

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

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

Case IPR2025-01445
Patent No. 11,009,162

DECLARATION OF DR. ROBERT A. DURHAM

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I. 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. 11,009,162, which I may abbreviate as “the ’162 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 ’162 Patent. I am being compensated at my normal rate for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

II. EXPERIENCE AND QUALIFICATIONS

3. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are detailed more fully in my curriculum vitae, which is included as Appendix A. My CV also lists publications on which I am a named author and identifies parties on behalf of whom

4. I am a consulting engineer with experience in a number of technical areas. I have expertise in the oil and gas industry, spanning from drilling and completion to downstream operations. As a consultant, I have worked with oil field

production companies, refining and chemical plants, equipment manufacturers, and technology development companies for over twenty years. My work relates to the subject matter of the U.S. Pat. No. 11,009,162 (“the ’162 Patent”), which I describe below in Section VII (“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 leadership positions 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 to 2012, I served as Secretary, Vice Chair, and 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, wellhead, 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 equipment operations in the Oil and Gas Industry. The PCIC Standards Subcommittee 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 eight years, holding two-year terms in each position: Secretary, Vice Chair, Chair, and Chair of the Advisory and Awards Committee.

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 IEEE membership 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 was administratively 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, where I was responsible for Engineering and Project Management of generation and cogeneration facilities across the U.S., I transitioned to the role of consulting engineer. In that role, I have served as a consulting engineer, designing, constructing, and analyzing various systems, particularly those in the oil and gas industry. This has included the design and selection of equipment, as well as the analysis of equipment failures in the oil and gas field, spanning from drilling and completion sites to production facilities, midstream locations, and downstream (refinery) sites.

10. I am also a Principal of PEDOCS, Inc., an oil and gas production company that has operated over 50 oil and gas production wells in Oklahoma. As such, I am familiar with oil and gas well operations, including well stimulation, completion, hydraulic fracturing, and production.

11. I have been familiar with oil and gas drilling, fracturing (fracing), completion and production 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, completion and

production sites over my engineering consulting engagements, including numerous water collection, storage and disposal facilities.

12. I have been familiar with power distribution, including generation, transmission, and distribution equipment. As an employee, I worked as a design and construction engineer for generation facilities for Central and Southwest (now American Electric Power (AEP)). I was also responsible for the design and construction of generation facilities when employed by EDG Power Group, as discussed above. While at AEP, I spent three years as a transmission planner, responsible for modeling transmission systems and developing plans for increased power distribution capacities at high voltages. While at New Dominion LLC, I owned and was responsible for the design, construction, and maintenance of several hundred miles of medium-voltage (5–25 kV) distribution lines, switchgear, drives, and motors used for oil and gas drilling, completion, and production. Over the last ~ 20 years, I have consulted with numerous clients, ranging from utilities to oil and gas development and production companies, on the design, upgrades, and maintenance of generation and power distribution facilities.

13. I have been familiar with the design, specification, construction and operation of Adjustable Speed Drive (ASD) systems for over 30 years. While at AEP, I gained my first exposure to ASDs (sometimes referred to as variable

frequency drives or VFDs). Between 1990 and 1992, while employed by Public Service Company of Oklahoma (an AEP company), I was responsible for overseeing the field installation of multiple 4,500+ hp VFDs for fans and pumps. I continued working with ASDs and related technologies, such as back-to-back inverter systems, throughout my career at AEP. When I took over as Manager of Electric Infrastructure at New Dominion, I was responsible not only for overhead lines but also for the specification, installation, and operation of all ASDs for production pump applications on both downhole and surface pumping systems. These ASDs ranged from a few hundred to around 1,000 HP at both medium and low voltages. At EDG Power Group, I was responsible for specifying and overseeing the installation of VFDs that ran pumps and fan motors on power generation facility installations. Since I began consulting nearly 20 years ago, I have specified, installed, analyzed, and torn down ASDs on numerous projects. As Standards Chair of the PCIC, I have been responsible for overseeing the management of several standard working groups for ASD applications in the Oil and Gas Industry, including IEEE 1662, 1826, and 1566. I am comfortable in stating that I have worked with several hundred ASDs throughout my career.

14. I have been familiar with control systems, Supervisory Control and Data Acquisition (SCADA) systems, and remote-control operations for over thirty

years. I have been familiar with web-based control systems over the last decade as part of my various consulting engagements, including drilling systems, fluid handling systems, production systems, and others. Throughout my career, I have designed control systems, including remote control systems, for various facilities, such as oil and gas production, water storage and disposal facilities, water treatment facilities, power generation plants, generator systems, and aggregate conveying systems, among others. The first control system I designed, for a water treatment facility, was as a junior engineer in 1990-1991. I am a licensed controls system engineer and a licensed petroleum engineer.

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

16. Therefore, based on my education, professional experience of over 30 years, and scholarly books and publications, I am an expert in the relevant field of the '162 Patent and have been an expert in this field since before the '162 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 '162 Patent and the prior art references at the time of filing.

III. TASK SUMMARY AND MATERIALS REVIEWED

17. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged Patent, to review certain prior-art references, and analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent. The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art (POSITA) at the time of the '162 Patent.

IV. LIST OF EXHIBITS

18. In forming my opinions, I have reviewed the Challenged Patent, its prosecution history and referenced 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. 11,668,162 to Oehring et. al (filed May 17, 2021 and issued June 6, 2023) (“ 162 Patent ” or “ Challenged Patent ”)
1003	File History of U.S Patent No. 11,668,162 (App. No. 16/728,359) (“ File History ”)
1004	U.S. Patent No. 11,549,348 to Cicci et. al (filed Nov. 20, 2020 and issued Jan. 10, 2023) (“ Cicci ”)
1005	U.S. Provisional Application No. 62/941,459 (“ Cicci Provisional ”)
1006	U.S. Patent Publication No. 2012/0255734 to Coli (filed April 6, 2012, and published Oct. 11, 2012) (“ Coli ”)

1007	Henry Liu, <i>Pipeline Engineering</i> . CRC Press, 2003. (“ Liu ”)
1008	Kemper Valve & Fitting Corp. – Union Swages, available at https://web.archive.org/web/20190405051213/http://www.kempervalue.com:80/unionswages.php
1009	2018 Australia Dixon Product Catalog, available at https://australia.dixonvalve.com/sites/default/files/downloadable_resources/product_literature/ADPL718%20Catalog_optimized_0.pdf
1010	Gardner Denver, Inc., Well Servicing Pump, Model GD-2500Q, Quintuplex, Operating and Service Manual, 300FWF996 Revision C, (“ Gardner-Denver ”) published in April 2005, Tulsa, OK, USA.
1011	American National Standard for Reciprocating Power Pumps, ANSI/HI 6.1 (2015)
1012	2018 U.S. Dixon Product Catalog
1013	Declaration of Holly Lagenfelder
1014	Declaration of Dr. Sylvia Hall-Ellis
1015	Michael Morton, “ <i>Unlocking the Earth: A Short History of Hydraulic Fracturing</i> ,” GEO ExPro, Vol. 10, No. 6, December 2013 https://geoexpro.com/unlocking-the-earth-a-short-history-of-hydraulic-fracturing/ (last accessed November 30, 2023)
1016	B.A. Wells and K.L. Wells. “Shooters – A “Fracking” History.” American Oil & Gas Historical Society, https://aoghs.org/technology/hydraulic-fracturing (last accessed November 30, 2023)
1017	Carl T. Montgomery and Michael B. Smith, “Hydraulic Fracturing: History of an Enduring Technology,” <i>Journal of Petroleum Technology</i> , Vol. 62, Issue 12 (Dec. 2010).
1018	Bourgoyne, A. T., Jr., K. K. Millheim, M. E. Chenevert and F. S. Young, Jr. (1986). <i>Applied Drilling Engineering</i> , SPE Textbook Series, Vol. 2.

1019	Vassiliou, M. S., Historical dictionary of the petroleum industry, Rowman & Littlefield (2018)
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 No. 11,959,371 to Oehring
1022	Waters, George, Dean, Barry, Downie, Robert, Kerrihard, Ken, Austbo, Lance, and Bruce McPherson. “ <i>Simultaneous Hydraulic Fracturing of Adjacent Horizontal Wells in the Woodford Shale.</i> ” 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. “ <i>Results of Stress-Oriented and Aligned Perforating in Fracturing Deviated Wells.</i> ” 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. “ <i>What is Stimulated Reservoir Volume (SRV)?</i> ” Paper presented at the SPE Shale Gas Production Conference, Fort Worth, Texas, USA, November 2008. doi: https://doi.org/10.2118/119890-MS (“ <i>Mayerhofer</i> ”)
1026	Roussel, Nicolas P., and Mukul M. Sharma. “ <i>Optimizing Fracture Spacing and Sequencing in Horizontal-Well Fracturing.</i> ” SPE Prod & Oper 26 (2011): 173–184. doi: https://doi.org/10.2118/127986-PA (“ <i>Roussel</i> ”)
1027	K. R. Webster, W. C. Goins, Jr., and S. C. Berry, “ <i>A Continuous Multistage Tracing Technique,</i> ” <i>Journal of Petroleum Technology</i> , vol. 17, no. 06, pp. 619-625, 1965, doi: 10.2118/977-pa. (“ <i>Webster</i> ”)

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. ("Rassenfoss")
1030	ASME Landmark "America's First Power Generating Gas Turbine," available at: https://www.asme.org/wwwasmeorg/media/resourcefiles/aboutasme/who%20we%20are/engineering%20history/landmarks/100-belle-isle-gas-turbine.pdf
1031	ADM Callaghan "GTS Admiral W.M. Callaghan" available at https://maritime.dot.gov/multimedia/gts-admiral-wm-callaghan
1032	GE Power & Water, <i>Power Generation Products</i> , https://web.archive.org/web/20140717214839/https://www.ge-distributedpower.com/products/power-generation
1033	GE Power & Water, GE's TM2500+ solution offers fast, mobile, and flexible power, Aeroderivative Mobile Gas Turbine Brochure, available at: https://web.archive.org/web/20140717215045/https://www.ge-distributedpower.com/component/cck/?task=download&file=seb_media_document&id=13183
1034	Eugene A. Avallone et al., <i>Marks' Standard Handbook for Mechanical Engineers</i> (11th ed. 2007)
1035	A brochure of Solar Turbines Turbomachinery Systems for Oil and Gas Applications advertising the "transportability" of its natural gas turbines from 2006 available at:

	https://web.archive.org/web/20061102043710/http://mysolar.cat.com/cda/files/127587/7/bo&g.pdf
1036	Solar Turbines – Titan 130 Generation Set, available at: https://web.archive.org/web/20060318215809/http://mysolar.cat.com/cda/layout?m=36056&x=7
1037	Solar Turbines - Gas Turbine Products for the Oil and Gas Industry, available at: https://web.archive.org/web/20060712013257/http://mysolar.cat.com/cda/layout?m=35881&x=7
1038	U.S. Patent No. 2019/0249754 to Oehring
1039	CRC Press Books, About Us, available at https://www.routledge.com/corporate/about-us/crc-press?srsltid=AfmBOoo4LdrPswlrDh199mp0iAWleSZK26v7xZFamobLss_WyPVplVts
1040	Dixon Product Literature website, available at https://australia.dixonvalve.com/en/knowledge-center/references-and-education/product-literature
1041	Amazon.com Dixon Frac Fitting, HUF100300CS, available at https://www.amazon.com/Dixon-FEMALE-SUB-FIG-HUF100300CS/dp/B00LT0TT2U
1042	Dixon History: 100 years, available at https://australia.dixonvalve.com/en/about-dixon/history
1043	Dixon History: First Commercial Hydraulic Fracturing Wells Drilled March 17, 1949, available at https://australia.dixonvalve.com/en/about-dixon/history
1044	Gardner Denver, <i>Operating and Servicing Manual: Well Servicing Pump Model GD-2500Q QUINTUPLEX</i> , August 2005, available at https://web.archive.org/web/20120917102614/http://www.quincieoilfield.com/pdf/3.0%20Gardner%20Denver/2500/GD2500Q%20Op%20&%20Service%20Manual.pdf

1045	Socket Weld Fittings Types and Applications –Complete Specification, ASME B16.11-2004 available at https://web.archive.org/web/20180210052553/https://www.octalsteel.com/socket-weld-pipe-fittings/ .
1046	Cambridge English Dictionary, definition of “weld,” https://web.archive.org/web/20170709094317/https://dictionary.cambridge.org/dictionary/english/weld
1047	Collin’s English Dictionary definition of “quintuplex”: https://www.collinsdictionary.com/dictionary/english/quintuplex
1048	Jacobs, Trent. “ <i>The Shale Evolution: Zipper Fracture Takes Hold</i> ,” JPT Technology Writer, October 2014, (2014): 60–67
1049	Turbines: Solar Mobile Turbomachinery, available at https://www.solarturbines.com/en_US/solutions/oil-and-gas/solar-mobile-turbomachinery.html
1050	CNC Flow Control, Oilfield Solutions: Valves, Fittings, & Flow Lines
1051	GTS Admiral W.M. Callaghan, available at https://www.maritime.dot.gov/multimedia/gts-admiral-wm-callaghan
1052	Caterpillar Acquires Kemper Valve & Fittings Corp. Press Release, available at: https://www.cat.com/en_US/news/engine-press-releases/caterpillaracquireskempervalfittingscorporationexpandingcatwel.html
1053	Declaration of Duncan Hall, dated June 7, 2021
1054	MARC record for ANSI/HI 6.1-6.5 (2015), available at: https://catalog.lindahall.org/discovery/sourceRecord?vid=01LINDAHALL_I NST:LHL&docId=alma999258734905961&recordOwner=01LINDAHALL_I NST

1055	Hydraulic Fracturing Institute Reciprocating Pump Standards: available at https://web.archive.org/web/20150808112714/http://estore.pumps.org/Standards/Reciprocating/Hardcopy.aspx
1056	Claim Listing
1057	Variable Speed Pumping: A Guide to Successful Applications
1058	Langewis, C. et al., “Practical Hydraulics for Positive Displacement Pumps for High-Pressure Waterflood Installations,” Journal of Petroleum Engineering 173 (1971)_

Other than prosecution history, Ex. 1003, all citations to exhibits reference original page numbers found in the underlying document, and all emphases are added.

V. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE

19. After reviewing the materials identified in the List of Exhibits, I have concluded that each of the Challenged Claims of the '162 Patent would have been obvious to a person of ordinary skill in the art, based on the following grounds.

Ground	Claims	Basis (35 U.S.C. §)	Prior Art
1	1-4, 8-10, 14	103	<i>Cicci, Coli, and Dixon</i>
2	1-6, 8-12, 14	103	<i>Cicci, Coli, Dixon, and Liu</i>
3	1-14	103	<i>Cicci, Coli, Dixon, Liu, and Gardner-Denver</i>
4A	1-14	103	<i>Cicci, Coli, Dixon, Liu, and Kemper</i>
4B	1-14	103	<i>Cicci, Coli, Dixon, Liu, Gardner-Denver, and Kemper</i>

5A	7	103	<i>Cicci, Coli, Dixon, Liu, Gardner-Denver, and ANSI/HI 6.1</i>
5B	7	103	<i>Cicci, Coli, Dixon, Liu, Gardner-Denver, Kemper, and ANSI/HI 6.1</i>

VI. LEGAL STANDARDS

A. LEVEL OF ORDINARY SKILL IN THE ART

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

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

B. LEGAL STANDARD FOR CLAIM CONSTRUCTION

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

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

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

25. I understand that to determine how a person of ordinary skill would 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.

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

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

C. ANTICIPATION

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

D. OBVIOUSNESS

29. I understand that the prior art may render a patent claim “obvious.” I understand that two or more prior art references (e.g., prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in

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

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

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

32. I understand that any evidence of secondary indicia of non-obviousness should be considered when evaluating whether a claimed invention would have been

obvious to one of ordinary skill at the time of invention. These secondary indicia of non-obviousness may include, for example:

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

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

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

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;

- the claimed subject matter would have been “obvious to try” choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to a POSITA;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent’s claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

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

E. PRIORITY DATE

36. I understand that, subject to the next paragraph, the asserted “priority date” of a patent is the earlier of: (a) the date on which a patent application is filed; or (b) the date on which an earlier-filed patent application is filed if the patentee claims the benefit of priority to that earlier-filed patent application.

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

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

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

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

VII. OVERVIEW OF THE CHALLENGED PATENT

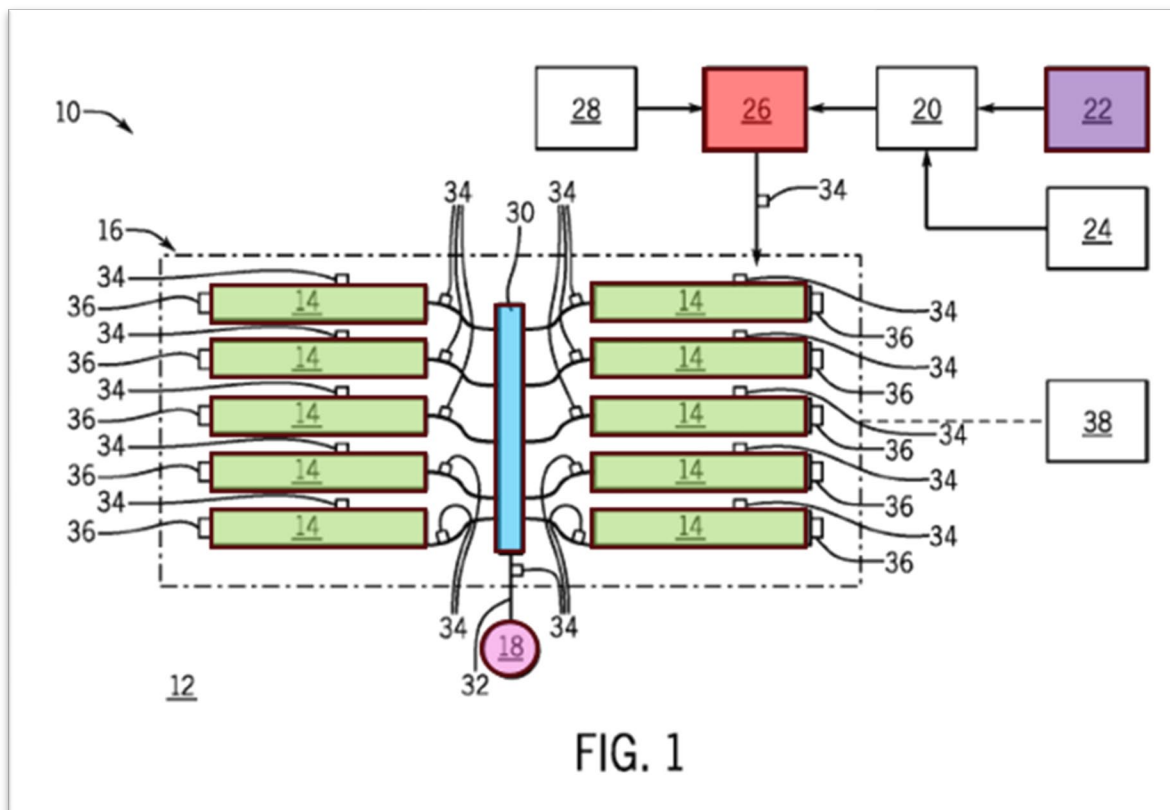
A. DISCLOSURE OF THE '162 PATENT

40. The '162 Patent relates to a “system and method for integrated flow supply line.”¹ The '162 Patent describes a conventional fracturing system comprising “an electric powered pump having an inlet and an outlet, the outlet coupled to a well associated with [a] subterranean formation and powered by at least one electric motor.”² The Patent also describes “a fluid source, coupled to the inlet of the electric powered pump, the fluid source providing a slurry for injection into

¹ Ex. 1001 ('162 Patent), cover.

² Ex. 1001 ('162 Patent), Abstract

the subterranean formation.”³ The Patent further describes a “hose extending between the fluid source and the electric powered pump.”⁴ Figure 1, below, illustrates a hydraulic fracturing system.⁵



Ex. 1001 ('162 Patent) Fig. 1 (annotated).

³ Ex. 1001 ('162 Patent), Abstract

⁴ Ex. 1001 ('162 Patent), Abstract.

⁵ Ex. 1001 ('162 Patent), 4:17-49.

The blender unit 26 (highlighted in red) receives fluid from the fluid source 22 (highlighted in purple) and adds proppant to form a slurry.⁶ The pumps 14 (highlighted in green) pressurize the slurry.⁷ The distribution system 30 (highlighted in blue), such as a missile, receives the slurry from the pump for injection into the wellhead.⁸

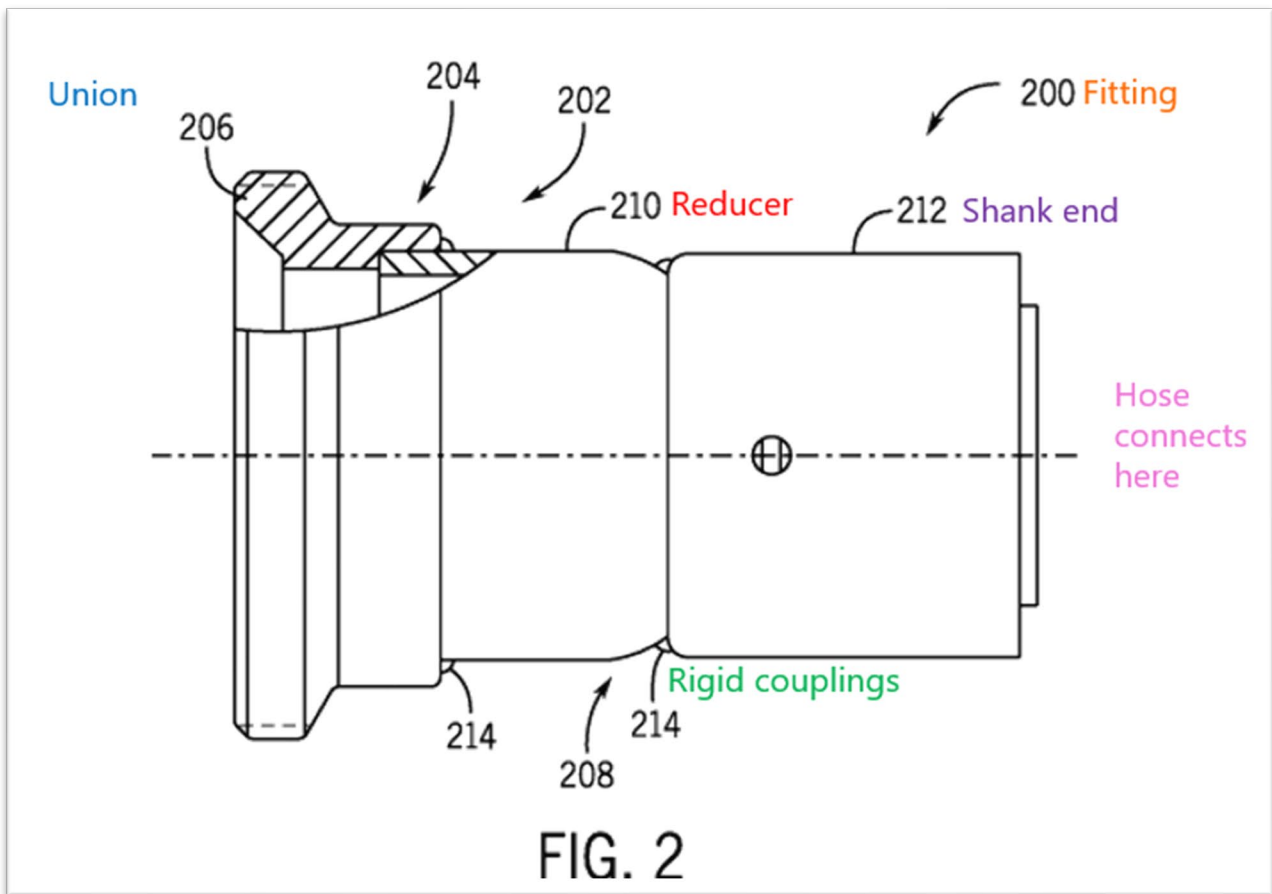
41. The Patent also describes a fitting between the hose and the electric powered pump with “a first end for receiving the hose at the first diameter and a second end for coupling to the electric powered pump at a second diameter.”⁹ An embodiment of the fitting is illustrated in Figure 2, below.

⁶ Ex. 1001 ('162 Patent), 4:24-47.

⁷ Ex. 1001 ('162 Patent), 4:19-21.

⁸ Ex. 1001 ('162 Patent), 4:34-36.

⁹ Ex. 1001 ('162 Patent), at Abstract.



EX1001 ('162 Patent), Fig. 2 (annotated).

The patent describes embodiments in which the first and second diameters have different relative sizes.¹⁰

42. As discussed below, fracturing systems as described, using flexible hoses and fittings, were well known before the time of the alleged invention of the '162 Patent. Additionally, fittings such as those described in the '162 Patent, with smaller hose ends and larger pump connection ends, were also well known before

¹⁰ Ex. 1001 ('162 Patent), 6:22-38.

the time of the alleged invention of the '162 Patent, both as integral fittings, and as an obvious combination of known individual fitting components.

B. PROSECUTION HISTORY OF THE '162 PATENT

43. U.S. Patent App. No. 16/728,359 Application (“the '359 Application”) that ultimately issued as the '162 Patent was filed on December 27, 2019. The Examiner allowed the claims without commenting on the alleged points of novelty.¹¹

C. PRIORITY DATE OF THE '162 PATENT

44. The '162 Patent was filed as U.S. Patent App. No. 16/728,359 (“the '359 Application”) on December 27, 2019. I have been asked to assume that the earliest possible priority date for the Challenged Claims of the '162 Patent would be no earlier than December 27, 2019, when the '359 Application was filed.

D. CHALLENGED CLAIMS

45. The Challenged Claims of the '162 Patent, which are Claims 1-14, are set forth below. Some of the claim elements have been further sub-divided (and labeled as part “1[a]”, “1[b]” or similar, where the first number indicates the claim number, and the following letter refer to sub parts of that claim) for ease of reference.

Claim	Description
1[p]	1. A hydraulic fracturing system for fracturing a subterranean formation, comprising:

¹¹ Ex. 1003 (File History), pgs. 280-285.

1[a]	an electric powered, multi-plunger hydraulic fracturing pump having an inlet and an outlet, the outlet coupled to a well associated with the subterranean formation and powered by at least one electric motor;
1[b]	a fluid source, coupled to the inlet of the electric powered pump, the fluid source providing a slurry for injection into the subterranean formation;
1[c]	a hose extending between the fluid source and the electric powered pump, the hose being flexible and having a first diameter;
1[d]	a fitting between the hose and the electric powered pump, the fitting having a first end for receiving the hose at the first diameter and a second end for coupling to the electric powered pump at a second diameter, the second diameter being larger than the first diameter; and
1[e]	a distribution system, positioned between the wellbore and the electric powered pump, the distribution system collecting the slurry from electric powered pumps for injection into the subterranean formation.
2	2. The system of claim 1, wherein the first diameter is approximately 5 inches and the second diameter is approximately 6 inches.
3[a]	3. The system of claim 1, wherein the fitting further comprises: a union at the second end, the union configured to couple to a mating fitting;
3[b]	a shank end at the first end, the shank end receiving at least a portion of the hose, the shank end being crimped over at least the portion of the hose; and
3[c]	a reducer between the union and the shank end, at least a portion of the reducer extending into a groove formed in the union, the union extending farther laterally than the reducer
4	4. The system of claim 3, wherein the fitting is formed as an integral piece with at least one rigid coupling between at least one of the union, the shank end, and the reducer.
5	5. The system of claim 1, wherein the first diameter is particularly selected based at least in part on a threshold, the threshold corresponding to a drop out rate for the slurry.
6	6. The system of claim 1, wherein the first diameter is particularly selected based at least in part on a pressure drop rate, a damage accumulation rate, or a suggested flow rate.

7	7. The system of claim 1, wherein the first diameter is associated with a second threshold, corresponding to a maximum suggested flow rate, an operating window for the electric powered pump exceeding the maximum suggested flow rate.
8[a]	8. The system of claim 1, further comprising: a plurality of electric powered, multi-plunger pumps, each pump receiving fluid from the fluid source;
8[b]	a plurality of hoses having the first diameter; and
8[c]	a plurality of fittings between respective hoses of the plurality of the hoses and respective pumps of the plurality of pumps, each of the pumps having a connection having the second diameter.
9[p]	9. A hydraulic fracturing system for fracturing a subterranean formation, comprising:
9[a]	an electric powered, multi-plunger hydraulic fracturing pump having an inlet and an outlet, the outlet coupled to a well associated with the subterranean formation and powered by at least one electric motor;
9[b]	a fluid source, coupled to the inlet of the electric powered pump, the fluid source providing a slurry for injection into the subterranean formation;
9[c]	a hose extending between the fluid source and the electric powered pump, the hose being flexible and having a first diameter;
9[d]	a fitting between the hose and the electric powered pump, the fitting comprising:
9[e]	a union arranged at a first end, the union having a second diameter, larger than the first diameter, and being configured to couple to the pump;
9[f]	a shank end configured to receive at least a portion of the hose, the shank end being securable to at least the portion of the hose, the shank end including an opening to receive the shank end; and
9[g]	a reducer positioned between the union and the shank end, the reducer being welded to the respective union and shank end at each end, the reducer having an increasing diameter along its axial length, the reducer extending at least partially into the union; and
9[h]	a distribution system, positioned between the wellbore and the electric powered pump, the distribution system collecting the slurry from electric powered pumps for injection into the subterranean formation.

10	10. The system of claim 9, wherein the first diameter is approximately 5 inches and the second diameter is approximately 6 inches.
11	11. The system of claim 9, wherein the first diameter is particularly selected based at least in part on a threshold, the threshold corresponding to a drop out rate for the slurry.
12	12. The system of claim 9, wherein the first diameter is particularly selected based at least in part on a pressure drop rate, a damage accumulation rate, or a suggested flow rate.
13	13. The system of claim 9, wherein the first diameter is associated with a second threshold, corresponding to a maximum suggested flow rate, an operating window for the electric powered pump exceeding the maximum suggested flow rate.
14[a]	14. The system of claim 9, further comprising: a plurality of electric powered, multi-plunger pumps, each pump receiving fluid from the fluid source;
14[b]	plurality of hoses having the first diameter; and
14[c]	a plurality of fittings between respective hoses of the plurality of the hoses and respective pumps of the plurality of pumps, each of the pumps having a connection having the second diameter.

VIII. LEVEL OF ORDINARY SKILL IN THE ART

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

completion, or production including design and/or analysis of hydraulic fracturing systems.

IX. CLAIM CONSTRUCTION

47. It is my opinion that a POSITA would have understood all the claim terms to have their plain and ordinary meaning, and I have applied the plain and ordinary meaning, in the context of the '162 Patent, for all claim terms.

X. TECHNOLOGY BACKGROUND AND STATE OF THE ART

48. 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 timeframe, and long before.

A. WELL DRILLING, COMPLETION, AND PRODUCTION

49. Generally, well drilling is the process of drilling a hole into the earth to extract natural resources, such as water, oil, or gas, from the earth formation or to inject a fluid downhole to, *e.g.*, stimulate production of a fluid, monitor formations, or store fluids and/or waste. Well completion is the process of preparing a well for production (or injection) after drilling operations. Well completion may include running production tubing strings, isolating hydrocarbon-producing zones,

perforating the tubing, stimulating the well (such as by injecting hydraulic fracturing fluid), or other processes to facilitate or enhance the recovery or injection of fluids. During production, the hydrocarbon resource is sent to the surface and collected for sale.

50. Various types of surface equipment are used in the drilling, completion, and production processes. For drilling, a drill bit is attached to a drill pipe. Blowout prevention equipment, which includes one or more valves that may be closed in case of a loss of control event (along with other emergency equipment), is installed on the well. Mud pumps are configured to pump mud (drilling fluid) from a mud pit into the drill pipe. A derrick is positioned over the well to suspend the drill string and run it into the well.

51. During completion operations, flow lines and valves on the surface are connected to the well to facilitate and control fluid flow into the well and/or tools run into the well. Pumps are connected to the flow lines to pump fluid through the lines and into the well.

52. During production operations, flow lines extending from the well direct the produced fluid through a series of valves to separate it, transport it to separators, tanks, and/or processing equipment.

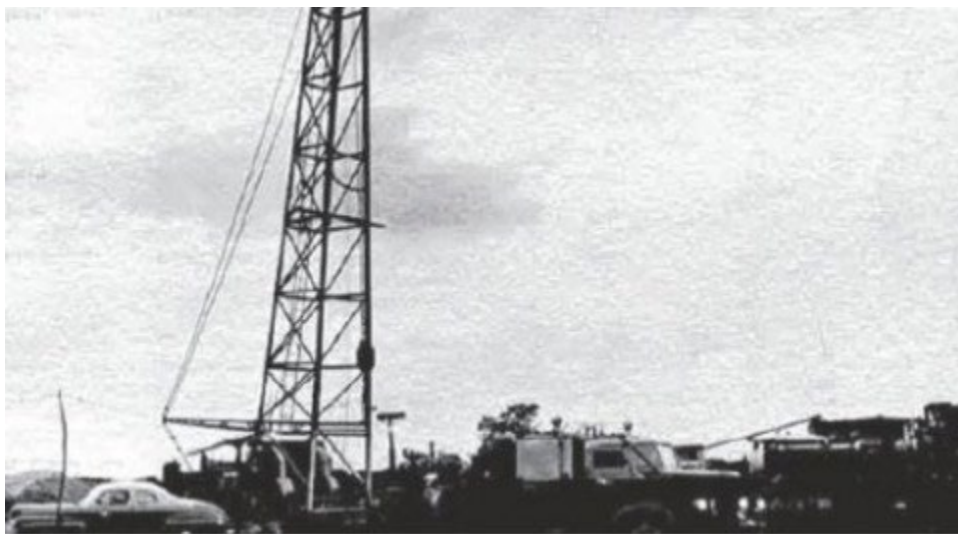
B. HISTORY OF HYDRAULIC FRACTURING

53. 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 1850s used explosives such as gunpowder ignited by red-hot iron or nitroglycerin “torpedoes.”¹² Hydraulic fracturing, in its modern form of pumping liquids and proppants (e.g., sand) into the formation, began in the 1940s using a process developed by Stanolind Oil and used by Halliburton in the mid-continent region. Early hydraulic fracturing in the 1940s and 1950s utilized frac pumps, including those that could operate at approximately 1,500 hp.¹³ On March 17, 1949, Stanolind and Haliburton performed the first commercial application of hydraulic fracturing at a location about 12 miles east of Duncan, Oklahoma.¹⁴

¹² Ex. 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)).

¹³ Ex. 1017 (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)).

¹⁴ Ex. 1016 (B.A. Wells and K.L. Wells. “Shooters – A “Fracking” History.” American Oil & Gas Historical Society, (<https://aoghs.org/technology/hydraulic-fracturing>) (last accessed November 30, 2023)).



54. The expansion of directional and horizontal drilling extended the use of hydraulic fracturing into previously underdeveloped “tight” formations, including shale.¹⁵ In oil and gas exploration, directional drilling is a technique for accessing hydrocarbon-bearing formations (oil and gas formations) that are not located immediately beneath the surface location, or to increase the amount of formation exposed to the wellbore. A tool or process is used to cause the wellbore to deviate from the vertical, allowing it to reach previously inaccessible formation locations, expose more of the hydrocarbon-bearing formation to the wellbore, or 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

¹⁵ Ex. 1017 (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)).

of directional wells was clearly motivated by economics.”¹⁶ It was the offshore fields of California that gave rise to the technology that 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.

55. Throughout the 1980s, directional drilling (a technique for accessing hydrocarbon-bearing formations (oil and gas formations) that are not located immediately beneath the surface location, or to increase the amount of formation exposed to the wellbore) increased. Techniques for drilling wells to intersect natural fractures were particularly focused on offshore pads and in the Austin Chalk trend of central Texas. The Austin Chalk is a soft, loosely cemented, and easily pulverized limestone characterized by natural fractures that are oriented primarily vertically. Horizontally deviated wells were drilled into the chalk to intersect several natural fractures, allowing for the transport of hydrocarbons into the wellbore. This was combined with artificial fracturing to increase the flow rate of hydrocarbons into the wellbore.

¹⁶ Ex. 1018 (Bourgoyne, A. T., Jr., K. K. Millheim, M. E. Chenevert and F. S. Young, Jr. (1986), Applied Drilling Engineering, Society of Petroleum Engineers.), pg. 3.



56. Because 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 2012.¹⁷ Other references, such as *Coli*, suggest that systems of pumps as large as 2,500 hp each, with a total system power of up to 40,000 hp, were used during the same period (four trailers, each with four 2,500 hp pumps operating in parallel).¹⁸

¹⁷ Ex. 1020 (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].

¹⁸ Ex. 1006 (*Coli*), [0049], FIG. 2.

These pumps are typically triplex or quintuplex positive displacement (plunger) type pumps.¹⁹ Although some fracturing systems have been converted to electric driven pump motors, the large majority of hydraulic pumping systems “are typically mobilized on skids or tractor-trailers and powered using diesel motors.”²⁰ These diesel engines require large amounts of diesel fuel, along with the requisite extra safeguards to address potential safety concerns.²¹

C. TYPES OF PUMPS – FRACTURING PUMP CHAIN

57. 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 liquid) blended with a proppant (*e.g.*, sand) and other chemicals into the downhole reservoir at a sufficient pressure to crack (fracture) the downhole rock. The sand-water mixture is then forced into the cracks, where the sand keeps the cracks (fractures) open to allow hydrocarbons, such as oil and natural gas, to flow out of the formation into the well bore. What has changed are the pressures and flowrate of the fracturing jobs, the sizes of equipment and the particular proppants, chemicals and liquids used.

¹⁹ Ex. 1020 (*Sanborn*), [0005]; Ex. 1006 (*Coli*), [0011].

²⁰ Ex. 1006 (*Coli*), [0005], [0007] (“standard fluid pumps require large volumes of diesel fuel and extensive equipment maintenance programs”).

²¹ Ex. 1020 (*Sanborn*), [0007].

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

59. In the blender, water is mixed with a proppant, such as sand, 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 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.

60. Once the fracturing slurry is blended to the proper makeup and consistency, it is transferred to the fracturing pumps using a blender discharge pump. This pump typically operates at a higher pressure than the water or chemical transfer pumps, for several reasons. First, the viscosity of the slurry is normally higher than that of water, which requires higher pressures to move the same volume of slurry.

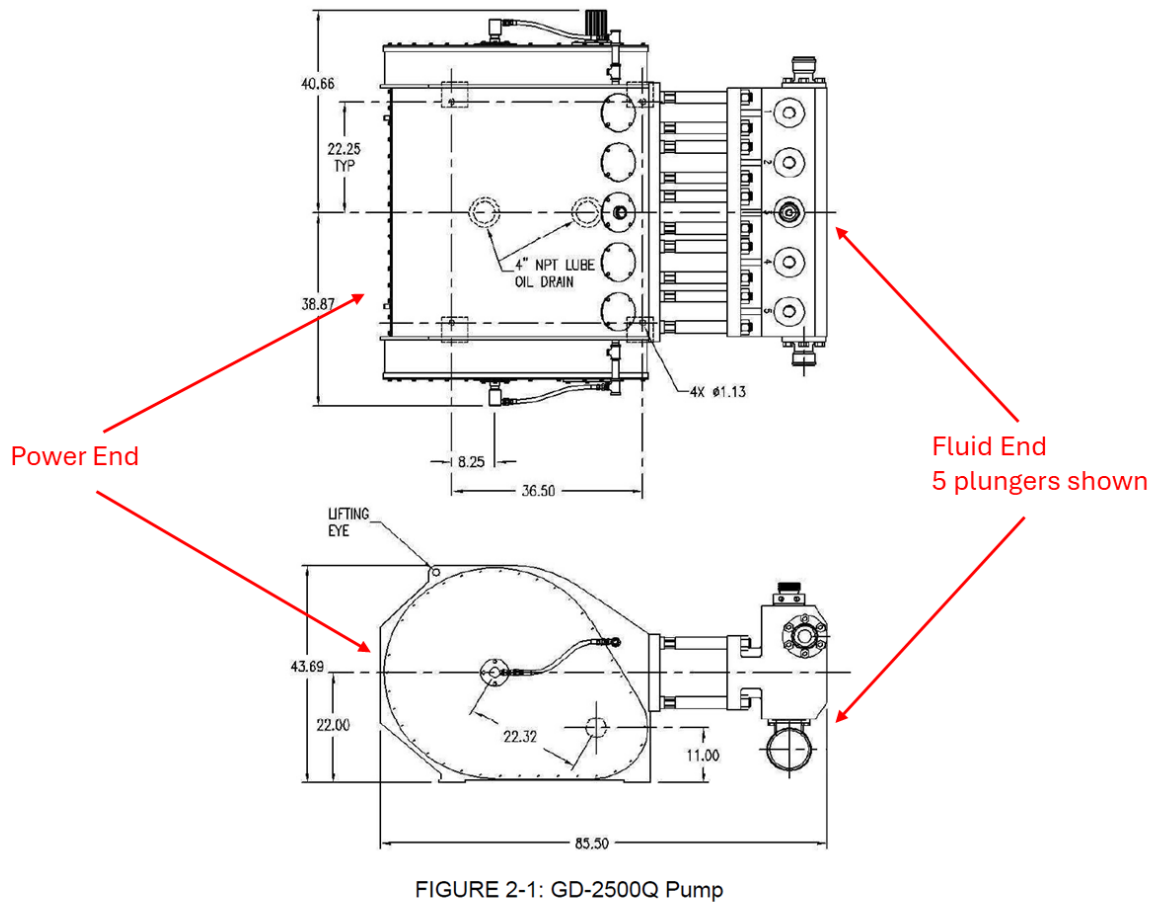
Second, the slurry is heavier than plain water, requiring additional horsepower to move the slurry (as compared to plain water). Finally, the large fracturing pumps are piston (or plunger) pumps, requiring a higher suction (input) pressure to ensure a sufficient flow and prevent cavitation, as explained below.

61. One example of a plunger pump commonly used in fracturing is a Gardner Denver “GD-2500Q Quintuplex Well Servicing Pump”. Gardner Denver describes the GD-2500Q as a “high horsepower, high rod load multi-purpose pump for various applications such as oil and gas well fracturing and acidizing.”²² Gardner describes that “[t]he GD-2500Q quintuplex pump uses only two major assemblies: power end and fluid end.”²³ A “quintuplex”²⁴ pump has 5 cylinders. In the case of the GD-2500Q, Gardner provides Figure 2.1, which shows the dimensions and key components of the GD02500Q.

²² Ex. 1010 (*Gardner-Denver*), pg. 9.

²³ Ex. 1010 (*Gardner-Denver*), pg. 10.

²⁴ Ex. 1047 (Collin’s Dictionary definition of quintuplex “fivefold, quintuple”.
<https://www.collinsdictionary.com/dictionary/english/quintuplex>).



Ex. 1010 (Gardner-Denver) Figure 2.1

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

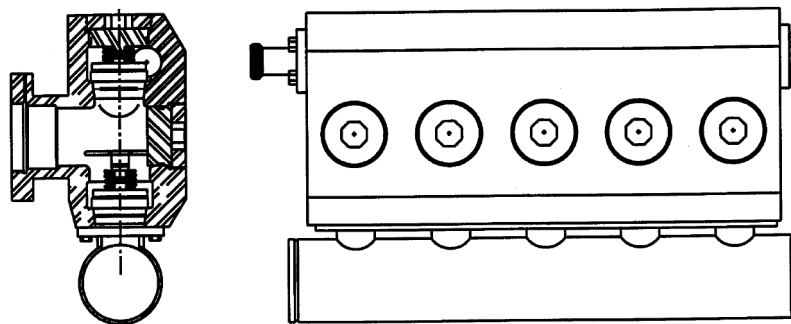


FIGURE 2-5: GD-2500Q Fluid End

62. A key characteristic of this type of fracturing pump is that the same amount of liquid is discharged from the pump with every stroke, largely independent of the pressure downstream. The result is that the flow at a particular pump speed remains relatively constant, while the pressure changes in response to changes in downstream conditions. Accordingly, as fracturing begins, reducing the downstream impedance of the fluid flow system, the pressure tends to drop while the flow rate remains relatively constant. Conversely, pressure rises with a relatively stable flow rate as downstream impedance increases. As a boundary condition, if a valve is closed downstream of a fracturing pump, the flow rate through the pump will remain relatively constant while the pressure rises extremely fast. Pressure will continue to increase until some condition reduces the downstream impedance. This is typically equipment failure, such as pump seals, piping failure, or rupturing of valve bodies.

63. Because the plungers are so large (~5" in diameter with ~8" stroke), a large amount of fluid must flow into the cylinder on each stroke. This tends to lower the suction pressure, as the void of the plunger must be filled by the incoming slurry. If the suction pressure gets too low, then cavitation occurs. Cavitation is a condition in which bubbles form in a liquid because the vapor pressure of the fluid exceeds the suction pressure. When the bubbles collapse, such as when the piston reaches the bottom of its stroke, noise, vibration and damaging forces are created. To avoid cavitation and the associated problems, the suction pressure must be maintained higher than the fluid's vapor pressure of the fluid (e.g., slurry), even during the intake phase of the piston. This is referred to as maintaining a Net Positive Suction Head (NPSH). The amount of NPSH necessary to avoid cavitation depends on several factors, including the suction line design, pump speed, suction valve spring strength, and the temperature and viscosity of the fluid. Gardner teaches several methods to reduce or eliminate cavitation. These techniques include, for example, using a suction stabilizer or pulsation damper, changing the supply line design, and reducing pump speed.²⁵

²⁵ Ex. 1010 (*Gardner-Denver*), pg. 30.

Cavitation, Fluid Knock
or Hammer.

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

D. PUMPING AND CAVITATION

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

known as cavitation.”²⁶ Cavitation has at least three negative effects on a pumping system:²⁷

The collapsing cavitation bubbles can erode the vane surface, especially when pumping water-based liquids.

Noise and vibration levels increase, potentially leading to shortened seal and bearing life.

The cavity areas will initially partially block the impeller passages, reducing pump performance. In extreme cases, total loss of pump-developed head occurs.

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

65. *Tutterow* further teaches that “[t]he amount by which the pressure in the pump inlet exceeds the liquid vapour pressure is expressed as a head of liquid and referred to as Net Positive Suction Head Available (NPSHA). This is a characteristic of the system design. The value of NPSH needed at the pump suction to prevent the pump from cavitating is known as NPSH Required (NPSHR).”²⁸

²⁶ Ex. 1057 (*Tutterow*), pg. 20; Ex. 1034 (Mark’s Handbook), pgs. 14-2.

²⁷ Ex. 1057 (*Tutterow*), pg. 20.

²⁸ Ex. 1057 (*Tutterow*), pg. 20.

66. Further, NPSHR “varies approximately with the square of speed in the same way as pump head.”²⁹ Accordingly, a 10% reduction in pump speed would result in a 19% reduction in NPSHR, and a 10% increase in speed would require a 21% increase in NPSHR. In any given system, reducing pump speed would decrease the risk of cavitation. It follows then that there is a specific speed that would eliminate cavitation for any given pump system. Simply reduce speed until the NPSH required matches or falls below the inlet pressure. It further follows that as speed increases, cavitation increases.

67. With specific regard to PD pumps, “a PD pump needs the incoming liquid to have a pressure margin above liquid vapour pressure to prevent cavitation within the suction passages or pumping chamber.”³⁰ PD pumps also have an additional problem outlined by *Tutterow*:³¹

The cavities [cylinders] on a positive displacement pump open and close as the pump operates and the liquid must flow quickly enough at the pump suction to fill the cavities completely with liquid. If the cavities do not fill with liquid, there will be a void, and apparent cavitation, resulting in a loss of both flow and pressure performance.

²⁹ Ex. 1057 (*Tutterow*), pg. 21.

³⁰ Ex. 1057 (*Tutterow*), pg. 30.

³¹ Ex. 1057 (*Tutterow*), pg. 30.

If the speed is increased, this filling process becomes more problematical, limiting the maximum speed. With viscous liquids, [such as fracturing fluid] the effect is more severe.

68. *Langewis* describes the use of positive displacement pumps to inject produced water into the formation in a waterflood oil & gas operation. The pumps described in *Langewis* are very similar in design and function to those used in hydraulic fracturing. *Langewis* describes “Net positive suction head (NPSH) is defined as the head, in feet of liquid above vapor pressure, required at the suction inlet of the pump to completely fill each cylinder on the suction stroke.”³² *Langewis* further describes NPSH required mathematically:

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

69. H_g represents “minimum pressure required for acceptable pump performance”. Further, *Langewis* teaches that “[t]he value of H_g should be obtained from the pump manufacturer. This term is a function of the diameter of the plunger, *speed of the pump*, type of valve used, valve-spring load and tolerance of the equipment. therefore, all pump manufacturers should have this value for their pumps.”³³

³² Ex. 1058 (*Langewis*), pg. 174.

³³ Ex. 1058 (*Langewis*), pgs. 174-175.

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

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

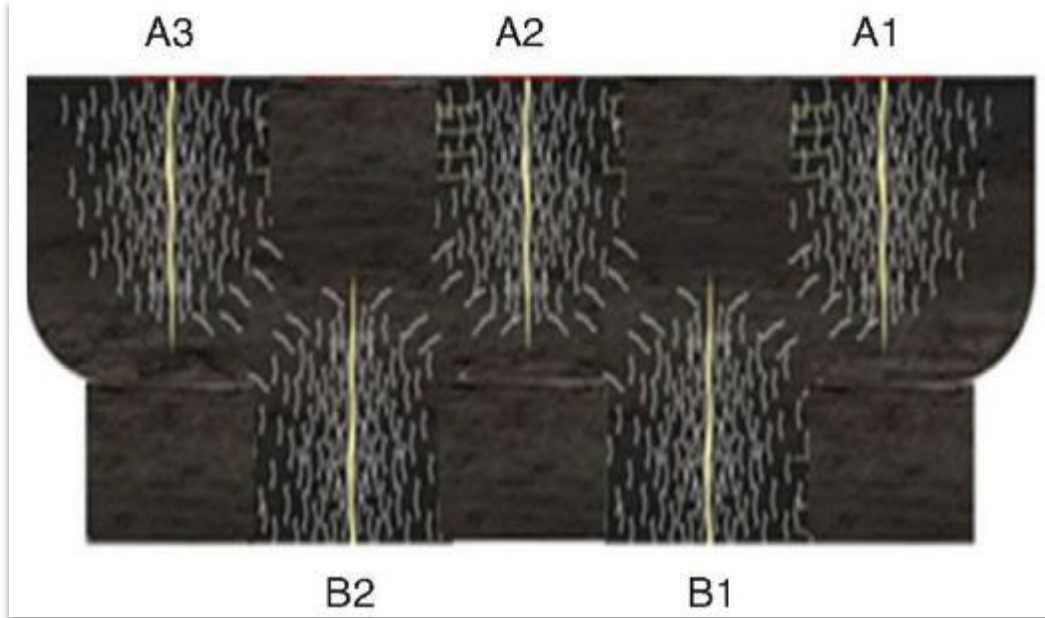
71. For most of the history of hydraulic fracturing, fracturing technology advances have largely been geared towards advancements in chemicals (such as the development of corrosion inhibitors, gels, and slickwater fracing), proppants, and increasing flow and pressure in fracturing operations. The goal, 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 is exposed increased from tens to hundreds of feet to several thousand feet.

72. In the mid-2000s, operators began experimenting with and then using a technique dubbed “zipper fracturing,” in which multiple wells, closely spaced in the

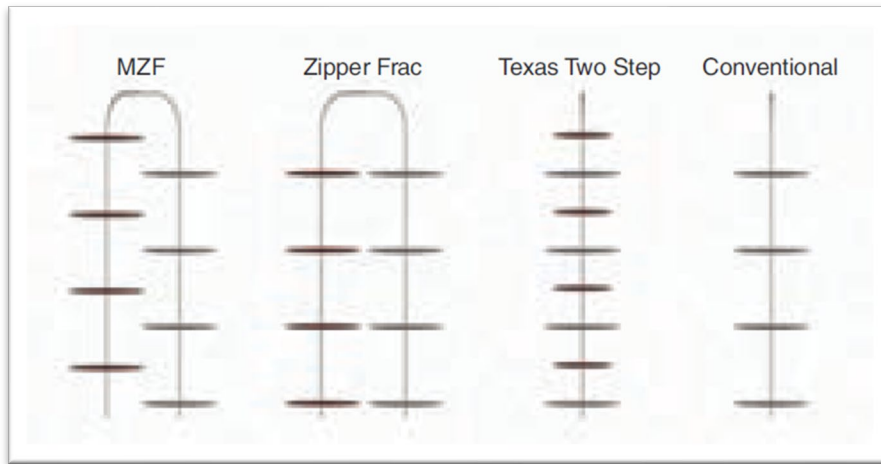
formation and often drilled from the same pad, were fractured simultaneously or sequentially. The result was that the fractures formed in one well were affected by the pressures and fractures in another well, leading to so-called “zipper fractures” that were longer, multidirectional, and exposed more formation to the wellbores than single well fracturing produced.

73. The image below was captured from *Jacobs*³⁴ and demonstrates the impact that simultaneous or sequential fracturing has on the fractures induced by wells. For the fractures nearest the wellbores, the fractures show a typical pattern of being aligned with the perforations, as shown in the figure below, 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, allowing for earlier and more complete recovery of hydrocarbons from the formation.

³⁴ Ex. 1048 (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>).



74. The figure below (with the wellbores represented vertically) from *Jacobs* shows various types of fracturing configurations beginning with conventional fracing (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.



Waters at 5.

75. As described by *Waters*, the process for developing zipper fractures involves maintaining pressure in the formation from one wellbore while 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 leakoff into the rock matrix, the fracture systems will remain pressurized until they are flown back. This pressurized system can provide the diversion [zipper fracture] desired when the adjacent lateral is stimulated subsequent to the initial stimulation.”³⁵

³⁵ Ex. 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>), pg. 8.

76. This allows one well stage to be pressurized and shut in (such as with a plug or a ball seal), then an adjacent well stage to be pressurized and gain the benefits of the stress induced by the other pressurized well. This has advantages not only for the development of fractures downhole but also for operational benefits. 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.³⁶

- 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.

77. The advantages of zipper fractures have been known for decades, as demonstrated by Pearson in an article published in the Journal of Petroleum Technology in 1992.³⁷ While not directly discussing the simultaneous or alternating

³⁶ Ex. 1022 (*Waters*), pg. 8.

³⁷ Ex. 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>).

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.”³⁸ *Pearson* further states that “[d]uring the past 7 years [before 1992], more than 600 new development wells have been fracture stimulated in the Kapurak River field. The large number of treatments has provided the opportunity for significant advances in the technical and operational aspects of hydraulically fracturing deviated wells.”³⁹

78. 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-documented nature of this process, dating back to 2008.

³⁸ Ex. 1023 (*Pearson*), Summary.

³⁹ Ex. 1023 (*Pearson*), Introduction.

79. 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 2008.⁴⁰ *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 completed horizontal azimuth wells in Eastern Parker County is discussed.”⁴¹ *Mutalik* further describes:⁴²

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

⁴⁰ Ex. 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>).

⁴¹ Ex. 1024 (*Mutalik*), Abstract.

⁴² Ex. 1024 (*Mutalik*), Background.

instead of two weeks.”⁴³ Mutalik further teaches that, as of 2008, “simultaneous fracturing operators are now experimenting with triple fracs (‘trifectas’) or even quad-fracs in some cases.”⁴⁴

80. In addition to the above references, *Mayerhofer*⁴⁵ and *Rousell*⁴⁶ 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).⁴⁷ 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.”⁴⁸

81. *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

⁴³ Ex. 1024 (*Mutalik*), Background.

⁴⁴ Ex. 1024 (*Mutalik*), Background.

⁴⁵ Ex. 1025 (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>).

⁴⁶ Ex. 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>).

⁴⁷ Ex. 1025 (*Mayerhofer*), pg. 12.

⁴⁸ Ex. 1025 (*Mayerhofer*), pg. 12.

and zipper-fracs to improve the performance of stimulation treatments in horizontal wells. Simultaneous fracturing of two or more parallel adjacent wells, also referred to as simul-fracs or zipper-fracs, aim to generate a more complex fracture network in the reservoir.”⁴⁹

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

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.

Jacobs at 1. In addition to discussing the production and operational benefits of such a process, *Jacobs* examines 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%.”⁵⁰

⁴⁹ Ex. 1026 (*Rousell*), pg. 1.

⁵⁰ Ex. 1048 (*Jacobs*), pg. 3.

F. TURBINE GENERATORS ON FRACTURING SITES

83. A gas turbine generator (GTG) is a well-known configuration for producing electric energy from natural gas. To begin, a generator is an electrical machine that converts mechanical rotational energy into electrical energy. According to Faraday's law of induction, a conductor moving inside a magnetic field generates a voltage. A generator creates voltage by rotating a coil of wires inside a magnetic field. The voltage generated is dependent on Faraday's Law:

$$Voltage = \frac{N\Delta(BA)}{\Delta t}$$

N is the number of turns in the coil, B is the average magnetic field, A is the area of the coil (perpendicular to the magnetic field), and t is time. The rotation of the coil changes the area of the coil that is perpendicular to the magnetic field as it rotates (ΔA), generating the voltage.

84. A gas turbine operates in the same manner as a jet engine on a commercial or military aircraft. In fact, a substantial portion of gas turbine generators in use today are derived from aircraft jet engines. A gas turbine draws in air and fuel into the front end of a compression stage, which increases the pressure (and reduces the volume) of the fuel/air mixture. The compressed fuel/air mixture is then ignited, causing it to heat up and expand. The hot gases then exit the turbine through the hot section, which features turbine blades that rotate as the hot gas

expands and exhausts. The turbine blades are attached to a shaft, which provides rotating power for both the compressor and intake sections, as well as the connected generator

85. The first gas turbine (GT) generator installation was at the Oklahoma Gas & Electric Bell Isle Generating Station. This gas turbine generator, manufactured by GE, had a capacity of 3,500 kW. The GT used for the Bell Isle installation was derived from a portable, locomotive gas turbine, which was also used in “early aircraft gas turbine practice.” In other words, it was an aeroderivative (derived from an airplane engine) gas turbine generator. The Belle Isle turbine generator was installed in July 1949 and stayed in operation until 1980. Several other GE gas turbine generators, based on the same technology as the Bell Isle GT generator, were installed across the country in the next 30 years. From 1966 to 1976 (representing a span of only 10 years of that period), GE installed 1,428 of the GT generators across the U.S.⁵¹

86. Another example of a gas turbine's early usage was the Pratt & Whitney FT4 gas turbines used on the MTS *ADM Callaghan*. By 1969, these FT4 gas turbines

⁵¹ Ex. 1030 (ASME Landmark “America’s First Power Generating Gas Turbine,” available at:

<https://www.asme.org/wwwasmeorg/media/resourcefiles/aboutasme/who%20we%20are/engineering%20history/landmarks/100-belle-isle-gas-turbine.pdf>).

“were replaced with the first production examples of the General Electric LM-2500 marine gas turbine. The LM-2500, a derivative of GE’s CF-6 aerojet engine, has since become ubiquitous in U.S. Naval Service...”⁵²

87. The LM-2500, offered by GE at least since 1969, is the land and marine (LM) version of the GE TM-2500 (Trailer Mounted) gas turbine generator, which is also a CF-6 aeroderivative gas turbine generator. I have extensive experience with GE CF-6 aeroderivative gas turbine generators, having served as the chief electrical and control systems engineer for the installation of several GE LM-6000 CF-6 aeroderivative gas turbine generator systems in the early 2000s.

88. At least by July 17, 2014 (and likely much earlier in view of *Coli*, discussed below), General Electric advertised a suite of turbine generators for sale, including the TM2500+.⁵³ A picture of the TM2500+ from General Electric is shown below:⁵⁴

⁵² Ex. 1051 (*Callaghan*).

⁵³ Ex. 1032 (GE Power & Water, *Power Generation Products*, <https://web.archive.org/web/20140717214839/https://www.ge-distributedpower.com/products/power-generation>).

⁵⁴ Ex. 1033 (GE Power & Water, GE’s TM2500+ solution offers fast, mobile, and flexible power, *Aeroderivative Mobile Gas Turbine Brochure*, available at: https://web.archive.org/web/20140717215045/https://www.ge-distributedpower.com/component/cck/?task=download&file=seb_media_document&id=13183).



Among the target applications for the TM2500+ turbine was to generate electricity for “Oil and Gas Mining” in areas with “Limited or no access to the electrical grid.”⁵⁵

Multiple applications in a wide range of industries

The TM2500+ solution can solve a number of industry challenges. These include, but are not limited to, difficult access to the electric grid, an unstable grid, emergencies and natural disasters, rapid demand growth such as large construction projects, as well as escalating electricity prices and seasonal shortages. More details on applications of the TM2500+ mobile gas turbine generator are detailed below.

	The Challenge	Description	Potential Industries	TM2500+ as a solution
	Limited or no access to the electric grid	Cases with challenging access to the electric grid include: • Lack of robust transmission and distribution network • Delayed grid access • Remote, islanded and mobile operations	Oil and Gas Mining General industry Power generation	Speed, Mobility, and Reliability Can deliver power where and when it is needed and bring power online within 10 minutes to stabilize the grid

⁵⁵ Ex. 1033 (GE Power & Water, GE’s TM2500+ solution offers fast, mobile, and flexible power, Aero-derivative Mobile Gas Turbine Brochure, available at: https://web.archive.org/web/20140717215045/https://www.ge-distributedpower.com/component/cck/?task=download&file=seb_media_document&id=13183).

89. The use of gas turbine generators in oil and gas exploration and production operations, including hydraulic fracturing (fracing), was well known even before the 2014 date of the GE TM2500+ websites, long before the priority dates of the Asserted Patents. As one example, while employed as manager of electric infrastructure by New Dominion LLC, an exploration and production company, from 2000 to 2002, I investigated the use of SOLAR brand gas turbines to support drilling, exploration, and production operations, including hydraulic fracturing, in central Oklahoma fields.⁵⁶ These fields, as is common in the E&P industry, were largely located in rural areas with very limited electrical infrastructure. The cost and time necessary for the expansion of the electric infrastructure made exploration and production in some regions a very difficult proposition. SOLAR gas turbine generators have been marketed to the oil and gas space since the 1960s. Back in 2006, SOLAR's offerings ranged from the 1,210 kW Saturn 20 to the 15MW Titan 130.⁵⁷ "Solar Turbomachinery" was a specific remote

⁵⁶ Ex. 1035 (A brochure of Solar Turbines *Turbomachinery Systems for Oil and Gas Applications* advertising the "transportability" of its natural gas turbines from 2006 available at:

<https://web.archive.org/web/20061102043710/http://mysolar.cat.com/cda/files/127587/7/bo&g.pdf>).

⁵⁷ Ex. 1036 (Solar Turbines - Titan 130 Generation Set, available at:

<https://web.archive.org/web/20060318215809/http://mysolar.cat.com/cda/layout?m=36056&x=7>).

single-trailer generation design introduced in 1987 for the oil and gas industry, which has sold over 2,000 units with more than 30 million total operating hours.⁵⁸ Although at New Dominion, negotiations with the utility company eventually made the decision to purchase and operate a generator less desirable, the use of a GTG for oil and gas operations was well known by at least 2000, and long before. These included many examples of “mobile” or “trailer mounted” gas turbine generators, including those manufactured by SOLAR Turbine.

90. By 2006, SOLAR sold “Gas Turbine Packages” that included Compressor Sets, Mechanical Drives, and Generator Sets.⁵⁹

91. As another example, U.S. Patent Pub. No. 2012/0255734 to Todd Coli and Eldon Schelske was filed April 6, 2012, based on an application earlier filed on April 7, 2011. The Abstract states:

The present invention provides a method and system for providing on-site electrical power to a fracturing operation, and an electrically powered fracturing system. Natural gas can be used to drive a turbine generator in the production of electrical power.

⁵⁸ Ex. 1049 (Turbines: Solar Mobile Turbomachinery, available at: https://www.solarturbines.com/en_US/solutions/oil-and-gas/solar-mobile-turbomachinery.html).

⁵⁹ Ex. 1037 (Solar Turbines - Gas Turbine Products for the Oil and Gas Industry, available at: <https://web.archive.org/web/20060712013257/http://mysolar.cat.com/cda/layout?m=35881&x=7>).

“A turbine suitable for this purpose is a TM2500+ turbine generator sold by General Electric. Other generation packages could be supplied by Pratt & Whitney or Kawasaki for example. Multiple options are available for turbine power generation, depending on the amount of electricity required.”⁶⁰ *Coli* at ¶[0044]. By March 2013, the technology had already been deployed in the field and was described in trade journals. According to the March 2013 *Oilweek*:

Calgary-based Evolution Well Services had developed a fracking system that relies not on diesel to fuel the massive pressure pumps needed for big frac jobs but rather natural gas-fuelled [*sic*, fueled] electricity, offering the opportunity to eliminate diesel engines and their related emissions and help with manpower and maintenance issues.

Eldon Schelske was interviewed in the article and described turbine generators as a known technology. He explained to *Oilweek* that Evolution’s “turbine can be powered with LNG or compressed natural gas [CNG], or it can use wellhead gas, which optimizes the benefits applicable to pad drilling operators, who might drill several weeks from a single location.” He based the idea of using natural-gas fueled electric power from “system[s] for offshore oil and gas development.” Schelske noted that the technology was already developed—he “didn’t need to reinvent the wheel”—because he was able to deploy “GE’s mobile TM2500 gas turbine to generate on-site power.”

⁶⁰ Ex. 1006 (*Coli*), [0044].

92. A POSITA would have been motivated to use turbine generators for on-site electrical power in an electrical fracturing site, because turbine generators are one of two choices available for local generation, such as at an oil and gas field or fracturing site. The other choice is a reciprocating engine. Reciprocating engines operate in the same manner as a typical car engine. A number of pistons are connected on a shaft so that the linear motion of the piston is converted to rotational motion of the shaft, and vice versa.

93. Both a turbine generator and a reciprocating generator have their advantages and disadvantages. The selection of which particular engine to use is an engineering design choice based on the relative merits of each option and the specific characteristics of the system being powered.

Turbine	Reciprocating Engine
More efficient at high loads	More efficient at low loads
Lighter	Simpler
More compact	Less Expensive
Faster startup	Requires more maintenance
Easier to transport	Designed for a single fuel
Higher power in a single package (trailer)	
Fuel flexible	

94. As one example, turbine generators were known to operate on multiple fuels in the same installation, without extensive modification, such as those I was involved in installing in the early 2000s. Reciprocating engines are typically run on

liquid fuels, such as diesel. This type of generating system is often referred to as “diesel generators.” In the vast majority of applications, gas turbine generators are run on natural gas due to its availability, cleanliness (operationally, inside the turbine, and environmentally), and lower cost compared to diesel fuel.

XI. OVERVIEW OF THE PRIOR ART

A. CICC (EX. 1004)

95. *Cicci* refers to United States Patent 11,549,348, which was filed on November 20, 2020, and issued on January 10, 2023.⁶¹ *Cicci* claims priority to U.S. Provisional Application No. 62/941,549 (“*Cicci Provisional*”) (Ex. 1005) filed on November 27, 2019. All of the portions of *Cicci* relied on in my declaration are supported by disclosures in *Cicci Provisional*. Accordingly, I understand *Cicci* to be prior art to the ’162 Patent.

96. *Cicci* describes “a hydraulic fracturing system using flexible hose or pipe”.⁶² The flexible pipe provides coupling between “a pump and a manifold of the hydraulic fracturing system.”⁶³ *Cicci* also discloses “a fitting affixed to each end of the flexible flow line” for connection to the fluid source (manifold) and the pump.⁶⁴

⁶¹ Ex. 1004 (*Cicci*), Cover.

⁶² Ex. 1004 (*Cicci*), Abstract; Ex. 1005 (*Cicci Provisional*), [1], [15]-[16].

⁶³ Ex. 1004 (*Cicci*), Abstract; Ex. 1005 (*Cicci Provisional*), [2], [15]-[16].

⁶⁴ See, e.g., Ex. 1004 (*Cicci*), 5:30–37; Ex. 1005 (*Cicci Provisional*), [24].

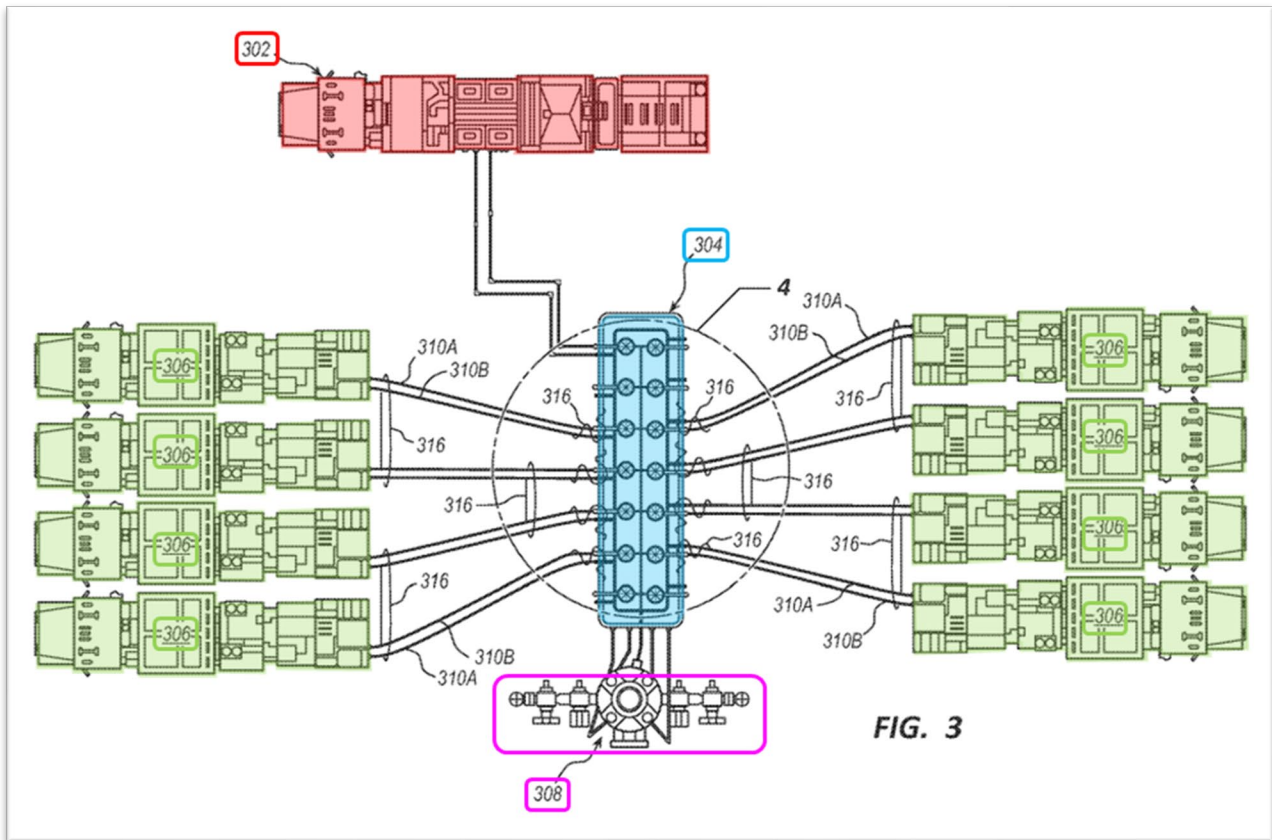
Cicci further discloses that the “flexible hose can be connected to the pump connections by any number of connection methods currently known or developed in the future, including [] wings on a threaded connection, such as a hammer union.”⁶⁵ *Cicci*’s flexible hoses have “an inner diameter of one to eight inches.”⁶⁶ *Cicci* discloses blender 302 [highlighted in red] that receives the fracturing fluid and blends it into a slurry.⁶⁷ *Cicci* further discloses that “[t]he pumps 306 [highlighted in green] deliver the pressurized fracturing fluid to the missile 304 [highlighted in blue]. The missile 304 then delivers the pressurized fracturing fluid to the wellhead 308 [magenta], which routes the fluid into the steel casing in the wellbore (not shown).”⁶⁸

⁶⁵ Ex. 1004 (*Cicci*), 7:40-47; Ex. 1005 (*Cicci Provisional*), [30].

⁶⁶ Ex. 1004 (*Cicci*), 1:64-65; Ex. 1005 (*Cicci Provisional*), [4].

⁶⁷ E. 1004 (*Cicci*), 5:14-29; Ex. 1005 (*Cicci Provisional*), [23].

⁶⁸ Ex. 1004 (*Cicci*), 5:25-40; Ex. 1005 (*Cicci Provisional*), [23]; *see also* Ex. 1004(*Cicci*), 1:9-19; Ex. 1005 (*Cicci Provisional*), [1].



Ex. 1004 (*Cicci*), Fig. 3; Ex. 1005 (*Cicci Provisional*), Fig 3 (annotated).

B. COLI (EX. 1006)

97. U.S. Patent Application Publication No. 2012/0255734 by Coli (“*Coli*”) was filed on April 6, 2012, and published on October 11, 2012. It claims priority to Provisional Application No. 61/472,861, filed on April 7, 2011.⁶⁹ The publication of *Coli* as well as the claimed priority date of *Coli* thus predates the claimed priority date of the Challenged Patent.

⁶⁹ Ex. 1006 (*Coli*), Cover.

98. Like the Challenged Patent and *Cicci, Coli* involves a “fracturing system” for “delivering fracturing fluid to a wellbore at a fracturing operation.”⁷⁰ *Coli* further discloses how the electrification of the fracturing operation improves costs,⁷¹ efficiency,⁷² safety,⁷³ and environmental impact.⁷⁴ For example, *Coli* discloses the use of natural-gas-powered turbines to generate electricity, which in turn powers electric motors for driving the pumps.⁷⁵ The turbines may use natural gas that is collected on site, thereby “obviating the need for a constant supply of diesel fuel to the site and reducing the site footprint and infrastructure required for the fracturing operation.”⁷⁶ Further, the smaller size and lighter weight of pumping modules with electric motors “allow[s] for placement of four pumps 22 in the same physical dimension (size and weight) as the spacing needed for a single pump in conventional diesel systems.”⁷⁷ Thus, “the number of fracturing modules 20 placed on each trailer 10” is “maximized.”⁷⁸

⁷⁰ Ex. 1006 (*Coli*), [0034].

⁷¹ Ex. 1006 (*Coli*), [0075].

⁷² Ex. 1006 (*Coli*), [0077].

⁷³ Ex. 1006 (*Coli*), [0066].

⁷⁴ Ex. 1006 (*Coli*), [0080].

⁷⁵ Ex. 1006 (*Coli*), [0042].

⁷⁶ Ex. 1006 (*Coli*), [0036], *see also* Ex. 1006 (*Coli*), [0075].

⁷⁷ Ex. 1006 (*Coli*), [0049].

⁷⁸ Ex. 1006 (*Coli*), [0052].

99. *Coli* further discloses that “[t]he electric motor can be capable of operation in the range of up to 1500 rpm and up to 20,000 [ft-lbs]⁷⁹ of torque.”⁸⁰ In addition, “[e]lectric motors controlled via variable frequency drive are far safer and easier to control than conventional diesel powered equipment.”⁸¹

100. *Coli* discloses that the “pump is a quintiplex [quintuplex] or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.,” and the “system can deliver a true 2500 hp directly to each pump 22.”⁸²

101. Thus, in my opinion, a POSITA would have understood that *Coli* discloses an entire fracturing system, similar to the system described in the Challenged Patent, that includes trailer-mounted electric pumps and motors, with associated variable frequency drives and natural-gas turbine generators.

⁷⁹ The unit of torque is ft-lb. There appears to be a typographical error in *Coli* insofar as it expresses torque in ft/lbs. The proper units for torque (in the US customary system) is ft-lb. As an example, 5 ft-lb is equivalent to a force of 5 lb acting on an arm with a length of 1 ft. “Ft/lb” is a unit of mass density. As an example, 5 ft/lb would mean a rod (or other linear device) that has a mass of 0.2. lb/ft. It would take 5 feet of rod to reach a mass of 1 lb. Accordingly, I understand that “20,000 ft/lb” is a typographical error and should be read “20,000 ft-lb”.

⁸⁰ Ex. 1006 (*Coli*), [0011].

⁸¹ Ex. 1006 (*Coli*), [0066].

⁸² Ex. 1006 (*Coli*), [0046], [0049]. I understand the Gardner Denver “SWGS-2500” well service pump to be a GD-2500Q power end with a “Super GWS Fluid End”, and that “SWGS” is a typo in *Coli* and should be “SGWS”.

C. Liu (Ex. 1007)

102. *Liu* refers to Pipeline Engineering by Henry Liu, a textbook published by CRC Press in 2003. *Liu* bears a copyright date of 2003. CRC Press is a publisher that publishes scientific and technical books.⁸³ Based on this, I understand that *Liu* would have been publicly available by at least 2003. I have also reviewed the declaration of Dr. Sylvia Hall-Ellis, which confirms that *Liu* was accessible to the public and indexed at the library by at least September 9, 2003, and accordingly would have been searchable and obtainable by the public by at least September 9, 2003.⁸⁴ This is consistent with the 2003 copyright date on the face of *Liu*. *Liu* therefore qualifies as prior art as a printed publication to the '162 Patent.

103. *Liu* contains well-known scientific principles regarding the flow of fluids, including slurries, through pipelines. *Liu* describes a “pipeline” as being a “common technology or a single transportation mode that has different applications”.⁸⁵ *Liu* contains both a “review of fluid mechanics pertinent to pipe

⁸³ Ex. 1039 (CRC Press Books, About Us, available at https://www.routledge.com/corporate/about-us/crc-press?srsId=AfmBOoo4LdrPswlrDh199mp0iAWleSZK26v7xZFFamobLss_WyPVplVts).

⁸⁴ Ex. 1014 (Declaration of Dr. Hall-Ellis), ¶50.

⁸⁵ Ex. 1007 (*Liu*), Preface.

flow” as well as “more advanced subjects,” including “flow of solid/liquid mixtures” (i.e., slurries).⁸⁶

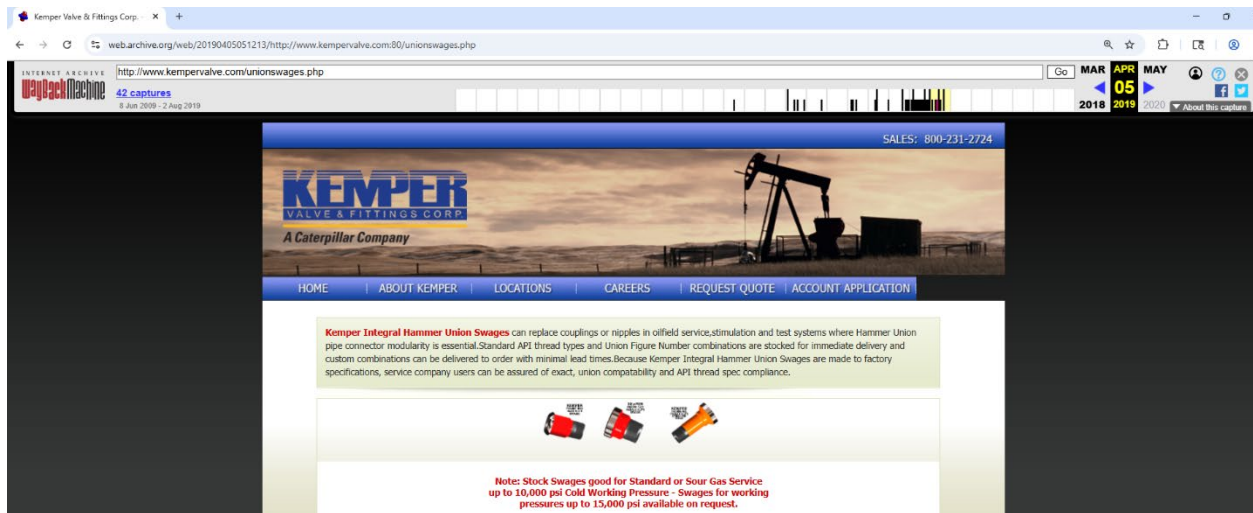
104. Chapter 5 of *Liu* discusses the “flow of solid particles transported by liquid in pipelines, namely slurry pipelines,”⁸⁷ and focuses on “horizontal or nearly horizontal pipes with particles suspended by a liquid.” This describes piping systems used in hydraulic fracturing nearly perfectly, where slurries are used regularly (such as proppant carried by water with other chemicals), and the piping system is horizontal or nearly horizontal on the surface.

D. KEMPER (EX. 1008)

105. *Kemper* is the webpage for Kemper Valve and Fittings Corp. *Kemper* would have been made available online such that a person interested in and ordinarily skilled in the subject matter could have located it through the exercise of ordinary diligence (e.g., through an Internet search engine using appropriate search terms). For example, a search of the Internet Archive reveals that *Kemper* was available on the Kemper website at <https://web.archive.org/web/20190405051213/http://www.kempervalue.com:80/unionswages.php>.

⁸⁶ Ex. 1007 (*Liu*), Preface.

⁸⁷ Ex. 1007 (*Liu*), pg. 131.

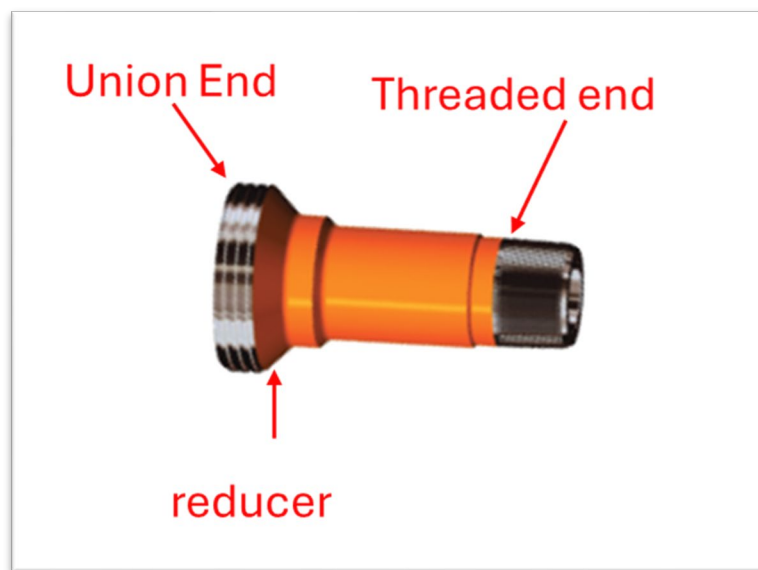


I am familiar with the Internet Archive and use it regularly to determine when websites were updated and when printed material was publicly available. I understand the Internet Archive displays the date the website was captured on the display page, as shown above. I also understand the URL of the Internet Archive records when the page was captured.⁸⁸ In this case, based on the URL above, I understand that the “20190405051213” portion of the URL indicates that the capture occurred on April 5, 2019 at 5:12:13 AM. According, *Kemper* was publicly accessible since at least April 5, 2019. *Kemper* is a prior art printed publication under at least 35 U.S.C. § 102(a)(1).

⁸⁸ Ex. 1053 (Affidavit of Duncan Hall), ¶5.

106. Kemper Valve and Fittings was acquired by Caterpillar, a global equipment provider, in 2017.⁸⁹ Kemper Valves would have been well-known to a POSITA in 2019.

107. Kemper discloses hammer union swages for fracturing applications, where the swage includes a reducer⁹⁰:



Kemper's union swages include ends with different diameters, including a difference in diameter of one inch.⁹¹

⁸⁹ Ex. 1052 (Press Release).

⁹⁰ Ex. 1008 (*Kemper*), 1 (annotated).

⁹¹ Ex. 1008 (*Kemper*), 1.

E. DIXON CATALOGS (EX. 1009 & EX. 1012)

108. *Dixon-Australia (Ex. 1009)* and *Dixon-U.S. (Ex. 1012)* are two publicly accessible product catalogs that were available by at least 2018. Since the product catalogs contain largely the same information for the purposes of my analysis, I will refer to them collectively as simply “Dixon,” unless I specify otherwise.

109. *Dixon-Australia (Ex. 1009)* is a product catalog by Dixon for the Australian market that is and has been publicly available on the Dixon website since at least 2018.⁹² The Dixon website lists “Publish Date: October 4, 2018” for the catalog⁹³:



⁹² Ex. 1040 (Dixon Product Literature website, available at <https://australia.dixonvalve.com/en/knowledge-center/references-and-education/product-literature>); Ex. 1013 (Lagenfelder Declaration), ¶¶4-5, 10.

⁹³ Ex. 1040 (Dixon Product Literature website, available at <https://australia.dixonvalve.com/en/knowledge-center/references-and-education/product-literature>).

This is consistent with the indicia in the catalog itself. For example, the catalog lists a copyright date of “Copyright 2018 by Dixon Valve and Coupling.”⁹⁴ The catalog is also labeled “ADPL718” in the top right of its cover page, indicating that it would have been made available to the public by July 2018 based on Dixon’s numbering convention.⁹⁵ The catalog also lists “New Products for 2018.”⁹⁶ Based on this information, I understand that *Dixon-Australia* would have been publicly accessible by at least October 2018.⁹⁷ It is therefore my understanding that *Dixon-Australia* qualifies as prior art to the ’162 Patent.

110. *Dixon-U.S.* (Ex. 1012) is a product catalog by Dixon for the U.S. market that was publicly accessible on the Dixon website by at least April 2018.⁹⁸ I understand that *Dixon-U.S.* was publicly available on Dixon’s website by April 2018.⁹⁹ To locate a copy of this catalog, I understand that a member of the public would navigate to the “Product Literature” page of Dixon’s website, see a list of Dixon’s product literature, be able to search in the “Search” field, and/or be able to filter by product category in the “Product Category” field.¹⁰⁰ I understand that Dixon

⁹⁴ Ex. 1009 (*Dixon-Australia*), pg. 667.

⁹⁵ Ex. 1009 (*Dixon-Australia*), Title; Ex. 1013 (Lagenfelder Declaration), ¶¶4, 8.

⁹⁶ Ex. 1009 (*Dixon-Australia*), pg. 10.

⁹⁷ Ex. 1013 (Lagenfelder Declaration), ¶10.

⁹⁸ Ex. 1013 (Lagenfelder Declaration), ¶¶4-5, 10.

⁹⁹ Ex. 1013 (Lagenfelder Declaration), ¶5.

¹⁰⁰ Ex. 1013 (Lagenfelder Declaration), ¶6.

also distributed almost 1,000 copies of Dixon-U.S. to its distributors in 2018.¹⁰¹ I also understand that a member of the public could also request a copy of this catalog by mail through the Dixon website.¹⁰²

111. This is also consistent with the indicia on the catalog itself. For example, the catalog lists a copyright date of “Copyright 2018 by Dixon Valve and Coupling.”¹⁰³ The catalog similarly lists “New Products for 2018.”¹⁰⁴ The Dixon-U.S. catalog is also labeled “DPL418,” which I understand indicates that it would have been made available to the public by April 2018 based on Dixon’s numbering convention.¹⁰⁵

112. Moreover, *Dixon-Australia* and *Dixon-U.S.* reference frac fittings with part numbers of, e.g., HUF100300CS.¹⁰⁶ Frac fittings with this part number appear to have been for sale as early as at least October 3, 2016.¹⁰⁷ It was common practice for a company releasing a product around the 2016-2018 timeframe, as the Dixon frac fittings were, to make a product manual readily available to the public, for

¹⁰¹ Ex. 1013 (Lagenfelder Declaration), ¶5.

¹⁰² Ex. 1013 (Lagenfelder Declaration), ¶7.

¹⁰³ Ex. 1012 (*Dixon-U.S.*), pg. 995.

¹⁰⁴ Ex. 1012 (*Dixon-U.S.*), pgs. 4-5.

¹⁰⁵ Ex. 1012 (*Dixon-U.S.*), Title; Ex. 1013 (Lagenfelder Declaration), ¶¶4-5.

¹⁰⁶ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

¹⁰⁷ Ex. 1041 (Amazon.com Dixon Frac Fitting, HUF100300CS, available at <https://www.amazon.com/Dixon-FEMALE-SUB-FIG-HUF100300CS/dp/B00LT0TT2U>).

example, by offering it for download from the company's website (as Dixon did), and/or by making a print version publicly available. *Dixon-Australia* and *Dixon-U.S.* indicate on their face, and the Dixon website demonstrates on its face, for at least *Dixon-Australia*, that *Dixon-Australia* and *Dixon-U.S.* were published and released in 2018.¹⁰⁸ The Marketing Manager for Dixon, Ms. Holly Lagenfelder, also testifies that these catalogs were publicly accessible in 2018. I have no reason to doubt these dates provided by Dixon. It is my understanding, therefore, that *Dixon-Australia* was publicly accessible by at least October 2018, and *Dixon-U.S.* was publicly accessible by at least April 2018.¹⁰⁹

113. Dixon is a well-established, global valve and fitting company that has been in the industry for over one hundred years.¹¹⁰ Dixon has been offering fittings for hydraulic fracturing wells since at least 1949.¹¹¹ I have personally used Dixon fittings, such as hammer unions, for over twenty years, and they were regularly

¹⁰⁸ Ex. 1009 (*Dixon-Australia*), pgs. 10, 667; Ex. 1040 (Dixon Product Literature website, available at <https://australia.dixonvalve.com/en/knowledge-center/references-and-education/product-literature>).

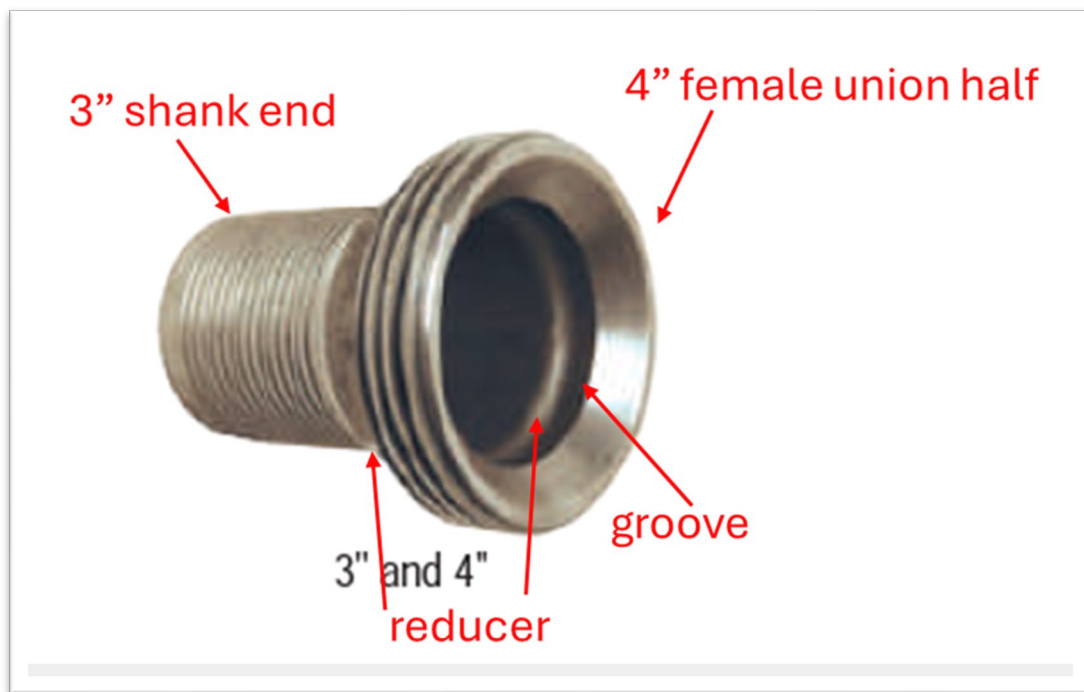
¹⁰⁹ Ex. 1013 (Lagenfelder Declaration), ¶10.

¹¹⁰ Ex. 1042 (Dixon History: 100 years, available at <https://australia.dixonvalve.com/en/about-dixon/history>).

¹¹¹ Ex. 1043 (Dixon History: First Commercial Hydraulic Fracturing Wells Drilled, March 17, 1949, available at <https://australia.dixonvalve.com/en/about-dixon/history>).

available at oil and gas supply houses for that period. It is my opinion that Dixon would have been a well-known company to a POSITA in 2019.

114. *Dixon* discloses a fitting used in hydraulic fracturing operations with a shank end for connecting to a hose, and a hammer union end for connecting to the pump, where the diameter of the end that connects to the pump is larger than the diameter of the end that connects to the hose¹¹²:



¹¹² Ex. 1009 (*Dixon-Australia*), pg. 149 (annotated); Ex. 1012 (*Dixon-U.S.*), pg. 78.

115. *Dixon*'s shank end is securable to a portion of the hose by crimping.¹¹³ *Dixon* additionally teaches a hose with a diameter of 5 inches.¹¹⁴ *Dixon*'s frac fitting also includes a reducer that forms an integral piece for the fitting through welding.¹¹⁵

F. GARDNER-DENVER CATALOG (EX. 1010)

116. *Gardner-Denver* is an operating and service manual for Gardner Denver's GD-2500Q Quintuplex pump (300FWF996 Rev C) that was originally published in 2001, and revised in August 2005,¹¹⁶ and a GD-2500Q Fluid End Parts list published in September 2011.¹¹⁷ I also understand that, according to the Internet Archive, *Gardner* was publicly available on the internet as of at least September 2012.¹¹⁸ The publication of *Gardner-Denver* and its public availability thus predate the claimed priority date of the Challenged Patents.

117. The public accessibility of *Gardner-Denver* by at least 2012 is further confirmed by the reference to *Gardner-Denver*'s pump in *Coli*, which was filed on

¹¹³ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

¹¹⁴ Ex. 1009 (*Dixon-Australia*), pg. 58.

¹¹⁵ Ex. 1009 (*Dixon-Australia*), pgs. 149-150; Ex. 1012 (*Dixon-U.S.*), pgs. 78-79.

¹¹⁶ Ex. 1010 (*Gardner-Denver*), pgs. 1, 46 of the PDF. *Gardner-Denver* also lists an original copyright date of 2001. Ex. 1010 (*Gardner-Denver*), pg. 46 of the PDF. *Gardner-Denver* lists on its face that "Rev C" was dated "August, 2005." Ex. 1010 (*Gardner-Denver*), pg. 1 of the PDF.

¹¹⁷ Ex. 1010 (*Gardner-Denver*) pg. 47 of the PDF.

¹¹⁸ Ex. 1053 (Declaration of Duncan Hall).

April 6, 2012, and published on October 11, 2012. *Coli* expressly discloses that the pump is a “quintiplex or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.”¹¹⁹ In my experience, it was common practice for a company releasing a product, such as *Gardner-Denver’s* Quintuplex pump, to make a product manual readily available to the public, for example, by offering it for download from the company’s or distributor’s websites (as *Gardner-Denver* did), and/or by making a print version publicly available. *Gardner-Denver* indicates on its face that it was published and released in 2005. I have no reason to doubt this date provided by *Gardner-Denver*.

118. *Gardner’s* “SWGS-2500”¹²⁰ pump is expressly cited in *Coli* as an example of a suitable “quintiplex [quintuplex] or triplex plunger style pump” to be coupled to an electric motor and used in a fracturing module.¹²¹ A POSITA would have understood that the “SWGS-2500 quintuplex pump” disclosed by *Coli* refers to a Gardner Denver GD-2500Q power end (or pump end) coupled with a Gardner Denver SGWS fluid end.

¹¹⁹ Ex. 1006 (*Coli*), [0046], [0049].

¹²⁰ In my opinion, a POSITA would have understood that “SWGS-2500” mentioned in *Coli* is a typographical error, and it refers to “SGWS-2500”—i.e., Super Gardner Well Services-2500, or a GD-2500Q power end coupled with a Super GWS Fluid End.

¹²¹ Ex. 1006 (*Coli*), [0046].

119. *Gardner-Denver* discloses that the GD-2500Q is a quintuplex pump with a “Stroke Length” of “8.0 inches,” and a “plunger size” (diameter) of “3.75, 4, 4.5, 5, 5.5, 5.75, 6, 6.5, [or] 6.75” inches.¹²² In addition, *Gardner-Denver* discloses that the input power to the pump, which is the same as the output power of the electric motor coupled to the pump, is 2200 or 2500 bhp.”¹²³ *Gardner-Denver* also discloses that the pump is rated at 2500 bhp (input power).¹²⁴

120. A POSITA would have understood that horsepower ratings for pumps are provided either as an input or an output horsepower. Input horsepower (sometimes referred to as brake horsepower) is the amount of power that must be delivered to the shaft for the pump to operate according to the specified pressure and flow rate. Output horsepower (sometimes referred to as hydraulic horsepower) is the amount of power delivered to the fluid being pumped. It is often specified in terms of pressure (PSI) and flow rate (GPM). Power (horsepower) is directly proportional to the pressure X flowrate. A POSITA would have understood that, in English units, the following equation yields the hydraulic horsepower.¹²⁵

$$Hp (hydraulic) = \frac{pressure (PSI) * flowrate (GPM)}{1714}$$

¹²² Ex. 1010 (*Gardner-Denver*), pg. 20 of the PDF.

¹²³ Ex. 1010 (*Gardner*), pg. 20 of the PDF.

¹²⁴ Ex. 1010 (*Gardner*), pg. 20 of the PDF.

¹²⁵ Ex. 1034 (*Mark's Handbook*), pgs. 14-13, 14-14.

121. In addition, a POSITA would have understood that *Gardner* discloses a plunger-type quintuplex pump for fracturing operations that includes an 8-inch stroke, 4.5-inch diameter plungers, and is rated at about 2250 (hydraulic) horsepower or more. Relatedly, a POSITA would have understood that an electric motor coupled to the *Gardner-Denver* pump would be equipped to provide a maximum continuous power output of more than 1500 horsepower.

122. *Gardner-Denver* also offers a range of suction manifolds with various connection types, including Victaulic and threaded inlets (hammer unions), and sizes, such as 6” and 8” inlet connections.¹²⁶

G. ANSI/HI 6.1 (Ex. 1011)

123. *ANSI/HI 6.1* is the “American National Standard for Reciprocating Power Pumps for Nomenclature, Definitions, Application and Operation” and is published by the American National Standards Institute (ANSI) and developed by the Hydraulic Institute.¹²⁷

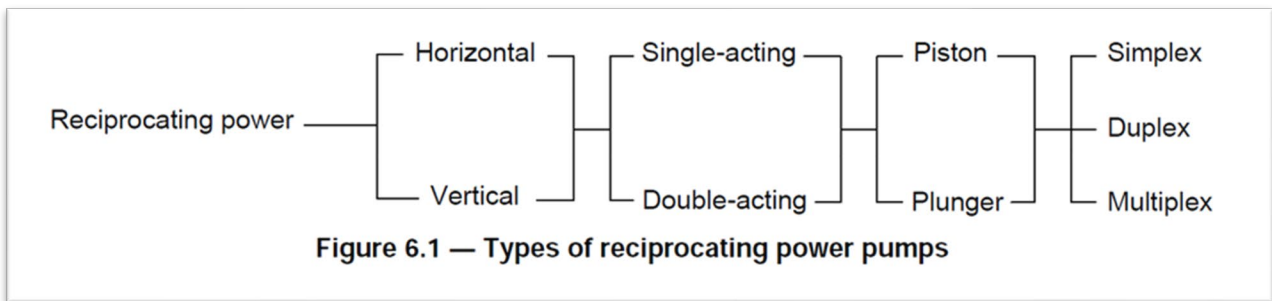
124. *ANSI/HI 6.1* describes, in the Scope of *ANSI/HI 6.1*, that “[t]he standard applies to reciprocating power pumps. It includes types and nomenclature; definitions; design and application; and installation, operation and maintenance.”¹²⁸

¹²⁶ Ex. 1010 (*Gardner-Denver*), pgs. 76-79 of the PDF.

¹²⁷ Ex. 1011 (*ANSI/HI 6.1*), Cover

¹²⁸ Ex. 1011 (*ANSI/HI 6.1*), pg. vi.

ANSI/HI 6.1 further teaches that “[a] reciprocating power pump is one driven by power from an outside source applied to the crankshaft of the pump. [] There are several variations and types of reciprocating power pumps,”¹²⁹ which are shown in Figure 6.1.



Ex. 1011 (*ANSI/HI 6.1*) Figure 6.1

125. Further, *ANSI/HI 6.1* describes the use of reciprocating power pumps to pump slurry, such as would have been used in hydraulic fracturing systems. *ANSI/HI 6.1* teaches that, when pumping slurry, “hydraulic passages should be sized so that the lowest velocity of the liquid will be above the critical carrying velocity of 1.2 to 1.8 m/s (4 to 6 ft/s) as an average. The highest velocity should be below that which causes excessive erosion. Typical average operating velocities through a reciprocating slurry pump's passages are 1.8 to 3.6 m/s (6 to 12 ft/s).”¹³⁰

¹²⁹ Ex. 1011 (*ANSI/HI 6.1*), pg. 1.

¹³⁰ Ex. 1011 (*ANSI/HI 6.1*), pg. 66.

126. Ex. 1011 is a true and correct copy of the *ANSI/HI 6.1* standard published in 2015. *ANSI/HI 6.1* bears a copyright date of 2015.¹³¹ It shows that it was “approved” by ANSI on March 5, 2015.¹³² I am familiar with the ANSI Standards process. I have chaired the Standards Subcommittee of the Petroleum and Chemical Industry Committee (PCIC) of the IEEE, which is responsible for nearly 50 standards related to the oil and gas industry. Several of the Standards that I was responsible for were approved as American National Standards during my tenure. I am currently the Vice-Chair of the PCIC and remain heavily involved in the standards process, including approval as an ANSI Standard. Some examples of the standards I was involved in, which became ANSI Standards, include IEEE 1017, IEEE 1018, and IEEE 1019 (of which I currently serve as chair of the successor standards), IEEE 303, and IEEE 515. Accordingly, I am familiar with the ANSI approval process and the time it takes for the approved standards to be publicly available.

127. In my experience, such standards are publicly accessible from the development organization (such as the IEEE) as soon as possible after approval by ANSI. In my experience, these standards are typically available within 30 days of

¹³¹ Ex. 1011 (*ANSI/HI 6.1*), Copyright Page.

¹³² Ex. 1011 (*ANSI/HI 6.1*), pg. i.

approval, although they may be made available within 90 days. In no case that I am aware of were the standards not publicly available within 90 days of approval. *ANSI/HI 6.1*, accordingly, would have been publicly accessible by June 2015, well before December 2019.

128. *ANSI/HI 6.1* would have been made available online such that a person interested in and ordinarily skilled in the subject matter of hydraulic fracturing pumps (e.g., plunger pumps) could have located it through the exercise of ordinary diligence (e.g., through an Internet search engine using appropriate search terms). These standards are available for purchase from at least the ANSI Store and the Hydraulic Institute's "e-store". For example, a search of the Internet Archive reveals that ANSI/HI 6.1 was available for purchase from the Hydraulic Institute at least by August 8, 2015.¹³³

¹³³ Ex. 1055

(<https://web.archive.org/web/20150808112714/http://estore.pumps.org/Standards/Reciprocating/Hardcopy.aspx>).



Hydraulic Institute Webstore August 8, 2015.

I am familiar with the Internet Archive and use it regularly to determine when websites were updated and when printed material was publicly available. I understand the Internet Archive displays the date the website was captured on the display page, as shown above (red box). I also understand the URL of the Internet Archive records when the page was captured. In this case, the URL of the Hydraulic Institute Website is:

<https://web.archive.org/web/20150808112714/http://estore.pumps.org/Standards/Reciprocating/Hardcopy.aspx>. I understand that the “201508112714” portion of the URL indicates that the capture occurred on August 8, 2015 at 11:27:14 AM.¹³⁴

129. ANSI/HI 6.1 was published and publicly available at least by August 8, 2015, and was a publication that persons of ordinary skill in the art reasonably

¹³⁴ Ex. 1053 (Affidavit of Duncan Hall), ¶5.

relied upon in the 2015 timeframe and later for detailed implementation requirements for reciprocating pumps used in hydraulic fracturing applications.

130. Further, *ANSI/HI 6.1* contains an International Standard Book Number (ISBN) of 978-1-935762-32-4. I understand, based on the declaration of Dr. Hall-Ellis, that MARC records are used to store bibliographic metadata in libraries.¹³⁵ Further, I understand that a MARC record comprises fields which contain specific data about the reference.¹³⁶ I understand that one of these fields, field (008), is the “date of creation for the MARC record” at a specific library, and that this MARC record creation data “reflects the date on which, or shortly after which, the item was first acquired or cataloged.”¹³⁷ Further, I understand that “[o]nce one library has cataloged and indexed a publication by creating a MARC record for that publication, other libraries that receive the publication do not create additional MARC records—the other libraries instead rely on the original MARC record.”¹³⁸ Accordingly, I understand that the MARC creation date represents a date that the publication was publicly available, and indexed into a library.

¹³⁵ Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶¶18, ¶21.

¹³⁶ Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶¶24-26.

¹³⁷ Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶29.

¹³⁸ Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶30.

131. Further, I understand that I have reviewed the MARC record for ANSI/HI 6.1 from the Linda Hall Library. I see that field “245,” which I understand indicates the title of the work, bears the same title as ANSI/HI 6.1, “American national standard for reciprocating power pumps for nomenclature, definitions, application, and operation.”¹³⁹ I see that field “260,” which I understand indicates the copyright date of the work, indicates a 2015 copyright date by the Hydraulic Institute, consistent with ANSI/HI 6.1.¹⁴⁰ I also see that field “500,” which I understand is the general notes field, reads “ANSI/HI 6.1-6.5-2015” and “Approved March 5, 2025, American National Standards Institute,” consistent with ANSI/HI 6.1.¹⁴¹ Finally, I see that in field “008” it reads “161031s2015.”¹⁴² I understand that this indicates that ANSI/HI 6.1 was first acquired or cataloged in the library by at least October 31, 2016.¹⁴³

132. This is further evidence that ANSI/HI 6.1 would have been publicly accessible well before December 2019.

¹³⁹ Ex. 1054 (MARC Record), field 245; Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶24.

¹⁴⁰ Ex. 1054 (MARC Record), field 260; Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶24.

¹⁴¹ Ex. 1054 (MARC Record), field 500; Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶26; <https://www.loc.gov/marc/bibliographic/bd5xx.html>.

¹⁴² Ex. 1054 (MARC Record), field 008.

¹⁴³ Ex. 1014 (Declaration of Dr. Hall-Ellis) ¶29.

XII. GROUND 1: THE COMBINATION OF *CICCI*, *COLI*, AND *DIXON* RENDER CLAIMS 1-4, 8-10, and-14 OBVIOUS.

133. It is my opinion that *Cicci*, in view of *Coli* and *Dixon* renders Claims 1-4, 8-10, and 14 of the '162 Patent obvious.

A. MOTIVATION TO COMBINE THE REFERENCES

134. A POSITA would have been motivated to combine the teachings of *Cicci* and the teachings of *Coli* and *Dixon* and would have had a reasonable expectation of success in the combination.

135. A POSITA would have been motivated to combine the teachings of *Coli* with those of *Cicci*. Both *Coli* and *Cicci* are in the same field of endeavor as the claimed invention of hydraulic fracturing systems. For example, the '162 Patent is directed to “[a] hydraulic fracturing system for fracturing a subterranean formation.”¹⁴⁴ It also describes in its Technical Field that “[t]his disclosure relates generally to hydraulic fracturing and more particularly to systems and methods for fluid supply lines utilized in hydraulic fracturing.”¹⁴⁵ *Cicci* discloses, “[h]ydraulic fracturing systems utilize fracturing fluid to collect gas and/or oil from geological formations deep below the earth’s surface. One or more fracturing pumps are used to pressurize the fracturing fluid to a level which exceeds the tensile strength of the

¹⁴⁴ Ex. 1001 ('162 Patent), Abstract.

¹⁴⁵ Ex. 1001 ('162 Patent), 1:8-10.

subterranean geological formations below the earth's surface. When distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the wellbore. After the wellbore is depressurized, proppant material in the fracturing fluid remain in the fissures to hold the fissures open so that oil and/or gas trapped within the geological formations can be harvested through the wellbore.”¹⁴⁶

136. Similarly, *Coli* discloses that “[t]he present invention provides a method and system for providing on-site electrical power to a fracturing operation, and an electrically powered fracturing system. Natural gas can be used to drive a turbine generator in the production of electrical power. A scalable, electrically powered fracturing fleet is provided to pump fluids for the fracturing operation”.¹⁴⁷

137. *Coli* also discloses that “[t]his invention relates generally to hydraulic stimulation of underground hydro-carbon-bearing formations, and more particularly, to the generation and use of electrical power to deliver fracturing fluid to a wellbore.”¹⁴⁸ *Coli* additionally discloses “[v]arious illustrative embodiments of a

¹⁴⁶ Ex. 1004 (*Cicci*), 1:7-19; Ex. 1005 (*Cicci Provisional*), [1].

¹⁴⁷ Ex. 1006 (*Coli*), Abstract.

¹⁴⁸ Ex. 1006 (*Coli*), [0003].

system and method for hydraulic stimulation of underground hydrocarbon-bearing formations.”¹⁴⁹

138. *Cicci* and *Coli* disclose similar and compatible hydraulic fracturing systems. Both *Cicci* and *Coli* disclose blending proppant and fluids together to create a fracturing fluid. *Cicci* teaches “[t]he hydraulic fracturing system 300 includes a blender 302, a manifold or a missile 304, one or more pumps 306, and a wellhead 308. The blender 302 is configured to receive components of a fracturing fluid (e.g., water, sand, chemicals, etc.) and blend the components into a slurry.”¹⁵⁰ *Coli* discloses “providing an electric blender module continuous and/or operatively associated with the fluid pump, the blender module comprising: a fluid source, a fluid additive source, and a centrifugal blender tub, and supplying electric power from the dedicated source to the blender module to effect blending of the fluid with fluid additives to generate the treatment fluid.”¹⁵¹

139. Both *Cicci* and *Coli* disclose pumps used to pump the fracturing fluid downhole and fracture underground formations. *Cicci* discloses “[o]ne or more fracturing pumps are used to pressurize the fracturing fluid to a level which exceeds the tensile strength of the subterranean geological formations below the earth's

¹⁴⁹ Ex. 1006 (*Coli*), [0009].

¹⁵⁰ Ex. 1004 (*Cicci*), 5:15–20; Ex. 1005 (*Cicci Provisional*), [23]

¹⁵¹ Ex. 1006 (*Coli*), [0012].

surface. When distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the wellbore;”¹⁵² while *Coli* discloses, “providing one or more electric fracturing modules at the site, each electric fracturing module comprising an electric motor and a coupled fluid pump, each electric motor operatively associated with the dedicated source of electric power; providing a wellbore treatment fluid for pressurized delivery to a wellbore, wherein the wellbore treatment fluid can be continuous with the fluid pump and with the wellbore; and operating the fracturing unit using electric power from the dedicated source to pump the treatment fluid to the well bore.”¹⁵³

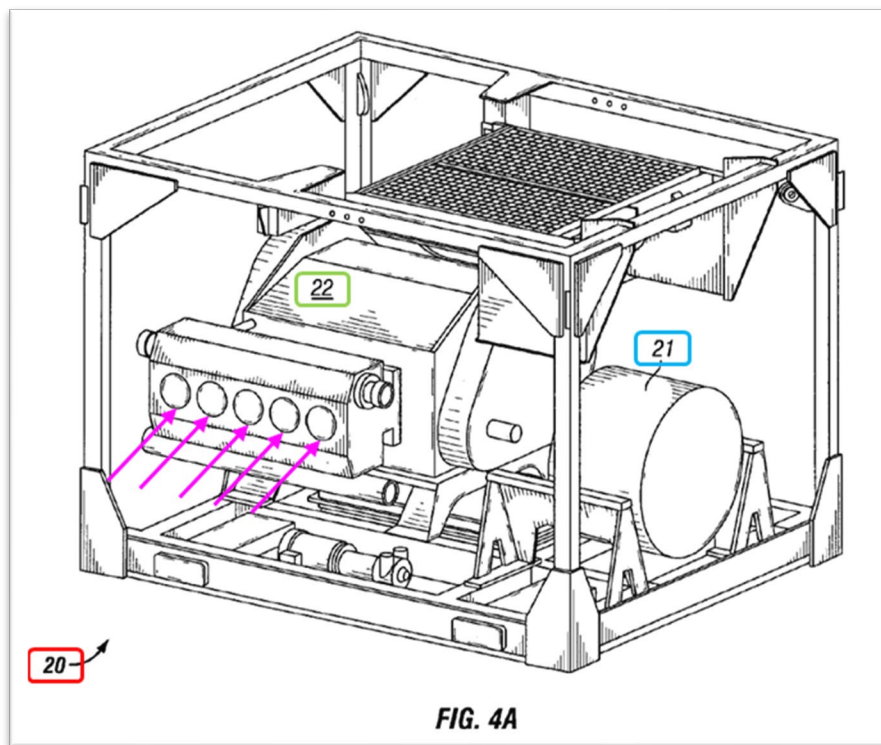
140. In light of *Cicci*’s disclosure of a fracturing pump,¹⁵⁴ a POSITA would have been motivated to look at other references, such as *Coli*, for implementation details of appropriate configurations of pumps, and how the pumps would have been powered. For example, *Coli* teaches that “an illustrative embodiment of fracturing module 20 [annotated in Fig. 4A in red] is provided. Fracturing module 20 can include an electric motor 21 [annotated in blue] coupled to one or more electric pumps 22 [annotated in green], in certain illustrative embodiments. A suitable pump

¹⁵² Ex. 1004 (*Cicci*) 1:7-19; Ex. 1005 (*Cicci Provisional*), [1].

¹⁵³ Ex. 1006 (*Coli*), [0009].

¹⁵⁴ Ex. 1004 (*Cicci*), 1:7-19, Ex. 1005 (*Cicci Provisional*), [1].

is a quintiplex [quintuplex] or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.”¹⁵⁵ *Coli* also again discloses that “[t]he pump can be a triplex or quintiplex [quintuplex] plunger style fluid pump.”¹⁵⁶



Ex. 1006 (*Coli*) Fig 4A (annotated)

141. A POSITA would have easily recognized that a “quintiplex” (quintuplex) pump is one with five plungers and a triplex plunger pump is one with

¹⁵⁵ Ex. 1006 (*Coli*), [0046].

¹⁵⁶ Ex. 1006 (*Coli*), [0011].

three plungers.¹⁵⁷ A POSITA would have understood both of these to be “multi-plunger” pumps. Fig. 4A shows an embodiment of *Coli* with a quintuplex (5-plunger) pump, with each plunger location identified by a magenta arrow.

142. A POSITA would have been motivated to incorporate *Coli*’s teachings on multi-plunger pumps into *Cicci*’s system, as *Coli* provides specific examples of pump configurations (triplex or quintuplex) suitable for hydraulic fracturing. Further, *Coli* details a specific example of a suitable pump, “the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.,”¹⁵⁸ which a POSITA would have recognized as being a multi-plunger (quintuplex or five-plunger) pump with a 6-inch inlet connection, as discussed in Section XI.F above.¹⁵⁹ *Coli* additionally provides implementation details of configurations for a plurality of pumps.¹⁶⁰ A POSITA would have been motivated to implement multi-plunger pumps in *Cicci*’s system, as *Coli* discloses that multi-plunger pumps were suitable for fracturing operations.¹⁶¹

143. A POSITA would have been further motivated to incorporate *Coli*’s teachings of an electric powered pump into *Cicci*’s system, in light of the express benefits disclosed by *Coli*. A POSITA would have been motivated to incorporate

¹⁵⁷ See Sections X.B and X.C above.¹⁵⁸ Ex. 1006 (*Coli*), [0046].

¹⁵⁸ Ex. 1006 (*Coli*), [0046].

¹⁵⁹ Ex. 1006 (*Coli*), [0046]; Ex. 1010 (*Gardner-Denver*), pgs. 76-79 of the PDF.

¹⁶⁰ Ex. 1006 (*Coli*), [0040], [0060], Figs. 2-3.

¹⁶¹ Ex. 1006 (*Coli*), [0049].

Coli's teachings of using an electric motor to power the pump to gain the benefits of reduced parasitic losses, increased horsepower delivered to the pump, reduced numbers of pieces of equipment, reduced footprint, reduced weight, reduced emissions, and reduced noise, as described by *Coli*, and as would have been well-known to a POSITA.¹⁶²

144. For example, *Coli* discloses the use of natural-gas-powered turbines to generate electricity, which in turn powers electric motors for driving the pumps.¹⁶³ In one embodiment, the turbines may use natural gas that is collected on site, thereby “obviating the need for a constant supply of diesel fuel to the site and reducing the site footprint and infrastructure required for the fracturing operation.”¹⁶⁴ Further, the smaller size and lighter weight of pumping modules with electric motors “allow[s] for placement of four pumps 22 in the same physical dimension (size and weight) as the spacing needed for a single pump in conventional diesel systems.”¹⁶⁵ Thus, “the number of fracturing modules 20 placed on each trailer 10” is “maximized.”¹⁶⁶

¹⁶² Ex. 1006 (*Coli*), [0046], [0049].

¹⁶³ Ex. 1006 (*Coli*) [0042].

¹⁶⁴ Ex. 1006 (*Coli*) [0036], *see also* Ex. 1006 (*Coli*), [0075].

¹⁶⁵ Ex. 1006 (*Coli*) [0049].

¹⁶⁶ Ex. 1006 (*Coli*) [0052].

145. *Coli* further discloses that “[t]he electric motor can be capable of operation in the range of up to 1500 rpm and up to 20,000 [ft-lbs]¹⁶⁷ of torque.”¹⁶⁸ In addition, “[e]lectric motors controlled via variable frequency drive are far safer and easier to control than conventional diesel powered equipment.”¹⁶⁹

146. *Coli* teaches that the use of electric motors to drive the pumps, rather than diesel motors, allows for an increase in power delivered to the pump from 1,800 hp to 2,500 hp because “parasitic losses are minimal in the electric fracturing system compared to the parasitic losses typical of diesel fueled systems,”¹⁷⁰ and because “pump 22 is directly coupled to electric motor 21,”¹⁷¹ without the use of a transmission, torque converter and cooling system, as explained by *Coli*.¹⁷²

147. Furthermore, *Coli* discloses that “the nominal weight of a conventional fluid pump is up to 120,000 lbs. In the present operation, each fracturing module 20

¹⁶⁷ The unit of torque is ft-lb. There appears to be a typographical error in *Coli* insofar as it expresses torque in ft/lbs. The proper units for torque (in the US customary system) is ft-lb. As an example, 5 ft-lb is equivalent to a force of 5 lb acting on an arm with a length of 1 ft. “Ft/lb” is a unit of mass density. As an example, 5 ft/lb would mean a rod (or other linear device) that has a mass of 0.2. lb/ft. It would take 5 feet of rod to reach a mass of 1 lb. Accordingly, I understand that “20,000 ft/lb” is a typographical error and should be read “20,000 ft-lb”.

¹⁶⁸ Ex. 1006 (*Coli*), [0011].

¹⁶⁹ Ex. 1006 (*Coli*), [0066].

¹⁷⁰ Ex. 1006 (*Coli*), [0049].

¹⁷¹ Ex. 1006 (*Coli*), [0049].

¹⁷² See, e.g., Ex. 1006 (*Coli*), [0049].

weighs approximately 28,000 lbs., thus allowing for placement of four pumps 22 in the same physical dimension (size and weight) as the spacing needed for a single pump in conventional diesel systems.”¹⁷³

148. A POSITA would have been motivated to incorporate *Coli*’s teachings of using an electric motor to power the pump in order to gain the benefits of reduced parasitic losses, increased horsepower delivered to the pump, reduced numbers of pieces of equipment, reduced footprint and reduced weight described by *Coli*. Reduced parasitic losses and increased horsepower delivered to the pump would have made the system more efficient. Reduced numbers of pieces of equipment would have resulted in lower maintenance requirements, as there would be fewer pieces of equipment to maintain. A reduced footprint would have allowed the system to be configured in a smaller space and/or arranged more easily. Reduced weight would have made it easier to transport the electric pumps described by *Coli*, as compared to other options such as diesel-powered pumps. It additionally would have been well-known to a POSITA that an electric motor would have reduced emissions and noise.¹⁷⁴ A POSITA would have been motivated to realize each of these benefits.

¹⁷³ Ex. 1006 (*Coli*), [0049].

¹⁷⁴ See, e.g., Ex. 1021 (*Oehring*), 1:46-55.

149. A POSITA would have had a reasonable expectation of success in the combination. Both *Cicci* and *Coli* disclose equipment used to construct a hydraulic fracturing system. *Cicci* discloses a pump in a hydraulic fracturing system, and *Coli* provides implementation details on appropriate ways to configure and power the pumps.¹⁷⁵ Accordingly, incorporating *Coli*'s teachings of electric-powered multi-plunger hydraulic fracturing pumps into *Cicci*'s teachings of a hydraulic fracturing system is merely applying a known technique to improve a known system in the same way.¹⁷⁶ Further, combining *Coli*'s teachings would have yielded predictable results for a POSITA, i.e., a fracturing system that is more efficient, has reduced equipment, a smaller footprint, lighter weight, and reduced noise and emissions, as compared to traditional, diesel-powered systems.

150. A POSITA would have been further motivated to incorporate the teachings of *Dixon* into the system of *Cicci/Coli*. *Dixon* is in the same field of endeavor as the claimed invention of hydraulic fracturing systems.¹⁷⁷ For example,

¹⁷⁵ Ex. 1004 (*Cicci*), 1:7-19; Ex. 1005 (*Cicci Provisional*), [1]; Ex. 1006 (*Coli*), Abstract, [0011], [0046], [0049] & Figs. 3, 4A.

¹⁷⁶ See, e.g., Ex. 1021 (*Oehring*), 1:46-65 (electric powered pumps were well known); see generally Ex. 1038 (*Oehring*) (multi-plunger pumps were well known).

¹⁷⁷ Ex. 1009 (*Dixon-Australia*), pg. 149.

Dixon discloses “Dixon Frac Fittings” that are “[u]sed in the fast paced transfer of water and sand slurry to a hydraulic fracturing site.”¹⁷⁸

151. A POSITA would have been motivated by the teachings of *Cicci* regarding fittings to look to references that teach about fittings and hoses that would have been useful in the fracturing system of *Cicci/Coli*. For example, *Cicci* discloses that “[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310. For example, each pump 306 can have a set of connections configured to interlock, engage, or otherwise *couple to a fitting affixed to each end of the flexible flow line 310*. Similarly, the missile or manifold 304 can include a set of connections configured to interlock, engage, or otherwise *couple to a fitting affixed to each end of the flexible flow line 310*.”¹⁷⁹

152. As another example, *Cicci* teaches “coupling a first end of a first flexible hose to one of the respective pump connections. The flexible hose can be connected to the pump connections by any number of connection methods currently known or developed in the future, [] such as a hammer union.”¹⁸⁰

153. A POSITA would have been motivated to look to *Dixon* for implementation details about such fittings, hoses and couplings. *Dixon* contains

¹⁷⁸ Ex. 1009 (*Dixon-Australia*), pg. 149.

¹⁷⁹ Ex. 1004 (*Cicci*), 5:30-37; Ex. 1005 (*Cicci Provisional*), [24] emphasis added.

¹⁸⁰ Ex. 1004 (*Cicci*), 7:40-47; Ex. 1005 (*Cicci Provisional*), [30].

information about commercially available products, including hoses and fittings, for use in “slurry” systems and, in particular, “frac” systems. For example, on the “Hose & Hose Assemblies Index page (page 11), *Dixon-Australia* specifically calls out “slurry” and “frac” systems in a graphic listing what a POSITA would have understood to be systems where *Dixon*’s teachings were applicable (annotated with a red box below).¹⁸¹



154. *Dixon* further teaches specific equipment, such as hoses and fittings, explicitly designed and sold for fracturing applications. For example, *Dixon-Australia* discloses an “anti-static high pressure and chemically resistant composite FRAC hose [that] is designed for suction and discharge use with hydraulic fracturing related applications.”¹⁸² *Dixon-Australia* further teaches that “[t]he hose

¹⁸¹ Ex. 1009 (*Dixon-Australia*), pg. 11 annotated.

¹⁸² Ex. 1009 (*Dixon-Australia*), pg. 58.

construction is medium to light weight and flexible for ease of handling yet remains robust, hard wearing and cost effective.”¹⁸³

155. As another example, *Dixon* teaches frac fittings which are “[u]sed in the fast paced transfer of water and sand slurry to a hydraulic fracturing site.”¹⁸⁴ These fittings have a one-piece design that “eliminates leak path experienced with two-piece threaded systems.”¹⁸⁵ Further, *Dixon* teaches “Frac Fittings,” which are used in “Suction Service,” and “King Crimp™ Style Short Frac Ferrules” and “King Crimp™ Style Heavy Duty Ferrules” for use in attaching hoses to “crimp style shanks” on the frac fittings.¹⁸⁶

156. *Dixon* also teaches the use of other fittings which would be useful in fracturing systems, including general information on hammer unions,¹⁸⁷ reducers,¹⁸⁸ hose and hose assemblies, industrial hose fittings, and pipe and pipe welding fittings that a POSITA would have found useful in designing the system of *Cicci/Coli*. *Dixon* is analogous art to the ’162 Patent as it is in the same field of endeavor of hydraulic

¹⁸³ Ex. 1009 (*Dixon-Australia*), pg. 58.

¹⁸⁴ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

¹⁸⁵ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

¹⁸⁶ See, e.g., Ex. 1009 (*Dixon-Australia*), pg. 150; Ex. 1012 (*Dixon-U.S.*), pg. 79.

¹⁸⁷ See, e.g., Ex. 1009 (*Dixon-Australia*), pg. 154-155; Ex. 1012 (*Dixon-U.S.*), pgs. 681-682.

¹⁸⁸ See, e.g., Ex. 1009 (*Dixon-Australia*) pg. 359, 405; Ex. 1012 (*Dixon-U.S.*), pgs. 608, 613, 628.

fracturing systems. *Dixon* also would have been reasonably pertinent to the problem with which the '162 Patent is concerned—fluid flow rates for fracturing operations¹⁸⁹—as *Dixon*'s frac fittings are would have been applicable for use with slurry flow in a hydraulic fracturing system to address such problems.

157. A POSITA would have been motivated to incorporate *Dixon*'s fittings into the system of *Cicci/Coli* to obtain the express benefits of *Dixon*'s fittings. For example, *Dixon*'s fittings have a “[o]ne piece design [which] eliminates leak path experienced with two-piece threaded systems.”¹⁹⁰ These Frac Fittings also are “[d]urable and safe with reliable hose retention when crimped as specified.”¹⁹¹ *Dixon* shows examples of various combinations of fitting sizes, including fittings for connecting the same size hose and union (Complete Male/Female Assembly) and combinations of Male/Female assemblies that would have attached a larger union to

¹⁸⁹ For example, the '162 Patent describes “problems with flow rates, as flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site.” Ex. 1001 ('162 Patent), 1:14-45. Similarly, during prosecution of the application that led to the '162 Patent, the applicant distinguished prior art by arguing that it did not “identify the problem associated with efficient fluid flow rates for fracturing operations.” Ex. 1003 ('162 Patent File History), pg. 433 (Sept. 29, 2020 Response to Nonfinal Rejection, pg. 8)

¹⁹⁰ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

¹⁹¹ Ex. 1009 (*Dixon-Australia*), pg. 149.

a smaller hose.¹⁹² A POSITA further would have been motivated to use *Dixon's* fittings to connect a pump with a connection of one diameter with a hose with a connection of a different, smaller diameter. Further, as detailed below in Sections XIII.D-E regarding Ground 2, a POSITA would have been further motivated to reduce the hose size to 5" to increase the velocity of the contained slurry, thus reducing the propensity of the proppant to drop out of the slurry and form a bed in the bottom of the hoses, potentially causing a screen out (plugging) of the hoses. This is based on Scientific Principles known to a POSITA, and outlined in the *Liu* textbook.

158. A POSITA would have had a reasonable expectation of success in combining the teachings of *Dixon* with those of *Cicci/Coli*. This would have been merely applying a known technique (the teachings of hoses and fittings from *Dixon*) to a known system (the hydraulic fracturing system of *Cicci/Coli*), ready for improvement (actual design and construction of the system) to yield predictable results (a practical fracturing system). *Dixon* teaches specific configurations of fittings that are designed for fracturing systems, as well as teachings regarding other

¹⁹² Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

industrial, piping, and weld fittings, which would have been useful in designing the system described by *Cicci/Coli*.¹⁹³

B. INDEPENDENT CLAIM 1

159. It is my opinion that the combination of *Cicci*, *Coli* and *Dixon* would have rendered Claim 1 obvious. The combined teachings of *Cicci*, *Coli* and *Dixon* disclose or render obvious each and every limitation of Claim 1, as discussed in the sections below.

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

160. To the extent the preamble is limiting, *Cicci* and *Coli* each disclose the preamble.

161. *Cicci* discloses, “[h]ydraulic fracturing systems utilize fracturing fluid to collect gas and/or oil from geological formations deep below the earth’s surface. One or more fracturing pumps are used to pressurize the fracturing fluid to a level which exceeds the tensile strength of the subterranean geological formations below the earth's surface. When distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the

¹⁹³ Ex. 1009 (*Dixon-Australia*), pgs. 11, 58, 149-151, 154, 405; Ex. 1012 (*Dixon-U.S.*), pgs. 78-79, 111-113, 118, 608, 613 628, 681.

wellbore. After the wellbore is depressurized, proppant material in the fracturing fluid remain in the fissures to hold the fissures open so that oil and/or gas trapped within the geological formations can be harvested through the wellbore.”¹⁹⁴

162. Similarly, *Coli* discloses that “[t]he present invention provides a method and system for providing on-site electrical power to a fracturing operation, and an electrically powered fracturing system. Natural gas can be used to drive a turbine generator in the production of electrical power. A scalable, electrically powered fracturing fleet is provided to pump fluids for the fracturing operation”.¹⁹⁵

163. *Coli* also discloses that “[t]his invention relates generally to hydraulic stimulation of underground hydro-carbon-bearing formations, and more particularly, to the generation and use of electrical power to deliver fracturing fluid to a wellbore.”¹⁹⁶ *Coli* additionally discloses that “[v]arious illustrative embodiments of a system and method for hydraulic stimulation of underground hydrocarbon-bearing formations are provided herein.”¹⁹⁷

¹⁹⁴ Ex. 1004 (*Cicci*), 1:7-19; Ex. 1005 (*Cicci Provisional*), [1].

¹⁹⁵ Ex. 1006 (*Coli*), Abstract.

¹⁹⁶ Ex. 1006 (*Coli*), [0003].

¹⁹⁷ Ex. 1006 (*Coli*), [0009].

164. A POSITA would have understood that *Coli*'s disclosures of hydraulic stimulation of underground hydrocarbon-bearing formations refer to a hydraulic fracturing system for fracturing a subterranean formation.

165. Accordingly, both *Cicci* and *Coli* disclose the preamble.

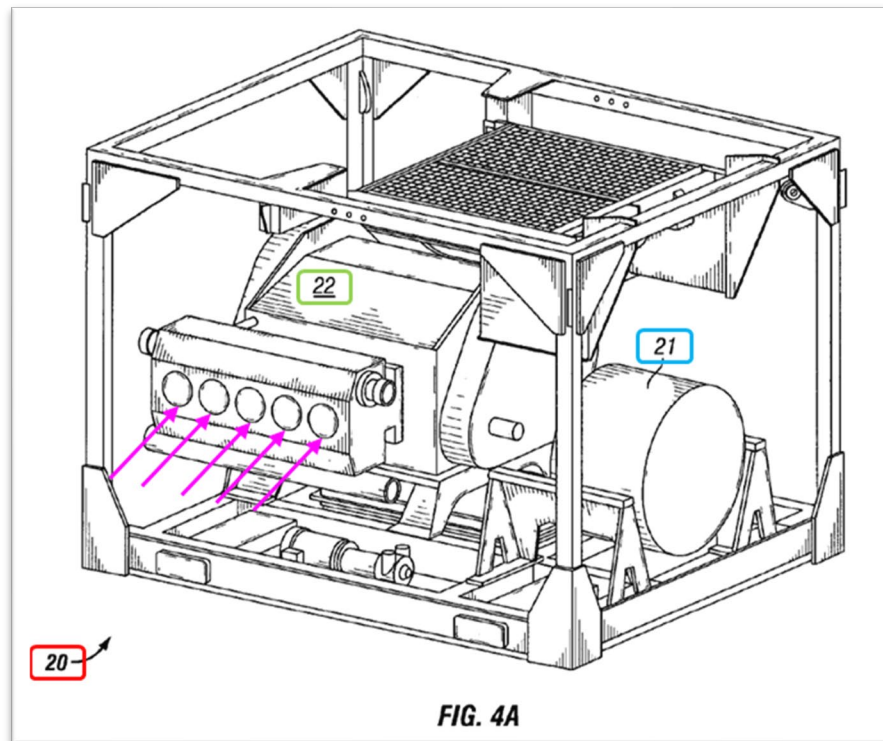
2. 1[a]: “an electric powered, multi-plunger hydraulic fracturing pump having an inlet and an outlet, the outlet coupled to a well associated with the subterranean formation and powered by at least one electric motor;”

166. The combination of *Cicci* and *Coli* discloses limitation 1[a].

167. As discussed above regarding 1[p], both *Cicci* and *Coli* disclose a hydraulic fracturing system for fracturing a subterranean formation. Additionally, as discussed above, both *Coli* and *Cicci* disclose that the hydraulic fracturing system contains pumps. *Coli* discloses using an electric-powered multi-plunger hydraulic fracturing pump as claimed. *Coli* discloses “an illustrative embodiment of fracturing module 20 [annotated in Fig. 4A in red] is provided. Fracturing module 20 can include an electric motor 21 [annotated in blue] coupled to one or more electric pumps 22 [annotated in green], in certain illustrative embodiments. A suitable pump is a quintiplex [quintuplex] or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.”¹⁹⁸ *Coli* also again discloses

¹⁹⁸ Ex. 1006 (*Coli*), Fig 4A annotated; Ex. 1006 (*Coli*), [0046].

that “[t]he pump can be a triplex or quintiplex [quintuplex] plunger style fluid pump.”¹⁹⁹



Ex. 1006 (*Coli*) Fig 4A annotated

168. A POSITA would have easily recognized that a quintiplex (or quintuplex) pump is one with five plungers and a triplex plunger pump is one with three plungers.²⁰⁰ A POSITA would have understood both of these to be “multi-

¹⁹⁹ Ex. 1006 (*Coli*), [0011].

²⁰⁰ See Sections X.B and X.C above.

²⁰¹ Ex. 1006 (*Coli*), [0040].

plunger” pumps. Fig. 4A above shows an embodiment of *Coli* with a quintuplex (5-plunger) pump, with each plunger location identified by a magenta arrow.

169. *Coli*’s electric-powered pump is powered by at least one electric motor. *Coli* further discloses that motor 21 is used to power the pump to pump fluid down the wellbore. *Coli* teaches “[e]ach fracturing module 20 can include an electric motor 21 and a fluid pump 22 coupled thereto. During fracturing, fracturing module 20 is operatively associated with turbine generator 30 to receive electric power therefrom. [] Fracturing modules 20 utilize electric power from turbine generator 30 to pump the fracturing fluid directly to the wellbore.”²⁰¹ Thus, *Coli* discloses an electric-powered multi-plunger hydraulic fracturing pump, which is powered by at least one electric motor. A POSITA would have been motivated to use *Coli*’s teachings of an electric motor driven multi-plunger fracturing pump to improve *Cicci*’s teachings of a fracturing system as discussed in Section XII.A above.

170. Further, *Cicci* discloses: “[t]he blender 302 delivers the blended fracturing fluid to the missile 304 at a low pressure. The missile 304 delivers the fracturing fluid to the pumps 306 at a relatively low pressure.”²⁰² *Cicci* thus discloses the delivery of the fracturing fluid from the blender to the pump, and from the pump

²⁰¹ Ex. 1006 (*Coli*), [0040].

²⁰² Ex. 1004 (*Cicci*), 5:20-23; Ex. 1005 (*Cicci Provisional*), [23].

to the missile. A POSITA would have understood that the delivery of fracturing fluid from the blender to the pump would have been through the pump's inlet, which would have been well-known to a POSITA.

171. *Cicci* also discloses: “[t]he pumps 306 then pressurize the fracturing fluid to a pressure ranging between 5,000 PSI to 15,000 PSI, or more. The pumps 306 deliver the pressurized fracturing fluid to the missile 304.”²⁰³ A POSITA would have understood that the pumps’ delivery of the fracturing fluid to the missile would have been through the pump’s outlet, which would have been well-known to a POSITA. A POSITA would have accordingly understood from *Cicci*’s disclosures the well-known fact that the pump has an inlet and an outlet.

172. Further, *Cicci* discloses that the outlet is coupled to a well associated with the subterranean formation through the missile 304. *Cicci* discloses that the pump is coupled to the wellbore: “[t]he pumps 306 then pressurize the fracturing fluid to a pressure ranging between 5,000 PSI to 15,000 PSI, or more. The pumps 306 deliver the pressurized fracturing fluid to the missile 304. The missile 304 then delivers the pressurized fracturing fluid to the wellhead 308, which routes the fluid into steel casing in the wellbore (not shown)”,²⁰⁴ which a POSITA would have

²⁰³ Ex. 1004 (*Cicci*), 5:23-26; Ex. 1005 (*Cicci Provisional*), [23].

²⁰⁴ Ex. 1004 (*Cicci*), 5:27-30; Ex. 1005 (*Cicci Provisional*), [23].

understood meant that *Cicci*'s pump's outlet is coupled to the wellbore, consistent with what would have been well-known to a POSITA. *Cicci* further discloses that the well is associated with the subterranean formation: "[w]hen distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the wellbore."²⁰⁵ A POSITA would have understood from *Cicci*'s disclosure that the well is associated with the subterranean formation, consistent with what would have been well-known to a POSITA.

173. Similarly, *Coli* describes that "[f]racturing modules 20 utilize electric power from the turbine generator 30 to pump the fracturing fluid directly to the wellbore."²⁰⁶ *Coli* further states that in a fracturing operation, "a 'slurry' of fluids and additives is injected into a hydrocarbon-bearing rock formation at a wellbore to propagate fracturing."²⁰⁷ A POSITA would have understood that the purpose of hydraulic fracturing operations was to inject fluids into a subterranean formation under pressure to create fissures or "fractures" in the formation.²⁰⁸

174. Accordingly, the combination of *Cicci* and *Coli* discloses Limitation 1[a] and renders Limitation 1[a] obvious.

²⁰⁵ Ex. 1004 (*Cicci*), 1:12-15; Ex. 1005 (*Cicci Provisional*), [1].

²⁰⁶ Ex. 1006 (*Coli*), [0040], see also Ex. 1006 (*Coli*), [0009].

²⁰⁷ Ex. 1006 (*Coli*), [0035], see also Ex. 1006 (*Coli*), [0003], [0009].

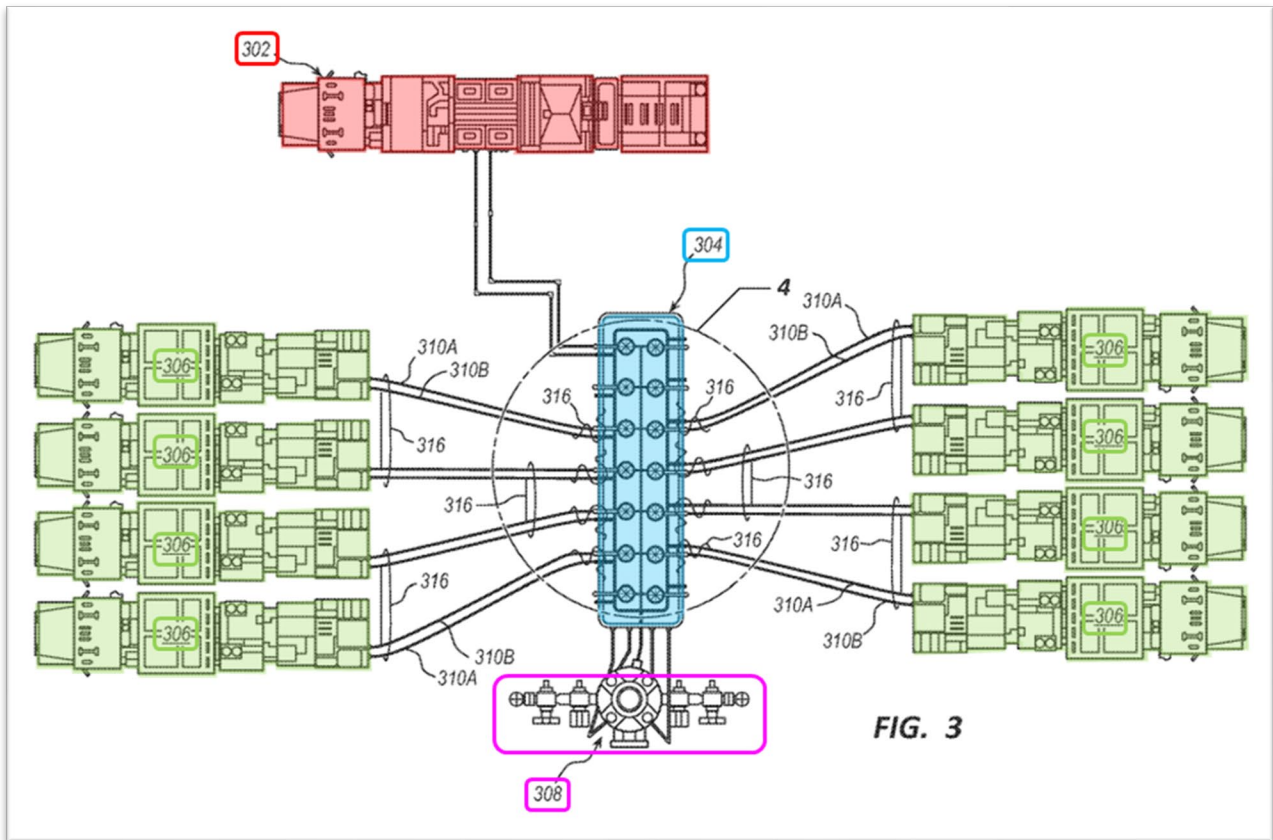
²⁰⁸ See, e.g., Ex. 1004 (*Cicci*), 1:7-19; Ex. 1005 (*Cicci Provisional*), [1].

3. 1[b]: “a fluid source, coupled to the inlet of the electric powered multi-plunger hydraulic fracturing pump, the fluid source providing a slurry for injection into the subterranean formation;”

175. The combination of *Cicci* and *Coli* discloses limitation 1[b].

176. *Cicci* discloses a basic fracturing system: “FIG. 3 is a top view of a hydraulic fracturing system 300 according to the present disclosure. The hydraulic fracturing system 300 includes a blender 302 [annotated in Fig. 3 in red], a manifold or a missile 304 [annotated in blue], one or more pumps 306 [annotated in green], and a wellhead 308 [annotated in magenta]. The blender 302 is configured to receive components of a fracturing fluid (e.g., water, sand, chemicals, etc.) and blend the components into a slurry. The blender 302 delivers the blended fracturing fluid to the missile 304 at a low pressure. The missile 304 delivers the fracturing fluid to the pumps 306 at a relatively low pressure. The pumps 306 then pressurize the fracturing fluid to a pressure ranging between 5,000 PSI to 15,000 PSI, or more. The pumps 306 deliver the pressurized fracturing fluid to the missile 304. The missile 304 then delivers the pressurized fracturing fluid to the wellhead 308, which routes the fluid into steel casing in the wellbore (not shown).”²⁰⁹

²⁰⁹ Ex. 1004 (*Cicci*), 5:14-29; Ex. 1005 (*Cicci Provisional*), [23].



Ex. 1004 (*Cicci*), Fig. 3 annotated.

177. Accordingly, *Cicci* discloses a fluid source (manifold/missile 304), coupled to the inlet of the pumps (pumps 306), the fluid source providing a slurry for injection into the subterranean formation (“The missile 304 then delivers the pressurized fracturing fluid to the wellhead 308, which routes the fluid into steel casing in the wellbore (not shown).”)²¹⁰ As discussed above regarding Limitation

²¹⁰ Ex. 1004 (*Cicci*), 5:26-29; Ex. 1005 (*Cicci Provisional*), [23].

1[a], once in the wellbore, “the highly pressurized fluid generates micro fissures or cracks within the geological formation surrounding the wellbore.”²¹¹

178. Accordingly, *Cicci* discloses Limitation 1[b], and the combination of *Cicci* and *Coli* renders Limitation 1[b] obvious.

4. 1[c]: “a hose extending between the fluid source and the electric powered pump, the hose being flexible and having a first diameter;”

179. The combination of *Cicci* and *Coli* discloses limitation 1[c].

180. *Cicci* describes a hose extending between the fluid source (missile 304) and the pump, which would have been electric-powered multi-plunger pumps in the combination of *Cicci* and *Coli*, as discussed above. *Cicci* discloses “a flexible pipe or hose (i.e., a flexible flow line) capable of withstanding pressure in excess [of] 15,000 PSI is utilized to couple various components of a fracturing system. For example, a flexible pipe or hose can be used to connect a pump to the manifold.”²¹² As discussed above in Section XII.B.2, the combination of *Cicci* and *Coli* teaches that the pump would be an electric-powered pump.

²¹¹ Ex. 1004 (*Cicci*), 1:12-15; Ex. 1005 (*Cicci Provisional*), [1]. See also Ex. 1006 (*Coli*), [0003], [0035].

²¹² Ex. 1004 (*Cicci*), 3:42-46; Ex. 1005 (*Cicci Provisional*), [15].

181. Further, *Cicci* discloses that “the plurality of flexible hoses can have an inner diameter of one to eight inches.”²¹³ Therefore, *Cicci* discloses the hose having a first diameter.

182. Accordingly, *Cicci* discloses Limitation 1[c], and the combination of *Cicci* and *Coli* renders Limitation 1[c] obvious.

5. 1[d]: “a fitting between the hose and the electric powered pump, the fitting having a first end for receiving the hose at the first diameter and a second end for coupling to the electric powered pump at a second diameter, the second diameter being larger than the first diameter; and”

183. The combination of *Cicci*, *Coli*, and *Dixon* disclose and would have rendered Limitation 1[d] obvious to a POSITA.

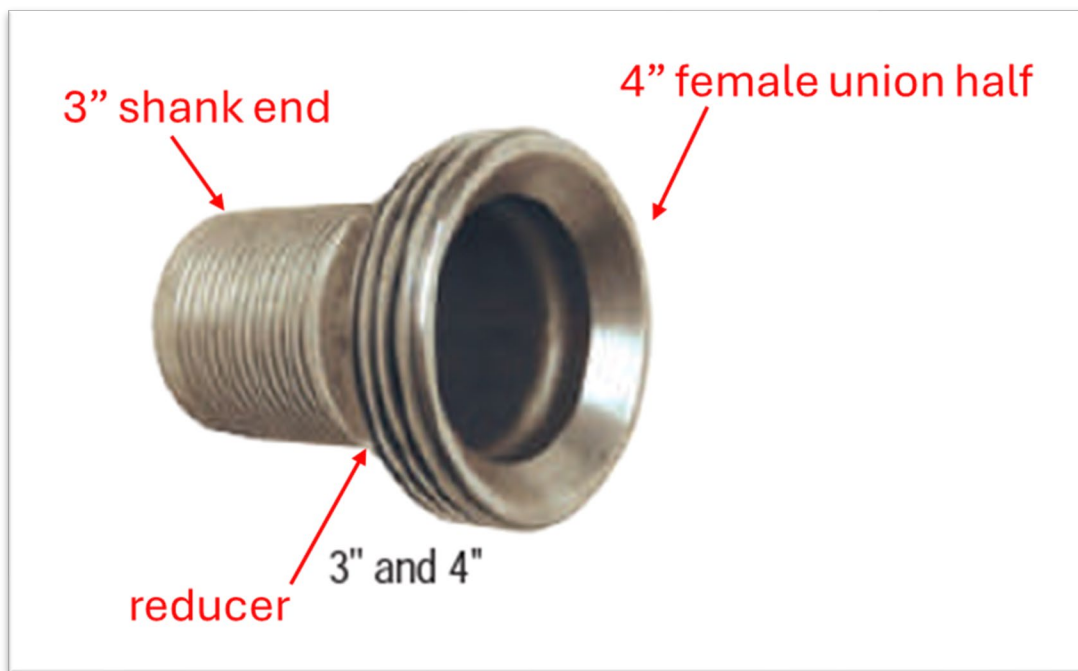
184. *Cicci* discloses a fitting between the hose and the pump. *Cicci* discloses “[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310. For example, each pump 306 can have a set of connections configured to interlock, engage, or otherwise couple to a fitting affixed to each end of the flexible flow line 310.”²¹⁴ A POSITA would have understood from this disclosure that the fitting has two ends—one for receiving the hose (a first end) and another end for coupling to

²¹³ Ex. 1004 (*Cicci*), 1:64-65, Claim 7; Ex. 1005 (*Cicci Provisional*) [4].

²¹⁴ Ex. 1004 (*Cicci*), 5:30-34; Ex. 1005 (*Cicci Provisional*), [24].

the pump (a second end). In combination with *Coli*, the “pump” is an electric-powered multi-plunger hydraulic fracturing pump.²¹⁵

185. *Dixon* discloses fittings for use in fracturing operations that provides an integrated assembly for connecting a larger diameter union with a smaller diameter hose.²¹⁶ For example, *Dixon* discloses a 3” shank end fitting with a 4” female union half, as shown below.



Ex. 1009 (*Dixon-Australia*), pg. 149 (annotated); Ex. 1012 (*Dixon-U.S.*), pg. 78 (annotated).

²¹⁵ See Section XII.B.2 above.

²¹⁶ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg.78.

186. A POSITA would have recognized the 3” end to be a “shank end”, at least because *Dixon* uses the term “shank” to name that type of hose connection throughout *Dixon*.²¹⁷ Further, the end of a fitting that inserts into a hose is commonly referred to as a shank. A POSITA would have understood that *Dixon*’s fitting has two ends—a first end (3” shank end) for receiving the hose and a second end (4” female union) for coupling to the pump.

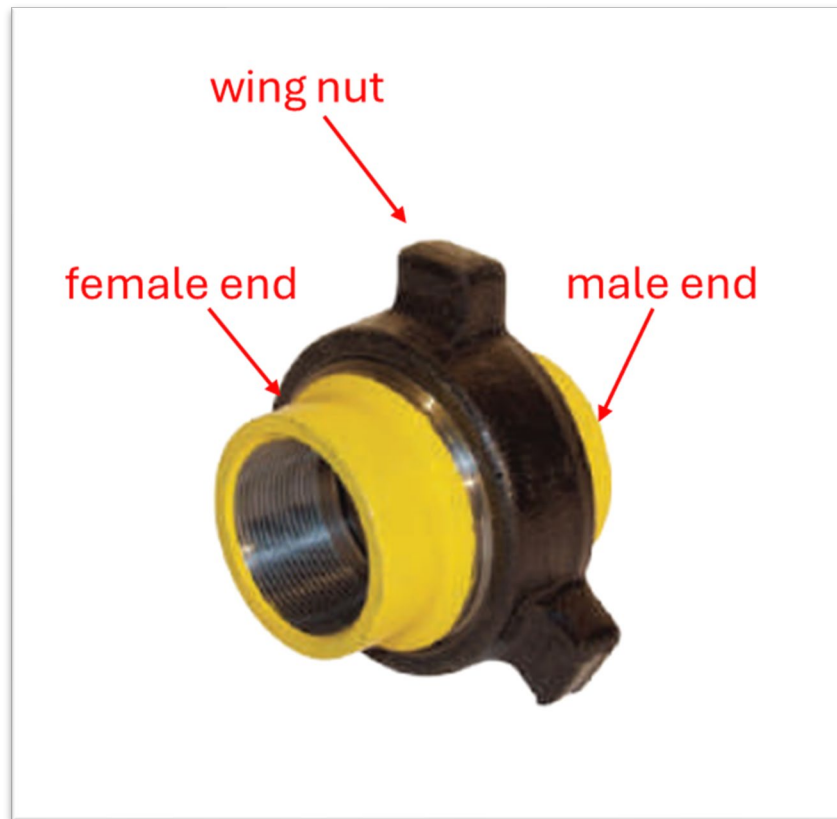
187. With respect to the second end, *Cicci* further teaches “coupling a first end of a first flexible hose to one of the respective pump connections. The flexible hose can be connected to the pump connections by any number of connection methods currently known or developed in the future, [] such as a hammer union.”²¹⁸ A POSITA would have understood from *Cicci*’s disclosure that the fitting has a second end for coupling to the pump.

188. A hammer union, as called out by *Cicci*, is shown by *Dixon* as a three-piece system for connecting piping, including hoses, to other fluid connections, such as a pump intake. *Dixon* teaches that hammer unions come in various sizes and pressure ratings (Figure Numbers), including hammer unions specifically designed

²¹⁷ Ex. 1009 (*Dixon-Australia*), pgs. 85, 91-95, 98-100; Ex. 1012 (*Dixon-U.S.*), pgs. 33-34, 67, 71, 74, 101, 104-106, 109-110.

²¹⁸ Ex. 1004 (*Cicci*), 7:41-47; Ex. 1005 (*Cicci Provisional*), [30].

for fracturing suction operations.²¹⁹ The figure below, taken from Dixon, page 154 and annotated, shows a typical 100 Series (Figure 100, up to 1000 PSI working pressure) hammer union with the three components identified.



Ex. 1009 (*Dixon-Australia*), pg. 154, excerpted and annotated; Ex. 1012 (*Dixon-U.S.*), pg. 681.

189. *Dixon* discloses just such a fitting for use in fracturing operations that provides an integrated assembly for connecting a larger diameter union with a

²¹⁹ Ex. 1009 (*Dixon-Australia*) pg. 154, 150; Ex. 1012 (*Dixon-U.S.*), pgs. 681-683.

smaller diameter hose.²²⁰ *Dixon* discloses “Dixon Frac Fittings” that are “[u]sed in the fast paced transfer of water and sand slurry to a hydraulic fracturing site.”²²¹ These fittings have a “[o]ne piece design [which] eliminates leak path experienced with two-piece threaded systems.”²²² These Frac Fittings also are “[d]urable and safe with reliable hose retention when crimped as specified.”²²³ *Dixon* shows examples of various combinations of fitting sizes, including fittings for connecting the same size hose and union (Complete Male/Female Assembly) and combinations of Male/Female assemblies that would have connected a larger union to a smaller hose.²²⁴

190. For example, *Dixon* discloses a 3” shank end fitting with a 4” female union half, as shown below.

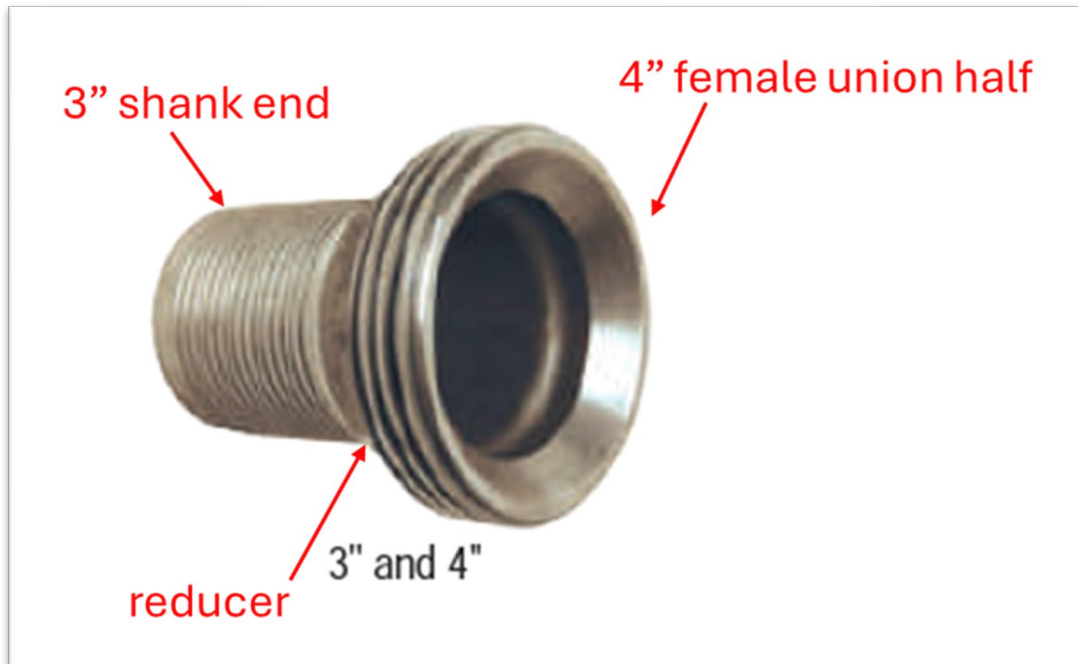
²²⁰ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

²²¹ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

²²² Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

²²³ Ex. 1009 (*Dixon-Australia*), pg. 149; *see also* Ex. 1009 (*Dixon-Australia*), pgs.150 and 151 showing the crimp ferrules that would be used with the shanks disclosed on pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78-79, 118

²²⁴ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.



Ex. 1009 (*Dixon-Australia*), pg. 149 excerpted and annotated; Ex. 1012 (*Dixon-U.S.*), pg. 78.

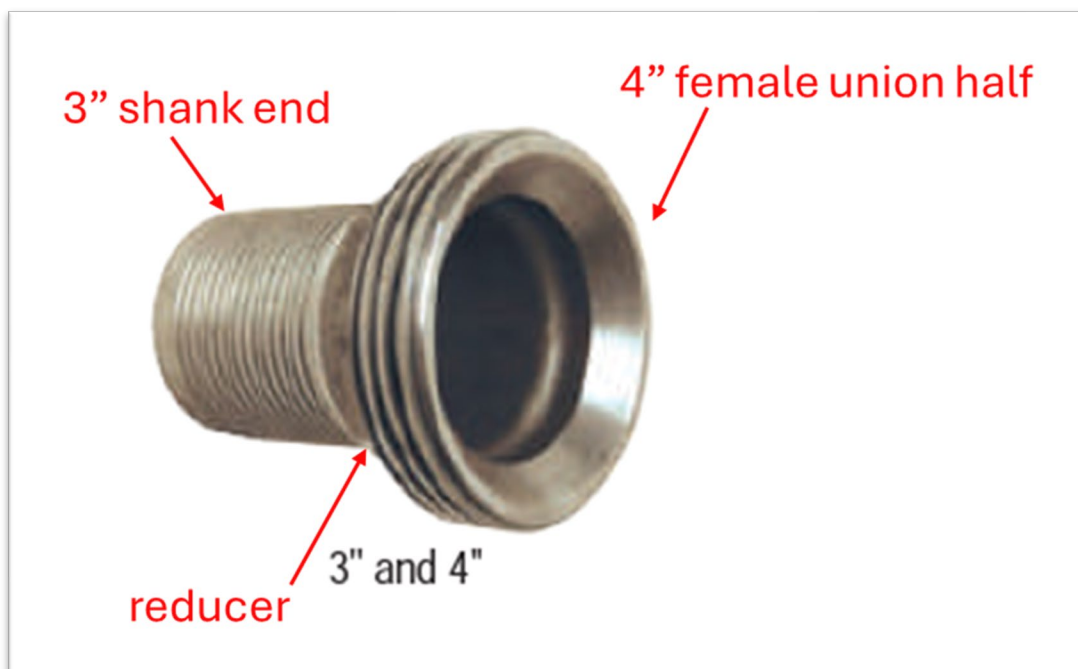
191. A POSITA would have recognized the 3" end to be a "shank end", at least because *Dixon* uses the term "shank" to mean that type of hose connection throughout *Dixon*.²²⁵ Further, the end of a fitting that inserts into a hose is commonly referred to as a shank.

192. A POSITA would have understood that each end of *Cicci*'s fitting would have a diameter (a first and second diameter), at which the fitting would receive the hose and couple to the pump, respectively. *Cicci* discloses that "the

²²⁵ See, e.g., Ex. 1009 (*Dixon-Australia*) pgs. 85, 91–96, 98–100 & Ex. 1012 (*Dixon-U.S.*), pgs. 33–34, 67, 71, 74, 101, 104–106, 109–110 and many others.

plurality of flexible hoses can have an inner diameter of one to eight inches.”²²⁶ A POSITA would have understood from *Cicci*’s disclosure of a hose “inner diameter” and that an “end” of the hose and the fittings coupled to the hose would have a diameter (e.g., a first diameter). Similarly, a POSITA would have understood that the end of the fitting coupled to the pump would also have a diameter (e.g., a second diameter).

193. Additionally, the first and second ends of *Dixon*’s fittings also have a first diameter (3” diameter) and a second diameter (4” diameter), as illustrated below:



²²⁶ Ex. 1004 (*Cicci*), 1:64-65; EX1005 (*Cicci Provisional*), [4].

Ex. 1009 (*Dixon-Australia*), pg. 149 (annotated); Ex. 1012 (*Dixon-U.S.*), pg. 78.

194. *Dixon's* fitting has a second diameter (4" female union) that is larger than the first diameter (3" shank end). *Dixon* shows examples of various combinations of fitting sizes, including combinations of Male/Female assemblies that would have connected a larger union to a smaller hose.²²⁷

195. A POSITA would have used the teachings of *Dixon* to connect a smaller diameter hose to a larger diameter union based on the teachings of *Dixon's* integral Frac Fittings to connect a smaller diameter hose to a larger diameter union. Such fittings and teachings were well-known at the time of the '162 Patent.²²⁸

196. Further, the '162 patent itself reveals that the use of multiple diameter fittings, such as *Dixon's* Frac Fittings would have been obvious. The '162 Patent admits that 6" fittings, such as "hammer unions, butterfly valves and other 6" steel pipe components" were "standard" in the fracturing industry.²²⁹ This is consistent with the teachings of the pump called out by *Coli* (Gardner-Denver SWGS-2500), which had 6" standard fittings.²³⁰ Further, the '162 Patent admits that 4" supply

²²⁷ Ex. 1009 (*Dixon-Australia*), pg. 149; ; Ex. 1012 (*Dixon-U.S.*), pg. 78.

²²⁸ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78; Ex. 1008, 1 (*Kemper*); EX1050, pg. 7 (*CNC*).

²²⁹ Ex. 1001 ('162 Patent), 3:65–4:2.

²³⁰ See Section XI.F above.

hoses were “standard” in fracturing systems.²³¹ During the prosecution of the ’162 Patent, the applicant additionally admitted that “[t]raditional fracturing systems typically use 6” connections for equipment and 4” hoses for fluid flow.”²³² The teachings of *Dixon’s* frac fittings to connect a larger diameter pump fitting (e.g. “standard” 6” pump connection) and a smaller diameter hose (e.g., “standard” 4” hose) would have been useful in connecting standard parts. Such a solution would have been obvious to a POSITA based on the teachings of *Cicci*, *Coli* and *Dixon*.

197. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Dixon* disclose and render obvious limitation 1[d].

6. 1[e]: “a distribution system, positioned between the wellbore and the electric powered pump, the distribution system collecting the slurry from electric powered pumps for injection into the subterranean formation.”

198. The *Cicci-Coli-Liu-Dixon* combination discloses limitation 1[e].

199. *Cicci* discloses a distribution system (including high pressure hoses 304A and manifold/missile 304)²³³ positioned between the wellbore and the pump

²³¹ Ex. 1001 (’162 Patent), 4:6–10.

²³² Ex. 1003 (’162 Patent File History), pg. 433 (Sept. 29, 2020 Response to Nonfinal Rejection, pg. 8)

²³³ It was well-known at the time of the ’162 Patent that the “missile” often contained manifolds for both the low pressure and high pressure connections of the pumps, so the disclosure of *Cicci* regarding missile 304 connecting both suction and discharge

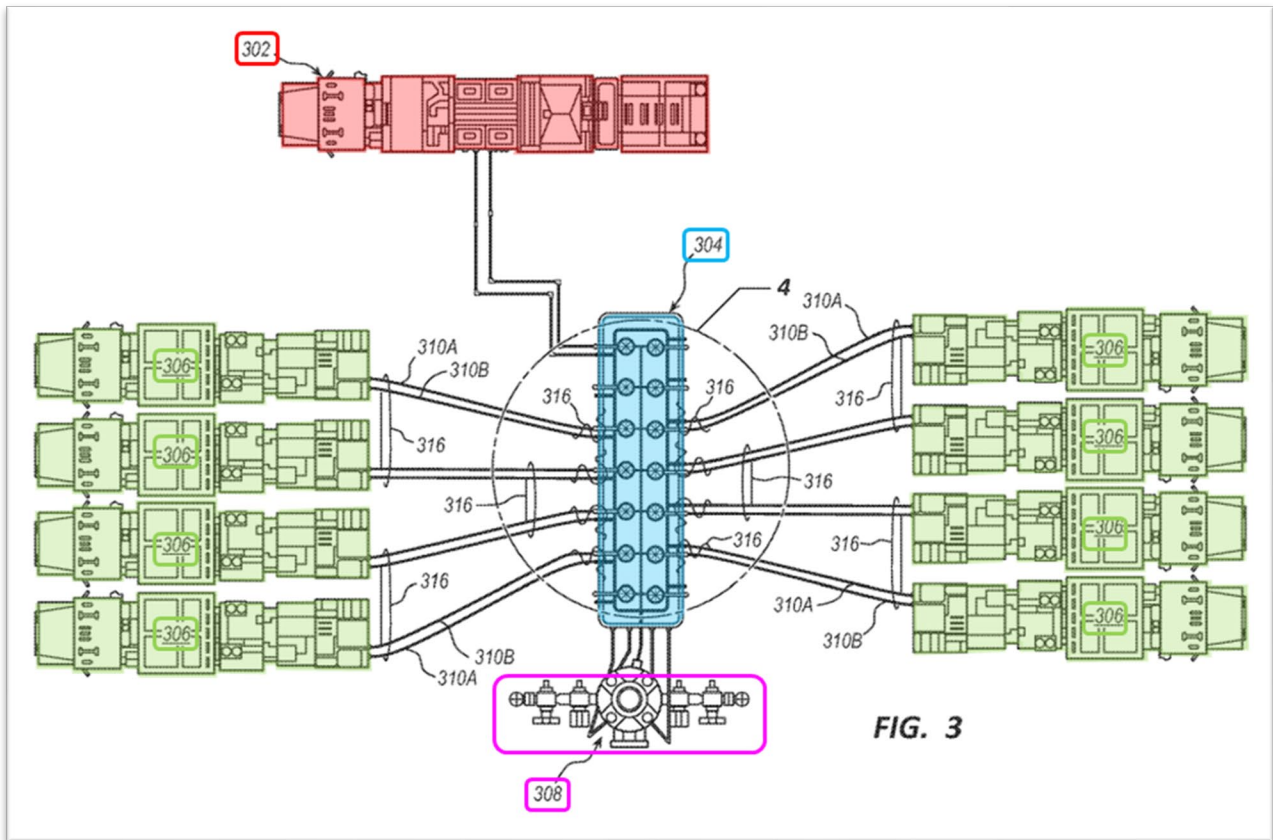
that collects the slurry from the pump for injection into the wellbore, and subsequently, the subterranean formation. For example, *Cicci* discloses that “[t]he pumps 306 deliver the pressurized fracturing fluid to the missile 304. The missile 304 then delivers the pressurized fracturing fluid to the wellhead 308, which routes the fluid into the steel casing in the wellbore (not shown).”²³⁴ *Cicci* further teaches that “each end of the high-pressure flexible flow lines 310A are coupled 60 to the pumps 306 or the missile 304, respectively.”²³⁵ Further, *Cicci* discloses that “[o]ne or more fracturing pumps are used to pressurize the fracturing fluid to a level which exceeds the tensile strength of the subterranean geological formations below the earth's surface. When distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the wellbore.”²³⁶

lines of the pump is consistent. Ex. 1004 (*Cicci*), 5:22-29; Ex. 1005 (*Cicci Provisional*), ¶[23].

²³⁴ Ex. 1004 (*Cicci*), 5:25-29; Ex. 1005 (*Cicci Provisional*), [23].

²³⁵ Ex. 1004 (*Cicci*), 6:58-60; Ex. 1005 (*Cicci Provisional*), [27].

²³⁶ Ex. 1004 (*Cicci*), 1:9-19; Ex. 1005 (*Cicci Provisional*), [1].



Ex. 1004 (*Cicci*), Fig. 3; Ex. 1005 (*Cicci Provisional*), Fig. 3 annotated and excerpted.

200. Accordingly, the combined teachings of *Cicci* and *Coli* disclose a distribution system (including high pressure hoses 310A and manifold/missile 304)²³⁷ which is fluidically between the well and the electric powered multi-plunger pump, and the distribution system collects the slurry from the electric powered

²³⁷ It was known at the time of the '162 Patent that the “missile” contained manifolds for both the low pressure and high pressure connections of the pumps, so the disclosure of *Cicci* regarding missile 304 connecting both suction and discharge lines of the pump is consistent.

multi-plunger hydraulic fracturing pump for injection into the wellbore, and subsequently, the formation. As discussed above, the pump is an electric-powered pump, and the fracturing fluid includes a slurry.²³⁸ Accordingly, *Cicci* discloses Limitation 1[e], and the combined teachings of *Cicci*, *Coli*, *Liu*, and *Dixon* render Limitation 1[e] obvious.

C. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS APPROXIMATELY 5 INCHES AND THE SECOND DIAMETER IS APPROXIMATELY 6 INCHES.”

201. Claim 2 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above and incorporated herein by reference, the combination of *Cicci*, *Coli*, and *Dixon* would have rendered the additional limitations of Claim 2 obvious.

202. A first diameter (end connecting to the hose) diameter of approximately 5 inches and a second diameter (end for connection to pump) of approximately 6 inches would have been obvious to a POSITA in view of, at least, the teachings of *Cicci*. *Cicci* discloses that each of “the plurality of flexible hoses can have an inner diameter of one inch to eight inches.”²³⁹ Accordingly, *Cicci* discloses a range of

²³⁸ Sections XII.B.2 and XII.B.3.

²³⁹ Ex. 1004 (*Cicci*) 1:64-65, Claim 7; Ex. 1005 (*Cicci Provisional*) [4], Claim 7.

acceptable flexible hose diameters, including 5 inches. It would have been obvious to use a diameter between 1 inches and 8 inches, including 5 inches.

203. *First diameter is approximately 5 inches.* A POSITA would have further found it obvious to modify *Dixon* for the first diameter to be approximately five inches, because it would have been obvious to use a 5” hose in light of *Dixon* and *Cicci*’s disclosures. *Dixon* discloses “Suction Service Fittings” for hydraulic fracturing that have a 5” diameter.²⁴⁰ This is particularly true in light of *Cicci*’s teachings of hoses between 1 and 8 inches in diameter.²⁴¹ It would have been obvious to a POSITA for the end of the fitting that connects to the hose to have a diameter (the first diameter) of approximately five inches, to correspond to a hose diameter of five inches, to which it connects.

204. A POSITA would have been motivated to use a 5-inch hose and a first diameter of approximately 5 inches when calculations regarding flow velocity, which would have been known to a POSITA, indicate that a 5” hose would increase velocity to the point that a bed of slurry would not be deposited in the hose, and thus avoid slurry drop-out, as discussed more fully below regarding Grounds 2 and 3. Additionally, it would have been obvious to a POSITA and a POSITA would have

²⁴⁰ Ex. 1009 (*Dixon-Australia*), pg. 150; Ex. 1012 (*Dixon-U.S.*), pg. 79.

²⁴¹ Ex. 1004 (*Cicci*), 1:64-65, Claim 7; Ex. 1005 (*Cicci Provisional*), [4].

been motivated to use a 5-inch hose and a first diameter of approximately 5 inches when the flow calculations indicate that 5 inches is an approximate hose size which would keep velocity of the fluid in the proper range, as discussed more fully below in Grounds 2 and 3.²⁴²

205. *Second diameter is approximately 6 inches.* It would have been obvious to a POSITA for the second diameter to be approximately 6 inches, as 6 inches was a well-known size for connection to a fracturing pump. For example, the '162 Patent admits that "6" (0.1524 m) components used in fracturing operations, such as but not limited to hammer unions, were "standard" even before the '162 Patent.²⁴³

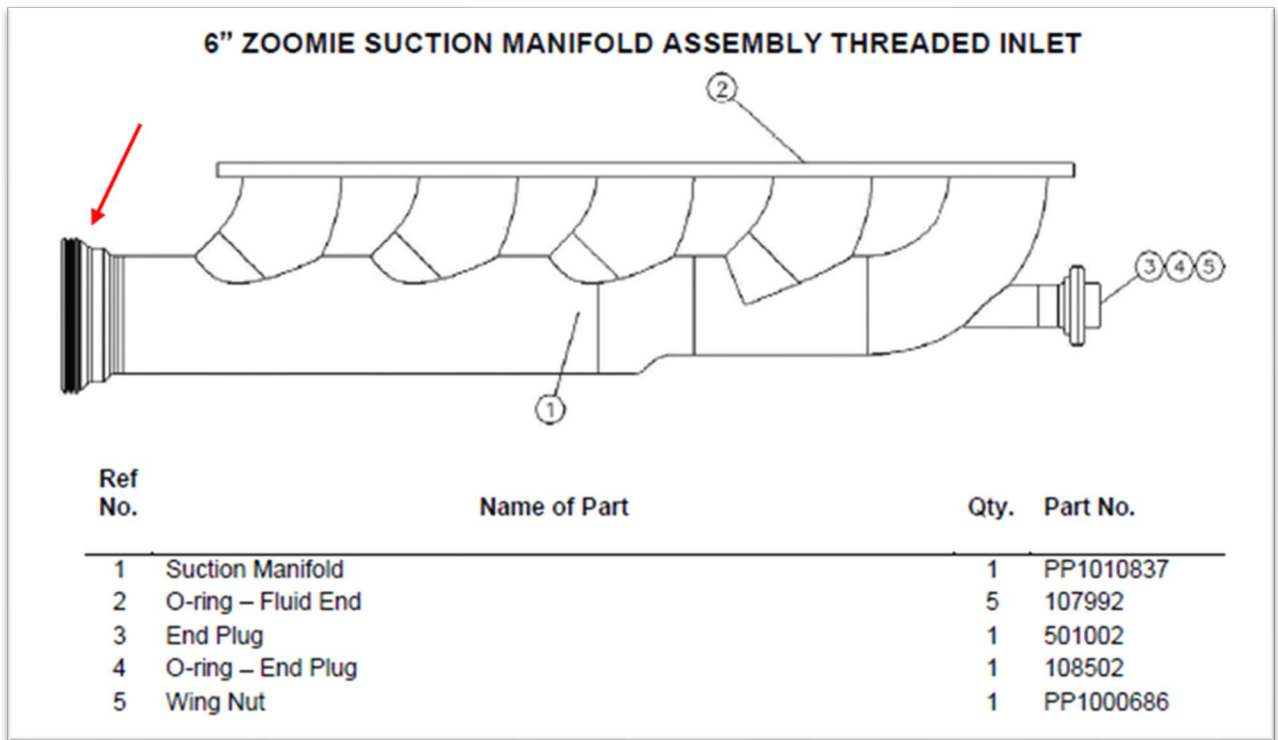
206. As another example, *Coli* discloses a "SWGS-2500 Well Service Pump sold by Gardner Denver, Inc."²⁴⁴ It would have been obvious to a POSITA to select a fitting diameter that is consistent with this disclosure. A POSITA would have understood that this disclosure of *Coli* teaches 6" inlet connections with both threaded (for hammer union) and Victaulic style inlet connections, as discussed below. For example, the "6" Zoomie Suction Manifold Assembly Threaded Inlet" shows an inlet that is recognizable to a POSITA as a hammer union end (red arrow

²⁴² See, e.g., Claims 5–7 below.

²⁴³ Ex. 1001 ('162 Patent), 3:66-4:2.

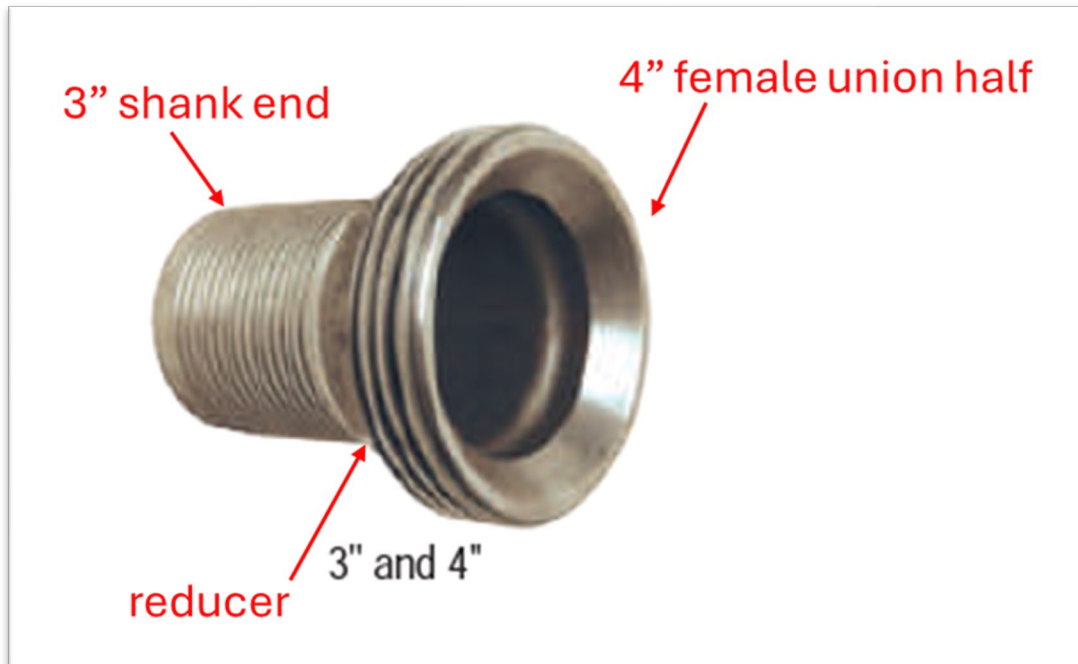
²⁴⁴ Ex. 1006 (*Coli*), [0046].

in the figure below) connected to a suction manifold.²⁴⁵ A POSITA would have understood this to be a 6" threaded inlet.



Ex. 1010 (*Gardner*) pg. 85 of the PDF.

A hammer union end from *Dixon* is shown for comparison.²⁴⁶



Ex. 1009 (*Dixon-Australia*) pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

207. Other connections and sizes include 6" Victaulic, 8" threaded (hammer union) and 8" Victaulic.²⁴⁷ Accordingly, *Gardner-Denver*, which contains information about the GD-2500 pump specifically referenced by *Coli*, discloses a 6" suction end (2nd diameter) for connection to the pump.

208. Moreover, it would have been obvious to use a 6" hammer union to connect to the 6" inlet manifold disclosed by *Coli*, as hammer unions were well known long before the '162 Patent, as discussed above.

²⁴⁸ Ex. 1009 (*Dixon-Australia*), pgs. 7 (referencing "made-to-order hose assemblies"), 99 ("[f]ittings are also available on special order for other sizes of hose OD's"); Ex. 1012 (*Dixon-U.S.*), pgs. 138, 142.

209. Additionally, a POSITA would have understood from the teachings of *Dixon* that combinations of sizes other than those specifically disclosed were available.²⁴⁸

210. Therefore, the combined teachings of *Cicci*, *Coli*, and *Dixon* would have rendered Claim 2 obvious to a POSITA.

D. DEPENDENT CLAIM 3

211. It is my opinion that the combination of *Cicci*, *Coli*, and *Dixon* would have rendered Claim 3 obvious. The combined teachings of *Cicci*, *Coli*, and *Dixon* disclose, or at least suggest, each and every limitation of Claim 3, as discussed in the sections below.

1. 3[a]: “3. The system of claim 1, wherein the fitting further comprises: a union at the second end, the union configured to couple to a mating fitting;”

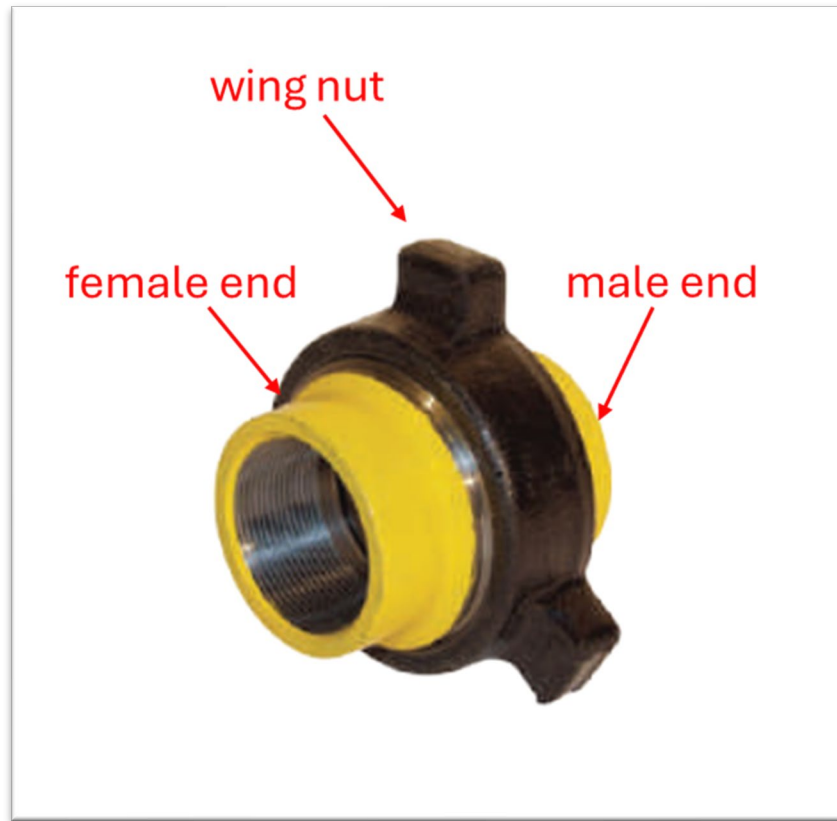
212. As I discussed above concerning limitation 1[d], the combination of *Cicci* and *Dixon* discloses a fitting comprising a union at the second end. For example, *Cicci* discloses “coupling a first end of a first flexible hose to one of the respective pump connections. The flexible hose can be connected to the pump

²⁴⁸ Ex. 1009 (*Dixon-Australia*), pgs. 7 (referencing “made-to-order hose assemblies”), 99 (“[f]ittings are also available on special order for other sizes of hose OD’s”); Ex. 1012 (*Dixon-U.S.*), pgs. 138, 142.

connections by any number of connection methods currently known or developed in the future,[] including threading wings onto a threaded connection, such as a hammer union.”²⁴⁹ The hammer union identified by *Cicci* is described by *Dixon* as a three-piece system for connecting piping, including hoses, to other fluid connections, such as a pump intake, as described by *Cicci*. *Dixon* teaches that hammer unions come in various sizes and pressure ratings (Figure Numbers), including hammer unions specifically designed for fracturing suction operations.²⁵⁰ The figure below, taken from *Dixon*, page 154 and annotated, shows a typical 100 Series (up to 1000 PSI working pressure) hammer union with the three components identified.

²⁴⁹ Ex. 1004 (*Cicci*), 7:40-47; Ex. 1005 (*Cicci Provisional*), [30].

²⁵⁰ Ex. 1009 (*Dixon-Australia*), pgs. 154, 150; Ex. 1012 (*Dixon-U.S.*), pg. 79, 681.



Ex. 1009 (*Dixon-Australia*) pg. 154; Ex. 1012 (*Dixon-U.S.*), pg. 681

213. A POSITA would have understood from the description of *Dixon* that one half of the hammer union (e.g., the female end) would be connected to the pump and the second half (e.g., the male end) would be connected to the hose, or vice versa. Accordingly, the fitting on the hose would comprise a union ($\frac{1}{2}$ of the hammer union), which is configured to couple to a mating fitting (the other $\frac{1}{2}$ of the hammer union). This is shown in the examples of the Frac Fittings from Dixon, including, for example, the HUM206600CS Frac Fitting which comprises one-half (male) of

the hammer union as shown below. This fitting would attach to the hose, while the other half of the union (female) would attach to the pump.



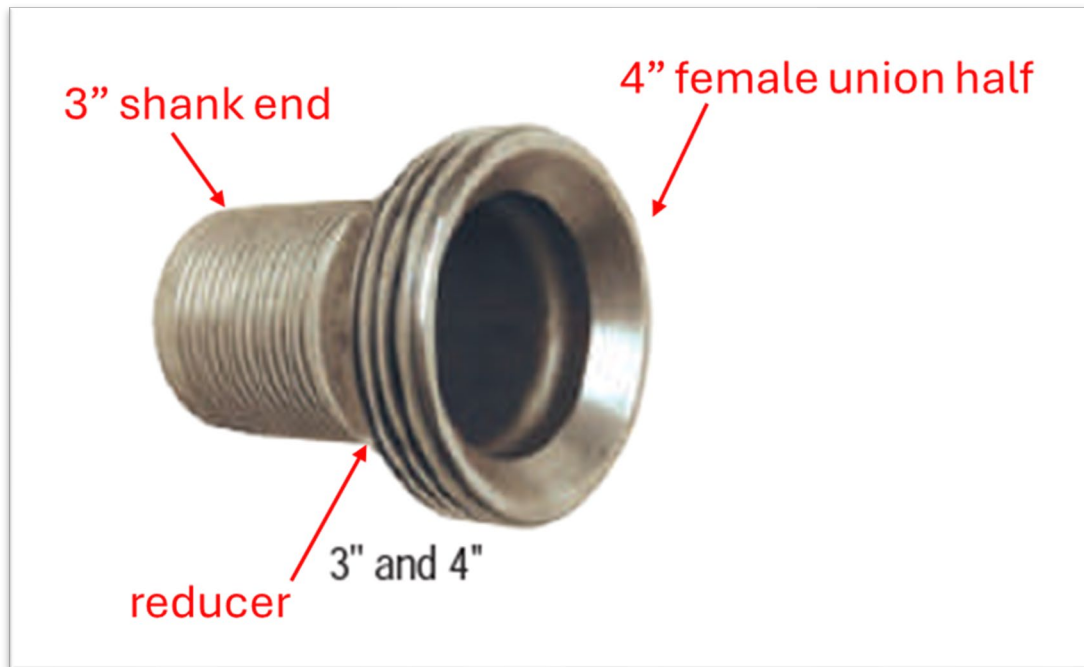
Ex. 1009 (*Dixon-Australia*) pg. 149 (annotated); Ex. 1012 (*Dixon-U.S.*), pg. 79.

A POSITA would have understood that the other half (female half) of the hammer union would have been attached to the pump. Therefore, the combined teachings of *Cicci*, *Coli*, and *Dixon* would have rendered Limitation 3[a] obvious to a POSITA.

2. 3[b]: “a shank end at the first end, the shank end receiving at least a portion of the hose, the shank end being crimped over at least the portion of the hose; and”

214. As I discussed above concerning limitation 1[d], the combination of *Cicci* and *Dixon* discloses a fitting comprising a shank end at the first end, the shank end receiving at least a portion of the hose. For example, *Dixon* discloses a shank

end at the first end. *Dixon* shows an example of a fitting with a 3” shank end and a 4” union end as shown below.²⁵¹



Ex. 1009 (*Dixon-Australia*), pg. 149 excerpted and annotated; Ex. 1012 (*Dixon-U.S.*), pg. 78

215. A POSITA would have recognized the 3” end to be a “shank end”, at least because *Dixon* uses the term “shank” to name that type of hose connection throughout *Dixon*.²⁵² Further, the end of a fitting that inserts into a hose is commonly

²⁵¹ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78 excerpted and annotated.

²⁵² See, e.g., Ex. 1009 (*Dixon-Australia*) pgs. 85, 91–96, 98–100 & Ex. 1012 (*Dixon-U.S.*), pgs. 33-34, 67, 71, 74, 101, 104-106, 109-110 and many others.

referred to as a shank. A POSITA would have understood that this shank end receives at least a portion of the hose.

216. *Dixon* further teaches that the shank is coupled with a ferrule that is crimped over at least the portion of the hose. For example, *Dixon* teaches a feature of its Frac Fittings that they are “[d]urable and safe with reliable hose retention when crimped as specified.”²⁵³ Further, a “400 PSI working pressure with a minimum 4:1 safety factor (hose burst: hose working pressure) is only achieved with Dixon carbon steel ferrule” and then goes on to quote specific part numbers.²⁵⁴ *Dixon* further describes that the ferrules specified are “King Crimp Style Heavy Duty Ferrules” as shown in the figure below.²⁵⁵

²⁵³ Ex. 1009 (*Dixon-Australia*), pg. 149.

²⁵⁴ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

²⁵⁵ Ex. 1009 (*Dixon-Australia*), pg. 151; *see also* Ex. 1009 (*Dixon-Australia*), pgs. 150-151 (showing the crimp ferrules that would be used with the shanks disclosed on pg. 149); Ex. 1012 (*Dixon-U.S.*), pgs. 79, 118.

King Crimp™ Style Heavy Duty Ferrules							
Feature:		400 PSI working pressure with a minimum 4:1 safety factor (hose burst: hose working pressure) is only achieved with heavy duty (HD) crimp ferrules, CF400-6CSHD through CF400-16CSHD.					
Hose ID (Inch)	Hose OD (mm)		Carbon Steel		Ferrule ID (Inch)	Ferrule Wall Thickness (mm)	Ferrule Overall Length (mm)
	From	To	Heavy Duty (HD) Part No.	Price \$			
4	114.70	115.90	CF400-6CSHD	81.80	4.625	3.05	102
	116.30	117.50	CF400-7CSHD	97.11	4.688	3.05	102
	117.90	119.10	CF400-8CSHD	97.11	4.750	3.05	102
	119.45	120.65	CF400-9CSHD	97.11	4.813	3.05	102
	121.00	122.25	CF400-10CSHD	97.11	4.875	3.05	102
	122.60	123.80	CF400-11CSHD	49.29	4.938	3.05	102
	124.20	125.40	CF400-12CSHD	68.10	5.000	3.05	102
	125.80	127.00	CF400-13CSHD	236.67	5.063	3.05	102
	127.40	128.60	CF400-14CSHD	69.21	5.125	3.05	102
	129.00	130.20	CF400-15CSHD	62.49	5.188	3.05	102
	130.60	131.80	CF400-16CSHD	81.80	5.250	3.05	102



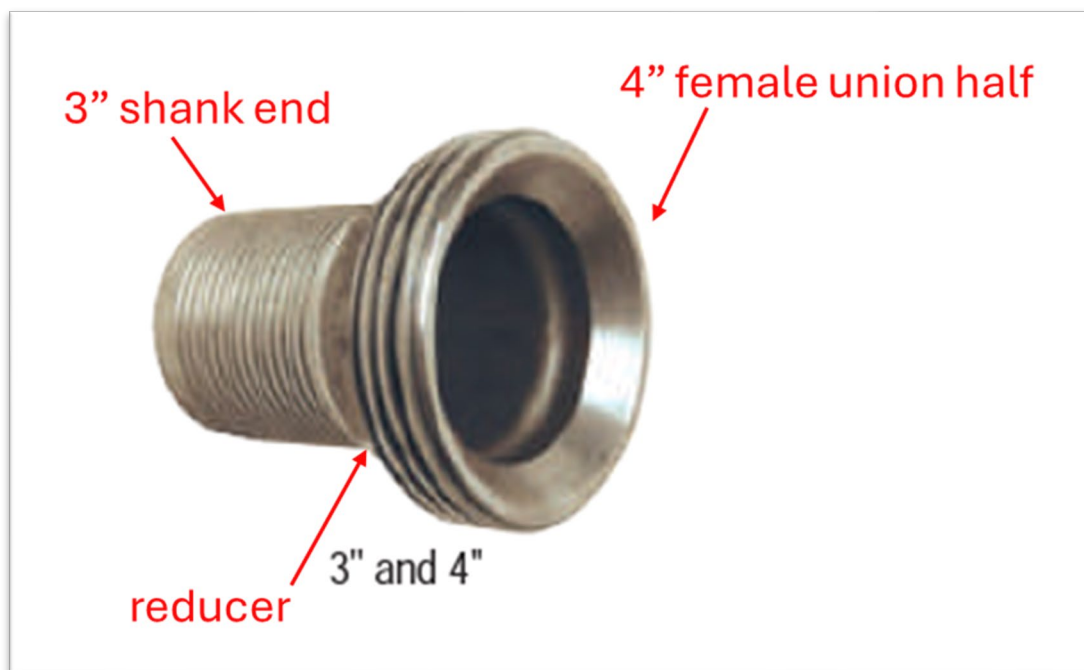
Ex. 1009 (*Dixon-Australia*), pg. 151; Ex. 1012 (*Dixon-U.S.*), pg. 118 excerpted.

217. A POSITA would have recognized, from at least the description in *Dixon*, that the shank end comprises both the shank interior to and a ferrule around (exterior to) a portion of the hose and that the ferrule is then crimped (squeezed or smashed) over the hose in order for the hose to engage the ribs or barbs of the shank. Thus, *Dixon* discloses Limitation 3[b].

218. Accordingly, the combined teachings of *Cicci*, *Coli*, *Liu*, and *Dixon* would have rendered Limitation 3[b] obvious to a POSITA.

3. 3[c]: “a reducer between the union and the shank end, at least a portion of the reducer extending into a groove formed in the union, the union extending farther laterally than the reducer”

219. *Dixon* discloses and renders obvious a reducer between the union and the shank end. *Dixon* shows an example of a fitting with a 3” shank end and a 4” union end as shown below.²⁵⁶



Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78 excerpted and annotated.

²⁵⁶ Ex. 1009 (*Dixon*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78 excerpted and annotated.

As shown by *Dixon*, there is (and would need to be) a reducer in the claimed location to enable the connection of the disparate-sized parts, and to allow for a smooth transition of the fluid flow.

220. *Dixon* further teaches individual components of “weld” hammer unions and reducers.²⁵⁷ A POSITA would have found it obvious to take the teachings of weld unions, as taught on page 150 of *Dixon*, and combine them with the teachings of weld reducers, as taught on page 359 of *Dixon* and weld such fittings together to form a reducing fitting, such as the “frac fittings” disclosed by *Dixon*.²⁵⁸ This would have been combined with the teaching of a hose shank, taught in numerous places in *Dixon*,²⁵⁹ to create a fitting that would enable a smaller hose size required by the flow parameters and calculations discussed below in Section XII.B.D-E.

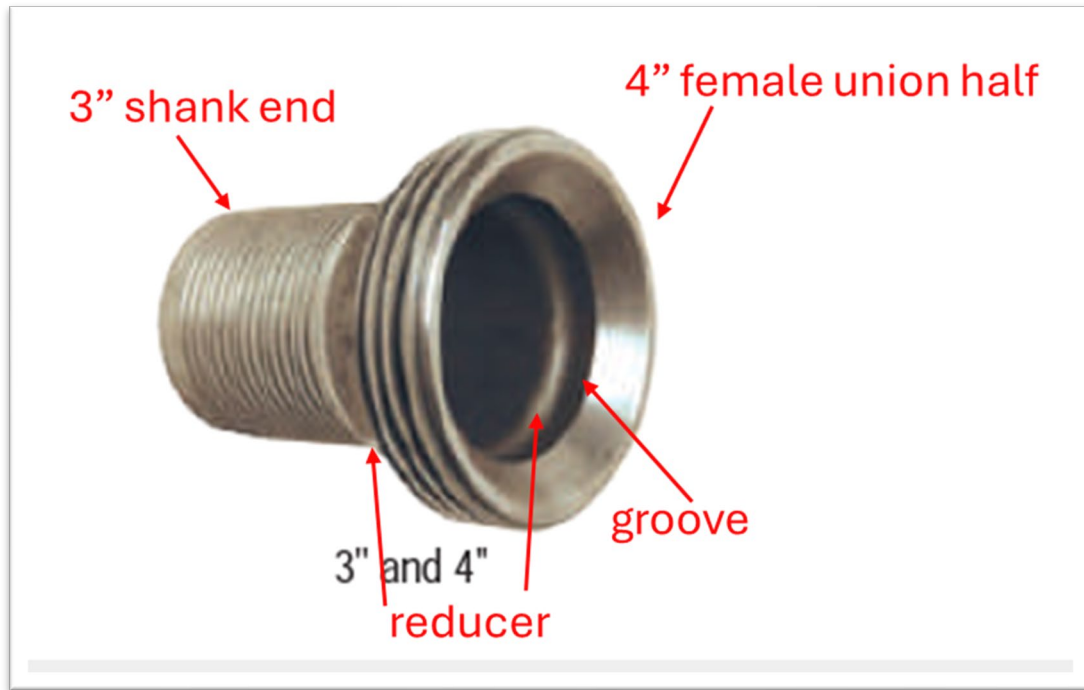
221. *Dixon* discloses a groove formed in the union, where at least a portion of the reducer extends into a groove formed in the union. For example, *Dixon* discloses a 3” shank end fitting with a 4” female union half, as shown below.²⁶⁰

²⁵⁷ Ex. 1009 (*Dixon-Australia*), pg. 150; Ex. 1012 (*Dixon-U.S.*), pg. 79.

²⁵⁸ I am relying on the teachings of *Dixon* that weld hammer unions and weld reducers were known, not specifically on the particular parts sold by *Dixon*.

²⁵⁹ See, e.g., Ex. 1009 (*Dixon-Australia*) pgs. 85, 91–96, 98–100 & Ex. 1012 (*Dixon-U.S.*), pgs. 33-34, 67, 71, 74, 101, 104-106, 109-110 and many others.

²⁶⁰ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78 excerpted and annotated.



Ex. 1009 (*Dixon-Australia*) pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78 excerpted and annotated.

222. The fitting shown features a groove in the hammer union, with at least a portion of the reducer extending into it. The fitting shown also discloses that the union extends farther laterally than the reducer, such as the threaded portion of the union.

223. As another example, *Dixon* further teaches “suction service fittings” that are designed for “socket weld” connections as shown in the figure below.²⁶¹

²⁶¹ Ex. 1009 (*Dixon-Australia*), pg.150; Ex. 1012 (*Dixon-U.S.*), pg. 79 excerpted and annotated.

Figure 206				
Size (Inch)	Figure	Description	Part No.	Price \$
5	50	socket weld x suction male hammer union (includes O-ring, no nut)	HUSM500SW-1	305.45
	50	socket weld x suction female hammer union	HUSF500SW	391.80
	N/A	split nut, suction and discharge, black	HUS500RN	200.54

Price Group: SD
AN08

Ex. 1009 (*Dixon-Australia*), pg. 150 Ex. 1012 (*Dixon-U.S.*), pg. 79 excerpted and annotated.

A POSITA would have recognized “socket weld” to be a weld type where the pipe or other fitting, such as a reducer, is inserted into a recessed area (groove) of another fitting, such as the suction service fittings taught by *Dixon*.²⁶² Accordingly, by combining the teachings of socket weld unions with those of *Dixon* regarding reducers and shanks, it would have been obvious to create a fitting by using a union with a “socket weld” connection, a reducer of the appropriate size, and a hose shank.²⁶³ In such a combination, a portion of the reducer would fit (and thus extend)

²⁶² Ex. 1045 (Socket Weld Fittings Types and Applications – Complete Specification, ASME B16.11-2004 available at: <https://web.archive.org/web/20180210052553/https://www.octalsteel.com/socket-weld-pipe-fittings/>).

²⁶³ Ex. 1009 (*Dixon-Australia*), pgs. 85, 91-95, 98-100, 149-150, 359, 405; Ex. 1012 (*Dixon-U.S.*), pgs. 33-34, 67-, 71, 74, 78-79, 101, 104-106, 109-110, 608, 613, 628.

into a groove formed in the union, and the union would extend farther laterally than the reducer, as a portion of the reducer is actually inside the union.

224. Accordingly, the combined teachings of *Cicci*, *Coli*, *Liu*, and *Dixon* would have rendered Limitation 3[c] obvious to a POSITA.

E. DEPENDENT CLAIM 4: “4. THE SYSTEM OF CLAIM 3, WHEREIN THE FITTING IS FORMED AS AN INTEGRAL PIECE WITH AT LEAST ONE RIGID COUPLING BETWEEN AT LEAST ONE OF THE UNION, THE SHANK END, AND THE REDUCER.”

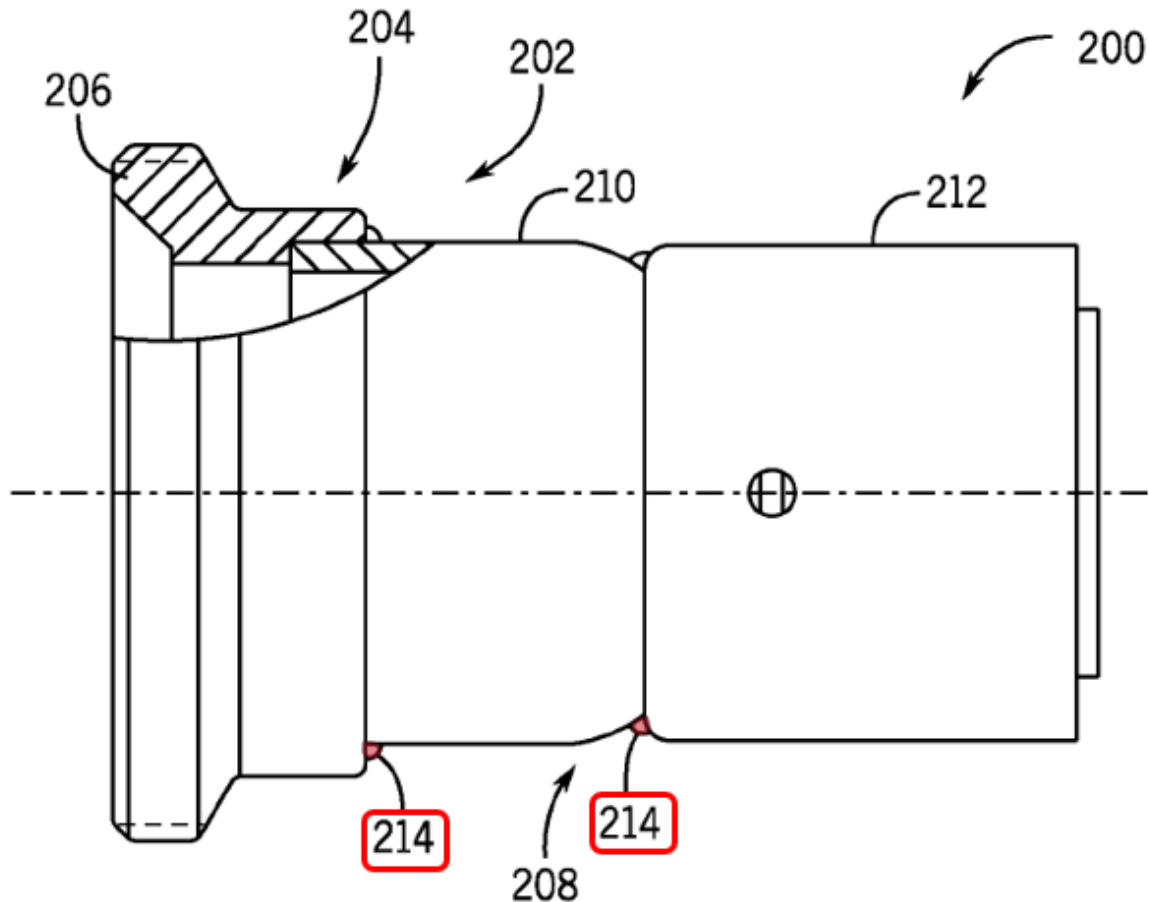
225. Claim 4 depends from Claim 3, which itself depends from Claim 1. In addition to the teachings regarding Claims 1 and 3, as discussed above and incorporated herein by reference, the combination of *Cicci*, *Coli*, and *Dixon* would have rendered the additional limitations of Claim 4 obvious.

226. *Dixon* teaches frac fittings that are formed as an integral piece. A POSITA would have been motivated to have the fittings as an integral piece, as taught by *Dixon*, at least because, as *Dixon* teaches, a “[o]ne-piece design eliminates leak path experienced with two-piece threaded systems.”²⁶⁴ A POSITA would have understood that “[o]ne piece design” refers to fittings that are formed as an integral piece.

²⁶⁴ Ex. 1009 (*Dixon-Australia*), pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.

227. One example of a “rigid coupling” is simply a weld or weld bead. The weld, once cooled, forms a rigid piece of metal that couples the pieces of metal (such as the socket weld union and reducer) together.²⁶⁵ This is consistent with the usage of the term “rigid coupling” in the ’162 Patent, which shows, for example, in the figure below, that “rigid coupling 214” (annotated in red below) is shown as what a POSITA would have easily recognized as a weld bead.

²⁶⁵ See, e.g., Ex. 1046 (Cambridge English Dictionary, definition of “weld,” <https://web.archive.org/web/20170709094317/https://dictionary.cambridge.org/dictionary/english/weld>) (describing a “weld (noun)” as “a joint made by welding” and weld (verb) as “to join two pieces of metal together permanently by melting the parts that touch”).

**FIG. 2**

Ex. 1001 ('162 Patent) Fig. 2 annotated.

228. Accordingly, by disclosing a “socket weld” union, as discussed above regarding limitation 3[c], and incorporated herein by reference, *Dixon* is disclosing the fitting with at least one “rigid coupling” between at least the union and the reducer. At least a “weld bead” as a rigid coupling would have been obvious to a

POSITA based on the teachings of *Dixon* and the general knowledge of a POSITA regarding socket welds and welding in general.

229. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Dixon* and the knowledge of a POSITA regarding socket welds would have rendered Claim 4 obvious to a POSITA.

F. DEPENDENT CLAIM 8

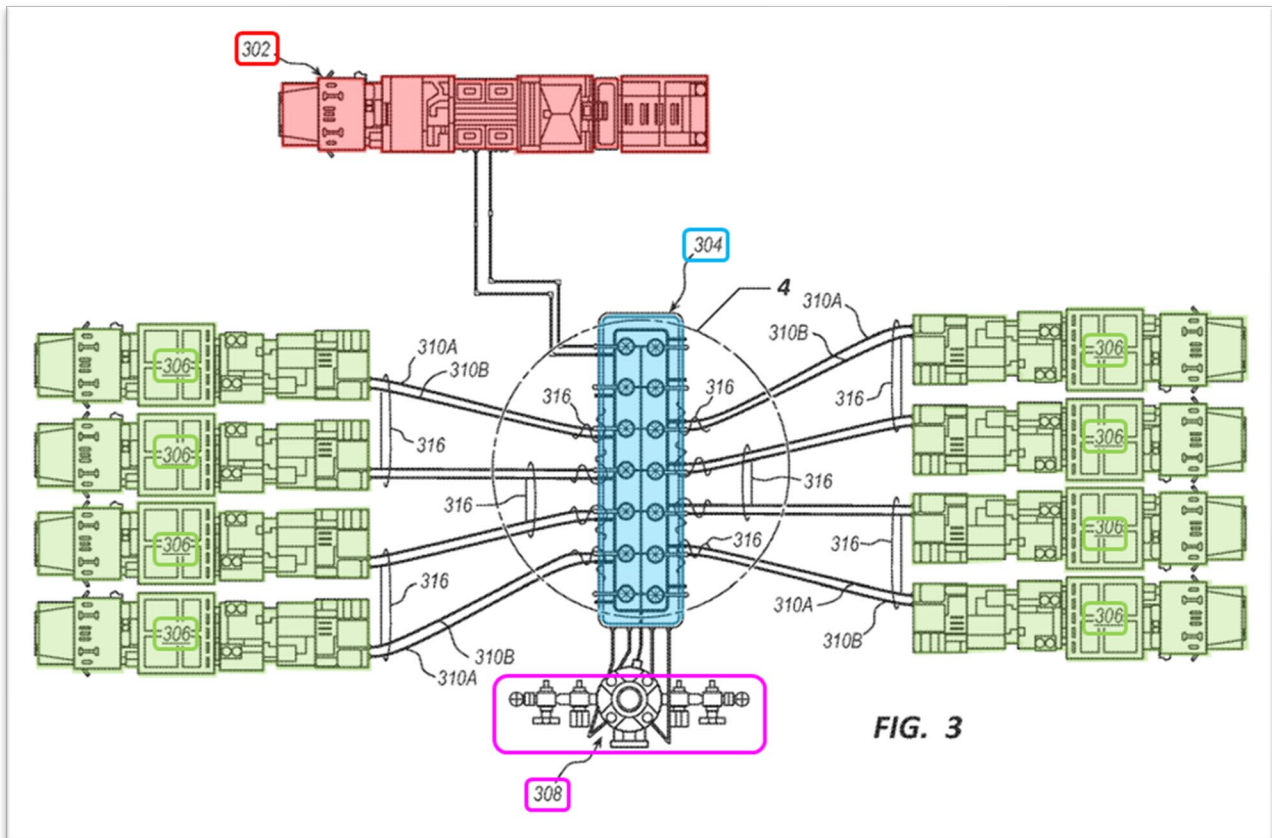
230. It is my opinion that the combination of *Cicci*, *Coli*, and *Dixon* would have rendered Claim 8 obvious. The combined teachings of *Cicci*, *Coli*, and *Dixon* disclose, or at least suggest, each and every limitation of Claim 8, as discussed in the subsections below.

1. 8[a]: “The system of claim 1, further comprising: a plurality of electric powered multi-plunger hydraulic fracturing pumps, each electric powered multi-plunger hydraulic fracturing pump receiving fluid from the fluid source;”

231. Both *Cicci* and *Coli* disclose using a plurality of pumps. For example, *Cicci* shows a system with eight pump trailers 306 (highlighted in green in the figure below) but discloses “one or more pumps 306”²⁶⁶ and “a plurality of pumps”²⁶⁷ disclosing to a POSITA the use of any number of pumps.

²⁶⁶ See, e.g., Ex. 1004 (*Cicci*), 5:17-29; Ex. 1005 (*Cicci Provisional*), [12].

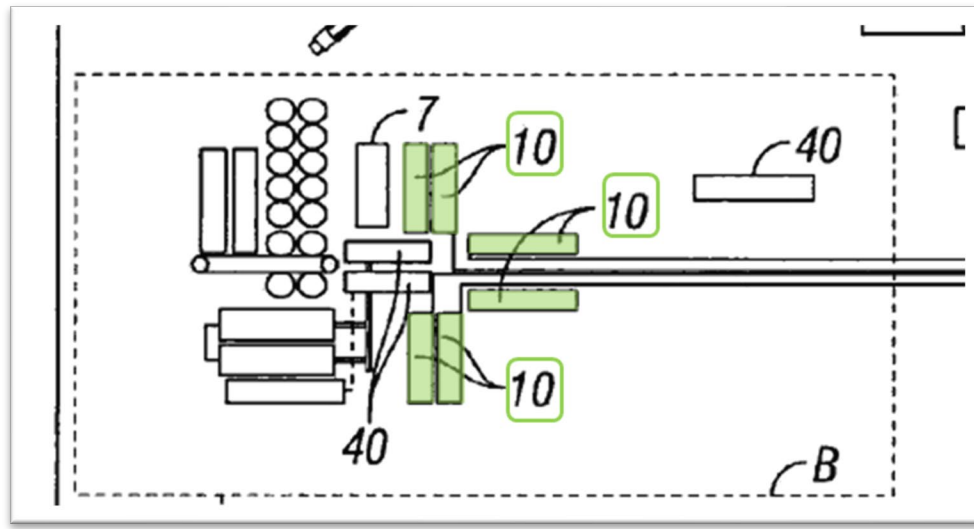
²⁶⁷ Ex. 1004 (*Cicci*), 1:26; Ex. 1005 (*Cicci Provisional*), [2].



Ex. 1004 (*Cicci*), Fig. 3; Ex. 1005 (*Cicci Provisional*), Fig. 3 annotated.

232. *Coli* discloses a different number of pumps. *Coli* teaches the use of six “fracturing trailers 10” (highlighted in green in the figure below).²⁶⁸

²⁶⁸ Ex. 1006 (*Coli*), Fig. 2 excerpted and annotated.

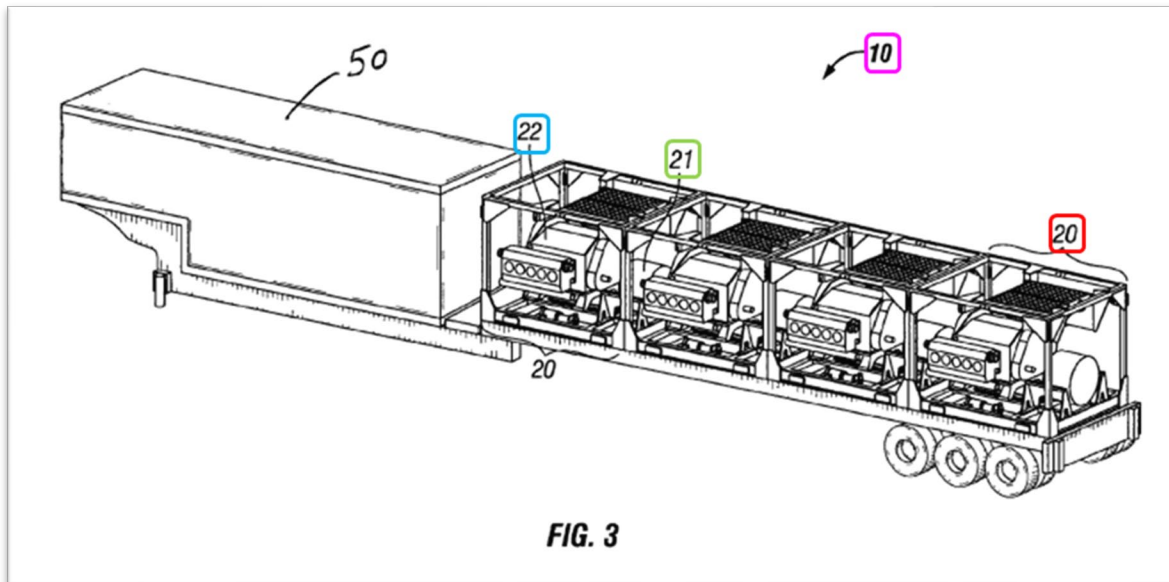


Ex. 1006 (*Coli*), Fig. 2 excerpted and annotated.

233. *Coli* also teaches that each fracturing trailer 10 (annotated in magenta in the figure below) contains as many as four fracturing modules, with each fracturing module 20 (annotated in red) containing a pump 22 (annotated in blue) and a motor 21 (annotated in green).²⁶⁹ *Coli* also discloses “a plurality of electric motors 21 and pumps 22 can be transported on a single trailer 10”,²⁷⁰ as shown in Fig. 3 of *Coli*, annotated below.

²⁶⁹ Ex. 1006 (*Coli*), Fig 3 (annotated). See also Section XIII.B.2 above.

²⁷⁰ Ex. 1006 (*Coli*), [0040].



Ex. 1006 (*Coli*), Fig. 3 annotated.

234. Accordingly, *Coli* at least discloses 24 pumps. *Coli* also discloses “providing one or more electric fracturing modules at the site, each electric fracturing module comprising an electric motor and a coupled fluid pump”²⁷¹ at least suggesting any number of pumps.

235. As discussed above regarding Limitation 1[a], *Coli* discloses the use of “electric powered multi-plunger hydraulic fracturing pumps.”²⁷² And as discussed above regarding Limitation 1[b], the *Cicci-Coli* combination further discloses the

²⁷¹ Ex. 1006 (*Coli*), [0009].

²⁷² See Section XII.B.2 above.

pump receiving fluid from the fluid source from the pump's inlet.²⁷³ *Cicci* further discloses “positioning a plurality of pumps adjacent to a manifold.”²⁷⁴

236. Further, *Cicci* teaches that “[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310.”²⁷⁵ Further still, *Cicci* teaches “[t]he missile 304 delivers the fracturing fluid to the pumps 306 at a relatively low pressure.”²⁷⁶ Accordingly, each electric-powered multi-plunger hydraulic fracturing pump, using the combined teachings of *Cicci* and *Coli*, receives fluid from the fluid source (missile 304).

237. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Dixon* disclose Limitation 8[a].

2. 8[b]: “a plurality of hoses having the first diameter; and”

238. As discussed below regarding Limitation 8[a], *Cicci* discloses that “[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310.”²⁷⁷ Additionally, *Cicci* discloses that “the plurality of flexible hoses can have an inner diameter of one to eight inches.”²⁷⁸ It would have been obvious to a POSITA, and a

²⁷³ See Section XII.B.3 above.

²⁷⁴ Ex. 1004 (*Cicci*), 1:25-26; Ex. 1005 (*Cicci Provisional*), [2].

²⁷⁵ Ex. 1004 (*Cicci*), 5:30-31; Ex. 1005 (*Cicci Provisional*), [24].

²⁷⁶ Ex. 1004 (*Cicci*), 5:19-26; Ex. 1005 (*Cicci Provisional*), [23].

²⁷⁷ Ex. 1004 (*Cicci*), 5:30-31; Ex. 1005 (*Cicci Provisional*), [24].

²⁷⁸ Ex. 1004 (*Cicci*), 1:64-65, Claim 7; Ex. 1005 (*Cicci Provisional*), [4].

POSITA would have been motivated, to size the pumps similarly and operate them in a similar manner, so that the flow conditions in each pump would be comparable.

239. Furthermore, it would have been obvious to a POSITA that each hose would have the same first diameter, allowing the hoses to be interchangeable. And it would have been obvious to a POSITA for that diameter to be the first diameter, as that is the diameter of the end of the fitting connected to the hose.²⁷⁹

240. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Dixon* disclose and render obvious Limitation 8[b].

3. 8[c]: “a plurality of fittings between respective hoses of the plurality of the hoses and respective pumps of the plurality of pumps, each of the pumps having a connection having the second diameter.”

241. *Cicci* discloses that “[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310. For example, each pump 306 can have a set of connections configured to interlock, engage, or otherwise couple to a fitting affixed to each end of the flexible flow line 310. Similarly, the missile or manifold 304 can include a set of connections configured to interlock, engage, or otherwise couple to a fitting affixed to each end of the flexible flow line 310.”²⁸⁰ Accordingly, not only

²⁷⁹ See Sections XII.B.5 and XII.F.2.

²⁸⁰ Ex. 1004 (*Cicci*), 5:30-37; Ex. 1005 (*Cicci Provisional*), [24].

does *Cicci* disclose a plurality of fittings on each hose, but also discloses that each pump would have its own hose, resulting in a plurality of fittings between the respective hoses of the plurality of hoses and respective pumps of the plurality of pumps.

242. It would have been obvious to a POSITA for each of the pumps to have a connection having the second diameter, as that is the diameter of the end of the fitting connected to the pump. A POSITA would have been motivated for each of the pumps (and fittings) to have a connection having the second diameter, so that the hoses and pumps would be interchangeable. Furthermore, as discussed above regarding Claim 2, pump manufacturers offer a limited selection of connection diameters. It would have at least been obvious to a POSITA to use pumps with the same diameter connection of the limited number of connections available.

243. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Dixon* disclose and render obvious Limitation 8[c].

G. INDEPENDENT CLAIM 9

244. It is my opinion that the combination of *Cicci*, *Coli*, and *Dixon* would have rendered Claim 9 obvious. The combined teachings of *Cicci*, *Coli*, and *Dixon* disclose, or at least suggest, each and every limitation of Claim 9, as discussed in the sections below.

1. 9[p]: “11. A hydraulic fracturing system for fracturing a subterranean formation, comprising:

245. The preamble to Claim 9 is identical to that of Claim 1. Accordingly, both *Cicci* and *Coli* disclose the preamble for the same reasons as those discussed in Section XII.B.1 above.

2. 9[a]: “an electric powered multi-plunger hydraulic fracturing pump having an inlet and an outlet, the outlet coupled to a well associated with the subterranean formation and powered by at least one electric motor;”

246. This claim limitation is the same as Limitation 1[a]. Accordingly, *Cicci* and *Coli* disclose Limitation 9[a] and Limitation 9[a] would have been obvious to a POSITA for the same reasons as those discussed in Section XII.B.2 above.

3. 9[b]: “a fluid source, coupled to the inlet of the electric powered pump, the fluid source providing a slurry for injection into the subterranean formation;”

247. This claim limitation is the same as Limitation 1[b]. Accordingly, *Cicci* discloses Limitation 9[b] and Limitation 9[b] would have been obvious to a POSITA for the same reasons as those discussed in Section XII.B.3 above.

4. 9[c]: “a hose extending between the fluid source and the electric powered pump, the hose being flexible and having a first diameter;”

248. This claim limitation is the same as Limitation 1[c]. Accordingly, *Cicci* discloses Limitation 9[c] and Limitation 9[c] would have been obvious to a POSITA for the same reasons as those discussed in Section XII.B.4 above.

5. 9[d]: “a fitting between the hose and the electric powered pump, the fitting comprising;”

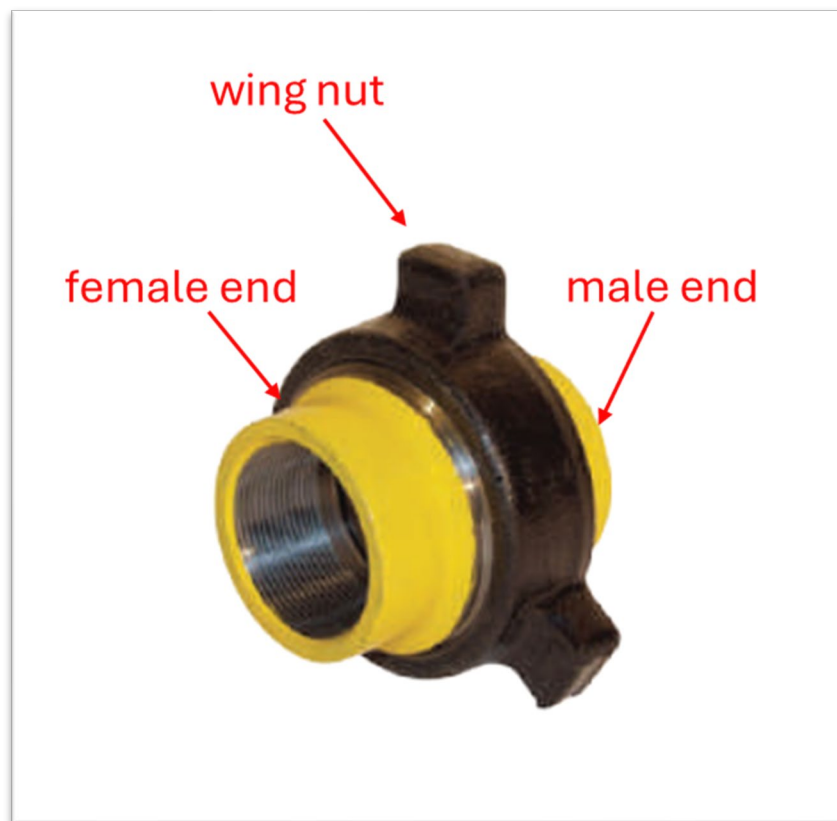
249. This claim limitation is a subset of the limitations in Limitation 1[d]. Accordingly, Limitation 9[d] is disclosed and would have been obvious to a POSITA for the same reasons as those discussed in Section XII.B.5 above.

6. 9[e]: “a union arranged at a first end, the union having a second diameter, larger than the first diameter, and being configured to couple to the pump;”

250. *Cicci* discloses a union arranged at a first end and being configured to couple to the pump. *Cicci* discloses coupling a first end of a first flexible hose to one of the respective pump connections. *Cicci* discloses that “[t]he flexible hose can be connected to the pump connections by any number of connection methods currently known or developed in the future,[] including threading wings onto a threaded connection, such as a hammer union.”²⁸¹ A hammer union, as described by *Dixon*,

²⁸¹ Ex. 1004 (*Cicci*), 7:41-47; Ex. 1005 (*Cicci Provisional*), [30].

is a three-piece system for connecting piping, including hoses, to other fluid connections, such as a pump intake, as described by *Cicci*. *Dixon* teaches that hammer unions come in various sizes and pressure ratings (Figure Numbers), including hammer unions specifically designed for fracturing suction operations.²⁸² The figure below, taken from *Dixon*, page 154 and annotated, shows a typical 100 Series (up to 1000 PSI working pressure) hammer union with the three components identified.



²⁸² Ex. 1009 (*Dixon-Australia*), pgs. 154, 150; Ex. 1012 (*Dixon-U.S.*), pgs. 79, 681.

Ex. 1009 (*Dixon-Australia*) pg. 154; Ex. 1012 (*Dixon-U.S.*), pg. 681

251. A POSITA would have understood from the description of *Dixon* that one half of the hammer union (e.g., the female end, a first end) would be connected to the pump and one half of the hammer union (e.g., the male end) would be connected to the hose. Accordingly, the fitting on the hose would comprise a union ($\frac{1}{2}$ of the hammer union) which is configured to couple to a mating fitting (the other $\frac{1}{2}$ of the hammer union), as further described above in Section XII.B.5 regarding limitation 1[d].

252. The union would have a second diameter larger than the first diameter (hose diameter), as discussed above for Limitation 1[d] (Section XII.B.5). As fracturing pumps have manufacturer-supplied headers with inlet connections of fixed sizes,²⁸³ a POSITA would have recognized that it is easier to combine well-known, commercially available components, as discussed above (Ground 1 Section XII.B.5) and below (Grounds 2 and 4 Sections XIII.B.2 and XV.C) regarding Limitation 1[d], designed for fracturing systems, to allow for a smaller hose size in order to increase velocity and minimize proppant drop out, than to go back to the manufacturer and get custom inlet headers for the fracturing pumps.

²⁸³ For example, the Gardner Denver 2500 referenced by *Coli* has 6" or 8" headers, as described more fully below regarding Claim 2.

253. Therefore, the combined teachings of *Cicci*, *Coli*, and *Dixon* would have rendered Limitation 9[e] obvious to a POSITA.

7. **9[f]: “a shank end configured to receive at least a portion of the hose, the shank end being securable to at least the portion of the hose, the shank end including an opening to receive the shank end; and”**

254. As I discuss above with respect to limitations 1[d] and 3[b], the fitting comprises a shank end configured to receive at least a portion of the hose. My discussion above with respect to limitation 3[b] explains that the shank end comprises a shank that is inserted into the hose and a ferrule that is crimped over the hose to engage the barbs / ridges on the shank end. A POSITA would have understood that crimping the ferrule over at least the portion of the hose renders the shank end “securable to at least the portion of the hose.” *Dixon* thus discloses that the shank end of the fitting is securable to at least the portion of the hose, for example by crimping a ferrule over the hose and securing it to the shank end, for the reasons that I discuss above with respect to limitation 1[d].

255. The combination of the ferrule and the ribs or barbs on the shank makes the shank end securable to the hose, such as when the ferrule is crimped. *Dixon* discloses that its fittings are “[d]urable and safe with reliable hose *retention* when

crimped as specified.”²⁸⁴ A POSITA would have understood from *Dixon*’s disclosure, and from what would have been well-known to a POSITA, that when the shank end ferrule is crimped over at least a portion of the hose, it is securable to at least the portion of the hose.

256. The shank end includes an opening to receive the hose. A POSITA would have recognized, from at least the description in *Dixon*, that the shank end comprises a ferrule around a portion of the hose and that the ferrule is then crimped (squeezed or smashed) over the hose in order for the hose to engage the ribs or barbs of the shank. When the ferrule is fitted around the shank (barb) before insertion of the shank into the hose, the ferrule would comprise an opening to receive the hose. The shank would be inserted into the hose, and the ferrule would surround the hose. This is consistent with the ‘162 Patent, which describes “an end of the hose may be inserted into the shank end 212 and crimped, thereby joining the hose to the fitting 200.”²⁸⁵

257. Therefore, the combined teachings of *Cicci*, *Coli*, and *Dixon* would have rendered Limitation 9[f] obvious to a POSITA.

²⁸⁴ Ex. 1009 (*Dixon-Australia*), pg. 149.

²⁸⁵ Ex. 1001 (‘162 Patent), 5:16-18.

8. 9[g]: “a reducer positioned between the union and the shank end, the reducer being welded to the respective union and shank end at each end, the reducer having an increasing diameter along its axial length, the reducer extending at least partially into the union; and”

258. As I discussed above with respect to limitation 3[c], *Dixon* discloses a reducer positioned between the union and the shank end. And as I discussed above with respect to Claim 4, it would have been obvious to a POSITA to weld the reducer to the union at one end. For the same reasons, it would have been obvious or well-known to a POSITA to weld the reducer to the shank end at the other end. *Dixon* further teaches individual components of “socket weld” hammer unions and reducers. A POSITA would have found it obvious to take *Dixon*’s teachings of socket weld unions, such as taught on page 150 of *Dixon* and combine them with the teachings of weld reducers, such as taught on page 359 of *Dixon* and weld such fittings together to form a reducing fitting, like the “frac fittings” disclosed by *Dixon*.²⁸⁶ This would have been combined with the teaching of a hose shank, taught in numerous places in *Dixon*²⁸⁷ to create a fitting that would have enabled a smaller

²⁸⁶ I am relying on the teachings of *Dixon* that butt weld hammer unions and butt weld reducers were known, not specifically on the particular parts sold by *Dixon*.

²⁸⁷ See, e.g., Ex. 1009 (*Dixon*) pgs. 85, 91–96, 98–100 & Ex. 1012 (*Dixon-U.S.*), pgs. 33-34, 67, 71, 74, 101, 104-106, 109-110 and many others.

hose size required by the flow parameters and calculations discussed below in Sections XIII.D-E.

259. A POSITA would have understood that the integral fittings shown in *Dixon*, for example, would have been either machined as a single part or welded together from various individual components, each of which would have been obvious based on the disclosure of *Dixon*. Accordingly, there was a finite number of ways to construct the “Frac Fittings” disclosed by *Dixon*, and it would have been obvious to a POSITA to at least try to construct the part by welding known parts together.

260. Further, based on the teachings of “socket weld” and “weld” fittings in *Dixon*, it would have been obvious to a POSITA to weld the parts together. In fact, a POSITA would have understood that to create an integral component, such as the “Frac Fittings” taught by *Dixon*, the parts would either be machined as an integral unit or welded together. Thus, welding is one of only a limited number of connection options to create an integral frac fitting and would have been at least obvious to weld the units together.

261. *Dixon* discloses that its reducer has an increasing diameter along its axial length, consistent with the well-known construction of reducers.²⁸⁸

262. *Dixon* also discloses the reducer extending at least partially into the union, for the reasons that I discuss with respect to limitation 3[c].

263. Therefore, the combined teachings of *Cicci*, *Coli*, and *Dixon* would have rendered Limitation 9[g] obvious to a POSITA.

9. 9[h]: “a distribution system, positioned between the wellbore and the electric powered pump, the distribution system collecting the slurry from electric powered pumps for injection into the subterranean formation.”

264. This claim limitation is the same as Limitation 1[e]. Limitation 9[h] is disclosed and would have been obvious to a POSITA for the same reasons as those discussed in Section XII.B.6 above.

H. DEPENDENT CLAIM 10: “10. THE SYSTEM OF CLAIM 9, WHEREIN THE FIRST DIAMETER IS APPROXIMATELY 5 INCHES AND THE SECOND DIAMETER IS APPROXIMATELY 6 INCHES.”

265. The limitations of Claim 10 are the same as those in Claim 2 and would have been obvious to a POSITA for the same reasons as those discussed in Section XII.C above.

²⁸⁸ See, e.g., EX1009 (*Dixon-Australia*), pgs. 359, 360, 460, 469 (each of which shows a reducer with an increasing diameter along its axial length); Ex. 1012 (*Dixon-U.S.*), pgs. 575, 592, 608, 613, 628.

I. DEPENDENT CLAIM 14

14[a]: “14. The system of claim 9, further comprising: a plurality of electric powered multi-plunger hydraulic fracturing pumps, each electric powered multi-plunger hydraulic fracturing pump receiving fluid from the fluid source;”

14[b]: “a plurality of hoses having the first diameter; and”

14[c]: “a plurality of fittings between respective hoses of the plurality of the hoses and respective pumps of the plurality of pumps, each of the pumps having a connection having the second diameter.”

266. The limitations of Claim 14 are the same as those in Claim 8 and would have been obvious to a POSITA for the same reasons as those discussed in Section XII.F above.

XIII. GROUND 2: THE COMBINATION OF CICC, COLI, DIXON, AND LIU RENDERS CLAIMS 1-6, 8-12, AND 14 OBVIOUS.**A. MOTIVATION TO COMBINE**

267. The reasons to combine *Cicci*, *Coli*, and *Dixon* are the same as those described above in Section XII.A, which are incorporated herein by reference. Nothing in *Liu* teaches away from such a combination.

268. A POSITA would have been further motivated to combine the *Cicci-Coli-Dixon* combination with *Liu*. A POSITA would have been further motivated to use *Liu*'s teachings of fluid flow, including fluid flow of a slurry, into the system of

Cicci, Coli, and Dixon. Liu merely compiles established scientific principles into a single reference. *Liu* accordingly is also evidence of knowledge of a POSITA.

269. *Liu* is analogous art to the '162 Patent because it is reasonably pertinent to the problem with which the inventor was involved. The '162 Patent is directed to the problem of fluid flow rates for fracturing operations. For example, the '162 Patent describes “problems with flow rates, as flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site.”²⁸⁹ Similarly, during prosecution of the application that led to the '162 Patent, the applicant distinguished prior art by arguing that it did not “identify the problem associated with efficient fluid flow rates for fracturing operations.”²⁹⁰ *Liu* teaches scientific principles directly applicable to the hydraulic fracturing systems of the '162 Patent and pertinent to the problem of efficient fluid flow rates for fracturing operations to which the inventor was involved.

270. A POSITA would have been motivated to look to *Liu* because *Liu* discloses scientific principles directly applicable to the hydraulic fracturing system of *Cicci/Coli/Dixon. Liu* discloses that these scientific principles are important for “practicing engineers who are confronted with pipeline engineering, construction,

²⁸⁹ Ex. 1001 ('162 Patent), 1:14-45.

²⁹⁰ Ex. 1003 ('162 Patent File History), pg. 433 (Sept. 29, 2020 Response to Nonfinal Rejection, pg. 8)

and/or operations issues in the real world.”²⁹¹ The information in *Liu* addresses piping systems containing “crude oil, natural gas, petroleum products, water, solids and slurries.”²⁹² As discussed above, both *Cicci* and *Coli* discuss using fracturing fluid, which is a slurry of proppant (e.g. sand), water and other chemicals, in a fracturing system.²⁹³ Further, as also discussed above, *Dixon* discloses commercially available products, including hoses and fittings, for use in a “slurry” system, and, in particular, “frac” systems.”²⁹⁴

271. A POSITA further would have been motivated to look to *Liu* because the information in *Liu* is appropriate for analyzing and sizing piping systems (including flexible hoses) for slurries, as disclosed by *Cicci* and *Coli*. *Liu* further teaches that the pipelines addressed are not only the “extensive network of underground pipelines” but also the “in-plant pipelines”²⁹⁵ used in most industrial plants, of which a fracturing site is one. Further, *Liu* teaches that “[t]his book will be useful not only to those employed by pipeline companies, but also to most

²⁹¹ Ex. 1007 (*Liu*), Foreword.

²⁹² Ex. 1007 (*Liu*), Foreword.

²⁹³ See Section XI.B above. Ex. 1004 (*Cicci*), 5:15-20; Ex. 1005 (*Cicci Provisional*), [23]; Ex. 1006 (*Coli*), [0012].

²⁹⁴ Section XII.A; Ex. 1009 (*Dixon-Australia*), pg. 11.

²⁹⁵ Ex. 1007 (*Liu*), Preface.

mechanical, civil, chemical, mining, petroleum, nuclear, and agricultural engineers who must deal with *piping or pipelines* in their professional work.”²⁹⁶

272. *Cicci* and *Liu* further describes that “the term “pipe” and “hose” are used interchangeably.”²⁹⁷ Accordingly, a POSITA would have understood the teachings of *Cicci* and *Liu* regarding pipe sizing to also apply to hose sizing.

273. A POSITA additionally would have been motivated to look to *Liu* because *Liu* describes piping and hoses used to transport slurries at a fracturing site, where the pipes or hoses are horizontal throughout much of their lengths, and thus are “nearly horizontal.” For example, Chapter 5 of *Liu* discusses “Flow of Solid-Liquid Mixture in Pipe (Slurry Pipelines).”²⁹⁸ Further, *Liu* teaches that Chapter 5 “discusses the flow of solid particles transported by a liquid in pipelines, namely, slurry pipelines. For simplicity, the discussion will focus on horizontal or nearly horizontal pipes with particles suspended by the liquid.”²⁹⁹

274. Accordingly, a POSITA would have been motivated to apply the established scientific principles of *Liu* to understand the fluid dynamics of the *Cicci/Coli/Dixon* system and to size equipment within the system. *Liu* specifically

²⁹⁶ Ex. 1007 (*Liu*), Preface.

²⁹⁷ Ex. 1004 (*Cicci*), 4:45-46; Ex. 1005 (*Cicci Provisional*), [19]; Ex. 1007 (*Liu*), pgs. 15, 336.

²⁹⁸ Ex. 1007 (*Liu*), pg. 131.

²⁹⁹ Ex. 1007 (*Liu*), pg. 131.

teaches that the principles in *Liu* are applicable to piping systems, which would include hose systems, at least because *Cicci* teaches the use of piping and hoses interchangeably. Furthermore, *Liu* dedicates an entire chapter to discussing and explaining the scientific principles behind slurry flow, which are applicable to the slurry used in the *Cicci/Coli* system.³⁰⁰

275. Moreover, a POSITA would have been motivated to apply the principles disclosed in *Liu* with the system of *Cicci/Coli/Dixon* in order to gain the benefits of maintaining sufficient fluid velocity and flow, and thus reducing the possibility of slurry drop-out, plugging of the hoses, and damaging cavitation, as taught by *Liu*.³⁰¹ Further, a POISTA would have been motivated to incorporate the teachings of *Liu* in order to calculate pressure drop in the system and ensure enough Net Positive Suction Head (NPSH) in order to prevent cavitation.

276. A POSITA would have had a reasonable expectation of success in combining the teachings of *Liu* with *Cicci/Coli/Dixon*, as *Liu* teaches scientific principles directly applicable to the slurry piping systems of *Cicci/Coli/Dixon*. Applying *Liu* would have involved merely applying a well-known technique (*Liu*'s disclosure of the scientific principles behind fluid flow) to a known system (the

³⁰⁰ See, e.g., Ex. 1007 (*Liu*), Chapter 5, pg. 131.

³⁰¹ Ex. 1007 (*Liu*), pgs. 132-133, 269.

hydraulic fracturing system of *Cicci/Coli/Dixon*), which was ready for improvement to yield predictable results. The predictable results expected would be a hydraulic fracturing system with hoses and piping sized properly in order to reduce the possibility of plugging the hoses, and minimize pressure drop, as discussed more fully below in Sections XIII.B.2, XIII.D, XIII.E, and XIV.F. Further, a POSITA would have expected predictable results in a fracturing system using hoses that are sized appropriately for the fluid flow through them as discussed more fully in Section XIII.D and XIII.E below. Further, a POSITA would have reasonably expected a fracturing system with reduced risk of damage, for example, from cavitation, as discussed in Section X.E, Section XIII.B.2, and Sections XIII.D-III.E below.

B. CLAIM 1

1. 1[p]-1[c] & 1[e]

277. Limitations 1[p] – 1[c] & 1[e] are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon* and *Liu*, for the same reasons as those discussed above regarding Ground 1 in Sections XII.B.1-XII.B.4 & XII.B.6.

2. 1[d]

278. The *Cicci/Coli/Dixon* combination discloses and/or renders obvious element 1[d] for the same reasons as those discussed above regarding Ground 1 in

Section XII.B.5. Further, a POSITA would have found it obvious for the second diameter to be larger than the first diameter, based on the teaching of general fluid dynamics taught by *Liu*. It would have been obvious to a POSITA, and a POSITA would have been motivated, for the second diameter to be larger than the first diameter to maintain a velocity of fluid flow high enough to avoid drop out in light of the disclosure of *Liu*, as detailed below and in my discussion in Claims 5-7.

279. Chapter 5 of *Liu* discusses “Flow of Solid-Liquid Mixture in Pipe (Slurry Pipelines).”³⁰² Further, *Liu* teaches that Chapter 5 “discusses the flow of solid particles transported by a liquid in pipelines, namely, slurry pipelines. For simplicity, the discussion will focus on horizontal or nearly horizontal pipes with particles suspended by the liquid.”³⁰³ Such a description describes piping, and hoses, used to transport slurries at a fracturing site, where the pipes or hoses are horizontal throughout much of their lengths, and thus are “nearly horizontal”.

280. As *Cicci* discloses, “[t]he blender 302 is configured to receive components of a fracturing fluid (e.g., water, sand, chemicals, etc.) and blend the components into a slurry.”³⁰⁴ Frac sand used as a proppant in fracturing operations

³⁰² Ex. 1007 (*Liu*), pg. 131.

³⁰³ Ex. 1007 (*Liu*), pg. 131.

³⁰⁴ Ex. 1004 (*Cicci*), 5:17-20; Ex. 1005 (*Cicci Provisional*), [23].

has a particle size between ~1.2mm (20 mesh) and ~0.13mm (120 mesh). This corresponds to a particle size between 1,200 μm and 130 μm .

281. *Liu* teaches the following:³⁰⁵

When the solid particles [in a slurry] are relatively coarse (say, having diameters greater than 10 μm), the turbulence in the pipe must be sufficiently high in order to be able to suspend the solid particles. Depending on the mean velocity of the flow and the terminal velocity of the solid particles in suspension, the mixture may be in one of the following states or regimes:

Pseudohomogeneous – This occurs when the particle size is relatively small and the velocity of the pipe flow is relatively high, i.e., relatively fine particles in strongly turbulent flow.

Heterogeneous – This occurs when particles are fully suspended but not uniformly distributed – nonhomogeneous. This happens when either the velocity is somewhat smaller or the particle size is somewhat larger than in the previous case.

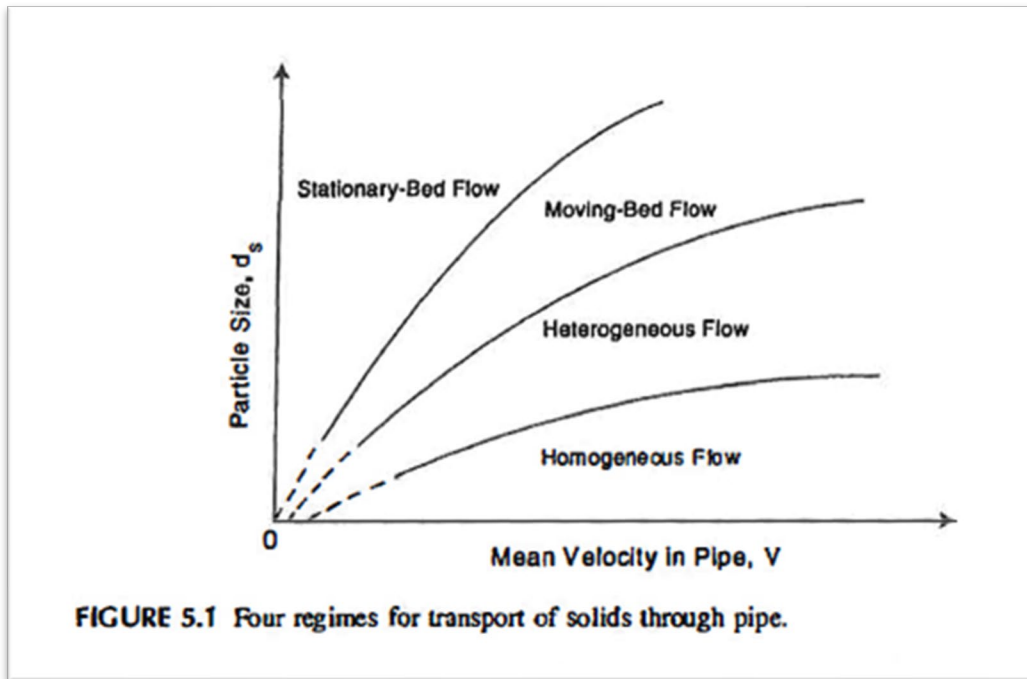
Moving-Bed Flow – Particles settle out of the flow and form a bed. The particles in the bed move in the flow direction by **sliding**, **rolling** or **saltation**. This happens when either the velocity of the flow is less than or the particle size is larger than in the previous case. Saltation refers to the phenomenon that some particles on the surface of the bed layer move intermittently in frog leaps.

Stationary-Bed Flow – Particles settle out on the bed, and they do not move in the bed. This happens with very coarse particles or very low velocity in pipes.

282. *Liu* further describes that “[t]he four states or regimes described above” are illustrated in Figure 5.1.³⁰⁶

³⁰⁵ Ex. 1007 (*Liu*), pg. 132.

³⁰⁶ Ex. 1007 (*Liu*), pg. 133.

Ex. 1007 (*Liu*), Figure 5.1

283. *Liu* then provides various equations and examples for calculating the flow regime that a certain flow arrangement creates. As Figure 5.1 shows, for a given particle size (e.g., the mean particle size in a frac proppant), there is a certain velocity that must be maintained to stay in Homogeneous Flow or Heterogeneous Flow. As velocity drops, the slurry enters Moving-Bed Flow or even Stationary-Bed Flow, which would result in proppant settling at the bottom of the hoses, or even cause a screen-out in a certain section of the hose.³⁰⁷ A reduction in the effective pipe diameter, such as in a Moving-Bed or Stationary-Bed regime would increase the

³⁰⁷ A “screen out” exists when sand (or other proppant) completely plugs the pipe or hose.

pressure drop in the pipe, reduce the suction head (NPSH) at the pump, and reduce the flow through the pipe (all else being equal), which would risk starving the pump of fluid and, at least, damaging cavitation.³⁰⁸ Accordingly, a POSITA would have known and been motivated to avoid flowing-bed or stationary-bed flow regimes when designing a piping system.

284. For example, *Liu* teaches “[c]avitation is a special type of damage caused by liquid flow on solids, including pumps []. It is caused by the low pressure generated by liquids, causing the liquid to vaporize (boil at room temperature). The vaporized liquid forms bubbles [].”³⁰⁹ *Liu* further teaches that when these bubbles collapse, “[t]hese collapsing bubbles can generate localized high pressure fluctuations of the order of 100,000 psi. Any solid that comes into contact with such bursting bubbles can become severely damaged in a relatively short time, on the order of days or weeks.”³¹⁰ *Liu* goes on to teach that pumps damaged by cavitation “not only lose efficiency but also may develop vibration and other problems.”³¹¹ Accordingly, a POSITA would be motivated to avoid cavitation. *Liu* teaches that to avoid cavitation make “sure that the available NPSH [net positive suction head] is

³⁰⁸ See, e.g., Section X.D and XI.C above

³⁰⁹ Ex. 1007 (*Liu*), pg. 269.

³¹⁰ Ex. 1007 (*Liu*), pg. 269.

³¹¹ Ex. 1007 (*Liu*), pg. 269.

at least a few feet greater than the required NPSH.”³¹² NPSH is the total amount of head (i.e., pressure) that is available at the suction of the pump. An increase in pressure drop caused by the reduction in available cross-sectional area of the hoses, such as occurs when proppant beds form, would reduce the NPSH and risk cavitation.

285. Furthermore, *Liu* teaches that the mean velocity of the slurry in the pipe (hose) is a function of the flow rate through the pipe and the pipe diameter (i.e., cross-sectional area). In Eq. (2.6), *Liu* states that velocity (V in m/s) is the ratio of the flow (Q in m³/s) to the cross-sectional area of the pipe (A in m²).³¹³

$$V = \frac{Q}{A}$$

286. Because the cross-sectional area of the pipe is directly related to diameter, rewriting Eq. (2.6) as a function of fluid flow and diameter (D in m) would yield the below.

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

³¹² Ex. 1007 (*Liu*), pg. 269.

³¹³ Ex. 1007 (*Liu*), pg. 21, Eq., (2.6). Eq. 2.6 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only with additional factors added to account for the solids.

287. *Liu* is just one example of the general knowledge of POSITA regarding fluid and slurry flow in piping systems. Accordingly, a POSITA would have known to perform the well-known calculations described in *Liu* and design the piping system to maintain flow in a homogeneous or, at the very least, a heterogeneous flow regime.

288. *Liu* also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. *Liu* teaches using the Darcy-Weisbach formula to calculate the “head loss” (i.e., pressure drop) in a pipe (including hoses), as shown in Equation 2.33, reproduced below.³¹⁴

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

Where:

h_L = head loss (pressure drop)

f = friction factor

L = length of the pipe

D = Diameter of the pipe

³¹⁴ Ex. 1007 (*Liu*), pg. 37, Eq., (2.33). Eq. 2.33 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only that the friction factor will increase due to the presence of solids.

V = velocity of the fluid

g = gravitational acceleration³¹⁵

289. As discussed above, the velocity of the fluid is a function of the diameter of the hose and the flow rate. Therefore, sizing a hose is a standard engineering tradeoff. For a given flow rate, increasing the diameter of the hose reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the risk of cavitation, for example. However, in a slurry flow system, reducing velocity too much leads to proppant drop-out, which reduces the cross-sectional area and increases pressure drop (or screen out), thereby increasing the risk of cavitation. Selecting a particular hose size is simply optimization of a slurry flow system, and would have been known to a POSITA, at least based on the teachings of *Cicci*, *Coli* and *Liu*. A POSITA would have selected a hose diameter that is smaller than the connection to reduce the possibility of low-velocity flow causing the formation of a proppant bed in the hose.

290. As fracturing pumps have manufacturer-supplied headers with inlet connections of fixed sizes,³¹⁶ a POSITA would have recognized that it is easier to combine well-known, commercially available components, designed for fracturing

³¹⁵ See Ex. 1007 (*Liu*) pgs. 35-37, Eq. (2.32) & (2.33).

³¹⁶ For example, the Gardner Denver 2500 referenced by *Coli* has 6" or 8" headers, as described more fully below regarding Claim 2.

systems, to allow for a smaller hose size to increase velocity, than to go back to the manufacturer and get custom inlet headers for the fracturing pumps.

291. Once a POSITA realized, based on the well-known principles taught by *Liu*, that the hose diameter would need to be smaller to reduce the risk of damaging cavitation, fluid starving the pumps or screen-out of the hoses, a POSITA would have looked to commercially available fittings, or the teachings of those fittings, such as contained in *Dixon* to allow the smaller hose to connect to the larger pump coupling.

292. Accordingly, limitation 1[d] would have been obvious to a POSITA based on the combined teachings of *Cicci*, *Coli*, *Dixon* and *Liu*.

C. CLAIM 2

293. The *Cicci/Coli/Dixon* combination renders obvious Claim 2 for the same reasons as those discussed above regarding Ground 1 in Section XII.C. Additionally, it would have been obvious to a POSITA for the first diameter to be approximately 5 inches when the flow calculations disclosed by *Liu*, detailed in my discussion of element 1[d] above (Section XIII.B.2) and Claims 5-7 below (Sections XIII.D-E and XIV.F), indicate that 5 inches is an appropriate size.

D. DEPENDENT CLAIM 5: “5. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS PARTICULARLY SELECTED BASED AT LEAST IN PART ON A THRESHOLD, THE THRESHOLD CORRESPONDING TO A DROP OUT RATE FOR THE SLURRY.”

294. Claim 5 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above in Ground 1 and incorporated herein by reference, the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* would have rendered the additional limitations of Claim 5 obvious.

295. It would have been well-known to a POSITA that the velocity of the pipe is based on both the flow rate of the system and the diameter of the pipe. As *Liu* also teaches maintaining velocity (and flow) in the pipe high enough to prevent the drop-out of solids (i.e., proppant) into a bed, *Liu* makes it obvious to select the pipe based on the flow rate.

296. As further discussed below, it would have been obvious to a POSITA for the first diameter (at the end receiving the hose) to be particularly selected based at least in part on a threshold, the threshold corresponding to a drop-out rate for the slurry, where the diameter is selected to maintain velocity high enough to prevent drop out of the slurry

297. As *Cicci* discloses, “[t]he blender 302 is configured to receive components of a fracturing fluid (e.g., water, sand, chemicals, etc.) and blend the

components into a slurry.”³¹⁷ Frac sand used as a proppant in fracturing operations has a particle size between ~1.2mm (20 mesh) and ~0.13mm (120 mesh). This corresponds to a particle size between 1,200 μm and 130 μm .

298. It would have been obvious to a POSITA, and a POSITA would have been motivated, to select the first diameter to maintain a velocity of the fluid flow high enough to avoid drop out in light of the disclosure of *Liu*.

299. *Liu* discloses selecting the diameter of a slurry piping system (which would have included the diameter of the fitting in the *Cicci-Coli-Dixon* combination), at least to maintain velocity high enough to suspend the slurry in the pipe and prevent “moving bed flow” or “stationary bed flow.”³¹⁸

300. For example, *Liu* teaches the following:³¹⁹

When the solid particles [in a slurry] are relatively coarse (say, having diameters greater than 10 μm), the turbulence in the pipe must be sufficiently high in order to be able to suspend the solid particles. Depending on the mean velocity of the flow and the terminal velocity of the solid particles in suspension, the mixture may be in one of the following states or regimes:

Pseudohomogeneous – This occurs when the particle size is relatively small and the velocity of the pipe flow is relatively high, i.e., relatively fine particles in strongly turbulent flow.

Heterogeneous – This occurs when particles are fully suspended but not uniformly distributed – nonhomogeneous. This happens when either the

³¹⁷ Ex. 1004 (*Cicci*), 5:17-20; Ex. 1005 (*Cicci Provisional*), [23].

³¹⁸ Ex. 1007 (*Liu*), pg. 132.

³¹⁹ Ex. 1007 (*Liu*) pg. 132.

velocity is somewhat smaller or the particle size is somewhat larger than in the previous case.

Moving-Bed Flow – Particles settle out of the flow and form a bed. The particles in the bed move in the flow direction by **sliding**, **rolling** or **saltation**. This happens when either the velocity of the flow is less than or the particle size is larger than in the previous case. Saltation refers to the phenomenon that some particles on the surface of the bed layer move intermittently in frog leaps.

Stationary-Bed Flow – Particles settle out on the bed, and they do not move in the bed. This happens with very coarse particles or very low velocity in pipes.

301. *Liu* discloses, and a POSITA would have understood, “moving-bed flow” and “stationary bed flow” to refer to drop out of the slurry.³²⁰ For example, *Liu* describes “moving-bed flow” as when “particles settle out of the flow and form a bed,” when there is insufficient velocity.³²¹ *Liu* further describes “stationary-bed flow” as when “particles settle out of the bed, and they do not move in the bed,” which also occurs at “very low velocity in pipes.”³²² This is consistent with the ’162 Patent, which describes “drop out” as particulates “drop[ping] out of the flow” when there is insufficient flow rate.³²³

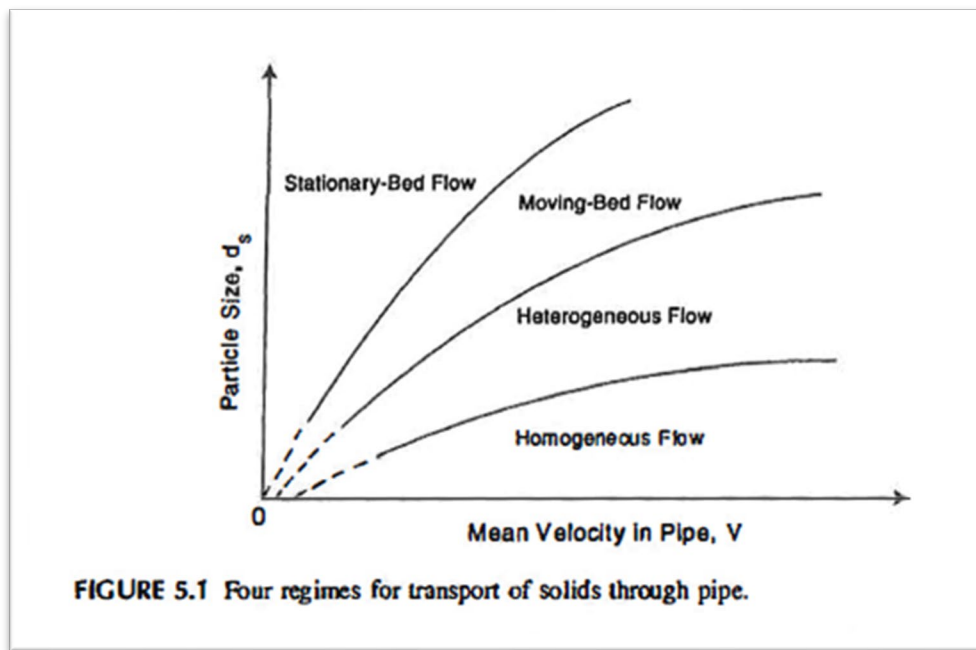
³²⁰ Ex. 1007 (*Liu*) pg. 132.

³²¹ Ex. 1007 (*Liu*) pg. 132.

³²² Ex. 1007 (*Liu*) pg. 132.

³²³ Ex. 1001 (’162 Patent), 1:40-45 (describing “flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site.”), 5:37-46 (discussing “maintaining flow rates above a threshold amount where particulates begin to drop out of the flow”).

302. *Liu* further describes that “[t]he four states or regimes described above are illustrated in Figure 5.1.”³²⁴



Ex. 1007 (*Liu*), pg. 132.

303. *Liu*, in Figure 5.1, shows a “drop out rate” or a velocity (tied directly to a flow rate through Eq. 2.6) at which drop out of the slurry in the piping system is avoided.³²⁵

304. *Liu* then provides various equations and examples for calculating the flow regime that a certain flow arrangement creates. As Figure 5.1 shows, for a given particle size (e.g. mean particle size in a frac proppant), there is a certain velocity

³²⁴ Ex. 1007 (*Liu*), pg. 133.

³²⁵ Ex. 1007 (*Liu*), pg. 133, Fig. 5.1.

that must be maintained in order to stay in Homogeneous Flow or Heterogenous Flow. As velocity drops, the slurry may enter Moving-Bed Flow or even Stationary-Bed Flow, which would result in proppant settling at the bottom of the hoses of *Cicci* or, in extreme cases, even cause a screen-out in a certain section of the pipe. A reduction in the effective pipe diameter, such as in a Moving-Bed or Stationary-Bed regime would increase the pressure drop in the pipe, reduce the suction head (NPSH) at the pump, and reduce the flow through the pipe (all else being equal), which would risk starving the pump of fluid and, at least, damaging cavitation.³²⁶ Accordingly, a POSITA would have known to avoid flowing-bed or stationary-bed flow regimes when designing a piping system.

305. A POSITA would have been motivated to avoid either a moving bed or a stationary flow regime to avoid the negative consequences of these flow regimes, including increased pressure drop, reduced flow, and cavitation.³²⁷ As velocity drops, the slurry enters Moving-Bed Flow or even Stationary-Bed Flow, which would result in proppant settling at the bottom of the hoses, or even cause a screen-out in a certain section of the hose.³²⁸ A reduction in diameter, such as in a Moving-Bed or Stationary-Bed regime, would increase the pressure drop in the pipe, reduce

³²⁶ See, e.g., Section X.D and Section XI.C above.

³²⁷ Ex. 1007 (*Liu*), pgs. 133, 269.

³²⁸ Ex. 1007 (*Liu*), pgs. 133, 269.

the suction head (NPSH) at the pump, and reduce the flow through the pipe (all else being equal), which would risk starving the pump of fluid and, at least, damaging cavitation.³²⁹

306. For example, *Liu* teaches “[c]avitation is a special type of damage caused by liquid flow on solids, including pumps []. It is caused by the low pressure generated by liquids, causing the liquid to vaporize (boil at room temperature). The vaporized liquid forms bubbles.”³³⁰ *Liu* further teaches that when these bubbles collapse, “these collapsing bubbles can generate localized high-pressure fluctuations of the order of 100,000 psi. Any solid that comes into contact with such bursting bubbles can become severely damaged in a relatively short time, on the order of days or weeks.”³³¹ *Liu* goes on to teach that pumps damaged by cavitation “not only lose efficiency but also may develop vibration and other problems.”³³² Accordingly, a POSITA would be motivated to avoid cavitation. *Liu* teaches that to avoid cavitation make “sure that the available NPSH [net positive suction head] is at least a few feet greater than the required NPSH.”³³³ NPSH is the total amount of head (i.e., pressure) that is available at the suction of the pump. An increase in pressure drop caused by

³²⁹ Ex. 1007 (*Liu*), pg. 269.

³³⁰ Ex. 1007 (*Liu*), pg. 269.

³³¹ Ex. 1007 (*Liu*), pg. 269.

³³² Ex. 1007 (*Liu*), pg. 269.

³³³ Ex. 1007 (*Liu*), pg. 269.

the reduction in available cross-sectional area of the hoses, such as occurs when proppant beds form, would reduce the NPSH and risk cavitation.

307. Accordingly, a POSITA would have known and been motivated to avoid flowing-bed or stationary-bed flow regimes when designing a piping system, and when selecting the diameters of the hose and fitting, and would have selected a hose diameter that keeps velocity high enough to avoid these flow regimes.

308. A POSITA would have understood that the first diameter affects the velocity of the fluid flow, and accordingly the drop-out threshold, based on the disclosure of *Liu*. *Liu* provides various equations and examples for calculating the flow regime that a certain flow arrangement creates. As Figure 5.1 shows, for a given particle size, there is a certain velocity that must be maintained to stay in Homogeneous Flow or Heterogeneous Flow.³³⁴

309. Furthermore, *Liu* teaches that the mean velocity of the slurry in the pipe (hose) is a function of the flow rate through the pipe and the pipe diameter (i.e., cross-sectional area). In Eq. (2.6), *Liu* teaches that velocity (V in m/s) is the ratio of the flow (Q in m³/s) and the cross-sectional area of the pipe (A in m²).³³⁵

³³⁴ Ex. 1007 (*Liu*), pg. 133.

³³⁵ Ex. 1007 (*Liu*), pg. 21, Eq. (2.6). Eq. 2.6 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only with additional factors added to account for the solids.

$$V = \frac{Q}{A}$$

310. Because the cross-sectional area of the pipe is directly related to diameter, rewriting Eq. (2.6) as a function of fluid flow and diameter (D in m) yields the below.

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

311. *Liu* is just one example of the scientific principles known to a POSITA regarding fluid and slurry flow in piping systems. Accordingly, a POSITA would have known to perform the well-known calculations described in *Liu* and design the piping system to maintain flow in a homogeneous or, at the very least, a heterogeneous flow regime.

312. *Liu* also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. *Liu* teaches using the Darcy-Weisbach formula to calculate “head loss” (i.e., pressure drop) in a pipe (including hoses), as shown in Equation 2.33, reproduced below.³³⁶

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

³³⁶ Ex. 1007 (*Liu*), pg. 37, Eq. (2.33). Eq. 2.33 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only that the friction factor will increase due to the presence of solids.

Where:

h_L = head loss (pressure drop)

f = friction factor

L = length of the pipe

D = Diameter of the pipe

V = velocity of the fluid

g = gravitational acceleration³³⁷

313. As discussed above, the velocity of the fluid is a function of the diameter of the hose and the flow rate. A smaller diameter hose, then, would increase velocity and increase pressure drop. A larger diameter hose would reduce velocity, which, if reduced too far, would result in proppant dropping out (settling out) of the slurry, leading to a further reduced diameter and, in some cases, plugging of the line. A reduction in diameter, such as from forming a bed of proppant in the hose, would also increase the pressure drop by reducing the effective diameter of the hose, increasing the risk of cavitation.

314. Pressure drop considerations, then, would place a lower limit on the first diameter while slurry drop out considerations would place an upper limit on the first diameter.

³³⁷ See Ex. 1007 (*Liu*), pgs. 26-29.

315. Therefore, sizing a hose is a standard engineering tradeoff. For a given flow rate, increasing the diameter of the hose reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the risk of cavitation, for example. However, in a slurry flow system, reducing velocity too much leads to proppant drop-out, which reduces the cross-sectional area and increases pressure drop, thereby increasing the risk of cavitation. Selecting a particular hose size is simply optimization of a slurry flow system, and would have been known to a POSITA, at least based on the teachings of *Cicci*, *Coli* and *Liu*. Accordingly, it would have been obvious to have a first diameter (the diameter of the end of the fitting connected to the hose) particularly selected based at least in part on a threshold, the threshold corresponding to a drop out rate for the slurry. The threshold being the velocity at which proppant starts to drop out of the slurry and form a bed in the hose.

316. Accordingly, the combined teachings of *Cicci*, *Coli*, *Liu* and *Dixon* would have rendered Claim 5 obvious to a POSITA.

E. DEPENDENT CLAIM 6: “6. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS PARTICULARLY SELECTED BASED AT LEAST IN PART ON A PRESSURE DROP RATE, A DAMAGE ACCUMULATION RATE, OR A SUGGESTED FLOW RATE.”

317. Claim 6 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above and incorporated herein by reference, the combination

of *Cicci*, *Coli*, *Liu*, and *Dixon* would have rendered the additional limitations of Claim 6 obvious.

318. As I discuss above with respect to Claim 5, *Liu* teaches particularly selecting the first diameter to maintain the desired flow rate or velocity of the system and avoid increased pressure drop, reduced flow, and cavitation.

319. As discussed above regarding Claim 5, and incorporated herein by reference, the velocity of the pipe is based on both the flow rate of the system and the diameter of the pipe. As *Liu* also teaches maintaining velocity (and flow) in the pipe high enough to prevent the drop-out of solids (i.e., proppant) into a bed, *Liu* makes it obvious to select the pipe based on the suggested (e.g., desired) flow rate.

320. *Liu* further teaches that pressure drop is a function of the hose diameter, and accordingly the first diameter (the end of the fitting receiving the hose). *Liu* also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. *Liu* teaches using the Darcy-Weisbach formula to calculate “head loss” (i.e. pressure drop) in a pipe (including hoses), shown in equation 2.33 which has been duplicated below.³³⁸

³³⁸ Ex. 1007 (*Liu*), pg. 37, Eq., (2.33). Eq. 2.33 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only that the friction factor will increase due to the presence of solids.

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

Where:

h_L = head loss (pressure drop)

f = friction factor

L = length of the pipe

D = Diameter of the pipe

V = velocity of the fluid

g = gravitational acceleration³³⁹

321. Recall, as discussed above, that the velocity of the fluid is a function of the diameter of the hose and the flow rate. Therefore, sizing a hose is a standard engineering tradeoff. For a given flow rate, increasing the diameter of the hose reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the risk of cavitation, for example. However, in a slurry flow system, reducing velocity too much leads to proppant drop-out, which reduces the cross-sectional area and increases pressure drop, thereby increasing the risk of cavitation. Selecting a particular hose size is simply optimization of a slurry flow system, and

³³⁹ See Ex. 1007 (*Liu*), pgs. 26-29.

would have been known to a POSITA, at least based on the teachings of *Cicci*, *Coli* and *Liu*.

322. In addition to pressure drop considerations, *Liu* also teaches an additional upper limit on slurry velocity, and the associated lower limit on the first diameter. *Liu* teaches that “[t]he solid particles in a slurry pipeline may cause wear (abrasion) to the pipe and to special equipment such as pumps, valves, and bends. Wear is especially serious *when the velocity is high*, the slurry is coarse, and the solid particles are dense and possess sharp edges.”³⁴⁰ A POSITA reading *Liu* would have understood that wear (abrasion, sometimes referred to as erosion) considerations would impact the selection of a first diameter, as a smaller pipe would increase velocity, and, for a slurry such as is used in hydraulic fracturing, increase wear. As velocity increases, wear or abrasion of the pipe increases. What *Liu* refers to as “wear” or abrasion would have been easily understood by a POSITA to be a damage accumulation rate as the term is used in the ’162 Patent.³⁴¹

323. Therefore, it would have been obvious to a PSOITA, based on the teachings of *Liu* that the first diameter would have been selected based at least on a pressure drop rate, a damage accumulation rate (e.g., wear), and/or a suggested flow

³⁴⁰ Ex. 1007 (*Liu*), pg. 143, emphasis added.

³⁴¹ See, e.g., Ex. 1001 (’162 Patent), 6:18-27.

rate. It would have been further obvious that both pressure drop and wear (abrasion) are based on the suggested flow rate.

324. Accordingly, the combined teachings of *Cicci*, *Coli*, and *Liu* would have rendered Claim 6 obvious to a POSITA.

F. CLAIM 8

1. 8[a], 8[c]

325. Elements 8[a] and 8[c] of Claim 8 are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Elements 8[a] and 8[c] in Ground 1, above.

2. 8[b]

326. Element 8[b] of Claim 8 is disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Element 8[b] in Ground 1, above. Additionally, for the same reasons discussed above regarding Claims 5 – 7 and Limitation 1[d], it would have been obvious to a POSITA based on the disclosure of *Liu* to size each of the hoses with the same diameter based on the flow conditions at the pumps.

G. CLAIM 9**1. 9[p]-[d], 9[f]-[h]**

327. Elements 9[p]-[d] and 9[f]-h] are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Elements 9[p]-[d] and 9[f]-[h], respectively, in Ground 1, above.

2. 9[e]

328. Element 9[e] of Claim 9 is rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Element 9[e] in Ground 1, above. Additionally, a POSITA would have found it obvious to use a union with a diameter larger than that of the hose, based on the teaching of general fluid dynamics taught by *Liu*. In particular, *Liu* teaches fluid dynamics concepts important “for practicing engineers who are confronted with pipeline engineering, construction, and/or operations issues in the real world.”³⁴² The information in *Liu* addresses piping systems containing “crude oil, natural gas, petroleum products, water, solids and slurries.”³⁴³ *Liu* teaches that these pipelines are not only the “extensive network of underground pipelines” but also the “in-plant

³⁴² Ex. 1007 (*Liu*), Foreword.

³⁴³ Ex. 1007 (*Liu*), Foreword.

pipelines”³⁴⁴ used in most industrial plants, of which a fracturing site is one. Further, *Liu* teaches that “[t]his book will be useful not only to those employed by pipeline companies, but also to most mechanical, civil, chemical, mining, petroleum, nuclear, and agricultural engineers who must deal with *piping or pipelines* in their professional work.”³⁴⁵

329. Accordingly, the information is appropriate for analyzing and sizing piping systems (including flexible hoses) for slurries, as disclosed by *Cicci* and *Coli*. *Cicci* further describes that “the term “pipe” and “hose” are used interchangeably.”³⁴⁶ Accordingly, a POSITA would understand the teachings of *Cicci* and *Liu* regarding pipe sizing to also apply to hose sizing.

330. Chapter 5 of *Liu* discusses “Flow of Solid-Liquid Mixture in Pipe (Slurry Pipelines).”³⁴⁷ Further, *Liu* teaches that Chapter 5 “discusses the flow of solid particles transported by a liquid in pipelines, namely, slurry pipelines. For simplicity, the discussion will focus on horizontal or nearly horizontal pipes with particles suspended by the liquid.”³⁴⁸ Such a description describes piping and hoses used to

³⁴⁴ Ex. 1007 (*Liu*), Preface.

³⁴⁵ Ex. 1007 (*Liu*), Preface.

³⁴⁶ Ex. 1004 (*Cicci*), 4:45-46; Ex. 1005 (*Cicci Provisional*), [19].

³⁴⁷ Ex. 1007 (*Liu*), pg. 131.

³⁴⁸ Ex. 1007 (*Liu*), pg. 131.

transport slurries at a fracturing site, where the pipes or hoses are horizontal throughout much of their lengths, and thus are “nearly horizontal”.

331. As *Cicci* discloses, “[t]he blender 302 is configured to receive components of a fracturing fluid (e.g., water, sand, chemicals, etc.) and blend the components into a slurry.”³⁴⁹ Frac sand used as a proppant in fracturing operations has a particle size between ~1.2mm (20 mesh) and ~0.13mm (120 mesh). This corresponds to a particle size between 1,200 μm and 130 μm .

332. *Liu* teaches the following:³⁵⁰

When the solid particles [in a slurry] are relatively coarse (say, having diameters greater than 10 μm), the turbulence in the pipe must be sufficiently high in order to be able to suspend the solid particles. Depending on the mean velocity of the flow and the terminal velocity of the solid particles in suspension, the mixture may be in one of the following states or regimes:

Pseudohomogeneous – This occurs when the particle size is relatively small and the velocity of the pipe flow is relatively high, i.e., relatively fine particles in strongly turbulent flow.

Heterogeneous – This occurs when particles are fully suspended but not uniformly distributed – nonhomogeneous. This happens when either the velocity is somewhat smaller or the particle size is somewhat larger than in the previous case.

Moving-Bed Flow – Particles settle out of the flow and form a bed. The particles in the bed move in the flow direction by **sliding**, **rolling** or **saltation**. This happens when either the velocity of the flow is less than or the particle size is larger than in the previous case. Saltation refers to the phenomenon that some particles on the surface of the bed layer move intermittently in frog leaps.

³⁴⁹ Ex. 1004 (*Cicci*). 5:17-20; Ex. 1005 (*Cicci Provisional*). [23].

³⁵⁰ Ex. 1007 (*Liu*) pg. 132.

Stationary-Bed Flow – Particles settle out on the bed, and they do not move in the bed. This happens with very coarse particles or very low velocity in pipes.

333. *Liu* further describes that “[t]he four states or regimes described above are illustrated in Figure 5.1.”³⁵¹

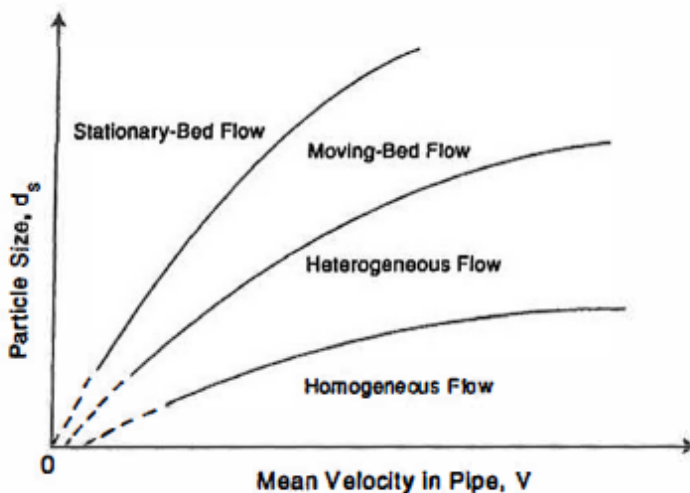


FIGURE 5.1 Four regimes for transport of solids through pipe.

334.

Ex. 1007 (*Liu*) pg. 132

335. *Liu* then provides various equations and examples for calculating the flow regime that a certain flow arrangement creates. As Figure 5.1 shows, for a given particle size (e.g., mean particle size in a frac proppant), there is a certain velocity that must be maintained in order to stay in Homogeneous Flow or Heterogeneous Flow. As velocity drops, the slurry enters Moving-Bed Flow or even Stationary-Bed Flow, which would result in proppant settling at the bottom of the hoses of *Cicci* or

³⁵¹ Ex. 1007 (*Liu*). pg. 133.

even cause a screen-out in a certain section of the pipe. A reduction in the effective pipe diameter, such as in a Moving-Bed or Stationary-Bed regime, would increase the pressure drop in the pipe, reduce the suction head (NPSH) at the pump, and reduce the flow through the pipe (all else being equal), which would lead to risk starving the pump of fluid and, at least, damaging cavitation.³⁵² Accordingly, a POSITA would have known to avoid flowing-bed or stationary-bed flow regimes when designing a piping system.

336. For example, *Liu* teaches “[c]avitation is a special type of damage caused by liquid flow on solids, including pumps []. It is caused by the low pressure generated by liquids, causing the liquid to vaporize (boil at room temperature). The vaporized liquid forms bubbles.”³⁵³ *Liu* further teaches that when these bubbles collapse, “these collapsing bubbles can generate localized high-pressure fluctuations of the order of 100,000 psi. Any solid that comes into contact with such bursting bubbles can become severely damaged in a relatively short time, on the order of days or weeks.”³⁵⁴ *Liu* goes on to teach that pumps damaged by cavitation “not only lose efficiency but also may develop vibration and other problems.”³⁵⁵ Accordingly, a

³⁵² See, e.g., Section X.E and Section XI.C above.

³⁵³ Ex. 1007 (*Liu*), pg. 269.

³⁵⁴ Ex. 1007 (*Liu*), pg. 269.

³⁵⁵ Ex. 1007 (*Liu*), pg. 269.

POSITA would be motivated to avoid cavitation. *Liu* teaches that to avoid cavitation make “sure that the available NPSH [net positive suction head] is at least a few feet greater than the required NPSH.”³⁵⁶ NPSH is the total amount of head (i.e., pressure) that is available at the suction of the pump. An increase in pressure drop caused by the reduction in available cross-sectional area of the hoses, such as occurs when proppant beds form, would reduce the NPSH and risk cavitation.

337. Furthermore, *Liu* teaches that the mean velocity of the slurry in the pipe (hose) is a function of the flow rate through the pipe and the pipe diameter (i.e., cross-sectional area). In Eq. (2.6), *Liu* teaches that velocity (V in m/s) is the ratio of the flow (Q in m³/s) and the cross-sectional area of the pipe (A in m²).³⁵⁷

$$V = \frac{Q}{A}$$

338. Because the cross-sectional area of the pipe is directly related to diameter, rewriting Eq. (2.6) as a function of fluid flow and diameter (D in m), yields the below.

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

³⁵⁶ Ex. 1007 (*Liu*), pg. 269.

³⁵⁷ Ex. 1007 (*Liu*), pg. 21, Eq., (2.6). Eq. 2.6 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only with additional factors added to account for the solids.

339. *Liu* is just one example of the general knowledge of POSITA regarding fluid and slurry flow in piping systems. Accordingly, a POSITA would have known to perform the well-known calculations described in *Liu* and design the piping system to maintain flow in a homogeneous or, at the very least, a heterogeneous flow regime.

340. *Liu* also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. *Liu* teaches that “head loss” (i.e. pressure drop) in a pipe (including hoses) can be calculated using the Darcy-Weisbach formula, shown in equation 2.33 which has been duplicated below.³⁵⁸

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

Where:

h_L = head loss (pressure drop)

f = friction factor

L = length of the pipe

D = Diameter of the pipe

V = velocity of the fluid

³⁵⁸ Ex. 1007 (*Liu*), pg. 37, Eq., (2.33). Eq. 2.33 is in a section describing “single-phase” flow, such as water flow with no solids. However, the basic relationship still applies to slurry flow, only that the friction factor will increase due to the presence of solids.

g = gravitational acceleration³⁵⁹

341. As discussed above, the velocity of the fluid is a function of the diameter of the hose and the flow rate. A reduction in diameter, such as from forming a bed of proppant in the hose, would increase the pressure drop by reducing the effective diameter of the hose, increasing the risk of cavitation.

342. Therefore, sizing a hose is a standard engineering tradeoff. For a given flow rate, increasing the diameter of the hose reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the risk of cavitation, for example. However, in a slurry flow system, reducing velocity too much leads to proppant drop-out, which reduces the cross-sectional area and increases pressure drop, thereby increasing the risk of cavitation. Selecting a particular hose size is simply optimization of a slurry flow system, and would have been known to a POSITA, at least based on the teachings of *Cicci*, *Colie* and *Liu*. As discussed above regarding limitation 1[d] (Section XIII.B.2) and Claims 5-6 (Section XIII.D-E), a POSITA would have found it obvious to use a reduced hose diameter, as compared to the diameter of the coupling to the pump (second diameter), when these calculations indicate that using a hose of the same size as standard pump suction inlet connections would have resulted in proppant dropout. A POSITA would have selected a hose

³⁵⁹ See Ex. 1007 (*Liu*), pgs. 26-29.

diameter that is smaller than the connection in order to reduce the possibility of low velocity flow causing formation of a proppant bed in the hose. It would have been easier for a POSITA to reduce hose size than to order custom pump suction inlets.

H. CLAIM 10

343. Dependent Claim 10 is rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Claim 2 in Sections XIII.C above.

I. CLAIM 11

344. Dependent Claim 11 is rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Claim 5 in Section XIII.D above.

J. CLAIM 12

345. Dependent Claim 12 is rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above with respect to Claim 6 in Section XIII.E above.

K. CLAIMS 3-4 AND 14

346. Claims 3-4, and 14 are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* for the same reasons as those discussed above in Ground 1 in Sections XII.D-E and XII.I above.

XIV. GROUND 3: THE COMBINATION OF *CICCI, COLI, DIXON, LIU* AND *GARDNER-DENVER* RENDERS CLAIMS 1-14 OBVIOUS

A. MOTIVATION TO COMBINE

347. The reasons to combine *Cicci, Coli, Dixon, and Liu* are the same as those described above in Section XIII.A, which are incorporated herein by reference. Nothing in *Gardner-Denver* teaches away from such a combination. To the extent that the Board finds that the teachings of *Gardner-Denver* would not have been included in the teachings of *Coli*, a POSITA would have been motivated to combine the teachings of *Gardner-Denver* with the system of *Cicci/Coli/Dixon/Liu*. Initially, *Coli* contains an express motivation to combine the references. *Coli* teaches that “[a] suitable pump [for *Coli*’s fracturing system] is a quintiplex [qunituplex] or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.”³⁶⁰ A POSITA incorporating the teachings of *Coli* would have been motivated to find information about the Gardner Denver (GD) SGWS-2500 pump, such as the information contained in *Gardner-Denver* .

348. A POSITA would have been motivated to look to *Gardner-Denver* for the implementation details of incorporating the *Gardner-Denver* pump expressly

³⁶⁰ Ex. 1006 (*Coli*), [0046]. I understand the Gardner Denver “SWGS-2500” well service pump to be a GD-2500Q power end with a “Super GWS Fluid End”, and that “SWGS” is a typo in *Coli* and should be “SGWS”.

disclosed in *Coli*. For example, *Gardner-Denver* discloses the interaction between plunger size, speed, flow rate (GPM) and PSI which would be expected from a GD SGWS-2500 pump as shown in the figure below.³⁶¹

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

Ex. 1010 (*Gardner-Denver*) pg. 20 of the PDF excerpted.

Gardner-Denver also discloses the Performance Ratings of the GD-2500Q power end as shown in the figure below.³⁶²

³⁶¹ Ex. 1010 (*Gardner-Denver*), pg. 20 of the PDF excerpted.

³⁶² Ex. 1010 (*Gardner-Denver*), pg. 20 of the PDF excerpted.

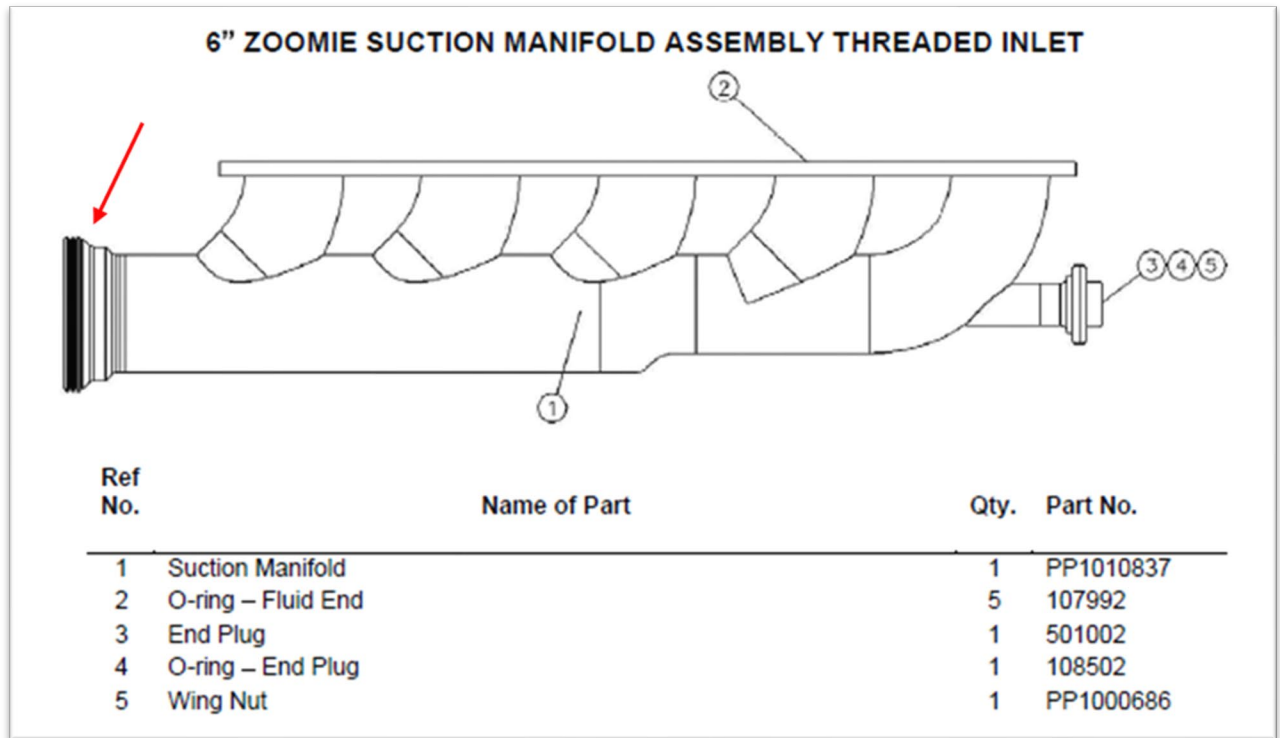
GD-2500Q PERFORMANCE RATING	
Rated Brake Horsepower	2500bhp
Stroke Length	8.0 inches
Maximum Rod Load	196,350 lbs.
Gear Box Ratio	6.353 : 1
Overall Length	86.25 in.(max.)
Overall Width	74.25 inches
Overall Height	43.69 inches
Weight (system dry)	14,570 lbs.

Ex. 1010 (*Gardner-Denver*) pg. 20 of the PDF excerpted

349. Furthermore, *Gardner-Denver* offers a range of suction manifolds with various connection types, including Victaulic and threaded inlets (hammer unions), as well as fixed sizes, such as 6” and 8” inlet connections.³⁶³ For example, the “6” Zoomie Suction Manifold Assembly Threaded Inlet” shows an inlet that is recognizable to a POSITA as a hammer union end (red arrow in the figure below) connected to a suction manifold.³⁶⁴ A POSITA would have understood this to be a 6” threaded inlet (hammer union half).

³⁶³ Ex. 1010 (*Gardner-Denver*), pgs. 84-88 of the PDF.

³⁶⁴ Ex. 1010 (*Gardner-Denver*), pg. 85 of the PDF.



Ex. 1010 (*Gardner-Denver*) pg. 77 of the PDF.

350. A POSITA would have found such information, and the rest of the information in *Gardner-Denver* for understanding *Coli's* teachings regarding applicable fracturing pumps, their characteristics, and the connections. A POSITA would have found the operating data to be valuable in evaluating, for example, how many pumps would be necessary to pump the fracturing fluid at the desired rate and pressure. Furthermore, a POSITA would have found the connection data disclosed by *Coli* valuable in understanding what kind of fittings would have been appropriate to connect to an applicable pump, such as the SGWS-2500.

351. Accordingly, *Gardner-Denver* is analogous art to the '162 Patent because it is directed to the same field of endeavor of hydraulic fracturing systems.³⁶⁵

352. A POSITA would have had a reasonable expectation of success in combining the teachings of *Gardner-Denver* with the *Cicci/Coli/Dixon/Liu* combination as it is merely the use of applying a known technique (the teachings of the characteristics of an applicable pump) to a known device (the fracturing system of *Cicci/Coli/Dixon/Liu*) ready for improvement (the practical design of the system) to yield predictable results (a system constructed with an applicable pump, for example a GD SGWS-2500).

B. INDEPENDENT CLAIM 1

353. It is my opinion that the combination of *Cicci, Coli, Dixon, Liu* and *Gardner-Denver* would have rendered Claim 1 obvious. The combined teachings of *Cicci, Coli, Dixon, Liu* and *Gardner-Denver* disclose, or at least suggest, each and every limitation of Claim 1, as discussed in the sections below.

1. Limitations 1[p] – 1[c], 1[e]

354. Limitations 1[p] – 1[c], 1[e] are disclosed and/or rendered obvious by the combination of *Cicci, Coli, Dixon, Liu*, and *Gardner-Denver* for the same reasons as those discussed above regarding Ground 1 in Sections XII.B.1-4, XII.B.6.

³⁶⁵ Ex. 1010 (*Gardner-Denver*), pg. 9 of the PDF.

2. Limitation 1[d]

355. The discussion of the disclosure and teachings of *Cicci*, *Coli*, *Dixon*, and/or *Liu* included regarding Grounds 1-2 above is incorporated herein by reference. The addition of *Gardner-Denver* renders Limitation 1[d] obvious, because *Gardner-Denver* discloses that commercially available fracturing pumps, for example, the Gardner Denver SGWS-2500 referenced by *Coli*, have 6” or 8” headers, as described more fully below regarding Claim 2. This would have motivated a POSITA to combine well-known, commercially available components, as discussed above, designed for fracturing systems, to allow for a smaller hose size, thereby increasing velocity, rather than going back to the manufacturer and obtaining custom inlet headers for the fracturing pumps.

356. Accordingly, Limitation 1[d] would have been obvious to a POSITA based on the combined teachings of *Cicci*, *Coli*, *Dixon*, *Liu* and *Gardner-Denver*.

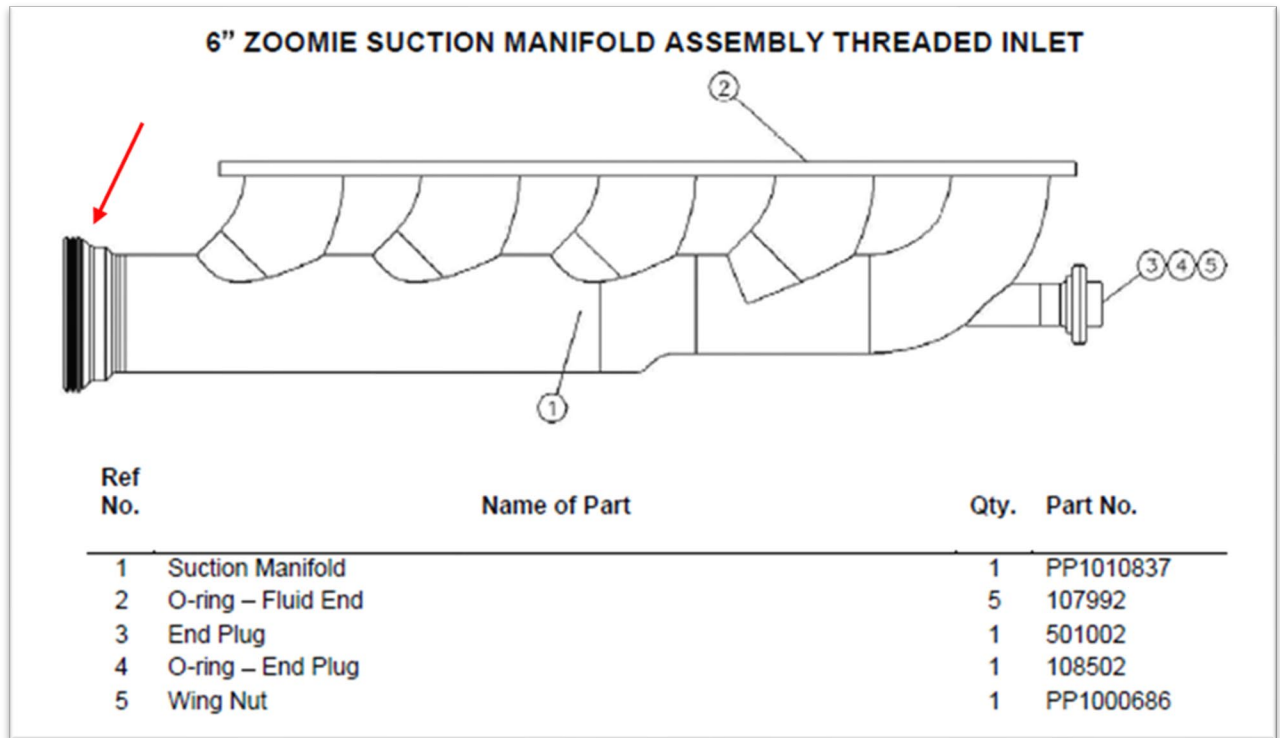
C. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS APPROXIMATELY 5 INCHES AND THE SECOND DIAMETER IS APPROXIMATELY 6 INCHES.”

357. The *Cicci/Coli/Dixon* combination renders obvious Claim 2 for the reasons that I discuss above with respect to Ground 1. It would have further been obvious for the second diameter to be approximately six inches in light of the additional disclosure of *Gardner-Denver*. As I discuss above, *Coli* discloses a

“SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.”³⁶⁶ It would have been obvious to a POSITA to select a fitting diameter that is consistent with this disclosure. A POSITA would have understood that this disclosure of *Coli* refers to 6” inlet connections with both threaded (for hammer union) and Victaulic style inlet connections, as discussed below. For example, the “6” Zoomie Suction Manifold Assembly Threaded Inlet” shows an inlet that is recognizable to a POSITA as a hammer union end (red arrow in the figure below) connected to suction manifold.³⁶⁷ A POSITA would have understood this to be a 6” threaded inlet (hammer union half). It would have been obvious to a POSITA to select a second diameter of 6 inches, as 6 inches was a well-known size for connection to a fracturing pump.

³⁶⁶ Ex. 1006 (*Coli*), [0046].

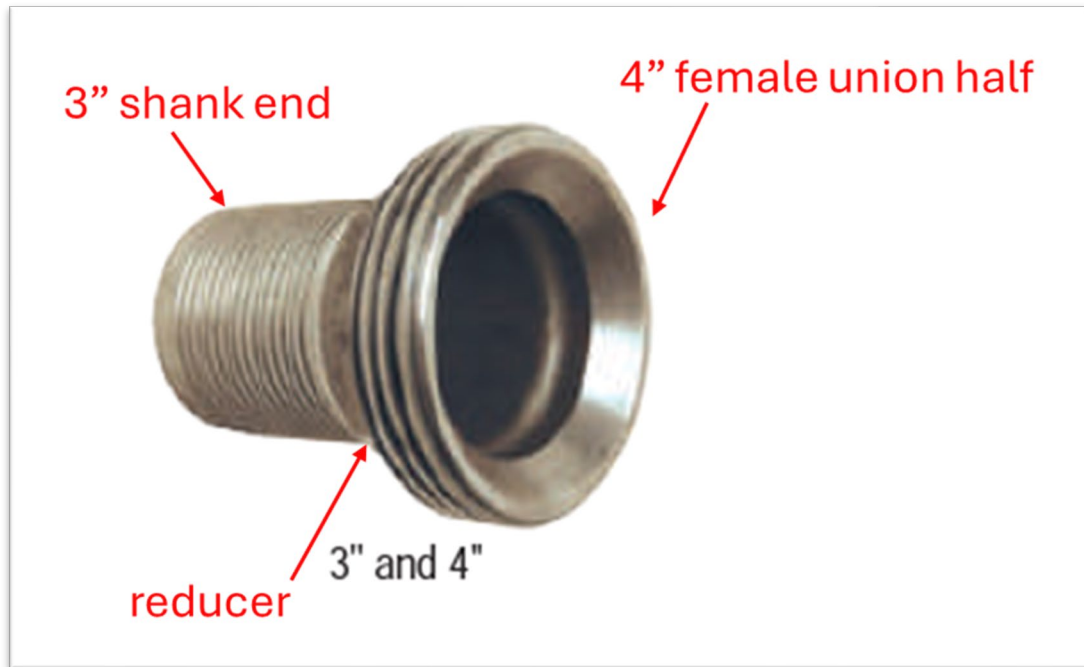
³⁶⁷ Ex. 1010 (*Gardner-Denver*), pg. 77 of the PDF.



Ex. 1010 (*Gardner*) pg. 77 of the PDF.

A hammer union end from Dixon is shown for comparison.³⁶⁸

³⁶⁸ Ex. 1009 (*Dixon-Australia*) pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78.



Ex. 1009 (*Dixon-Australia*) pg. 149; Ex. 1012 (*Dixon-U.S.*), pg. 78

358. Other connections and sizes include 6" Victaulic, 8" threaded (hammer union) and 8" Victaulic.³⁶⁹ Accordingly, *Gardner-Denver*, which contains information about the GD-2500 pump specifically referenced by *Coli*, discloses a 6" suction end (2nd diameter) for connection to the pump. Moreover, it would have been obvious to use a 6" hammer union to connect to the 6" inlet manifold disclosed by *Coli* as hammer unions were well known long before the '162 Patent, as discussed above.³⁷⁰

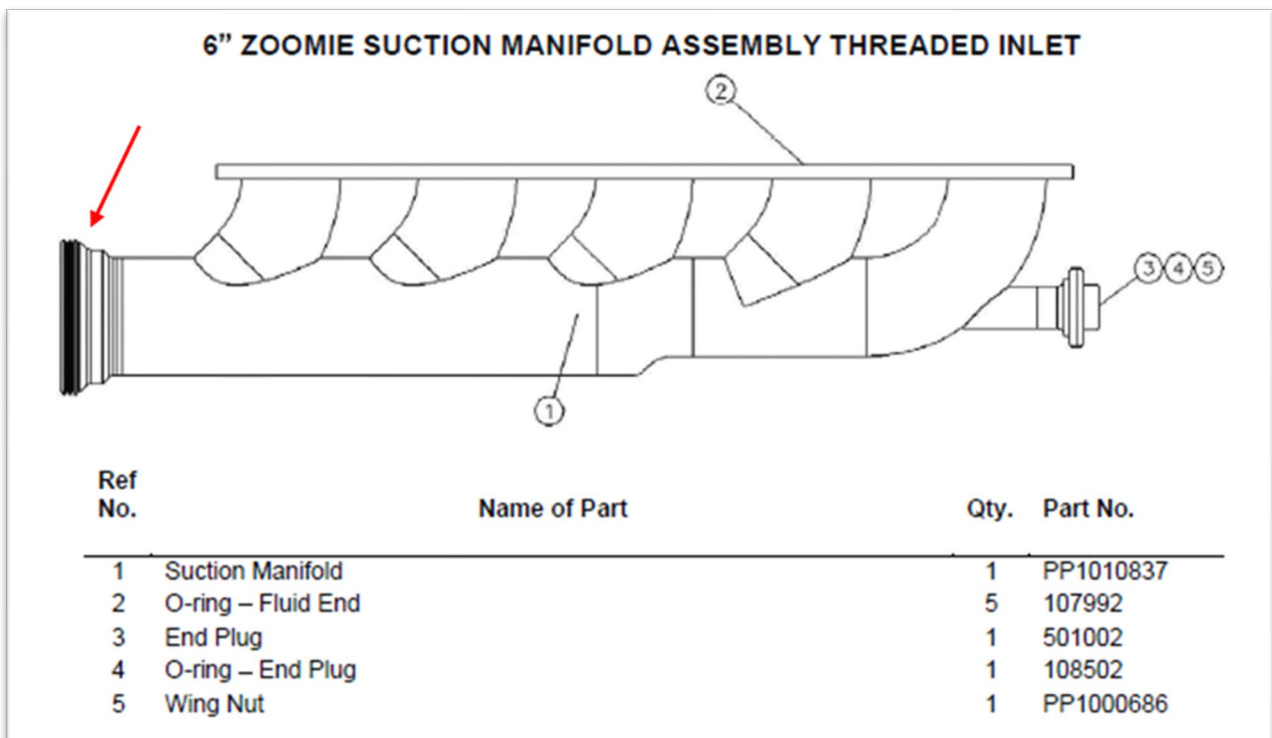
³⁶⁹ Ex. 1010 (*Gardner-Denver*) pgs. 64-79 of the PDF.

³⁷⁰ Ex. 1001 ('162 Patent), 3:65-4:2.

359. Accordingly, Dependent Claim 2 would have been obvious to a POSITA based on the combined teachings of *Cicci, Coli, Liu, Dixon* and *Gardner*.

D. CLAIM 3

360. Claim 3 depends from Claim 1. In addition to the teachings regarding Claim 1 discussed above in Section XIV.B and incorporated herein by reference, the combination of *Cicci, Coli, Liu, Dixon*, and *Gardner-Denver* would have rendered the additional limitations of Claim 3 obvious. With respect to limitation 3[a], the addition of *Gardner-Denver* further shows that the other half (female half) of the hammer union would have been attached to the pump, for example as shown in *Gardner-Denver*:



Ex. 1010 (*Gardner-Denver*) pg. 77 of the PDF.

E. DEPENDENT CLAIMS 4-6 & 8

361. Dependent Claims 4-6 and 8 are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, *Liu* and *Gardner-Denver* for the same reasons as those discussed above regarding Grounds 1 and 2 in Sections XII.D-F and XIII.D-F.

362. Accordingly, Claims 4-6 and 8 would have been obvious to a POSITA based on the combined teachings of *Cicci*, *Coli*, *Dixon*, *Liu* and *Gardner-Denver*.

F. DEPENDENT CLAIM 7: “7. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS ASSOCIATED WITH A SECOND THRESHOLD, CORRESPONDING TO A MAXIMUM SUGGESTED FLOW RATE, AN OPERATING WINDOW FOR THE ELECTRIC POWERED PUMP EXCEEDING THE MAXIMUM SUGGESTED FLOW RATE.”

363. Claim 7 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above in Section XIV.B and incorporated herein by reference, the combination of *Cicci*, *Coli*, *Liu*, *Dixon*, and *Gardner-Denver* would have rendered the additional limitations of Claim 7 obvious.

364. As discussed above regarding Claim 6, in Section XIII.E, *Liu* teaches that pressure drop and a damage accumulation rate (e.g., wear or abrasion on the hose) would have impacted the selection of a first diameter. Pressure drop and wear

are both directly related to velocity. Velocity (V), in turn, is related to both flowrate (Q) and diameter (D) of the hose as shown in the equation below.

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

365. The first diameter would have been selected based on an upper limit on velocity, above which pressure drop and/or wear would have been unacceptable.

366. In a similar manner, for any given diameter of hose, there is a maximum flowrate (Q) above which velocity would be too high, leading to unacceptable pressure drop or wear. Accordingly, it would have been obvious to a POSITA that for any given first diameter, there is a second threshold that corresponds to a maximum flowrate which would limit pressure drop and wear to acceptable levels. The first diameter is therefore associated with this second threshold.

367. *Coli* teaches “[c]onventional blenders powered by a diesel hydraulic system are typically housed on a forty-five foot tractor trailer and are capable of approximately 100 bbl/min. In contrast, the dual configuration of blender module 40 having first blender unit 47a and second blender unit 47b provides a total output capability of 240 bbl/min in the same physical footprint as a conventional

blender.”³⁷¹ As the fluid supplied by the blender would have the same rate as the fluid entering the wellbore, *Coli* at least suggests a range of maximum flow rates for the entire system between 100 bbl/min and 240 bbl/min(4200 GPM to 10,080 GPM).³⁷² This total would be divided by the total number of pumps available in the system to provide the flowrate required by each pump..

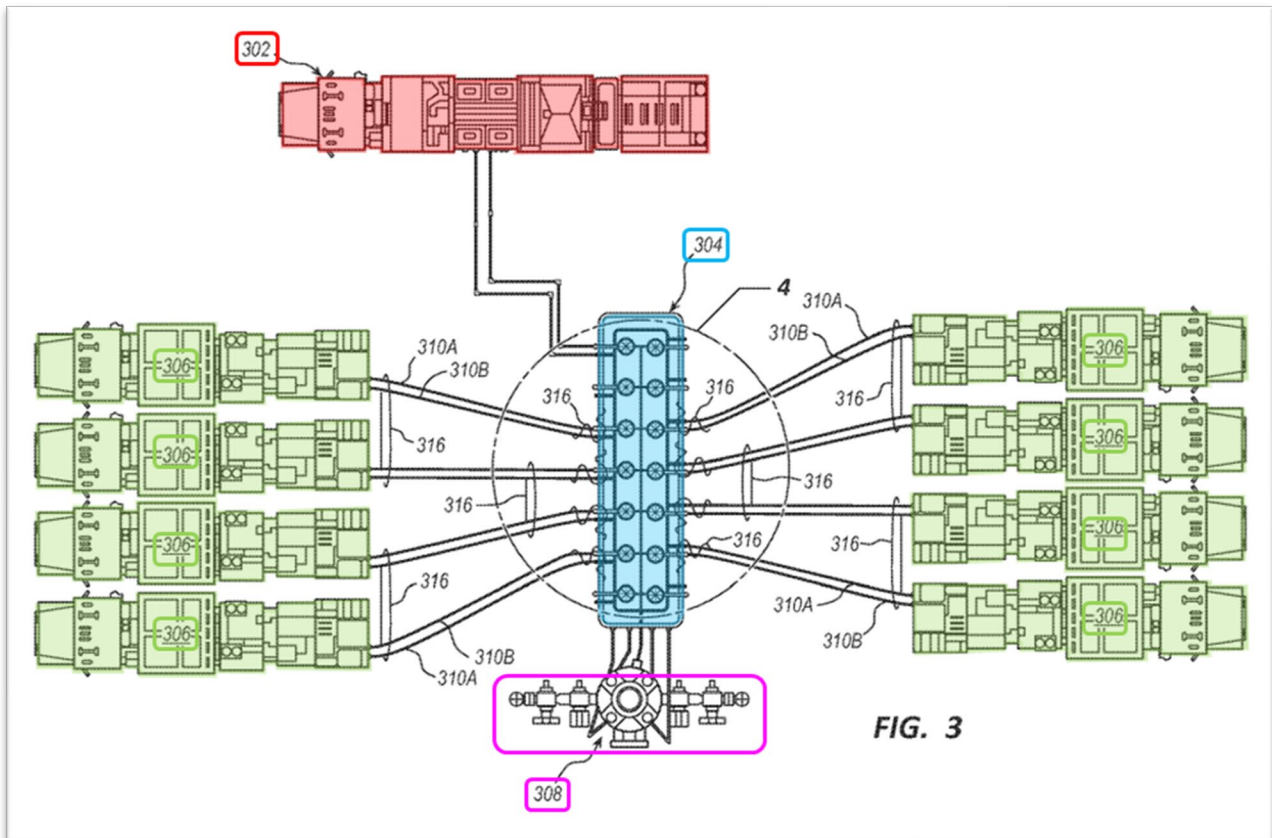
368. It would have been well known to a POSITA to select the proper number of pumps to perform the fracturing job according to the fracturing design. For example, *Cicci* shows a system with eight pump trailers 306 (highlighted in green in the figure below) but discloses “one or more pumps 306”³⁷³ and “a plurality of pumps”³⁷⁴ disclosing to a POSITA the use of any number of pumps.

³⁷¹ Ex. 1006 (*Coli*), [0060].

³⁷² Bbl stands for “barrel” which is a standard oilfield term used to represent 42 gallons.

³⁷³ See, e.g., Ex. 1004 (*Cicci*), 5:17-20; Ex. 1005 (*Cicci Provisional*), [12].

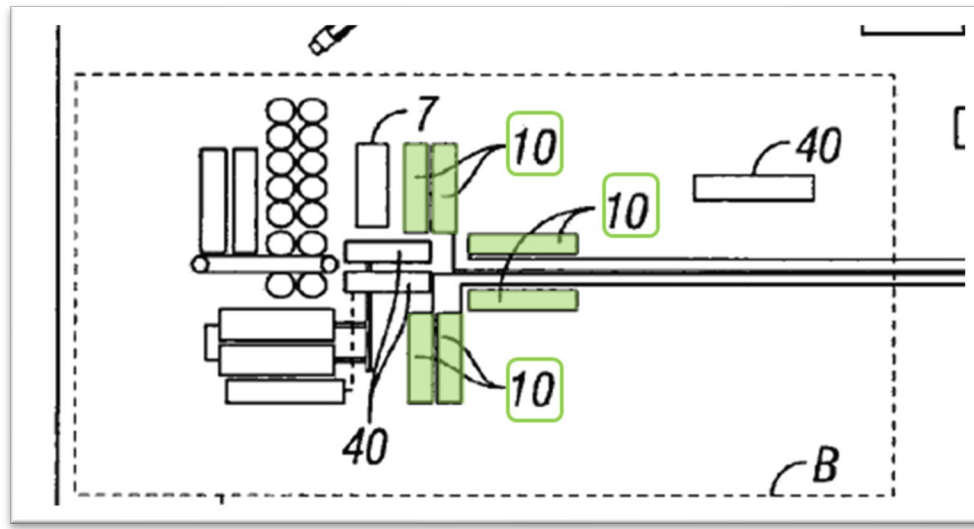
³⁷⁴ Ex. 1004 (*Cicci*), 1:25-26; Ex. 1005 (*Cicci Provisional*), [2].



Ex. 1004 (*Cicci*) Fig. 3; Ex. 1005 (*Cicci Provisional*) Fig. 3 annotated

369. *Coli* discloses a different number of pumps. *Coli* teaches the use of six “fracturing trailers 10” (highlighted in green in the figure below).³⁷⁵

³⁷⁵ Ex. 1006 (*Coli*), Fig. 2 excerpted and annotated.

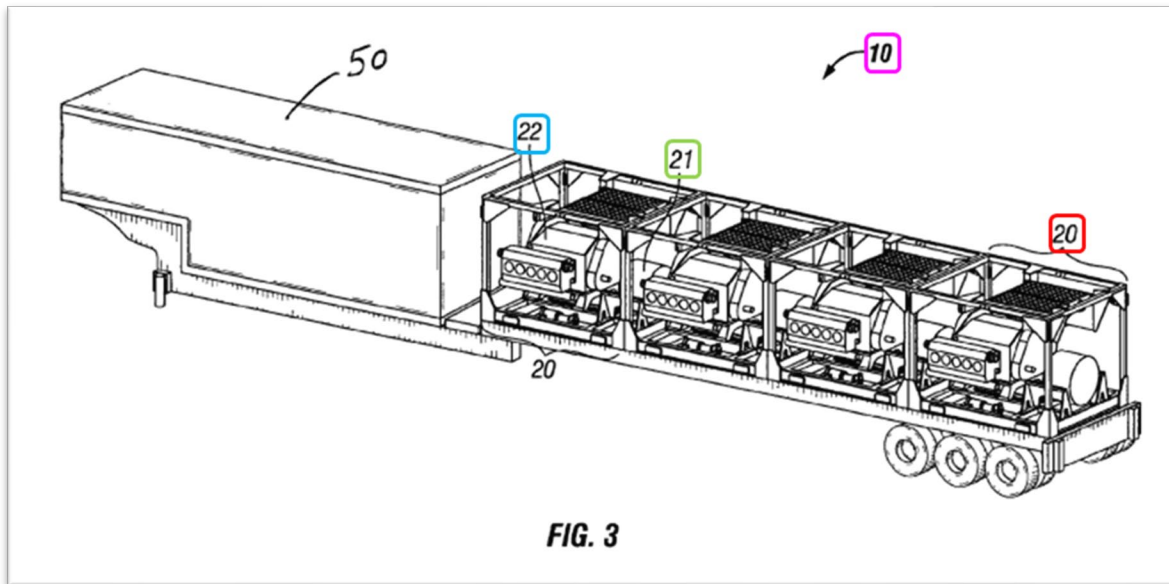


Ex. 1006 (*Coli*) Fig. 2 excerpted and annotated

370. *Coli* also teaches that each fracturing trailer 10 (annotated in magenta in the figure below) contains as many as four fracturing modules, with each fracturing module 20 (annotated in red) containing a pump 22 (annotated in blue) and a motor 21 (annotated in green).³⁷⁶ *Coli* also discloses “a plurality of electric motors 21 and pumps 22 can be transported on a single trailer 10”,³⁷⁷ as shown in Fig. 3 of *Coli*, annotated below.

³⁷⁶ Ex. 1006 (*Coli*), Fig 3 (annotated). See also Section XIII.B.2 above.

³⁷⁷ Ex. 1006 (*Coli*), [0040].



Ex. 1006 (*Coli*), Fig 3 annotated.

371. Accordingly, *Coli* at least discloses 24 pumps. *Coli* also discloses “providing one or more electric fracturing modules at the site, each electric fracturing module comprising an electric motor and a coupled fluid pump”³⁷⁸ at least suggesting any number of pumps.

372. *Gardner-Denver*, which contains information regarding the GD-2500 pump specifically referenced by *Coli* as suitable for hydraulic fracturing, teaches that the “operating window” for each pump is between 191 GPM (4.5 BPM, red box in the figure below) and 2,044 GPM (48.66 BPM), depending on the design, speed and specific well conditions.³⁷⁹ For the conditions specified in *Cicci* (“5,000 PSI to

³⁷⁸ Ex. 1006 (*Coli*), [0009].

³⁷⁹ Ex. 1010 (*Gardner-Denver*), pg. 20 excerpted and annotated.

15,000 PSI or more”),³⁸⁰ the range of each pump is 191 GPM (4.5 BPM, annotated in red in the figure below) to 734 GPM (17.5 BPM, annotated in blue).

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

Ex. 1010 (*Gardner-Denver*) pg. 20 excerpted and annotated.

373. Using the teachings of *Coli*, a potential range of maximum flow rates (100 bbl/min to 240 bbl/min), in the system of *Cicci*, with 8 pumps, would require a maximum flow rate between 12.5 bbl/min (525 GPM) and 30 bbl/min (1,260 GPM) per pump respectively. However, in the system of *Coli* with as many as 24 pumps, each pump would require a maximum flow rate between 4.2 bpm (175 GPM) and 10 bbl/min (420 GPM). A POSITA, then would have understood to select (or at least

³⁸⁰ Ex. 1004 (*Cicci*), 5:23-25; Ex. 1005 (*Cicci Provisional*), [23].

operate) the proper number of pumps (at least between 8 and 24, but actually any number based on the “one or more” disclosure of both *Cicci* and *Coli*) so that the maximum flow rate, as determined by the pressure drop and damage accumulation considerations discussed above, for each pump falls within the operating window of the pumps, as shown by *Gardner-Denver*.

374. In this manner, the fracturing job would be accomplished with the minimum number of pumps, which would be a benefit to a POSITA in reducing capital expenditures and, potentially, operating costs (for example, lower fuel or electricity consumption). It would have been obvious to a POSITA, then, that the operating window of the pump would exceed the maximum flowrate determined by the size of the pipe, based on pressure drop and/or wear (damage accumulation).

375. Further, as there are a finite number of sizes of piping systems available (such as the ~4” – ~8” sizes shown in Dixon’s “frac hose” disclosure), and the operating window for pumps is so large (e.g., 4.5 BPM – 48.66 BPM shown in *Gardner*), it would be obvious that the operating window of the pump would, in some cases, exceed the second threshold determined by a maximum suggested velocity, and the associated maximum suggested flowrate.

376. Accordingly, the combined teachings of *Coli*, *Cicci*, *Dixon*, *Liu* and *Gardner-Denver* render a maximum suggested flow rate, an operating window for

the electric powered multi-plunger hydraulic fracturing pump exceeding the maximum suggested flow rate as claimed.

377. As discussed above regarding Claim 5 and Claim 6, in Sections XIII.D and XIII.E, the selection of the first diameter is a standard engineering problem with standard trade-offs. It is simply an optimization of the slurry flow system. Accordingly, a POSITA would have recognized a variety of desired “suggested” flow rates throughout the fracturing operation, such as a minimum flow rate and a maximum flow rate, as disclosed by *Coli*, and select the first diameter based on those flow rates. Because the maximum suggested flowrate depends on the selected first diameter, the second threshold, corresponding to a maximum suggested flowrate, is associated with the first diameter.

378. Accordingly, the combined teachings of *Coli*, *Cicci*, *Dixon*, *Liu* and *Gardner-Denver* render wherein the first diameter is associated with a second threshold, corresponding to a maximum suggested flow rate, an operating window for the electric powered pump exceeding the maximum suggested flow rate obvious to a POSITA. Thus, Claim 7 would have been obvious to a POSITA based on the combined teachings of *Coli*, *Cicci*, *Dixon*, *Liu* and *Gardner-Denver*.

G. INDEPENDENT CLAIM 9

379. It is my opinion that the combination of *Cicci, Coli, Liu, Dixon* and *Gardner-Denver* would have rendered Claim 9 obvious. The combined teachings of *Cicci, Coli, Liu, Dixon* and *Gardner-Denver* disclose, or at least suggest, each and every limitation of Claim 9, as discussed in the sections below.

1. Limitations 9[p] – 9[c], 9[e] – 9[h]

380. Limitations 9[p] – 9[c], 9[e] – 9[h] are disclosed and/or rendered obvious by the combination of *Cicci, Coli, Liu, Dixon* and *Gardner-Denver* for the same reasons as those discussed above regarding Ground 1 in Sections XII.B.1-4 and XII.B.6.

2. Limitation 9[d]

381. Limitation 9[d] is disclosed or rendered obvious by the combination of *Cicci, Coli, Dixon, Liu*, and *Gardner-Denver* for the same reasons as those set forth for limitation 1[d] in Section XIV.B.2 above.

H. DEPENDENT CLAIM 10

382. Claim 10 is rendered obvious by the combination of *Cicci, Coli, Dixon, Liu*, and *Gardner-Denver* for the same reasons as those set forth for Claim 2 in Section XIV.C above.

I. DEPENDENT CLAIMS 11-12, & 14

383. Dependent Claims 11-12 & 14 are disclosed and/or rendered obvious by the combination of *Cicci, Coli, Liu, Dixon* and *Gardner-Denver* for the same reasons as those discussed above regarding Grounds 1 and 2 in Sections XII.I, XIII.I-

J.

J. DEPENDENT CLAIM 13: “13. THE SYSTEM OF CLAIM 11, WHEREIN THE FIRST DIAMETER IS ASSOCIATED WITH A SECOND THRESHOLD, CORRESPONDING TO A MAXIMUM SUGGESTED FLOW RATE, AN OPERATING WINDOW FOR THE ELECTRIC POWERED MULTI-PLUNGER HYDRAULIC FRACTURING PUMP EXCEEDING THE MAXIMUM SUGGESTED FLOW RATE.”

384. The limitations of Claim 13 are the same as those in Claim 7 and would have been obvious to a POSITA for the same reasons as those discussed in Section XIV.F above.

XV. GROUNDS 4A AND 4B THE COMBINATION OF *CICCI, COLI, DIXON, LIU* AND *KEMPER*, WITH OR WITHOUT *GARDNER-DENVER* RENDERS CLAIMS 1-14 OBVIOUS

385. It is my opinion that the combination of *Cicci, Coli, Dixon, Liu*, and *Kemper*, with or without the teachings of *Gardner-Denver* renders Claims 1-14 of the '162 Patent obvious.

A. MOTIVATION TO COMBINE

386. The motivation and rationale for combining *Cicci*, *Coli*, *Dixon*, and *Liu*, (and/or *Gardner-Denver*) are the same as those discussed above regarding Grounds 1 and 2 in Section XIV.A.

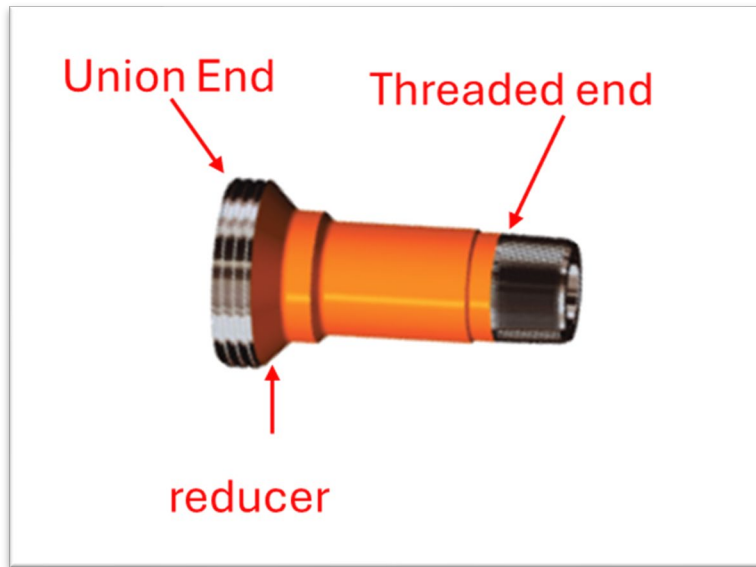
387. A POSITA would have been motivated to incorporate the teachings of *Kemper* into the combination of *Cicci*, *Coli*, *Dixon*, and *Liu* (with or without *Gardner-Denver*), as *Kemper* provides additional information and disclosure of integral fittings that contain a hammer union, reduced to connect to an additional fitting. *Kemper* provides a description of “Union Swages,” which have a union on one end that reduces to a different type of connection on the other end.

388. *Kemper* describes union swages for use in “oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential.”³⁸¹

Kemper Integral Hammer Union Swages can replace couplings or nipples in oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential. Standard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times. Because Kemper Integral Hammer Union Swages are made to factory specifications, service company users can be assured of exact, union compatibility and API thread spec compliance.

389. *Kemper* discloses the Union Swages with the reduction in size from the union to the pipe (or hose) end.

³⁸¹ Ex. 1008 (*Kemper*), pg. 1 excerpted and annotated.



Ex. 1008 (Kemper), pg. 1 (annotated).

390. *Kemper* shows a variety of union swages that couple a larger union to a smaller connection, such as, for example, a 4" female union to a 3" line pipe thread and a 3" female union to a 2 7/8" EUE 8 round thread.³⁸²

³⁸² EUE 8RD (8 round) is an API standard thread describing external upset end thread with a pitch of 8 threads per inch.

2" 1502 FEMALE X 5 1/2" 8RD SC	1515SW2X55SC	10,000	21.2
3" 1502 FEMALE X 2" LPTL	1503SW2X2L	10,000	12.8
3" 1502 FEMALE X 2 3/8" EUE 8RD	1503SW2X2375E	10,000	12
3" 1502 FEMALE X 2 7/8" EUE 8RD	1503SW2X2875E	10,000	12.6
3" 1502 FEMALE X 3" LPT	1503SW2X3L	10,000	13.8
3" 1502 FEMALE X 3 1/2" EUE 8RD	1503SW2X35E	10,000	14.4
3" 1502 FEMALE X 4" LPT	1503SW2X4L	10,000	17.3
3" 1502 FEMALE X 4" 8RD SC	1503SW2X4SC	10,000	-
3" 1502 FEMALE X 4" 8RD LC	1503SW2X4LC	10,000	-
3" 1502 FEMALE X 5 1/2" 8RD SC	1503SW2X55SC	10,000	23.2
3" 1502 FEMALE X 7" 8RD SC	1503SW2X7SC	10,000	28.5
4" 1002 FEMALE X 2" LPT	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 3/8" EUE 8RD	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 7/8" EUE 8RD	1204SW2X2875E	10,000	18.8
4" 1002 FEMALE X 3" LPT	1204SW2X3L	10,000	-
4" 1002 FEMALE X 3 1/2" EUE 8RD	1204SW2X35E	10,000	19.6

Ex. 1008 (*Kemper*), pg. 1 excerpted and annotated.

391. *Kemper* also discloses that “[s]tandard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times.”³⁸³ A POSITA would have recognized that the specific configurations shown in *Kemper* all had threaded connections, instead of connectors to connect to hoses (shanks or barbs), and would have been motivated to design and construct a “custom combination” of union swage with a barb or shank fitting, based on the teachings of *Dixon*.

392. *Kemper*, then, is analogous art to the '162 Patent because it is in the same field of endeavor of a hydraulic fracturing system.

393. A POSITA would have had a reasonable expectation of success in incorporating the teachings of *Kemper* into the system of *Cicci/Coli/Dixon/Liu* at

³⁸³ Ex. 1008 (*Kemper*), pg. 1.

least because it is use of a known technique (commercial fittings including union swages) to a known system (the fracturing system *Cicci/Coli/Liu/Dixon* incorporating *Dixon*'s teachings of reducing Frac Fittings) ready for improvement (a more clear understanding of a reduction in size between the union and the other end of the fitting) to yield predictable results (a reduction in size between the union and the other end of the fitting).

394. To the extent that the Board finds that the teachings of *Gardner-Denver* would not have been included in the teachings of *Coli*, A POSITA would have been motivated to combine the teachings of *Gardner-Denver* with the system of *Cicci/Coli/Liu/ Dixon* and *Kemper* are the same as those discussed above regarding Ground 3, which is incorporated herein by reference. Nothing in *Kemper* teaches against the combination with *Gardner-Denver* .

B. INDEPENDENT CLAIM 1

395. It is my opinion that the combination of *Cicci, Coli, Liu, Dixon* and *Kemper*, with or without *Gardner-Denver* , would have rendered Claim 1 obvious. The combined teachings of *Cicci, Coli, Liu, Dixon* and *Kemper*, with or without *Gardner-Denver* , disclose, or at least suggest, each and every limitation of Claim 1, as discussed in the sections below.

1. Limitations 1[p] – 1[c], & 1[e]

396. Limitations 1[p] – 1[c] & 1[e] are disclosed and/or rendered obvious by the combination of *Cicci, Coli, Dixon, Liu, and Kemper* with or without *Gardner-Denver*, for the same reasons as those discussed above regarding Ground 1 in Sections XII.B.1-4 and XII.B.6.

2. Limitation 1[d]

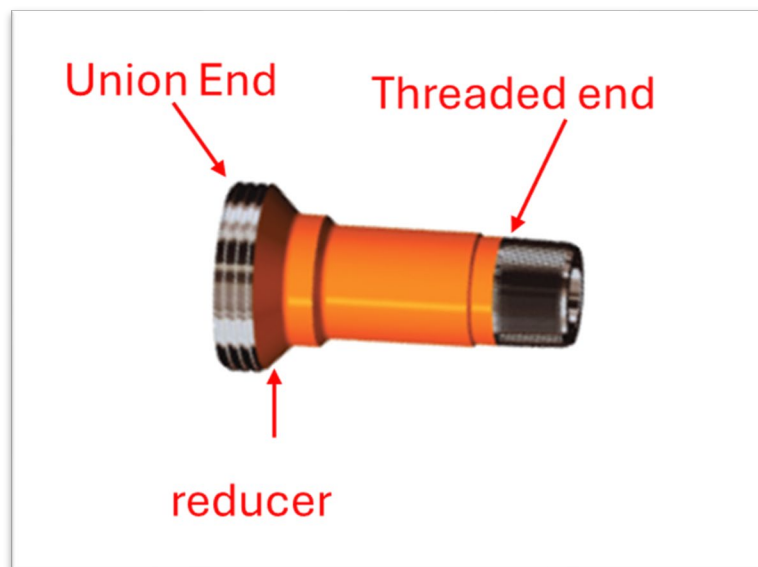
397. The *Cicci/Coli/Dixon*, *Cicci/Coli/Dixon/Liu*, and *Cicci/Coli/Dixon/Gardner-Denver* combinations disclose or render obvious limitation 1[d] for the reasons that I discuss above in Grounds 1-3. *Kemper*, in combination with the references in Grounds 1, 2, and/or 3, also discloses the fitting recited in 1[d]. The fitting that a POSITA would have looked to, based on the disclosure of at least *Cicci/Coli/Dixon* is referred to as a “Union Swage”. *Kemper* discloses “Union Swages,” which have a union on one end that reduces to a different type of connection on the other end, with a smaller diameter than the first end.

398. *Kemper* describes union swages for use in “oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential.”³⁸⁴

³⁸⁴ Ex. 1008 (*Kemper*), pg. 1.

Kemper Integral Hammer Union Swages can replace couplings or nipples in oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential. Standard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times. Because Kemper Integral Hammer Union Swages are made to factory specifications, service company users can be assured of exact, union compatibility and API thread spec compliance.

399. *Kemper* discloses Union Swages with the reduction in size from the union to the pipe (or hose) end. In other words, *Kemper* discloses that the end connecting to the pump (second end) has a larger diameter (second diameter) than the diameter (first diameter) of the end connecting to the pipe or hose (first end).



E. 1008 (Kemper), pg. 1 (annotated).

400. *Kemper* thus shows what would be easily recognizable to a POSITA as a reducer between the pipe thread end and the union end.

401. *Kemper* shows a variety of union swages that couple a larger union to a smaller connection, such as, for example, a 4” female union to a 3” line pipe thread and a 3” female union to a 2 7/8” EUE 8 round thread.³⁸⁵

2" 1502 FEMALE X 5 1/2" 8RD SC	1515SW2X55SC	10,000	21.2
3" 1502 FEMALE X 2" LPTL	1503SW2X2L	10,000	12.8
3" 1502 FEMALE X 2 3/8" EUE 8RD	1503SW2X2375E	10,000	12
3" 1502 FEMALE X 2 7/8" EUE 8RD	1503SW2X2875E	10,000	12.6
3" 1502 FEMALE X 3" LPT	1503SW2X3L	10,000	13.8
3" 1502 FEMALE X 3 1/2" EUE 8RD	1503SW2X35E	10,000	14.4
3" 1502 FEMALE X 4" LPT	1503SW2X4L	10,000	17.3
3" 1502 FEMALE X 4" 8RD SC	1503SW2X4SC	10,000	-
3" 1502 FEMALE X 4" 8RD LC	1503SW2X4LC	10,000	-
3" 1502 FEMALE X 5 1/2" 8RD SC	1503SW2X55SC	10,000	23.2
3" 1502 FEMALE X 7" 8RD SC	1503SW2X7SC	10,000	28.5
4" 1002 FEMALE X 2" LPT	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 3/8" EUE 8RD	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 7/8" EUE 8RD	1204SW2X2875E	10,000	18.8
4" 1002 FEMALE X 3" LPT	1204SW2X3L	10,000	-
4" 1002 FEMALE X 3 1/2" EUE 8RD	1204SW2X35E	10,000	19.6

Ex. 1008 (*Kemper*) pg. 1 excerpted and annotated

402. *Kemper* also discloses that “[s]tandard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times.”³⁸⁶ A POSITA would have recognized that the specific configurations shown in *Kemper* all had threaded connections, instead of connectors to connect to hoses (shanks or barbs), and would have been motivated to design and construct a “custom combination” of union swage with a barb or shank fitting, based on the teachings of *Dixon*.

³⁸⁵ EUE 8RD (8 round) is an API standard thread describing external upset end thread with a pitch of 8 threads per inch.

³⁸⁶ Ex. 1008 (*Kemper*), pg. 1.

403. Accordingly, the combination of *Cicci*, *Coli*, *Liu*, *Dixon* and *Kemper* (with or without *Gardner-Denver*) render Limitation 1[d] obvious.

C. DEPENDENT CLAIM 2: “2. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS APPROXIMATELY 5 INCHES AND THE SECOND DIAMETER IS APPROXIMATELY 6 INCHES.”

404. Claim 2 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above and incorporated herein by reference, the combination of *Cicci*, *Coli*, *Liu*, *Dixon*, and *Kemper*, with or without *Gardner-Denver*, would have rendered the additional limitations of Claim 2 obvious. As I discuss above in Grounds 1-3, incorporated herein by reference, the combination of *Cicci*, *Coli*, and *Dixon*, with or without *Liu* and *Gardner-Denver*, disclose or render Claim 2 obvious.

405. Claim 2 would have been obvious further in view of *Kemper*. A POSITA would have understood from the teachings of both *Dixon* and *Kemper* that combinations of sizes other than those specifically disclosed were available. In particular, *Kemper* states that “custom combinations can be delivered to order with minimal lead times.”³⁸⁷ A POSITA would have ordered custom combinations to connects standard pump connection sizes (e.g., 6”) to a smaller, 5” connection, when a 5” hose is desired, either based on the teachings of *Cicci* regarding hose diameters

³⁸⁷ Ex. 1008 (*Kemper*), pg. 1.

between 1” and 8”, and/or when the calculations taught by *Liu* indicate that 5” is an appropriate size, based on the balanced velocity considerations.

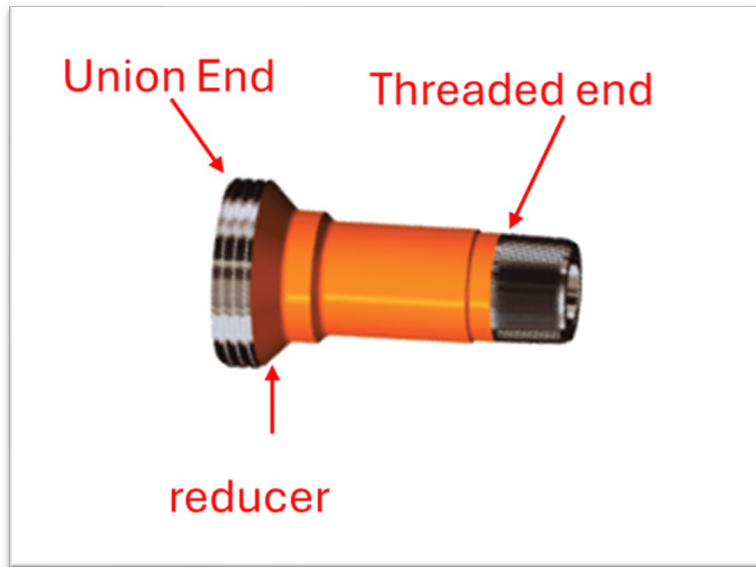
406. Further still, the '162 Patent admits that “6” (0.1524 m) components, such as but not limited to hammer unions, were “standard” even before the '162 Patent.

407. Therefore, the combined teachings of *Cicci*, *Coli*, *Liu*, *Dixon*, and *Kemper*, with or without *Gardner*, would have rendered Claim 2 obvious to a POSITA.

D. DEPENDENT CLAIM 3

408. Claim 3 depends from Claim 1. In addition to the teachings regarding Claim 1 as discussed above and incorporated herein by reference, the combination of *Cicci*, *Coli*, *Liu*, *Dixon*, and *Kemper*, with or without *Gardner*, would have rendered the additional limitations of Claim 3 obvious. As I discuss above in Grounds 1-3, the combination of *Cicci*, *Coli*, and *Dixon*, with or without *Liu* and *Gardner-Denver*, render Claim 3 obvious.

409. *Kemper* additionally discloses a reducer, as recited in limitation 3[c]. *Kemper* shows what would be easily recognizable to a POSITA as a reducer between the pipe thread end and the reducer as shown below.



Ex. 1008 Kemper, pg. 1 excerpted and annotated.

E. DEPENDENT CLAIMS 4 – 8

410. Dependent Claims 4 – 8 are disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, *Liu*, and *Kemper*, with or without *Gardner-Denver*, for the same reasons as those discussed above regarding Grounds 1-3 in Sections XII.E, XIII.D-F, XIV.F.

F. INDEPENDENT CLAIM 9

411. Independent Claim 9 is disclosed and/or rendered obvious by the combination of *Cicci*, *Coli*, *Dixon*, *Liu*, and *Kemper*, with or without *Gardner-Denver*, for the same reasons as those discussed above regarding Ground 3 in Section XIV.G.

412. Limitation 9[d] is disclosed and/or rendered obvious by the combination of *Cicci, Coli, Dixon, Liu, and Kemper*, with or without *Gardner-Denver*, for the same reasons discussed above with respect to limitation 1[d] in Section XV.B.2 above.

G. CLAIM 10

413. Claim 10 is rendered obvious by the combination of *Cicci, Coli, Dixon, Liu, and Kemper*, with or without *Gardner-Denver*, for the same reasons as those discussed above with respect to Claim 2 in section XIV.C above.

H. DEPENDENT CLAIMS 11-14

414. Dependent Claims 11-14 are disclosed and/or rendered obvious by the combination of *Cicci, Coli, Dixon, Liu, and Kemper*, with or without *Gardner-Denver*, for the same reasons as those discussed above regarding Ground 3 in Sections XIII.H – XIII.K.

XVI. GROUNDS 5A AND 5B: THE COMBINATION OF *CICCI, COLI, DIXON, LIU, GARDNER-DENVER* AND *ANSI 6.1*, WITH OR WITHOUT *KEMPER* RENDERS CLAIM 7 OBVIOUS

A. MOTIVATION TO COMBINE

415. The motivation for a POSITA to combine *Cicci, Coli, Dixon, Liu* and *Gardner-Denver* is the same as that discussed above in Section XIV.A. The

motivation for a POSITA to combine *Cicci/Coli/Dixon/Liu/Gardner-Denver* and *Kemper* is the same as that discussed above in Section XV.A. Nothing in *ANSI/HI 6.1* teaches away from the combination.

416. A POSITA would have been further motivated to combine the teachings of *ANSI/HI 6.1* with the combination of *Cicci, Coli, Dixon, Liu* and *Gardner-Denver*, with or without *Kemper*, and would have had a reasonable expectation of success in doing so. *ANSI/HI 6.1* is analogous art to the '162 Patent because it is directed to the same field of endeavor as the '162 Patent of hydraulic fracturing systems, as it describes operations of plunger pumps commonly used in hydraulic fracturing, as I explain further below.³⁸⁸ *ANSI/HI 6.1* also would have been reasonably pertinent to the problem with which the '162 Patent is concerned—fluid flow rates for fracturing operations³⁸⁹—as *ANSI/HI 6.1* relates to sizing hydraulic pumps and piping to maintain sufficient fluid velocity or flow.³⁹⁰

³⁸⁸ Ex. 1011 (*ANSI/HI 6.1*), pg. 66.

³⁸⁹ For example, the '162 Patent describes “problems with flow rates, as flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site.” Ex. 1001 at 1:14-45. Similarly, during prosecution of the application that led to the '162 Patent, the applicant distinguished prior art by arguing that it did not “identify the problem associated with efficient fluid flow rates for fracturing operations.” Ex. 1003 ('162 Patent File History), pg. 433 (Sept. 29, 2020 Response to Nonfinal Rejection, pg. 8)

³⁹⁰ Ex. 1011 (*ANSI/HI 6.1*), pg. 66.

417. *ANSI/HI 6.1* is the “American National Standard for Reciprocating Power Pumps” and is published by the American National Standards Institute (ANSI) and developed by the Hydraulic Institute.³⁹¹ *ANSI/HI 6.1* describes that “Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus and other criteria for approval have been met by the standards developer.”³⁹² Further, *ANSI/HI 6.1* discloses that “Consensus is established when, in the judgement of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests [] Consensus requires that all view and objections be considered, and that a concerted effort be made toward their resolution.”³⁹³

418. *ANSI/HI 6.1* teaches that the “purpose and aims of the Hydraulic Institute” includes “develop and publish standards for pumps” and “to collect and disseminate information of value to its members and to the public”.³⁹⁴ Further, *ANSI/HI 6.1* that “Hydraulic Institute Standards are adopted in the public interest and are designed to help eliminate misunderstandings between the manufacturer, the purchaser and/or the user and to assist the purchaser in selecting and obtaining the

³⁹¹ Ex. 1011 (*ANSI/HI 6.1*) Cover

³⁹² Ex. 1011 (*ANSI/HI 6.1*) pg. ii.

³⁹³ Ex. 1011 (*ANSI/HI 6.1*) pg. ii.

³⁹⁴ Ex. 1011 (*ANSI/HI 6.1*) pg vi.

proper product for a particular need.”³⁹⁵ Further, *ANSI/HI 6.1* describes that “An Institute Standard defines the product, material, process or procedure with reference one or more of the following: nomenclature, composition, construction, dimensions, tolerances, safety, operating characteristics, performance, quality, rating, testing and service for which designed.”³⁹⁶ Further, *ANSI/HI 6.1* describes, in the Scope of *ANSI/HI 6.1*, that “[t]he standard applies to reciprocating power pumps. It includes types and nomenclature; definitions; design and application; and installation, operation and maintenance.”³⁹⁷ A POSITA would have recognized, from these disclosures, that *ANSI/HI 6.1* represented industry consensus for definitions; design and application; and installation, operation and maintenance of reciprocating power pumps.

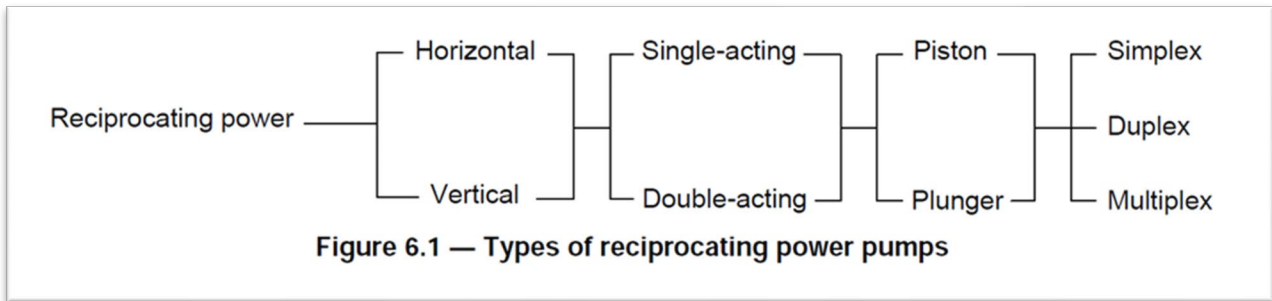
419. *ANSI/HI 6.1* further teaches that “[a] reciprocating power pump is one driven by power from an outside source applied to the crankshaft of the pump. [] There are several variations and types of reciprocating power pumps,”³⁹⁸ which are shown in Figure 6.1.

³⁹⁵ Ex. 1011 (*ANSI/HI 6.1*) pg vi.

³⁹⁶ Ex. 1011 (*ANSI/HI 6.1*) pg vi.

³⁹⁷ Ex. 1011 (*ANSI/HI 6.1*) pg vi.

³⁹⁸ Ex. 1011 (*ANSI/HI 6.1*) pg 1.

Ex. 1011 (*ANSI/HI 6.1*) Figure 6.1

Accordingly, a POSITA would have understood that the teachings in *ANSI/HI 6.1* are directed towards the type of pumps used for hydraulic fracturing in the system of *Cicci/Coli*, as described above in Section XII.B.2, which is incorporated herein by reference. For example, *Coli* discloses that pumps for hydraulic fracturing “can be a triplex or quintuplex plunger style fluid pump,”³⁹⁹ which is one of the types of reciprocating pumps for which disclosure is made in *ANSI/HI 6.1*. Accordingly, a POSITA would have found the information contained in *ANSI/HI 6.1* useful in applying reciprocating pumps in the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, and would have looked to *ANSI/HI 6.1* for implementation details for the multi-plunger hydraulic fracturing pump in the hydraulic fracturing system of the *Cicci/Coli/Dixon/Liu/Gardner-Denver* combination, with or without *Kemper*.

³⁹⁹ Ex. 1006 (*Coli*) ¶[0011]; see also [0015], [0035], [0046], [0050], Claim 6, Claim 7, Claim 27.

420. Further, *ANSI/HI 6.1* describes the use of reciprocating power pumps to pump slurry, such as would have been used in the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*. As discussed above in Section XII.B.3 and XIII.A, which are each incorporated herein by reference, the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, incorporates a slurry comprised of proppant and water to perform hydraulic fracturing. Like the combination of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, *ANSI/HI 6.1* discloses that “[r]eciprocating pumps are used to handle slurries for in-plant process and pipeline applications.”⁴⁰⁰ A POSITA would have recognized that “in-plant” applications would include a hydraulic fracturing plant, such as the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*.

421. Like *Liu*, which discloses that slurry velocities should be maintained between a minimum velocity (high enough to prevent solid dropout) and a maximum velocity (low enough to prevent unacceptable pressure drop or wear), as discussed above in Sections XIII.D – XIII.E and XIV.F, and incorporated herein by reference, *ANSI/HI* teaches that “hydraulic passages should be sized to that the lowest velocity of the liquid will be above the critical carrying velocity of 1.2 to 1.8 m/s (4 to 6 ft/s) as an average. The highest velocity should be below that which causes excessive

⁴⁰⁰ Ex. 1011 (*ANSI/HI 6.1*) pg 66.

erosion. Typical average operating velocities through a reciprocating slurry pump's passages are 1.8 to 3.6 m/s (6 to 12 ft/s).”⁴⁰¹ A POSITA would have been motivated to apply these teachings to the hydraulic passages of the hoses in the system of *Cicci/Coli/Dixon/Liu* to obtain the benefits of avoiding such excessive erosion, which would damage the pipe and equipment. A POSITA would have had a reasonable expectation of success in doing so at least because the same slurry passes through the passages of the pump and the hoses, and the same scientific principle, as described by *Liu*, apply.

422. *ANSI/HI 6.1* further teaches that the “critical carrying velocity” is “the mean velocity of the specific slurry in a particular conduit, above which the solids phase remains in suspension and below which solid-liquid separation occurs.”⁴⁰² Accordingly, *ANSI/HI 6.1*’s teachings are complimentary to those in *Liu*. Further a POSITA would have understood that the “excessive erosion” that *ANSI/HI 6.1* teaches to avoid is the same wear (abrasion) that *Liu* teaches occurs with high velocity slurries.

423. Accordingly, while *Liu* describes the scientific principles which would enable a POSITA to apply the pumps and hoses successfully, *ANSI/HI 6.1* provides

⁴⁰¹ Ex. 1011 (*ANSI/HI 6.1*) pg 66.

⁴⁰² Ex. 1011 (*ANSI/HI 6.1*) pg 34.

real-world examples of numbers which should be used while applying those principles. Accordingly, a POSITA would have been motivated to apply the limits on velocity of the slurry described by *ANSI/HI 6.1* when applying those principles described in *Liu* to the practical application of those principles in the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*. A POSITA accordingly would have been motivated to look to *ANSI/HI 6.1* for implementation details.

424. A POSITA would have had a reasonable expectation of success in applying the teachings of *ANSI/HI 6.1* to the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, at least because the combination merely applies a known technique (practical limits on slurry velocity) to a known system (the hydraulic fracturing system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*) ready for improvement (the practical application of *Liu*'s scientific principles) to yield predictable results (a system which minimizes proppant drop out and wear/abrasion/erosion).

B. DEPENDENT CLAIM 7: “7. THE SYSTEM OF CLAIM 1, WHEREIN THE FIRST DIAMETER IS ASSOCIATED WITH A SECOND THRESHOLD, CORRESPONDING TO A MAXIMUM SUGGESTED FLOW RATE, AN OPERATING WINDOW FOR THE ELECTRIC POWERED PUMP EXCEEDING THE MAXIMUM SUGGESTED FLOW RATE.”

425. Claim 7 would have been obvious to a POSITA based on the combined teachings of *Cicci*, *Coli*, *Dixon*, *Liu* and *Gardner-Denver*, with or without *Kemper*, as discussed above in Section XIV.F, incorporated herein by reference. *ANSI/HI 6.1* provides further evidence that Claim 7 would have been obvious to a POSITA.

426. *Liu* teaches, as discussed in Sections XIII.D – XIII.E and XIV.F, that velocity of a slurry should be held between a minimum velocity, to preventing slurry dropout, and a maximum velocity, to prevent unacceptable pressure drop and wear (abrasion). *Liu* further teaches that the velocity (V) of a fluid, is related to both flowrate (Q) and diameter (D) of the hose as shown in the equation below.

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

427. While *Liu* contains these known scientific principles, *ANSI/HI 6.1* provides real-world velocities useful for applying these principles. For example, *ANSI/HI 6.1* teaches that, when pumping a slurry, “hydraulic passages should be sized to that the lowest velocity of the liquid will be above the critical carrying velocity of 1.2 to 1.8 m/s (4 to 6 ft/s) as an average. The highest velocity should be

below that which causes excessive erosion. Typical average operating velocities through a reciprocating slurry pump's passages are 1.8 to 3.6 m/s (6 to 12 ft/s).”⁴⁰³

A POSITA would have recognized that the same principles would have applied to the hydraulic passages of the hoses in the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, particularly in light of the abrasion teachings of *Liu*. A POSITA would have been motivated to apply these teachings to the hoses to obtain the benefits of avoiding excessive erosion, would damage the pipe and equipment. It would have been obvious to a POSITA to apply such teachings to the hoses, at least because the same slurry passes through the passages of the pump and the hoses, and the same scientific principle, as describe by *Liu*, would apply.

428. *ANSI/HI 6.1* further teaches that the “Critical carrying velocity” is “the mean velocity of the specific slurry in a particular conduit [e.g., hose], above which the solids phase remains in suspension and below which solid-liquid separation occurs.”⁴⁰⁴ Accordingly, *ANSI/HI 6.1*’s teachings are complimentary to those in *Liu*. Further a POSITA would have understood that the “excessive erosion” that *ANSI/HI 6.1* teaches to avoid is the same wear (abrasion) that *Liu* teaches occurs with high velocity slurries.

⁴⁰³ Ex. 1011 (*ANSI/HI 6.1*), pg. 66.

⁴⁰⁴ Ex. 1011 (*ANSI/HI 6.1*) pg 34.

429. A POSITA, then, would have understood, based on the combined teachings of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, and *ANSI/HI 6.1*, that velocities of the slurry in the hydraulic fracturing system should be maintained between 1.8 to 3.6 m/s (6 to 12 ft/s) to minimize slurry drop out and to minimize wear/abrasion/erosion. For any given diameter of hose, there is a maximum flow rate above which velocity would exceed 12 ft/s, leading to unacceptable pressure drop or wear. Further, for any given diameter of hose, there is a minimum flow rate below which velocity would be below 6 ft/s, leading to unacceptable slurry drop-out. Accordingly, it would have been obvious to a POSITA that for any given first diameter, there is a second threshold that corresponds to a maximum flow rate which would limit pressure drop and wear to acceptable levels.

430. Applying *Liu*'s formula, described above, it would have been obvious to a POSITA to calculate example minimum and maximum flowrates which would apply the limits of *ANSI/HI 6.1* with various hose sizes which would have been obvious to use, as described above in Section XII.B – XII.C and XIII.D – XIII.E, and incorporated herein by reference (e.g., hose sizes smaller than the diameter of standard fracturing pump connections, 6"). These minimum and maximum flowrates are contained in the table below.

Diameter of Hose (inches)	Minimum Flowrate (BPM)	Maximum Flow Rate (BPM)
3	3.15	6.29
4	5.60	11.19
5	8.74	17.49

431. As discussed above in Section XIV.F *Gardner-Denver* describes that its pump has a range of operations, teaches that the “operating window” for each pump is between 191 GPM (4.5 BPM, red box in the figure below) and 2,044 GPM (48.66 BPM) depending on the design, speed and specific well conditions.⁴⁰⁵ For the conditions specified in *Cicci* (“5,000 PSI to 15,000 PSI or more”),⁴⁰⁶ the range of each pump is 191 GPM (4.5 BPM, annotated in red) to 734 GPM (17.5 BPM, annotated in blue).

⁴⁰⁵ Ex. 1010 *Gardner* pg. 20 of the PDF excerpted and annotated.

⁴⁰⁶ Ex. 1004 (*Cicci*) 2:39-42; Ex. 1005 (*Cicci Provisional*) [12].

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

Ex. 1010 Gardner pg. 20 of the PDF excerpted and annotated

A comparison of the operating range of the *Gardner-Denver* pump with the practical maximum flowrate thresholds described by *ANSI/HI 6.1*, applying the principles of *Liu* shows that the operating range exceeds the maximum flowrate threshold of the hose sizes which would have been obvious to a POSITA to use in the system of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*.

432. Accordingly, the combination of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, and *ANSI/HI 6.1* teaches wherein the first diameter is associated with a second threshold, corresponding to a maximum suggested flow rate, an operating window for the electric powered pump exceeding the maximum

suggested flow rate. Thus, Claim 7 would have been obvious to a POSITA based on the combined teachings of *Cicci/Coli/Dixon/Liu/Gardner-Denver*, with or without *Kemper*, and *ANSI/HI 6.1*.

XVII. CONCLUSION

433. 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 August 29, 2025.



Dr. Robert A. Durham