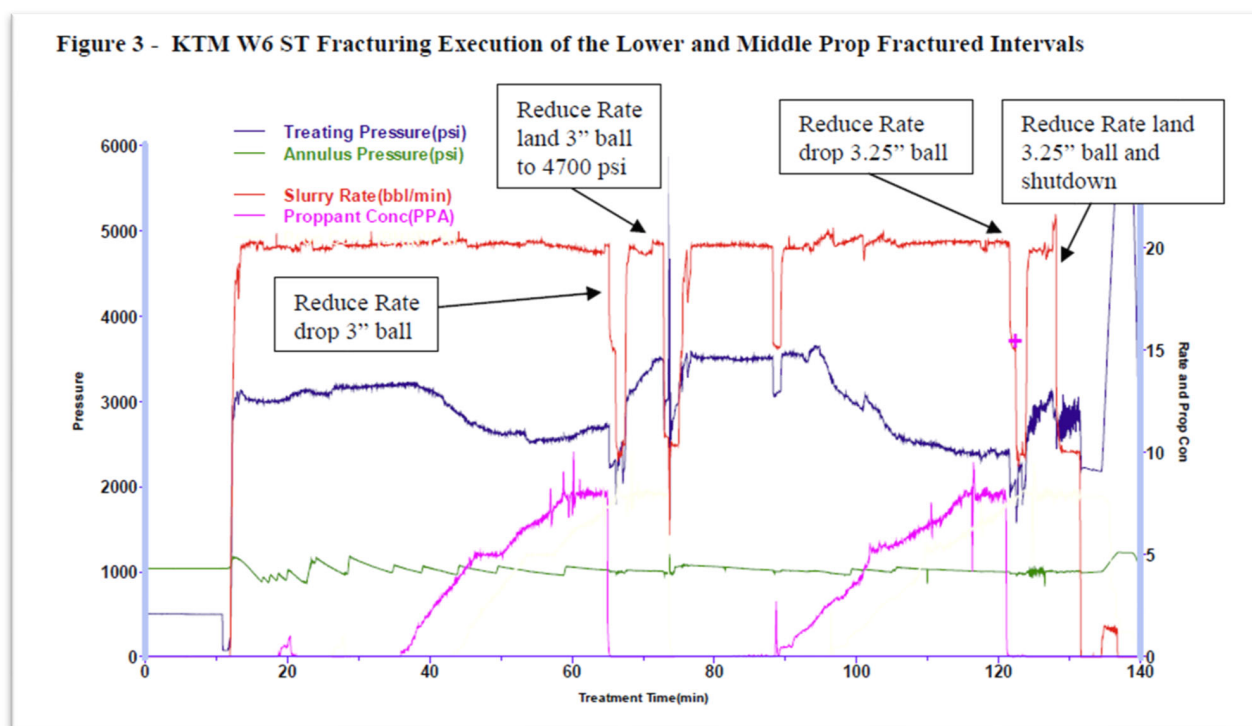
E. OPERATION PARAMETERS FOR FRACTURING

90. Whether part of a zipper fracturing operation and/or continuous pumping operation, a hydraulic fracturing operation includes operational parameters such as fluid flow and pressure that are specific to the operation. For example, operators have long known to open a second well for continuous pumping only if there is sufficient flow to support operation of two wells, but not so much flow that it would blow a valve or cause damage to the system. *Casero* further discusses a reduction in flowrate between stages to allow for a mechanical operation to be executed during a frac job. In using the CPMSS technique, a mechanical operation includes dropping a ceramic ball into a well on a packer sleeve. As Oberhofer details, the ball performs two functions. First, it acts as a seal to isolate the stages below the ball (like a valve). Secondly, after the ball lands and pump rate is increased again, the differential pressure across the ball/seat causes activation of a sleeve, opening access to the perforations to be fractured.⁴¹

⁴⁰ *Id.*

⁴¹ *Casero* at 4; R. Oberhofer, “Application of Ball-Drop Technology to Improve Efficiency and Stimulation of Limited Entry Completion Systems,” in *Abu Dhabi International Petroleum Exhibition & Conference*, 2016, vol. Day 2

91. Before the mechanical operations are completed, Casero describes “[t]he pumping rate is consistent at 20 bpm until the rate is reduced to have a controlled launch of the frac ball on the surface and then again when the ball is calculated to land at the fracture port”.⁴² Casero’s Figure 3 shows the rate reduction used to complete the mechanical operation.⁴³



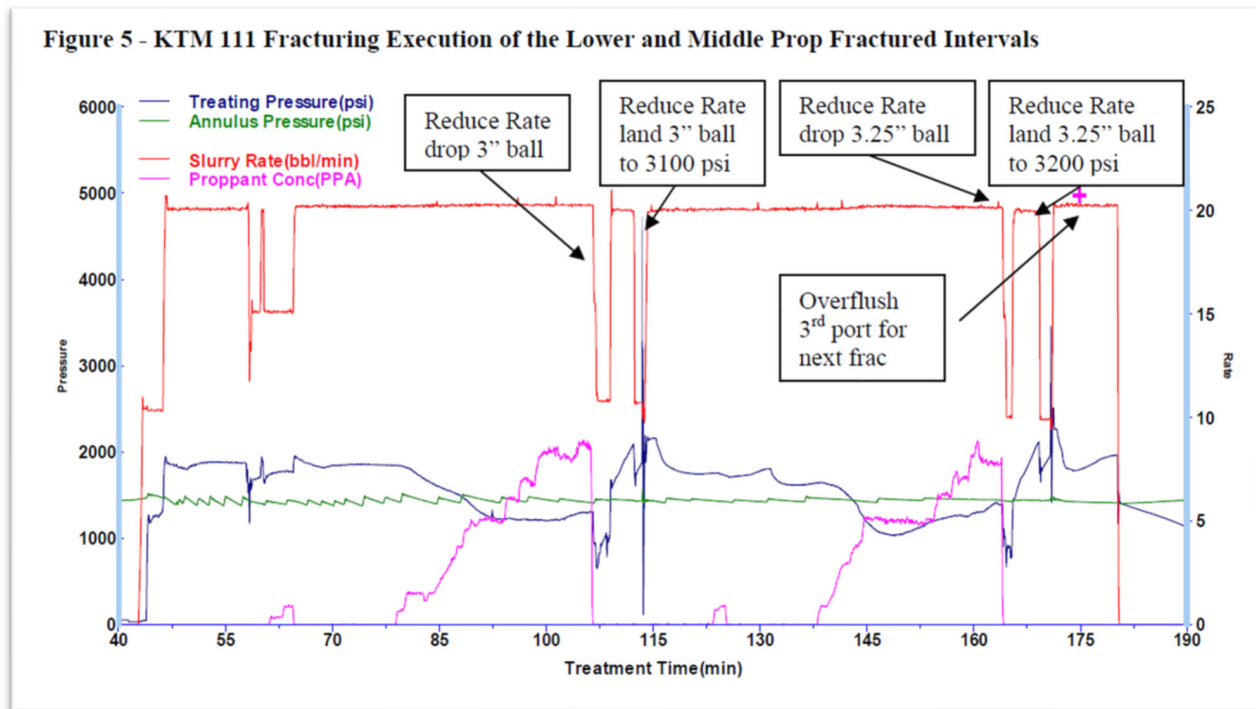
92. Figure 3 shows not only the reduction in rates necessary for controlled mechanical operations, but also the increase and then decaying pressures consistent

Tue, November 08, 2016, D021S052R004, doi: 10.2118/183427-ms. [Online]. Available: <https://doi.org/10.2118/183427-MS> (Ex. 1030).

⁴² Casero at 5.

⁴³ Casero at 16.

with a fracturing operation taking place when using positive displacement pumps. As further teaching, Figure 5 of Casero shows similar rate reductions in order to undertake mechanical operations.



93. *Tolman* describes another “Method and Apparatus Associated for Simultaneous Stimulation of Multi-Well Pads” in which “ExxonMobil has drilled multiple wells from single pads, and new technologies have been developed to efficiently stimulate the multiple pay zones in each well.” The technologies described by *Tolman* enable “simultaneous stimulation of multiple wells on the same

or different well pads, and while drilling additional wells.”⁴⁴ Like *Casero*, *Tolman* teaches suspending mechanical operations during high flow (high pressure) operations.⁴⁵ In the system of *Tolman*, where the pumps are continuously operating, the “high pressure pumping” which results in/from high flow pumping, must be reduced in order for mechanical operations, such as valve manipulations, to occur.

94. The restriction on mechanical operations during high flow / high pressure conditions described by at least *Casero* and *Tolman* is because mechanical operations, such as closing a valve or opening a valve, during high flow / high pressure conditions could result in damage to equipment and safety concerns. For example, closing a valve when there is high flow through the valve would result in high fluid velocity through the valve orifice, particularly as the valve neared a full close position. This high velocity increases damage to components such as the valve seats and seals, as well as causing vibrations through the piping system. Additionally in systems using positive displacement pumps, such as those used for hydraulic fracturing, closing a valve during high flow conditions would create extremely high pressure increases and would result in damage to pumps, seals, piping (iron) or other

⁴⁴ Tolman, R. C., et al. (2009). Method and Apparatus for Simultaneous Stimulation of Multi-Well Pads. SPE Hydraulic Fracturing Technology Conference, at 1 (Ex. 1031).

⁴⁵ *Tolman* at 4.

mechanical equipment. This is due to the inherent characteristics of positive displacement pumps. (See Section IX.B).

95. The above examples show that it has been well known and documented that operational parameters, including flowrate, to be commonly considered during valve and pump mechanical operations for hydraulic fracturing.

F. TESTING

96. It has also long been established to vary operational parameters to conduct performance testing for fracturing operations. For example, since at least the 1980s the value of measuring oscillations in the pressure of a fracturing system to indicate the extent of the fractures downhole has been known. Oscillations in the well are created in two primary ways. First, during flowing conditions, if flow is suddenly changed (reduced) either through shutting a valve or a reduction in rate, the momentum of the flowing fluid creates a natural oscillation called water hammer. Second, during some well tests an intentional pressure transient or spike is created by suddenly opening and then closing a valve, or by the forced oscillations of the positive displacement pumps. The changes in the pressure oscillations, either natural or artificial, provide information about the extent of the fractures downhole.

97. According to *Holzhausen*, as early as 1985, “[t]he growth of a hydraulic fracture increases the period of free oscillation in a well. Simultaneously, the decay

rate of free oscillations decreases.”⁴⁶ Holzhausen refers to the “impedance of the hydraulic fracture” as the effect that fractures have on the fluid stream. “Because impedance is a function of fracture dimensions and the elasticity of the surrounding rock, impedance analysis offers a promising new approach for evaluating fracture geometry.”⁴⁷ *Holzhausen* defines fracture impedance as “the ratio of volume change [in a fracture] to head [pressure] change,” and is used to describe the effect that fractures have on the fluid stream.⁴⁸ The primary reason that analysis of the fracture impedance is possible is “[t]he configuration of surface and downhole pipe (tubing, casing, etc.) remains constant during a hydraulic-fracturing treatment, whereas the geometry of the fracture changes continuously as it is being created.”⁴⁹ Accordingly, any change in behavior of the oscillations (decay, period, etc.) can be attributed to the changes in the fracture geometry. According to *Holzhausen* “[i]t is a well-known result from steady-state LaPlace analysis that the character of free oscillations is determined by the singularities of the impedance with respect to frequency.”⁵⁰

⁴⁶ G. R. Holzhausen and R. P. Gooch, "Impedance of Hydraulic Fractures: Its Measurement and Use for Estimating Fracture Closure Pressure and Dimensions," in *SPE/DOE Low Permeability Gas Reservoirs Symposium*, 1985, vol. All Days, SPE-13892-MS, doi: 10.2118/13892-ms. [Online]. Available: <https://doi.org/10.2118/13892-MS>, at 1 (Ex. 1032).

⁴⁷ *Id.*

⁴⁸ *Holzhausen* at 3

⁴⁹ *Id.* at 2

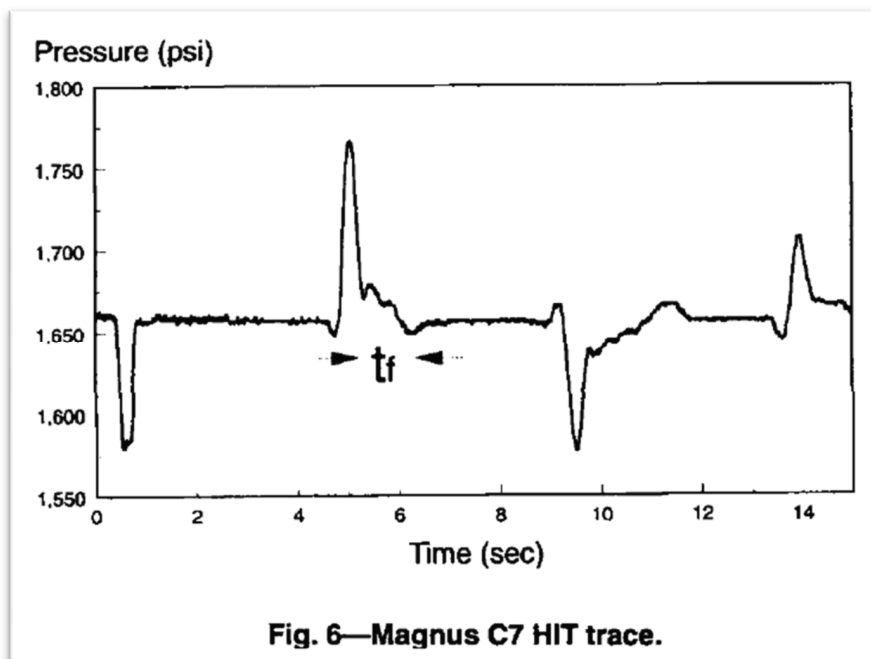
⁵⁰ *Id.* at 4

98. *Paige* tested *Holzhausen's* concepts in field testing. During *Paige's* tests "a pressure pulse is introduced into a well, and the resulting pressure trace is interpreted to give fracture dimensions."⁵¹ *Paige* refers to this as "Hydraulic impedance testing (HIT)"⁵² Further, "HIT uses the transient response of the fluid in the wellbore and fracture that results from the introduction of a pressure pulse into the well to provide information about the fracture." *Paige* determined, through a series of field tests that "fracture length is obtained from the delay time ($t_f = 1.8$ sec in Fig. 6) and the wavespeed".⁵³ Thus, as was common in well testing, *Paige's* testing involved varying and monitoring operational parameters over a period of time to assess the effects in the well.

⁵¹ R. W. Paige, L. R. Murray, and J. D. M. Roberts, "Field Application of Hydraulic Impedance Testing for Fracture Measurement," *SPE Production & Facilities*, vol. 10, no. 01, pp. 7-12, 1995, doi: 10.2118/26525-pa., at 1 (Ex. 1033).

⁵² *Id.*

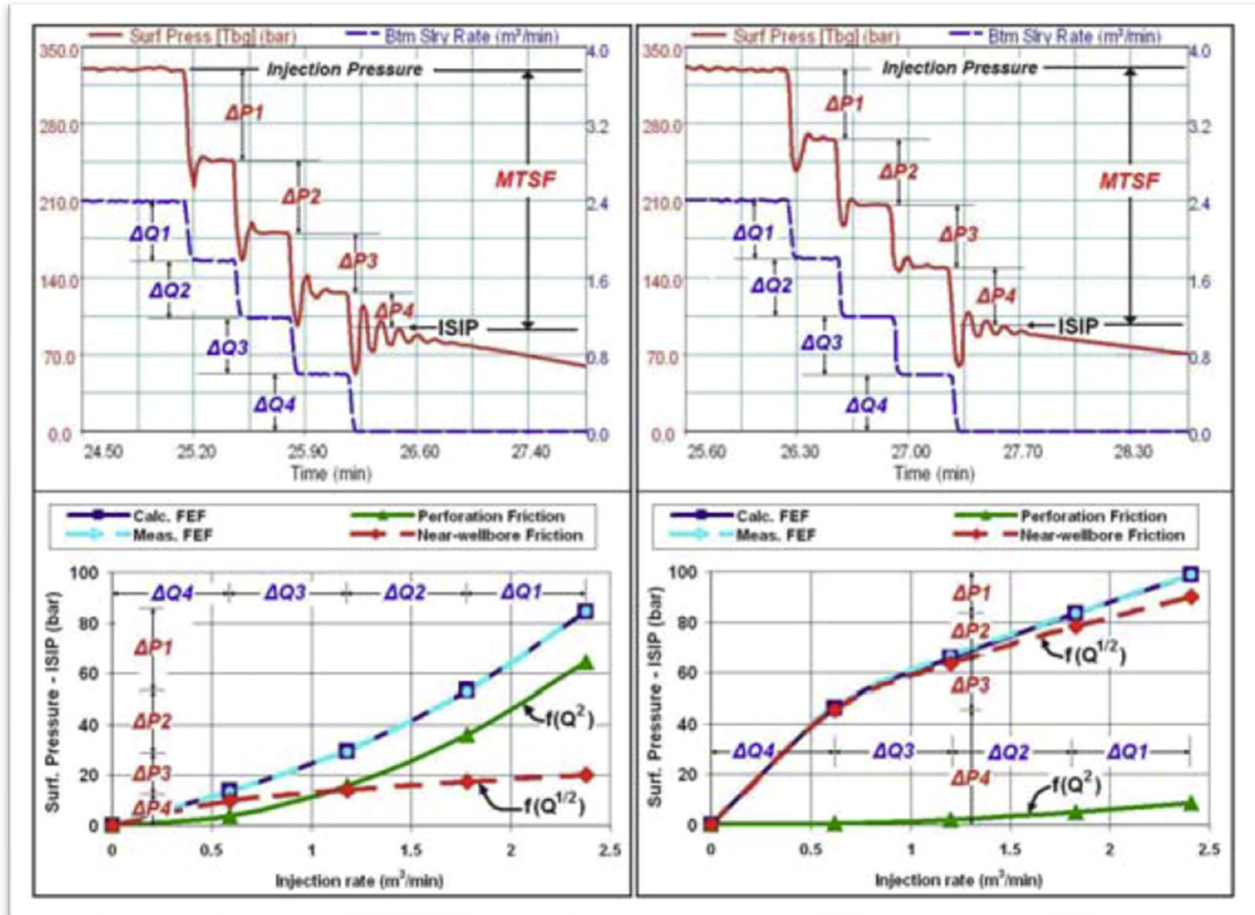
⁵³ *Paige* at 4.



99. *Massaras* describes using the same principles as *Paige* and *Halzhousen* to analyze fracture geometry using a “Rate Step-down Test (RST) also referred to as “Step-Down Test (SDT)” which, by 2007 had “been used worldwide for over 15 years”. To properly execute an RST, “a relatively large fluid volume should be injected prior to initiating the RST procedure of abrupt flow rate changes”.⁵⁴ During a properly designed RST “the fracture geometry will not change dramatically during the very short RST procedure” because of the large volume injected into the fractures prior to the RST. Using the tests in *Massaras*, the characteristics of the pressure

⁵⁴ L. V. Massaras, A. Dragomir, and D. Chiriac, "Enhanced Fracture Entry Friction Analysis of the Rate Step-Down Test," in *SPE Hydraulic Fracturing Technology Conference*, 2007, vol. All Days, SPE-106058-MS, doi: 10.2118/106058-ms. [Online]. Available: <https://doi.org/10.2118/106058-MS>, at 6 (Ex. 1034).

transients after a flow-rate reduction (often referred to as water hammer), such as shown in Figure 9, may be used to indicate fracture geometry.



Massaras, Figure 9.

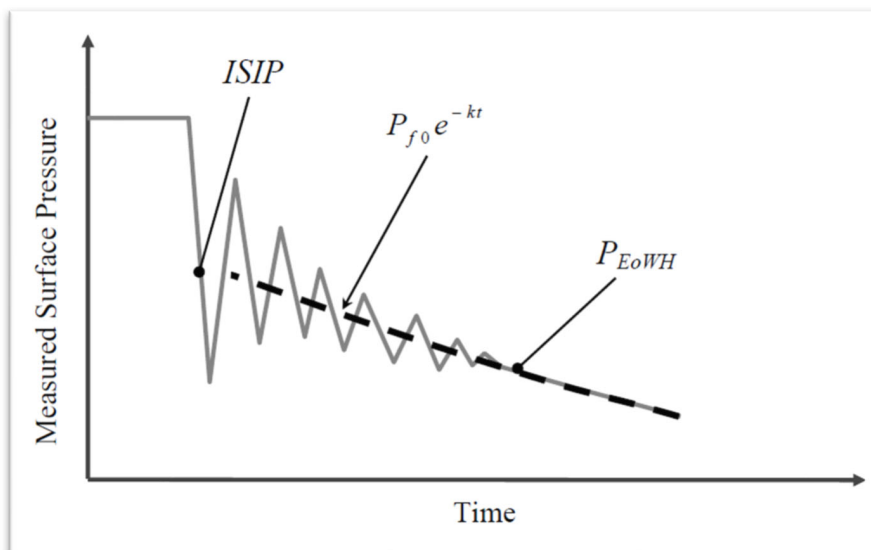
100. *Mondal* expanded the understanding of pressure transient analysis, particularly as it relates to measured “water hammer”. “Water hammer is a surge or pressure wave that is created due to a sudden change in flow velocity in a confined

system.”⁵⁵ According to *Mondal*, water hammer analysis was known as early as 1900. In a fractured well, however, traditional water hammer analysis is incomplete as “the presence of a porous medium [fractures] at the downstream/upstream end of an injection/production well makes it different from the traditional pipeline water hammer analysis.”⁵⁶ In *Mondal*, based on work by *Paige* and others, “pressure and rate transients can be calculated at any point in the well or at the bottomhole” based on known well and fluid parameter relationships.⁵⁷ In *Mondal*’s analysis, a step change reduction in flowrate was applied to a well, the resulting pressure oscillations (water hammer) were evaluated and applied using the known well and fluid relationships to determine the geometry of the fractures at the end of the wellbore. The energy storage characteristics of the wellbore and fluid create the resonance, as measured by the period (length of time), of the wellbore, and resistive features of the well bore create a loss of oscillation height over time. The relationships between these yield characteristics of the fractures.

⁵⁵ S. Mondal, "Pressure transients in wellbores: Water hammer effects and implications for fracture diagnostics," 2010, at 12 (Ex. 1035).

⁵⁶ *Mondal* at 21.

⁵⁷ *Mondal* at 34.



Mondal, Figure 2.9

101. *Mondal* teaches that the period of these oscillations is several seconds (~6-10 seconds, depending on well length). In order to properly evaluate the characteristics of the well, a sufficient number of the oscillations must be captured in order to calculate the period and decay rate, as shown in Figure 2.9 above. These data allow the user to “estimate fracture dimensions from water hammer data”.⁵⁸ Accordingly, a POSITA would have been well aware of operationally reducing flow at the end of the fracture stage in order to perform a rate step down (RST) or water hammer analysis. Further, a POSITA would have been well aware that the reduction in flow would need to be held steady for a period of time necessary to capture a sufficient number of oscillations in order for the trend described above to be

⁵⁸ *Mondal* at 66.

determined. Flow schedules such as the ones in *Massaras* and *Tolman* with intentional reductions in flowrate below a threshold would have been well known to a POSITA long before the '779 Patent application.

X. OVERVIEW OF THE PRIOR ART

A. KRUPA

102. U.S. Patent Publication No. 2022/0268141A1 (“Krupa”) was filed on February 18, 2022, and published on August 25, 2022. Krupa properly claims priority to U.S. Provisional App. No. 63/153,607, which was filed on February 25, 2021. Krupa is prior art to the '779 Patent because Krupa’s effective filing date (February 25, 2021) is before the '779’s priority date (May 17, 2021). Krupa is entitled, “System and Method for an Automated and Intelligent Frac Pumping”.

103. *Krupa* describes a “fracturing system with a plurality of devices connected together and in fluid communication with one or more wells.” *Krupa* also describes the use of a computer controller for “at least one continuous pumping operations for one or more wells and a fracturing pumping plan provided on a software application.”⁵⁹ References to continuous pumping can be found throughout *Krupa*.⁶⁰ *Krupa* teaches “The system may also include at least one continuous

⁵⁹ Krupa at Abstract.

⁶⁰ See, e.g., Ex 1003 [0016], [0017], [0042]-[0045], [0046], [0058]-[0059], cl 1, cl 10-14, cl 20.

pumping operations for one or more wells and a fracturing pumping plan provided on a software application. The fracturing plan may include instructions to perform at least one continuous pumping operations for the one or more wells. The instructions may include a sequence of valve operations to direct fluid flow through a selected path into the one or more wells.”⁶¹ Further, *Krupa* discloses “Such fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected path and/or control pressure and pump rates within the system.” ⁶² *Krupa* also discloses “a wide variety of hydraulic fracturing equipment is used in oil and natural gas fields”⁶³, and describes this equipment to include “many gauges and meters for *flow rate*, fluid density, treating pressure, etc.”⁶⁴ Further, *Krupa* points out that these “plurality of sensors working in conjunction with built hydraulic fracturing system may streamline and improve efficiency[] due, in part, to reducing or eliminating human interaction with the hydraulic fracturing systems by automating fracturing operations for continuous pumping in one or more wells.”⁶⁵

⁶¹ Ex. 1003 at Abstract.

⁶² Ex. 1003 [0018].

⁶³ Ex. 1003 [0002].

⁶⁴ Ex. 1003 [0002] (emphasis added); *see also* [0014].

⁶⁵ Ex. 1003 at [0016].

104. *Krupa*'s continuously pumping hydraulic fracturing system comprises "a first wellhead assembly **201a** of a first well, a second wellhead assembly **201b** of a second well, a third wellhead assembly **201c** of a third well, and a fourth wellhead assembly **201d** of a fourth well," (wellhead assemblies and wells annotated in red below) along with valves associated with each wellhead and well.⁶⁶ Figure 1 of *Krupa* shows one arrangement of the wellheads and valves, each "coupled to at least one time and efficiency (TE) or zipper manifold **102** [(annotated in blue)] through one or more flow lines (not shown)."⁶⁷

⁶⁶ Ex.1003 at [0038].

⁶⁷ Ex. 1003 at [0019].

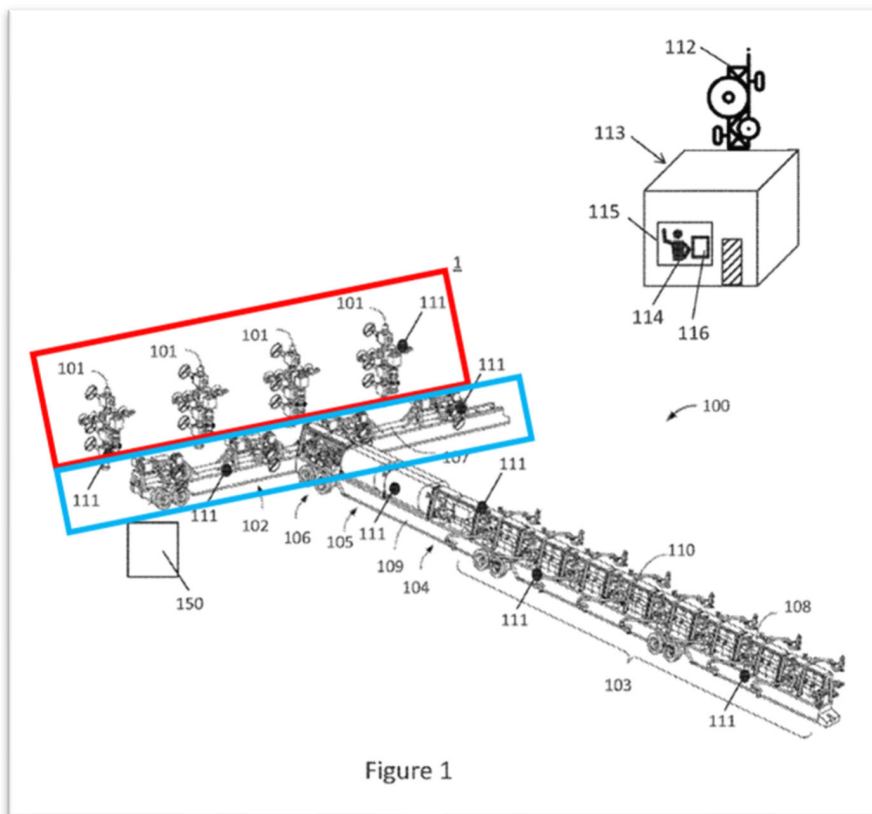


Figure 1

105. *Krupa* discloses specific examples of valve switching and sequencing to hydraulically fracture the wells while continuously pumping. As an example, Fig. 2A shows opening a first set of valves **221** and **222** (annotated in green) between a first well and a manifold in a hydraulic fracturing pumping system **200** to allow “fluid flow (see arrow **232**) to the first wellhead assembly **201a** [annotated in red]”.⁶⁸

⁶⁸ Ex 1003 [0042] see also [0040] “for illustration purposes closed valves are shown as blacked out while open valves are shown having no fill, thereby indicating the available path of fluid flow (see arrows 230-235) through the system.”

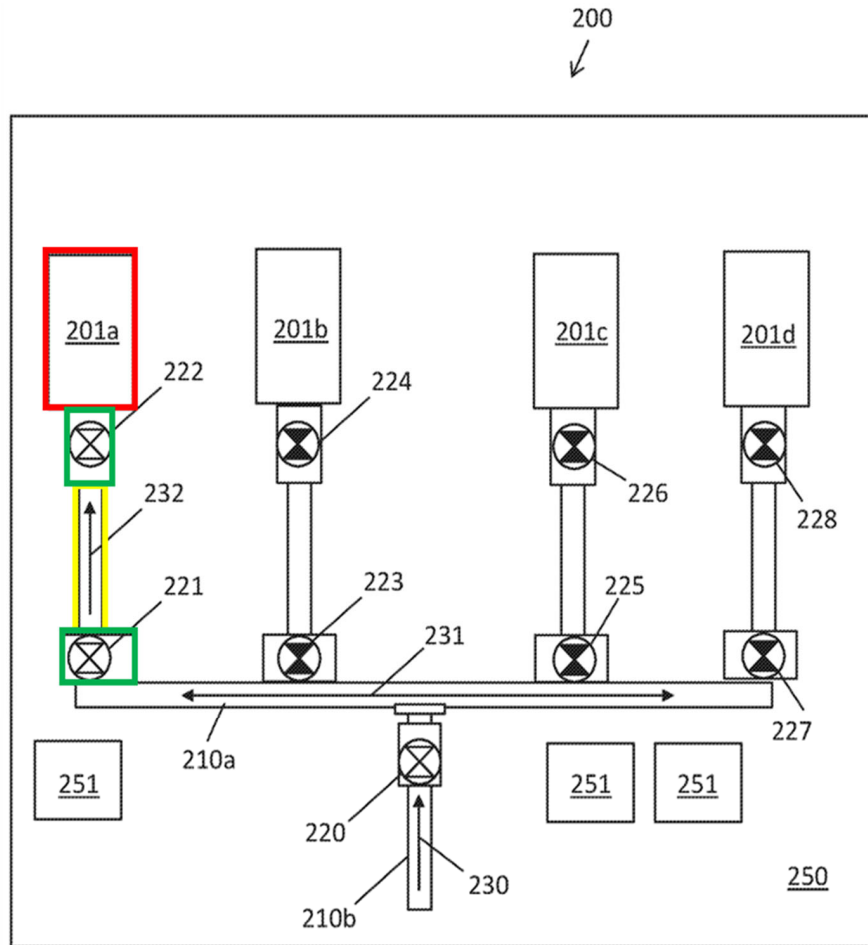
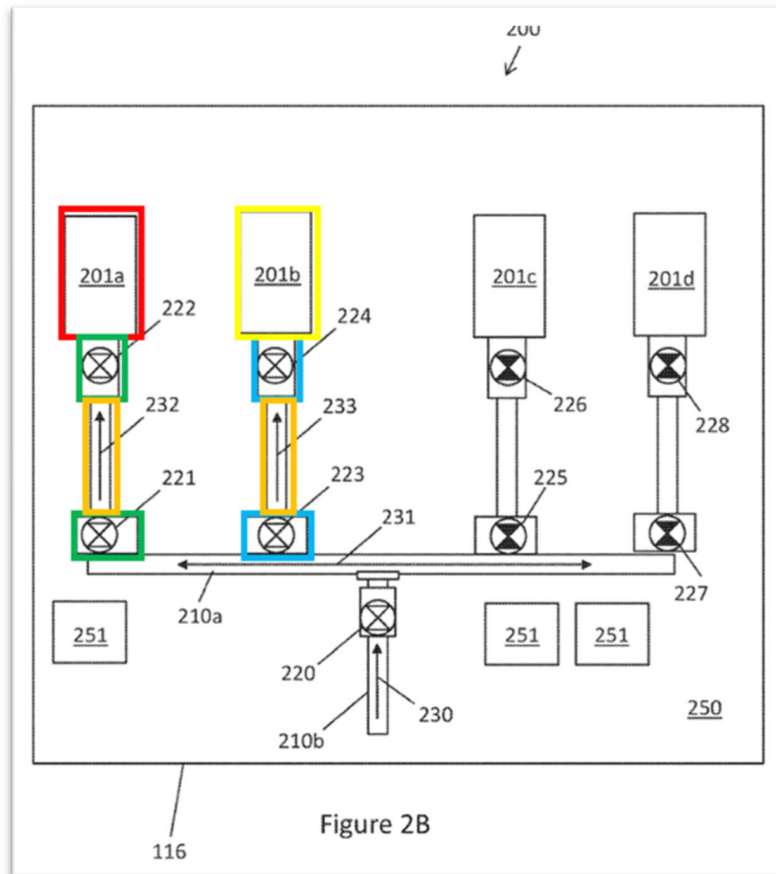


Figure 2A

106. Based, at least partly, on sensing a reduced pump flowrate and that the “pressure has stabilized at the reduced pump rate”, *Krupa*’s system moves to the next step of the continuous pumping fracturing operation, where fluids are pumped “into a second well via the at least one pump manifold while continuously pumping

the fluids into the first well by opening a second set of valves [223 and 224],”⁶⁹ as shown in Fig. 2B.

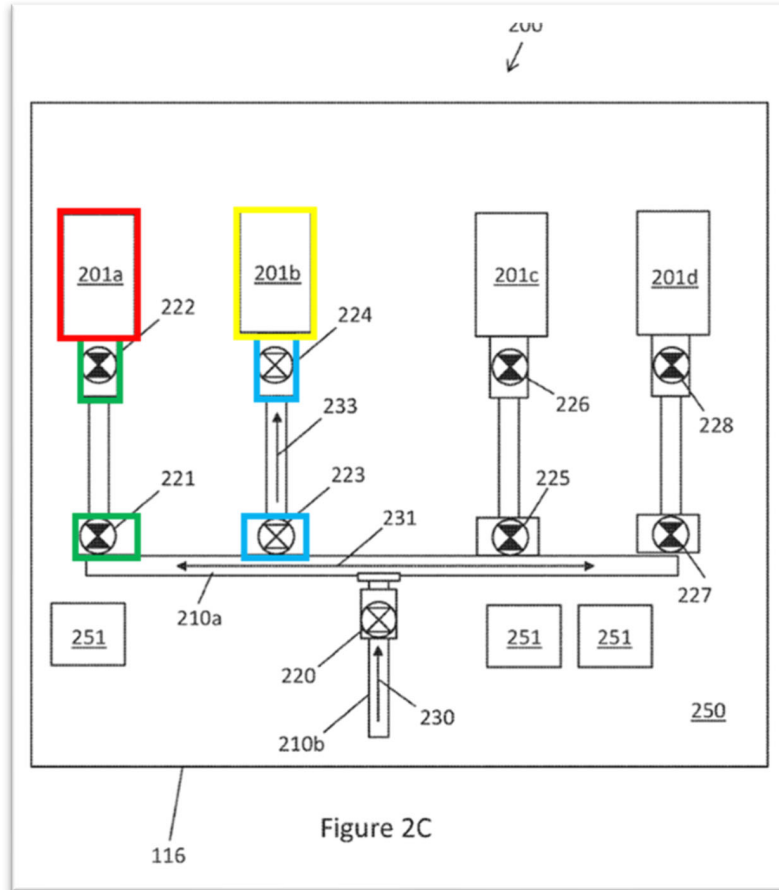


107. After establishing flow into both wells, “[t]he method further includes closing the first set of valves to stop pumping the fluids into the first well and isolating and continuously pumping the fluids into the second well.”⁷⁰ This configuration is shown in Fig. 2C, in which the first set of valves 221 and 222 are closed and the second set of valves 223 and 224 remain open. In this manner,

⁶⁹ Ex 1003 at [0005], [0042].

⁷⁰ Ex 1003 at [0005].

“automatic hydraulic fracturing pumping may be used for continuous non-stop pumping for one or more wells.”⁷¹



108. *Krupa*’s teaching of opening and closing (sequencing) valves continues through the third well (201c) and fourth well (201d) by opening and closing the appropriate valves based, at least in part, on sensing flow in specific ranges or thresholds. These switching sequences are further depicted in Fig. 2D – Fig. 2G of *Krupa*. Although *Krupa* uses language such as first and second well in order to keep

⁷¹ Ex 1003 at [0017].

track of the steps of the method, it is clear from the disclosure of *Krupa* that the teachings of switching from first well to the second well are equally applicable to switching from second well to first well and would further apply to teaching of the third well and fourth well, and vice versa. *Krupa* discloses in ¶ [0046]: “While it is noted that FIGS. 2A-2G describe the sequence of the fracturing pumping plan from the first wellhead assembly **201a** to the fourth wellhead assembly **201d**, the sequence may be conducted between any of the wellhead assemblies **201a-201d** in any order.”⁷² “Further, the sequence may be conducted from one wellhead assembly to a plurality of wellhead assemblies,” or may transition “operations from two wells to two wells, etc. (one or more transitioning to one or more while continuously pumping).”⁷³

B. KAJARIA

109. “*Kajaria*” is U.S. Patent Publication No. 2017/0275980A1. *Kajaria* was filed on March 28, 2017 and published on September 28, 2017. *Kajaria* is prior art to the ’779 Patent because *Kajaria*’s filing date is before the ’779’s priority date (May 17, 2021) and is even before the filing date of the earliest application in the chain of CIP parent applications to the ’779 Patent (December 14, 2017).

⁷² Ex 1003 at [0046].

⁷³ *Id.*

110. The '779 Patent was allowed over Kajaria only after all the claims were amended or maintained to require that conditions of flowrate were met and/or determined when performing fracturing operations. The Examiner explained that subject matter allowable over Kajaria was “determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time.”⁷⁴ It was undisputed that Kajaria disclosed the elements of the claims related to opening/closing valves and fracturing wells.

111. Kajaria teaches multi-well hydraulic fracturing sites where multiple wells are connected to a hydraulic fracturing manifold via fluid supply lines, where “an operator can use the hydraulic fracturing manifold to isolate wells as they complete a frac cycle, and to redirect fluid to a different well that is ready to begin a new frac cycle,” which “is known in the industry as ‘zip’ fracking.”⁷⁵ In other words, a zipper manifold allows selective fluid flow to one or more wells in a multi-well fracking system. Valves associated with each well and located upstream from the well tree may “allow or prevent flow before the flow reaches a particular tree,” which “allows an operator to easily direct flow between wells at a multi-well site as needed

⁷⁴ Ex. 1010, p. 7 (Office Action dated 1/5/2022).

⁷⁵ Ex 1004, [0006].

in the course of operations.”⁷⁶ With this arrangement, different wells operating on different cycles in a hydraulic fracturing operation may have pressurized fluid provided “to a particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle.”⁷⁷ Kajaria teaches “it is possible [to] direct flow between wells continuously simply by opening or closing the valves ... associated with individual wells.”⁷⁸

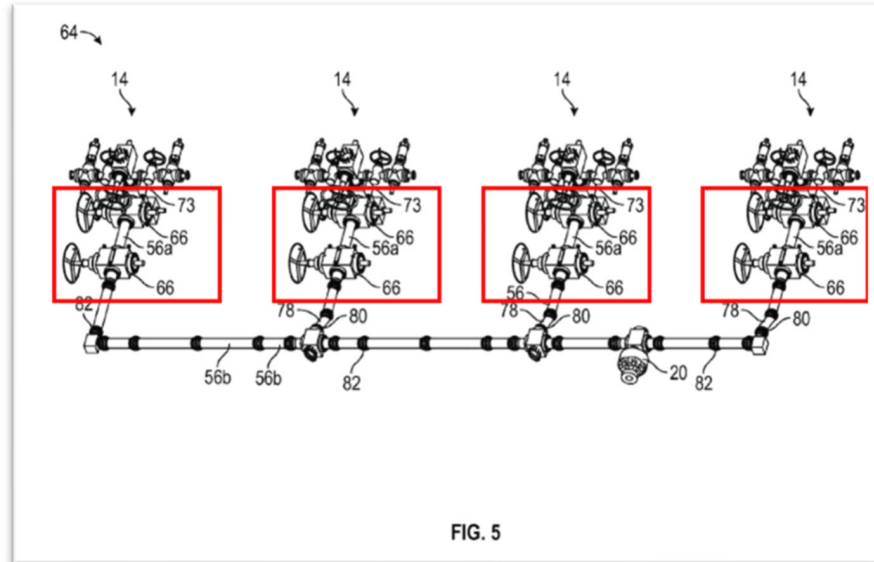
112. *Kajaria* discloses a well fracturing site with at least four wells 14 (annotated in red):

⁷⁶ *Id.* at [0035].

⁷⁷ *Id.*

⁷⁸ *Id.*

the valves **66** associated with individual wells.”⁸⁰ Fig. 5 of *Kajaria* depicts the valves **66** (annotated in red) associated with each well.



Kajaria Fig. 5

114. *Kajaria* teaches using a manifold in its flow system. *Kajaria* discloses “The pumps in typical fracing operations pump the fluid to a frac pump output header, also known as a missile, which in turn passes the fluid to a hydraulic fracturing manifold. The hydraulic fracturing manifold is located between the missile and a tree (assortment of valves and controls) located above the opening of a well bore.”⁸¹ *Kajaria*’s disclosure teaches improved connections at the fracturing location, as well as continued use of the fracturing, or zipper, manifold. *Kajaria*

⁸⁰ Ex. 1004 at [0035].

⁸¹ Ex. 1004 at [0006].

discloses “Embodiments of the present disclosure are directed to systems and methods for coupling manifolds to trees at well sites.”⁸²

115. *Kajaria* further teaches monitoring different parameters to allow an operator to control the fracturing operation, including a wide variety of equipment: “[m]onitoring equipment **38** can be mounted on a control vehicle **40**, and connected to, e.g., the pumps **10**, blender **32**, the trees **14**, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”⁸³

C. JACKSON

116. U.S. Patent Publication No. 2007/0023184 (“Jackson”) was filed May 30, 2006 and published February 1, 2007. Jackson is prior art to the ’779 Patent because Jackson’s filing date is before the ’779’s priority date (May 17, 2021) and is even before the filing date of the earliest application in the chain of CIP parent applications to the ’779 Patent (December 14, 2017).

117. *Jackson* is directed to “[a] process for fracturing a selected region of a formation including: introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached.”⁸⁴ *Jackson* describes a fracturing process

⁸² Ex. 1004 at [0024].

⁸³ Ex. 1004 at [0028].

⁸⁴ Ex. 1005 at Abstract.

that includes “introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached, adjusting the flow of the fracturing fluid ... to reach a second threshold, adjusting the flow of the fracturing fluid ... to reach a third threshold, and ceasing flow of the fracturing fluid to the region of the formation.”⁸⁵

Jackson teaches that these thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] flow rate threshold; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”⁸⁶

118. *Jackson* teaches that fracturing is conducted in “stages” and using thresholds, such as a flowrate threshold, a time threshold, or a combination of flowrate and time, is used to determine when the stage is complete. As an example, *Jackson* discloses “The first threshold may be reached during a pressurization step and that pressurization may be stopped after a fixed time, such as at least one minute, after a peak pressure is reached, after a fixed quantity of flow (which may be measured either as a mass flow or as a normalized volumetric flow, for example) or

⁸⁵ Ex 1005 at Abstract

⁸⁶ Ex 1005 at [0017] see also Claim 20

after a formation condition is determined.”⁸⁷ *Jackson* provides an example of the fracturing stages, including the reduced flow that signals the end of the fracturing stage. For example, Fig. 3 shows a reduction in “Nitrogen Rate” and “Proppant”, which together form the fracturing fluid, at the end of the fracturing stage.

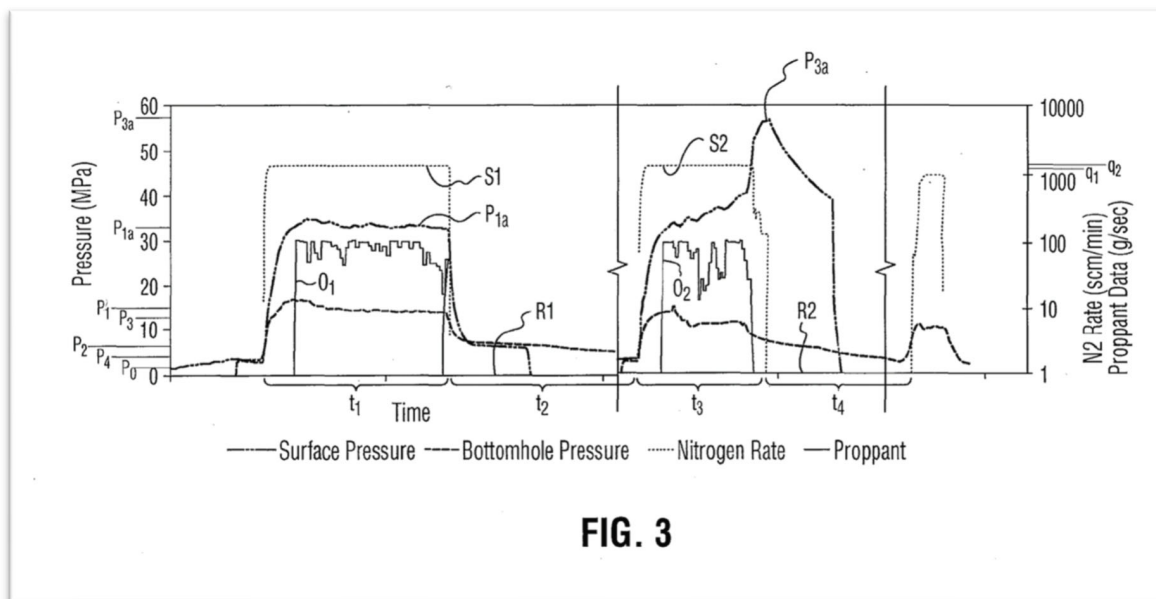


FIG. 3

Jackson Fig. 3

119. Finally, *Jackson* discloses several specific flowrate thresholds as examples including at least “300 scm (standard cubic meters per minute)”, “0 scm” and “1000 scm.” Further, *Jackson* discloses several specific combined flowrate and time thresholds including “time period of more than 1 minute and less than 24 hours

⁸⁷ Ex 1005 [0018]

of a flow rate of dilation fluid⁸⁸ of less than 300 scm”⁸⁹ and “the first threshold may be defined, at least in part, by an introduction of dilation fluid for a period of 30 seconds to 20 minutes at a flow rate of at least 300 scm, the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm, which may include 0 scm, and the third threshold may be defined as an introduction of dilation fluid for a period of 30 seconds to 20 minutes at a flow rate of at least 300 scm.”⁹⁰

D. MARTINO

120. “*Martino*” is U.S. Patent Publication No. 2017/0315566, filed April 28, 2016, and published November 2, 2017. Martino is prior art to the ’779 Patent because Martino was filed before the ’779’s priority date (May 17, 2021).

121. Martino teaches valve control systems used in well systems. Martino’s valve control systems are able to receive feedback indicative of fluid data (e.g., pressure, flowrate, etc.) of fluid from anywhere in the well system and compare the feedback to a predetermined range.⁹¹ Based on the comparison between the measured fluid data and the predetermined range, a controller may be used to operate

⁸⁸ A dilation fluid is a type of fracturing fluid, as Jackson teaches that the disclosed methods include “pressurizing” and “urging a fracture dilation fluid with a proppant” into the well. *See, e.g.*, Ex. 1005 at Claim 30.

⁸⁹ Ex 1005 [0021]; *see also* Claim 22.

⁹⁰ Ex. 1006 at [0021].

⁹¹ Ex. 1006, Abstract, [0003], [0021], [0056].

a valve in the valve control system.⁹² Martino teaches there may be many reasons to control a valve in a well system using the valve control system, e.g., if wear on the valve is indicated or if certain pressure conditions detected.⁹³ For example, the valve control system “may enable precise control (e.g., quick open and/or close or slow open and/or close) over a flow rate of fluid through a fluid-handling system.”⁹⁴

XI. GROUND 1 & 2: ANTICIPATED BY AND/OR OBVIOUS OVER KRUPA

122. It is my opinion that *Krupa* discloses each and every element of Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31 and 36 the '779 Patent. To the extent that the Board determines *Krupa* does not anticipate Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31 or 36, it is my opinion that *Krupa* at least renders these Claims of the '779 Patent obvious.

A. INDEPENDENT CLAIM 1

123. It is my opinion that *Krupa* discloses, or at least renders obvious, Claim 1 of the '779 Patent. Details regarding the specific disclosures of *Krupa* are contained in the subsections following.

⁹² Ex. 1006, Abstract, [0003], [0021].

⁹³ Ex. 1006, [0021]-[0024].

⁹⁴ Ex 1006, [0021].

a. **1.1.1: “1. A method, comprising:”**

124. To the extent the preamble is limiting, *Krupa* discloses a method of hydraulically fracturing a plurality of wells.⁹⁵ The title of *Krupa* is “System and Method for an Automated and Intelligent Frac Pumping”. A POSITA would have recognized “frac pumping” to refer to pumping related to hydraulic fracturing. *Krupa* further describes “a built hydraulic fracturing system ... in fluid combination with one or more wells” as well as “instructions to perform at least one continuous pumping operations for the one or more wells.”⁹⁶

125. Accordingly, *Krupa* discloses the preamble to Claim 1.

b. **1.1.2: “(a) permitting performance of a first hydraulic fracturing operation on a first well,”**

126. *Krupa* discloses this limitation. As discussed above regarding the preamble, *Krupa* is directed towards continuous hydraulic fracturing pumping. Further, *Krupa* teaches “The system may also include at least one continuous pumping operations for one or more wells and a fracturing pumping plan provided on a software application. The fracturing plan may include instructions to perform at least one continuous pumping operations for the one or more wells. The instructions may include a sequence of valve operations to direct fluid flow through

⁹⁵ 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.

⁹⁶ Ex. 1003 at Abstract.

a selected path into the one or more wells.”⁹⁷ Further, *Krupa* discloses “Such fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected path and/or control pressure and pump rates within the system.”⁹⁸ *Krupa* discloses that the fluids being pumped and controlled by the fracturing plan are fracturing fluids. For example, *Krupa* discloses the “fluids may refer to slurries, liquids, gases, and/or mixtures thereof. In some embodiments, solids may be present in the fluids.”⁹⁹

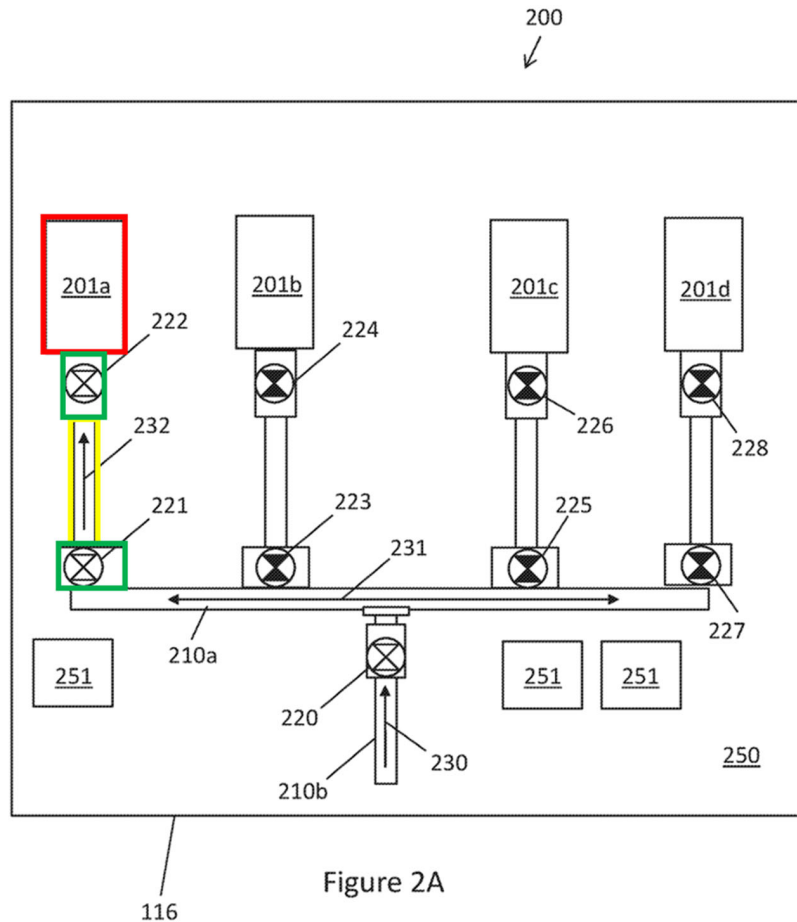
127. As part of this fracturing plan, *Krupa* discloses “The method may include pumping fluids into a first well via at least one pump manifold by opening a first set of valves.”¹⁰⁰ Controlling valves to direct frac fluids to the first well as part of a fracturing plan is a disclosure of “permitting performance of a first fracturing operation on a first well” as claimed. Fig. 2A of *Krupa* shows this configuration of the hydraulic fracturing system.

⁹⁷ Ex. 1003 at Abstract.

⁹⁸ Ex. 1003 at [0018].

⁹⁹ Ex. 1003 at [0018].

¹⁰⁰ Ex. 1003 at [0005].



128. *Krupa* discloses, for illustrative purposes in Figures 2A – 2G, “closed valves are shown as blacked out while open valves are shown having no fill, thereby indicating the available path of fluid flow (see arrows 230-235) through the system.”¹⁰¹ As shown in Fig. 2A, the valves **221** and **222** (annotated in green) which allow flow of fracturing fluid into wellhead **201a** (annotated in red, associated with the first well) are open, thus permitting performance of a first hydraulic fracturing operation on a first well.

¹⁰¹ Ex. 1003 at [0040].

129. Accordingly, *Krupa* discloses the limitations of 1.1.2.

- c. **1.1.3: “which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and”**

130. *Krupa* discloses this limitation. As discussed above regarding 1.1.2, *Krupa* discloses “pumping fluids into a first well via at least one pump manifold by opening a first set of valves.”¹⁰²

131. Accordingly, *Krupa* discloses the limitations of 1.1.3.

- d. **1.2: “measuring a flow rate of the fluid being pumped into the first well;”**

132. *Krupa* discloses measuring the flowrate as claimed in element 1.2. As discussed above regarding Claim 1.1, *Krupa* discloses pumping fluid into the first well by opening a first valve. Further, *Krupa* discloses the use of flowmeters, including flowmeters specifically associated with the valve(s) on each wellhead. For example, *Krupa* describes a “wide variety of hydraulic fracturing equipment is used in oil and natural gas fields”¹⁰³, and describes this equipment to include “many gauges and meters for *flow rate*, fluid density, treating pressure, etc.”¹⁰⁴ Further, *Krupa* points out that these “plurality of sensors working in conjunction with built hydraulic fracturing system may streamline and improve efficiency ... due, in part,

¹⁰² Ex. 1003 [0005], *see also* Claim 1.

¹⁰³ Ex. 1003 at [0002].

¹⁰⁴ Ex. 1003 at [0002] (emphasis added); *see also* [0014].

to reducing or eliminating human interaction with the hydraulic fracturing systems by automating fracturing operations for continuous pumping in one or more wells.”¹⁰⁵ *Krupa* further explicitly teaches “some of the plurality of sensors **111** may be associated with each of the valves of the wellhead assembly **101**” and “the plurality of sensors **111** may be any sensor or device capable of wireline monitoring, valve monitoring, pump monitoring, flow line monitoring, accumulators and energy harvesting, and equipment performance and damage.”¹⁰⁶ A POSITA would understand that flow line monitoring may include sensors capable of monitoring flow rate, as *Krupa* also recognizes flow rate sensors are commonly used for fracturing operations.¹⁰⁷ A POSITA would also understand that pump monitoring is a common form of monitoring flow rate, as the pump rate is proportional to the flow rate, as discussed above in Section IX.B. Additionally, a POSITA may be motivated to use pump monitoring because pump monitoring may be a lower cost option for monitoring flow rate when compared with using multiple, dedicated flow meters in the system.

133. Accordingly, *Krupa* discloses measuring the flow rate of fluid being pumped into the first well, as claimed in Claim element 1.2.

¹⁰⁵ Ex. 1003 at [0016].

¹⁰⁶ Ex. 1003 at [0024]; *see also* [0028].

¹⁰⁷ Ex. 1003 at [0014], [0024].

134. To the extent that the Board determines that “measuring a flow rate of the fluid being pumped into the first well” is not expressly disclosed by *Krupa* then such a measurement would be obvious from the teachings of *Krupa*, as *Krupa* discloses sensors that include those for measuring “flow rate” and that the sensors are “associated with each of the valves of the wellhead assembly,” as claimed, and that the sensors further monitor flow lines. Additionally, this element would have been obvious to a POSITA based on their general engineering knowledge, as measuring flowrate into the well was done long before the application which led to the ‘779 Patent. (See Sections IX.A – IX.F).

e. **1.3: “(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and”**

135. *Krupa* discloses, or at least renders obvious, “determining the flow rate of the fluid being pumped into the first well is below a flow rate threshold” as claimed. As discussed above regarding 1.2, *Krupa* teaches sensors to measure a variety of conditions, including flowrate. *Krupa* further teaches that sensors, such as the flowrate sensor, would be used to determine the state of the fracturing job:

In a non-limiting example, the plurality of sensors **111** may aid in monitoring a valve position to determine current job state and provides choices for possible stages. In some examples, the plurality of sensors may provide information such that a current state of the hydraulic fracturing operation, possible failures of hydraulic fracturing equipment, maintenance or service requirements, and compliance issues that may arise is obtained. By obtaining such information, the automated hydraulic fracturing systems may form a closed loop valve

control system, valve control and monitoring without visual inspection, and reduce or eliminate human interaction with the hydraulic fracturing equipment.¹⁰⁸

For the system to effect a “closed loop valve control system...[which] reduces or eliminated human interaction” with the system, the system necessarily would need to use some measurement to determine when one step (stage) of the fracturing process is finished, and then direct the system to move to the next stage.

136. As one example of using flowrate to determine the state of the fracturing job, *Krupa* teaches pumping fluid into the well “at a full pump rate ... of about 50-150 bbl./min.”¹⁰⁹ Further, *Krupa* teaches “a pump rate may be reduced from the full pump rate. For example, the pump rate may be reduced to 5-15 bbl./min. Once a pressure has stabilized at the reduced pump rate, the software application may move the fracturing pumping plan to the next step.”¹¹⁰ *Krupa*’s system teaches reduced flow below a flowrate threshold (i.e., 15 bbl./min), which would have been measured with at least one of the plurality of sensors disclosed by *Krupa*.

137. It was well-known to a POSITA at the time of the ‘779 Patent that a reduction in flowrate is common at the end of the fracturing stage, particularly during

¹⁰⁸ Ex. 1003 at [0026].

¹⁰⁹ Ex. 1003 at [0042].

¹¹⁰ *Id.*

a zipper or continuous pumping operation. The reduction in flowrate is for at least two reasons, e.g., to perform a rate step test (RST or water hammer test) to measure the effectiveness of the fracturing operation, and to allow for safely executed mechanical operations such as dropping a ball or manipulating valves.¹¹¹

138. *Krupa* teaches that once the pumping flowrate (as well as pressure) have stabilized below e.g., 15 bbl./min, the system determines that the fracturing job is at the end of that particular stage, and then “move[s] the fracturing pumping plan to the next step.”¹¹²

139. Accordingly, *Krupa* discloses the limitation claimed in 1.3. To the extent that the Board finds that “determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold” is not explicitly disclosed by *Krupa*, then such a determination would be obvious from the teachings of *Krupa* regarding a reduction in flow indicating the end of the stage, and the subsequent “move to the next step” executed by the software application. Additionally, this element would have been obvious to a POSITA based on their general engineering knowledge, particularly a POSITA’s knowledge of a rate step test (RST), or the measurement of water hammer in order to characterize fractures in the downhole formation. As discussed above in Sections IX.C-IX.F, a step-change reduction in

¹¹¹ See, e.g., Sections IX.C-IX.F.

¹¹² Ex. 1003 at [0042].

flowrate, held for a time long enough to measure the water hammer oscillations, is necessary in order to perform a rate step test.

f. **1.4: “has been below the flow rate threshold for a threshold amount of time;”**

140. *Krupa* discloses, or at least renders obvious, the claimed limitation that the flowrate “has been below the flow rate threshold for a threshold amount of time.” As discussed above regarding 1.3, *Krupa* teaches monitoring flow rate at a reduced pump rate, e.g., “5-15 bbl./min.” *Krupa* further teaches monitoring the flow rate and ensuring that “pressure has stabilized at the reduced pump rate” before moving to the next stage of the pumping plan, which necessarily and inherently requires waiting a period of time to make sure the pressure is stable. *Krupa*’s system teaches reduced flow below a flowrate threshold (i.e., 15 bbl./min), which would have been measured with at least one of the plurality of sensors disclosed by *Krupa*. Thus, *Krupa* determines that the flowrate is below the flowrate threshold (“reduced pump rate”) for a threshold amount of time (“once a pressure has stabilized at the reduced pump rate, the software application may move the fracturing pumping plan to the next step”¹¹³). As an example of a threshold amount of time, a POSITA would have recognized, based on the general knowledge of an RST, that a stabilized pressure

¹¹³ Ex. 1003 at [0042].

and flowrate occurs after the water hammer levels have declined sufficiently that a measurement of the fracture network would be made.

141. Further, to the extent that the Board finds that *Krupa* does not explicitly disclose this limitation, a POSITA would have recognized that a stabilized flow and pressure measurement would mean that there was an acceptably small deviation around the target rate for a period of time. Accordingly, ensuring flowrate and pressure are “stabilized at the reduced pump rate” would be accomplished, for example, to ensure that the water hammer (RST) cycles have been sufficiently measured to determine the effectiveness of the fracturing stage, or to allow for safe and controlled mechanical operations such as valve manipulation or ball drops, which would be examples of the “next step” of the fracturing pumping plan disclosed by *Krupa*. Further, a POSITA would have immediately recognized that measuring changes in flowrate over time is a common and necessary part of a zipper or continuous pumping fracturing operation, such as discussed above in Section IX.¹¹⁴

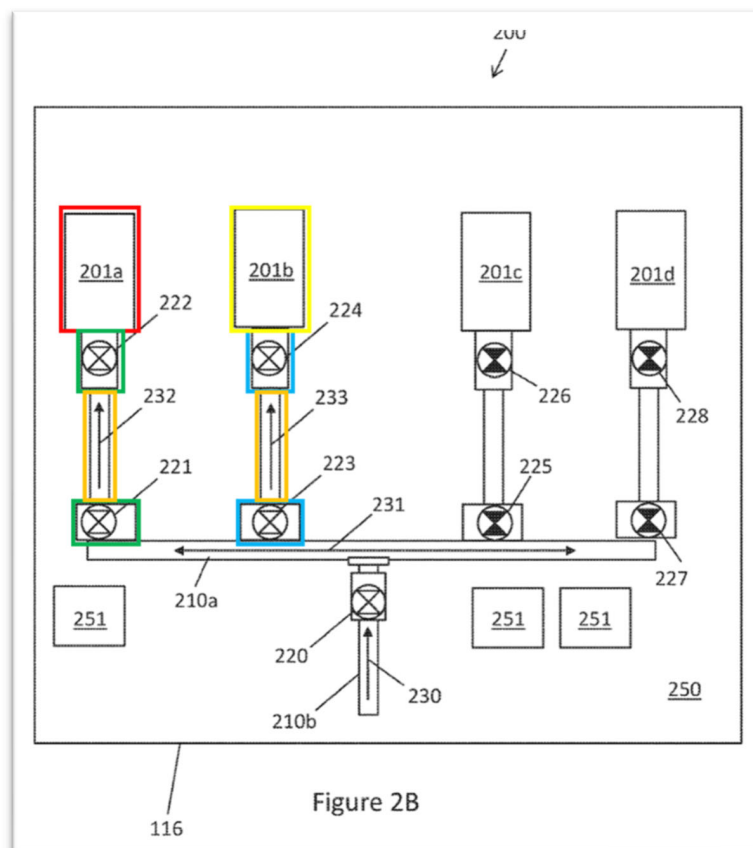
142. Accordingly, *Krupa* discloses or at least renders obvious to a POSITA having general engineering knowledge at the time of the '779 Patent the claimed limitation that the measured flow rate “has been below the flow rate threshold for a threshold amount of time;” based on the teachings of *Krupa*.

¹¹⁴ See e.g., IX.C-IX.E; and Casero’s flow rate v. time (Fig. 3).

- g. **1.5: “(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;”**

143. *Krupa* discloses this limitation. *Krupa* teaches “[t]he method may also include pumping the fluids into a second well via the at least one pump manifold while continuously pumping the fluids into the first well *by opening a second set of valves,*” either of which is the claimed second valve.¹¹⁵

144. This configuration of the hydraulic fracturing system is shown in Fig. 2B.



¹¹⁵ Ex 1003 at [0005] (emphasis added).

145. In Fig. 2B, second valves **223, 224** (annotated in blue) are opened while first valves **221, 222** (annotated in green) are still open. This allows fracturing fluid flow both into first wellhead **201a** (annotated in red) and second **201b** (annotated in yellow).

146. Accordingly, *Krupa* discloses the limitation of 1.5.

- h. **1.6: “(d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and”**

147. *Krupa* discloses this limitation. As discussed above regarding 1.5, “[t]he method may also include pumping the fluids into a second well via the at least one pump manifold while continuously pumping the fluids into the first well *by opening a second set of valves,*” *i.e.*, by opening the claimed second valve.¹¹⁶ Further, this is part of the “fracturing plan” and “built hydraulic fracturing system”¹¹⁷ that *Krupa* is directed to. By pumping fluid into the second well via opening the second valves, *Krupa*’s plan and system are permitting performance of a second hydraulic fracturing operation on the second well.

148. Accordingly, *Krupa* discloses the limitation contained in 1.6.

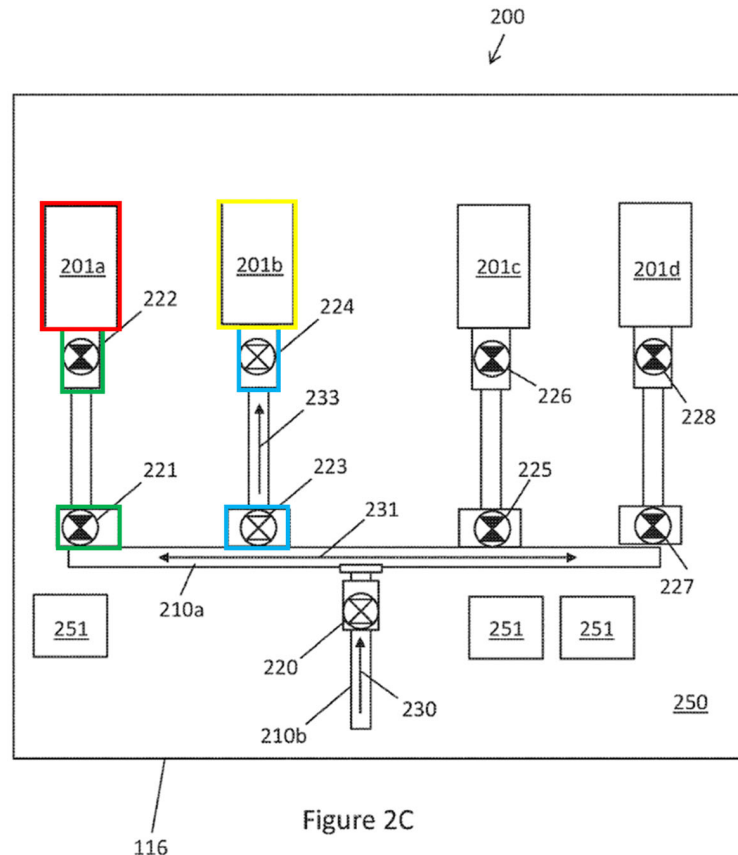
¹¹⁶ Ex. 1003 at [0005] (emphasis added).

¹¹⁷ Ex. 1003 at [0007].

- i. **1.7: “(e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;”**

149. *Krupa* discloses this limitation. *Krupa* teaches “[t]he method further includes closing the first set of valves to stop pumping the fluids into the first well and isolating and continuously pumping the fluids into the second well.”¹¹⁸ The disclosure of “continuously pumping fluids into the second well” discloses that the valve closure is completed “during pumping of the fluid into the second well via the second valve” as claimed. This configuration of the hydraulic fracturing system is shown in Fig. 2C.

¹¹⁸ Ex. 1003 at [0005].



150. In Fig. 2c, valves **223**, **224** (annotated in blue) are open, but valves **221**, **222** (annotated in green) are closed. This allows fracturing fluid flow into only **201b** (annotated in yellow). Accordingly, *Krupa* discloses the limitation contained in Claim 1.7.

- j. **1.8: “wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.”**

“The method may include pumping fluids into a first well via at least one pump manifold by opening a first set of valves. The method may also include pumping the fluids into a second well via the at least one pump manifold *while continuously pumping* the fluids into the first well by opening a second set of valves. The method further includes closing the first set of valves to stop pumping the fluids into the first well and isolating and *continuously pumping* the fluids into the second well.”¹¹⁹

152. *Krupa* further describes continuously pumping to both the first and second valves throughout the specification. As an example, *Krupa* discloses “The fracturing plan may include pre-made instructions to perform at least one continuous pumping operations for one or more wells.”¹²⁰ As another example, *Krupa* discloses “The system may also include at least one continuous pumping operations for one or more wells and a fracturing pumping plan provided on a software application.”¹²¹ Further examples can be found throughout *Krupa* including:¹²² “The method may also include pumping the fluids into a second well via the at least one pump manifold while continuously pumping the fluids into the first well by opening a second set of valves;”¹²³ “The method further includes closing the first set of valves to stop pumping the fluids into the first well and isolating and continuously pumping the

¹¹⁹ Ex. 1003 at [0005] (emphasis added).

¹²⁰ Ex. 1003 at [0006].

¹²¹ Ex. 1003 at [0007].

¹²² See, e.g., Ex 1003 at [0016], [0017], [0042]-[0045], [0046], [0058]-[0059], Claims 1, 10-14, and 20.

¹²³ Ex. 1003 at [0005].

fluids into the second well.”¹²⁴ Because *Krupa* discloses each and every element of claim 1, claim 1 is anticipated by *Krupa*. To the extent that the Board finds claim 1 is not anticipated by *Krupa*, claim 1 is obvious over *Krupa* alone for the reasons discussed above.

B. DEPENDENT CLAIM 2

153. Dependent Claim 2 depends from Claim 1. In addition to the disclosure of the limitations of Claim 1 discussed above, *Krupa* discloses the additional limitations of Claim 2:

- a. **“2.The method of claim 1, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.”**

154. *Krupa* teaches, “[t]he method may include pumping fluids into a first well *via at least one pump manifold* by opening a first set of valves. The method may also include pumping the fluids into a second well *via the at least one pump manifold* while continuously pumping the fluids into the first well by opening a second set of valves.”¹²⁵

¹²⁴ *Id.*

¹²⁵ Ex. 1003 at [0005] (emphasis added).

C. DEPENDENT CLAIM 3

157. Dependent Claim 3 depends from Claim 1. In addition to the disclosure of the limitations of Claim 1 discussed above, *Krupa* discloses the limitations of Claim 3:

a. “3. The method of claim 1, wherein the second valve is opened after step (b).”

158. The limitation in Claim 3 is substantially similar to the limitation discussed regarding 1.5 but missing the limitation that the second valve is opened “during pumping of the fluid into the first well via the first valve.” Accordingly, Claim 3 is disclosed for the same reasons as those discussed regarding 1.5 above in Section XI.A.g. For example, *Krupa* teaches that after the flowrate is below the flowrate threshold (i.e. “reduced pump rate”) for a threshold amount of time (“[o]nce a pressure has stabilized at the reduced pump rate, the software application may move the fracturing pumping plan to the next step”¹²⁷). The “next step” taught by *Krupa* in one example is: “As shown in FIG. 2B, the fracturing pumping plan may include operating the second wellhead assembly **201b** [annotated in yellow] to conduct hydraulic fracturing pumping. For example, a second set of valves **223, 224** [annotated in blue] may be opened while the first set of valves **221, 222** [annotated in green] remain open during the pumping of the flush fluid. With both the first set

¹²⁷ Ex. 1003 at [0042].

160. Accordingly, *Krupa* discloses the limitation in Claim 3. Therefore, Claim 3 is anticipated by *Krupa*, or alternatively obvious over *Krupa* alone for the reasons discussed above.

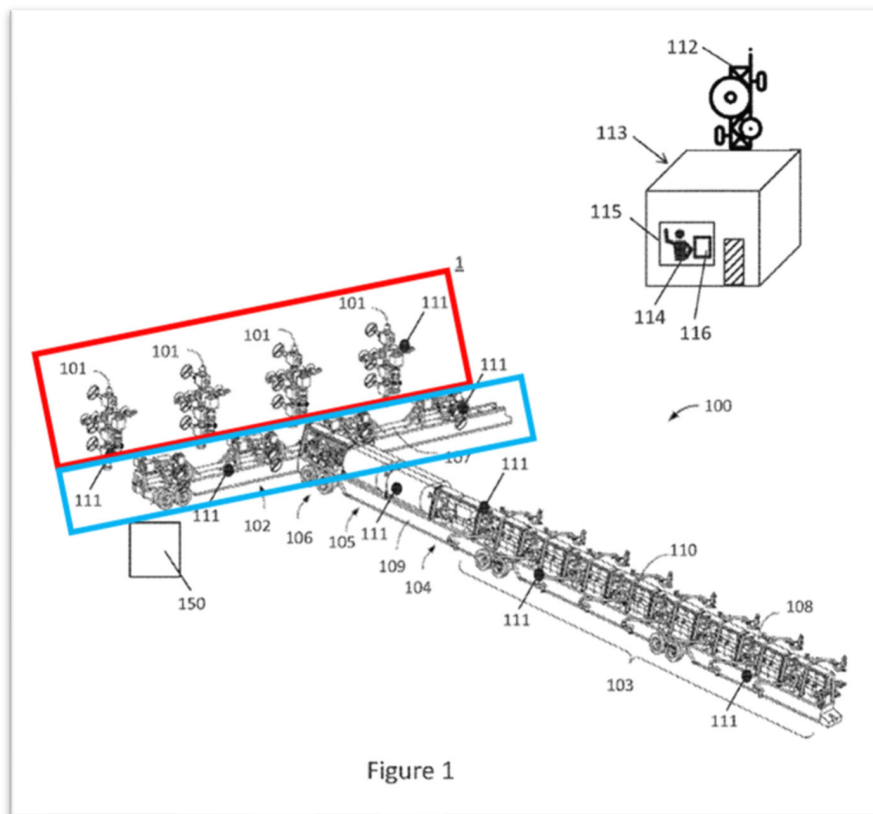
D. DEPENDENT CLAIM 6

161. Dependent Claim 6 depends from Claim 1. In addition to the disclosure of the limitations of Claim 1 discussed above, *Krupa* discloses the limitations of Claim 6:

a. “6. The method of claim 1, wherein each of the first and second valves is a zipper valve.”

162. *Krupa* discloses this limitation. Fig. 1 of *Krupa* “shows an automated hydraulic fracturing pumping system according to embodiments” of the disclosure of *Krupa*. Further, “The built hydraulic fracturing pumping system **100** may include at least one wellhead assembly **101** [annotated in red] (e.g., a Christmas tree) coupled to at least one time and efficiency (TE) or zipper manifold **102** [annotated in blue] through one or more flow lines (not shown).”¹²⁹

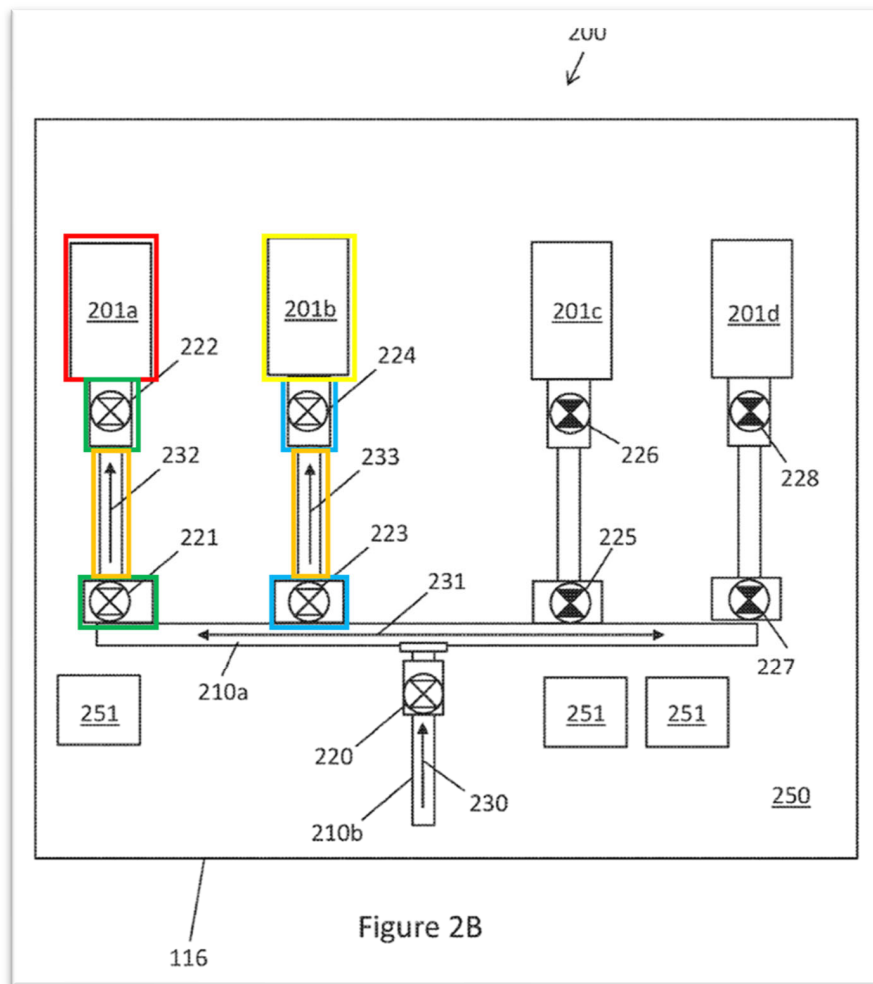
¹²⁹ Ex. 1003 at [0019].



163. Further, *Krupa* discloses valves as part of the zipper manifold, and these valves are used to pump fluid to the wellhead assembly or to isolate the wellhead assembly from the pressurized fluid. “In use, the at least one pump manifold **103** may be fluidly connected to and receive pressurized fracking fluid from one or more high pressure pumps (not shown), and direct that pressurized fracking fluid to the zipper manifold **102**, which may include one or more valves that may be closed to isolate the wellhead assembly **101** from the flow of pressurized fluid within the zipper manifold **102** and pump manifold **103**.”¹³⁰ A POSITA would immediately

¹³⁰ Ex. 1003 at [0019].

recognize the valves on the zipper manifold to be “zipper valves”, or valves used to open or isolate a wellhead during a zipper frac operation.¹³¹ Further, a POSITA would recognize the valves on the zipper manifold to be the valves depicted with the manifold in Figures 2A – 2G as described above regarding Claim 3, e.g. valves **221** and **223** shown annotated in green and blue respectively.



¹³¹ See Section IX.C.

164. Accordingly, *Krupa* discloses wherein each of the first and second valves is a zipper valve, as claimed in Claim 6. To the extent that the Board determines that a “zipper valve” is not explicitly disclosed by *Krupa*, then it would have been obvious to a POSITA having general engineering knowledge of such operations that the valves associated with zipper manifold **102** would have been “zipper valves,” based on the teachings of *Krupa* regarding sequential or simultaneous (i.e., zipper) fracturing operations.¹³² Accordingly, Claim 6 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* alone for the reasons discussed above.

E. INDEPENDENT CLAIM 8

165. It is my opinion that Claim 8 of the '779 Patent is disclosed by *Krupa*. With the exception of Claim 8 being an “apparatus” claim, and the claim further containing a description of structure of the apparatus, namely known computer elements for executing instructions, Claim 8 is substantially similar to Claim 1. As discussed below, *Krupa* contains disclosure of the structure of apparatus which is strikingly similar to that of Claim 8 of the '779 Patent.

¹³² See, e.g., Sections IX.C-IX.D.

a. **8.1.1 : “An apparatus comprising:”**

166. To the extent the preamble is limiting, *Krupa* discloses the preamble.¹³³

The title of *Krupa* is “System and Method for an Automated and Intelligent Frac Pumping.”¹³⁴ *Krupa* discloses “An automated hydraulic fracturing system may include a computing system for implementing methods disclosed herein.”¹³⁵ Accordingly, *Krupa* discloses a computing system that is an example of the apparatus as described in the rest of Claim 8.

b. **8.1.2: “a non-transitory computer readable medium; and”**

167. *Krupa* discloses this limitation. Specifically, *Krupa* discloses “Software instructions in the form of computer readable program code to perform embodiments of the disclosure may be stored, in whole or in part, temporarily or permanently, *on a non-transitory computer readable medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium.*”¹³⁶

168. Thus, *Krupa* discloses “a non-transitory computer readable medium” as claimed in Claim 8.1.2.

¹³³ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 8 out of an abundance of caution.

¹³⁴ Ex. 1003.

¹³⁵ Ex. 1003 at [0027].

¹³⁶ Ex. 1003 at [0032] (emphasis added).

c. **8.2.1: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors,”**

169. *Krupa* discloses the limitations of Claim 8.2.1. When describing its’ apparatus and system, *Krupa* discloses:

*Software instructions in the form of computer readable program code to perform embodiments of the disclosure may be stored, in whole or in part, temporarily or permanently, on a non-transitory computer readable medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium. Specifically, the software instructions may correspond to computer readable program code that, when executed by a processor(s), ...may perform one or any of the automated hydraulic fracturing systems features described herein, including that associated with data interpretation and automated hydraulic fracturing pumping systems.*¹³⁷

170. A POSITA would have immediately equated the “software instructions” of *Krupa* to the claimed “plurality of instructions.” A POSITA would have also immediately recognized the “computer readable code, what when executed by a processor(s)” of *Krupa* to be a disclosure of the instructions are “executable by one or more processors,” as claimed.

171. Accordingly, *Krupa* discloses “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors” as claimed in 8.2.1.

¹³⁷ Ex. 1003 at [0032] (emphasis added).

d. **8.2.2: “wherein, when the instructions are executed by the one or more processors, the following steps are executed:”**

172. *Krupa* discloses this limitation as well. When discussing the system and apparatus of *Krupa*, the following disclosure is made:

Software instructions in the form of computer readable program code to perform embodiments of the disclosure may be stored, in whole or in part, temporarily or permanently, on a non-transitory computer readable medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium. Specifically, the software instructions may correspond to *computer readable program code that, when executed by a processor(s), ...may perform one or any of the automated hydraulic fracturing systems features described herein*, including that associated with data interpretation and automated hydraulic fracturing pumping systems.¹³⁸

173. A POSITA would have immediately equated the disclosure of “that when executed by a processor(s) may perform one or any of the automated hydraulic fracturing systems features described herein” to the claimed “when the instructions are executed by the one or more processors, the following steps are executed.”

174. Accordingly, *Krupa* discloses “wherein, when the instructions are executed by the one or more processors, the following steps are executed” as claimed in 8[c].

¹³⁸ Ex. 1003 at [0032] (emphasis added).

- e. 8.3: “(a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and
- 8.4: measuring a flow rate of the fluid being pumped into the first well; and
- 8.5: “(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and
- 8.6: has been below the flow rate threshold for a threshold amount of time;”
- 8.7: “(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;”
- 8.8: “(d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and”
- 8.9: “(e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;”
- 8.10: “wherein, during each of step (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.”

175. The language in claim limitations 8.3 through 8.10 is identical to that of limitations 1.1 through 1.8. *Krupa* discloses the limitations of 8.3 through 8.10 for the same reasons as those discussed regarding 1.1 through 1.8 in Section XI.A.

176. Because *Krupa* discloses each and every element of claim 8, claim 8 is anticipated by *Krupa*. To the extent that the Board finds claim 8 is not anticipated by *Krupa*, claim 8 is obvious over *Krupa* alone for the reasons discussed above.

F. DEPENDENT CLAIM 9

177. Dependent Claim 9 depends from Claim 8. In addition to the disclosure of the limitations of Claim 8 discussed above, *Krupa* discloses the additional limitations of Claim 9:

- a. **“9. The apparatus of claim 8, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of ps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.”**

178. Except for depending from Claim 8 and being an apparatus claim, Claim 9 is identical to Claim 2 and is disclosed by *Krupa* for the same reasons as those described above regarding Claim 2 in Section XI.B. Accordingly, Claim 8 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* alone for the reasons discussed above.

G. DEPENDENT CLAIM 10

179. Dependent Claim 10 depends from Claim 8. In addition to the disclosure of the limitations of Claim 8 discussed above, *Krupa* discloses the additional limitations of Claim 10:

- a. **“10. The apparatus of claim 8, wherein the second valve is opened after step (b).”**

180. Except for depending from Claim 8 and being an apparatus claim, Claim 10 is identical to Claim 3 and is disclosed by *Krupa* for the same reasons as those described above regarding Claim 3 in Section XI.C. Accordingly, Claim 10 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* alone for the reasons discussed above.

H. DEPENDENT CLAIM 13

181. Dependent Claim 13 depends from Claim 8. In addition to the disclosure of the limitations of Claim 8 discussed above, *Krupa* discloses the additional limitations of Claim 13:

- a. **“13. The apparatus of claim 8, wherein each of the first and second valves is a zipper valve.”**

182. Except for depending from Claim 8 and being an apparatus claim, Claim 13 is identical to Claim 6 and is disclosed by *Krupa* for the same reasons as those described above regarding Claim 6 in Section XI.D. Accordingly, Claim 13

is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* alone for the reasons discussed above.

I. INDEPENDENT CLAIM 15

183. It is my opinion that *Krupa* discloses, or at least renders obvious Claim 15 of the '779 Patent. Details regarding the specific disclosures of *Krupa* are contained in the subsections following. *Krupa* discloses in ¶ [0046]:

While it is noted that FIGS. 2A-2G describes the sequence of the fracturing pumping plan from the first wellhead assembly **201a** to the fourth wellhead assembly **201d**, the sequence may be conducted between any of the wellhead assemblies **201a-201d** in any order.... While described above with respect to transitioning from one well to a second well, embodiments herein also contemplate transitioning operations from two wells to two wells, etc. (one or more transitioning to one or “more while continuously pumping”).¹³⁹

184. Although *Krupa* uses language such as first and second well in order to keep track of the steps of the method, it is clear from the disclosure of *Krupa* that the teachings of switching from first well to the second well are equally applicable to switching from second well to first well and would further apply to teaching of the third well and fourth well, and vice versa. In the analysis below I annotate the disclosure of *Krupa* to tie the disclosure to the claim language based on the teachings of *Krupa* that valve and fracturing operations can be conducted in any order.

¹³⁹ Ex. 1003 at [0046].

- a. **15.1: “15. A method of hydraulically fracturing at least first and second wells of a plurality of wells, the first and second wells being associated with first and second valves, respectively, the method comprising:”**

185. To the extent the preamble is limiting, *Krupa* discloses a method of hydraulically fracturing a plurality of wells, including a first and second well, each well with associated valves.¹⁴⁰ The title of *Krupa* is “System and Method for an Automated and Intelligent Frac Pumping”. A POSITA would have recognized “frac pumping” to refer to pumping related to hydraulic fracturing. *Krupa* further describes “a built hydraulic fracturing system ... in fluid communication with one or more wells” as well as “instructions to perform at least one continuous pumping operations for the one or more wells,”¹⁴¹ which are examples of hydraulic fracturing.

186. *Krupa* further discloses “first and second wells being associated with first and second valves”. *Krupa* discloses “pumping fluids into a first well ... by opening a first set of valves” and “pumping the fluids into a second well ... by opening a second set of valves.”¹⁴² For illustrative purposes in Figures 2A – 2G “closed valves are shown as blacked out while open valves are shown having no fill,

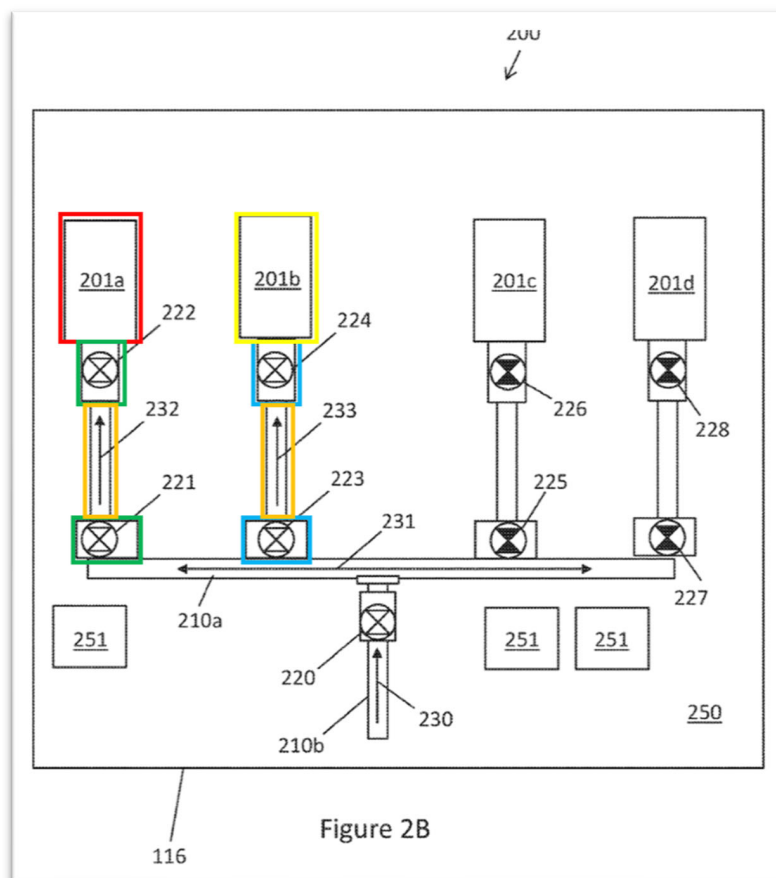
¹⁴⁰ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 15 out of an abundance of caution.

¹⁴¹ Ex. 1003 at Abstract.

¹⁴² Ex. 1003 at [0005].

thereby indicating the available path of fluid flow (see arrows 230-235) through the system.”¹⁴³

187. *Krupa* further discloses first and second wellheads associated with first and second valves in a series of Figures (Figure 2A – Figure 2G). Figure 2B is shown below as a representative example.



188. With reference to Figure 2B (and also applicable to Figures 2A – 2G) *Krupa* identifies the various components in the figures including “first wellhead

¹⁴³ Ex. 1003 at [0040].

assembly **201a** of a first well [annotated in red], [and] a second wellhead assembly **201b** of a second well [annotated in yellow].”¹⁴⁴ *Krupa* further describes the valves shown in the figures including pumping fluid “into the first wellhead assembly **201a** via first set of valves **221, 222** [annotated in green]”¹⁴⁵ and “a second set of valves **223, 224** [annotated in blue]” which are opened to allow hydraulic fracturing pumping into the second well via wellhead assembly **201b**.¹⁴⁶

189. Accordingly, *Krupa* discloses the preamble of Claim 15.

b. **15.2.1: “(a) permitting hydraulic fracturing of the second well, comprising:**

190. *Krupa* discloses this limitation. As discussed above regarding the preamble, *Krupa* is directed towards “continuous pumping operations for one or more wells and a fracturing pumping plan provided on a software application” that includes “a sequence of valve operations to direct fluid flow through a selected path into the one or more wells.”¹⁴⁷ Further, *Krupa* discloses “Such fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected

¹⁴⁴ Ex. 1003 at [0038].

¹⁴⁵ Ex. 1003 at [0042].

¹⁴⁶ Ex. 1003 at [0043].

¹⁴⁷ Ex. 1003 at Abstract.

path and/or control pressure and pump rates within the system.”¹⁴⁸ *Krupa* discloses that the fluids being pumped and controlled by the fracturing plan are fracturing fluids. For example, *Krupa* discloses “Such fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected path and/or control pressure and pump rates within the system. ... Further, fluids may refer to slurries, liquids, gases, and/or mixtures thereof. In some embodiments, solids may be present in the fluids.”¹⁴⁹ The described fluids would have been recognized by a POSITA as “frac fluids”.

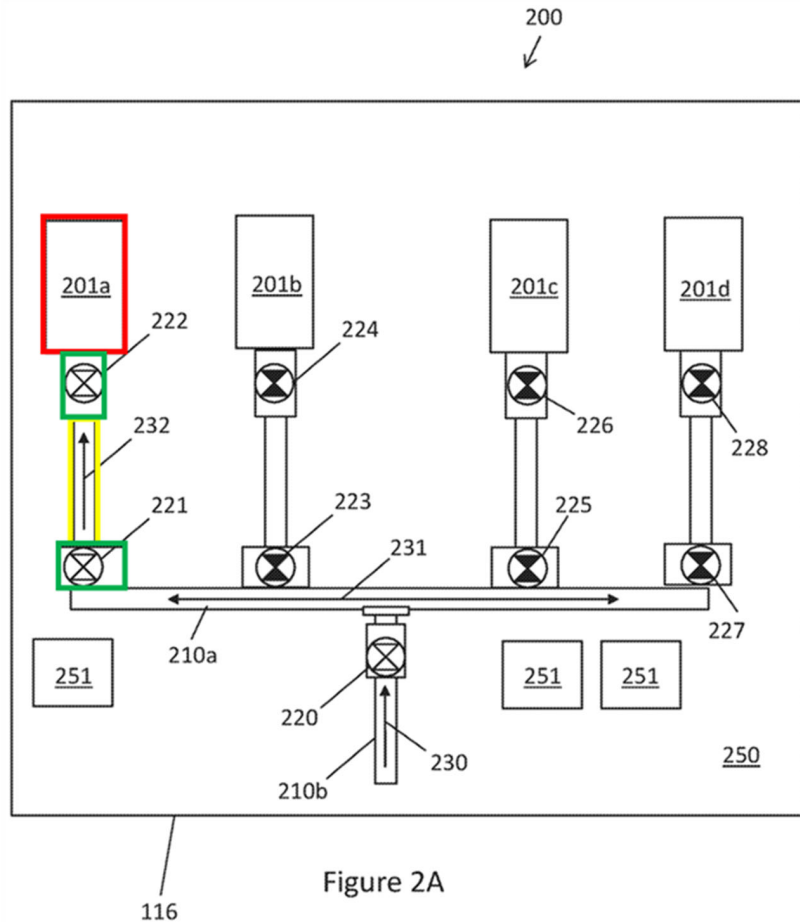
191. As part of this fracturing plan, *Krupa* discloses the method may include pumping fluids into a well (*i.e.*, the claimed second well) via at least one pump manifold by opening an associated set of valves (*i.e.*, the claimed second valve).¹⁵⁰ Because *Krupa* discloses controlling valves to direct frac fluids to the second well as part of a fracturing plan, *Krupa* discloses “permitting hydraulic fracturing of the second well” as claimed. Fig. 2A of *Krupa* shows this configuration of the hydraulic fracturing system. *Krupa* terms the wells and associated valves “first” through

¹⁴⁸ Ex. 1003 at [0018].

¹⁴⁹ Ex. 1003 at [0018].

¹⁵⁰ Ex. 1003 at [0005].

“fourth” merely to distinguish between the wells, but may be renumbered.¹⁵¹ Thus, while Krupa’s Fig. 2A shows fluid flow to a well **201a** labeled as the first well, this well may equally be labeled a second well.



192. As shown in Fig. 2A, the valves **221** and **222** (annotated in green), which are each equivalent to the claimed second valve, are open and allow flow of fracturing fluid into wellhead **201a** (annotated in red), which is equivalent to the

¹⁵¹ Ex. 1003 at [0046].

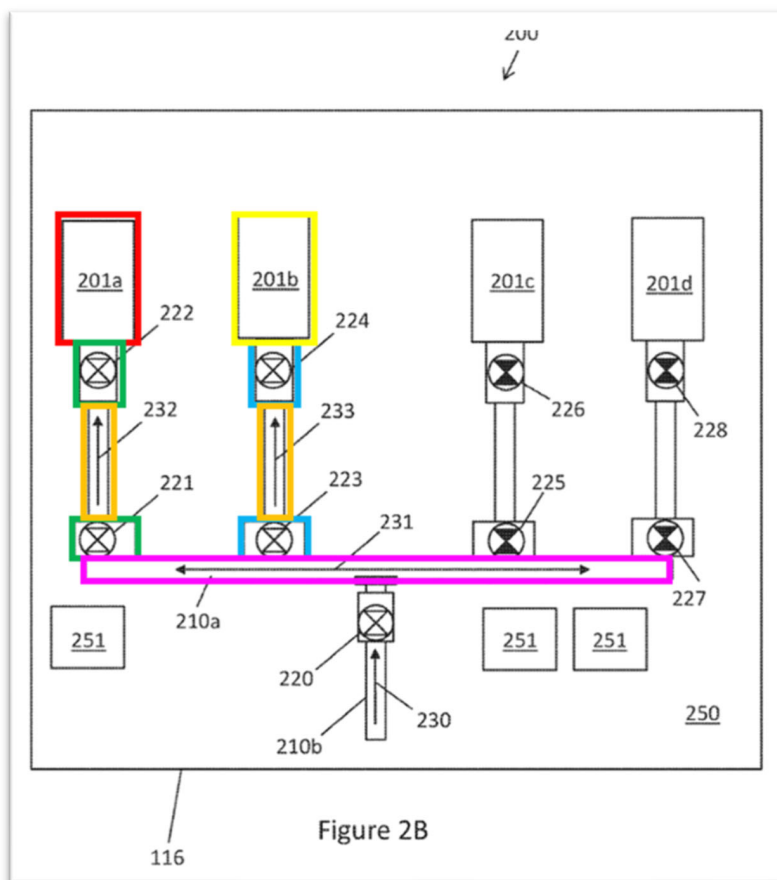
claimed second well. With the flow of fracturing fluid through the second valves **221, 222**, a hydraulic fracturing operation is permitted on the second well **201a**.

193. Accordingly, *Krupa* discloses the limitations of 15.2.1.

- c. **15.2.2: “opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and”**

194. As discussed above and shown in Fig. 2B of *Krupa*, *Krupa* discloses pumping fluids into a second well via at least one pump manifold by opening an associated set of valves.¹⁵²

¹⁵² Ex. 1003 [0005]



195. Accordingly, *Krupa* discloses “opening the second valve associated with the second well” as claimed. Thus, *Krupa* discloses 15.2.2.

d. **15.3: “measuring a flow rate of the fluid being pumped into the second well;”**

196. *Krupa* discloses measuring the flowrate as claimed in element 15.2.2. As discussed above regarding Claim 15.2.1, *Krupa* discloses pumping hydraulic fracturing fluid into a second well via at least one pump manifold by opening a second set of valves.¹⁵³

¹⁵³ Ex. 1003 at [0005].

197. Further, *Krupa* discloses the use of flowmeters, including flowmeters specifically associated with the valve(s) on each wellhead. *Krupa* describes “a wide variety of hydraulic fracturing equipment is used in oil and natural gas fields”¹⁵⁴, and describes this equipment to include “many gauges and meters for *flow rate*, fluid density, treating pressure, etc.”¹⁵⁵ *Krupa* points out that these “plurality of sensors working in conjunction with built hydraulic fracturing system may streamline and improve efficiency... due, in part, to reducing or eliminating human interaction with the hydraulic fracturing systems by automating fracturing operations for continuous pumping in one or more wells.”¹⁵⁶ *Krupa* further explicitly teaches “some of the plurality of sensors **111** may be associated with each of the valves of the wellhead assembly 101” and “the plurality of sensors **111** may be any sensor or device capable of wireline monitoring, valve monitoring, pump monitoring, flow line monitoring, accumulators and energy harvesting, and equipment performance and damage.”¹⁵⁷

198. Accordingly, *Krupa* discloses measuring the flow rate of fluid being pumped into the second well, as claimed in Claim element 15.2.2. To the extent that the Board determines that “measuring a flow rate of the fluid being pumped into the

¹⁵⁴ Ex. 1003 at [0002].

¹⁵⁵ Ex. 1003 at [0002] (emphasis added); *see also* [0014].

¹⁵⁶ Ex. 1003 at [0016].

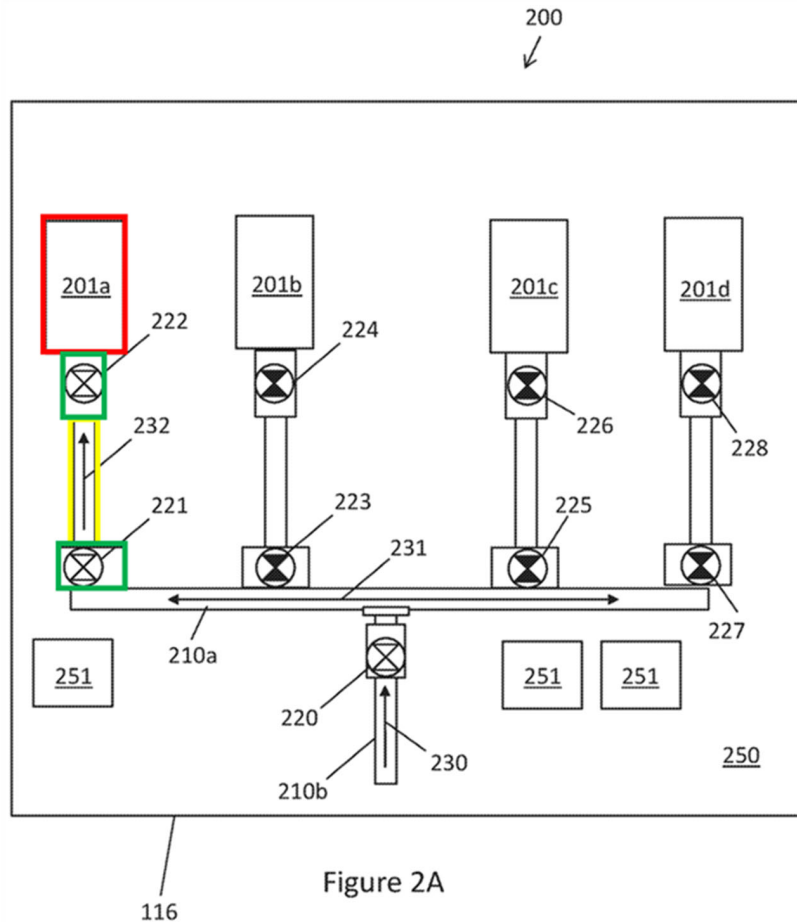
¹⁵⁷ Ex. 1003 at [0024]; *see also* [0028].

second well” is not expressly disclosed by *Krupa* then such a measurement would be obvious from the teachings of *Krupa* that sensors include those for measuring “flow rate” and sensors are “associated with each of the valves of the wellhead assembly”, and the sensors further monitor flow lines. Additionally, this element would have been obvious to a POSITA based on their general engineering knowledge as monitoring flowrate into the well was well-known prior to the ’779 Patent. (See Sections IX.A – IX.F).

e. **15.4.1: “(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising:”**

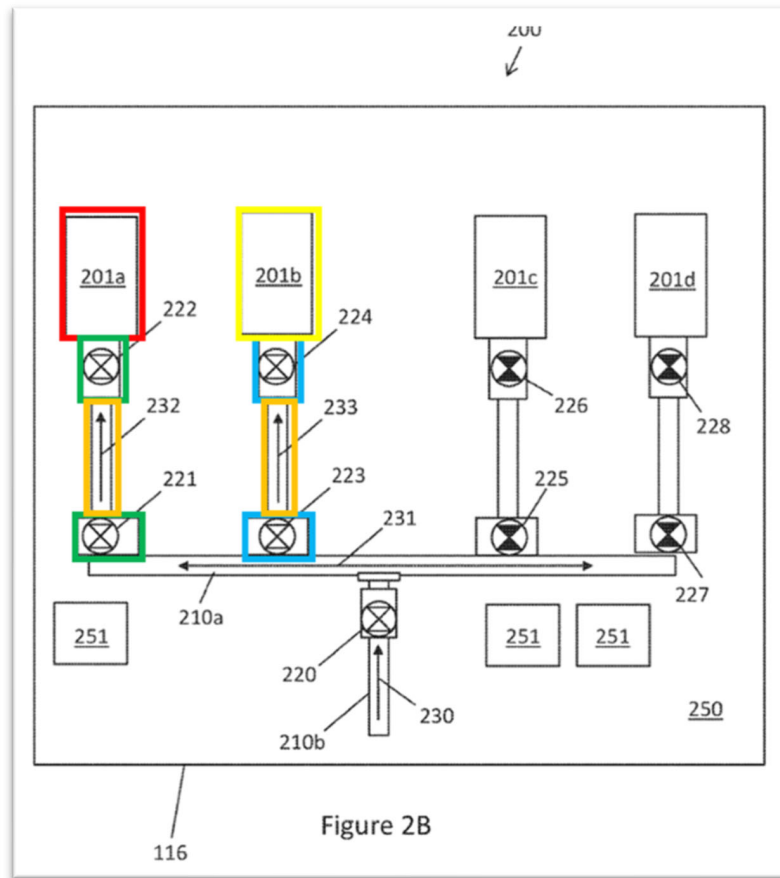
199. *Krupa* discloses the sequence of operations described in this claim element. *Krupa*’s method “may also include pumping the fluids into a second well via at least one pump manifold by ...opening a second set of valves.”¹⁵⁸ Because *Krupa* discloses controlling valves to direct frac fluids to the well as part of a fracturing plan, *Krupa* discloses “permitting hydraulic fracturing of the second well” as claimed. This is shown in Fig. 2A, where the second well is represented by **201a** (annotated in red) and the second valves are represented by **221, 222** (annotated in green).

¹⁵⁸ Ex. 1003 at [0005].



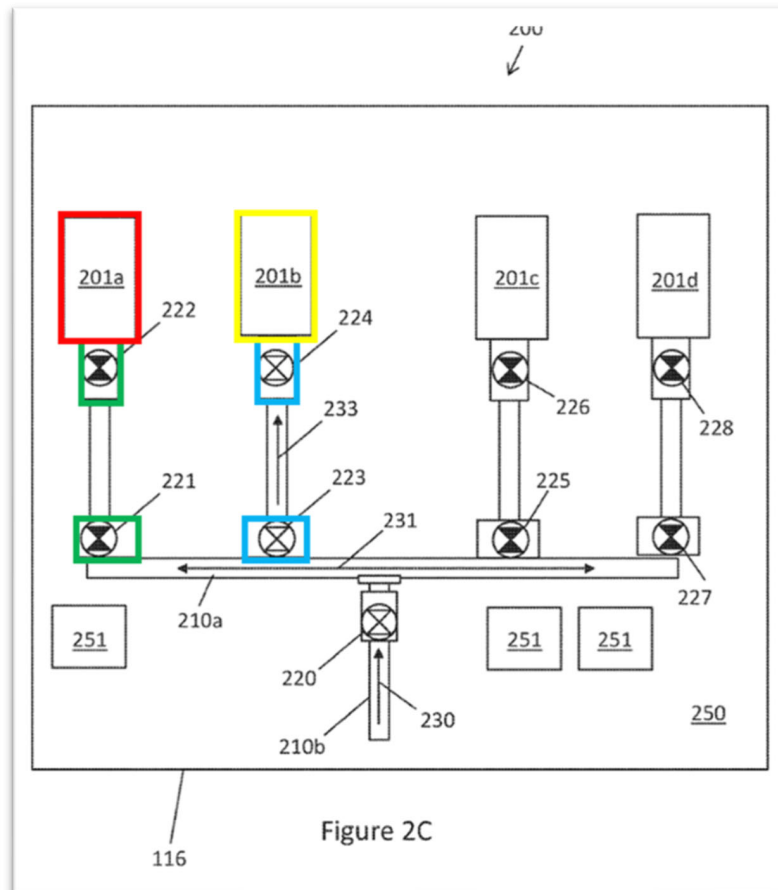
200. *Krupa* further teaches pumping the fluids into another well **201b** (equivalent to the claimed first well) via the at least one pump manifold while continuously pumping the fluids into the second well **201a** by opening another set of valves **223**, **224** (equivalent to the claimed first valve), as shown in Fig. 2B below.¹⁵⁹

¹⁵⁹ Ex. 1003 at [0005].



201. Further still, *Krupa* discloses after the first and second valves are open (with fluid flowing to the respective wells), the second set of valves (valves **221**, **222**) are closed to stop pumping the fluids into the second well (**201a**), thereby isolating and continuously pumping the fluids into the first well (**201b**), as shown in *Krupa's* Fig. 2C below.¹⁶⁰

¹⁶⁰ Ex. 1003 at [0005].



202. By opening valves associated with the first well to direct fluids to the first well and subsequently closing valves associated with the second well, *Krupa* discloses swapping between fracturing the claimed second well and the claimed first well.

203. To the extent that the Board determines that *Krupa* does not explicitly teach swapping from permitting hydraulic fracturing the claimed “second well” to permitting hydraulic fracturing of the claimed “first well”, it would have been obvious to a POSITA, based on the teaching of *Krupa* that “the sequence may be

conducted between any of the wellhead assemblies **201a-201d** in any order,¹⁶¹ to swap from fracturing the “second well” to fracturing the “first well.”

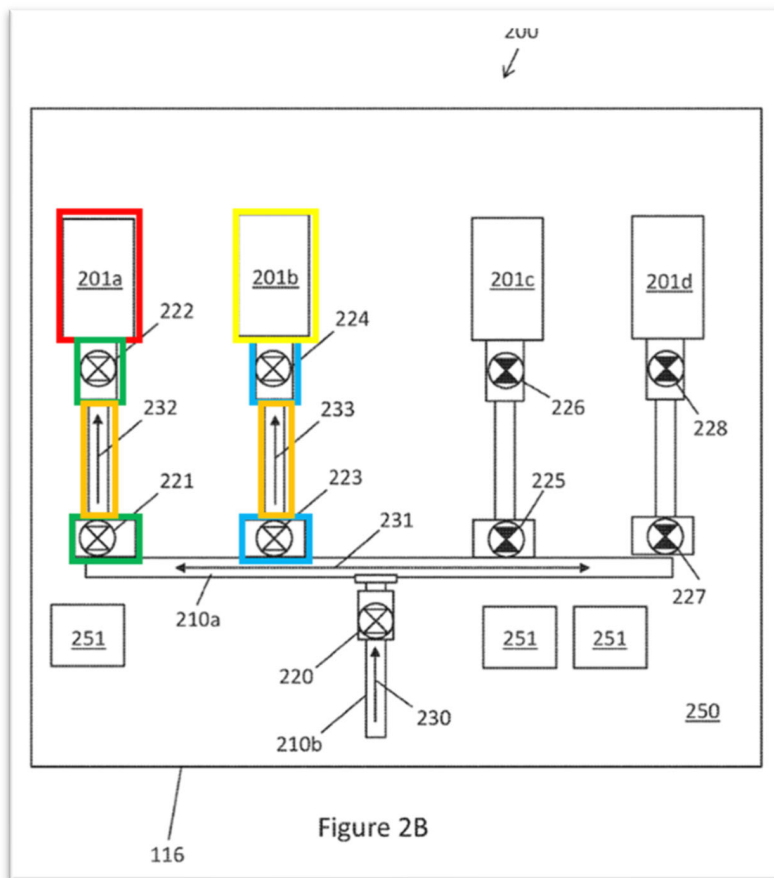
204. Accordingly, *Krupa* discloses, or at least renders obvious, the limitations of 15.4.1.

f. **15.4.2: “opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and”**

205. As discussed above regarding 15.4.1, *Krupa* discloses fracturing methods include “pumping the fluids into a second well [(equivalent to the claimed first well)] via the at least one pump manifold while continuously pumping the fluids into the first well [(equivalent to the claimed second well)] by opening a second set of valves [(equivalent to the claimed first valves)].”¹⁶² This configuration is shown in Fig. 2B.

¹⁶¹ Ex. 1003 at [0046].

¹⁶² Ex. 1003 at [0005].

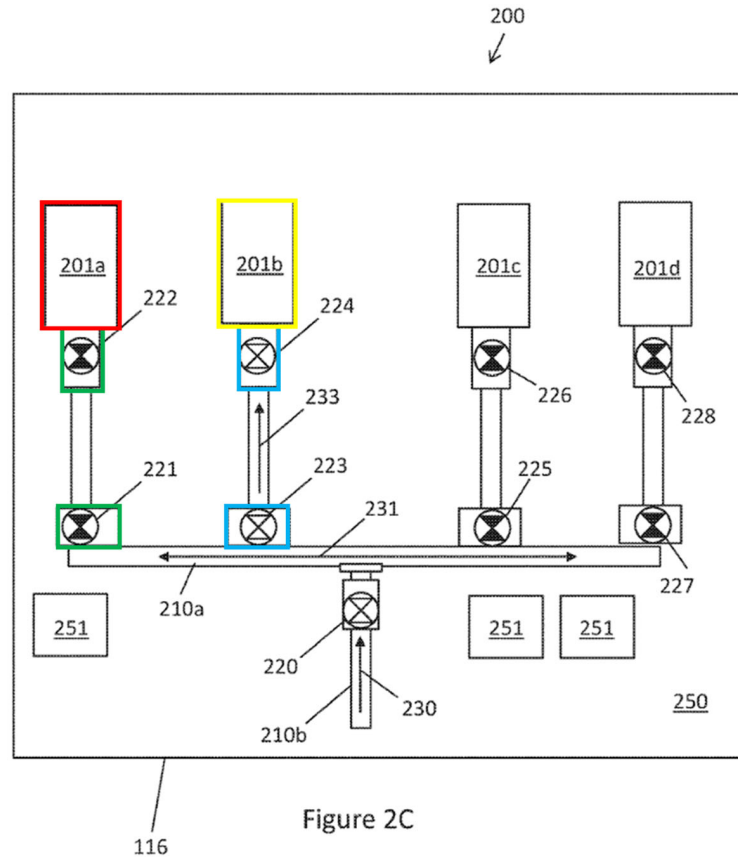


206. Accordingly, *Krupa* discloses the limitation of 15.4.2.

g. **15.4.3: “closing the second valve associated with the second well;”**

207. *Krupa* discloses this limitation. *Krupa* teaches “[t]he method further includes closing the first set of valves [(equivalent to the claimed second valve)] to stop pumping the fluids into the first well [(equivalent to the claimed second well)] and isolating and continuously pumping the fluids into the second well [(equivalent

to the claimed first well)].”¹⁶³ This configuration of the hydraulic fracturing system is shown in Fig. 2C.



208. In Fig. 2C, valves **223**, **224** (claimed first valve, annotated in blue) are open, but valves **221**, **222** (claimed second valve, annotated in green) are closed. This allows fracturing fluid flow into only **201b** (annotated in yellow).

209. Accordingly, *Krupa* discloses the limitations of 15.4.3.

¹⁶³ Ex. 1003 at [0005].

h. **15.5: “wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”**

210. *Krupa* discloses this limitation. *Krupa* describes methods of pumping fluids into a well via at least one pump manifold by opening an associated set of valves and, while continuously pumping the fluids into the well, the fluids are also pumped into a subsequent well via the at least one pump manifold by opening a subsequent set of valves associated with the subsequent well.¹⁶⁴ The method further includes closing the first set of associated valves to stop pumping the fluids into the first well while continuously pumping the fluids into the subsequent well.¹⁶⁵

211. In the disclosure above, hydraulic fracturing fluid is continuously pumped to both sets of valves “via the at least one pump manifold.” *Krupa* further describes continuously pumping to both the first and second valves throughout the specification. As an example, *Krupa* discloses “The fracturing plan may include pre-made instructions to perform at least one continuous pumping operations for one or more wells.”¹⁶⁶ As another example, *Krupa* discloses “The system may also include at least one continuous pumping operations for one or more wells and a fracturing

¹⁶⁴ Ex. 1003 at [0005], FIGS. 2A-2G.

¹⁶⁵ Ex. 1003 at [0005], FIGS. 2A-2G.

¹⁶⁶ Ex. 1003 at [0006].

pumping plan provided on a software application.”¹⁶⁷ Further examples can be found throughout *Krupa*.¹⁶⁸

212. Accordingly, *Krupa* discloses the limitation of 15.5.

- i. **15.6: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”**

213. *Krupa* discloses determining that the flowrate measured at step a) (Limitation 15.3) has satisfied one or more flowrate conditions and then using that determination to make valve changes, as claimed in limitation 15.6. *Krupa* teaches establishing a “full pump rate, such as a rate of about 50-150 bbl./min”, or a reduced pump rate of “5-15 bbl./min”.¹⁶⁹ A POSITA, as discussed regarding 15.3, would have understood that these flowrates are measured flowrates as *Krupa* teaches a variety of sensors including those for measuring “flow rate,” and sensors are “associated with each of the valves of the wellhead assembly,” and further the sensors monitor flow lines. These measured flow values are used to determine whether the flowrate has satisfied various flowrate conditions such as a pump rate of “5-15 bbl./min”, “[o]nce a total volume of the flush fluid is pumped” or “[o]nce

¹⁶⁷ Ex. 1003 at [0007].

¹⁶⁸ See, e.g., Ex. 1003 at [0016], [0017], [0042]-[0046], [0058]-[0059], Claims 1, 10-14, 20.

¹⁶⁹ Ex. 1003 at [0042].

a pressure has stabilized at the reduced pump rate,” and *Krupa* uses these satisfied conditions to determine when to move to the next step of the fracturing plan (i.e., open or close the next set of valves or make a flowrate change), which would include opening a first valve to a first well before closing a second valve to a second well, as discussed above regarding 15.4.2 – 15.4.3.¹⁷⁰

214. Accordingly, *Krupa* discloses the limitations of 15.6. To the extent that the Board determines that the various conditions including specific flow rate ranges, “pressure has stabilized at the reduced pump rate,” “injection is established” do not explicitly teach “determining that the flow rate has satisfied one or more conditions”, then such a determination would have been obvious to a POSITA based on the teachings of *Krupa* regarding using well fluid conditions as tests before moving to the next step.

215. Further, to the extent it is argued that the fluid being measured in the examples above is a “flush fluid” and is not a fracturing fluid¹⁷¹, it would have been obvious to a POSITA to apply the teachings of measuring a flowrate of a flush fluid to that of a fracturing fluid, particularly in light of the teaching of *Krupa* that

¹⁷⁰ See, e.g., Ex. 1003 at [0005], [0042]-[0045].

¹⁷¹ A flush fluid is part of the hydraulic fracturing process and not only flushes proppant out of the wellbore but also “pads” the beginning of the next stage by opening fractures before proppant is pumped. Accordingly a “flush fluid” is a fracturing fluid.

“fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected path and/or control pressure and pump rates within the system. ... Further, fluids may refer to slurries, liquids, gases, and/or mixtures thereof. In some embodiments, solids may be present in the fluids.”¹⁷²

216. Accordingly, *Krupa* discloses, or at least renders obvious, the limitations of 15.6.

- j. **15.7: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”**

217. Claim element 15.7 is the second prong of an “OR” statement in claim 15. As discussed above regarding 15.6, the first prong of the “OR” clause is satisfied by the disclosures of *Krupa* and, as a result, *Krupa* anticipates, or at least renders obvious, the entire “OR” statement.

218. Nevertheless, the remaining second prong of 15.7 is also disclosed by *Krupa*. The claimed sequence of valves (*i.e.*, opening the first valve after or during closing of the second valve) was well-known to a POSITA as a “conventional” or non-continuous fracturing operation, and is taught by *Krupa*. *Krupa* discloses “steps

¹⁷² Ex. 1003 at [0018].

of a typical frac operation may include ... shutting in of the first well [claimed second well], then moving to the next well [claimed first well].”¹⁷³

219. Accordingly, *Krupa* discloses both optional prongs of limitation 15.7.

220. To the extent the Board determines that *Krupa* does not explicitly teach the sequence of valve operations (*i.e.*, opening first valve after/during closing second valve) in response to flowrate conditions being met, this would have been obvious to a POSITA. As discussed above, continuous operations (*i.e.*, opening first valve while second valve is still open) are taught by *Krupa* as being allowed by certain flowrate conditions. Absent flowrate conditions that would allow continuous pumping, a POSITA would have known that, in the alternative, the proper response would be to revert to conventional valve sequences. In other words, if the system of *Krupa* determines that continuous pumping operations should not proceed, then the backup would, obviously, be conventional fracturing operations (*i.e.*, opening the first valve only after the second valve is closed).

221. Because *Krupa* discloses each and every element of claim 15, claim 15 is anticipated by *Krupa*. To the extent that the Board finds claim 15 is not anticipated by *Krupa*, claim 15 is obvious over *Krupa* alone for the reasons discussed above.

¹⁷³ Ex. 1003 at [0058].

J. DEPENDENT CLAIM 16

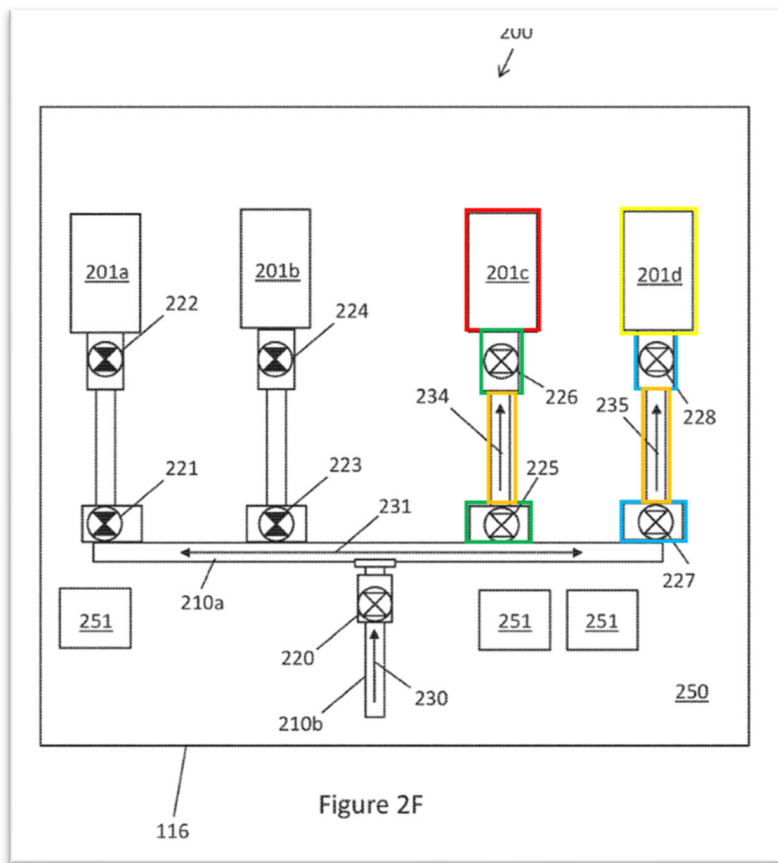
222. Dependent Claim 16 depends from Claim 15. In addition to the disclosure of the limitations of Claim 15 discussed above, *Krupa* discloses the additional limitations of Claim 16:

- a. **16.1: “16. The method of claim 15, wherein the plurality of wells further comprises third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein the method further comprises:”**

223. *Krupa* discloses this limitation. *Krupa* describes a system containing “a third wellhead assembly **201c** of a third well, [(equivalent to the claimed fourth well)]” and “a fourth wellhead assembly **201d** of a fourth well [(equivalent to the claimed third well)]”.¹⁷⁴ *Krupa* further discloses third and fourth wellheads associated with third and fourth valves in a series of Figures (Figure 2A – Figure 2G). In Figures 2A – 2G, “closed valves are shown as blacked out while open valves are shown having no fill, thereby indicating the available path of fluid flow (see arrows 230-235) through the system.”¹⁷⁵ Figure 2F is shown below as a representative example.

¹⁷⁴ Ex. 1003 at [0038].

¹⁷⁵ Ex. 1003 at [0040].



Ex. 1003, Figure 2F.

224. With reference to Figure 2F (and also applicable to Figures 2A – 2G) *Krupa* identifies the various components in the figures including “third wellhead assembly **201c** of a third well [claimed fourth well, annotated in red], and a fourth wellhead assembly **201d** of a fourth well [claimed third well, annotated in yellow].”¹⁷⁶ *Krupa* further describes the valves shown in the figures by teaching with “the third set of valve **225**, **226** [claimed fourth valve annotated in green] open, the flush fluid flows ... into ... the third wellhead assembly **201c** [claimed fourth

¹⁷⁶ Ex. 1003 at [0038].

well],”¹⁷⁷ and with “the fourth set of valves **227, 228** [claimed third valve annotated in blue] open the flush fluid flows ... into ... the fourth wellhead assembly **201d** [claimed third well]”.¹⁷⁸ Accordingly, *Krupa* discloses third and fourth valves associated with third and fourth wells.

225. Thus, *Krupa* discloses, claim limitation 16.1.

226. To the extent that Patent Owner argues that the fluid being measured and switched in the examples above is a “flush fluid” and is not a fracturing fluid,¹⁷⁹ it would have been obvious to a POSITA to apply the teachings of measuring a flowrate of a flush fluid to that of a fracturing fluid, particularly in light of the teaching of *Krupa* that “fracturing plans may include automating valves within the hydraulic fracturing system to have a valve sequencing (e.g., opening and closing) to direct fluids (e.g., frac fluid) in a selected path and/or control pressure and pump rates within the system. [] Further, fluids may refer to slurries, liquids, gases, and/or mixtures thereof. In some embodiments, solids may be present in the fluids.”¹⁸⁰

¹⁷⁷ Ex. 1003 at [0044].

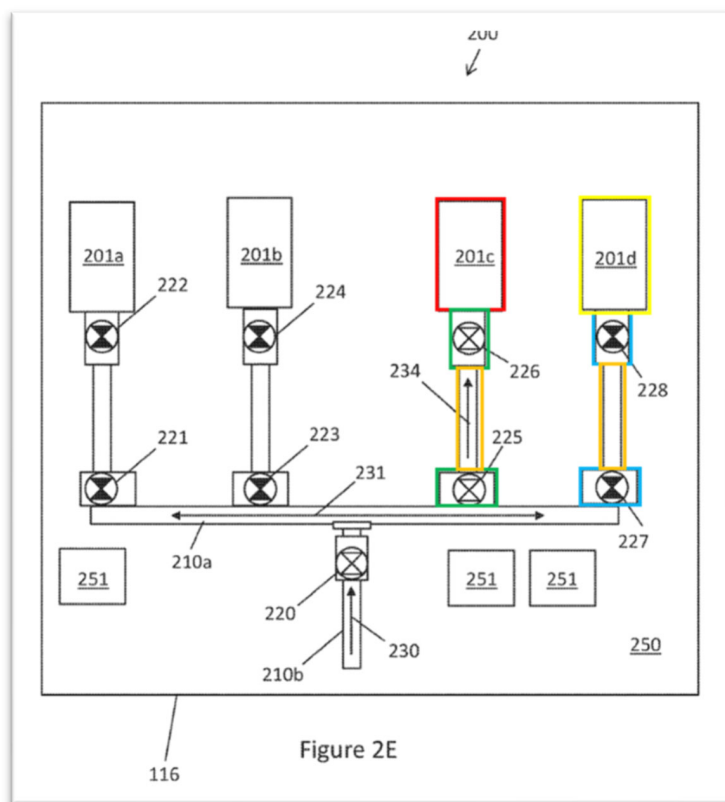
¹⁷⁸ Ex. 1003 at [0045].

¹⁷⁹ A flush fluid is part of the fracturing process and not only flushes proppant out of the wellbore but also “pads” the beginning of the next stage by opening fractures before proppant is pumped. Accordingly a “flush fluid” is a fracturing fluid.

¹⁸⁰ Ex. 1003 at [0018].

b. **16.2: “(c) permitting hydraulic fracturing of the fourth well; and”**

227. *Krupa* discloses this limitation. “In FIG. 2E, the third wellhead assembly **201c** [(equivalent to the claimed fourth well)] may be isolated and hydraulic fracturing operations may be conducted.”¹⁸¹ Fig. 2E also shows the valves **225**, **226** (annotated in green) associated with the wellhead assembly **201c** (equivalent to the claimed fourth well) in the “open” configuration to allow fluid flow **234** into the well.¹⁸²



¹⁸¹ Ex. 1003 at [0045].

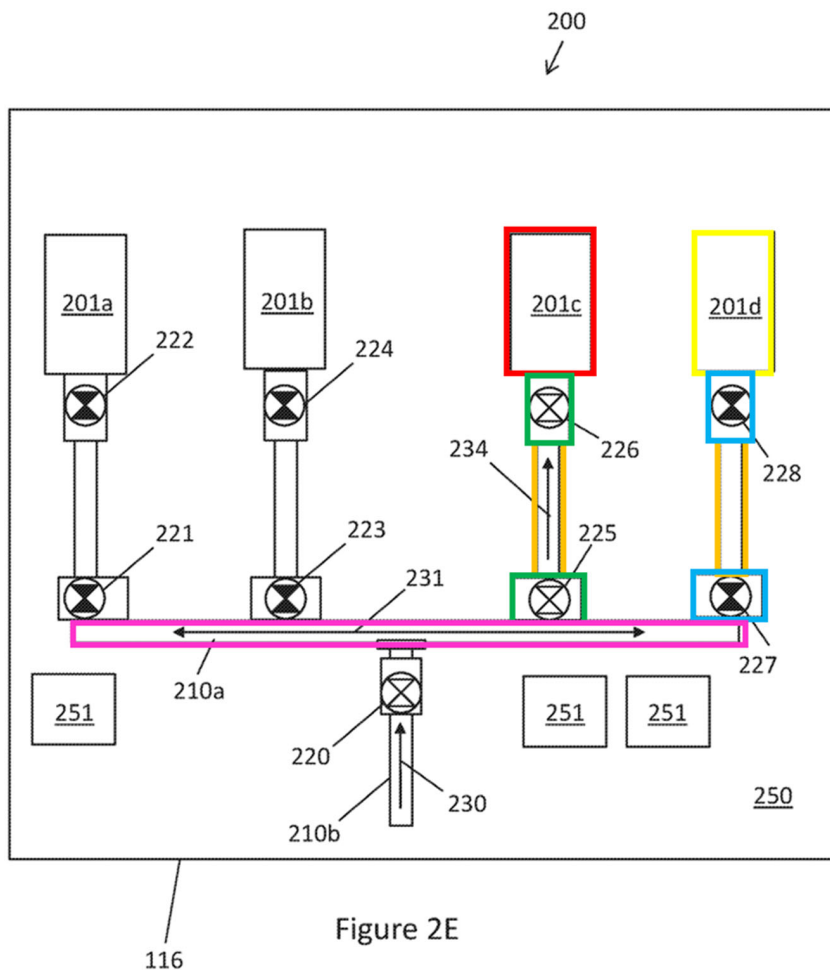
¹⁸² See Ex. 1003 at [0045].

228. Thus, *Krupa* discloses permitting hydraulic fracturing of the fourth well.

- c. **16.3: “(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.”**

229. *Krupa* discloses the sequence of operations described in this claim element. *Krupa* teaches, “In FIG. 2E, the third wellhead assembly **201c** [(equivalent to the claimed fourth well, annotated in red)] may be isolated and hydraulic fracturing operations may be conducted.”¹⁸³

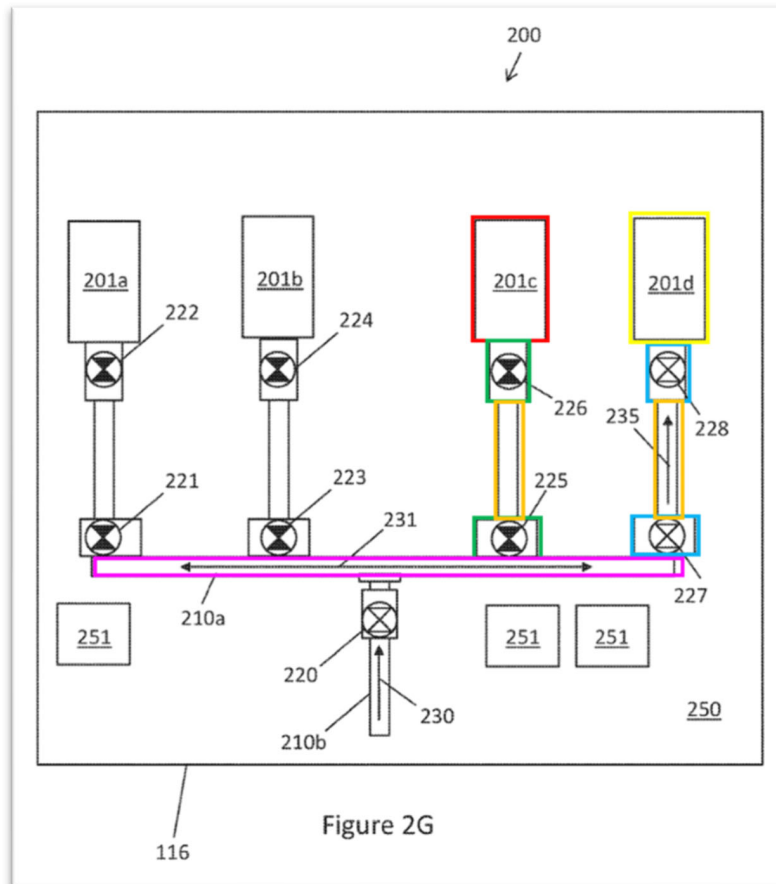
¹⁸³ Ex. 1003 at [0045].



230. Further, after hydraulic operations are concluded on the fourth well “[a]s shown by Fig. 2F, the fracturing pumping plan may next open a fourth set of valves **227**, [(equivalent to the claimed third valve)] **228** while the third set of valves **225**, [(equivalent to the claimed fourth valve)] **226** are still open.”¹⁸⁴ After certain fluid conditions are met, *Krupa* discloses “the third set of valves **225**, [(claimed fourth valve)] **226** may be closed remotely to shut in the third wellhead assembly **201c**, [(claimed fourth well)] as shown by FIG. 2G. In FIG. 2G, the fourth wellhead

¹⁸⁴ Ex. 1003 at [0045].

assembly **201d** [(claimed third well)] may be isolated and hydraulic fracturing operations may be conducted.”¹⁸⁵



231. Accordingly, *Krupa* discloses the limitations of 16.3. Therefore, Claim 16 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

¹⁸⁵ Ex. 1003 at [0045].

K. DEPENDENT CLAIM 17

232. Dependent Claim 17 depends from Claim 16. In addition to the disclosure of the limitations of Claim 16 discussed above, *Krupa* discloses the additional limitations of Claim 17:

- a. **“17. The method of claim 16, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.”**

233. *Krupa* teaches simultaneous injection of fracturing fluid into multiple wells simultaneously. For example, Claim 10 of *Krupa* discloses “A method, comprising: providing a fracturing pumping plan on a software application, the fracturing plan comprising pre-made instructions to perform at least one continuous pumping operations for one or more wells; executing the fracturing pumping plan to perform the at least one continuous pumping operations in a built hydraulic fracturing system coupled to the one or more wells.”¹⁸⁶ Claim 13 of *Krupa* discloses “The method of claim 10, wherein the pre-made instructions further comprise instructions to simultaneously perform the at least one continuous pumping operations on a plurality of wells, different than the one or more wells, coupled to the built hydraulic fracturing system.”¹⁸⁷

¹⁸⁶ Ex. 1003 at Claim 10.

¹⁸⁷ Ex. 1003 at Claim 13.

234. Continuously pumping fracturing fluid is disclosed by *Krupa* throughout the specification. As an example, *Krupa* discloses “The fracturing plan may include pre-made instructions to perform at least one continuous pumping operations for one or more wells.”¹⁸⁸ As another example, *Krupa* discloses in Figs. 2A-G pumping fluid continuously through a manifold (shown by fluid flow arrow 231) as valves to selected wells are opened/closed to direct the pumped fluid to the selected wells, where the fluid may be a frac fluid.¹⁸⁹ Further examples can be found throughout *Krupa*.¹⁹⁰

235. Accordingly, *Krupa* discloses the limitations of Claim 17.

236. To the extent that the Board determines that *Krupa* does not explicitly teach simultaneous fracturing the second and fourth wells and simultaneous fracturing the first and third wells, simultaneous fracturing of the selected pairs of wells would have been obvious based on *Krupa*’s teaching that the operations “may be conducted between any of the wellhead assemblies ... in any order.”¹⁹¹ Further, *Krupa* also teaches “the sequence may be conducted from one wellhead assembly to

¹⁸⁸ Ex. 1003 at [0006].

¹⁸⁹ Ex. 1003 at [0018] and Figs. 2A-G.

¹⁹⁰ See, e.g., Ex. 1003 at [0016], [0017], [0042]-[0046], [0058]-[0059], Claims 1, 10-14, and 20.

¹⁹¹ Ex. 1003 at [0046].

a plurality of wellhead assemblies,”¹⁹² which would include the first and third wells and second and fourth wells claimed.

237. Further simultaneous pumping as claimed would have been obvious to a POSITA having general engineering knowledge of simultaneous and zipper fracturing operations based on the teachings of *Krupa* regarding simultaneous fracturing. (See Sections IX.C – IX.D). Therefore, Claim 17 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

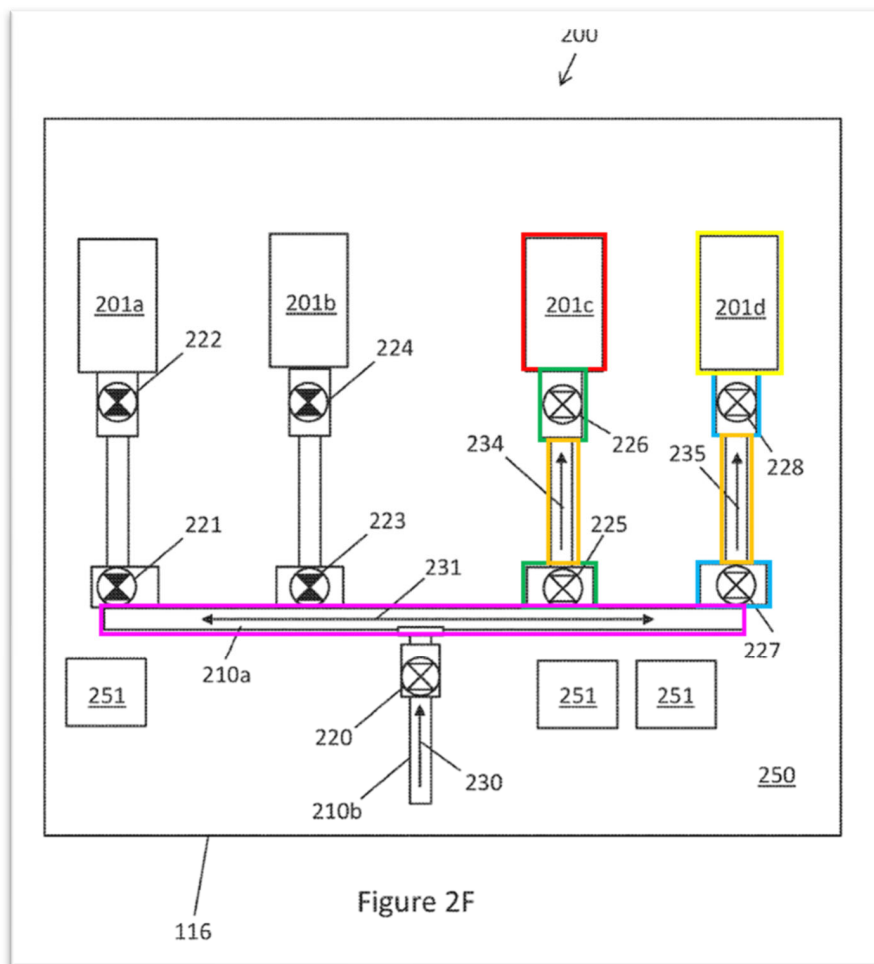
L. DEPENDENT CLAIM 18

238. Dependent Claim 18 depends from Claim 16. In addition to the disclosure of the limitations of Claim 16 discussed above, *Krupa* discloses the additional limitations of Claim 18:

- a. **18.1: “18. The method of claim 16, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;”**

239. *Krupa* discloses this limitation. As described above regarding Claim 16, hydraulic operations are conducted using at least manifold **210a** (annotated in pink below).

¹⁹² Ex. 1003 at [0046].



240. As can be seen in Figure 2F, fracturing fluid is continuously pumped via zipper manifold **210a** to both the claimed fourth valve (valve **225**) and the claimed third valve (valve **227**). This is even made clearer in the text of the specification of *Krupa*. While describing the swap from hydraulic fracturing well **201c** to well **201d** (where well **201c** is equivalent to the claimed “fourth well” and well **201d** is equivalent to the claimed “third well”), *Krupa* discloses: “With both the third set of valves **225**, **226** [(claimed fourth valve)] and the fourth set of valves **227**, **228** [(claimed third valve)] open, the ... fluid flows (see arrows **234**, **235**) into

both the third wellhead assembly **201c** [(claimed fourth well)] and the fourth wellhead assembly **201d**” (claimed third well).¹⁹³ Further still, teaching of continuous pumping of fracturing fluid to the valves and associated wells is contained throughout *Krupa*.¹⁹⁴

241. Accordingly, *Krupa* discloses 18.1, both in the figures and in the text of the specification.

242. To the extent that the Board determines that *Krupa* does not explicitly teach continuously pumping fluid to both the third and fourth valves via a hydraulic manifold, it would have been obvious to a POSITA having general engineering knowledge (*see* Sections IX.A – IX.F), based on the teaching of *Krupa*, as the use of manifolds was well established in the hydraulic fracturing field long before the ‘779 Patent.

b. **18.2: “wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and”**

243. *Krupa* discloses this limitation. Step (c) of Claim 16 is “permitting hydraulic fracturing of the fourth well.” *Krupa* discloses opening the fourth valve in order to permit hydraulic fracturing fluid of the fourth well. *Krupa* teaches

¹⁹³ Ex. 1003 at [0045].

¹⁹⁴ *See, e.g.*, Ex. 1003 at [0005]-[0007], [0016], [0017], [0042]-[0046], [0058]-[0059], and Claims 1, 10-14, and 20.

“Referring to FIG. 2D, in one or more embodiments, the fracturing pumping plan may next open a third set of valves **225, 226** [(i.e., claimed fourth valve), and with] the third set of valves **225, 226** [(i.e., claimed fourth valve)] open, the ... fluid flows (see arrows **233, 234**) into ... the third wellhead assembly **201c** [(i.e., claimed fourth well)]. ...In FIG. 2E, the third wellhead assembly **201c** [(i.e., claimed fourth well)] may be isolated and hydraulic fracturing operations may be conducted.”¹⁹⁵ Accordingly, *Krupa* teaches opening the fourth valve **225** in order to permit pumping of fluid into the fourth well through wellhead **201c** and valve **225**.

244. Thus, *Krupa* discloses limitation 18.2.

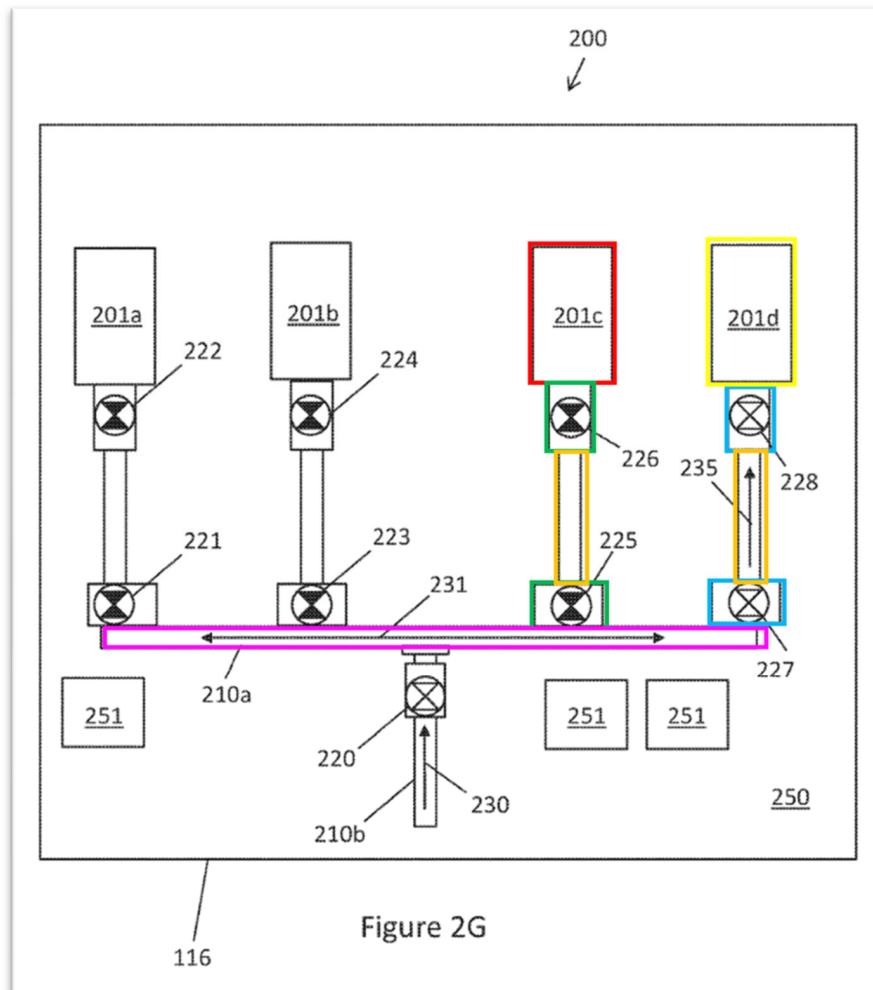
- c. **18.3.1: “wherein step (d) comprises opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and”**

245. *Krupa* discloses this limitation. Step (d) of Claim 16 is “swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.” *Krupa* teaches “the fracturing pumping plan may next open a fourth set of valves **227, 228** [(i.e., claimed third valve)]”¹⁹⁶ to allow fluid to flow into the third wellhead assembly **201d**, as shown by fluid flows (see arrows **234, 235**) into both the third wellhead assembly **201d** and the fourth wellhead assembly

¹⁹⁵ Ex. 1003 at [0044]-[0045].

¹⁹⁶ Ex. 1003 at [0045].

201c.¹⁹⁷ *Krupa* further discloses, “[i]n Fig. 2G, the fourth wellhead assembly **201d** [(i.e., claimed third well)] may be isolated and hydraulic fracturing operations may be conducted.”¹⁹⁸



246. Thus, *Krupa* discloses Limitation 18.3.1.

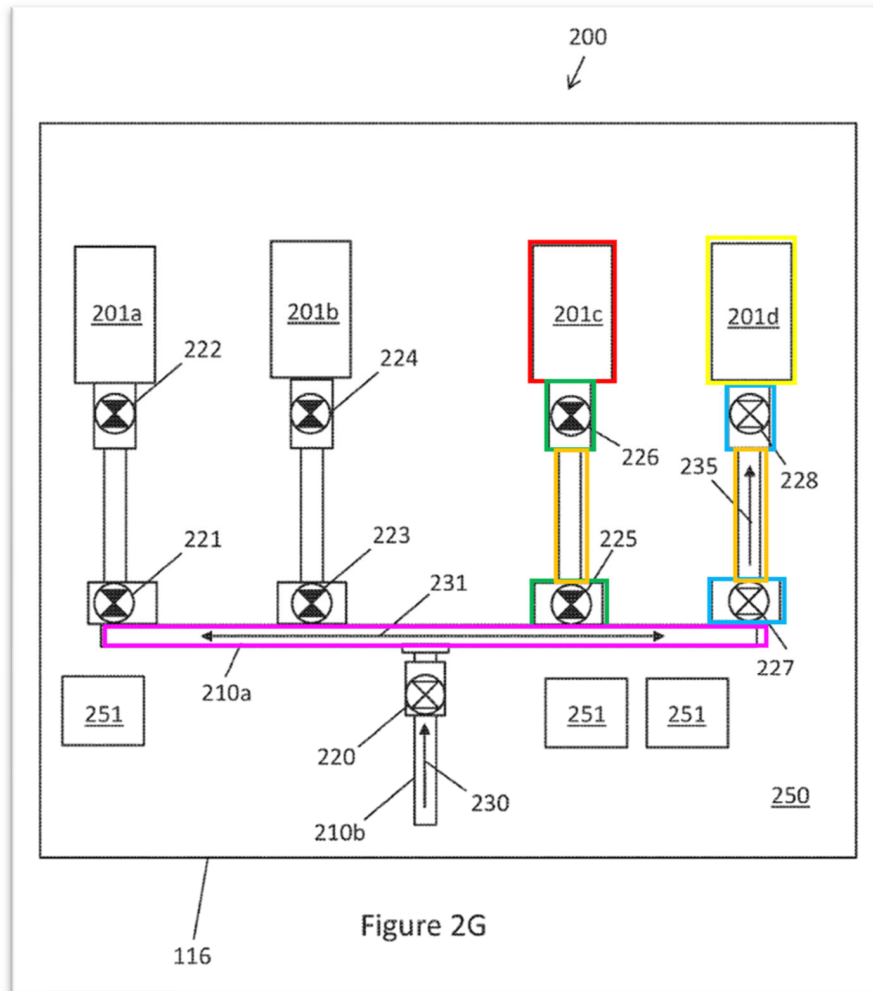
¹⁹⁷ Ex. 1003 at [0045].

¹⁹⁸ Ex. 1003 at [0045].

d. **18.3.2: “closing the fourth valve associated with the fourth well.”**

247. *Krupa* discloses this limitation. *Krupa* teaches, during the swap from the fourth well to the third well, “Once injection is established and pressure has stabilized in both the third wellhead assembly **201c** [(i.e., claimed fourth well)] and the fourth wellhead assembly **201d** [(i.e., claimed third well)], the third set of valves **225, 226** [(i.e., claimed fourth valve)] may be closed remotely to shut in the third wellhead assembly **201c** [(i.e., claimed fourth well)], as shown by Fig. 2G.”¹⁹⁹

¹⁹⁹ Ex. 1003 at [0045].



248. Accordingly, *Krupa* discloses Limitation 18.3.2. Therefore, Claim 18 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

M. INDEPENDENT CLAIM 25

249. It is my opinion that *Krupa* discloses and anticipates Claim 25 or at least renders obvious Claim 25 of the '779 Patent. With the exception of this being an “apparatus” claim, and the claim further containing a description of structure of the apparatus, namely known computer elements for executing instructions, Claim

25 is essentially identical to Claim 15. As discussed below, *Krupa* contains disclosure of apparatus structure which is strikingly similar to that of Claim 25 of the '779 Patent.

- a. **25.1: “25. An apparatus adapted to hydraulically fracture first and second wells, the first and second wells being associated with first and second valves, respectively, the apparatus comprising:”**

250. To the extent the preamble is limiting, *Krupa* discloses the preamble.²⁰⁰ The title of *Krupa* is “System and Method for an Automated and Intelligent Frac Pumping”. A POSITA would have recognized “frac pumping” to refer to pumping related to hydraulic fracturing. *Krupa* further describes “a built hydraulic fracturing system ... in fluid communication with one or more wells” as well as “instructions to perform at least one continuous pumping operations for the one or more wells,”²⁰¹ which are each examples of hydraulic fracturing. Further, *Krupa* describes a system containing “a first wellhead assembly **201a** of a first well, [and] a second wellhead assembly **201b** of a second well”.²⁰² References to hydraulic fracturing a plurality of wells, including a first and a second well appear throughout *Krupa*.

²⁰⁰ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 25 out of an abundance of caution.

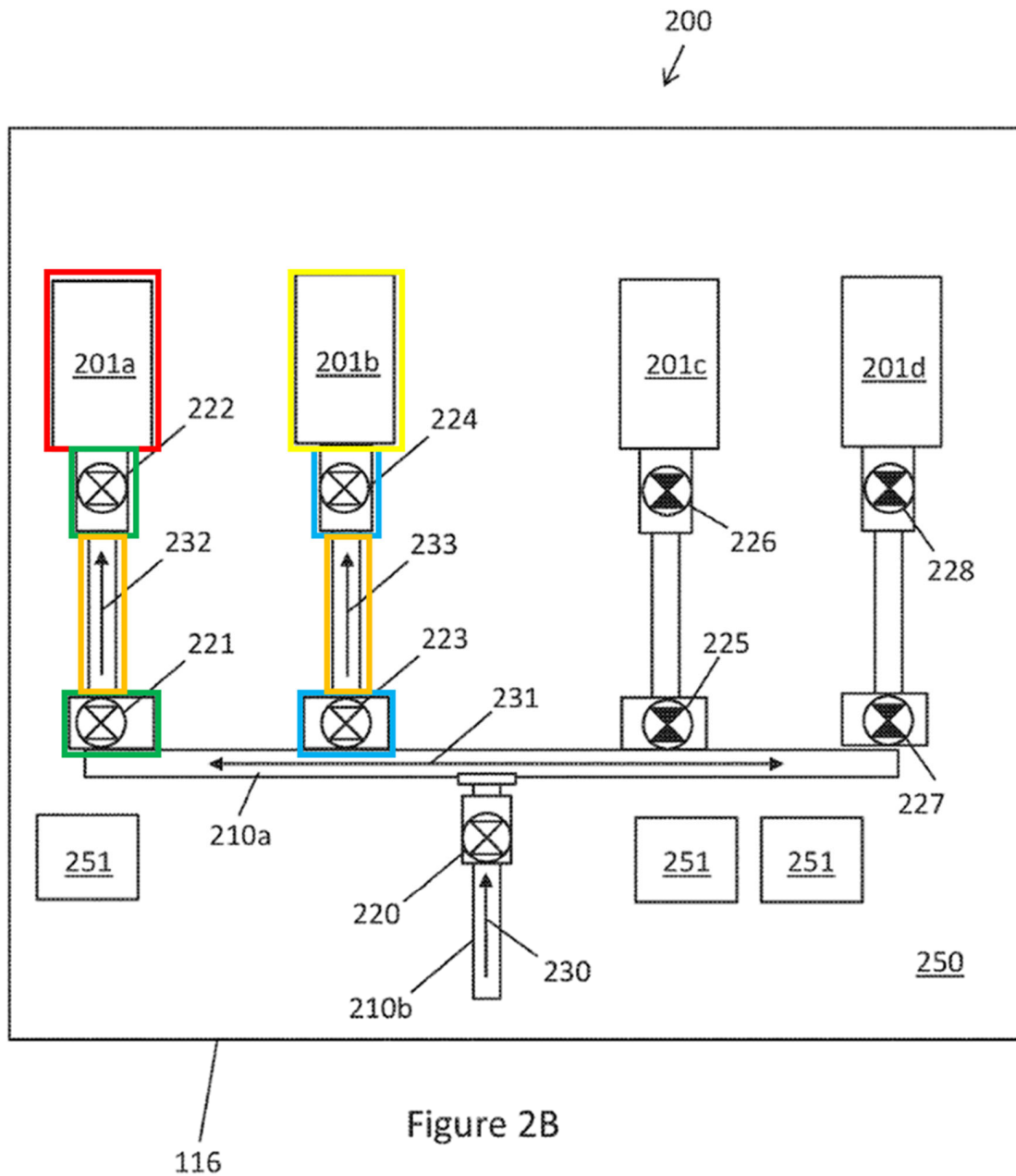
²⁰¹ Ex. 1003 at Abstract.

²⁰² Ex. 1003 at [0038].

251. *Krupa* further discloses “first and second wells being associated with first and second valves.” *Krupa* discloses “pumping fluids into a first well ... by opening a first set of valves. The method may also include pumping the fluids into a second well ... by opening a second set of valves.”²⁰³ For illustrative purposes in Figures 2A-2G “closed valves are shown as blacked out while open valves are shown having no fill, thereby indicating the available path of fluid flow (see arrows 230-235) through the system.”²⁰⁴ *Krupa* further discloses first and second wellheads associated with first and second valves in a series of Figures (Figures 2A-2G). Figure 2B is shown below as a representative example.

²⁰³ Ex. 1003 at [0005].

²⁰⁴ Ex. 1003 at [0040].



Ex. 1003, Figure 2B.

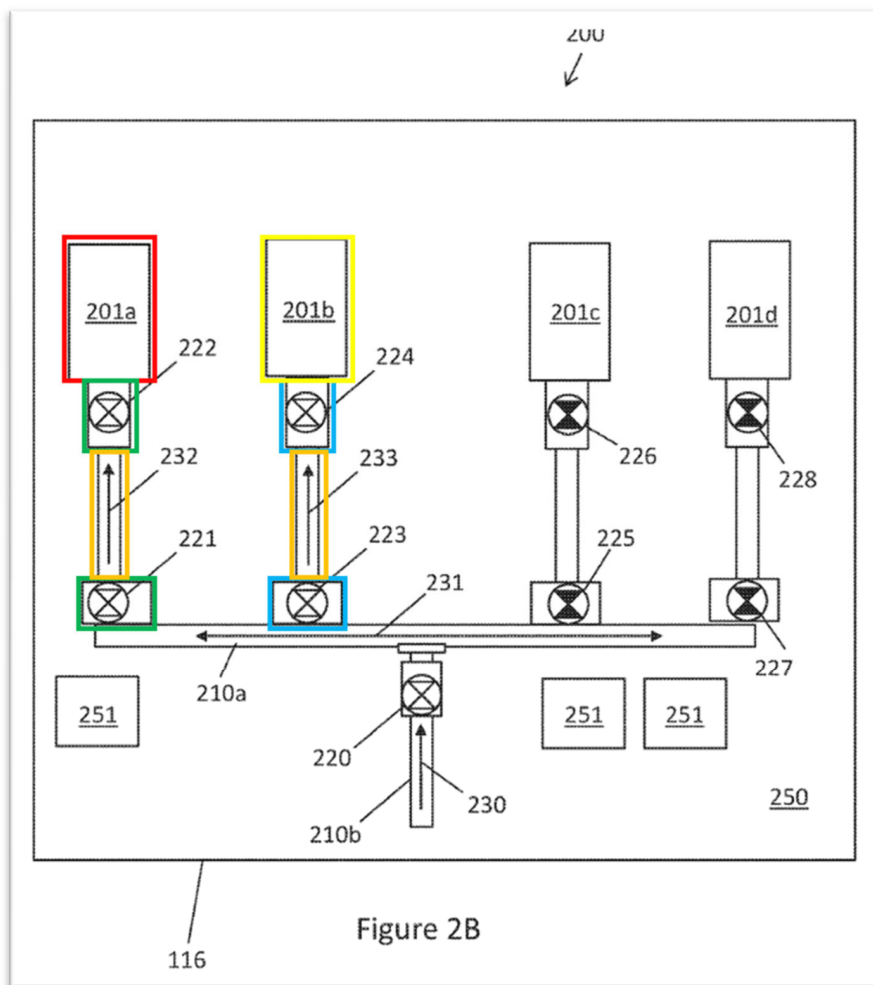
252. With reference to Figure 2B (and also applicable to Figures 2A-2G) *Krupa* identifies the various components in the figures including “first wellhead assembly **201a** of a first well [annotated in red], [and] a second wellhead assembly

201b of a second well [annotated in yellow].”²⁰⁵ *Krupa* further describes the valves shown in the figures including pumping fluid “into the first wellhead assembly **201a** via a first set of valves **221, 222** [annotated in green]”²⁰⁶ and “a second set of valves **223, 224** [annotated in blue]” which are opened to allow hydraulic fracturing pumping into the second well via wellhead assembly **201b**: “[w]ith both the first set of valves **221, 222** and the second set of valves **223, 224** open, the fluish fluid flows (see arrows **232, 233**) [annotated in orange] into both the first wellhead assembly **201a** and the second wellhead assembly **201b**.”²⁰⁷

²⁰⁵ Ex. 1003 at [0038].

²⁰⁶ Ex. 1003 at [0042].

²⁰⁷ Ex. 1003 at [0043].



253. Thus, *Krupa* discloses an apparatus adapted to hydraulically fracture first and second wells (201a, 201b), the first and second wells being associated with first and second valves (221, 223), respectively. Accordingly, *Krupa* discloses the preamble of Claim 25.

b. 25.2: “a non-transitory computer readable medium; and”

254. *Krupa* discloses “[s]oftware instructions in the form of computer readable program code to perform embodiments of the disclosure may be stored, in whole or in part, temporarily or permanently, *on a non-transitory computer readable*

*medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium.”*²⁰⁸

255. Accordingly, *Krupa* discloses, and, therefore, anticipates “a non-transitory computer readable medium.”

- c. **25.3: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed:”**

256. *Krupa* discloses the limitations of Claim 25.3. When describing its’ apparatus and system, *Krupa* discloses “[s]oftware instructions in the form of computer readable program code to perform embodiments of the disclosure may be stored, in whole or in part, temporarily or permanently, on a non-transitory computer readable medium such as a CD, DVD, storage device, a diskette, a tape, flash memory, physical memory, or any other computer readable storage medium. Specifically, the software instructions may correspond to computer readable program code, that when executed by a processor(s), may perform one or any of the automated hydraulic fracturing systems features described herein, including that associated with data interpretation and automated hydraulic fracturing pumping systems.”²⁰⁹

²⁰⁸ Ex. 1003 at [0032] (emphasis added).

²⁰⁹ Ex. 1003 at [0032] (emphasis added).

257. A POSITA would have immediately equated the “software instructions” of *Krupa* to the claimed “plurality of instructions stored on the non-transitory computer readable medium.” A POSITA would have also immediately recognized the “computer readable code, that when executed by a processor(s)” to be a disclosure of the instructions being “executable by one or more processors.”

258. A POSITA would have immediately equated the disclosure of “that when executed by a processor(s) may perform one or any of the automated hydraulic fracturing systems features described herein” to the claimed “when the instructions are executed by the one or more processors, the following steps are executed.”

259. Accordingly, *Krupa* discloses “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors” and “wherein, when the instructions are executed by the one or more processors, the following steps are executed” as claimed.

- d. 25.4: “(a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and”

25.5: “measuring a flow rate of the fluid being pumped into the second well;”

25.6: “(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising: opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well;”

25.7: “wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”

25.8: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”

25.9: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”

260. Except for being rewritten as an apparatus claim, the language in Limitations 25.4 through 25.9 is identical to that of Limitations 15.2 through 15.7. *Krupa* discloses 25.4 through 25.9 for the same reasons as those discussed regarding 15.2 through 15.7 in Section XI.I.

261. Because *Krupa* discloses each and every element of claim 25, claim 25 is anticipated by *Krupa*. To the extent that the Board finds claim 25 is not anticipated by *Krupa*, claim 25 is obvious over *Krupa* alone for the reasons discussed above.

N. DEPENDENT CLAIM 26

262. Dependent Claim 26 depends from Claim 25. In addition to the disclosure of the limitations of Claim 25 discussed above, *Krupa* discloses the additional limitations of Claim 26:

- a. **26.1: “26. The apparatus of claim 25, wherein the apparatus is further adapted to hydraulically fracture third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein, when the instructions are executed by the one or more processors, the following steps are also executed”**

263. Other than depending from Claim 25 and being an apparatus claim with computer language to execute the steps (which is already discussed with respect to base Claim 25), this limitation is substantially similar to 16.1 and is disclosed by *Krupa* for the same reasons as those discussed regarding 16.1 in Section XI.J.a.

- b. **26.2: “(c) permitting hydraulic fracturing of the fourth well;”**

264. Other than depending from Claim 25 and being an apparatus claim, this limitation is substantially similar to 16.2 and is disclosed by *Krupa* for the same reasons as those discussed regarding 16.2 in Section XI.J.b.

- c. **26.3: “(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.**

265. Other than depending from Claim 25 and being an apparatus claim, this limitation is substantially similar to 16.3 and is disclosed by *Krupa* for the same reasons as those discussed regarding 16.3 in Section XI.J.c. Therefore, Claim 26 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

O. DEPENDENT CLAIM 27

266. Dependent Claim 27 depends from Claim 26. In addition to the disclosure of the limitations of Claim 27 discussed above, *Krupa* discloses the additional limitations of Claim 26:

- a. **“27. The apparatus of claim 26, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.”**

267. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Claim 17 and is disclosed by *Krupa* for the same reasons as those discussed regarding Claim 17 in Section XI.K. Therefore, Claim 27 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

P. DEPENDENT CLAIM 28

268. Dependent Claim 28 depends from Claim 26. In addition to the disclosure of the limitations of Claim 26 discussed above, *Krupa* discloses the additional limitations of Claim 28:

- a. **28.1: “28. The apparatus of claim 26, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;”**

269. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.1 and is disclosed by *Krupa* for the same reasons as those discussed regarding Limitation 18.1 in Section XI.L.a.

- b. **28.2: “wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and”**

270. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.2 and is disclosed by *Krupa* for the same reasons as those discussed regarding Limitation 18.2 in Section XI.L.b.

- c. **28.3.1: “wherein step (d) comprises: opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and”**

271. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.3.1 and is disclosed by *Krupa* for the same reasons as those discussed regarding Limitation 18.3.1 in Section XI.L.c.

d. **28.3.2: “closing the fourth valve associated with the fourth well.”**

272. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.3.2 and is disclosed by *Krupa* for the same reasons as those discussed regarding Limitation 18.3.2 in Section XI.L.d. Therefore, Claim 28 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

Q. **DEPENDENT CLAIM 31**

273. Dependent Claim 31 depends from Claim 25. In addition to the disclosure of the limitations of Claim 25 discussed above, *Krupa* discloses the additional limitations of Claim 31:

a. **31.1: “31. The method of claim 25, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold, or both; and”**

274. *Krupa* teaches that the “next step” (opening next set of valves) occurs after flowrate has been reduced, for example, “a pump rate may be reduced from the full pump rate. For example, the pump rate may be reduced to 5-15 bbl./min. Once a pressure has stabilized at the reduced pump rate, the software application may move the fracturing pumping plan to the next step.”²¹⁰ *Krupa*’s system teaches

²¹⁰ Ex. 1003 at [0042].

reduced flow below an upper flowrate threshold (*i.e.*, 15 bbl./min), and above a lower flowrate threshold (*i.e.*, 5 bbl. / min) as the flowrate condition before the next step (opening valves) is initiated. Thus, *Krupa* discloses that the flowrate measured at step (a) has satisfied the one or more flowrate conditions when the flowrate measured at step (a) is below an upper flow rate threshold, above a lower flowrate threshold, or both.

275. Accordingly, *Krupa* discloses the Limitation 31.1.

276. To the extent that the Board finds that “flow rate” is not explicitly disclosed as a condition by *Krupa*, then such a determination would be obvious from the teachings of *Krupa* regarding a reduction in flow indicating the end of the stage, and the subsequent “move to the next step” executed by the software application. Additionally, this element would have been obvious to a POSITA based on their general engineering knowledge, particularly knowledge of a rate step test (RST), or the measurement of water hammer in order to characterize fractures in the downhole formation. As discussed above in Sections IX.A-IX.F, a step-change reduction in flow rate, held for a time long enough to measure the water hammer oscillations, is necessary in order to perform a rate step test.

- b. **31.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.**

277. Limitation 31.2 essentially defines the portion excluded by Limitation 31.1. In other words, Limitation 31.2 merely says that if the flow rates conditions in Limitation 31.1 are not met, then the flow rate measured at step (a) “has not been satisfied.” Thus, this limitation does not add anything more technically to claim 31 other than the use of the phrase “not met.” Because *Krupa* discloses meeting certain flowrate thresholds, as discussed above, *Krupa* also discloses that when the flowrate does not meet the desired threshold, whether it’s above an upper threshold or lower than a lower threshold, the measured flowrate “has not satisfied the one or more flow rate conditions.” Moreover, this is standard practice for any flow system – if a measured flowrate is outside the required flow rate, then a flowrate condition is not met.

278. Therefore, Claim 31 is anticipated by *Krupa*, or in the alternative, would have been obvious to a POSITA in light of the disclosure of *Krupa* for the reasons discussed above.

R. DEPENDENT CLAIM 36

279. Dependent Claim 36 depends from Claim 15. In addition to the disclosure of the limitations of Claim 15 discussed above, *Krupa* discloses the additional limitations of Claim 36:

- a. **36.1: “36. The method of claim 15, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold or both and”**

280. With the exception of depending from Claim 15, this claim limitation is identical to 31.1 and is disclosed and/or rendered obvious by *Krupa* for the same reasons as those discussed above regarding 31.1 in Section XI.Q.a.

- b. **36.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.”**

281. With the exception of depending from Claim 15, this claim limitation is identical to 31.2 and is disclosed and/or rendered obvious by *Krupa* for the same reasons as those discussed above regarding 31.2 in Section XI.Q.b. Therefore, Claim 36 is anticipated by *Krupa*, or in the alternative, obvious over *Krupa* for the reasons discussed above.

XII. GROUND 3: OBVIOUS OVER KAJARIA IN VIEW OF JACKSON

282. It is my opinion that the combination of *Kajaria* and *Jackson* discloses and/or suggests all limitations of Claims 1-3, 6, 8-10, 13, 15-17, 18, 25-28, 31, 36, thereby rendering these claims obvious. To the extent *Kajaria* alone does not anticipate or render obvious Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, and 36, the relevant limitations are disclosed or rendered obvious by *Jackson*, as presented below.

A. RATIONALE AND MOTIVATION FOR COMBINING *KAJARIA* WITH *JACKSON*

283. A POSITA would have been motivated to combine *Jackson* with *Kajaria*. *Jackson* is in the same field of endeavor of oil and gas well systems as *Kajaria* (as well as the ‘779 Patent) and is directed to solving the same problem – controlling well operations. *Kajaria* is directed to a “flow system for use at a hydraulic fracturing wellsite... The flow system further includes a valve in the fluid conduit.”²¹¹ *Jackson* is directed to a “process for fracturing a selected region of a formation including: introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached.”²¹²

284. Both *Kajaria* and *Jackson* address the introduction of a fracturing fluid including proppant into a well to be fractured, the fluid being pressurized by one or more pressure pumps. *Kajaria* teaches “The fluid used to fracture the formation is typically pumped into the well by high-powered hydraulic fracturing pumps.”²¹³ *Jackson* similarly teaches “[w]here flow from a well is poor, an operator may wish to attempt to make the fissures and fractures open, connect and/or propagate away from the well. One such method is to pump a fluid such as a gas or an aqueous, foam

²¹¹ Ex. 1004 at Abstract.

²¹² Ex. 1005 at Abstract.

²¹³ Ex. 1004 at [0045].

or emulsion, into an oil well such that the frac sand may be introduced into the fine fissures under pressure.”²¹⁴

285. Further, *Kajaria* provides an express motivation to combine. *Kajaria* teaches monitoring different parameters to allow an operator to control the fracturing operation but does not provide specific detail as to what parameters are monitored. “Monitoring equipment **38** can be mounted on a control vehicle **40** and connected to, e.g., the pumps, **10**, blender **32**, the trees **14**, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”²¹⁵ *Jackson* provides a list of specific parameters to be measured, to be used as “thresholds” in order to trigger a move to the next stage of the fracturing operation. For example, *Jackson* discloses that thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] *flow rate threshold*; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”²¹⁶ Further, *Jackson* further discloses “As will be appreciated, however, generally other process

²¹⁴ Ex. 1005 at [0045].

²¹⁵ Ex. 1004 at [0028].

²¹⁶ Ex. 1005 at [0017]; *see also* Claim 20.

parameters such as *flow rate*, pressure, volume, formation condition, etc. are observed to assess a formation fracturing process.”²¹⁷ Accordingly, a POSITA would have looked to Jackson for teaching which parameters should be measured in the system of *Kajaria* to allow the operator to control different parameters of the fracturing operation.

286. A POSITA would have been motivated to include *Jackson’s* teachings of measuring flowrate and using a flowrate threshold as part of the control of the valves to improve the system of *Kajaria*. For example, the inclusion of a flowrate and time-based threshold would help *Kajaria* ensure that the proper volume of fracturing fluid is pumped down the wells to initiate the pressure pulse. Further, measuring flowrate and combining it with the time threshold would allow the operator to determine whether equipment failure, such as leaks or failed pumps, would prevent proper operation of the pulsed treatment of *Kajaria*. Further still, measuring the flowrate of each well and using the flowrate as part of the threshold during the valve switching would allow the user to compare the effectiveness of treatment between the two wells. As would have been known to a POSITA, a different pressure response with a comparable flowrate, or a similar pressure

²¹⁷ Ex. 1005 at [0019] (emphasis added).

response with varying flowrates, provides information about the quality of the fractures in the different wells.²¹⁸

287. To the extent that *Kajaria* does not already teach using flowrate and time thresholds as the trigger to move to the next stage (*e.g.*, flowrate above or below a threshold for a threshold period of time), a POSITA would be motivated to use the threshold levels from *Jackson*, or otherwise incorporate the teachings of flowrate and time thresholds from *Jackson* into the fracturing system of *Kajaria* at least for the reasons described above. A POSITA, therefore, would recognize that combining the teachings of *Kajaria* and *Jackson* is a simple substitution of one known element for another (*e.g.*, specific thresholds) to obtain predictable results. Further a POSITA would recognize that the addition of specific thresholds from *Jackson* to the method of *Kajaria* is the use of a known technique (specific thresholds) to a known method of *Kajaria* and used in the same way, to transition to the next stage of fracturing operations. To the extent *Jackson* gives examples using a gas fracturing fluid, *Jackson* also contemplates hydraulic fracturing fluids (*e.g.*, liquid based), and a POSITA would understand that including fracturing thresholds for the operation of valves, as taught by *Jackson*, would equally apply for hydraulic and/or gas fracturing systems. A POSITA would have had a reasonable expectation of success in combining *Kajaria* with *Jackson* for the same reasons.

²¹⁸ See, *e.g.*, Section IX.F.

B. INDEPENDENT CLAIM 1

288. It is my opinion that *Kajaria* combined with *Jackson* renders obvious Claim 1 of the '779 Patent. *Kajaria* and *Jackson*, either alone or in combination disclose, or at least render obvious, each and every limitation of Claim 1. Details regarding the specific disclosures of *Kajaria* and *Jackson* are contained in the subsections following.

a. 1.1.1: “1. A method, comprising:”

289. To the extent the preamble is limiting, *Kajaria* discloses a method of hydraulically fracturing a plurality of wells.²¹⁹ The title of *Kajaria* is “Systems and Methods for Fracturing a Multiple Well Pad”.²²⁰ *Kajaria* further describes “a method of providing pressurized fluid to a plurality of wells at a hydraulic fracturing site.”²²¹ Further, *Kajaria* teaches “selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication between the at least one hydraulic fracturing pump and the at least one of the wells using valves positioned in the fluid conduit and corresponding to each of the plurality of wells”.²²² Further, in the system of *Kajaria*, “it is possible [to] direct flow between wells continuously

²¹⁹ 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.

²²⁰ Ex. 1004.

²²¹ Ex. 1004 at [0010].

²²² Ex. 1004 at [0010].

simply by opening or closing the valves 66 associated with individual wells.”²²³ A POSITA would have recognized this to mean that the fluid is pumped continuously to the valves at each well.

290. Accordingly, *Kajaria* discloses the preamble to Claim 1.

b. **1.1.2: “(a) permitting performance of a first hydraulic fracturing operation on a first well,”**

291. *Kajaria* discloses “permitting performance of a first hydraulic fracturing operation on a first well.” As discussed above regarding the preamble, *Kajaria* teaches hydraulic fracturing operations at a multi-well fracturing site. *Kajaria* further discloses “providing pressurized fluid to a plurality of wells at a hydraulic fracturing site.”²²⁴

292. Still further, *Kajaria* discloses “pressurizing fluid with at least one hydraulic fracturing pump, ... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²²⁵

293. A POSITA would, therefore, have understood *Kajaria* to disclose “permitting performance of a first hydraulic operation on a first well” as claimed. Accordingly, *Kajaria* discloses Limitation 1.1.2.

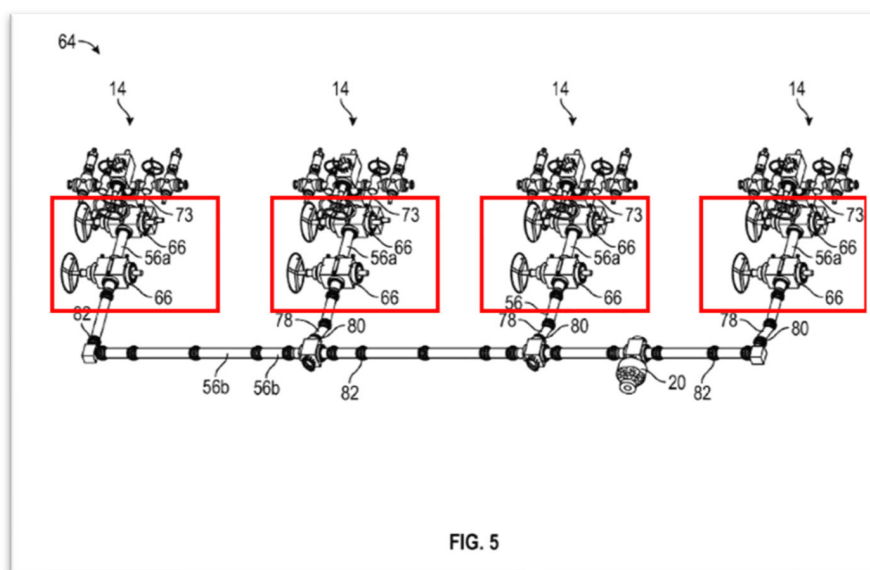
²²³ Ex. 1004 at [0035].

²²⁴ Ex. 1004 at [0010].

²²⁵ Ex. 1004 at [0010].

c. **1.1.3: “which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and”**

294. *Kajaria* discloses this limitation. As discussed above regarding 1.1.2, *Kajaria* discloses “pressurizing fluid with at least one hydraulic fracturing pump, ... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²²⁶ Further, *Kajaria* teaches “it is possible [to] direct flow between wells *continuously* simply by opening or closing the valves **66** associated with individual wells.”²²⁷ Fig. 5 of *Kajaria* depicts the valves **66** (annotated in red) associated with each well.



²²⁶ Ex. 1004 at [0010].

²²⁷ Ex. 1004 at [0035].

295. Accordingly, *Kajaria* discloses “pumping fluid into the first well via a first valve associated with the first well” as claimed.

d. **1.2: “measuring a flow rate of the fluid being pumped into the first well;”**

296. The combination of *Kajaria* and *Jackson* renders measuring the flowrate as recited in Limitation 1.2 obvious. *Kajaria* teaches monitoring different parameters to allow an operator to control the fracturing operation but does not provide specific detail as to what parameters are monitored. “Monitoring equipment **38** can be mounted on a control vehicle **40** and connected to, e.g., the pumps, **10**, blender **32**, the trees **14**, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”²²⁸ *Jackson* provides a list of specific information to be measured, to be used as “thresholds” in order to trigger a move to the next stage of the fracturing operation. For example, *Jackson* discloses that thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] *flow rate threshold*; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold

²²⁸ Ex. 1004 at [0028].

and (f) a formation condition threshold.”²²⁹ Further, *Jackson* further discloses “As will be appreciated, however, generally other process parameters such as *flow rate*, pressure, volume, formation condition, etc. are observed to assess a formation fracturing process.”²³⁰ Accordingly, a POSITA would have looked to *Jackson* for teaching which parameters should be measured in the system of *Kajaria* to allow the operator to control different parameters of the fracturing operation.

297. Further still, *Jackson* discloses several specific flowrate thresholds as examples including at least “300 scm”, “0 scm” and “1000 scm.” A POSITA would understand that in order to “observe” flow rate, as disclosed by *Jackson*, the flowrate being pumped into the well would be measured, as recited in Limitation 1.2.

298. A POSITA having general engineering knowledge would have found it obvious to combine *Jackson* and *Kajaria* to measure flowrate of fluid being pumped into a well to monitor/control a fracturing process in view of *Jackson* teaching that process parameters including flowrate were commonly observed to assess a formation fracturing process. Accordingly, the combination of *Kajaria* and *Jackson* render Limitation 1.2 obvious. Additionally, this element would have been obvious to a POSITA having general engineering knowledge as measuring flowrate into a well was well-known long before the ’779 Patent. (See Sections IX.A – IX.F).

²²⁹ Ex. 1005 at [0017] (emphasis added); *see also* Claim 20.

²³⁰ Ex. 1005 at [0019] (emphasis added).

e. **1.3: “(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and”**

299. The combination of *Kajaria* and *Jackson* renders obvious, “determining the flow rate of the fluid being pumped into the first well is below a flow rate threshold” as claimed. As discussed above regarding Limitation 1.2, the combination of *Kajaria* and *Jackson* discloses and/or renders obvious to a POSITA measuring a flowrate. *Kajaria* teaches monitoring of different parameters to allow for control of the fracturing operation. *Jackson* provides further teaching regarding the use of flowrate as a threshold for taking action (*i.e.*, moving the fracturing process to the next step).

300. *Jackson* teaches that the thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] *flow rate threshold*; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”²³¹ Further, *Jackson* specifically discloses a combination of flowrate and time. *Jackson* teaches “the first threshold may be reached by introduction of a fracturing fluid over a period of time. As will be appreciated, however, other process parameters such as flow rate, pressure, volume, formation condition etc. are

²³¹ Ex. 1005 at [0017] (emphasis added); *see also* Claim 20.

observed to assess a formation fracturing process.”²³² Further, as an example of a combined flowrate / time threshold, *Jackson* teaches “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm.”²³³ In this example, the fracturing fluid flowrate must have been below a flowrate threshold of 300 scm (standard cubic feet per minute) for a time threshold of at least one minute, up to 24 hours.

301. Accordingly, *Jackson* discloses “determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold” as recited in Limitation 1.3. It would be obvious to a POSITA to include the flow rate thresholds of *Jackson* in the method of *Kajaria* in order to monitor different parameters to allow for control of the fracturing operation, a stated objective of *Kajaria*, including moving the fracturing process to the next step, as explained by *Jackson*. The combination of *Kajaria* and *Jackson*, therefore, renders Limitation 1.3 obvious.

302. Further, this element would have been obvious to a POSITA having general engineering knowledge, particularly as it relates to RST and water hammer tests. (See Sections IX.A-IX.F).

²³² Ex. 1005 at [0019].

²³³ Ex. 1005 at [0021], *see also* Claim 22.

f. **1.4: “has been below the flow rate threshold for a threshold amount of time;”**

303. The combination of *Kajaria* and *Jackson* renders obvious this claim limitation. As discussed above regarding Limitation 1.3, *Jackson* specifically teaches a threshold of a flowrate for a threshold amount of time. In one embodiment of *Jackson*, “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm.”²³⁴ Accordingly, the flow rate threshold disclosed by *Jackson* in that example, is 300 scm and the threshold amount of time is 1 minute up to 24 hours.

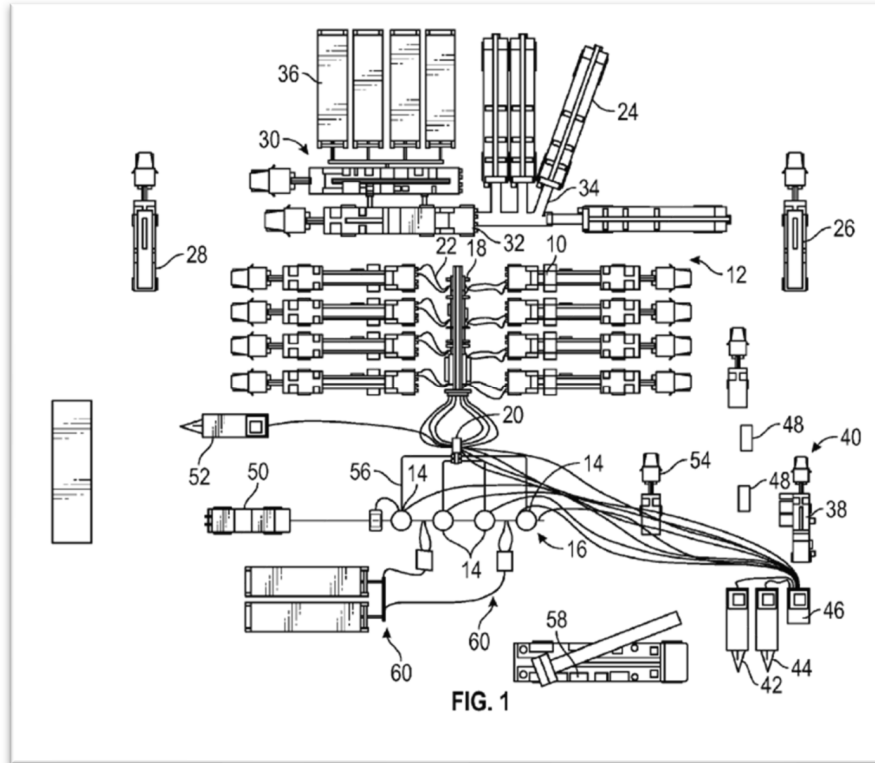
304. Accordingly, *Jackson* discloses the flow rate “has been below the flow rate threshold for a threshold amount of time” as recited in Limitation 1.4. It would be obvious to a POSITA to include the flowrate and time thresholds of *Jackson* in the method of *Kajaria* in order to monitor different parameters to allow for control of the fracturing operation, a stated objective of *Kajaria*, including moving the fracturing process to the next step, as explained by *Jackson*. Therefore, the combination of *Kajaria* and *Jackson* renders Limitation 1.4 obvious.

²³⁴ Ex. 1005 at [0021].

- g. **1.5: “(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;”**

305. *Kajaria* discloses this limitation. *Kajaria* teaches a flow system for a hydraulic fracturing multi-well site, each well “including a tree attached to a wellhead [14, 16], an inlet head [20] in fluid communication with at least one hydraulic fracturing pump at the well site,” a fluid conduit [56] between the inlet head and the tree, and a “valve [66] permitting fluid flow through the fluid conduit when in the open position, and preventing fluid flow through the fluid conduit when in the closed position.”²³⁵ *Kajaria* shows this configuration in Figs. 1, 4 and 5. Fig. 1 shows the overall layout of the well pad including the components listed above (with the exception of valve 66).

²³⁵ Ex. 1004 at Abstract.



Kajaria, Fig. 1

306. Fig. 5 provides more detail of the components between inlet head **20** and the wellhead **14**, including valve **66** (annotated in red).

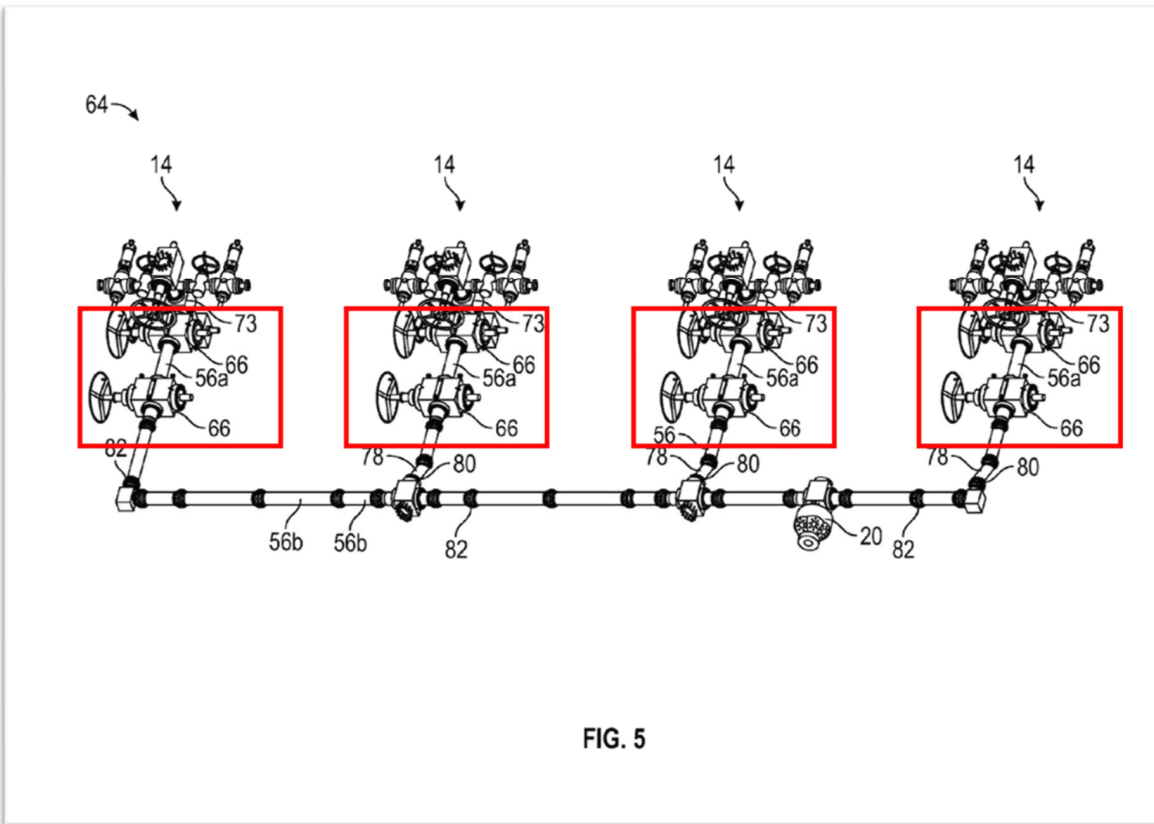


FIG. 5

Kajaria, Fig. 5

Kajaria further teaches “In this manner, selective flow to the trees may be utilized to control, for example, fracturing operations.”²³⁶ *Kajaria* further describes this process:²³⁷

One reason the ability to allow or prevent flow before the flow reaches a particular tree **14** is advantageous is because it allows an operator to easily direct flow between wells at a multi-well site as needed in the course of operations. For example, different wells might operate on different cycles in a hydraulic fracturing operation. Thus, it may be desirable to provide pressurized fluid to a

²³⁶ Ex. 1004 at [0024].

²³⁷ Ex. 1004 at [0035].

particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle. With the flow system 64 of the present technology it is possible [to] direct flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.

307. A POSITA would have understood that *Kajaria's* disclosure of “continuously” directing flow between multiple wells “simply by opening or closing the valves” associated with each of the wells would include opening a second valve associated with a second well while fluid is being pumped into the first well via the first associated valve to continuously pump fluid between the first and second wells. In order for fluid to be “continuously” pumped between the wells, it would be necessary to open the second valve while the previous valve is still open.

308. Accordingly, *Kajaria* discloses, or at least renders obvious Limitation 1.5, and the combination of *Kajaria* and *Jackson* (discussed above) renders Claim 1 as a whole obvious.

- h. **1.6: “(d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and”**

309. *Kajaria* discloses this limitation. As discussed above regarding 1.5, *Kajaria* discloses a multi-well hydraulic fracturing system including a second well. Further, *Kajaria* explains fracturing operations: “[h]ydraulic fracturing is a

technique used to stimulate production from some hydrocarbon producing wells.”²³⁸ Further, *Kajaria* teaches fluid is directed to the wells by pumping the fluid. As *Kajaria* explains, “[t]he fluid used to fracture the formation is typically pumped into the well by high-powered hydraulic fracturing pumps.”²³⁹ Further still, *Kajaria* teaches “direct[ing] flow between wells continuously simply by opening or closing the valves **66** associated with individual wells.”²⁴⁰ By opening valve **66** associated with the second well, *Kajaria* discloses, or at least renders obvious, “permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve” as claimed.

310. Accordingly, *Kajaria* discloses, or at least renders obvious Limitation 1.6, and the combination of *Kajaria* and *Jackson* (discussed above) renders obvious Claim 1 as a whole.

- i. **1.7: “(e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;”**

311. *Kajaria* discloses this limitation. As described above regarding 1.5, *Kajaria* teaches “direct[ing] flow between wells continuously simply by opening or

²³⁸ Ex. 1004 at [0005].

²³⁹ Ex. 1004 at [0006].

²⁴⁰ Ex. 1004 at [0035].

closing the valves **66** associated with individual wells.”²⁴¹ As shown in Fig. 14 of *Kajaria*, each tree (well) 14 has a corresponding valve **66** that can be opened or closed to allow or prevent fluid flow into the well.²⁴²

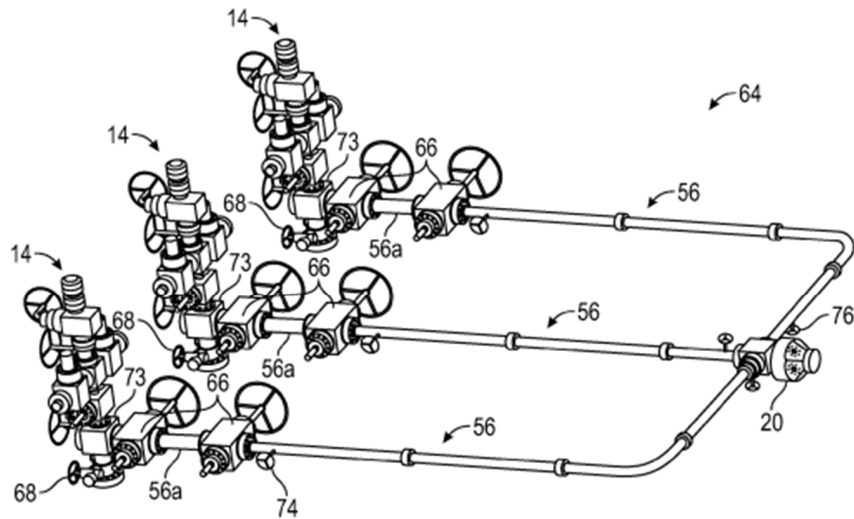


FIG. 4

Kajaria, Fig. 4

312. A POSITA would have understood that *Kajaria*’s disclosure of “continuously” directing flow between multiple wells “simply by opening or closing the valves” associated with each of the wells would include closing a first valve associated with a first well while fluid is being pumped into the second well via the second associated valve. This procedure would allow a sequence of operations of

²⁴¹ Ex. 1004 at [0035].

²⁴² Ex. 1004 at [0034]-[0035].

fracturing on wells while continuously directing flow as *Kajaria* teaches opening and closing valves to continuously direct flow to the wells.

313. Accordingly, *Kajaria* discloses, or at least renders obvious, Limitation 1.7, and the combination of *Kajaria* and *Jackson* (discussed above) renders obvious Claim 1 as a whole.

- j. **1.8: “wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.”**

314. *Kajaria* discloses this limitation. As described above, *Kajaria* discloses “direct[ing] flow between wells *continuously* simply by opening or closing the valves **66** associated with individual wells.”²⁴³ A POSITA would have understood this to be a disclosure of continuously pumping fluid to the first valve and the second valve, (valves **66** associated with the first and second wells) as claimed.

315. Accordingly, *Kajaria* discloses, or at least renders obvious, Limitation 1.8, and the combination of *Kajaria* and *Jackson* (discussed above) renders obvious Claim 1 as a whole.

316. In view of the above, the combination of *Kajaria* and *Jackson* discloses each and every element of Claim 1. A person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Kajaria* for the reasons

²⁴³ Ex. 1004 at [0035] (emphasis added).

discussed above, and therefore Claim 1 as a whole is obvious over *Kajaria* and *Jackson*.

C. **DEPENDENT CLAIM 2**

317. Dependent Claim 2 depends from Claim 1. In addition to the disclosure of Claim 1 discussed above, *Kajaria* discloses Claim 2.

- a. **“2. The method of claim 1, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; and wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.”**

318. *Kajaria* discloses this limitation. As discussed above regarding the preamble, *Kajaria* teaches hydraulic fracturing operations at a multi-well fracturing site.

319. Further still, *Kajaria* discloses “pressurizing fluid with at least one hydraulic fracturing pump, ... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²⁴⁴ *Kajaria* discloses pumping fluid into a well of a plurality of wells at a hydraulic fracturing site. The plurality of wells would include the first well. *Kajaria* further teaches the use of a manifold. In describing conventional fracking operations,

²⁴⁴ Ex. 1004 at [0010].

Kajaria discloses “pumps in typical fracing operations pump the fluid to a frac pump output header, also known as a missile, which in turn passes the fluid to a hydraulic fracturing manifold. The *hydraulic fracturing manifold* is located between the missile and a tree (assortment of valves and controls) located above the opening of a well bore.”²⁴⁵ *Kajaria* teaches that, in conventional fracking systems, “the hydraulic fracturing, or *zipper manifold*, is typically located near the missile, and some distance from some or all of the wells.”²⁴⁶ *Kajaria* teaches improved connections between the manifold and the wells at the fracturing location, as well as continued use of the fracturing, or zipper, manifold. *Kajaria* discloses “[e]mbodiments of the present disclosure are directed to systems and methods for coupling manifolds to trees at well sites.”²⁴⁷ A POSITA would have understood the “manifold” described in *Kajaria*’s invention to be the “hydraulic fracturing, or zipper manifold” referred to in the description of conventional fracing systems. This was a well-known configuration of a hydraulic fracturing layout.²⁴⁸

320. Accordingly, the combination of *Kajaria* and *Jackson* renders obvious Claim 2 for the reasons discussed above. A POSITA having general engineering

²⁴⁵ Ex. 1004 at [0006] (emphasis added).

²⁴⁶ Ex. 1004 at [0007] (emphasis added).

²⁴⁷ Ex. 1004 at [0024].

²⁴⁸ See Section IX.C.

knowledge (see Sections IX.A-IX.E), would have known that the use of manifolds was well established in the hydraulic fracturing field long before the '779 Patent.

D. DEPENDENT CLAIM 3

321. Dependent Claim 3 depends from Claim 1. In addition to the disclosure of Claim 1 discussed above, *Kajaria* discloses Claim 3:

a. “3. The method of claim 1, wherein the second valve is opened after step (b).”

Kajaria teaches a multi-well fracturing system that provides “selective flow” to multiple wells, which “may be utilized to control, for example, fracturing operations.”²⁴⁹ This “is advantageous ... because it allows an operator to easily direct flow between wells at a multi-well site as needed in the course of operations,” which may include providing “pressurized fluid to a particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle.”²⁵⁰ Thus, with *Kajaria*’s flow system “it is possible [to] direct flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.”²⁵¹

322. A POSITA would have understood that *Kajaria*’s disclosure of “continuously” directing flow between multiple wells “simply by opening or closing

²⁴⁹ Ex. 1004 at [0024].

²⁵⁰ Ex. 1004 at [0035].

²⁵¹ Ex. 1004 at [0035].

the valves” associated with each of the wells would include opening a second valve associated with a second well while fluid is being pumped into the first well via the first associated valve to continuously pump fluid between the first and second wells. In order for fluid to be “continuously” pumped between the wells, it would be necessary to open the second valve while the previous valve is still open.

323. As discussed above with Limitations 1.3-1.4, *Kajaria* teaches monitoring of different parameters to allow for control of the fracturing operation, while *Jackson* provides further teaching regarding the use of flowrate and amount of time thresholds for taking action (i.e., moving the fracturing process to the next step).²⁵²

324. Further, *Jackson* specifically discloses a combination of flowrate and time thresholds as a signal to move to the next stage of fracturing operations. For example, *Jackson* teaches “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm.”²⁵³ In this example, the fracturing fluid flowrate must be below a flowrate threshold of 300 scm (standard cubic feet per minute) for a time threshold of at least one minute, up to 24 hours in order to move to the next step in the fracturing process.

²⁵² Ex. 1005 at [0017]; *see also* Claim 20.

²⁵³ Ex. 1005 at [0021]; *see also* Claim 22.

325. It would be obvious to a POSITA to include the flowrate and amount of time thresholds of *Jackson* in the method of *Kajaria* in order to monitor different parameters to allow for control of the fracturing operation, a stated objective of *Kajaria*, including moving the fracturing process to the next step, which includes opening a second valve to a second well while fluid is “continuously” being pumped into a first well via a first associated valve, as suggested by *Kajaria*. Using the flowrate monitoring techniques of *Jackson* in the methods of *Kajaria* would have involved a simple substitution of one known technique for another to achieve predictable control of the fracturing operation.

326. The combination of *Kajaria* and *Jackson*, therefore, renders Claim 3 obvious for the reasons discussed above.

E. DEPENDENT CLAIM 6

327. Dependent Claim 6 depends from Claim 1. In addition to the disclosure of Claim 1 discussed above, *Kajaria* discloses Claim 6.

a. “6. The method of claim 1, wherein each of the first and second valves is a zipper valve.”

328. *Kajaria* discloses this limitation. *Kajaria* discloses:²⁵⁴

With this arrangement, an operator can use the hydraulic [f]racturing manifold to isolate wells as they complete a frac cycle, and to redirect fluid to a different well that is ready to begin a new frac cycle. In some instances, actuated valves can improve transition time, increasing

²⁵⁴ Ex. 1004 at [0006].

efficiency. Use of a hydraulic fracturing manifold in this manner is known in the industry as "zip" fracking.

329. Further, *Kajaria* makes it clear that the “zip fracking” manifold is a “zipper manifold”: “when servicing multiple wells, the hydraulic fracturing, or zipper manifold, is typically located near the missile, and some distance from some or all of the wells.”²⁵⁵ The “actuated valves” associated with “zip” fracking and the “zipper manifold” as described above would have been recognized as “zipper valves” by a POSITA at the time of the ’779 Patent.

330. Accordingly, *Kajaria* discloses this limitation, and the combination of *Kajaria* and *Jackson* renders obvious Claim 6 for the reasons discussed above. To the extent that the Board determines that a “zipper valve” is not explicitly disclosed by *Kajaria*, then it would have been obvious to a POSITA with general engineering knowledge regarding such operations that the valves associated with zipper manifold would have been “zipper valves,” based on the teachings of *Kajaria* regarding sequential or simultaneous (i.e., zipper) fracturing operations.²⁵⁶

F. INDEPENDENT CLAIM 8

331. It is my opinion that Claim 8 of the ’779 Patent would have been obvious based on the teachings of *Kajaria* and *Jackson*. With the exception of Claim

²⁵⁵ Ex. 1004 at [0007].

²⁵⁶ See, e.g., Sections IX.C-IX.D.

8 being an “apparatus” claim, and the claim further containing a description of structure of the apparatus, namely known computer elements for executing instructions, Claim 8 is substantially similar to Claim 1. As discussed below, *Kajaria* discloses the apparatus claimed in Claim 8 of the ‘779 Patent.

a. **8.1.1: “An apparatus comprising:”**

8.1.2: “a non-transitory computer readable medium; and”

8.2.1: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors,”

8.2.2: “wherein, when the instructions are executed by the one or more processors, the following steps are executed:”

332. *Kajaria* teaches that “[m]onitoring equipment 38 can be mounted on a control vehicle 40, and connected to, e.g., the pumps 10, blender 32, the trees 14, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”²⁵⁷ During prosecution of the ‘779 Patent, the examiner understood that the “control vehicle 40 would have computer readable medium to allow [an] operator to control the valves for the fracturing process.”²⁵⁸ The Applicant did not disagree,

²⁵⁷ Ex. 1004 at [0028].

²⁵⁸ Ex. 1010 at p. 4.

but in response, the Applicant incorporated allowable subject matter into the independent claims.²⁵⁹

333. Whether or not Kajaria's disclosure of the control vehicle inherently included non-transitory computer readable medium, it was well known in the art to use computer systems having non-transitory computer readable medium to control valves and other equipment in hydraulic fracturing operations. For example, as discussed above, *Krupa*, discloses computer systems with non-transitory computer readable medium that are used for executing hydraulic fracturing operations.

334. Additionally, it was well known even prior to the filing date of *Kajaria* that computer systems have non-transitory computer readable medium and that such systems were used to control valves in well systems. Thus, it would have been obvious to use a control system, including a processor that executes instructions stored on a memory component to control valves in a well system, in the control vehicle of *Kajaria* in order "to allow the operator to control different parameters of the fracturing operation."²⁶⁰

335. Accordingly, *Kajaria* discloses, or at least renders obvious, a computing system which is an example of the apparatus as described in the rest of Claim 8.

²⁵⁹ Ex. 1009 at p. 81-103.

²⁶⁰ Ex. 1004 at [0028].

- b. 8.3: “(a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and
- 8.4: measuring a flow rate of the fluid being pumped into the first well; and
- 8.5: (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and
- 8.6: has been below the flow rate threshold for a threshold amount of time;
- 8.7: (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;
- 8.8: (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and
- 8.9: (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;
- 8.10: wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.

336. With the exception of being rewritten as an apparatus claim, the language in Limitations 8.3 through 8.10 is identical to that of Limitations 1.1 through 1.8. The combination of *Kajaria* and *Jackson* discloses or at least renders obvious Limitations 8.3 through 8.10 for the same reasons as those discussed regarding Limitations 1.1 through 1.8 in Section XII.B. In view of the above, the

combination of *Kajaria* and *Jackson* discloses each and every element of Claim 8. A person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Kajaria* for the reasons discussed above, and therefore Claim 8 as a whole is obvious over *Kajaria* and *Jackson*.

G. DEPENDENT CLAIM 9

- a. **“9. The apparatus of claim 8, wherein each of the first and second valves is in fluid communication with a hydraulic manifold from which fluid is pumped to the first valve and/or the second valve; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped from the hydraulic manifold to the first valve, the second valve, or both the first valve and the second valve.”**

337. Except for depending from Claim 8 and being an apparatus claim, Claim 9 is identical to Claim 2 and is disclosed by *Kajaria* for the same reasons as those described above regarding Claim 2 in Section XII.C.

H. DEPENDENT CLAIM 10

- a. **“10. The apparatus of claim 8, wherein the second valve is opened after step (b).”**

338. Except for depending from Claim 8 and being an apparatus claim, Claim 10 is identical to Claim 3 and is disclosed by *Kajaria* for the same reasons as those described above regarding Claim 3 in Section XII.D. Accordingly, Claim 10 is obvious over the combination of *Kajaria* and *Jackson* for the reasons discussed above.

I. DEPENDENT CLAIM 13

- a. **“13. The apparatus of claim 8, wherein each of the first and second valves is a zipper valve.”**

339. Except for depending from Claim 8 and being an apparatus claim, Claim 13 is identical to Claim 6 and is disclosed by *Kajaria* for the same reasons as those described above regarding Claim 6 in Section XII.E. Accordingly, Claim 13 is obvious over the combination of *Kajaria* and *Jackson* for the reasons discussed above.

J. INDEPENDENT CLAIM 15

340. It is my opinion that the combination of *Kajaria* and *Jackson* renders obvious Claim 15 of the '779 Patent. Details regarding the specific disclosures of *Kajaria* and *Jackson* are contained in the subsections following.

- a. **15.1: “15. A method of hydraulically fracturing at least first and second wells of a plurality of wells, the first and second wells being associated with first and second valves, respectively, the method comprising:”**

341. To the extent the preamble is limiting, *Kajaria* discloses a method of hydraulically fracturing a plurality of wells, including a first and second well, each well with associated valves.²⁶¹ The title of *Kajaria* is “Systems and Methods for Fracturing a Multiple Well Pad.” A “multiple well pad” would include at least a first

²⁶¹ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 15 out of an abundance of caution.

and second well. *Kajari* further discloses “flow system for use at a hydraulic fracturing well site. The flow system includes a plurality of trees, each tree attached to a wellhead... The flow system further includes a plurality of valves in the fluid conduit, each valve corresponding to one of the plurality of trees,”²⁶² as shown, for example, in Figs. 1, 4, and 5. Accordingly, each well has an associated wellhead tree and each tree comprises at least one valve. Accordingly, *Kajaria* discloses at least a first and second well and associated first and second valves.

342. Thus, *Kajaria* discloses the preamble.

b. **15.2.1: “(a) permitting hydraulic fracturing of the second well, comprising:”**

343. As discussed above regarding the preamble, *Kajaria* discloses hydraulic fracturing operations of multiple wells, which would include a second well. Further, as discussed above regarding the preamble, each well has an associated valve. *Kajaria* discloses “equipment used in the hydrocarbon industry, and in particular to systems and methods for hydraulic fracturing operations.”²⁶³ *Kajaria* further teaches “a flow system for use at a hydraulic fracturing well site... includ[ing] a plurality of valves in the fluid conduit ... each valve permitting fluid flow through the fluid conduit when in the open position.”²⁶⁴ Since each valve

²⁶² Ex. 1004 at [0009].

²⁶³ Ex. 1004 at [0003].

²⁶⁴ Ex. 1004 at [0009].

permits hydraulic fluid flow at a hydraulic fracturing well site when in the open position, *Kajaria* discloses, or at the very least renders obvious, permitting hydraulic fracturing of the second well.

344. Thus, *Kajaria* discloses Limitation 15.2.1.

- c. **15.2.2: “opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and”**

345. As discussed above regarding 15.2.1, *Kajaria* teaches hydraulic fracturing of the second well by opening the second valve associated with the second well to allow fluid to be pumped into the second well.

346. Accordingly, *Kajaria* discloses Limitation 15.2.2. The combination of *Kajaria* and *Jackson*, therefore, renders obvious Limitation 15.2.2.

- d. **15.3: “measuring a flow rate of the fluid being pumped into the second well;”**

347. The combination of *Kajaria* and *Jackson* renders measuring the flowrate as claimed in limitation 15.3 obvious. *Kajaria* discloses “downhole sensors and tools ... to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”²⁶⁵ It would have been obvious to a POSITA that one of the pieces of “information” that would be sensed would be flowrate into the well.

²⁶⁵ Ex. 1004 at [0028].

348. To the extent that *Kajaria* does not explicitly disclose or alone render obvious measuring a flowrate of fluid being pumped into the first well, *Jackson* provides such a specific disclosure. *Jackson* teaches, throughout the disclosure, the use of flowrate of fluid into the well as a threshold. For example, *Jackson* discloses that thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] *flow rate threshold*; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”²⁶⁶ Further, *Jackson* discloses “As will be appreciated, however, generally other process parameters such as *flow rate*, pressure, volume, formation condition, etc. are observed to assess a formation fracturing process.”²⁶⁷ Further, *Jackson* discloses several specific flowrate thresholds as examples including at least “300 scm”, “0 scm” and “1000 scm.” A POSITA would understand that in order to “observe” flowrate, as disclosed by *Jackson*, the flowrate being pumped into the well would be measured, as recited in 15.3.

349. Accordingly, the combination of *Kajaria* and *Jackson* render claim limitation 15.3 obvious. A POSITA having general engineering knowledge would

²⁶⁶ Ex. 1005 at [0017] (emphasis added); *see also* Claim 20.

²⁶⁷ Ex. 1005 at [0019] (emphasis added).

have known that measuring flowrate into a well was well-known long before the '779 Patent. (See Sections IX.A – IX.F).

e. **15.4.1: “(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising:”**

350. As discussed above regarding the preamble, *Kajaria* discloses hydraulic fracturing operations of multiple wells, which would include a second well. Further, as discussed above regarding the preamble, each well has an associated valve. *Kajaria* discloses “equipment used in the hydrocarbon industry, and in particular to systems and methods for hydraulic fracturing operations.”²⁶⁸ *Kajaria* further teaches “a flow system for use at a hydraulic fracturing well site ... includ[ing] a plurality of valves in the fluid conduit ... each valve permitting fluid flow through the fluid conduit when in the open position.”²⁶⁹ In order to swap between fracturing the second well and fracturing the first well, the operator would simply, based on the teaching of *Kajaria*, open the valve **66** to allow fluid to go to a first well **14** and close the valve **66** to prevent fluid flow to a second well **14**. Since each valve permits hydraulic fluid flow at a hydraulic fracturing well site when in the open position, *Kajaria* discloses, or at least renders obvious swapping from fracturing a second well to fracturing a first well as claimed.

²⁶⁸ Ex. 1004 at [0003].

²⁶⁹ Ex. 1004 at [0009].

351. *Kajaria* also discloses “it may be desirable to provide pressurized fluid to a particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle. With the flow system **64** of [*Kajaria*] it is possible to direct flow between wells continuously simply by opening or closing the valves **66** associated with individual wells. Thus, the flow of pressurized fluid into wells can be managed efficiently. In addition, while flow to a tree **14** is stopped, due to the closing of the corresponding valve **66**, valves on the tree can be operated to allow the operator to insert a line, frac isolation ball, etc. as needed.”²⁷⁰ Thus, *Kajaria* discloses swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well.

352. Thus, *Kajaria* discloses Limitation 15.4.1.

- f. **15.4.2: “opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and”**

353. As discussed above regarding 15.4.1, *Kajaria* teaches hydraulic fracturing of the first well by opening the first valve associated with the first well.

354. Accordingly, *Kajaria* discloses Limitation 15.4.2.

²⁷⁰ Ex. 1004 at [0035].

g. **15.4.3: “closing the second valve associated with the second well;”**

355. *Kajaria* discloses this limitation. *Kajaria* further teaches “a flow system for use at a hydraulic fracturing well site ... includ[ing] a plurality of valves in the fluid conduit ... each valve ... preventing fluid flow through the fluid conduit [and the well] when in the closed position.”²⁷¹ Since each valve prevents hydraulic fluid flow at a hydraulic fracturing well site when in the closed position, *Kajaria* discloses closing the second valve associated with the second well.

h. **15.5: “wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”**

356. *Kajaria* discloses this limitation. *Kajaria* teaches: “With the flow system **64** of [*Kajaria*] it is possible [to] direct flow between wells continuously simply by opening or closing the valves **66** associated with individual wells.”²⁷² In order for flow to be directed continuously to the wells, it is necessary for the flow to be pumped continuously to the associated valves.

357. Accordingly, *Kajaria* discloses during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold as recited in Limitation 15.5.

²⁷¹ Ex. 1004 at [0009].

²⁷² Ex. 1004 at [0035].

- i. **15.6: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”**

358. As discussed above, *Kajaria* discloses a multi-well fracturing system that “allows an operator to easily direct flow between wells at a multi-well site as needed in the course of operations,” which may include providing “pressurized fluid to a particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle.”²⁷³ Thus, with *Kajaria*’s flow system “it is possible [to] direct flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.”²⁷⁴

359. A POSITA would have understood that *Kajaria*’s disclosure of “continuously” directing flow between multiple wells “simply by opening or closing the valves” associated with each of the wells would include opening a first valve associated with a first well before a second valve to a second well is closed. In order for fluid to be “continuously” pumped between the wells, it would be necessary to open the first valve while the second valve is still open (before closing the second

²⁷³ Ex. 1004 at [0035].

²⁷⁴ Ex. 1004 at [0035].

valve). *Kajaria* also teaches monitoring different parameters to allow for control of the fracturing operation.

360. *Jackson* provides further teaching regarding the use of flowrate conditions (e.g., flowrate and amount of time thresholds) for taking action, i.e., moving the fracturing process to the next step.²⁷⁵

361. It would be obvious to a POSITA to use the process of *Jackson* of using flowrate conditions to determine when to move a fracturing process to the next step in the method of *Kajaria* in order to allow for control of the fracturing operation, a stated objective of *Kajaria*, which may include opening a first valve to a first well before closing a second valve to a second well to “continuously” pump fluid to the first and second wells, as suggested by *Kajaria*.

362. The combination of *Kajaria* and *Jackson*, therefore, renders obvious Limitation 15.6.

- j. **15.7: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”**

363. Limitation 15.7 is the second prong of an “OR” statement in claim 15. As discussed above regarding 15.6, the first prong of the “OR” is satisfied by the

²⁷⁵ Ex. 1005 at [0017]; *see also* Claim 20.

disclosures of *Kajaria* and *Jackson*, and as a result, *Kajaria* and *Jackson* render obvious, the entire “OR” statement.

364. Nevertheless, the second prong is at least rendered obvious by *Kajaria* because *Kajaria* discloses that in conventional hydraulic fracturing operations, an operator can use a fracturing manifold “to isolate wells as they complete a frac cycle, and to redirect fluid to a different well that is ready to begin a new frac cycle.”²⁷⁶ *Kajaria* also discloses selectively directing fluid between wells “continuously” by providing “pressurized fluid to a particular well at a particular time or place in the frac cycle, while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle,” which would include the alternative valve sequence in this limitation of closing a valve to one well “during” opening a valve to another well.²⁷⁷ Thus, *Kajaria* discloses this limitation.

365. To the extent the Board determines that *Kajaria* does not explicitly teach the sequence of valve operations (*i.e.*, opening first valve after/during closing second valve) in response to flowrate conditions being met, this would have been obvious to a POSITA. As discussed above, continuous operations (*i.e.*, opening one valve while another valve is still open) are taught by *Kajaria* as part of a controlled fracturing operation, where monitoring equipment may provide information to an

²⁷⁶ Ex. 1004 at [0006].

²⁷⁷ Ex. 1004 at [0035] (emphasis added).

operator “to allow the operator to control different parameters of the fracturing operation.”²⁷⁸ Absent flowrate conditions that would allow continuous pumping, a POSITA would have known that, in the alternative, the proper response would be to revert to conventional valve sequences. In other words, if the system of *Kajaria* determines that continuous pumping operations should not proceed, then the backup would, obviously, be conventional fracturing operations (*i.e.*, opening the first valve after the second valve is closed). Thus, this limitation is also rendered obvious by *Kajaria* and *Jackson*.

366. For the reasons described above, the combination of *Kajaria* and *Jackson* renders claim 15 as a whole obvious.

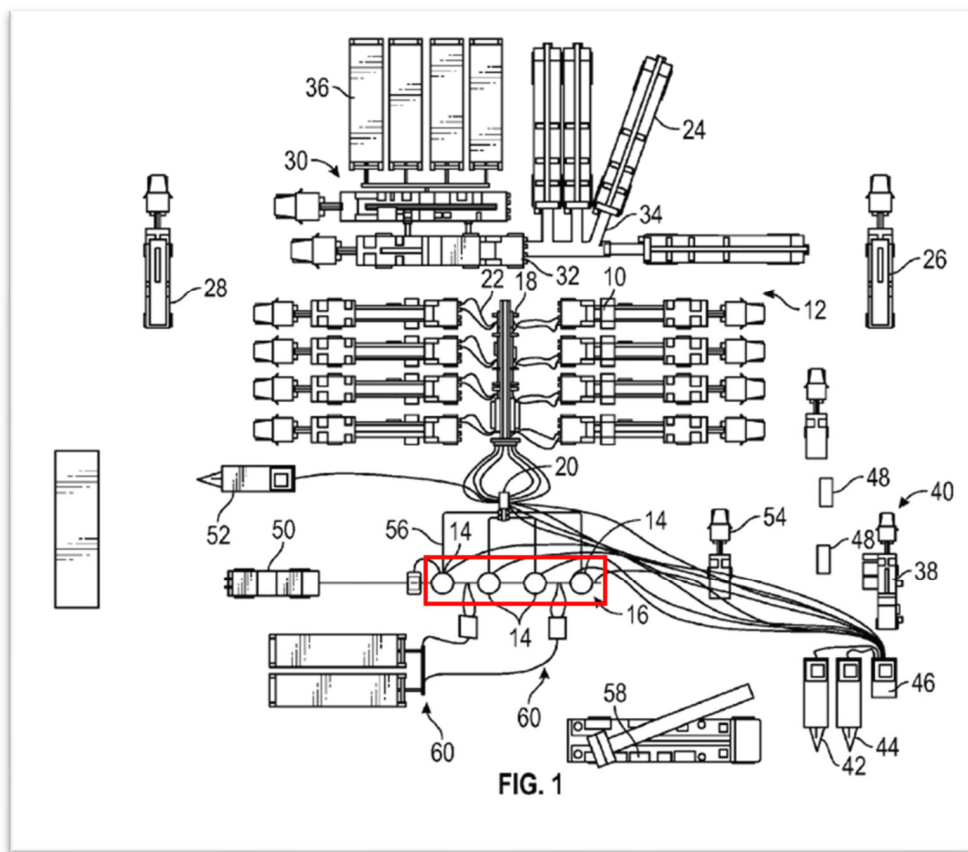
K. DEPENDENT CLAIM 16

367. Dependent Claim 16 depends from Claim 15. In addition to the disclosure of the limitations of Claim 15 discussed above, *Kajaria* discloses the additional limitations of Claim 16:

- a. **16.1: “16. The method of claim 15, wherein the plurality of wells further comprises third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein the method further comprises:”**

368. *Kajaria* discloses at least a third and fourth well (annotated in red) associated with its “multiple well pad”, as shown in Fig. 1

²⁷⁸ Ex. 1004 at [0028].



369. Further, *Kajaria* teaches valves **66** (annotated in red) associated with each of the third and fourth wells, as shown in Fig. 5.

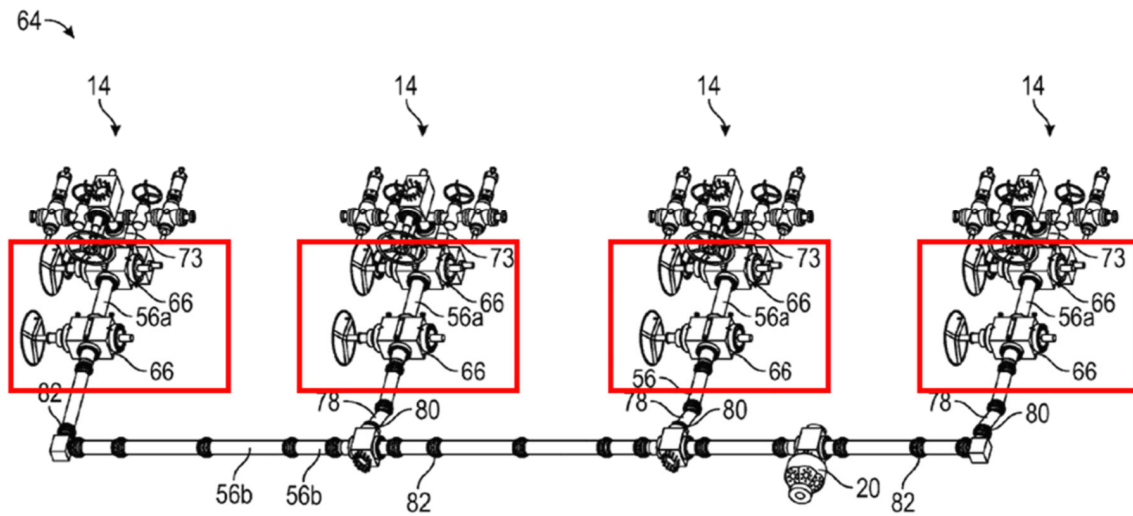


FIG. 5

370. Accordingly, *Kajaria* discloses a third and fourth well associated with third and fourth valves as claimed in 16.1.

b. 16.2: “(c) permitting hydraulic fracturing of the fourth well; and”

371. *Kajaria* discloses this limitation. The title of *Kajaria* is “Systems and Methods for Fracturing a Multiple Well Pad.” As discussed above regarding 16.1, *Kajaria* discloses a fourth well as part of the “Multiple Well Pad.”

372. *Kajaria* further describes “a method of providing pressurized fluid to a plurality of wells at a hydraulic fracturing site.”²⁷⁹ Further, *Kajaria* teaches “selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication between the at least one hydraulic fracturing pump and the at least one of the wells using valves positioned in the fluid conduit and corresponding to each of the plurality of wells”.²⁸⁰ Further, in the system of *Kajaria*, “it is possible [to] direct flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.”²⁸¹ Further, *Kajaria* teaches hydraulic fracturing operations at a multi-well fracturing site. *Kajaria* further discloses “providing pressurized fluid to a plurality of wells at a hydraulic fracturing site.”²⁸²

373. Further still, *Kajaria* discloses “pressurizing fluid with at least one hydraulic fracturing pump, ... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²⁸³

²⁷⁹ Ex. 1004 at [0010].

²⁸⁰ Ex. 1004 at [0010].

²⁸¹ Ex. 1004 at [0035].

²⁸² Ex. 1004 at [0010].

²⁸³ Ex. 1004 at [0010].

Therefore, *Kajaria* discloses permitting hydraulic fracturing of the fourth well as recited in 16.2.

c. **16.3: “(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.”**

374. As discussed above regarding 16.2, *Kajaria* discloses hydraulic fracturing operations of multiple wells, which would include a fourth well and a third well. Further, as discussed above regarding the preamble, each well has associated valves. *Kajaria* discloses “equipment used in the hydrocarbon industry, and in particular to systems and methods for hydraulic fracturing operations.”²⁸⁴ *Kajaria* further teaches “a flow system for use at a hydraulic fracturing well site” including “a plurality of valves in the fluid conduit ... each valve permitting fluid flow through the fluid conduit when in the open position, and preventing fluid flow through the fluid conduit when in the closed position.”²⁸⁵ In order to swap between fracturing the fourth well and fracturing the third well, the operator would simply, based on the teaching of *Kajaria*, open the valve **66** to allow fluid to go to a third well **14** and close the valve **66** to prevent fluid flow to a fourth well **14**. Since each valve permits hydraulic fluid flow at a hydraulic fracturing well site when in the open position,

²⁸⁴ Ex. 1004 at [0003].

²⁸⁵ Ex. 1004 at [0009].

Kajaria discloses, or at least renders obvious swapping from fracturing a fourth well to fracturing a third well as claimed.

375. Accordingly, *Kajaria* discloses, or at least renders obvious, limitation 16.3. For the reasons discussed above, Claim 16 is obvious over the combination of *Kajaria* and *Jackson*.

L. DEPENDENT CLAIM 17

376. Dependent Claim 17 depends from Claim 16. In addition to the disclosure of the limitations of Claim 16 discussed above, *Kajaria* discloses the additional limitations of Claim 17:

- a. **“17. The method of claim 16, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.”**

377. As discussed above, *Kajaria* teaches directing fluid between wells continuously by operating the valves associated with individual wells.²⁸⁶ This “allows an operator to easily direct flow between wells at a multi-well site as needed,” to provide fluid to a well at a particular time/place, “while simultaneously stopping the flow of fluid into another well that is in a different place in the frac cycle.”²⁸⁷ A POSITA would have found it obvious to use the system and methods

²⁸⁶ Ex. 1004 at [0035].

²⁸⁷ Ex. 1004 at [0035].

of *Kajaria* “to easily direct flow between wells at a multi-well site as needed in the course of operations,” which would encompass different orders for fracturing the multiple wells, simultaneously and/or sequentially, based on *Kajaria*’s teachings of opening and closing the valves associated with each well while continuously pumping fluid to each of the associated valves.

378. Thus, *Kajaria* discloses, or at least renders obvious, the limitations of Claim 17. Therefore, Claim 17 is obvious over the combination of *Kajaria* and *Jackson* for the reasons discussed above.

M. DEPENDENT CLAIM 18

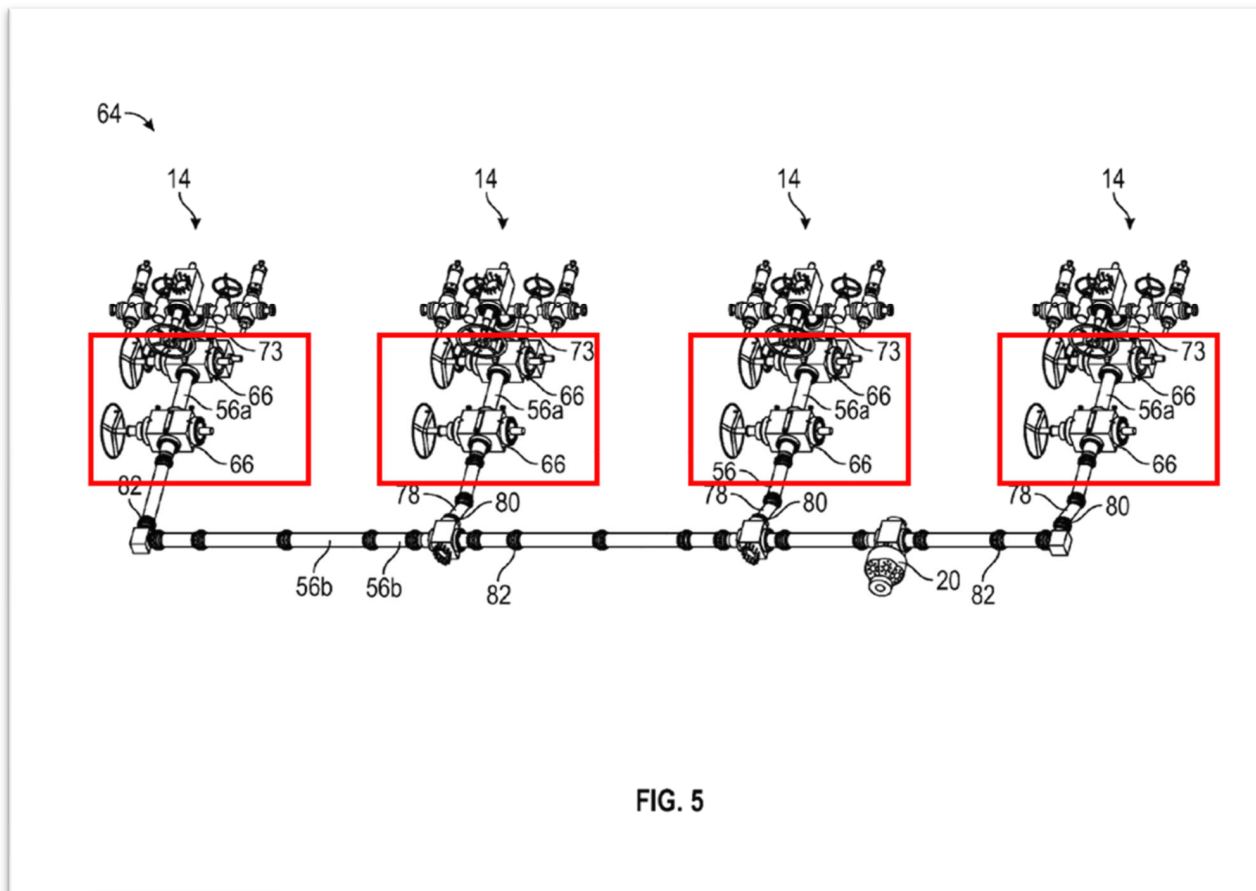
379. Dependent Claim 18 depends from Claim 16. In addition to the disclosure of the limitations of Claim 16 discussed above, *Kajaria* discloses the additional limitations of Claim 18:

- a. **18.1: “18. The method of claim 16, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;”**

380. *Kajaria* discloses this limitation. *Kajaria* discloses “pressurizing fluid with at least one hydraulic fracturing pump ... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²⁸⁸ Further, *Kajaria* teaches “it is possible [to] direct flow between wells

²⁸⁸ Ex. 1004 at [0010].

continuously simply by opening or closing the valves **66** associated with individual wells.”²⁸⁹ Fig. 5 of *Kajaria* depicts the valves **66** associated with each well, including a third and fourth well (annotated in red).



381. *Kajaria* discloses, “The pumps in typical fracturing operations pump the fluid to a frac pump output header, also known as a missile, which in turn passes the fluid to a hydraulic fracturing manifold. The hydraulic fracturing manifold is located between the missile and a tree (assortment of valves and controls) located above the

²⁸⁹ Ex. 1004 at [0035].

opening of a well bore.”²⁹⁰ Further, “[e]mbodiments of the present disclosure are directed to systems and methods for coupling manifolds to trees at well sites.”²⁹¹ Accordingly, *Kajaria* discloses both continuously pumping to the third and fourth valves and that this pumping is completed using a manifold.

382. Thus, *Kajaria* renders obvious Limitation 18.1.

b. **18.2: “wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and”**

383. *Kajaria* discloses “permitting performance of a first hydraulic fracturing operation on a first well.” As discussed above, *Kajaria* discloses a fourth valve associated with the fourth well as part of the “Multiple Well Pad.” *Kajaria* discloses pumping fluid to the plurality of wells, including the fourth well, “pressurizing fluid with at least one hydraulic fracturing pump... and selectively directing the fluid into a well via the fluid conduit by opening and closing fluid communication ... using valves positioned in the fluid conduit and corresponding to each of the plurality of wells.”²⁹² *Kajaria* further teaches “a flow system for use at a hydraulic fracturing well site” including “a plurality of valves in the fluid conduit,” “each valve permitting fluid flow through the fluid conduit when in the open

²⁹⁰ Ex. 1004 at [0006].

²⁹¹ Ex. 1004 at [0024].

²⁹² Ex. 1004 at [0010].

position, and preventing fluid flow through the fluid conduit when in the closed position.”²⁹³ Further still, *Kajaria* teaches “direct[ing] flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.”²⁹⁴ Based on the disclosure of *Kajaria* it would at least have been obvious to a POSITA to open the fourth valve associated with the fourth well to permit pumping fluid into the fourth well.

384. Accordingly, *Kajaria* discloses, or at least renders obvious, Limitation 18.2.

- c. **18.3.1: “wherein step (d) comprises opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and”**

385. *Kajaria* discloses this limitation. As discussed above regarding 18.2, *Kajaria* discloses pumping fluid to the plurality of valves associated with the multiple wells at the pad site. Further, *Kajaria*, teaches a flow system for use at a hydraulic fracturing well site including “a plurality of valves in the fluid conduit ... each valve permitting fluid flow through the fluid conduit when in the open position, and preventing fluid flow through the fluid conduit when in the closed position.”²⁹⁵ Further still, *Kajaria* teaches “direct[ing] flow between wells continuously simply

²⁹³ Ex. 1004 at [0009].

²⁹⁴ Ex. 1004 at [0035].

²⁹⁵ Ex. 1004 at [0009].

by opening or closing the valves 66 associated with individual wells,” which would have included valves to a third well.²⁹⁶ Based on the disclosure of *Kajaria* it would at least have been obvious to a POSITA to open the third valve associated with the third well to permit pumping fluid into the third well.

386. Accordingly, *Kajaria* discloses, or at least renders obvious, Limitation 18.3.1.

d. **18.3.2: “closing the fourth valve associated with the fourth well.”**

387. *Kajaria* discloses this limitation. *Kajaria* teaches a flow system for use at a hydraulic fracturing well site including “a plurality of valves in the fluid conduit ... each valve permitting fluid flow through the fluid conduit when in the open position and preventing fluid flow through the fluid conduit when in the closed position.”²⁹⁷ Further still, *Kajaria* teaches “direct[ing] flow between wells continuously simply by opening or closing the valves 66 associated with individual wells.”²⁹⁸ Based on the disclosure of *Kajaria* it would at least have been obvious to a POSITA to close the fourth valve associated with the fourth well.

²⁹⁶ Ex. 1004 at [0035].

²⁹⁷ Ex. 1004 at [0009].

²⁹⁸ Ex. 1004 at [0035].

388. Accordingly, *Kajaria* discloses, or at least renders obvious, Limitation 18.3.2. In view of the above, the combination of *Kajaria* and *Jackson* renders Claim 18 obvious.

N. **INDEPENDENT CLAIM 25**

389. It is my opinion that *Kajaria* discloses Claim 25 or at least renders obvious Claim 25 of the '779 Patent, and the combination of *Kajaria* and *Jackson* renders Claim 25 obvious. With the exception of this being an “apparatus” claim, and the claim further containing a description of structure of the apparatus, namely known computer elements for executing instructions, Claim 25 is essentially similar to Claim 15. It would have been obvious to perform Claim 15’s method with a computer, such that the method steps may be performed more safely and efficiently. As discussed below, *Kajaria* contains disclosure of the structure of apparatus that is equivalent to that of Claim 25 of the '779 Patent.

a. **25.1: “An apparatus adapted to hydraulically fracture first and second wells, the first and second wells being associated with first and second valves, respectively, the apparatus comprising:”**

390. For the same reasons discussed above regarding Limitation 15.1, *Kajaria* discloses a system for hydraulically fracturing first and second wells, the first and second wells being associated with first and second valves. Additionally, for the same reasons discussed above regarding Limitations 8.1.1-8.2.2, *Kajaria* discloses, or renders obvious, using an apparatus having a non-transitory computer

readable medium and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the claimed steps are executed.

- b. **25.2: “a non-transitory computer readable medium; and”**
25.3: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed:”

391. Limitations 25.2 and 25.3 are identical to Limitations 8.1.2-8.2.2 and are disclosed or rendered obvious by *Kajaria* for the same reasons as those described above regarding Claim 8 in Section XII.F.

- c. 25.4: “(a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and
- 25.5: “measuring a flow rate of the fluid being pumped into the second well;”
- 25.6.1: “(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising:”
- 25.6.2: “opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and”
- 25.6.3: “closing the second valve associated with the second well;”
- 25.7: “wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”
- 25.8: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”
- 25.9: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”

392. The language in Limitations 25.4 through 25.9 is identical to that of Limitations 15.2 through 15.7. *Kajaria* discloses Limitations 25.4 through 25.9 for the same reasons as those discussed regarding 15.2 through 15.7 in Section XII.J. In

view of the above, the combination of *Kajaria* and *Jackson* discloses each and every element of Claim 25, and renders Claim 25 obvious. A person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Kajaria* for the reasons discussed above, and therefore Claim 25 as a whole is obvious over *Kajaria* and *Jackson*.

O. DEPENDENT CLAIM 26

- a. **26.1: “26. The apparatus of claim 25, wherein the apparatus is further adapted to hydraulically fracture third and fourth wells, the third and fourth wells being associated with third and fourth valves, respectively; and wherein, when the instructions are executed by the one or more processors, the following steps are also executed”**

393. Other than depending from Claim 25 and being an apparatus claim with computer language to execute the steps (which is already discussed with respect to Claim 25), this limitation is substantially similar to 16.1 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding 16.1 in Section XII.K.a.

- b. **26.2: “(c) permitting hydraulic fracturing of the fourth well;”**

394. Other than depending from Claim 25 and being an apparatus claim, this limitation is substantially similar to 16.2 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding 16.2 in Section XII.K.b.

- c. **26.3: “(d) swapping from permitting hydraulic fracturing of the fourth well to permitting hydraulic fracturing of the third well.**

395. Other than depending from Claim 25 and being an apparatus claim, this limitation is substantially similar to 16.3 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding 16.3 in Section XII.K.c. In view of the above, the combination of *Kajaria* and *Jackson* renders Claim 26 obvious.

P. DEPENDENT CLAIM 27

396. The combination of *Kajaria* and *Jackson* obvious, Claim 27 of the '779 Patent. Further detail is provided below.

- a. **“27. The apparatus of claim 26, wherein steps (a) and (c) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold; and wherein steps (b) and (d) are executed simultaneously using hydraulic fracturing fluid from the hydraulic manifold.”**

397. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Claim 17 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding Claim 17 in Section XII.L. In view of the above, the combination of *Kajaria* and *Jackson* renders Claim 27 obvious.

Q. DEPENDENT CLAIM 28

398. The combination of *Kajaria* and *Jackson* renders obvious, Claim 28 of the '779 Patent. Further detail is provided below.

- a. **28.1: “28. The apparatus of claim 26, wherein, during step (d), hydraulic fracturing fluid is continuously pumped to the third and fourth valves via the hydraulic manifold;”**

399. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.1 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding Limitation 18.1 in Section XII.M.a.

- b. **28.2: “wherein step (c) comprises opening the fourth valve associated with the fourth well to permit pumping of fluid into the fourth well via the fourth valve; and”**

400. Other than depending from Claim 26 and being an apparatus claim, this limitation is substantially similar to Limitation 18.2 and is rendered obvious by the combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding Limitation 18.2 in Section XII.M.b.

- c. **28.3.1: “wherein step (d) comprises: opening the third valve associated with the third well to permit pumping of fluid into the third well via the third valve; and”**

28.3.2: “closing the fourth valve associated with the fourth well.”

401. The language in Limitations 28.3.1 and 28.3.2 is identical to that in Limitations 18.3.1 and 18.3.2 in Claim 18 and is rendered obvious by the

combination of *Kajaria* and *Jackson* for the same reasons as those discussed regarding Limitation 18.3 in Sections XII.M.c – XII.M.d. In view of the above, the combination of *Kajaria* and *Jackson* renders Claim 28 obvious.

R. DEPENDENT CLAIM 31

402. Dependent Claim 31 depends from Claim 25. In addition to the disclosure of the limitations of Claim 25 discussed above, the combination of *Kajaria* and *Jackson* discloses the additional limitations of Claim 31:

- a. **31.1: “31. The method of claim 25, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold, or both; and”**

403. This claim limitation merely sets forth optional flowrate measurements, including flowrates below an upper flowrate threshold, or above a lower flowrate threshold, or both, and thus only one needs to be shown in the prior art. As discussed above regarding the motivation to combine, *Jackson* discloses using various thresholds as a trigger for moving the fracturing operation to the next stage. As an example, *Jackson* discloses “there is a process for fracturing a formation including: introducing a supply of fracturing fluid to the formation until a first threshold is reached, adjusting the flow of the fracturing fluid to reach a second threshold, adjusting the flow to reach a third threshold and ceasing flow of the

fracturing fluid to the formation, the fracturing fluid being a non-participating gas and including a proppant in at least one of the stages”.²⁹⁹

404. *Jackson* further teaches specifically that the thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) a time period threshold; (b) a non-participating gas [fracturing fluid] flow rate threshold; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”³⁰⁰ *Jackson* teaches “the first threshold may be reached by introduction of a fracturing fluid over a period of time. As will be appreciated, however, other process parameters such as flow rate, pressure, volume, formation condition etc. are observed to asses a formation fracturing process.”³⁰¹ *Jackson* teaches “[i]n one embodiment, the first threshold is defined as an introduction of fluid for a time period in the range of 1 to 10 minutes and a flow rate of dilation fluid of at least 1000 scm,”³⁰² which a POSITA would have understood to be “above a lower threshold” as claimed. Further, as an example of a combined flowrate/time threshold, *Jackson* teaches “the second threshold may be defined as a time period of

²⁹⁹ Ex. 1005 at [0003].

³⁰⁰ Ex. 1005 at [0017]; *see also* Claim 20.

³⁰¹ Ex. 1005 at [0019].

³⁰² Ex. 1005 at [0020].

more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm”.³⁰³ In this example, the fracturing fluid flowrate must be below a flowrate threshold of 300 scm (standard cubic feet per minute) for a time threshold of at least one minute, up to 24 hours. Thus, *Jackson* discloses wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold or above a lower flow rate threshold, as claimed.

405. It would have been obvious to a POSITA to include the fluid flowrate thresholds of *Jackson* in the hydraulic fracturing plan of *Kajaria* so that the determined flowrate triggers moving the fracturing operation to the next stage. This combination of *Kajaria* and *Jackson* would render obvious wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold or above a lower flow rate threshold or both. Accordingly, the combination of *Kajaria* and *Jackson*, therefore, renders Limitation 31.1 obvious.

³⁰³ Ex. 1005 at [0021]; *see also* Claim 22.

- b. **31.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.**

406. Limitation 31.2 essentially defines the portion excluded by Limitation 31.1. In other words, Limitation 31.2 merely says that if the flowrate conditions in Limitation 31.1 are not met, then the flowrate measured at step (a) “has not been satisfied.” Thus, this limitation does not add anything more technically to claim 31 other than the use of the phrase “not met.” Because *Kajaria* and *Jackson* disclose meeting certain flow rate thresholds, as discussed above, *Kajaria* and *Jackson* also disclose that when the flow rate does not meet the desired threshold, whether it is above an upper threshold or lower than a lower threshold, the measured flow rate “has not satisfied the one or more flow rate conditions.” Moreover, this is standard practice for any flow system—if a measured flowrate is outside the required flowrate, then a flowrate condition is not met.

407. The combination of *Kajaria* and *Jackson* discloses each and every limitation of Claim 31. Accordingly, Claim 31 would have been obvious to a POSITA in light of the disclosures of *Kajaria* and *Jackson*, for the reasons discussed above.

S. DEPENDENT CLAIM 36

408. Dependent Claim 36 depends from Claim 15. In addition to the disclosure of the limitations of Claim 15 discussed above, *Kajaria* and *Jackson* discloses the additional limitations of Claim 36:

a. **36.1: “36. The method of claim 15, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold or both and”**

36.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.”

409. With the exception of depending from Claim 15, Limitations 36.1-36.2 are identical to 31.1-31.2 and are disclosed and/or rendered obvious by *Kajaria* and *Jackson* for the same reasons as those discussed above regarding 31.1-31.2 in Section XII.R. In view of the above, the combination of *Kajaria* and *Jackson* renders Claim 36 obvious.

XIII. GROUND 4: OBVIOUS OVER KRUPA IN VIEW OF JACKSON

410. It is my opinion that the combination of *Krupa* and *Jackson* discloses and/or suggests all limitations of Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36, thereby rendering these claims obvious. To the extent *Krupa* alone does not anticipate or render obvious Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36, this ground is presented as an alternative to Grounds 1-2. Ground 4 incorporates by

reference the discussion of Grounds 1-2 above. The relevant limitations disclosed by *Jackson* are presented below. All other elements of Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36 are disclosed or rendered obvious by *Krupa* as described above in Grounds 1-2. Although disclosed, or at least rendered obvious by *Krupa*, *Jackson* provides additional disclosure regarding the use of “flowrate thresholds” in a fracturing operation recited in certain claims, as addressed below.

A. RATIONALE AND MOTIVATION FOR COMBINING *KRUPA* WITH *JACKSON*

411. A POSITA would have been motivated at the time of invention of the ’779 Patent (*i.e.*, the priority date), with a reasonable expectation of success, to combine *Jackson* with *Krupa*. *Jackson* is in the same field of endeavor of oil and gas well systems, including drilling, completion, and production technologies, as *Krupa* (as well as the ’779 Patent) and is directed to solving the same problem—controlling well operations. *Krupa* is directed to “a built hydraulic fracturing system with a plurality of devices connected together and in fluid communication with one or more wells.”³⁰⁴ *Jackson* is directed to a “process for fracturing a selected region of a formation including: introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached.”³⁰⁵

³⁰⁴ Ex. 1003 at Abstract.

³⁰⁵ Ex. 1005 at Abstract.

412. Both references modify fluid flow at different points in the fracturing stage or sub-stage in order to, for example, increase or decrease pressure in the formation, or to conduct mechanical operations. Further, both references use “thresholds” to determine when to move to the next stage of the fracturing operation. *Krupa* discloses pumping “at a full pump rate, such as a rate of about 50-150 bbl/min”³⁰⁶ until a volume threshold is reached, and then reducing the rate, “[o]nce a total volume of the flush fluid is pumped,” for example, to “5-15 bbl./min.”³⁰⁷ *Krupa* then teaches, after flowrate conditions are met (e.g., pressure has stabilized at the reduced pump rate), “the software application may move the fracturing plan to the next step.” *Krupa*, therefore, teaches the use of thresholds, of at least volume, pressure, time and flowrate, to determine when to move to the next step of the fracturing process.

413. Similarly, *Jackson* discloses, for example, “introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached, adjusting the flow of the fracturing fluid ... to reach a second threshold, adjusting the flow of the fracturing fluid ... to reach a third threshold, and ceasing flow of the fracturing fluid to the formation.”³⁰⁸ *Jackson*’s use of thresholds to determine when

³⁰⁶ Ex. 1003 at [0042].

³⁰⁷ Ex. 1003 at [0042].

³⁰⁸ Ex. 1005 at Abstract.

and how to adjust well conditions, including flowrate of the fracturing fluid, is strikingly similar to the disclosure of *Krupa*.

414. To the extent that *Krupa* does not already teach using flowrate and time thresholds as the trigger to move to the next stage (*e.g.*, flowrate below a threshold for a threshold period of time), a POSITA would be motivated to use the threshold levels from *Jackson*, or otherwise incorporate the teachings of flowrate and time thresholds from *Jackson* in order to, for example, determine when to move to the next stage of the fracturing process (*i.e.*, the software application may move the fracturing plan to the next step.) Both *Krupa* and *Jackson* disclose similar functions of thresholds being used to trigger the control system to move to the next stage of the fracturing operation. A POSITA, therefore, would recognize that combining the teachings of *Krupa* and *Jackson* is a simple substitution of one known element for another (*e.g.*, specific thresholds) to obtain predictable results. Further a POSITA would recognize that the addition of specific thresholds from *Jackson* to the method of *Krupa* is the use of a known technique (specific thresholds) to a known method of *Krupa* and used in the same way, to transition to the next stage of fracturing operations. A POSITA would have had a reasonable expectation of success in combining *Krupa* and *Jackson* for the same reasons.

B. INDEPENDENT CLAIM 1

415. It is my opinion that Claim 1 of the '779 Patent would have been obvious over *Krupa* in view of *Jackson*. Details regarding the specific disclosures of *Jackson* are contained in the subsections following.

- a. **1.1.1 – 1.2: “1. A method, comprising: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well;”**

416. Limitations 1.1.1-1.2 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.A.a-XI.A.d above.

- b. **1.3: “(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and”**

417. To the extent that the Board finds that *Krupa* alone does not disclose or render obvious this claim limitation, *Jackson* discloses this limitation. As discussed above regarding the motivation to combine, *Jackson* discloses using various thresholds as a trigger for moving the fracturing operation to the next stage. As an example, *Jackson* discloses “there is a process for fracturing a formation including: introducing a supply of fracturing fluid to the formation until a first threshold is reached, adjusting the flow of the fracturing fluid to reach a second threshold, adjusting the flow to reach a third threshold, and ceasing flow of the fracturing fluid

to the formation, the fracturing fluid being a non-participating gas and including a proppant in at least one of the stages.”³⁰⁹

418. *Jackson* further teaches specifically that the thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] flow rate threshold; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”³¹⁰ Further, *Jackson* specifically discloses a combination of flow rate and time. *Jackson* teaches “the first threshold may be reached by introduction of a fracturing fluid over a period of time. As will be appreciated, however, other process parameters such as flow rate, pressure, volume, formation condition, etc. are observed to assess a formation fracturing process.”³¹¹

419. Further, as an example of a combined flowrate / time threshold, *Jackson* teaches “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm.”³¹² A POSITA would understand *Jackson*’s “dilation fluid” to be a type of fracturing fluid,

³⁰⁹ Ex. 1005 at [0003].

³¹⁰ Ex. 1005 at [0017] (emphasis added); *see also* Claim 20.

³¹¹ Ex. 1005 at [0019].

³¹² Ex. 1005 at [0021]; *see also* Claims 22.

as Jackson teaches that the disclosed methods include “pressurizing” and “urging a fracture dilation fluid with a proppant” into the well.³¹³ Thus, in Jackson’s example, the fracturing fluid flowrate must be below a flowrate threshold of 300 scm (standard cubic feet per minute) for a time threshold of at least one minute, up to 24 hours.

420. Accordingly, *Jackson* discloses “determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold” as recited in Limitation 1.3. It would have been obvious to a POSITA to determine a flowrate threshold of a fluid pumped into a well is below a rate threshold as disclosed in *Jackson* in the hydraulic fracturing plan of *Krupa* to ensure a particular operation or stage of the fracturing process is underway or completed. The combination of *Krupa* and *Jackson*, therefore, renders 1.3 obvious.

c. **1.4: “has been below the flow rate threshold for a threshold amount of time;”**

421. To the extent that the Board finds that *Krupa* alone does not disclose or render obvious this claim limitation, *Jackson* discloses this limitation. As discussed above regarding 1.3, *Jackson* specifically teaches a threshold of a flowrate for a threshold amount of time. In one embodiment of *Jackson*: “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow

³¹³ Ex. 1005 at Claim 30.

rate of dilation fluid of less than 300 scm.”³¹⁴ Accordingly, the flowrate threshold disclosed by *Jackson*, in that example, is 300 scm and the threshold amount of time is 1 minute up to 24 hours.

422. Accordingly, *Jackson* discloses the flowrate “has been below the flow rate threshold for a threshold amount of time” as recited in Limitation 1.4. It would have been obvious to a POSITA to determine the flowrate has been below the flowrate threshold for a threshold amount of time as disclosed in *Jackson* in the hydraulic fracturing plan of *Krupa* to ensure an operation of the fracturing process was completed and to determine when to move to the next stage of the fracturing process. The combination of *Krupa* and *Jackson*, therefore, renders Limitation 1.4 obvious.

- d. **1.5 – 1.8: “(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.”**

423. Limitations 1.5-1.8 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.A.g-XI.A.j above.

³¹⁴ Ex. 1005 at [0021]; *see also* Claim 22.

424. Because the combination of *Krupa* and *Jackson* disclose each and every element of Claim 1, and because a person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Krupa* for the reasons discussed above, Claim 1 as a whole would have been obvious to a POSITA in light of the disclosures of *Krupa* and of *Jackson*.

C. INDEPENDENT CLAIM 8

425. It is my opinion that Claim 8 of the '779 Patent would have been obvious over *Krupa* in view of *Jackson*. Details regarding the specific disclosures of *Jackson* are contained in the subsections following.

- a. **8.1.1 – 8.4: “8. An apparatus, comprising: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and measuring a flow rate of the fluid being pumped into the first well; and”**

426. Limitations 8.1.1 – 8.4 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.F above.

- b. **8.5 – 8.6: “(b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and has been below the flow rate threshold for a threshold amount of time;”**

427. To the extent that the Board finds that *Krupa* alone does not disclose or render obvious this claim limitation, *Jackson* discloses this limitation. The limitations of 8.5-8.6 are identical to those of 1.3-1.4 and are disclosed by *Jackson* for the same reasons as discussed above regarding 1.3-1.4 in Sections XIII.B.b-XIII.B.c.

428. Further, it would have been obvious to a POSITA to determine the flowrate of the fluid pumped into the well is below a flowrate threshold for a threshold amount of time as disclosed in *Jackson* in the hydraulic fracturing plan of *Krupa* to ensure an operation of the fracturing process was completed and to determine when to move to the next stage of the fracturing process. Therefore, the combination of *Krupa* and *Jackson* renders Limitations 8.5-8.6 obvious.

- c. 8.7 – 8.10: “(c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well; (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well; wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.”

429. Limitations 8.7 – 8.10 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.E.e above.

430. Because the combination of *Krupa* and *Jackson* discloses each and every element of Claim 8, and because a person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Krupa* for the reasons discussed above, Claim 8 as a whole would have been obvious to a POSITA in light of the disclosures of *Krupa* and of *Jackson*.

D. INDEPENDENT CLAIM 15

431. It is my opinion that Claim 15 of the '779 Patent would have been obvious over *Krupa* in view of *Jackson*. Details regarding the specific disclosures of *Jackson* are contained in the subsections following.

- a. 15.1 – 15.5: “15. A method of hydraulically fracturing at least first and second wells of a plurality of wells, the first and second wells being associated with first and second valves, respectively, the method comprising: (a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and measuring a flow rate of the fluid being pumped into the second well; (b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising: opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”

432. Limitations 15.1-15.5 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.I.a-XI.I.h above.

- b. 15.6: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b);”

433. To the extent that *Krupa* alone does not render this claim limitation obvious, *Jackson* discloses this limitation. As discussed above regarding the motivation to combine, *Jackson* discloses using various thresholds as a trigger for moving the fracturing operation to the next stage. As an example, *Jackson* discloses there is a process for fracturing a formation including: “introducing a supply of

fracturing fluid to ... the formation until a first threshold is reached, adjusting the flow of the fracturing fluid to ... reach a second threshold, adjusting the flow ... to reach a third threshold and ceasing flow of the fracturing fluid to ... the formation, the fracturing fluid being a non-participating gas and including a proppant in at least one of the stages”.³¹⁵

434. *Jackson* further teaches specifically that the thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) *a time period threshold*; (b) a non-participating gas [fracturing fluid] *flow rate threshold*; (c) a well bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”³¹⁶ Further, *Jackson* specifically discloses a combination of flowrate and time. *Jackson* teaches “the first threshold may be reached by introduction of a fracturing fluid over a period of time. As will be appreciated, however, other process parameters such as flowrate, pressure, volume, formation condition, etc. are observed to assess a formation fracturing process.”³¹⁷ *Jackson*, accordingly, specifically identifies a “flow rate condition” as a criterion to be met before moving to the next stage of operations. As discussed above, *Krupa* discloses

³¹⁵ Ex. 1005 at Abstract.

³¹⁶ Ex. 1005 at [0017] (emphasis added); *see also* Claim 20.

³¹⁷ Ex. 1005 at [0019].

a hydraulic fracturing plan for hydraulically fracturing multiple wells that includes opening valves to permit and closing valves to restrict fluid flow into one, two, or more wells. Opening and closing wells in *Krupa* allows for moving between different stages of *Krupa*'s hydraulic fracturing plan. It would have been obvious to a POSITA to include the criteria of flowrate conditions disclosed in *Jackson* in the hydraulic fracturing plan disclosed in *Krupa*, as discussed above in Section XIII.A, such that in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b), as the criteria used would include opening the first valve before the second valve is closed, as claimed, to move the fracturing operation to the next stage.

435. Accordingly, the combination of *Krupa* and *Jackson* renders Limitation 15.6 obvious.

- c. **15.7: “or; in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”**

436. Limitation 15.7 is the second prong of an “OR” statement in Claim 15. Thus, Limitation 15.7 is optional. As discussed above regarding 15.6 in Sections XIII.D.b, the first prong of the “OR” is rendered obvious by the disclosure of *Krupa*,

or alternatively, by the combination of *Krupa* and *Jackson*, and as a result, satisfies the entire “OR” statement.

437. Nevertheless, Limitation 15.7 is also disclosed by *Krupa*. The claimed sequence of valves (*i.e.*, opening the first valve after or during closing of the second valve) was well-known to a POSITA as a “conventional” or non-continuous fracturing operation, and is taught by *Krupa*. *Krupa* discloses “steps of a typical frac operation may include ... shutting in of the first well [(which is equivalent to the claimed second well)], then moving to the next well [(which is equivalent to the claimed first well)].”³¹⁸

438. To the extent the Board determines that *Krupa* does not explicitly teach the sequence of valve operations (*i.e.*, opening first valve after/during closing second valve) is not specifically disclosed by *Krupa* in response to flowrate conditions being met, this would have been obvious to a POSITA. As discussed above, continuous operations (*i.e.*, opening first valve while second valve is still open) are taught by *Krupa* as being allowed by certain flowrate conditions. Absent flowrate conditions that would allow continuous pumping, a POSITA would have known that, in the alternative, the proper response would be to revert to conventional valve sequences. In other words, if the system of *Krupa* determines that continuous pumping operations should not proceed, then the backup would, obviously, be conventional

³¹⁸ Ex. 1003 at [0058].

fracturing operations (*i.e.*, opening the first valve only after the second valve is closed).

439. Because the combination of *Krupa* and *Jackson* discloses each and every element of Claim 15, and because a person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Krupa* for the reasons discussed above, Claim 15 as a whole would have been obvious to a POSITA in light of the disclosures of *Krupa* and of *Jackson*.

E. INDEPENDENT CLAIM 25

440. It is my opinion that Claim 25 of the '779 Patent would have been obvious over *Krupa* in view of *Jackson*. Details regarding the specific disclosures of *Jackson* are contained in the subsections following.

- a. 25.1 – 25.7: “25. An apparatus adapted to hydraulically fracture first and second wells, the first and second wells being associated with first and second valves, respectively, the apparatus comprising: a non-transitory computer readable medium; and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed: (a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and measuring a flow rate of the fluid being pumped into the second well; (b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising: opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and closing the second valve associated with the second well; wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”

441. Limitations 25.1-25.7 are disclosed or at least obvious over the teachings of *Krupa* for the same reasons as those discussed in Sections XI.M above.

- b. 25.8: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”

442. The language in Limitation 25.8 is identical to that of Limitation 15.6. *Jackson* discloses, and the combination of *Krupa* and *Jackson* renders obvious, Limitation 25.8 for the same reasons as those discussed regarding 15.6 in Section XIII.D.b above.

- c. **25.9: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”**

443. Limitation 25.9 is the second prong of an “OR” statement in Claim 25. Therefore, Limitation 25.9 is optional. Additionally, the language in Limitation 25.9 is identical to that of Limitation 15.7. The combination of *Krupa* and *Jackson* renders obvious Limitation 25.9 for the same reasons as those discussed regarding 15.7 in Section XIII.D.c above.

444. Because the combination of *Krupa* and *Jackson* discloses each and every element of Claim 25, and because a person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Krupa* for the reasons discussed above, Claim 25 would have been obvious to a POSITA in light of the disclosures of *Krupa* and of *Jackson*.

F. DEPENDENT CLAIM 31

445. Dependent Claim 31 depends from Claim 25. In addition to the disclosure of the limitations of Claim 25 discussed above, *Krupa* and *Jackson* disclose or render obvious the additional limitations of Claim 31:

- a. **31.1: “31. The method of claim 25, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold, or both; and**

446. This claim limitation merely sets forth optional flowrate measurements, including flow rates below an upper flowrate threshold, or above a lower flowrate threshold, or both, and thus only one needs to be shown in the prior art. To the extent the Board determines that *Krupa* alone does not disclose or render obvious this claim limitation, *Jackson* discloses this limitation. As discussed above regarding the motivation to combine, *Jackson* discloses using various thresholds as a trigger for moving the fracturing operation to the next stage. As an example, *Jackson* discloses “there is a process for fracturing a formation including: introducing a supply of fracturing fluid to the formation until a first threshold is reached, adjusting the flow of the fracturing fluid to reach a second threshold, adjusting the flow to reach a third threshold, and ceasing flow of the fracturing fluid to the formation, the fracturing fluid being a non-participating gas” “and including a proppant in at least one of the stages”.³¹⁹

447. *Jackson* further teaches specifically that the thresholds “may be defined by at least one criterion selected from a set of criteria consisting of: (a) a time period threshold; (b) a non-participating gas [fracturing fluid] flow rate threshold; (c) a well

³¹⁹ Ex. 1005 at [0003] and Abstract.

bore surface or bottom hole pressure threshold; (d) a well bore surface or bottom hole rate of pressure change threshold (e) a gas quantity threshold and (f) a formation condition threshold.”³²⁰ *Jackson* teaches “the first threshold may be reached by introduction of a fracturing fluid over a period of time. As will be appreciated, however, other process parameters such as flow rate, pressure, volume, formation condition etc. are observed to assess a formation fracturing process.”³²¹ *Jackson* teaches “[i]n one embodiment, the first threshold is defined as an introduction of fluid for a time period in the range of 1 to 10 minutes and a flow rate of dilation fluid of at least 1000 scm,”³²² which a POSITA would have understood to be “above a lower threshold” as claimed. Further, as an example of a combined flowrate/time threshold, *Jackson* teaches “the second threshold may be defined as a time period of more than 1 minute and less than 24 hours of a flow rate of dilation fluid of less than 300 scm”.³²³ In this example, the fracturing fluid flowrate must be below a flowrate threshold of 300 scm (standard cubic feet per minute) for a time threshold of at least one minute, up to 24 hours. Thus, *Jackson* discloses wherein the flowrate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate

³²⁰ Ex. 1005 at [0017]; *see also* Claim 20.

³²¹ Ex. 1005 at [0019].

³²² Ex. 1005 at [0020].

³²³ Ex. 1005 at [0021]; *see also* Claim 22.

measured at step (a) is below an upper flow rate threshold or above a lower flow rate threshold, as claimed.

448. It would have been obvious to a POSITA to include the fluid flowrate thresholds of *Jackson* in the hydraulic fracturing plan of *Krupa* so that the determined flowrate triggers moving the fracturing operation to the next stage. This combination of *Krupa and Jackson* would render obvious wherein the flowrate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold or above a lower flow rate threshold or both. Accordingly, the combination of *Krupa and Jackson*, therefore, renders Limitation 31.1 obvious.

- b. **31.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.**

449. Limitation 31.2 essentially defines the portion excluded by Limitation 31.1. In other words, Limitation 31.2 merely says that if the flowrates conditions in Limitation 31.1 are not met, then the flowrate measured at step (a) “has not been satisfied.” Thus, this limitation does not add anything more technically to Claim 31 other than the use of the phrase “not met.” Because *Krupa and Jackson* disclose meeting certain flowrate thresholds, as discussed above, *Krupa and Jackson* also disclose that when the flowrate does not meet the desired threshold, whether it’s above an upper threshold or lower than a lower threshold, the measured flowrate

“has not satisfied the one or more flow rate conditions.” Moreover, this is standard practice for any flow system—if a measured flowrate is outside the required flowrate, then a flowrate condition is not met.

450. Because the combination of *Krupa* and *Jackson* disclose each and every element of Claim 31, and because a person of ordinary skill in the art would have been motivated to incorporate the teachings of *Jackson* with *Krupa* for the reasons discussed above, Claim 31 as a whole would have been obvious to a POSITA in light of the disclosures of *Krupa* and *Jackson*.

G. DEPENDENT CLAIM 36

451. Dependent Claim 36 depends from Claim 15. In addition to the disclosure of the limitations of Claim 15 discussed above, *Krupa* discloses the additional limitations of Claim 36:

- a. **36.1: “36. The method of claim 15, wherein the flow rate measured at step (a) has satisfied the one or more flow rate conditions when the flow rate measured at step (a) is below an upper flow rate threshold, above a lower flow rate threshold or both and”**

452. With the exception of depending from Claim 15, this claim limitation is identical to 31.1 and would have been obvious to a POSITA in light of the disclosures of *Krupa* and *Jackson* for the same reasons as those discussed above regarding 31.1 in Section XIII.F.a.

- b. **36.2: “wherein the flow rate measured at step (a) has not satisfied the one or more flow rate conditions when the flow rate measured at step (a) is above the upper flow rate threshold or below the lower flow rate threshold.”**

453. With the exception of depending from Claim 15, this claim limitation is identical to 31.2 and would have been obvious to a POSITA in light of the disclosures of *Krupa* and *Jackson* for the same reasons as those discussed above regarding 31.2 in Section XIII.F.b. Accordingly, Claim 36 is obvious in view of *Krupa* and *Jackson*.

H. DEPENDENT CLAIMS 2, 3, 6, 9, 10, 13, 16-18, AND 26-28

454. Claims 2, 3, 6, 9, 10, 13, 16-18, and 26-28 are disclosed and/or rendered obvious by *Krupa* for the same reasons as those discussed in Section XI.B-XI.P above. Accordingly, the combination of *Krupa* and *Jackson* render these claims obvious.

XIV. GROUND 5: OBVIOUS OVER KAJARIA IN VIEW OF JACKSON AND MARTINO

455. It is my opinion that the combination of *Kajaria*, *Jackson*, and *Martino* discloses and/or suggests all limitations of Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36, thereby rendering these claims obvious. To the extent *Kajaria* and *Jackson* do not render obvious Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36, this ground is presented as an alternative to Ground 3. Ground 5 incorporates by reference the discussion of Ground 3 above. The relevant limitations disclosed by *Martino* are

presented below. All other elements of Claims 1-3, 6, 8-10, 13, 15-18, 25-28, 31, 36, are disclosed or rendered obvious by *Kajaria* and *Jackson*, as described above in Ground 3. Although these claims are at least rendered obvious by *Kajaria* and *Jackson*, *Martino* provides additional disclosure regarding the apparatus elements in the claims.

A. RATIONALE AND MOTIVATION FOR COMBINING *KAJARIA* AND *JACKSON* WITH *MARTINO*

456. A POSITA would have been motivated to combine *Martino* with *Kajaria* and *Jackson*, as *Martino* is in the same field of endeavor of oil and gas well systems as *Kajaria* and *Jackson* (as well as the ‘779 Patent) and is directed to solving the same problem—controlling well operations. *Kajaria* is directed to “a flow system for use at a hydraulic fracturing wellsite,” where valves are operated to selectively direct fluid flow into one or more wells.³²⁴ *Jackson* is directed to “[a] process for fracturing a selected region of a formation including: introducing a supply of fracturing fluid to the region of the formation until a first threshold is reached.”³²⁵ *Martino* is directed to valve control systems that operate to control valves in a well system based on measured fluid data in the system and predetermined fluid data ranges.³²⁶

³²⁴ Ex. 1004 at Abstract.

³²⁵ Ex. 1005 at Abstract.

³²⁶ Ex. 1006 at Abstract and [0021].

457. Both *Kajaria* and *Jackson* teach or suggest using control systems to control equipment in the well system. *Kajaria* teaches that “[m]onitoring equipment **38** can be mounted on a control vehicle **40**, and connected to, *e.g.*, the pumps **10**, blender **32**, the trees **14**, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”³²⁷ Although *Jackson* does not explicitly state a control system is used, *Jackson* teaches performing various control actions in the well system, such as adjusting the flow of fluid into a well until threshold(s) are reached, and states that “various fluid injection equipment and systems are known and may be employed, as desired to supply fracing fluid to a wellbore.”³²⁸ A POSITA would have recognized that one of the fluid injection systems which would have been used was a control system to control at least opening and closing of the valves.

458. Further, *Kajaria* provides an express motivation to combine. *Kajaria* teaches using a “control vehicle” to monitor different system parameters and allow an operator to control the fracturing operation but does not provide specific detail as to what apparatus elements the control vehicle contains.³²⁹ To the extent it would not have been obvious that the control vehicle includes the claimed apparatus elements

³²⁷ Ex. 1004 at [0028].

³²⁸ Ex. 1005 at [0004] and [0048].

³²⁹ Ex. 1004 at [0028].

(instructions stored on non-transitory computer readable medium and executable by processor(s)) to allow an operator to control the fracturing process, as taught by *Kajaria, Martino* discloses these elements.

459. *Martino* discloses valve control systems for use in “fluid-handling systems,” such as “a water/steam/chemicals injection system” “or other system for conveying fluids” into an oil or gas well.³³⁰ The valve control systems include a “control device **250** [with] a processor **252** and a memory component **254**.”³³¹ The processor **252** may be configured to execute instructions stored on the memory component **254**, *e.g.*, “to execute instructions corresponding to one or more control modes based on feedback received from one or more components of the overall system.”³³² Further, the valve control system “may be coupled to a controller **226** of the overall system (*e.g.*, a mineral extraction system) via a communications bus **228** or other electronic coupling device,” where the controller may receive feedback from components of the overall well system.³³³ The valve control system is configured to adjust a valve in the well system based on the difference between predetermined threshold ranges and the received feedback, which may include “characteristics of

³³⁰ Ex. 1006 at [0025].

³³¹ Ex. 1006 at [0046] and Fig. 7.

³³² Ex. 1006 at [0046].

³³³ Ex. 1006 at [0044].

the fluid flowing through the ... valve, and/or feedback received from other components of the fluid-handling system (e.g., pressure, flow rate, etc.).”³³⁴ Accordingly, a POSITA would have looked to *Martino* for teaching on valve control systems in order “to allow the operator to control different parameters of the fracturing operation” (*Kajaria*) based on predetermined thresholds in the fracturing operation of *Kajaria* and *Jackson*.³³⁵

460. A POSITA would have been motivated to include *Martino*’s teachings of valve control systems that control well system valves based on the differences between predetermined thresholds and measured well system fluid parameters as part of the control system in *Kajaria* and *Jackson* in order to improve control of the well operations. For example, the inclusion of a processor configured to execute instructions stored on a memory component corresponding to valve control based on feedback received from the well system would help *Kajaria* ensure that the valves are operated at the correct time to conduct the fracturing operations. Further, using a processor configured to execute instructions stored on a memory component corresponding to valve control based on measured feedback received from the well system (such as measured pressure and flowrate) would help ensure that valves are operated according to a threshold schedule, as outlined by *Jackson*.

³³⁴ Ex. 1006 at [0021] and [0052].

³³⁵ Ex. 1004 at [0028].

461. To the extent that *Kajaria* and *Jackson* do not already teach using a plurality of instructions stored on non-transitory computer readable medium and executable by one or more processors, a POSITA would be motivated to use these apparatus elements from *Martino*, or otherwise incorporate the teachings of using the control system apparatus elements from *Martino* into the fracturing system of *Kajaria* and *Jackson* at least for the reasons described above. A POSITA, therefore, would recognize that combining the teachings of *Kajaria*, *Jackson*, and *Martino* is a simple substitution of one known element (*e.g.*, control system apparatus elements) for another (*e.g.*, a control vehicle) to obtain predictable results. Further a POSITA would recognize that the addition of the specific control system apparatus elements from *Martino* to the system of *Kajaria* and *Jackson* is the use of a known technique (apparatuses) to a known method of *Kajaria* and used in the same way, to control opening and closing of valves according to feedback and thresholds. A POSITA would have had a reasonable expectation of success in combining *Kajaria* and *Jackson* with *Martino* for the same reasons.

B. INDEPENDENT CLAIM 8

462. It is my opinion that Claim 8 of the '779 Patent would have been obvious based on the teachings of *Kajaria*, *Jackson* and *Martino*.

- a. **8.1.1: “An apparatus comprising:”**
8.1.2: “a non-transitory computer readable medium; and”
8.2.1: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors,”
8.2.2: “wherein, when the instructions are executed by the one or more processors, the following steps are executed:”

463. *Kajaria* and *Martino* disclose limitations 8.11-8.2.2. *Kajaria* teaches that “[m]onitoring equipment **38** can be mounted on a control vehicle **40**, and connected to, *e.g.*, the pumps **10**, blender **32**, the trees **14**, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation.”³³⁶ During prosecution of the ’779 Patent, the examiner understood that the “control vehicle 40 would have computer readable medium to allow [an] operator to control the valves for the fracturing process.”³³⁷ The applicant did not disagree, but in response, the Applicant incorporated allowable subject matter into the independent claims.³³⁸

464. Whether or not *Kajaria*’s disclosure of the control vehicle inherently or obviously included processor(s) executing instructions on non-transitory computer readable medium, it was well known in the art to use computer systems having

³³⁶ Ex. 1004 at [0028].

³³⁷ Ex. 1010 at p. 4.

³³⁸ Ex. 1009 at p. 81-103.

processor(s) executing instructions on non-transitory computer readable medium to control valves and other equipment in hydraulic fracturing operations. For example, *Martino* is particularly directed to controlling valves that may be used in well systems to adjust and control the flow of fluid therethrough. The valves taught by *Martino* are controlled by a control device (e.g., a controller) that “include a processor 252 and a memory component.”³³⁹ “[T]he processor 252 may be configured to execute instructions stored on the memory component.”³⁴⁰ “For example, the processor 252 may be configured to execute instructions corresponding to one or more control modes based on feedback received from one or more components of the overall system (e.g., mineral extraction system).”³⁴¹ It would have been obvious to use a control system, as disclosed by *Martino*, including a processor that executes instructions stored on a memory component to control valves in a well system, in the control vehicle of *Kajaria* in order “to allow the operator to control different parameters of the fracturing operation.”³⁴²

465. Further, *Martino* teaches that the computing elements of the valve control system may receive measured feedback from the well system, e.g.,

³³⁹ Ex. 1006 at [0046].

³⁴⁰ Ex. 1006 at [0046].

³⁴¹ Ex. 1006 at [0046].

³⁴² Ex. 1004 at [0028].

“characteristics of the fluid flowing through the ... valve, and/or feedback received from other components of the fluid-handling system (e.g., pressure, flow rate, etc.).”³⁴³ Computing elements of the valve control system may further send instructions to operate a valve based on a comparison between the received feedback and a predetermined range of a fluid parameter.³⁴⁴ Thus, a POSITA would have found it obvious to use the computing elements disclosed by *Martino* to control valves in a multi-well fracturing system according to an injection schedule using flowrate and time thresholds, as taught in *Jackson*.

466. Accordingly, *Kajaria* and *Martino* render obvious a computing system that is an example of the apparatus as described in Claim 8.

³⁴³ Ex. 1006 at [0021].

³⁴⁴ Ex. 1006 at [0052].

- b. 8.3: “(a) permitting performance of a first hydraulic fracturing operation on a first well, which first hydraulic fracturing operation comprises pumping fluid into the first well via a first valve associated with the first well, and
- 8.4: measuring a flow rate of the fluid being pumped into the first well; and
- 8.5: (b) determining that the flow rate of the fluid being pumped into the first well is below a flow rate threshold and
- 8.6: has been below the flow rate threshold for a threshold amount of time;
- 8.7: (c) during pumping of the fluid into the first well via the first valve, opening a second valve associated with a second well;
- 8.8: (d) permitting performance of a second hydraulic fracturing operation on the second well, which second hydraulic fracturing operation comprises pumping fluid into the second well via the second valve; and
- 8.9: (e) during pumping of the fluid into the second well via the second valve, closing the first valve associated with the first well;
- 8.10: wherein, during each of steps (a), (b), (c), (d), and (e), fluid is continuously pumped to the first valve, the second valve, or both the first valve and the second valve.

467. Limitations 8.3-8.10 are disclosed or at least obvious over the teachings of *Kajaria* and *Jackson* for the same reasons as those discussed in Section XII.F above. Accordingly, the combination of *Kajaria* and *Jackson* renders these claim limitations obvious.

468. Because *Kajaria*, *Jackson*, and *Martino* disclose each and every element of Claim 8 and because a POSITA would have been motivated to combine *Martino* with *Kajaria* and *Jackson* for the reasons discussed above, Claim 8 would have been obvious to a POSITA in light of the disclosures of *Kajaria*, *Jackson*, and *Martino*.

C. **INDEPENDENT CLAIM 25**

469. It is my opinion that the combination of *Kajaria*, *Jackson*, and *Martino* renders Claim 25 obvious.

- a. **25.1: “An apparatus adapted to hydraulically fracture first and second wells, the first and second wells being associated with first and second valves, respectively, the apparatus comprising:”**

470. To the extent the preamble is limiting, *Kajaria* discloses a method of hydraulically fracturing a plurality of wells, including a first and second well, each well with associated valves.³⁴⁵ The title of *Kajaria* is “Systems and Methods for Fracturing a Multiple Well Pad.” A “multiple well pad” would include at least a first and second well. *Kajari* further discloses “flow system for use at a hydraulic fracturing well site. The flow system includes a plurality of trees, each tree attached to a wellhead... The flow system further includes a plurality of valves in the fluid

³⁴⁵ I understand that the preambles may not be limiting. However, I include analysis of the preamble for Claim 15 out of an abundance of caution.

conduit, each valve corresponding to one of the plurality of trees,”³⁴⁶ as shown, for example, in Figs. 1, 4, and 5. Accordingly, each well has an associated wellhead tree and each tree comprises at least one valve. Accordingly, *Kajaria* discloses at least a first and second well and associated first and second valves.

471. Additionally, for the same reasons discussed above regarding Limitations 8.1.1-8.2.2, *Kajaria* and *Martino* disclose, or render obvious, using an apparatus having a non-transitory computer readable medium and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the claimed steps are executed.

b. 25.2: “a non-transitory computer readable medium; and”

472. This limitation is identical to Limitation 8.1.2 and is disclosed or rendered obvious by *Kajaria* and *Martino* for the same reasons as those described above regarding Claim 8.

³⁴⁶ Ex. 1004 at [0009].

- c. **25.3: “a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors, the following steps are executed:”**

473. This limitation is identical to Limitation 8.2 and is disclosed or rendered obvious by *Kajaria* and *Martino* for the same reasons as those described above regarding Claim 8.

- d. 25.4: “(a) permitting hydraulic fracturing of the second well, comprising: opening the second valve associated with the second well to permit pumping of fluid into the second well via the second valve; and
- 25.5: “measuring a flow rate of the fluid being pumped into the second well;”
- 25.6.1: “(b) swapping from permitting hydraulic fracturing of the second well to permitting hydraulic fracturing of the first well, comprising:”
- 25.6.2: “opening the first valve associated with the first well to permit pumping of fluid into the first well via the first valve; and”
- 25.6.3: “closing the second valve associated with the second well;”
- 25.7: “wherein, during step (b), hydraulic fracturing fluid is continuously pumped to the first and second valves via a hydraulic manifold; and”
- 25.8: “wherein in response to determining that the flow rate measured at step (a) has satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) before the second valve associated with the second well is closed at step (b); or”
- 25.9: “in response to determining that the flow rate measured at step (a) has not satisfied one or more flow rate conditions, the first valve associated with the first well is opened at step (b) during or after the second valve associated with the second well is closed at step (b).”

474. The language in Limitations 25.4 through 25.9 is identical to that of Limitations 15.2 through 15.7. *Kajaria* and *Jackson* disclose or render obvious

Limitations 25.4-25.9 for the same reasons as those discussed regarding 15.2-15.7 in Section XII.J.

475. Because *Kajaria*, *Jackson*, and *Martino* disclose each and every element of Claim 25 and because a POSITA would have been motivated to combine *Martino* with *Kajaria* and *Jackson* for the reasons discussed above, Claim 25 would have been obvious to a POSITA in light of the disclosures of *Krupa*, *Jackson*, and *Martino*.

D. CLAIMS 1-3, 6, AND 15-18 AND 36

476. Claims 1-3, 6, 15-18 and 36 are disclosed and/or rendered obvious by *Kajaria* and *Jackson* for the same reasons as those discussed in Section XII above. Although Claims 1-3, 6, 15-18, and 36 are method claims that do not require an apparatus with a non-transitory computer readable medium, and a plurality of instructions stored on the non-transitory computer readable medium and executable by one or more processors, wherein, when the instructions are executed by the one or more processors to perform the steps claimed, the method steps could be performed by such an apparatus. Accordingly, the combination of *Kajaria*, *Jackson*, and *Martino*, which discloses the use of such an apparatus in wellbore applications, would also render these claims obvious.

E. DEPENDENT CLAIMS 9, 10, 13, 26-28, 31

477. Claims 9, 10, 13, 26-28, and 31 are disclosed and/or rendered obvious by *Kajaria* and *Jackson* for the same reasons as those discussed in Section XII above. Additionally, Claims 9, 10, 13, 26-28, and 31 depend from independent Claims 8 and 25, which as discussed above, are rendered obvious by *Kajaria*, *Jackson*, and *Martino*. Accordingly, the combination of *Kajaria*, *Jackson*, and *Martino* renders these claims obvious.

XV. SECONDARY CONSIDERATIONS

478. I have not seen any evidence of secondary considerations related to the '779 Patent. Should the Patent Owner put forth any alleged evidence of secondary considerations in this proceeding or any related proceeding, I reserve the right to consider such evidence, to consider whether any such evidence has a nexus to any claims of the Challenged Patent, and to update my analysis.

XVI. CONCLUSION

Based on my education, experience, and expertise, it is my opinion that all of the Challenged claims are anticipated and/or obvious in view of *Krupa*, *Kajaria*, *Jackson*, and/or *Martino* for the reasons discussed above.

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 December 1, 2023.



Dr. Robert A. Durham

APPENDIX A

Dr. ROBERT A DURHAM, PhD, FIEEE

Resume
Specialization
Honors & Awards
Publications

Dr ROBERT A DURHAM, PhD, FIEEE

Robert A Durham is the Principal of D² Tech Solutions, a technology related firm concentrating on Mechanical and Electrical systems and energy conversions. He also serves as a Principal Scientist of THEWAY LABs, Tulsa, OK, an engineering and energy consulting firm that provides design and failure analysis of facilities and system installations.

Dr. Durham's work experience is broad and encompasses all areas of the energy industry. Dr. Durham spent 11 years with AEP/CSW, at the time the country's largest utility, in electrical engineering positions in the power generation and transmission planning departments. He then accepted a position as Manager of Electric Infrastructure for New Dominion, LLC., a major independent energy producer in Oklahoma. Dr. Durham then moved on to hold the position of Vice President of Engineering and Project Management for EDG Power Group, an Engineering Procurement and Construction company specializing in design and construction of small to medium size power generating facilities. Dr. Durham left EDG Power Group to accept his current positions. Dr. Durham has been accepted as an expert and offered testimony in several jurisdictions.

Dr. Durham's extensive client list includes the development of a broad spectrum of forensic, electrical and facilities projects for many companies. He has also taught University offered courses in electrical engineering review for board licensure. He has published five books, six magazine articles and over 40 other technical papers and articles. Dr. Durham's extensive work on standards and electrical systems has resulted in his elevation to Fellow of the IEEE, the highest grade of recognition in the electrical technology industry.

Dr. Durham received the B.S. in electrical engineering from the University of Tulsa in 1992 and the M.E. in Technology Management from The University of Tulsa in 1997. Tulsa, OK. In 2004, Dr. Durham received a PhD in Engineering Management from Kennedy Western University.

Degrees Earned

BSEE, with Honors, The University of Tulsa
Master of Engineering, The University of Tulsa
PhD , Kennedy Western University

Area of Specialization

lightning & grounding
failure analysis & forensic engineering
electrical power systems & safety
power generation
utility industry competition
economics & management
petroleum & chemical industry
electrical / mechanical energy conversion

Registration

Professional Engineer - Oklahoma
Professional Engineer – Texas
Professional Engineer – California
Professional Engineer – New Hampshire (Inactive)
Professional Engineer – Kansas
Professional Engineer – North Carolina (Inactive)
Professional Engineer – Missouri
Professional Engineer – Arkansas
Professional Engineer – Virginia (Inactive)
Professional Engineer – Illinois (Inactive)
Electrical Contractor - Oklahoma

Work History

D² Tech Solutions, Inc. 2002 - 2022
Principal

THEWAY Corp. 2004 - 2022
Principal Scientist

EDG Power Group, Inc. 2002 - 2004
Vice President Engineering & Project Management

New Dominion, LLC 2000 - 2002
Mgr Electric Infrastructure

Central & Southwest, Inc 1989 - 2000
Electrical Engineer

Professional Memberships

Fellow	Institute of Electrical and Electronic Engineers
Diplomate	American College of Forensic Examiners, International
Member	National Association of Fire Investigators
Voting Member	National Fire Protection Institute, Electrical Section
Executive Member	Petroleum and Chemical Industry Committee, IEEE
Diplomate,	
Past Board Member	American Board of Forensic Engineering and Technology
Member	IEEE Standards Association
Past Chair	Production Subcommittee, IEEE IAS/PCIC
CFC	American College of Forensic Examiners
Member	International Association of Arson Investigators
CFEI, CVFEI	National Association of Fire Investigators
Past Chair	Tulsa Section IEEE
Chair	IEEE RP1017.1 Working Group
Chair	IEEE RP1017.2 Working Group
Chair	IEEE RP1017.3 Working Group
Chair	IEEE RP1017.4 Working Group
Past Chair	IEEE PCIC Standards Subcommittee
Secretary	IEEE Petroleum and Chemical Industry Committee

Honors and Awards

Fellow of the IEEE

For contributions to submersible electrical equipment analysis and multi-point ground method in hazardous petroleum and chemical environments.

Honor Societies

Tau Beta Pi, national engineering honors

Eta Kappa Nu, national electrical engineering honors

Dr. Durham's publications have often successfully competed for outstanding paper awards from journals of the Institute of Electrical and Electronic Engineers (PCIC and IAS). This is an

international competitive peer review and evaluation of papers that provide a significant contribution to the advancement and understanding of electrical applications.

IEEE Industry Applications Society, New Orleans, LA: Prize Article for “Data Quality and Grounding: Considerations in a Mixed Use Facility”

PCIC, Cincinnati, OH: Prize Paper for “Grounding and Bonding Conductors: Solid, Stranded, Bare or Insulated”

PCIC, New Orleans, LA: Prize paper for "Industrial Design Application for Power Distribution over Extra-Long Distances"

PCIC, Philadelphia, PA: Prize paper for "Paradigm Shifts and Impact on Engineers and Industry"

Transactions on Industry Applications, Orlando, FL: Prize Paper for "Lightning, Grounding, and Protection for Control Systems”.

PCIC, Denver, CO: Prize Paper for “Grounding System Design for Isolated Locations and Plant Systems”

PCIC, St. Louis, MO: First place for "Lightning, Grounding, and Protection for Distributed Control and Communications Systems: A Retrofit".

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Robert A Durham, PhD, PE
Expert Witness
Previous Four Years from September 15, 2023

Attorney	Case	Location	Issue	
Haynes Boone	Nabors v. Helmerich & Payne et al	Northern District, TX	Intellectual Property	Trial
McDermott Will & Emery LLP	Halliburton V. U.S. Well Services	Western District, TX	Intellectual Property	Trial
Jones, Oten & Jewell	Davis v. Tapp	Garfield County, OK	Fire / Injury	Trial
Haynes & Boone	Nabors Driling v. Helmerich & Payne et al	Northern District, TX	Intellectual Property	Depo
Mattingly Law	Fulton v. Aviagen et al	Muskogee County, OK	Building Codes	Trial
Baker Botts	US Well Services v. Halliburton	Western District, TX	Intellectual Property	Depo
Kelly, Morgan	Montanez v. Deepwell Energy Svcs	Ector County, TX	Flash Fire / Injury	Depo
Baker Botts	IPR 2021-01316	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01238	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01315	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01065	USPTO PTAB	Intellectual Property	Depo
Clancy & Thompson	Borth v. Phillips & Sons Trucking et al	Canadian County, OK	Injury	Depo
Baker Botts	IPR 2021-01034	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01033	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01032	USPTO PTAB	Intellectual Property	Depo
Stephen Jones	Davis v. Tapp	Garfield County	Fire / Injury	Depo
Kelly, Morgan	Calvillo v. On Point	Travis County, TX	Flash Fire / Injury	Depo
Hartline Barger	Ramirez v. Home Depot	Southern District, TX	Electrical Failure / Fire	Depo

Mcafee & Taft	Hale v. Southeast Colorado Power Association	Baca County, CO	Electrical Failure / Fire	Depo
Hartline Barger	Siqueros v. Templo Monte Horeb et al	El Paso County, TX	Injury	Depo
Naman, Howell	Lentz v Brenntag Pacific et al	Upton County, TX	Flash Fire / Injury	Depo
Craft Law Firm	Cason v. Cimarex et al	Victoria County, TX	Flash Fire / Injury	Depo
Naman, Howell	Lentz v Brenntag Pacific et al	Upton County, TX	Flash Fire / Injury	Depo