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 No. IPR2025-01539
Patent 11,668,420

PETITION FOR *INTER PARTES* REVIEW OF CLAIMS 1-20 OF U.S. PATENT NO. 11,668,420

TABLE OF CONTENTS

Page

I. MANDATORY NOTICES 1
II. STANDING AND FEES 2
III. THE '420 PATENT 2
A. Subject Matter 2
B. Prosecution History 4
C. Priority Date 5
IV. SUMMARY OF PRIOR ART AND GROUNDS 5
A. Cicci (EX1004) 5
B. Coli (EX1006) 7
C. Liu (EX1007) 8
D. Kajaria (EX1008) 9
E. Dixon Catalogs (EX1009, EX1012) 11
F. Gardner-Denver Catalog (EX1010) 14
G. ANSI/HI 6.1 (EX1011) 15
H. Grounds 16
V. LEVEL OF ORDINARY SKILL 16
VI. CLAIM CONSTRUCTION 17
VII. THE CHALLENGED CLAIMS ARE UNPATENTABLE 17
A. Ground 1 17
1. Motivation to Combine 17
2. Claim 1 27
3. Claim 2 45
4. Claim 3 47
5. Claim 4 48
6. Claim 5 50
7. Claim 6 52
8. Claim 7 54
9. Claim 9 55

10. Claim 10 59
11. Claim 11 61
12. Claim 12 66
13. Claim 13 66
14. Claim 14 67
15. Claim 15 67
16. Claim 16 67
17. Claim 18 67
18. Claim 19 67

B. Ground 2 67
1. Motivation to Combine 67
2. Claim 1 69
3. Claim 2 70
4. Claim 8 72
5. Claim 11 75
6. Claim 12 76
7. Claim 17 76
8. Claims 3-7, 9-10, 13-16, and 18-19 76

C. Grounds 3A and 3B 76
1. Motivation to Combine 76
2. Claim 20 81

D. Ground 4 85
1. Motivation to Combine 85
2. Claim 8 88
3. Claim 17 91

VIII. CONCLUSION 91

LIST OF EXHIBITS

Ex. No.[1]	Description
1001	U.S. Patent No. 11,668,420 to Jared Oehring *et al.* (the "'420 Patent")
1002	Declaration of Dr. Robert Durham
1003	File History for U.S. Patent No. 11,668,420 (App. No. 17/321,936) ("File History")
1004	U.S. Patent No. 11,549,348 to Cicci et. al ("*Cicci*")
1005	U.S. Provisional Application No. 62/941,459 (*"Cicci Provisional")*
1006	U.S. Patent Publication No. 2012/0255734 to Coli ("*Coli*")
1007	H. Liu, *Pipeline engineering*. CRC Press, 2003 ("*Liu*")
1008	U.S. Patent No. 9,127,545 to Kajaria
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*") 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 Langenfelder
1014	Declaration of Dr. Sylvia Hall-Ellis, Ph.D.
1015	Michael Morton, "*Unlocking the Earth: A Short History of Hydraulic Fracturing*," GEO ExPro, Vol. 10, No. 6, December 2013 https://geoexpro.com/unlocking-the-earth-a-short-history-of- hydraulic-fracturing/ (last accessed November 30, 2023)

[1] Citations to patents are made by column and line number. Citations to patent publications are made by paragraph number. Citations to EX1003, EX1010, EX1011, and EX1053 are made with reference to the Bates-stamped pagination. Citations to other exhibits are to the original page numbers found in the underlying document. All emphases and annotations are added unless otherwise indicated.

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," *Journal of Petroleum Technology*, Vol. 62, Issue 12 (Dec. 2010).
1018	Bourgoyne, A. T., Jr., K. K. Millheim, M. E. Chenevert and F. S. Young, Jr. (1986). Applied Drilling Engineering. *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 *et al.* entitled "System and Process for Extracting Oil and Gas by Hydraulic Fracturing" ("*Sanborn*")
1021	U.S. Patent No. 11,959,371 to Oehring
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 ("*Waters*")
1023	Pearson, C.M., Bond, A.J., Eck, M.E., and J.H. Schmidt. "*Results of Stress-Oriented and Aligned Perforating in Fracturing Deviated Wells*." J Pet Technol 44 (1992): 10–18. doi: https://doi.org/10.2118/22836-PA
1024	Mutalik, P N, & 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 ("*Mutalik*")
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 ("*Mayerhofer*")
1026	Roussel, Nicolas P., and Mukul M. Sharma. "*Optimizing Fracture Spacing and Sequencing in Horizontal-Well Fracturing*." SPE Prod &

	Oper 26 (2011): 173–184. doi: https://doi.org/10.2118/127986-PA ("*Roussell*")
1027	K. R. Webster, W. C. Goins, Jr., and S. C. Berry, "*A Continuous Multistage Tracing Technique*," *Journal of Petroleum Technology,* vol. 17, no. 06, pp. 619-625, 1965, doi: 10.2118/977-pa. ("*Webster*")
1028	A. Casero, G. Pace, B. Malone, F. Cantaloube, L. Tealdi, H. Malonga, and R. Seale, "*Continuous Pumping, Multistage, Hydraulic Fracturing in Kitina Field, Offshore Congo, West Africa*," in *SPE International Symposium and Exhibition on Formation Damage Control*, 2008, vol. All Days, SPE-112442-MS, doi: 10.2118/112442-ms. [Online]. Available: https://doi.org/10.2118/112442-MS ("*Casero*")
1029	S. Rassenfoss, "*A Look Into What Fractures Really Look Like*," Journal of Petroleum Technology*,* vol. 70, no. 11, pp. 28-36, 2018, doi: 10.2118/1118-0028-jpt. ("*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, *Power Generation Products*, 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., Marks' Standard Handbook for Mechanical Engineers (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	Intentionally Left Blank
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. "*The Shale Evolution: Zipper Fracture Takes Hold*," JPT Technology Writer, October 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	Intentionally Left Blank
1053	Affidavit of Mina Ching, dated September 23, 2025
1054	Hydraulic Fracturing Institute Reciprocating Pump Standards: available at https://web.archive.org/web/20171029162737/http:/estore.pumps.org/Standards/Reciprocating/PumpsPDF.aspx
1055	Hydraulic Fracturing Institute Reciprocating Pump Standards: available at https://web.archive.org/web/20150808112714/http://estore.pumps.org/Standards/Reciprocating/Hardcopy.aspx
1056	File History for U.S. Patent No. 11,009,162
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)
1059	Claim Listing

I. MANDATORY NOTICES

Real Party in Interest: Liberty Energy Services LLC, Liberty Energy Inc. (collectively, "Liberty" or "Petitioners"), and Liberty Advanced Equipment Technologies LLC are the real parties in interest.

Related Matters: The '420 Patent is involved in a pending lawsuit between Petitioners and U.S. Well Services, LLC ("Patent Owner," or "PO") entitled *ProFrac Services LLC et al. v. Liberty Energy Services LLC et al.*, Case No.2:25-cv-522 (E.D. Tex.) ("Liberty Litigation"). Petitioners have challenged the parent patent, U.S. No. 11,009,162 ("the '162 Patent"), to which the '420 Patent is a continuation, in *Liberty Energy Inc. et al. v. U.S. Well Services, LLC*, Case No. IPR2025-01445 (PTAB).

Lead Counsel and Back-Up Counsel: Petitioners designate lead and back-up counsel as noted below. A Power of Attorney is filed concurrently herewith under 37 C.F.R. §42.10(b).

Lead Counsel	Backup Counsel
Chad C. Walters, Reg. No. 48,022 Baker Botts L.L.P. 2001 Ross Ave., Suite 900 Dallas, TX 75201-2980 Phone: (214) 953-6511 chad.walters@bakerbotts.com	Melissa L. Muenks, Reg. No. 78,860 Baker Botts L.L.P. 401 S. 1st Street, Suite 1300 Austin, Texas 78704 Phone: (214) 322-2671 melissa.muenks@bakerbotts.com Jacob McDonald, Reg. No. 74,336 Baker Botts L.L.P. 2001 Ross Ave., Suite 900 Dallas, TX 75201-2980

	Phone: (214) 953-6652 jacob.mcdonald@bakerbotts.com

Service Information: Correspondence to lead and back-up counsel can be provided at the postal and electronic addresses above. Petitioners also consent to service by electronic mail at chad.walters@bakerbotts.com, melissa.muenks@bakerbotts.com, jacob.mcdonald@bakerbotts.com, and DLLibertyvUSWellServicesIPRs@bakerbotts.com.

II. STANDING AND FEES

Standing: Petitioners certify under 37 C.F.R. §42.104(a) that the '420 Patent is eligible for *inter partes* review and that Petitioners are not barred or estopped from requesting *inter partes* review on the grounds set forth herein.

Fees: The Office is authorized to charge the fee set forth in 37 C.F.R. §42.15(a) to Deposit Account No. 02-0384 as well as any additional fees that might be due in connection with this Petition.

III. THE '420 PATENT

A. Subject Matter

The '420 Patent describes a conventional fracturing system as illustrated in Figure 1:

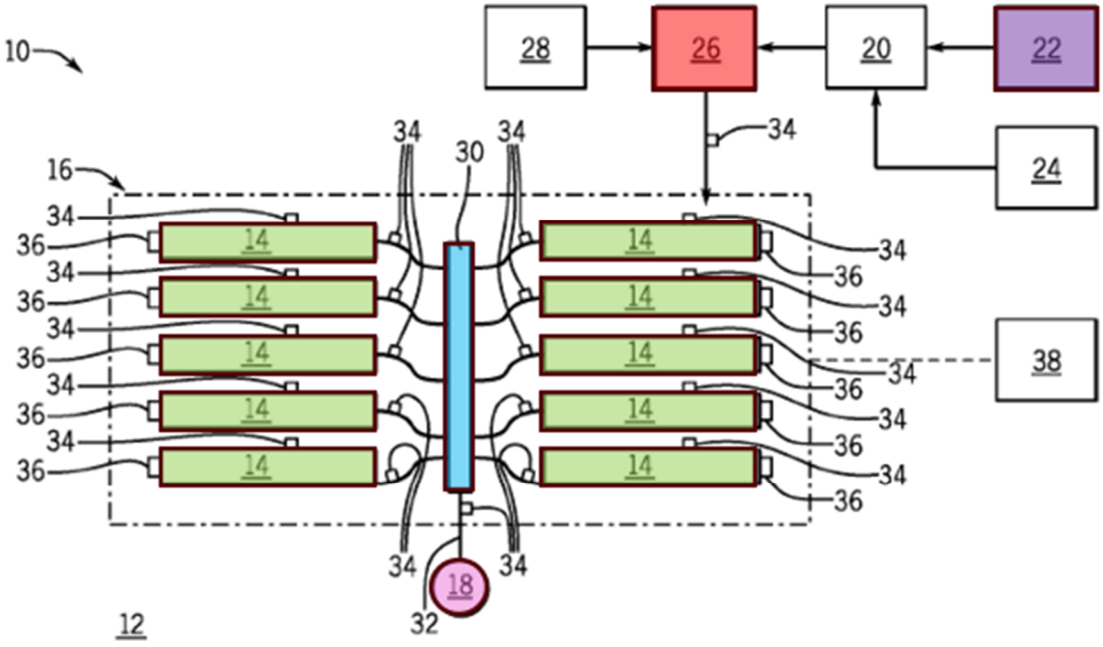


FIG. 1

EX1001, Fig. 1, 4:28-60. The blender unit 26 (red) receives fluid from the fluid source 22 (purple) and adds proppant to form a slurry. *Id.*, 4:28-51. The pumps 14 (green) pressurize the slurry. *Id.*, 4:30-42. The distribution system 30 (blue), such as a missile, receives the slurry from the pump for injection into the wellhead. *Id.*, 4:45-50. The patent further describes a "hose extending between the fluid source and the electric powered pump[.]" *Id.*, Abstract.

The Patent also describes a fitting between the hose and the 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," illustrated below:

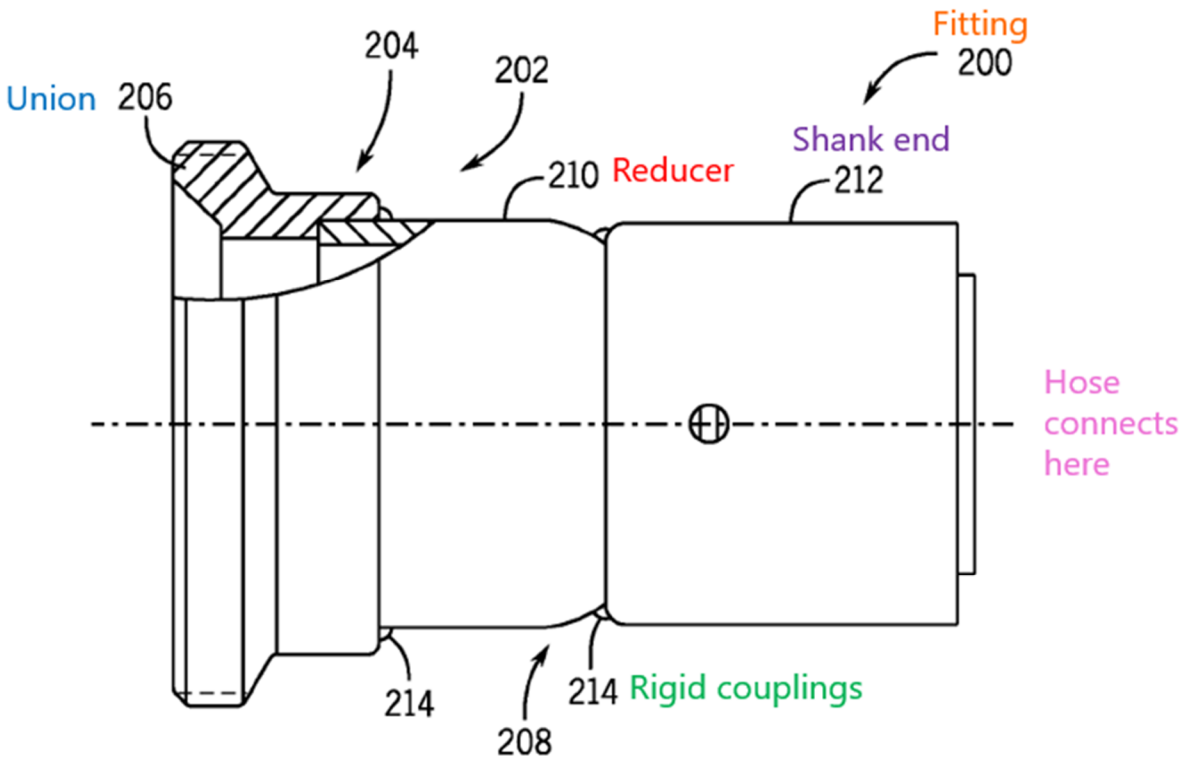


FIG. 2A

Id., Fig. 2A, Abstract. The patent describes a third diameter, associated with the hose's body. *Id*., 6:28-30. The patent describes embodiments in which the first, second, and third diameters have different relative sizes. *Id*., 6:22-38.

B. Prosecution History

The '936 Application that ultimately issued as the '420 Patent was filed on May 17, 2021. The Examiner allowed the claims without any substantive rejections, despite the prior art. EX1003, 16, 160. The Examiner identified the following as alleged points of novelty: "wherein a system comprising an electric powered multi-plunger hydraulic fracturing pump, a fluid source, and a hose extended between the

two, wherein the hose comprises a pair of fittings with the diameters as claimed." *Id*., 160.

C. Priority Date

The '420 Patent was filed on May 17, 2021, and lists that it is a continuation of U.S. Application No. 16/728,359 ("the '359 Application"), filed December 27, 2019, and issued as the '162 Patent. For purposes of this Petition, Petitioner assumes that the earliest possible priority date for the Challenged Claims of the '420 Patent would be no earlier than December 27, 2019, when the '359 Application was filed.

IV. SUMMARY OF PRIOR ART AND GROUNDS

A. Cicci (EX1004)

United States Patent 11,549,348 ("*Cicci*") was filed on November 20, 2020. *Cicci* claims priority to U.S. Provisional Application 62/941,459 ("*Cicci Provisional*") (EX1005) filed on November 27, 2019. The subject matter relied on in *Cicci* is disclosed in *Cicci Provisional*. *Cicci* properly claimed benefit to, was filed copending with, and shared a common inventor with the *Cicci Provisional*. EX1004, (22), (60), (72); 35 U.S.C. §102(d); MPEP §2154.01(b). *Cicci* was effectively filed on November 27, 2019, and qualifies as prior art under §102(a)(2).

Cicci describes "a hydraulic fracturing system using flexible hose or pipe." EX1004, Abstract; EX1005, ¶¶[1], [15]-[16]. The flexible pipe couples "a pump and a manifold of the hydraulic fracturing system." EX1004, Abstract; EX1005, ¶¶[15]-[16]. *Cicci* also discloses "a fitting affixed to each end of the flexible flow line" for

connection to the fluid source (manifold) and the pump. EX1004, 5:30-37; EX1005, ¶[24]. *Cicci*'s "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." EX1004, 7:42-47; EX1005, ¶[30]. *Cicci*'s hoses have "an inner diameter of one to eight inches." EX1004, 1:64-65; EX1005, ¶[4].

Cicci discloses blender 302 [red] that receives the fracturing fluid and blends it into a slurry. EX1004, 5:14-29; EX1005, ¶[23]. *Cicci* further discloses that "[t]he pumps 306 [green] deliver the pressurized fracturing fluid to the missile 304 [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)." EX1004, 1:9-19, 5:25-29; EX1005, ¶¶[1], [23].

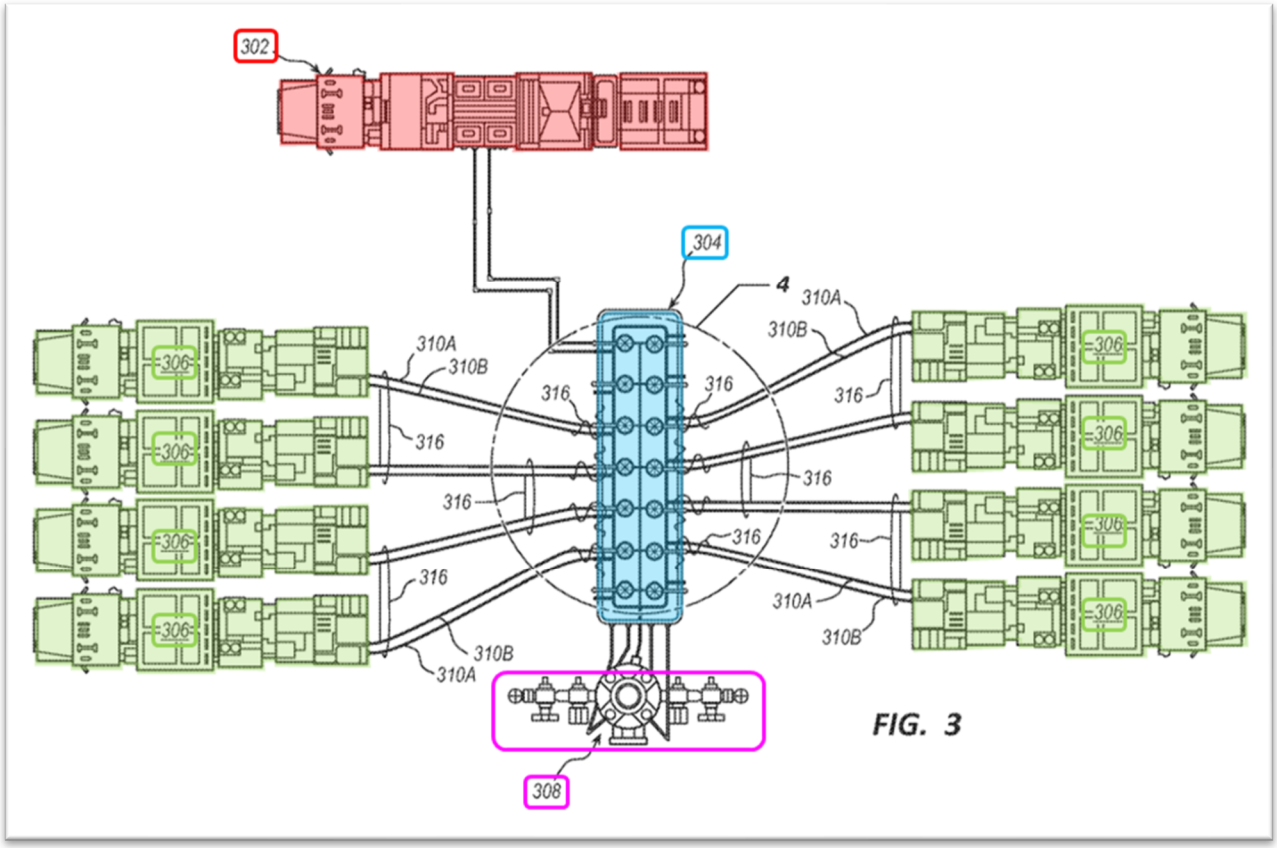


FIG. 3

EX1004, Fig. 3; EX1005, Fig 3; EX1002, ¶¶97-99.

B. Coli (EX1006)

U.S. Patent Application Publication No. 2012/0255734 ("*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. *Coli* qualifies as prior art under §§102(a)(1)-(2).

Like the '420 Patent, *Coli* involves a "fracturing system" for "delivering fracturing fluid to a wellbore at a fracturing operation." EX1006, ¶[0034]. For example, *Coli* discloses electric motors for driving the pumps. *Id.*, ¶[0042]. *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." *Id*., ¶¶[0046], [0049]; EX1002, ¶¶100-104.

C. Liu (EX1007)

Pipeline Engineering by Henry Liu ("*Liu*") is a textbook published in 2003. EX1007, Cover; EX1039. *Liu* was publicly accessible and indexed at the library, and accordingly would have been searchable and obtainable by the public, by at least September 9, 2003. EX1014, ¶¶14, 41-49. *Liu* qualifies as prior art under § 102(a)(1).

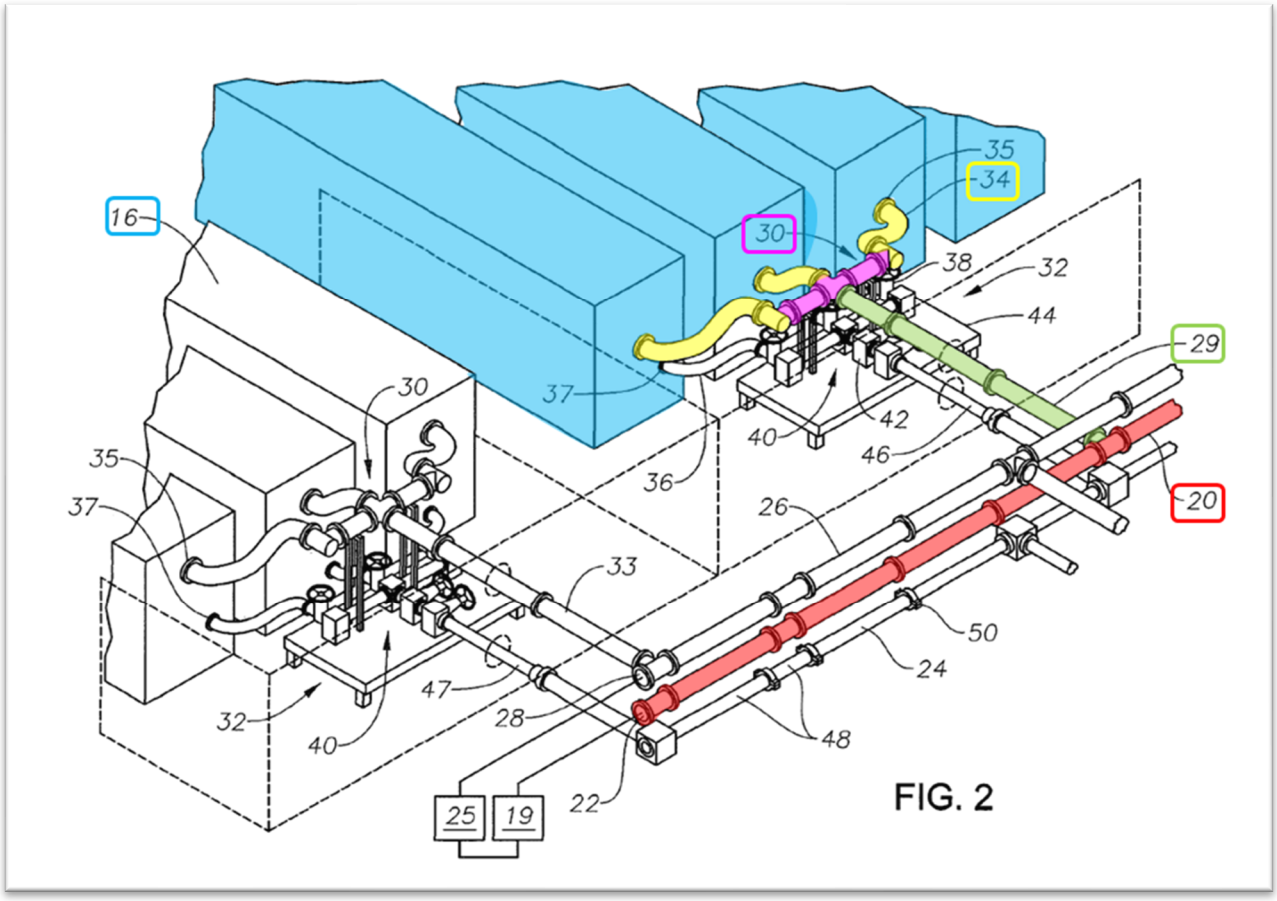
Liu discloses scientific principles regarding fluid flow, including slurries, through pipelines. EX1002, ¶106; EX1007, Preface. *Liu* contains a "review of fluid mechanics pertinent to pipe flow" and "more advanced subjects," including "flow of solid/liquid mixtures" (slurries). *Id*.

Chapter 5 discusses "the flow of solid particles transported by a liquid in pipelines, namely, slurry pipelines," and focuses on "horizontal or nearly horizontal pipes with particles suspended by a liquid," which applies to hydraulic fracturing piping systems, which use slurries (such as proppant carried by water with chemicals), and where the piping system is horizontal or nearly horizontal on the surface. EX1007, 131; EX1002, ¶¶105-107.

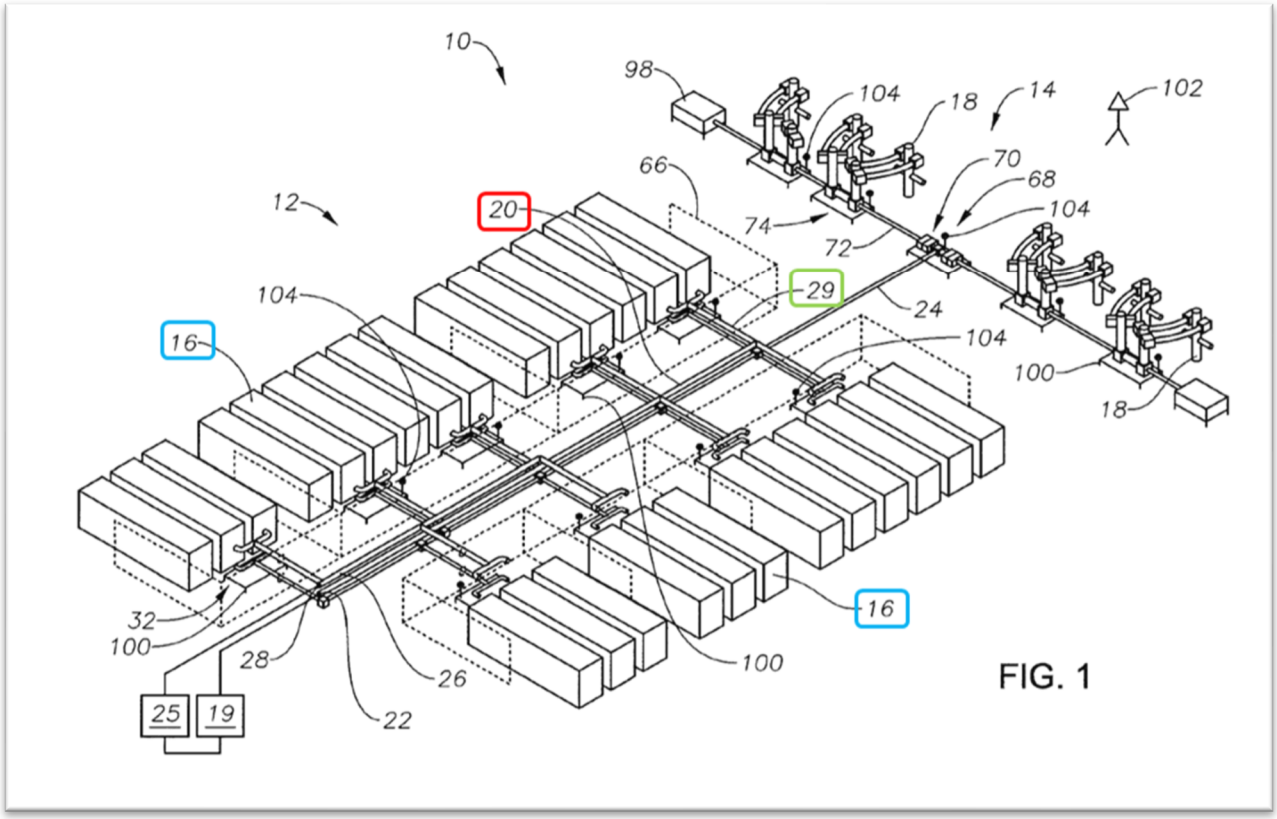
D. Kajaria (EX1008)

U.S. Patent No. 9,127,545 (EX1008) ("*Kajaria*") was filed on April 25, 2013. EX1008, (22). *Kajaria* qualifies as prior art under §§102(a)(1)-(2).

Kajaria discloses connecting to the inlet of a plurality of pumps from a single line connected to the fluid source 20. EX1008, 1:19-31, 4:16-45, Figs. 1-2; EX1002, ¶¶108-111. *Kajaria* discloses various examples, including the connection to three pump inlets, and the connection to two pump inlets from a single line. *Id.*, Figs. 1-2.


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FIG. 2

Id., Fig. 2.



EX1008, Fig. 1.

E. Dixon Catalogs (EX1009, EX1012)

Dixon-Australia (EX1009) and *Dixon-U.S.* (EX1012) (collectively, "*Dixon*")[2] are product catalogs that were publicly accessible by at least 2018, and are prior art under §102(a)(1). EX1002, ¶¶112-120; EX1013, ¶¶1-13.

[2] References to "*Dixon*" refer to both catalogs because the catalogs have the same disclosure of the claim limitations as applied in this Petition.

Dixon-Australia (EX1009) was publicly accessible on the Dixon website since at least October 2018. EX1040; EX1013, ¶8. The Dixon website lists "Publish Date: October 4, 2018":



EX1040, 7.

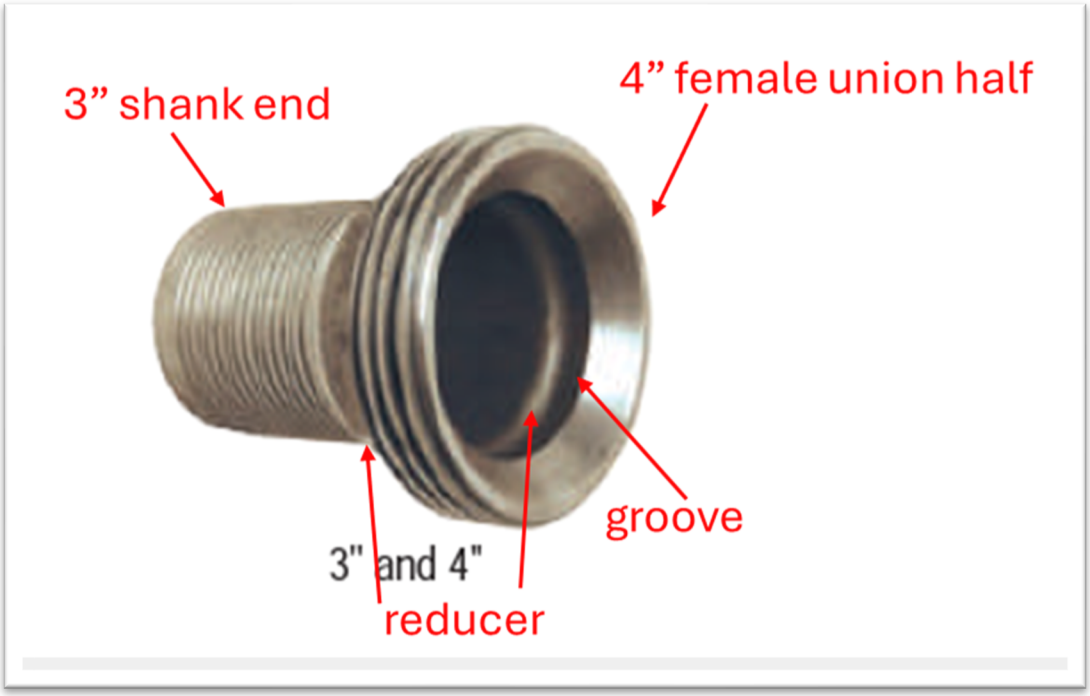
Dixon-U.S. (EX1012) was also publicly accessible on the Dixon website by at least April 2018. EX1013, ¶¶4-5, 10. To locate this catalog, a POSITA would navigate to "Product Literature" page of Dixon's website, see a list of Dixon's product literature, be able to search in the "Search" field, and/or be able to filter by product category in the "Product Category" field. *Id*., ¶6. Dixon also distributed almost 1,000 copies of *Dixon-U.S.* to its distributors in 2018. *Id*., ¶5. A POSITA could also request a copy of this catalog on Dixon's website. *Id*., ¶7.

This is consistent with indicia in the catalogs themselves. For example, the catalogs list a copyright date of "Copyright 2018 by Dixon Valve and Coupling." EX1009, 667; EX1012, 993. The catalogs also list "New Products for 2018."

EX1009, 10; EX1012, 2-3. The *Dixon-Australia* catalog is labeled "ADPL718," indicating that it would have been publicly accessible by July 2018. EX1009, Title; EX1013, ¶¶4, 8. The *Dixon-U.S.* catalog is labeled "DPL418," indicating that it would have been publicly accessible by April 2018. EX1012, Title; EX1013, ¶¶4-5; *see also* EX1009, 149; EX1012, 78; EX1041.

Based on this information, *Dixon-Australia* would have been publicly accessible by at least October 2018, and *Dixon-U.S.* would have been publicly accessible by at least April 2018. EX1002, ¶¶116-117; EX1013, ¶¶4-5. Dixon would have been a well-known company to a POSITA in 2019. EX1002, ¶118; EX1042-EX1043.

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 end that connects to the pump has a larger diameter than that of the end that connects to the hose:



EX1009, 149; EX1012, 78; EX1002, ¶119.

F. Gardner-Denver Catalog (EX1010)

Gardner-Denver is an operating and service manual for Gardner Denver's GD-2500Q Quintuplex pump that was originally published in 2001, and revised in 2005 (EX1010, 1, 46), and a GD-2500Q parts list published in 2005. EX1010, 47, 83; EX1002, ¶¶121-127. *Gardner-Denver* was publicly accessible on the internet by at least September 2012. EX1053, 1, 27-112. It additionally would have been common-place for a company releasing a product, such as Gardner-Denver's Quintuplex pump, to make the product manual readily available to the public, for example, by offering it for download from the company or distributor's website (as

Gardner-Denver did) and/or by making a print version publicly available. EX1002, ¶122. *Gardner-Denver* qualifies as prior art under §102(a)(1).

Coli references Gardner-Denver's "SWGS-2500"[3] pump as a "quintiplex or triplex plunger style pump" coupled to an electric motor and used in a fracturing module. EX1006, ¶[0046]. A POSITA would have understood the "SWGS-2500 quintuplex pump" refers to a Gardner Denver GD-2500Q power end (or pump end) coupled with a Gardner Denver SGWS fluid end. EX1002, ¶123. The public accessibility of *Gardner-Denver* by at least 2012 is further confirmed by this express reference in *Coli*, which was filed in 2012. EX1006, (22), ¶[0046].

G. ANSI/HI 6.1 (EX1011)

ANSI/HI 6.1 is the "American National Standard for Reciprocating Power Pumps," published in 2015. EX1011, 1, 3-4; EX1002, ¶¶128-135. *ANSI/HI 6.1* bears a copyright date of 2015 and was "approved" on March 5, 2015. EX1011, 3. *ANSI/HI 6.1* would have been publicly accessible online after its approval by at least June 2015, such that a POSITA could have located it through the exercise of ordinary diligence. EX1002, ¶¶131-132. *ANSI/HI 6.1* was publicly accessible from the

[3] A POSITA would have understood that "SWGS-2500" refers to "SGWS-2500"—*i.e.*, Super Gardner Well Services-2500, or a GD-2500Q power end coupled with a Super GWS Fluid End. EX1002, ¶123.

Hydraulic Institute by at least August 8, 2015 and/or October 29, 2017. *Id*., ¶¶133-134; EX1053, 1, 4-8; EX1054-EX1055. *ANSI/HI 6.1* also was publicly accessible and indexed at the library, and accordingly would have been searchable and obtainable by the public, by at least October 9, 2014. EX1014, ¶¶50-54. *ANSI/HI 6.1* therefore is prior art under §102(a)(1).

ANSI/HI 6.1 describes reciprocating power pumps to pump slurry, as would have been used in hydraulic fracturing systems. EX1011, 76; EX1002, ¶130. *ANSI/HI 6.1* teaches ranges of fluid velocities to avoid excessive corrosion. *Id*.

H. Grounds

Ground	Claims	Basis (35 U.S.C. §)	Prior Art
1	1-7, 9-16, 18-19	103	*Cicci, Coli, Dixon,* and *Liu*
2	1-19	103	*Cicci, Coli, Dixon, Liu,* and *Gardner-Denver*
3A	20	103	*Cicci, Coli, Dixon, Liu,* and *Kajaria*
3B	20	103	*Cicci, Coli, Dixon, Liu, Gardner-Denver,* and *Kajaria*
4	8, 17	103	*Cicci, Coli, Dixon*, *Liu, Kajaria, Gardner-Denver,* and *ANSI/HI 6.1*

EX1002, ¶19; EX1059 (listing challenged claim elements).

V. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art ("POSITA") 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. EX1002, ¶48.

VI. CLAIM CONSTRUCTION

Claim terms in IPR are construed according to their "ordinary and customary meaning" to a POSITA. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-13 (Fed. Cir. 2005) (*en banc*); 37 C.F.R. §42.100(b). Constructions are proposed "only to the extent necessary." *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). For purposes of this proceeding and grounds presented herein, Petitioners do not present any constructions. EX1002, ¶49.

VII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1

The *Cicci-Coli-Dixon-Liu* combination renders obvious claims 1-7, 9-16, 18-19. EX1002, ¶¶136-344.

1. Motivation to Combine

A POSITA would have been motivated to combine *Cicci*, *Coli*, *Dixon*, and *Liu*, and would have a reasonable expectation of success. EX1002, ¶¶137-173.

A POSITA would have been motivated to combine *Coli* with *Cicci*. EX1002, ¶¶137-155. Both *Coli* and *Cicci* are analogous art to the '420 Patent because they

are in the same field of endeavor of hydraulic fracturing systems. *Id.*; EX1001, Abstract, 1:17-19; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, Abstract, ¶¶[0003], [0009].

Coli and *Cicci* disclose similar and compatible hydraulic fracturing systems. EX1002, ¶¶142-143. Both *Cicci* and *Coli* disclose blending proppant and fluids to create a fracturing fluid. *Id*.; EX1004, 5:15-20; EX1005, ¶[23]; EX1006, ¶[0012]. Both *Cicci* and *Coli* disclose pumps used to pump the fracturing fluid downhole and fracture underground formations. EX1002, ¶143; EX1004, 1:9-15; EX1005, ¶[1]; EX1006, ¶[0009].

In light of *Cicci*'s disclosure of fracturing pumps, a POSITA would have been motivated to look to similar hydraulic fracturing references, such as *Coli*, for implementation details of appropriate pump configurations and power sources. EX1002, ¶¶144-145; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, ¶¶[0011], [0046], Figs. 3, 4A. 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. *See id*.; EX1002, ¶146. *Coli* additionally provides implementation details of configurations for a plurality of pumps. EX1006, ¶¶[0040], [0060], Figs. 2-3. 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. *Id*.; EX1006, ¶[0049].

A POSITA also would have been motivated to incorporate *Coli*'s electric-powered pump into *Cicci*'s system, considering the express benefits disclosed by *Coli*. EX1002, ¶¶147-154. A POSITA would have been motivated to incorporate *Coli's* electric motor 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 would have been well-known. *Id.*; EX1006, ¶¶[0046], [0049]. As *Coli* discloses, electric-powered pumps "obviate[e] the need for a constant supply of diesel fuel to the site and reduc[es] the site footprint and infrastructure required for the fracturing operation[.]" EX1006, Abstract. Further, the smaller size and lighter weight of electric pumps "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[.]" *Id*., ¶[0049]. Thus, "the number of fracturing modules 20 placed on each trailer 10" is "maximized." *Id*., ¶[0052]. *Coli* discloses how the electrification of the fracturing operation improves costs, efficiency, safety, and environmental impact. *Id*., ¶¶[0066], [0075], [0077], [0080].

For example, *Coli* teaches that using electric motors to drive the pumps, rather than diesel motors, allows for an increase in power delivered to the pump, reduces

parasitic losses, and allows for the pump to directly couple to the motor. *Id*. Reduced parasitic losses and increased horsepower delivered to the pump would increase the system's efficiency. EX1002, ¶154. Reduced numbers of pieces of equipment would lower maintenance requirements, as there would be fewer pieces of equipment to maintain. *Id*. A reduced footprint would allow the system to be configured in a smaller space and/or arranged more easily. *Id*. Reduced weight would make it easier to transport the pumps. *Id*. Additionally, an electric motor would reduce emissions and noise. *Id*.; EX1021, 1:46-65. A POSITA would have been motivated to realize these benefits. *Id*.

A POSITA would have had a reasonable expectation of success in the combination. EX1002, ¶155. Both *Cicci* and *Coli* disclose the equipment used to construct a hydraulic fracturing system. *Id*. *Cicci* discloses a pump in a hydraulic fracturing system, and *Coli* provides implementation details for those pumps. *Id.*; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, Abstract, ¶¶[0011], [0046], [0049], Figs. 3, 4A. Accordingly, incorporating *Coli's* electric-powered multi-plunger hydraulic fracturing pumps into *Cicci's* hydraulic fracturing system is merely applying a known technique to an improved known system in the same way. EX1002, ¶155; EX1021, 1:46-65 (electric-powered pumps were well known); EX1038, ¶¶[0033], [0040] (multi-plunger pumps were well known). Furthermore, combining *Coli*'s teachings would have yielded predictable results for a POSITA—a fracturing system

that is more efficient, has reduced equipment, a smaller footprint, lighter weight, and reduced noise and emissions, compared to diesel-powered systems. *Id*.

A POSITA would have been further motivated to incorporate *Dixon* into the *Cicci-Coli* system. *Id*., ¶¶156-165. *Dixon* is analogous art to the '420 Patent as it is in the same field of endeavor of hydraulic fracturing systems. *Id*., ¶156; EX1009, 149; EX1012, 78. For example, *Dixon* discloses "Dixon Frac Fittings" that are "[u]sed in the fast-paced transfer of water and sand slurry to a hydraulic fracturing site." EX1009, 149; EX1012, 78. *Dixon* also would have been reasonably pertinent to the problem with which the '420 Patent is concerned—fluid flow rates for fracturing operations—as *Dixon*'s frac fittings would have been applicable for use with slurry flow in a hydraulic fracturing system to address such problems. *Id*.; EX1002, ¶156; EX1001, 1:37-54; EX1056, 433.

A POSITA would have been motivated by *Cicci*'s disclosure of fittings to look to references that teach about fittings and hoses. EX1002, ¶¶157-158. For example, *Cicci* discloses fittings or couplings connecting the pump to flexible flow lines. *Id*.; EX1004, 5:31-37, 7:42-47; EX1005, ¶¶[24], [30]. A POSITA would have been motivated to look to *Dixon* for implementation details about such fittings, hoses, and couplings. EX1002, ¶¶159-162. *Dixon* contains information about commercially available hoses and fittings for "slurry" systems and hydraulic fracturing applications. *Id.*; EX1009, 11, 58, 149-151; EX1012, 78-82, 118. *Dixon*

also teaches other fittings useful in fracturing systems, including hammer unions, reducers, hose and hose assemblies, industrial hose fittings and pipe and pipe welding fittings, a POSITA would have found useful in the *Cicci-Coli* system. *Id.*; EX1009, 154, 405; EX1012, 628, 681-83.

A POSITA would have been motivated to incorporate *Dixon*'s fittings into the *Cicci-Coli* system to obtain the express benefits of *Dixon*'s fittings. EX1002, ¶163. For example, *Dixon*'s fittings have a "[o]ne piece design [which] eliminates leak path experienced with two-piece threaded systems." EX1009, 149; EX1012, 78 (similar). These Frac Fittings also are "[d]urable and safe with reliable hose retention when crimped as specified." EX1009, 149. *Dixon* shows various examples 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 a smaller hose. EX1009, 149; EX1012, 78.

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. EX1002, ¶164. A POSITA would have been further motivated to reduce the hose size to 5-inches to increase the slurry's velocity, 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. *Id.*; *infra*, §§VII.A.2(g), VII.A.3, VII.A.7-8.

A POSITA would have had a reasonable expectation of success in combining *Dixon* with *Cicci-Coli*. EX1002, ¶165. Such a combination would have been merely applying a known technique (*Dixon*'s hoses and fittings) to a known system (hydraulic fracturing system), ready for improvement (actual design and construction of the system) to yield predictable results (a practical fracturing system). *Id. Dixon* teaches specific fitting configurations designed for fracturing systems, as well as teachings regarding other industrial, piping, and weld fittings that would have been useful in designing the system described by *Cicci-Coli. Id.*; EX1009, 11, 58, 149-151, 154, 405; EX1012, 78-81, 111-113, 118, 608, 613, 628, 681.

A POSITA would have been further motivated to combine the *Cicci-Coli-Dixon* combination with *Liu*. EX1002, ¶¶166-173. A POSITA would have been motivated to use *Liu's* fluid flow teachings, including fluid flow of a slurry, into the *Cicci-Coli-Dixon* system. *Id.*, ¶166. *Liu* compiles established scientific principles into a single reference. *Id.*

Liu is analogous art to the '420 Patent because it is reasonably pertinent to the problem with which the inventor was involved. *Id*., ¶167. The '420 Patent is directed to the problem of fluid flow rates for fracturing operations. For example, the '420 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." EX1001, 1:49-54. Similarly, during prosecution of the parent '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." EX1056, 433. *Liu* teaches scientific principles directly applicable to the hydraulic fracturing systems of the '420 Patent and pertinent to the problem of efficient fluid flow rates for fracturing operations to which the inventor was involved. EX1002, ¶167.

A POSITA would have been motivated to look to *Liu* because *Liu* discloses scientific principles applicable to *Cicci-Coli-Dixon*. EX1002, ¶168. *Liu* is applicable to "pipeline engineering, construction, and/or operations issues in the real world." EX1007, Foreword. *Liu* addresses piping systems containing "crude oil, natural gas, petroleum products, water, solids and slurries." *Id*. 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. EX1004, 5:15-20; EX1005, ¶[23]; EX1006, ¶[0012]. Similarly, *Dixon* contains information about commercially available products, including hoses and fittings, for use in "slurry" and "frac" systems. EX1009, 11; EX1002, ¶¶159-161, 168.

A POSITA further would have been motivated to look to *Liu* because *Liu*'s disclosure is also appropriate for analyzing and sizing piping systems (including

flexible hoses) for slurries, as disclosed by *Cicci* and *Coli*.[4] *Id*., ¶169. *Liu* addresses not only the "extensive network of underground pipelines" but also the "[i]n-plant pipelines" used in most industrial plants, of which a fracturing site is one. *Id*.; EX1007, Preface. Further, *Liu* is useful to "engineers who must deal with *piping or pipelines* in their professional work." EX1007, Preface.

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." EX1002, ¶¶107, 170; EX1007, 131. For example, Chapter 5 discusses "Flow of Solid-Liquid Mixture in Pipe (Slurry Pipelines)," and "the flow of solid particles transported by a liquid in pipelines, namely, slurry pipelines," "focus[ing] on horizontal or nearly horizontal pipes with particles suspended by the liquid." *Id.*

Accordingly, a POSITA would have been motivated to apply *Liu*'s principles to understand the *Cicci-Coli-Dixon* system's fluid dynamics and to size equipment

[4] *Cicci* and *Liu* further describe that "the term 'pipe' and 'hose' are used interchangeably." EX1004, 4:45-46; EX1005, ¶[19]; *e.g.*, EX1007, 15, 336. Accordingly, a POSITA would have understood *Cicci* and *Liu*'s teachings regarding pipe sizing to also apply to hose sizing. EX1002, ¶169.

within the system. EX1002, ¶171. *Liu*'s principles apply to piping systems, including hose systems. *Id*. Furthermore, *Liu* dedicates an entire chapter to slurry flow, which applies to the slurry in the *Cicci-Coli-Dixon* system. *Id*.; EX1007, 131-148.

A POSITA would have been motivated to apply *Liu*'s principles to the *Cicci-Coli-Dixon* system to gain the benefits of maintaining sufficient fluid velocity and flow, and thus reducing the possibility of slurry drop-out, plugging the hoses, and/or damaging cavitation, as taught by *Liu*. EX1002, ¶172; EX1007, 132-133, 269.

A POSITA would have had a reasonable expectation of success in combining *Liu* with *Cicci-Coli-Dixon,* as *Liu* teaches scientific principles directly applicable to the *Cicci-Coli-Dixon* slurry piping system. EX1002, ¶173. Applying *Liu* would have involved merely applying a well-known technique (*Liu's* scientific principles behind fluid flow) to a known system (the *Cicci-Coli-Dixon* hydraulic fracturing system), which was ready for improvement to yield predictable results. *Id*. The predictable results expected would be a hydraulic fracturing system with hoses sized properly to reduce the possibility of plugging the hoses, and minimize pressure drop. *Id*. Further, a POSITA would have expected predictable results in a fracturing system using hoses that are sized appropriately for the fluid flow. *Id*. Further, a POSITA would have reasonably expected a fracturing system with reduced risk of damage, for example, from cavitation. *Id.*, ¶¶59-72, 173; *infra*, §§VII.A.2(g), VII.A.3, VII.A.7-8.

2. Claim 1

a) 1[p]

To the extent the preamble is limiting, the *Cicci-Coli-Dixon-Liu* combination discloses the preamble. EX1002, ¶¶175-180.

Cicci discloses a "[h]ydraulic fracturing system[]" for fracturing "subterranean geological formations." EX1004, 1:7-19; EX1005, ¶[1]. *Coli* similarly discloses a "fracturing system" for "hydraulic stimulation of underground hydro-carbon bearing formations." EX1006, Abstract, ¶¶[0003], [0009]. A POSITA would have understood *Coli*'s disclosure refers to a hydraulic fracturing system for fracturing a subterranean formation. EX1002, ¶179.

b) 1[a]

The *Cicci-Coli-Dixon-Liu* combination discloses limitation 1[a]. EX1002, ¶¶181-188.

Cicci and *Coli* each disclose a hydraulic fracturing pump. *Id*., ¶¶181-182; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, Abstract.

Coli discloses an electric-powered multi-plunger hydraulic fracturing pump. EX1002, ¶183. *Coli* discloses "[f]racturing module 20 [red] can include an electric motor 21 [blue] coupled to one or more electric pumps 22 [green]." EX1006, ¶[0046].

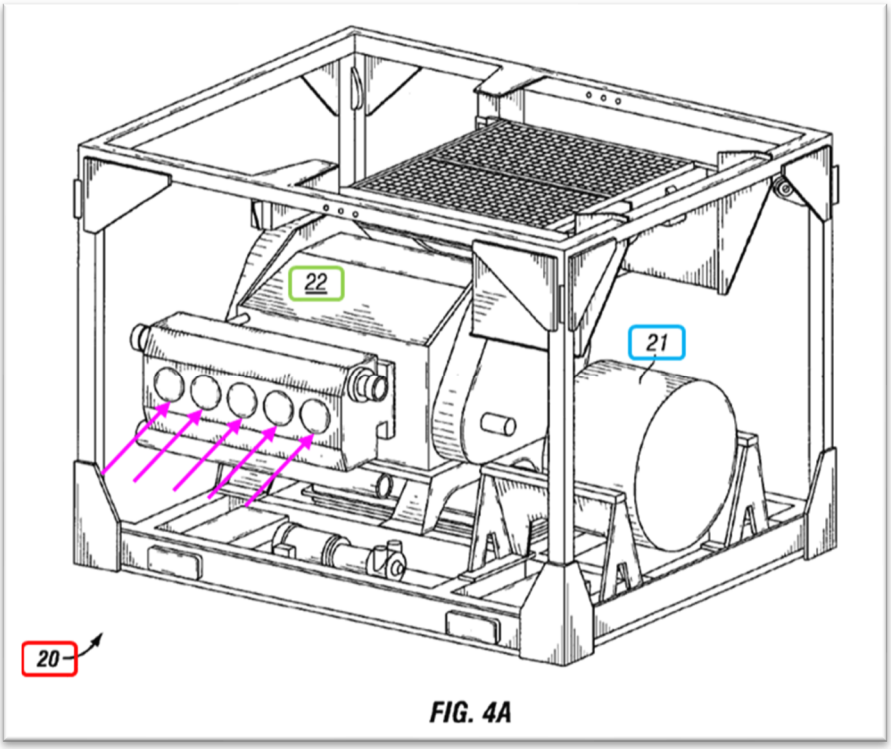


FIG. 4A

EX1006, Fig 4A. *Coli* discloses "[a] suitable pump is a quintiplex or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver[.]" *Id*., ¶¶[0046], [0011]. A POSITA would have recognized that a quintiplex (or quintuplex) pump has five plungers and a triplex plunger pump has three plungers, and accordingly are "multi-plunger" pumps. EX1002, ¶¶59-65, 182. Fig. 4A illustrates a quintuplex (5-plunger) pump, with magenta arrows identifying each plunger. *Id*., ¶182; EX1006, Fig. 4A.

Coli's electric-powered pump is powered by at least one electric motor. EX1002, ¶183. *Coli* teaches "[e]ach fracturing module 20 can include an electric motor 21 and a fluid pump 22 coupled thereto." EX1006, ¶[0040]. A POSITA would have been motivated to use *Coli's* electric motor-driven multi-plunger fracturing

pump to improve *Cicci's* fracturing system. *Supra*, §VII.A.1; EX1002, ¶¶147-154, 183.

Further, *Cicci* discloses the delivery of fracturing fluid from the blender to the pump, and from the pump to the missile. EX1004, 5:20-37; EX1005, ¶[23]. A POSITA would have understood from this disclosure that the pump has an inlet and an outlet. EX1002, ¶¶184-186.

Cicci also discloses that the outlet is coupled to a well associated with the subterranean formation through missile 304. *Id*. *Cicci* discloses that "[t]he missile 304 then delivers the pressurized fracturing fluid to the wellhead 308, which routes the fluid into steel casing in the wellbore (not shown)," which a POSITA would have understood meant that *Cicci*'s pump's outlet is coupled to the wellbore. EX1004, 5:23-26; EX1005, ¶[23]; EX1002, ¶186. *Cicci* also discloses that "[w]hen distributed into a wellbore, the highly pressurized fluid generates micro fissures or cracks within the geological formations surrounding the wellbore," which a POSITA would have understood meant that the well is associated with the subterranean formation. *Id*.; EX1004, 1:12-15; EX1005, ¶[1].

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." EX1006, ¶¶[0040], [0009]. *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." *Id.*, ¶¶[0035], [0003], [0009]. A POSITA would have understood that hydraulic fracturing operations inject fluids into a subterranean formation under pressure to create fissures or "fractures" in the formation. EX1002, ¶187; EX1004, 1:7-19; EX1005, ¶[1].

c) 1[b]

The *Cicci-Coli-Dixon-Liu* combination discloses limitation 1[b]. EX1002, ¶¶189-191.

Cicci discloses fracturing system 300 that "includes a blender 302 [red], a manifold or a missile 304 [blue], one or more pumps 306 [green], and a wellhead 308 [magenta]."

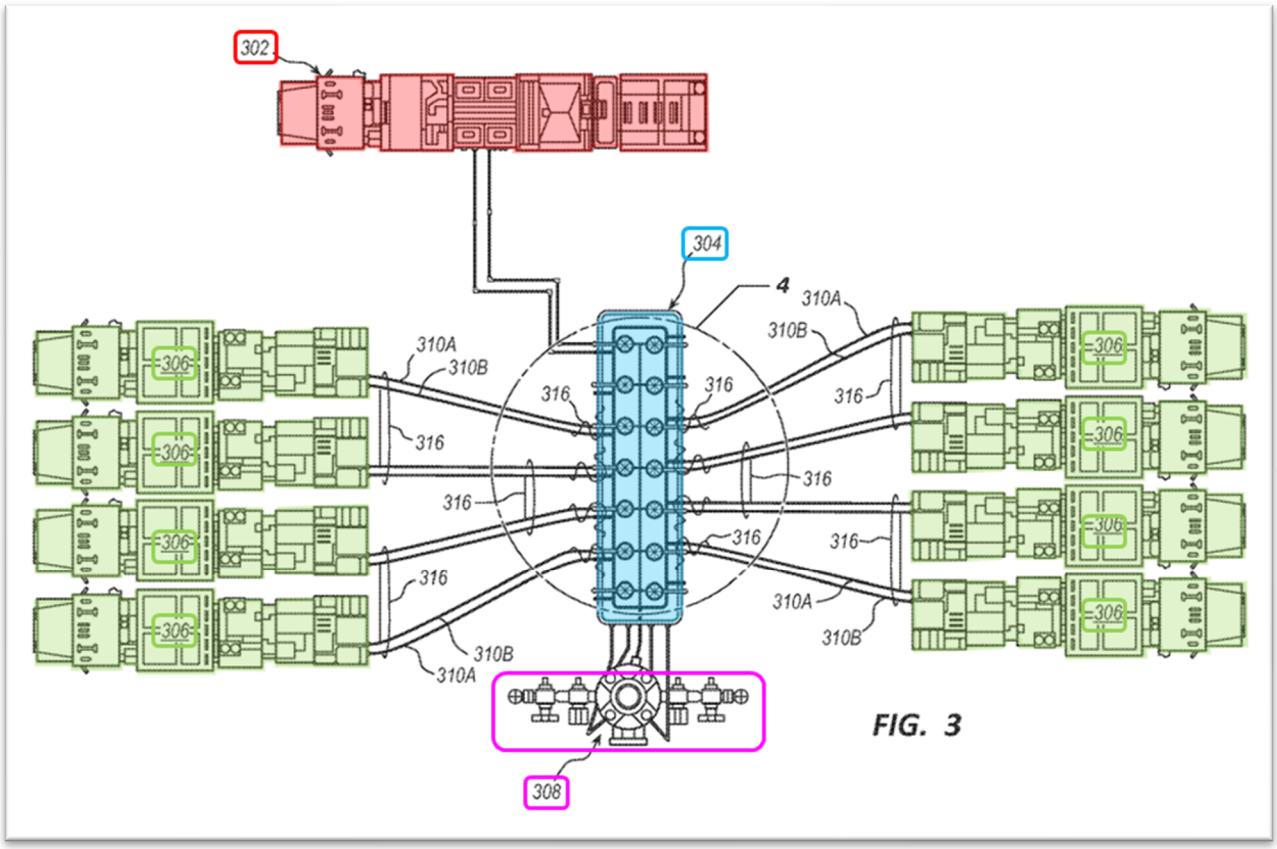


FIG. 3

EX1004, Fig. 3, 5:14-29; EX1005, ¶[23].

Cicci's "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 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)." EX1004, 5:14-29; EX1005, ¶[23].

Accordingly, *Cicci* discloses a fluid source (manifold/missile 304), coupled to the inlet of the pump (pumps 306) 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)."). EX1004, 5:25-29; EX1005, ¶[23]; *see also* EX1004, 1:12-15; EX1005, ¶[1]; EX1006, ¶¶[0003], [0035]; *supra*, §VII.A.2(b) (pump is an electric-powered multi-plunger hydraulic fracturing pump).

d) 1[c]

The *Cicci-Coli-Dixon-Liu* combination discloses limitation 1[c]. EX1002, ¶¶192-193. *Cicci* discloses a hose extending between the fluid source (missile 304) and the electric-powered multi-plunger hydraulic fracturing pump. *Id*.; *supra*,

§VII.A.2(b)-(c). *Cicci* discloses "a flexible pipe or hose (*i.e.*, a flexible flow line) . . . used to connect a pump to the manifold." EX1004, 3:42-46; EX1005, ¶[15].

e) 1[d]

The *Cicci-Coli-Dixon-Liu* combination discloses limitation 1[d]. EX1002, ¶¶194-197.

Cicci discloses a first end for coupling to the fluid source (manifold 304). *Id.* *Cicci* discloses "coupling a second end of the first flexible hose to one of the plurality of manifold connections [fluid source]." EX1004, 4:30-35; EX1005, ¶[18].

Cicci also discloses that "the plurality of flexible hoses can have an inner diameter of one to eight inches." EX1004, 1:64-65, Claim 7; EX1005, ¶[4]. A POSITA would have understood that the hose's first end has a first diameter. EX1002, ¶196.

f) 1[e]

The *Cicci-Coli-Dixon-Liu* combination discloses limitation 1[e]. EX1002, ¶¶198-199.

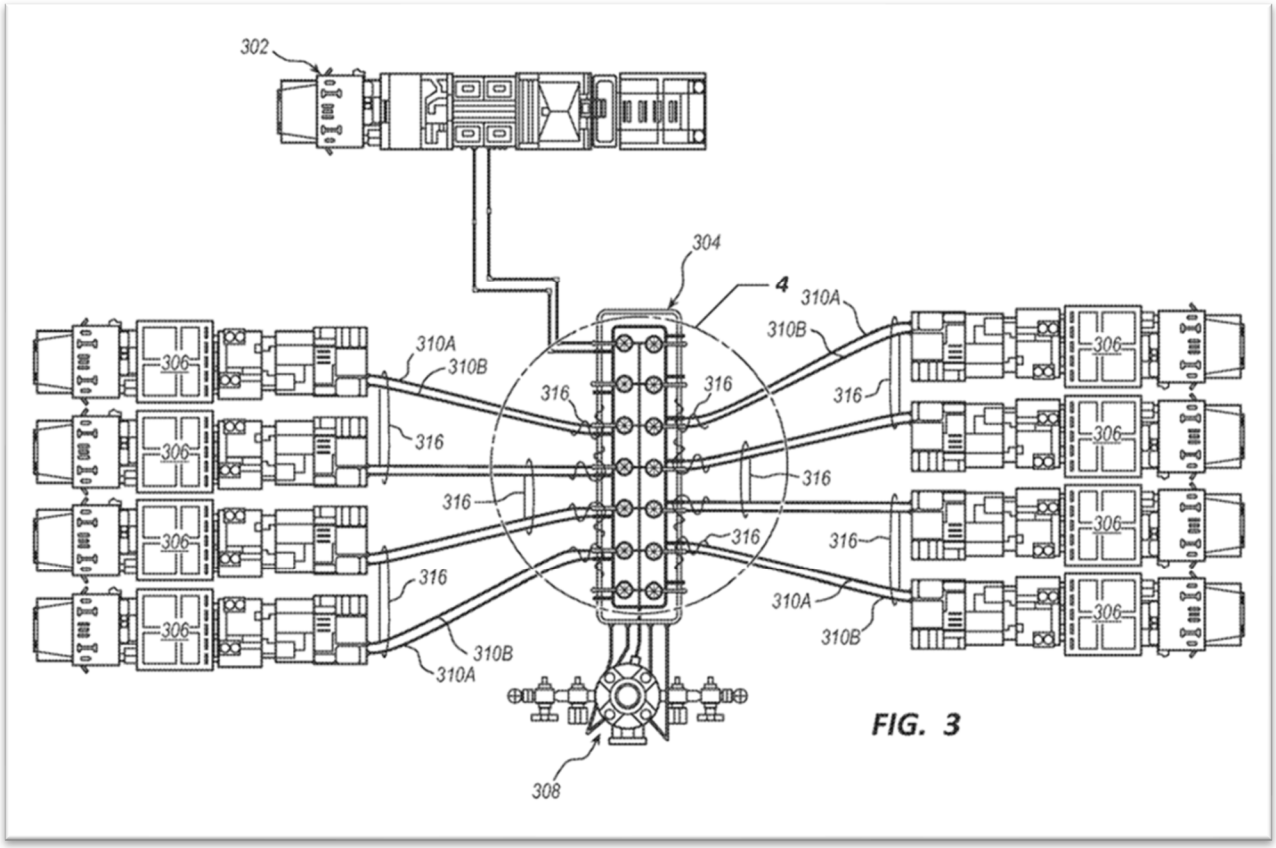
The *Cicci-Coli-Dixon-Liu* combination discloses an inlet of the electric-powered multi-plunger hydraulic fracturing pump. *Supra*, §VII.A.2(b). *Cicci* discloses "coupling a first end of a first flexible hose (*i.e.*, flexible flow line) with one of the respective pump connections." EX1004, 4:30-33; EX1005, ¶[18]. Thus, *Cicci* discloses the hose's second end for coupling to the pump's inlet. EX1002,

¶198. Further, a POSITA would have understood based on *Cicci* that the second end has a diameter (second diameter) for the same reasons as limitation 1[d]. EX1002, ¶¶196, 198; *supra*, §VII.A.2(e); EX1004, 1:64-65, Claim 7; EX1005, ¶[4].

g) 1[f]

The *Cicci-Coli-Dixon-Liu* combination renders obvious limitation 1[f]. EX1002, ¶¶200-222.

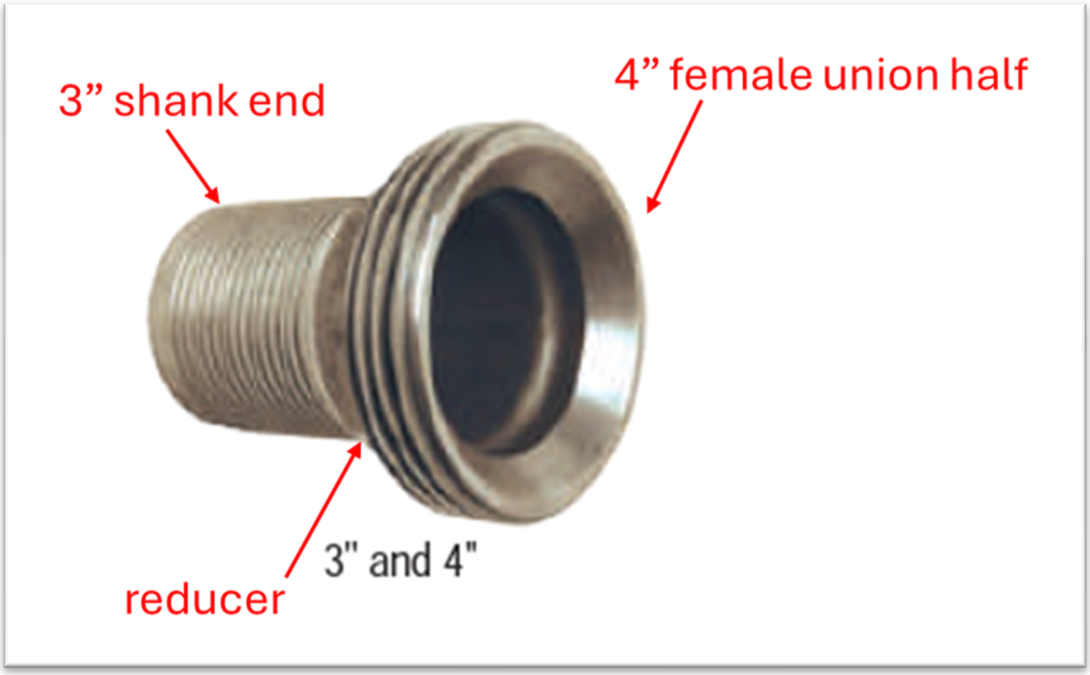
Cicci's hose has a body between the first end and the second end. EX1002, ¶200. Figure 3 illustrates hoses 310 with a body between their two ends:



EX1004, Fig. 3; EX1005, Fig. 3.

Cicci discloses that "the plurality of flexible hoses can have an inner diameter of one to eight inches." EX1004, 1:64-65; EX1005, [4]. Accordingly, *Cicci*'s hose's body has a diameter (third diameter). EX1002, ¶201.

Dixon discloses fittings for fracturing operations that connect larger-diameter unions at the pump end with smaller-diameter hoses. EX1009, 149; EX1012, 78; EX1002, ¶202. For example, *Dixon* discloses a 3-inch shank end fitting with a 4-inch female union half:



EX1009, 149; EX1012, 78. A POSITA would have understood that *Dixon*'s 3-inch end receives the hose, and that the 4-inch female union couples to the pump. EX1002, ¶202. A POSITA accordingly would have understood based on *Dixon* that the third diameter is less than the second diameter. *Id*.

Dixon's frac fittings to connect a larger-diameter pump (*e.g*. "standard" 6-inch pump connection) and a smaller diameter hose (*e.g*., "standard" 4-inch hose) would have been obvious, and useful to a POSITA in connecting standard parts. EX1002, ¶203; EX1006, ¶[0046]; EX1010, 76-79 (*Coli*'s Gardner-Denver SWGS-2500 pump with a 6-inch standard fitting); EX1001, 4:8-12 (6-inch fittings were "standard"), 4:16-23 (4-inch hoses were "standard"); EX1056, 433 (applicant to parent '162 Patent admitting "[t]raditional fracturing systems typically use 6" connections for equipment and 4" hoses for fluid flow"). Such a solution would have been obvious based on the *Cicci-Coli-Dixon-Liu* combination. EX1002, ¶203.

It further would have been obvious for the third diameter to be less than both the first diameter and the second diameter based on *Liu*. EX1002, ¶¶204-222. Based on *Cicci*'s blenders that blend components into a slurry (EX1004, 5:17-20; EX1005, ¶[23]), a POSITA would have been motivated to look to *Liu* to understand the slurry fluid dynamics for the third diameter size. EX1002, ¶204.

It would have been obvious for the third diameter to be less than the first and second diameters to maintain a slurry velocity high enough to avoid drop out and cavitation, in light of *Liu*. EX1002, ¶205. *Liu* discloses sizing the diameter of a slurry piping system (including the third diameter), to maintain velocity high enough to suspend the slurry in the hose and prevent "moving bed flow" or "stationary bed flow." EX1002, ¶¶205-207; EX1007, 132. *Liu* discloses "moving-bed flow" and

"stationary bed flow" to refer to drop out of the slurry. EX1002, ¶207; EX1007, 301. For example, *Liu* describes "moving-bed flow" as when "[p]articles settle out of the flow and form a bed," occurring when there is insufficient velocity. EX1007, 132. *Liu* further describes "stationary-bed flow" as when "[p]articles settle out on the bed, and they do not move in the bed," occurring at "very low velocity in pipes." *Id*. This is consistent with the '420 Patent, which describes "drop out" as particulates "drop[ping] out of the flow" when there is insufficient flow rate. EX1001, 1:49-54 (describing "flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site."); *id*., 5:49-53 (discussing "maintaining flow rates above a threshold amount where particulates begin to drop out of the flow").

Liu's 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 is avoided. EX1007, 133, Fig. 5.1; EX1002, ¶¶208-209.

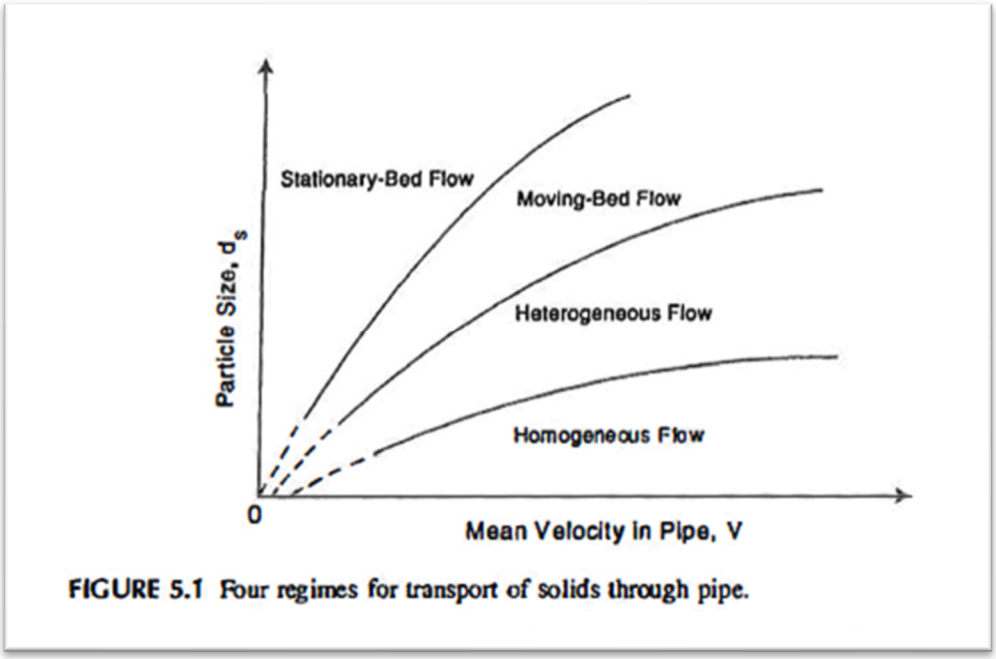


FIGURE 5.1 Four regimes for transport of solids through pipe.

EX1007, Fig. 5.1, 133.

A POSITA would have been motivated to avoid moving-bed or stationary-flow regimes to avoid their negative consequences, including increased pressure drop, reduced flow, and cavitation. EX1002, ¶¶59-72, 210-213; EX1007, 133, 269. As velocity drops, the slurry enters moving-bed or stationary-bed flow, resulting in proppant settling at the bottom of the hose, or even screen-out in a section of the hose. *See id*. A reduction in 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, which would risk starving the pump of fluid and damaging cavitation. EX1007, 269; EX1002, ¶¶66-72, 210. Accordingly, a POSITA would have been motivated to avoid moving-bed or stationary-bed flow regimes and cavitation when designing a piping system, and

to use a third diameter that is less than both the first and second diameters to keep the velocity high enough to avoid these flow regimes. EX1002, ¶213.

A POSITA would have been motivated, based on *Liu*'s disclosure, to use a third diameter that is less than both the first and second diameters to avoid moving bed or stationary-bed flow regimes and cavitation. *Id. 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." EX1007, 269. NPSH is the total amount of head (pressure) available at the suction of the pump. EX1002, ¶212. An increase in pressure drop caused by reducing the hose's available cross-sectional area, such as occurs when proppant beds form, reduces the NPSH and risks cavitation. *See id.*

A POSITA would have understood that the third diameter affects the fluid flow velocity, and accordingly the drop-out threshold, based on *Liu*. EX1002, ¶214. *Liu* provides various equations 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. *Id*.; EX1007, Fig. 5.1, 133.

For example, *Liu* teaches that the mean slurry velocity in the pipe (hose) is a function of the flow rate through the pipe and the pipe diameter (cross-sectional area). EX1007, 21; EX1002, ¶215. In Eq. (2.6), *Liu* states that velocity (V in m/s) is the ratio of the flow (Q in m^3/s) to the pipe's cross-sectional area (A in m^2).

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

Id. Because the hose's cross-sectional area is directly related to diameter, Eq. (2.6) rewritten as a function of fluid flow and diameter (D in m), is below:

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

Id. , ¶216.

Liu also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. *Id.*, ¶218. *Liu* teaches that "head loss" (pressure drop) in a pipe (including hoses) is calculated in Equation 2.33, below. EX1007, 37, Eq. 2.33.

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

Where:

h_L = head loss (pressure drop)

f = friction factor

L = pipe length

D = pipe diameter

V = fluid velocity

g = gravitational acceleration

EX1007, 26-29; EX1002, ¶218.

A POSITA would have performed *Liu*'s calculations to design the piping system, including the third diameter, to maintain flow in a homogeneous or, at the

very least, a heterogeneous flow regime. EX1002, ¶217. This would have involved the third diameter being less than both the first and second diameters. *Id*. A POSITA would have used a hose with a body that has a third diameter that is smaller than the connection diameters (first and second diameters) to reduce the possibility of low-velocity flow causing the formation of a proppant bed in the hose, based on *Liu*. *Id*., ¶221.

h) 1[g]

The *Cicci-Coli-Dixon-Liu* combination discloses and renders obvious limitation 1[g]. EX1002, ¶¶223-236.

Cicci discloses a pair of fittings, a first fitting forming the first end (at the fluid source) and a second fitting forming the second end (at the pump). *Id*., ¶224. *Cicci* discloses "*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* [hose]. 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*." EX1004, 5:30-37; EX1005, ¶[24].

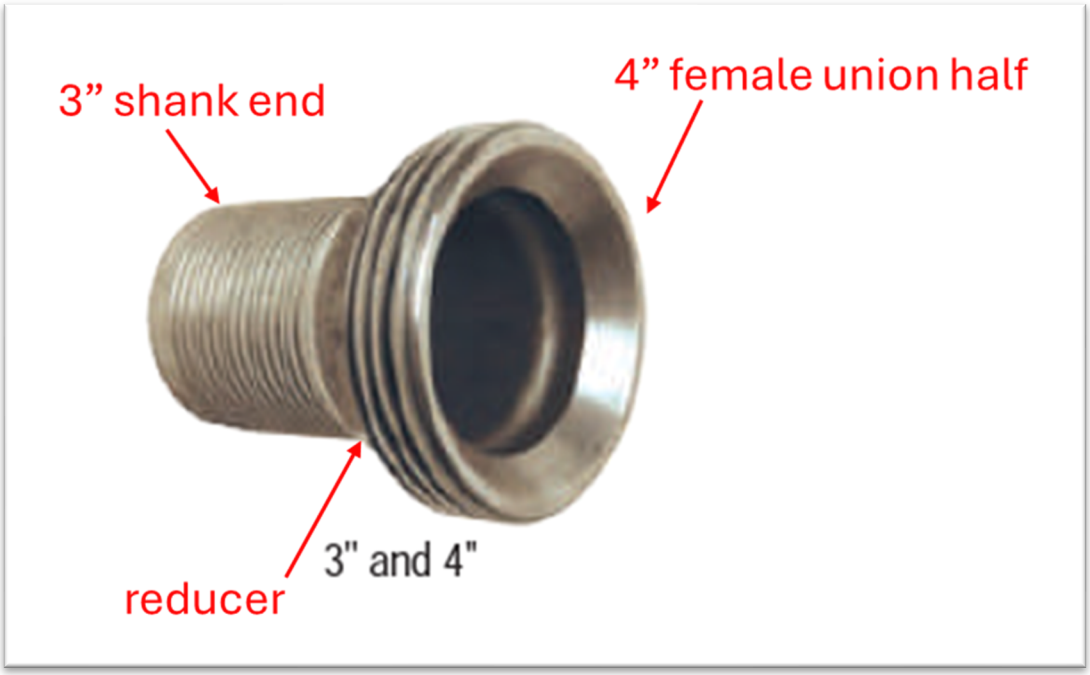
Cicci accordingly discloses a pair of fittings where each fitting couples to the hose (flexible flow line). EX1002, ¶225. A POSITA would have understood that one fitting (a first fitting) forms the first end of the hose for coupling to missile/manifold 304, and the second fitting (a second fitting) forms the second end of the hose for

coupling to the pump inlet, based on *Cicci*'s disclosure that each fitting is "affixed to each end of the flexible flow line." *Id*.; EX1004, 5:30-37; EX1005, [24]. In the combination, the "pump" is an electric-powered multi-plunger hydraulic fracturing pump. *Supra*, §VII.A.2(b). A POSITA would have been motivated to use such a fitting to allow the smaller-diameter hose to the connect to the larger-diameter pump. EX1002, ¶225; *supra*, §VII.A.2(g).

A POSITA further would have understood each fitting of *Cicci*'s pair of fittings to have two ends, one end for receiving at least a portion of the hose body, and another end for engaging the respective fluid source (manifold/missile 304) and pump, respectively. EX1004, 5:30-37; EX1005, ¶[24]; EX1002, ¶226. *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*." EX1004, 7:40-47; EX1005, ¶[30]. A POSITA would have understood from *Cicci*'s disclosure that each fitting has a union for engaging the electric-powered multi-plunger hydraulic fracturing pump. EX1002, ¶226; *supra*, §VII.A.2(b).

Dixon also discloses each fitting having a shank end for receiving at least a portion of the hose body and a union for engaging the respective fluid source and pump. *Dixon* discloses fittings for fracturing operations that connect larger-diameter

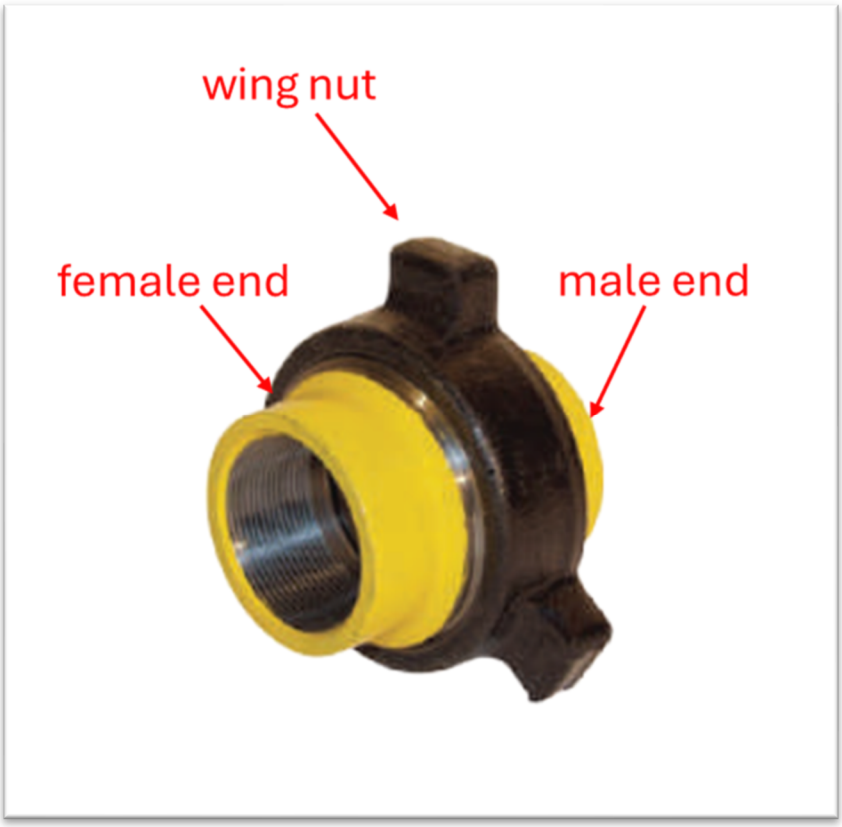
unions with smaller-diameter hoses. EX1009, 149; EX1012, 78; EX1002, ¶227. For example, *Dixon* discloses a 3-inch shank end fitting with a 4-inch female union half:



EX1009, 149; EX1012, 78. A POSITA would have recognized the 3-inch end to be a “shank end” for receiving at least a portion of the hose body because *Dixon* uses the term “shank” to name that type of hose connection. EX1009, 85, 91-96, 98-100; EX1012, 33-34, 67, 71, 74, 101, 104-106, 109-110; EX1002, ¶228. A POSITA would have understood that *Dixon*’s fitting has two ends—a shank end for receiving at least a portion of the hose body and a union (4-inch female union) for engaging the pump and fluid source, respectively. *Id*.

The hammer union, disclosed by *Cicci* and *Dixon*, is as a three-piece system for connecting piping, including hoses, to other fluid connections, such as a pump

intake, as described by *Cicci*. EX1002, ¶229; EX1004, 7:40-47; EX1005, [30]; EX1009, 149-151, 154; EX1012, 78-79, 112. *Dixon* teaches hammer unions in various sizes, including hammer unions for fracturing suction operations. EX1009, 79, 150, 154, 681; EX1012, 681. *Dixon* shows a typical hammer union with the three components identified:



EX1009, 150, 154; EX1012, 681-83; EX1002, ¶229. *Dixon* shows various fitting sizes, including combinations of Male/Female assemblies, to connect a larger union to a smaller hose. EX1009, 149; EX1012, 78.

A POSITA would have understood from *Dixon* that one half of the hammer union (*e.g.*, the male end) would be connected to the pump and the second half (*e.g.*,

the female end) would be connected to the hose, or vice versa. EX1002, ¶231. Accordingly, each fitting on the hose would comprise a union (½ of the hammer union) which is configured to couple to a mating fitting (the other ½ of the hammer union). *Id.* This is shown in *Dixon*'s Frac Fittings, including, for example, the HUM206600CS Frac Fitting, which comprises one-half (male) of the hammer union:



EX1009, 149; EX1012, 79. A POSITA would have understood that the hammer union's other half (female half) attaches to the pump. EX1002, ¶¶231-232. Moreover, it would have been obvious to use a 6-inch hammer union to connect to the 6-inch inlet manifold disclosed by *Coli* as hammer unions were well known. *Id.*; EX1001, 4:8-13.

Dixon also discloses a shank end, which a POSITA would have understood receives at least a portion of the hose. EX1002, ¶¶233-234. *Dixon* teaches that the shank is coupled with a ferrule that is crimped over at least the portion of the hose. EX1009, 149; EX1012, 78; EX1002, ¶234. *Dixon* further describes "King Crimp Style Heavy Duty Ferrules" as shown below. EX1009, 151; EX1012, 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



EX1009, 151; *id*., 150-151 (showing the crimp ferrules that would be used with the shanks disclosed on pg. 149); EX1012, 78-81. A POSITA would have recognized from *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 and receive at least a portion of the hose. EX1002, ¶234.

3. Claim 2

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 2. EX1002, ¶¶237-245; *supra*, §VII.A.2.

A third diameter (hose) of approximately 5 inches and a second diameter (end for connection to pump) of approximately 6 inches would have been obvious. EX1002, ¶238. *Cicci* discloses that each of "the plurality of flexible hoses can have an inner diameter of one inch to eight inches." EX1004, 1:64-65, Claim 7; EX1005, ¶[4]. Accordingly, *Cicci* discloses a range of hose diameters, including 5 inches. *See id*.; EX1002, ¶238. *Dixon* discloses "Suction Service Fittings" for hydraulic fracturing with 5-inch diameters. EX1009, 150; EX1012, 79. Based on these combined teachings, a POSITA would have found it obvious to use a 5-inch hose. EX1002, ¶239. A POSITA would have been motivated to use a 5-inch hose when a 5-inch hose would keep velocity in the proper range and avoid drop-out. EX1002, ¶240; *supra*, §VII.A.2(g).

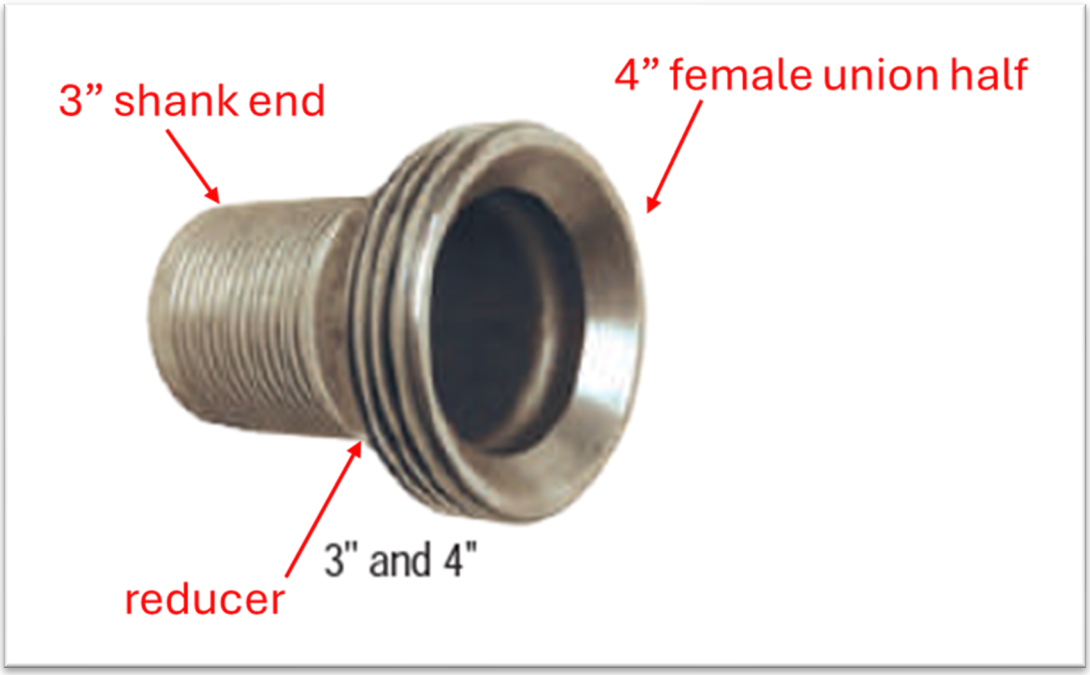
It would have been obvious for the second diameter to be approximately 6 inches. *Coli* discloses a "SWGS-2500 Well Service Pump sold by Gardner Denver." EX1006, ¶[0046]. A POSITA would have understood that *Coli*'s disclosure refers to 6-inch inlet connections with both threaded (for hammer union) and Victaulic style inlet connections. EX1002, ¶¶241-242; EX1010, 76-79. It would have been obvious to select a fitting diameter consistent with this disclosure. EX1002, ¶243; *see also* EX1001, 4:8-13 ("6" (0.1524 m) components" including "hammer unions"

were "standard"). And a POSITA would have understood from *Dixon* that other combinations of sizes were available. *See, e.g.*, EX1009, 7 (referencing "made-to-order hose assemblies"), 99 ("[f]ittings are also available on special order for other sizes of hose OD's"); EX1012, 138, 142; EX1002, ¶244.

4. Claim 3

The *Cicci-Coli-Dixon-Liu* combination discloses and renders obvious Claim 3. EX1002, ¶¶246-251; *supra*, §VII.A.2.

Dixon discloses a reducer between the union and the shank end. EX1002, ¶247. *Dixon* shows a fitting with a 3-inch shank end and a 4-inch union end:



EX1009, 149; EX1012, 78. *Dixon*'s reducer is in the claimed location to enable the connecting disparate-sized parts, and to allow for smooth fluid flow. EX1002, ¶247.

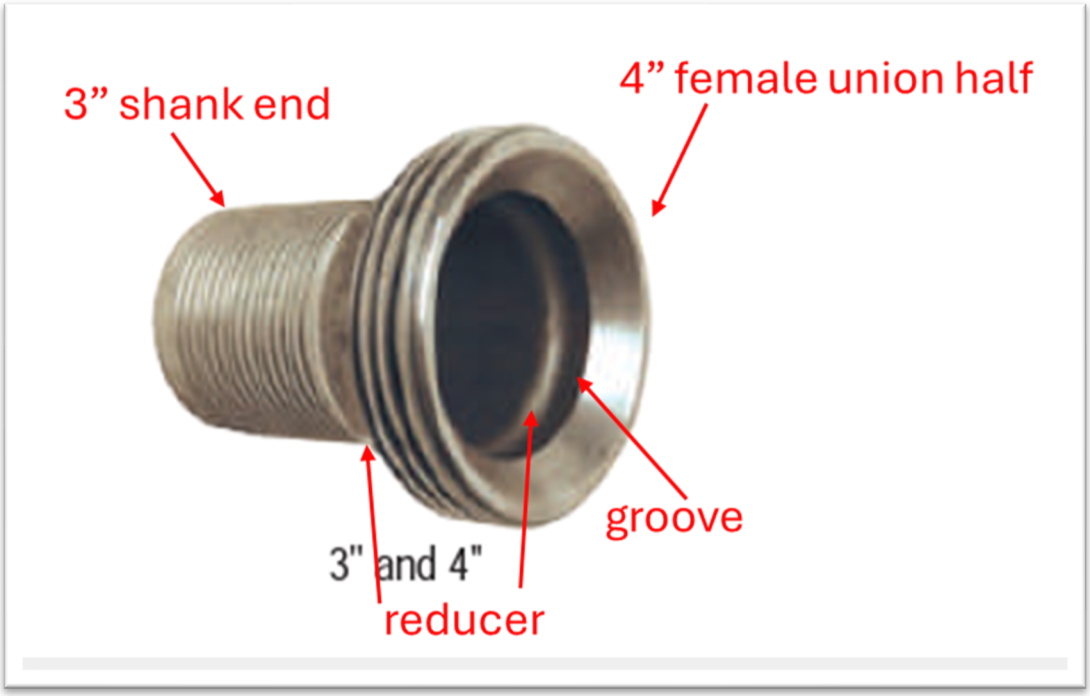
Dixon further teaches individual components of "weld" hammer unions and reducers. EX1009, 150; EX1012, 79. A POSITA would have found it obvious to take *Dixon*'s weld unions and combine them with *Dixon*'s weld reducers (EX1009, 359; EX1012, 608) and weld such fittings together to form a reducing fitting, such as *Dixon*'s "frac fittings." EX1002, ¶248. This would have been combined with *Dixon*'s hose shank to create a fitting that would enable a smaller hose size. *See, e.g.*, EX1009, 85, 91-96, 98-100; EX1012, 33-34, 67, 71, 74, 101, 104-106, 109-110; EX1002, ¶249.

It would have been obvious for each fitting of the pair of fittings to comprise this reducer to allow each fitting to connect the smaller-diameter hose to the larger-diameter pump and fluid source. EX1002, ¶250.

5. Claim 4

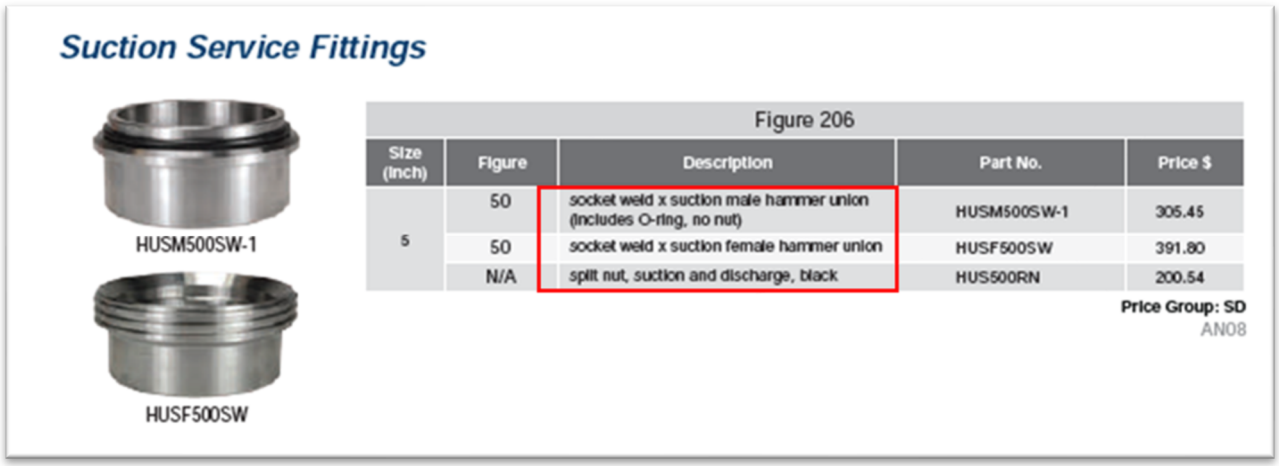
The *Cicci-Coli-Dixon-Liu* combination discloses and renders obvious Claim 4. EX1002, ¶¶252-256; *supra*, §VII.A.4.

Dixon discloses at least a portion of the reducer of each fitting extends into a groove formed in the union. For example, *Dixon* discloses a 3" shank end fitting with a 4" female union half:



EX1009, 149; EX1012, 78. The fitting shown features a groove in the hammer union, with at least a portion of the reducer extending into it. *See id.*; EX1002, ¶254. The union in the fitting shown also extends farther laterally than the reducer, such as the threaded portion of the union. *See id.*

Additionally, *Dixon* teaches “suction service fittings” that are designed for “socket weld” connections:



EX1009, 150; EX1012, 79. 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*. EX1045; EX1002, ¶255. Accordingly, by combining the socket weld unions with *Dixon*'s reducers and shanks, it would have been obvious to create a fitting by using a union with a "socket weld" connection, a reducer, and a hose shank. *Id*. In such a combination, a portion of the reducer extends into a groove formed in the union, and the union extends farther laterally than the reducer, as a portion of the reducer is inside the union. *Id.*

6. Claim 5

The *Cicci-Coli-Dixon-Liu* combination discloses and renders obvious Claim 5. EX1002, ¶¶257-261; *supra*, §VII.A.4.

Dixon discloses each of the fittings formed as an integral piece. EX1002, ¶258. A POSITA would have been motivated for each fitting of the pair of fittings

to be formed as an integral piece for *Dixon*'s express benefits that a "[o]ne-piece design eliminates leak path experienced with two-piece threaded systems." *Id*.; EX1009, 149; EX1012, 78. A POSITA would have understood that "[o]ne-piece design" refers to fittings that are formed as an integral piece. EX1002, ¶258.

Dixon discloses the fittings with at least one "rigid coupling" between at least the union and the reducer. *Id.*, ¶259. One example of a "rigid coupling" is a weld or weld bead. *Id*. The weld forms a rigid piece of metal that couples the metal pieces (such as the socket weld union and reducer) together. *Id.*; EX1046. This is consistent with the '420 Patent's "rigid coupling 214" (red), which a POSITA would have recognized as a weld bead.

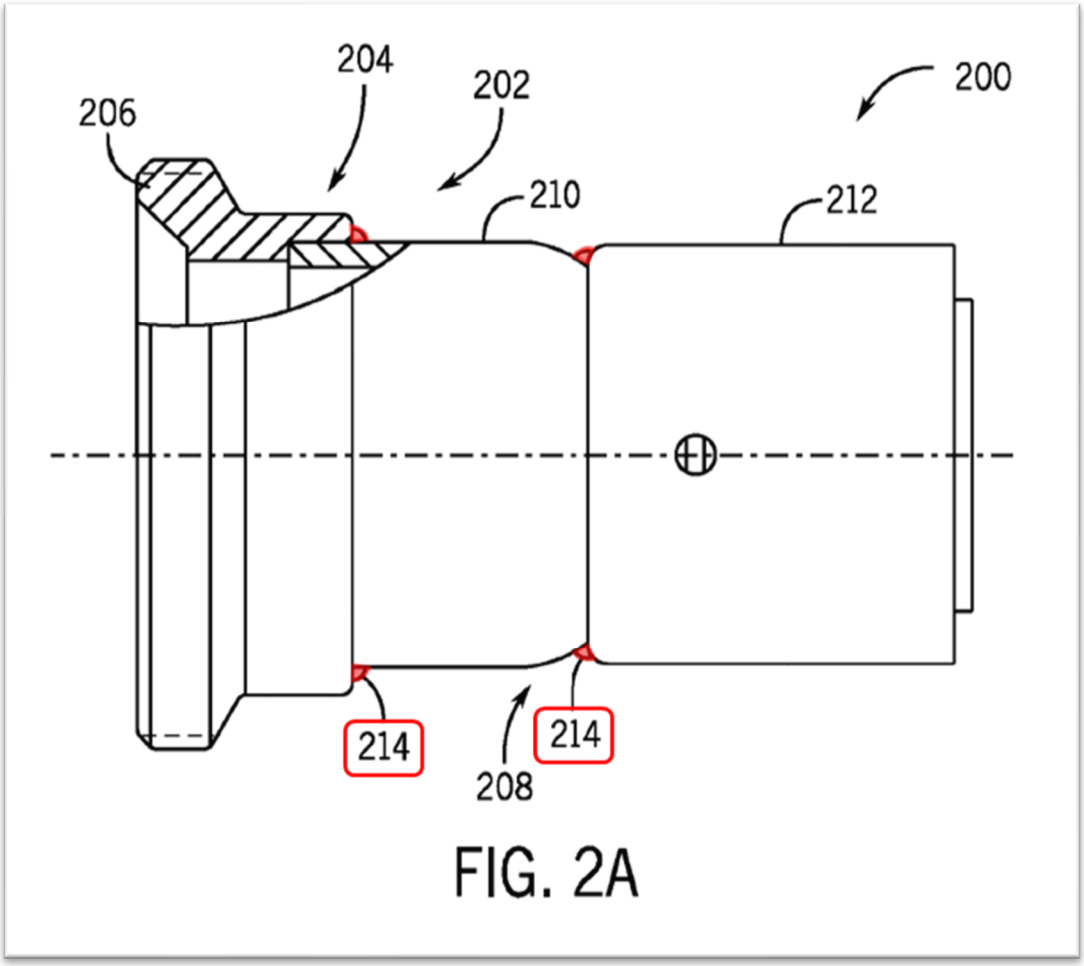


FIG. 2A

EX1001, Fig. 2A; EX1002, ¶259.

Accordingly, *Dixon*'s "socket weld" union is a "rigid coupling" between at least the union and the reducer. EX1002, ¶260; *supra*, §VII.A.4. A "weld bead" as a rigid coupling thus would have been obvious. EX1002, ¶260.

7. Claim 6

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 6. EX1002, ¶¶262-268; *supra*, §VII.A.2.

It would have been obvious for the third diameter (hose) to be particularly selected based at least in part on a threshold, the threshold corresponding to a drop-out rate for the slurry. *Id*.

Liu teaches maintaining velocity (and flow) in the pipe high enough to prevent the drop-out of solids (proppant) into a bed, thus rendering it obvious to select the third diameter (hose) based on the flow rate, and to maintain velocity high enough to prevent slurry drop-out. EX1002, ¶¶263, 267. It would have been obvious, and a POSITA would have been motivated, to select the third diameter to maintain slurry velocity high enough to avoid drop out and cavitation in light of *Liu*. *Id.*, ¶267; *supra*, §VII.A.(g). This would have involved particularly selecting the third diameter based at least on a threshold corresponding to a drop-out rate for the slurry. *Id*.

The velocity in the pipe is based on both the flow rate and the pipe's diameter. EX1007, 21; EX1002, ¶263. *Liu* teaches maintaining velocity in the pipe high enough to prevent the drop-out of solids (proppant) into a bed, rendering it obvious to select the diameter based on the flow rate. *Id.*, ¶267.

As discussed above, the fluid velocity is a function of the hose diameter and flow rate. EX1002, ¶263. A smaller diameter increases velocity and pressure drop. *Id*. A larger diameter reduces velocity, and if reduced too fair, results in proppant dropping out (settling out) of the slurry, leading to a further reduced diameter and, in some cases, plugging the line. *Id*. A reduction in diameter, such as from forming

a bed of proppant in the hose, would also increase the pressure drop by reducing the hose's effective diameter, increasing the cavitation risk. *Id*. Pressure drop considerations thus place a lower limit on the third diameter, while slurry drop-out considerations place an upper-limit on the first diameter. *Id*.

Therefore, sizing a hose, and selecting the third diameter, is a standard engineering tradeoff. EX1002, ¶264. For a given flow rate, increasing the hose diameter reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the cavitation risk. *Id*. 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 cavitation risk. *Id*. Selecting a particular diameter is simply optimization of a slurry flow system, and would have been known to a POSITA, based on the *Cicci-Coli-Dixon-Liu* combination. *Id*. Accordingly, it would have been obvious for the third diameter (hose) to be particularly selected based at least in part on a threshold, the threshold corresponding to a drop-out rate for the slurry. EX1002, ¶¶264-266.

8. Claim 7

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 7. EX1002, ¶¶269-276; *supra*, §VII.A.2. *Liu* teaches particularly selecting the third diameter to maintain the suggested flow rate or velocity, and avoid increased pressure drop, reduced flow, and cavitation. *Supra*, §§ VII.A.2.(g), VII.A.7. *Liu* further teaches that

pressure drop is a function of the hose diameter (third diameter). *Id*.; EX1007, 26-29, 37, Eq. 2.33; EX1002, ¶270.

Liu also teaches an additional upper limit on slurry velocity, and the associated lower limit on the first diameter. EX1002, ¶274. *Liu* teaches that "wear (abrasion) to the pipe" and "pumps, valves, and ends" is "especially serious when the [fluid] velocity is high." EX1007, 143. A POSITA would have understood that wear (abrasion or erosion) considerations impact the selection of a third diameter, as a smaller pipe would increase velocity and increase wear. EX1002, ¶¶66-72, 274. A POSITA would have understood the '420 Patent's "damage accumulation rate" to include such "wear" or abrasion taught by *Liu*. *Id*.

Accordingly, it would have been obvious that the third diameter is particularly selected based at least in part on a pressure drop rate, a damage accumulation rate, or a suggested flow rate. EX1002, ¶275.

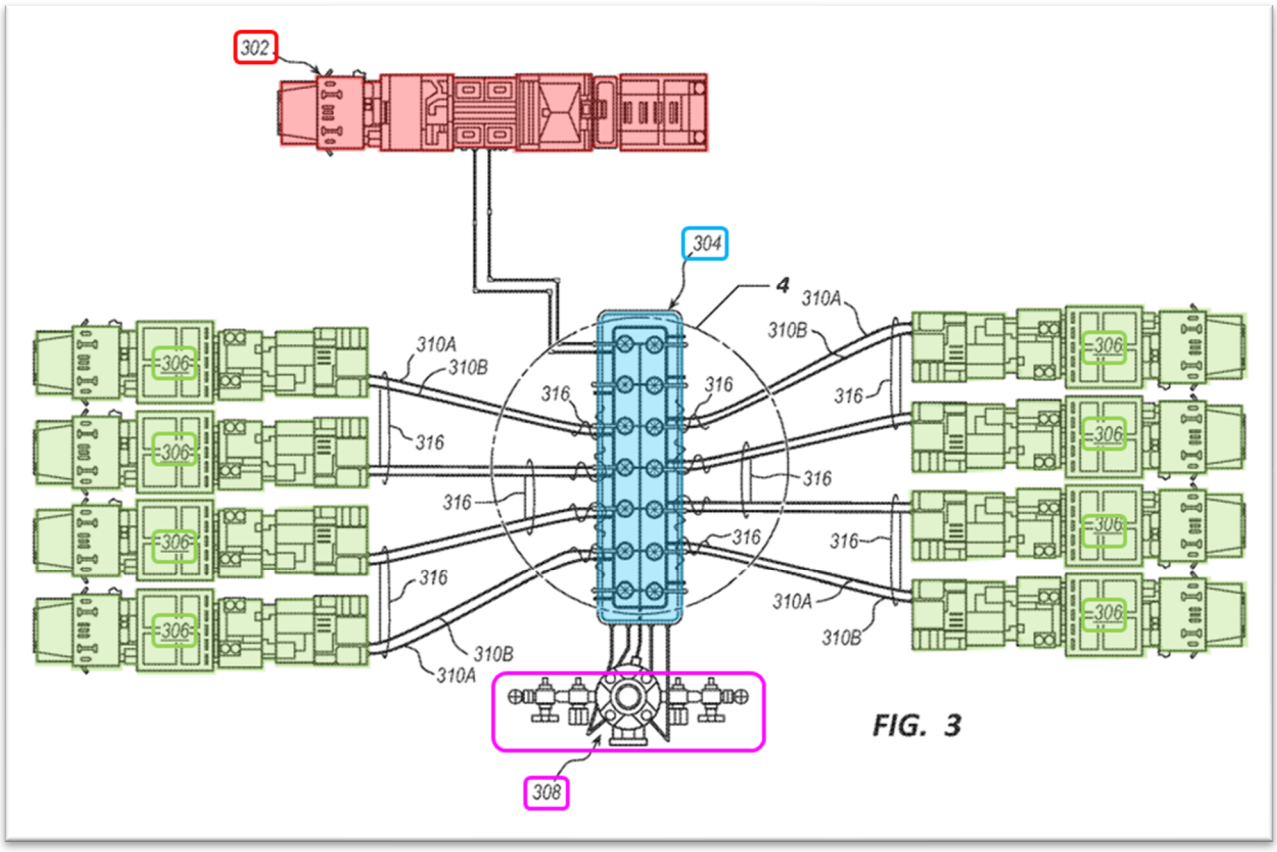
9. Claim 9

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 9. EX1002, ¶¶277-290.

a) 9[a]

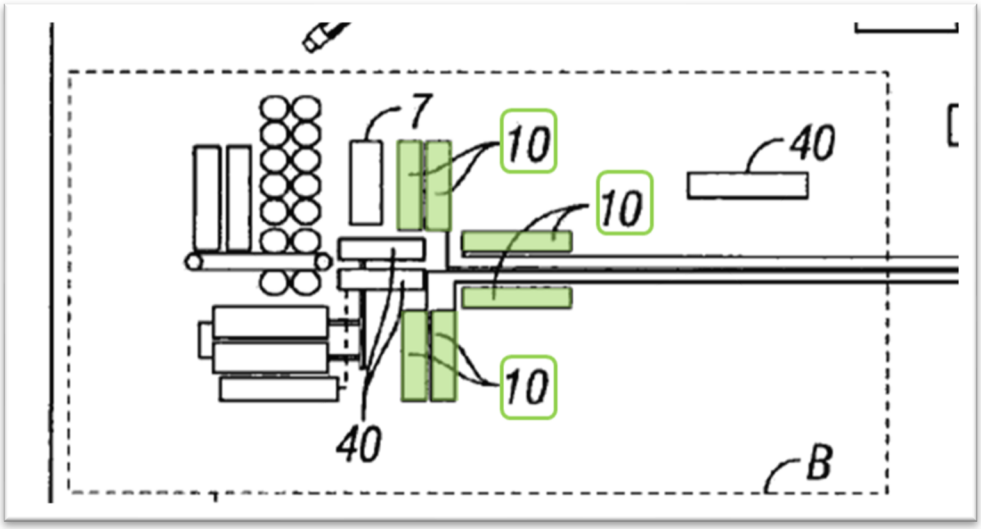
Cicci and *Coli* disclose a plurality of pumps. *Cicci* illustrates eight pump trailers 306 (green), and discloses "one or more pumps 306" and "a plurality of

pumps," indicating any number of pumps. EX1002, ¶¶278-281; EX1004, 1:25-26, 5:15-29; EX1005, ¶¶[2], [23].



EX1004, Fig. 3; EX1005, Fig. 3.

Coli teaches six "fracturing trailers 10" (green):



EX1006, Fig. 2. *Coli* also teaches that each fracturing trailer 10 (magenta) contains as many as four fracturing modules, with each fracturing module 20 (red) containing a pump 22 (blue) and a motor 21 (green). EX1006, Fig. 3; EX1002, ¶280. *Coli* also discloses "a plurality of electric motors 21 and pumps 22 can be transported on a single trailer 10" as in Fig. 3. EX1006, ¶[0040].

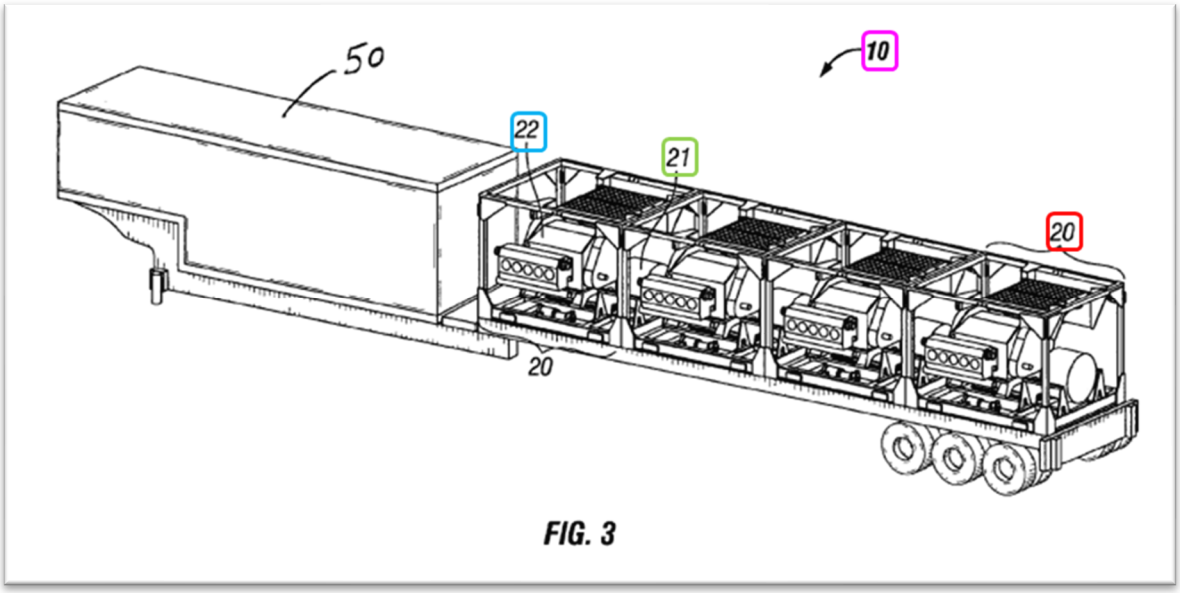


FIG. 3

EX1006, Fig. 3. Accordingly, *Coli* at least discloses 24 pumps. EX1002, ¶281. *Coli* also discloses "providing one or more electric fracturing modules at the site." EX1006, ¶[0009].

Coli discloses that the pumps are "electric powered multi-plunger hydraulic fracturing pumps." *Supra*, §VII.A.2(b).

The *Cicci-Coli-Dixon-Liu* combination further discloses each pump receiving fluid from the fluid source. *Supra*, §VII.A.2(c). For example, *Cicci* discloses "[e]ach pump 306 is coupled to the missile 304 by a set of flexible flow lines 310," and "[t]he missile 304 delivers the fracturing fluid to the pumps 306." EX1004, 5:22-23, 5:30-31; EX1005, ¶¶[23]-[24]. Accordingly, each pump receives fluid from the fluid source (missile 304). EX1002, ¶283.

b) 9[b]

The combination discloses and renders obvious a plurality of hoses having the third diameter. *Supra*, §VII.A.2(g); EX1004, 1:64-65, 5:30-31, Claim 7; EX1005, ¶¶[4], [24]; EX1002, ¶¶285-286. *Cicci* discloses a plurality of hoses ("set of flexible flow lines 310"). EX1004, 5:30-31; EX1005, ¶[24]. It would have been obvious to size each of the hoses with the same diameter based on the pumps' flow conditions. EX1002, ¶285; *supra*, §§VII.A.2(g), VII.A.7-8. Furthermore, it would have been obvious that each hose has the third diameter, allowing for interchangeability. EX1002, ¶285.

c) 9[c]

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." EX1004, 5:30-37; EX1005, [24]. Accordingly, *Cicci* discloses a plurality of fittings on each hose, and that each pump has its own hose, resulting in a plurality of fittings between the respective hoses of the plurality of hoses and respective electric-powered multi-plunger hydraulic fracturing pumps of the plurality of pumps. EX1002, ¶288; *supra*, §§VII.A.2(b), VII.A.9(a).

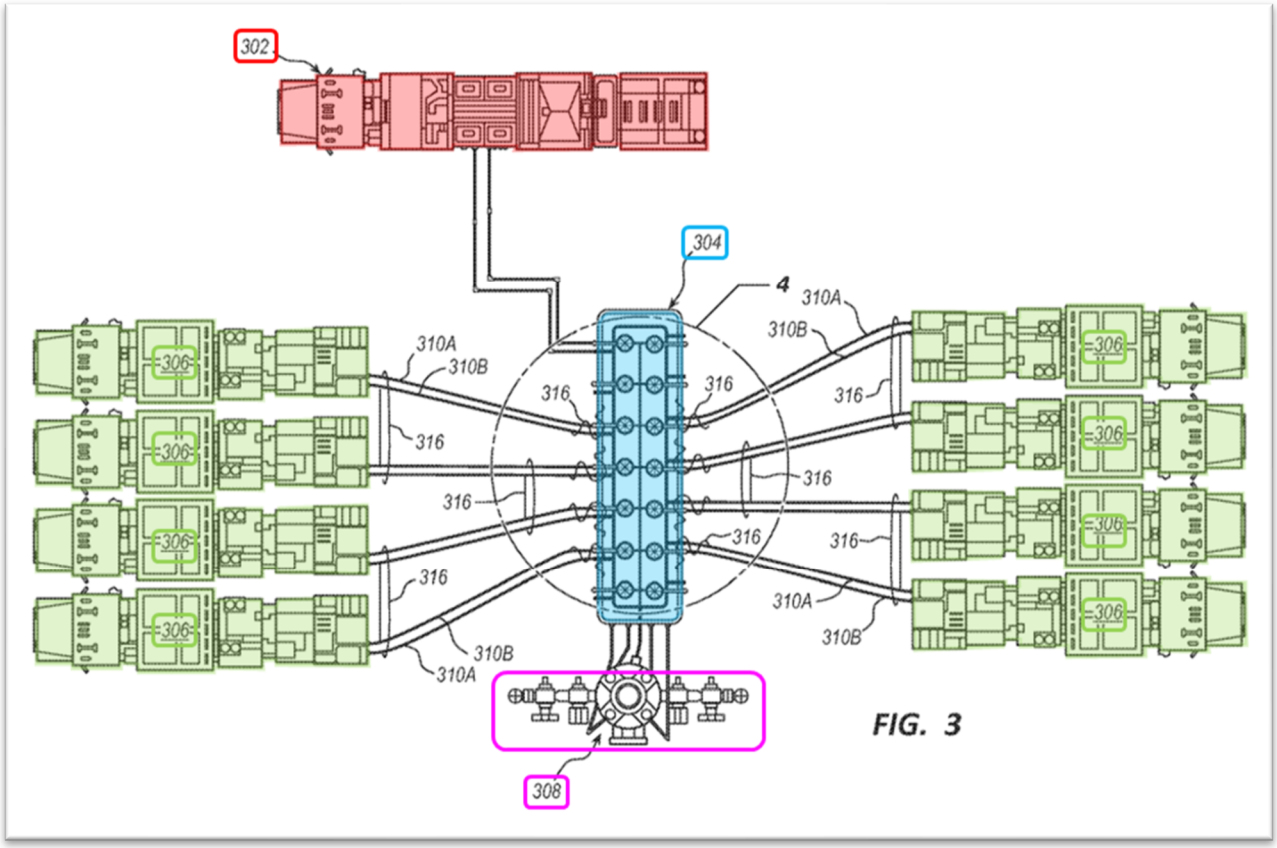
It would have been obvious for each of the pumps to have a connection having the second diameter, as that is the diameter of the fitting end connected to the pump. *Supra*, §VII.A.2(f). A POSITA would have been motivated for the pumps to have a connection having the second diameter to obtain the benefits of interchangeability. EX1002, ¶289. It therefore would have been obvious to use pumps with the same diameter connection of the limited number of connections available. *Id.*; *supra*, §VII.A.3.

10. Claim 10

The *Cicci-Coli-Dixon-Liu* combination discloses Claim 10. EX1002, ¶¶291-293.

Cicci discloses a distribution system (including high pressure hoses 310A and manifold/missile 304)[5] positioned between the wellbore and the pump that collects the slurry from the pump for injection into the wellbore, and subsequently, the subterranean formation. EX1002, ¶292. *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)." EX1004, 5:25-39; EX1005, ¶[23]; *see also* EX1004, 1:9-19; EX1005, ¶¶[1], [27].

[5] The "missile" contains manifolds for both the low-pressure and high-pressure pump connections, consistent with *Cicci*'s missile 304 connecting both suction and discharge lines of the pump. EX1002, ¶292; EX1004, 5:22-29; EX1005, ¶[23].



EX1004, Fig. 3; EX1005, Fig 3. The pump is an electric-powered multi-plunger hydraulic fracturing pump, and the fracturing fluid includes a slurry. *Supra*, §§VII.A.2(b)-(c).

11. Claim 11

a) 11[p]

Supra, §VII.A.2(a); EX1002, ¶¶296-299.

b) 11[a]

Supra, §VII.A.2(b); EX1002, ¶300.

c) 11[b]

Supra, §VII.A.2(c); EX1002, ¶301.

d) 11[c]

Supra, §VII.A.2(d); EX1002, ¶302.

e) 11[d]

Supra, §VII.A.2(e); EX1002, ¶303.

f) 11[e]

Supra, §VII.A.2(f); EX1002, ¶304.

g) 11[f]

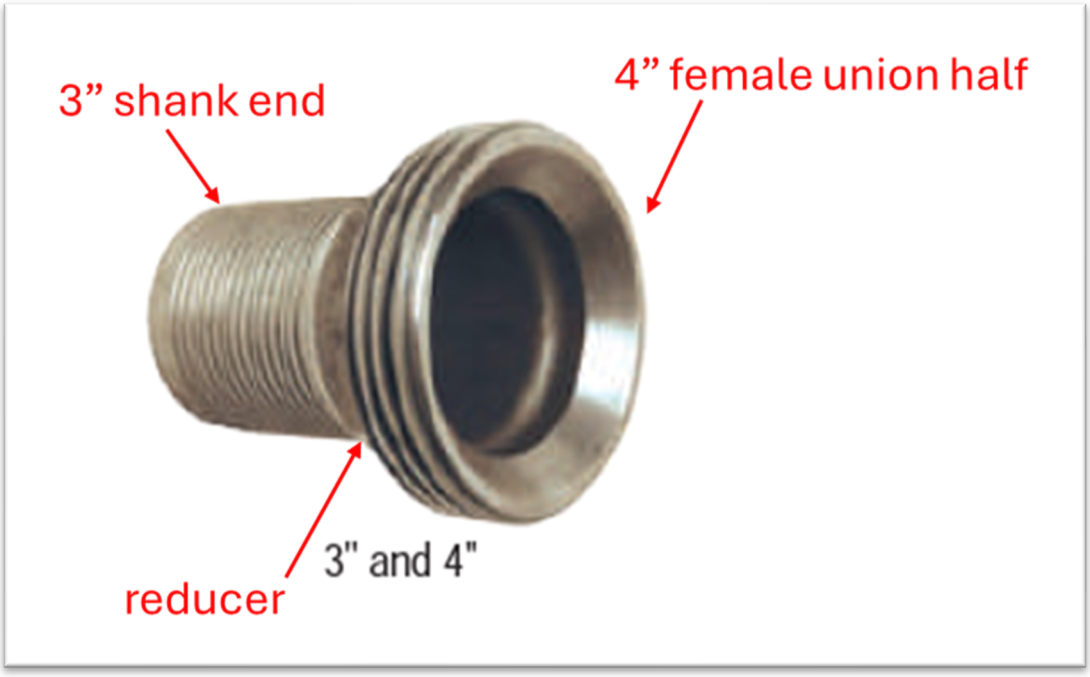
Supra, §VII.A.2(g); EX1002, ¶305.

h) 11[g]

Supra, §VII.A.2(h); EX1002, ¶¶306-308.

i) 11[h]

The *Cicci-Coli-Dixon-Liu* combination discloses a union arranged at an end of the fitting, which a POSITA would have understood as a first fitting end. *Supra*, §VII.A.2(h); EX1002, ¶¶309-318. *Dixon* discloses that the union has a diameter, which a POSITA would have understood is a union diameter. *Id*., ¶313. For example, *Dixon*'s fittings have a union half with a 4-inch diameter.



Id.; EX1009, 149; EX1012, 78.

The union diameter is larger than the first diameter, as illustrated above. *See id.* The union diameter of the 4-inch female union half is larger than the diameter of the hose end it connects to (first diameter). *Id.*; EX1002, ¶314.

j) 11[i]

The *Cicci-Coli-Dixon-Liu* combination discloses a shank end at a second fitting end, configured to receive at least a portion of the hose. *Supra*, §VII.A.2(h); EX1002, ¶¶319-327.

Dixon discloses that the shank end is securable to at least the portion of the hose, for example by crimping it to the hose. *Dixon* teaches that the shank is coupled with a ferrule that is crimped over at least the portion of the hose. For example, *Dixon* teaches that its Frac Fittings are “[d]urable and safe with reliable hose

retention when crimped as specified." EX1009, 149; EX1012, 78. A POSITA would have understood from *Dixon* that when the ferrule's shank end is crimped over at least a portion of the hose, it is securable to at least the portion of the hose. EX1002, ¶323.

Dixon further describes "King Crimp Style Heavy Duty Ferrules" as shown below. EX1009, 151; EX1012, 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



EX1009, 151; *id*., 150-151 (showing the crimp ferrules that would be used with the shanks disclosed on pg. 149); EX1012, 78-81. A POSITA would have recognized from *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 crimped over the hose for the hose to engage the shank's ribs/barbs. EX1002, ¶325. The shank end accordingly 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. *Id*. The combination of the ferrule and the ribs/barbs on the shank makes the shank end securable to the hose, such as when the ferrule is crimped. *Id*.

The shank end includes an opening to receive the hose. *Id*., ¶326. A POSITA would have understood that when the ferrule is fitted around the shank end before insertion of the shank into the hose, the ferrule would comprise an opening to receive the hose. *Id*. The shank would be inserted into the hose, and the ferrule would surround the hose. *Id*. This is consistent with the '420 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." EX1001, 5:28-30.

k) 11[j]

The *Cicci-Coli-Dixon-Liu* combination renders obvious limitation 11[i]. EX1002, ¶¶328-335. *Dixon* discloses a reducer positioned between the union and the shank end, the reducer extending at least partially into the union. *Supra*, §§VII.A.2(h), VII.A.4-5; EX1002, ¶¶328-329.

It would have been obvious to weld the reducer to the respective union and shank end at each end. EX1002, ¶¶331-334. *Dixon* discloses individual components of "socket weld" hammer unions and reducers. A POSITA would have found it obvious to take *Dixon*'s socket weld unions (*see, e.g*., EX1009, 150; EX1012, 79) and combine them with *Dixon*'s weld reducers (*see, e.g*., EX1009, 359; EX1012,

613), and weld them together to form a reducing fitting, like the "frac fittings" disclosed by *Dixon*. EX1002, ¶333. This would have been combined with *Dixon*'s hose shank (*see, e.g.*, EX1009, 85, 91-96, 98-100; EX1012, 33-34, 67, 71, 74, 101, 104-106, 109-110) to create a fitting that would have enabled a smaller hose size for the flow parameters and calculations. *Supra*, §§VII.A.2(g), VII.A.7-8; EX1002, ¶331.

A POSITA would have understood that *Dixon*'s integral fittings are machined as a single part or welded together from the individual components. EX1002, ¶332. Based on *Dixon*'s "socket weld" and "weld" fittings, it would have been obvious to weld the parts together. *Id*. Thus, welding is one of a limited number of connection options to create an integral frac fitting. *Id*. Accordingly, there was a finite number of ways to construct the "Frac Fittings," and it would have been obvious to construct the part by welding known parts together. *Id.*

Dixon's reducer has an increasing diameter along its axial length. EX1002, ¶330; *see, e.g.*, EX1009, 359, 360, 460, 469 (illustrating reducers with increasing diameters along their axial lengths); EX1012, 575, 592, 608, 613, 628.

12. Claim 12

Supra, §VII.A.3; EX1002, ¶336.

13. Claim 13

Supra, §VII.A.5; EX1002, ¶337.

14. Claim 14

Supra, §VII.A.6; EX1002, ¶338.

15. Claim 15

Supra, §VII.A.7; EX1002, ¶339.

16. Claim 16

Supra , §VII.A.8; EX1002, ¶340.

17. Claim 18

a) 18[a]

Supra, §VII.A.9(a); EX1002, ¶¶341-342.

b) 18[b]

Supra, §VII.A.9(b); EX1002, ¶343.

c) 18[c]

Supra, §VII.A.9(c); EX1002, ¶344.

18. Claim 19

Supra, §VII.A.10; EX1002, ¶345.

B. Ground 2

The *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination renders obvious Claims 1-19. EX1002, ¶¶346-389.

1. Motivation to Combine

A POSITA would have been motivated to combine *Gardner-Denver* with the *Cicci-Coli-Dixon-Liu* combination. *Supra*, §VII.A.1; EX1002, ¶¶347-353.

Gardner-Denver is analogous art to the '420 Patent because it is in the same field of endeavor regarding hydraulic fracturing systems. EX1010, 15; EX1001, 1:17-19, Abstract; EX1002, ¶348.

Coli contains an express motivation to combine the references. *Id*. *Coli* teaches that "[a] suitable pump is a quintiplex or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver." EX1006, ¶[0046]; EX1002, ¶349. A POSITA incorporating *Coli* would have been motivated to find information about the Gardner Denver (GD) SGWS-2500 pump, such as the information contained in *Gardner-Denver*. EX1002, ¶349.

A POSITA would have been motivated to look to *Gardner-Denver* for the implementation details and operating parameters of the Gardner-Denver pump disclosed in *Coli*. EX1002, ¶¶350-352; EX1010, 20, 85. A POSITA would have found *Gardner-Denver* helpful for understanding *Coli's* teachings regarding applicable fracturing pumps, their characteristics, and the connections. EX1002, ¶¶352. A POSITA would have found the operating data to be valuable in evaluating how many pumps would be necessary to pump the fracturing fluid at the suggested rate and pressure. *Id*. Furthermore, a POSITA would have found the connection data valuable in understanding the fittings appropriate to connect to the pump, such as the SGWS-2500. *Id*.

A POSITA would have had a reasonable expectation of success in combining *Gardner-Denver* with *Cicci-Coli-Dixon-Liu* combination as it is merely applies a known technique (applying a known pump) to a known device (*Cicci-Coli-Dixon-Liu*'s fracturing system) ready for improvement (the system's practical design) to yield predictable results (a system with an applicable pump, *e.g.*, GD SGWS-2500). EX1002, ¶353.

2. Claim 1

a) 1[p]-1[e]

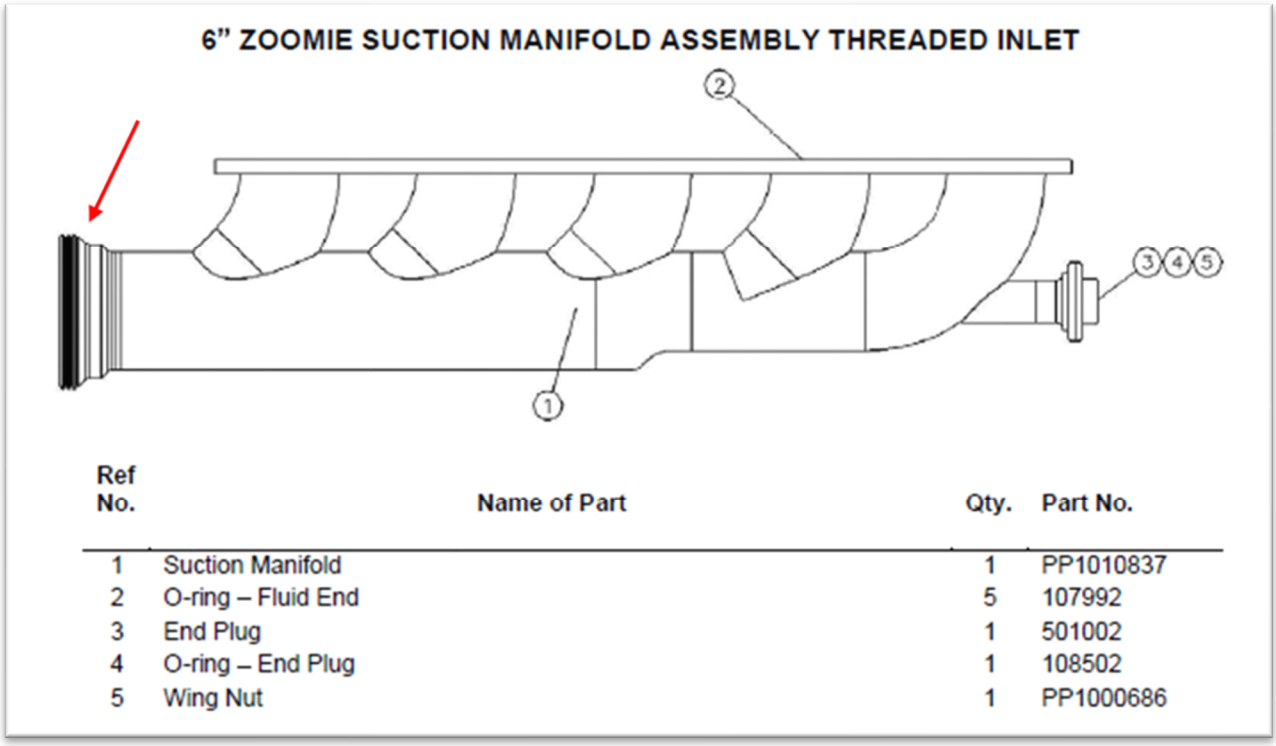
Limitations 1[p]-[e] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination for the same reasons in Ground 1. *Supra*, §§VII.A.2(a)-(f); EX1002, ¶355.

b) 1[f]

Supra, §VII.A.2(g). Adding *Gardner-Denver* renders limitation 1[f] obvious. *Gardner-Denver* discloses that commercially available fracturing pumps, for example, the Gardner Denver SGWS-2500 referenced by *Coli*, with 6-inch or 8-inch headers. *Infra*, §VII.B.3; EX1002, ¶¶356-357. This would have motivated a POSITA to combine well-known, commercially available components 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. EX1002, ¶356.

c) 1[g]

Supra, §VII.A.2(h). Adding *Gardner-Denver* further renders obvious limitation 1[g], as a POSITA would have understood from *Gardner-Denver* that the hammer union's other half (female half) attaches to the pump:



6" ZOOMIE SUCTION MANIFOLD ASSEMBLY THREADED INLET

Ref No.	Name of Part	Qty.	Part No.
1	Suction Manifold	1	PP1010837
2	O-ring – Fluid End	5	107992
3	End Plug	1	501002
4	O-ring – End Plug	1	108502
5	Wing Nut	1	PP1000686

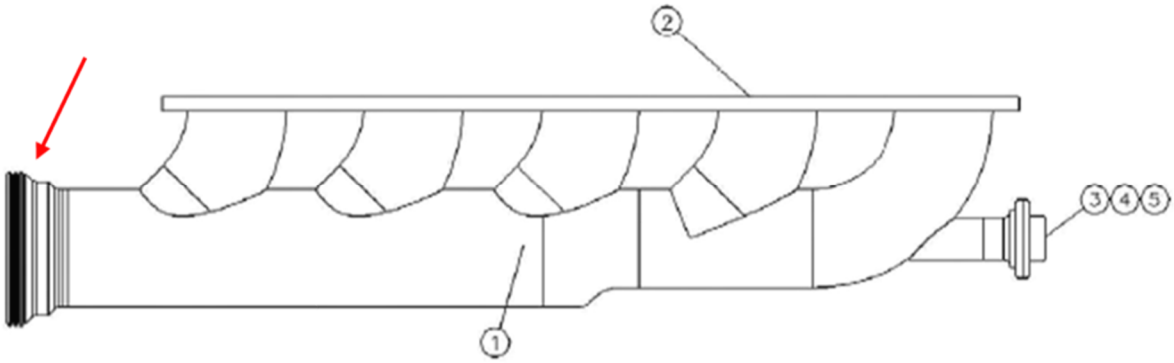
EX1010, 77; EX1002, ¶358.

3. Claim 2

Supra, §VII.A.3. It would have further been obvious for the second diameter to be approximately six inches in light of *Gardner-Denver*. EX1002, ¶¶359-366. *Coli* discloses a "SWGS-2500 Well Service Pump sold by Gardner Denver, Inc." EX1006, [0046]. It would have been obvious to use a fitting diameter consistent with this disclosure. EX1002, ¶363. A POSITA would have understood that *Coli* refers to 6-inch inlet connections with both threaded (for hammer union) and Victaulic

style inlet connections. *Id*. *Gardner-Denver* discloses suction manifolds with various connection types, including Victaulic and threaded inlets (for hammer unions) and fixed sizes, such as 6-inch and 8-inch connections. EX1010, 76-79. For example, the "6" Zoomie Suction Manifold Assembly Threaded Inlet" shows a hammer union end (red arrow) connected to a suction manifold. EX1010, 77; EX1002, ¶363. A POSITA would have understood this to be a 6-inch threaded inlet (hammer union half). *Id*.

6" ZOOMIE SUCTION MANIFOLD ASSEMBLY THREADED INLET



Ref No.	Name of Part	Qty.	Part No.
1	Suction Manifold	1	PP1010837
2	O-ring – Fluid End	5	107992
3	End Plug	1	501002
4	O-ring – End Plug	1	108502
5	Wing Nut	1	PP1000686

EX1010, 77.

Other connections and sizes include 6-inch Victaulic, 8-inch threaded (hammer union) and 8-inch Victaulic. EX1010, 76-79. Accordingly, *Gardner-Denver*, which contains information about the GD-2500 pump specifically referenced by *Coli,* discloses a 6-inch suction end for connection to the pump. *Id*.

Moreover, it would have been obvious to use a 6-inch hammer union to connect to the 6-inch inlet manifold disclosed by *Coli*. EX1002, ¶¶364-365; EX1001, 4:8-13; *supra*, §VII.A.2(h).

4. Claim 8

The *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination renders obvious Claim 8. EX1002, ¶¶367-381; *supra*, §VII.B.2.

Liu discloses that pressure drop and damage accumulation rate (*e.g.*, wear or abrasion on the hose) would have impacted the third diameter. *Supra*, §VII.A.8. Pressure drop and wear are directly related to velocity. *See id.*; EX1002, ¶368. Velocity (V), in turn, is related to both flowrate (Q) and hose diameter (D):

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

Id. The third diameter would have been selected based on an upper limit on velocity, above which pressure drop and/or wear would have been unacceptable. EX1002, ¶369.

In a similar manner, for any given hose diameter, there is a maximum flowrate above which velocity would be too high, leading to unacceptable pressure drop or wear. EX1002, ¶370. Accordingly, it would have been obvious that the third diameter is associated with a second threshold that corresponds to a maximum suggested flowrate, which would limit pressure drop and wear to acceptable levels. *Id*.

For example, *Coli* teaches blenders with outputs of approximately 100-240 bbl/min. EX1006, ¶[0060]. As the fluid supplied by the blender has the same rate as the fluid entering the wellbore, *Coli* teaches the system's range of maximum flow rates between 100-240 bbl/min (4200-10,080 GPM). EX1004, 5:17-25; EX1005, ¶[12]; EX1002, ¶371. This total would be divided by the total number of available pumps to provide the flowrate required by each pump. EX1002, ¶¶371-375.

Gardner-Denver, which contains information regarding the GD-2500 pump referenced by *Coli*, teaches that the "operating window" for each pump is between 191 GPM (red) and 2,044 GPM (blue), depending on the design, speed, and well conditions. EX1010, 20. For the conditions in *Cicci* ("5,000 PSI to 15,000 PSI, or more"), each pump's range is 191 GPM (red) to 734 GPM (blue). *Id.*; EX1004, 2:39-42; EX1005, ¶[12]; EX1002, ¶376.

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	

EX1010, 20.

Using *Coli*'s potential range of maximum flow rates (100-240 bbl/min), in *Cicci*'s system with 8 pumps would require a maximum flow rate between 12.5-30 bbl/min (525-1,260 GPM) per pump, respectively. EX1002, ¶377. However, in *Coli*'s system with as many as 24 pumps, each pump would require a maximum flow rate between 4.2-10 bbl/min (175-420 GPM). *Id*. A POSITA would have understood to operate the proper number of pumps (at least 8-24, or any number based on *Cicci-Coli*) so that each pump's maximum flow rate, as determined by the pressure drop and damage accumulation considerations, falls within the pump's operating window, as shown by *Gardner-Denver*. *Id.* 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). EX1002, ¶378. It would have been obvious that the operating window for the pump would exceed the maximum suggested flowrate determined by the pipe size, based on pressure drop and/or wear (damage accumulation). *Id.*

Further, as there are a finite number of pipe sizes of available (*e.g.*, the approximately 4-8 inch in *Dixon*), and the pump's operating window is large (*e.g.*, 4.5-48.66 BPM in *Gardner-Denver*), it would have been obvious that the pump's operating window would exceed the second threshold. *Id*., ¶379.

Accordingly, the *Coli-Cicci-Dixon-Liu-Gardner-Denver* combination renders obvious a maximum suggested flow rate, an operating window for the electric-powered multi-plunger hydraulic fracturing pump exceeding the maximum suggested flow rate. *Id.*, ¶¶380-381. Because the maximum suggested flowrate depends on the third diameter, the second threshold, corresponding to a maximum suggested flowrate, is associated with the third diameter. *Id.*, ¶380; *supra* §§VII.A.6-7.

5. Claim 11

a) 11[p]-[e], 11[g], 11[i]

Limitations 11[p]-[e], 11[g], and 11[i] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination for the same reasons as Ground 1. *Supra*, §§VII.A.11(a)-(f), (h), (j); EX1002, ¶¶383-384.

b) 11[f]

Supra, §§VII.A.11(g), VII.B.2(b); EX1002, ¶385.

c) 11[h]

Supra, §§VII.A.11(i), VII.B.2(c); EX1002, ¶386.

6. Claim 12

Supra, §§VII.A.12, VII.B.3; EX1002, ¶388.

7. Claim 17

Supra, §VII.B.4; EX1002, ¶389.

8. Claims 3-7, 9-10, 13-16, and 18-19

Claims 3-7, 9-10, 13-16, and 18-19 are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination for the same reasons as Ground 1. *Supra*, §§VII.A.4-10, VII.A.13-18; EX1002, ¶¶382, 387.

C. Grounds 3A and 3B

The *Cicci-Coli-Dixon-Liu-Kajaria* combination, with or without *Gardner-Denver*, renders obvious claim 20. EX1002, ¶¶390-407.

1. Motivation to Combine

A POSITA would have been motivated to combine the *Cicci-Coli-Dixon-Liu* combination with *Kajaria*, with or without *Gardner-Denver*. EX1002, ¶¶391-398;

supra §§VII.A.1, VII.B.1. *Kajaria* is analogous art to the '420 Patent because it is in the same field of endeavor regarding hydraulic fracturing systems. EX1008, 1:18-41; EX1002, ¶¶392-394; *supra*, §VII.A.1.

Kajaria discloses a hydraulic fracturing system similar to and compatible with the *Cicci-Coli-Dixon-Liu* system, including a fluid source, blender, pumps, and "various hoses and pipelines to direct the flow of the fracturing fluid into the wellbore." EX1008, 1:19-31; EX1002, ¶¶392-394; *supra*, §VII.A.1. *Kajaria* discloses that "slurry is conveyed to the pump trucks 16 [blue] by way of a slurry pipeline or first low-pressure pipeline 20 [red]." EX1008, 4:16-18, 4:31-45, Fig. 2. Accordingly, like *Cicci*, *Kajaria* discloses a low-pressure pipeline 20 connecting a fluid source to a pump. EX1002, ¶392; *supra*, §VII.A.1.

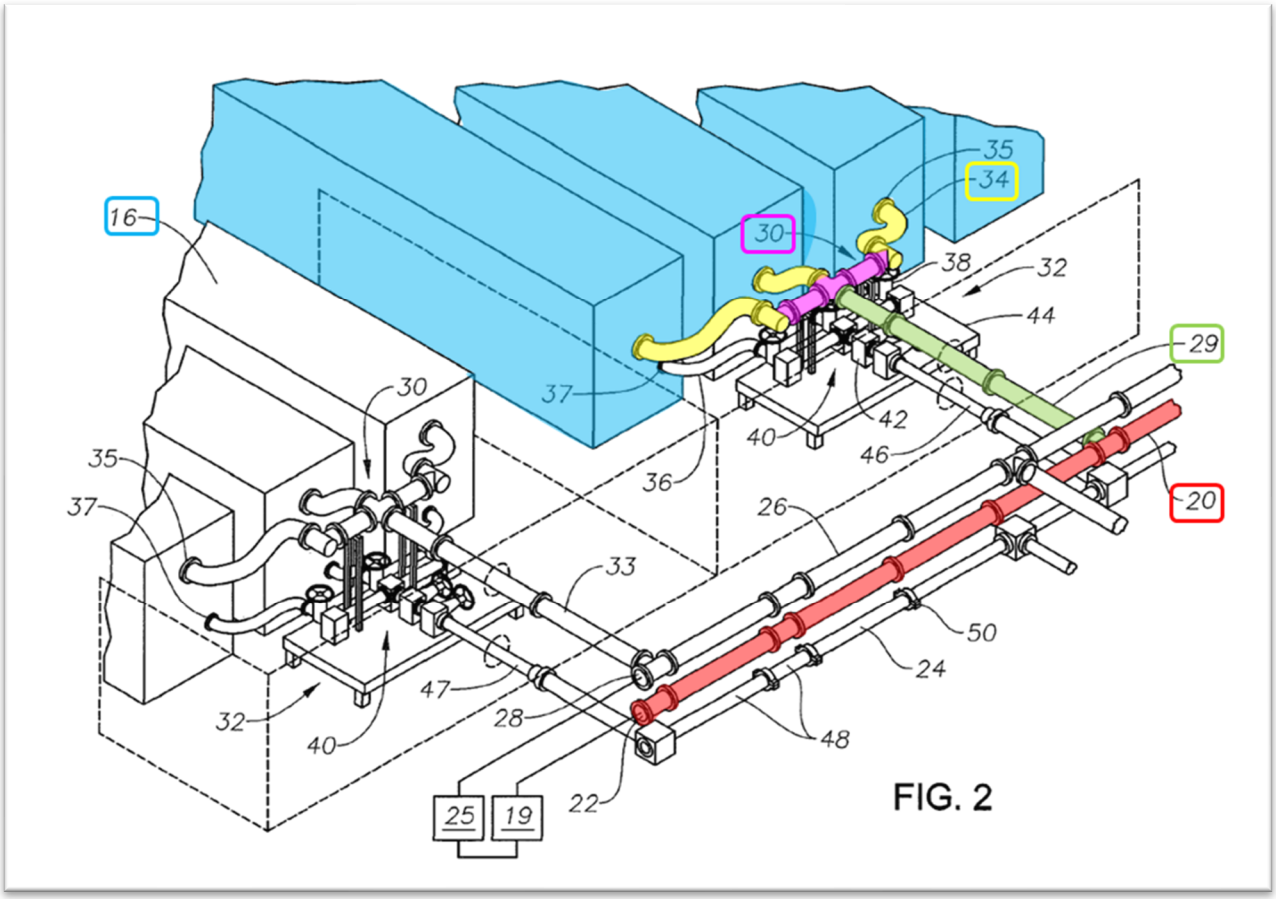
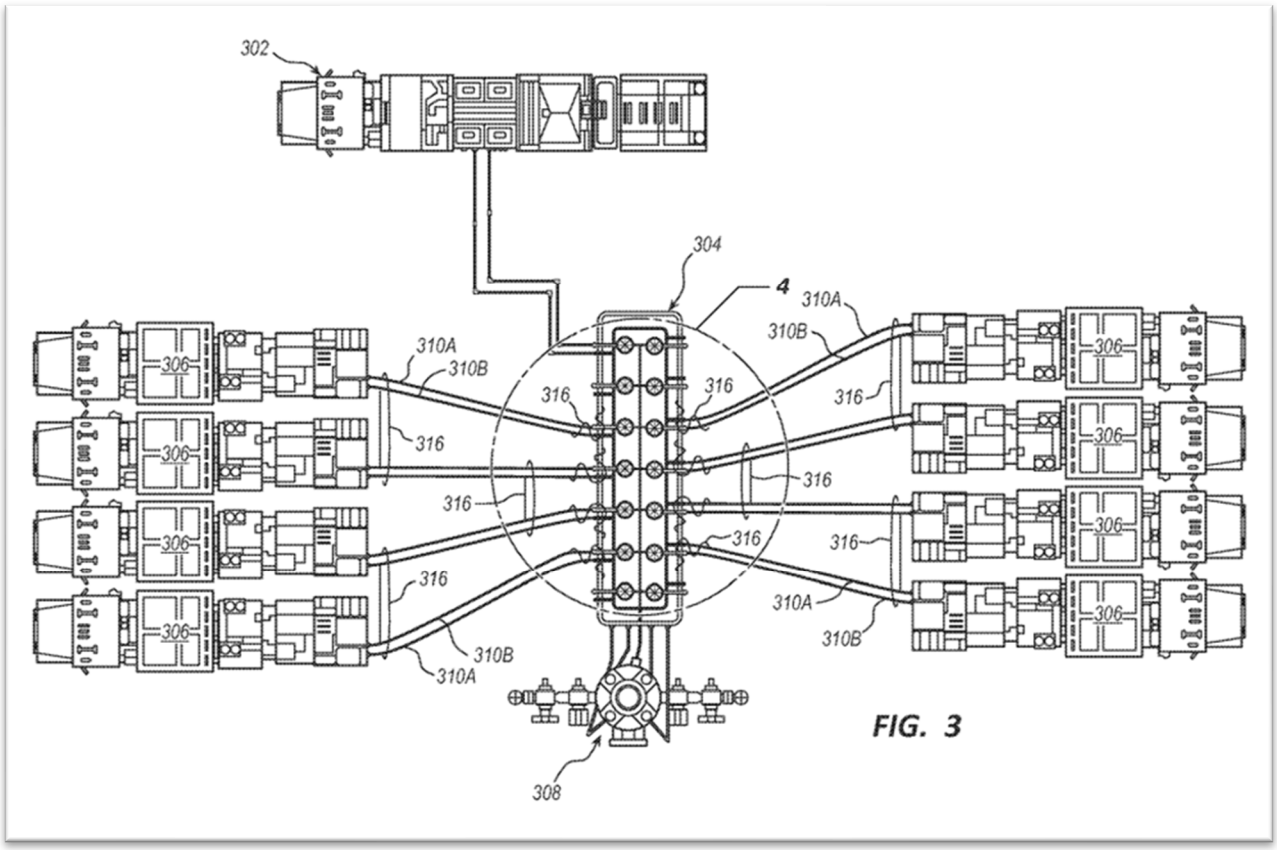


FIG. 2

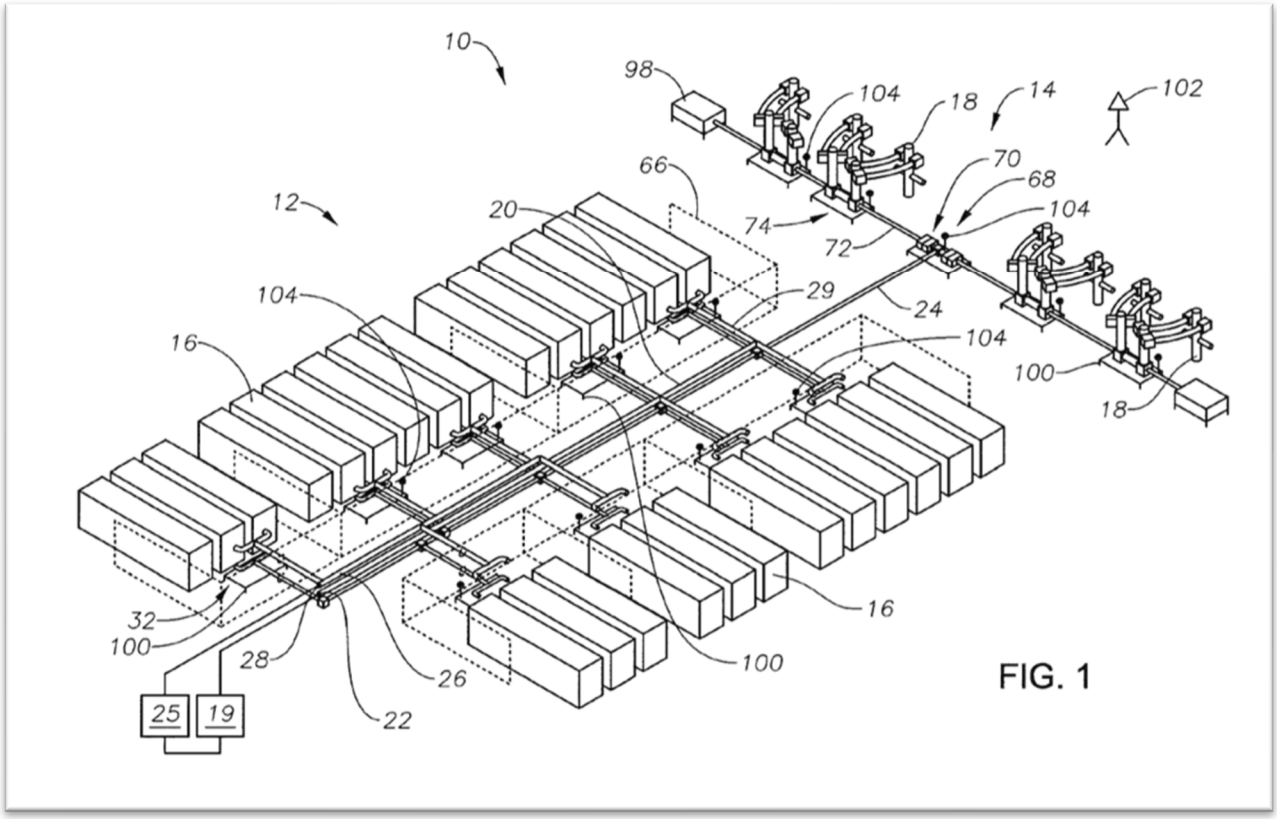
EX1008, Fig. 2. *Kajaria* discloses connecting to the inlet of a plurality of pumps from a single line connected to the fluid source 20. *See id.*; EX1002, ¶394.

A POSITA would have been motivated to incorporate *Kajaria's* feeding multiple pumps from a single flow line into *Cicci*'s hose connecting a fluid source to a pump to gain the benefits of easier assembly, reduced clutter, fewer manifold connections, fewer lines, and reduced chance of forming a proppant bed in the line. EX1002, ¶395. For example, a POSITA would also have understood, by comparing *Cicci*'s, Fig. 3 with *Kajaria*'s Fig. 1, that *Kajaria's* site was less cluttered (fewer lines between the pumps and the manifold), and required fewer connections at the

fluid source end (manifold/missile). *Id*., ¶396. For example, *Kajaria*'s system requires one suction connection at the manifold for every two (or three) pumps, whereas *Cicci*'s system requires one suction connection at the manifold for each pump. *Id*.



EX1004, Fig. 3; EX1005, Fig. 3.



EX1008, Fig. 1

A POSITA would have understood that such a modification reduces the likelihood of forming a proppant bed in the line. EX1002, ¶397. For example, a POSITA would have recognized that the slurry flow into the single suction line would be the sum of the flows of the two individual pumps. *Id*. This would increase the flow rate through the line, which would increase the velocity and reduce the likelihood of forming a proppant bed in the line, particularly during low-flow conditions, as discussed above in Ground 1. *Id*.; *supra*, §VII.A.2(g).

A POSITA would have had a reasonable expectation of success in the combination as it is simply applying a known technique (feeding the suction of two

pumps from a single line connecting to the manifold) to a known system (the *Cicci-Coli-Dixon-Liu* system, with or without *Gardner-Denver*) ready for improvement to yield predictable results (easier assembly, reduced clutter, fewer manifold connections, fewer lines, and reduced chance of forming a proppant bed in the line). EX1002, ¶398. This is further confirmed by *Kajaria*'s teaching that its system is "readily configured and assembled at a well site" due to its modularity. *Id*.; EX1008, Abstract.

2. Claim 20

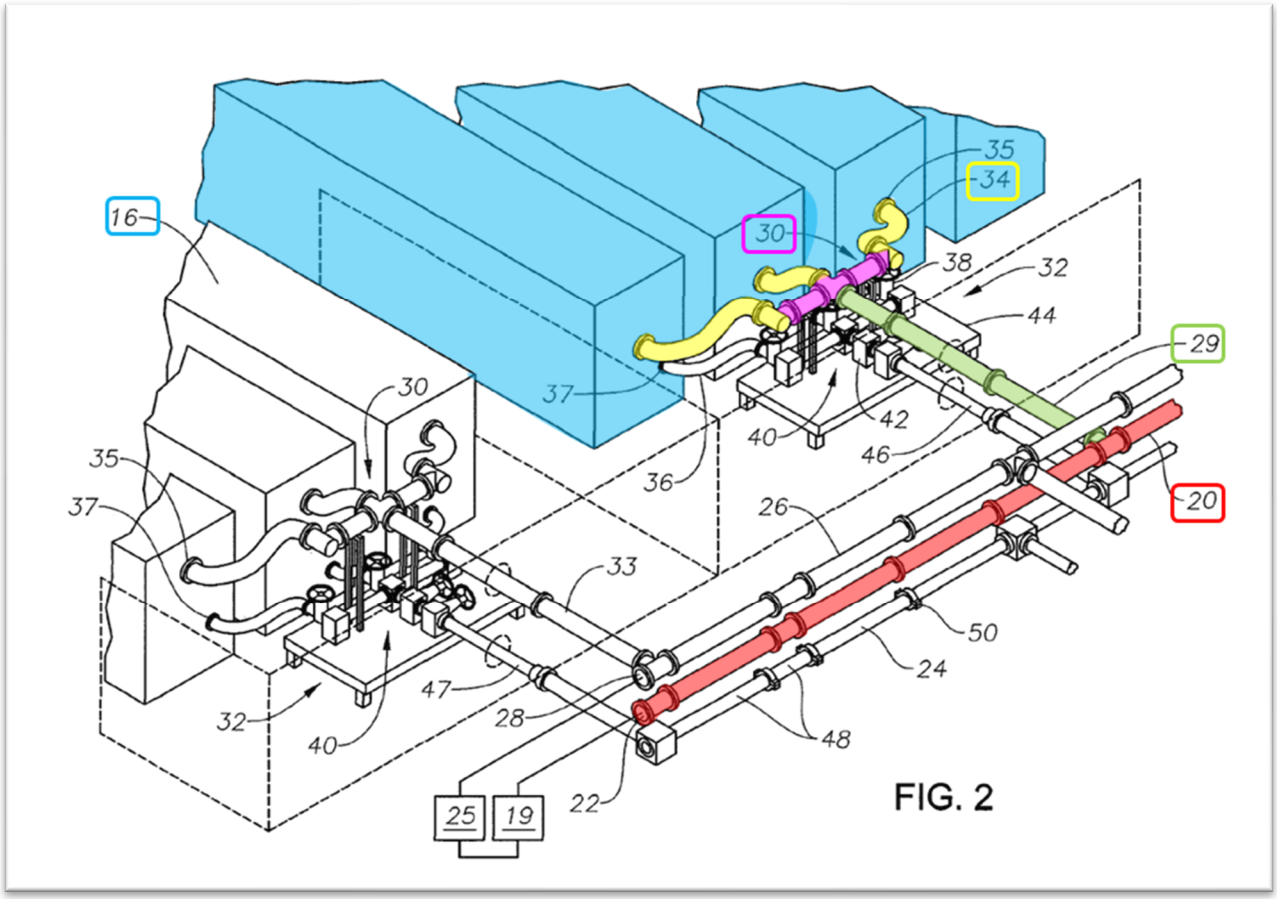
The *Cicci-Coli-Dixon-Liu-Kajaria* combination, with or without *Gardner-Denver*, renders obvious Claim 20. EX1002, ¶¶399-407; *supra*, §§VII.A.11, VII.B.5.

Kajaria discloses a third end of the hose for coupling to a second electric-powered multi-plunger hydraulic fracturing pump. EX1002, ¶400; *supra*, §VII.A.2(b). *Kajaria* discloses that "a plurality of high-pressure, high volume fracturing pumps, and various hoses and pipelines to direct the flow of the fracturing fluid to the wellbore." EX1008, 1:27-31. *Kajaria* discloses a single flow line to feed two pumps from the same suction line, which is connected to the fluid source. *Id*.; EX1002, ¶400.

Kajaria discloses that "slurry is conveyed to the pump trucks 16 [blue] by way of a slurry pipeline or first low-pressure pipeline 20 [red]." EX1008, 4:16-18.

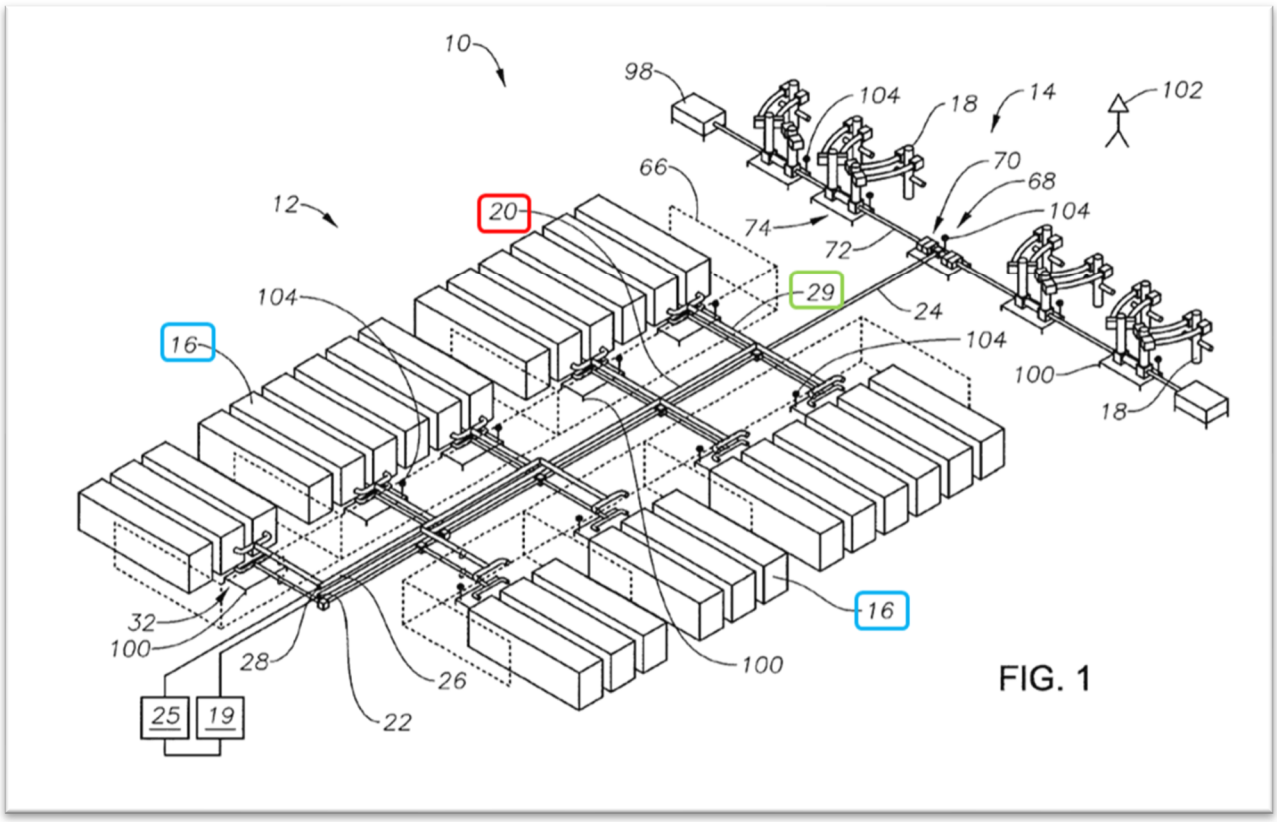
Accordingly, *Kajaria* discloses a fluid source as low-pressure pipeline 20. EX1002, ¶401.

Kajaria discloses "the slurry travels from first low-pressure pipeline 20 to truck slurry supply branch 29 [green]. Truck slurry supply branch 29 is in fluid communication with a distribution junction 30 [magenta]." EX1008, 4:31-33. *Kajaria* also discloses that "distribution junction 30 is in fluid communication with multiple truck connection lines 34 [yellow] and divides the slurry flowing in truck slurry supply branch 29 between the truck connection lines 34. Truck connection line 34 may be . . . either a flexible flow line or a rigid pipeline." *Id*., 4:40-45.

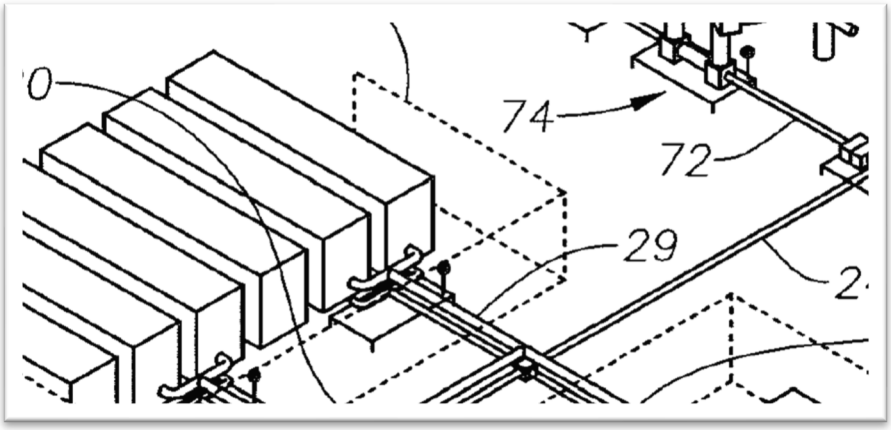


EX1008, Fig. 2.

Accordingly, *Kajaria* discloses a third end of the hose for coupling to a second electric-powered multi-plunger hydraulic fracturing pump by connecting to the inlet of a plurality of pumps from a single line connected to the fluid source 20. EX1002, ¶¶402-403. Although Fig. 2 shows the connection to three pump inlets, other examples are also disclosed, including the connection to two pump inlets from a single line. *Id.*; EX1008, Figs. 1-2.



EX1008, Fig. 1.



EX1008, Fig. 1 (detail).

Cicci discloses a third fitting positioned on the third end of the hose for coupling to an electric-powered multi-plunger hydraulic fracturing pump for the

same reasons above. *Supra*, §§VII.A.2(h), VII.A.2.11(h)-(k); EX1002, ¶404. It would have been obvious to use the third fitting for the same reasons as the fitting coupling to the electric-powered multi-plunger hydraulic fracturing pump discussed above. *Id*.

The third fitting, and the connection to the second electric-powered multi-plunger hydraulic fracturing pump, would have the second diameter for the same reasons discussed above. *Supra*, §§VII.A.2(f), VII.A.11.(f); EX1002, ¶405. It further would have been obvious for the second pump and third fitting to have the same diameter as the first pump and fitting, respectively, recited in Claim 11, to allow for interchangeability and standard sizing of pump parts and connections. EX1002, ¶¶405-406. A POSITA would have had a reasonable expectation of success in using the second diameter, because it is the diameter already used for the first pump and for the same reasons with respect to the first pump. *Id.*; *supra*, §VII.A.11(f).

D. Ground 4

The *Cicci-Coli-Dixon-Liu-Kajaria-Gardner-Denver-ANSI/HI 6.1* combination renders obvious Claims 8 and 17. EX1002, ¶¶408-426.

1. Motivation to Combine

A POSITA would have been motivated to combine *ANSI/HI 6.1* with the *Cicci-Coli-Liu-Dixon-Gardner-Denver* combination and would have had a reasonable expectation of success. EX1002, ¶¶408-417; *supra*, §VII.B.1.

ANSI/HI 6.1 is analogous art to the '420 Patent because it is directed to the same field of endeavor of hydraulic fracturing systems. EX1002, ¶409; EX1011, 76. *ANSI/HI 6.1* also would have been reasonably pertinent to the problem with which the '420 Patent is concerned—fluid flow rates for fracturing operations—as *ANSI/HI 6.1* relates to sizing hydraulic pumps and piping to maintain sufficient fluid velocity or flow. *Id*. *ANSI/HI 6.1* is a standard approved by the American National Standard when consensus is established. EX1011, 3-4; EX1002, ¶¶409-411.

A POSITA would have understood that *ANSI/HI 6.1* is directed towards the hydraulic fracturing pumps in the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system. EX1002, ¶412; EX1011, 11, 44, 76. For example, *Coli*'s "triplex or quintuplex plunger style fluid pump," is a reciprocating pump to which *ANSI/HI 6.1* relates. EX1006, ¶¶[0011], [0015], [0035], [0046], [0050], Claims 6-7, 27; EX1002, ¶412. Accordingly, a POSITA would have looked to *ANSI/HI 6.1* for implementation details for the pump in the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system. EX1002, ¶412.

Further, *ANSI/HI 6.1* describes reciprocating power pumps to pump slurry, as would have been used in the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system. EX1002, ¶413; *supra*, §VII.B.1. *ANSI/HI 6.1* discloses that "[r]eciprocating pumps are used to handle slurries for in-plant process and pipeline applications." EX1011, 76. A POSITA would have recognized that "in-plant" applications would include a

hydraulic fracturing plant, such as the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system. EX1002, ¶413.

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), *ANSI/HI 6.1* teaches sizing pumps' hydraulic passages within operating carrying velocities, and below a highest velocity which would otherwise cause "excessive erosion." EX1011, 76. A POSITA would have been motivated to apply these teachings to pump and hose slurry passages in the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system to obtain the benefits of avoiding excessive erosion, which would damage the pipe and equipment. EX1002, ¶414. A POSITA would have had a reasonable expectation of success in doing so because the same slurry passes through the pumps and hoses, and the same principles apply. *Id*.

Liu discloses wear (abrasion) at high velocities. *Supra*, §VII.A.8. A POSITA would have been motivated to look to *ANSI/HI 6.1* for implementation details of avoiding damaging erosion. For example, *ANSI/HI 6.1* 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." EX1011, 44. 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. EX1002, ¶415. Accordingly, *ANSI/HI 6.1* and *Liu*'s teachings are complimentary. *Id*.

ANSI/HI 6.1 provides real-world numbers, applying *Liu*'s principles. *Id*., ¶416. Accordingly, a POSITA would have been motivated to apply the slurry velocity limits in *ANSI/HI 6.1* when applying *Liu*'s principles to the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system. *Id.* A POSITA accordingly would have been motivated to look to *ANSI/HI 6.1* for implementation details. *Id.*

A POSITA would have had a reasonable expectation of success in applying *ANSI/HI 6.1* to the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system because the combination merely applies a known technique (practical limits on slurry velocity) to a known system (hydraulic fracturing system) ready for improvement (applying *Liu*'s principles) to yield predictable results (minimizing proppant drop out and wear/abrasion/erosion). EX1002, ¶417.

2. Claim 8

Supra, §VII.B.2. *ANSI/HI 6.1* further renders Claim 8 obvious. EX1002, ¶¶418-425. *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)." EX1011, 76. A POSITA would have recognized that this applies to the *Cicci-Coli-Dixon-Liu-Gardner-Denver* hoses' hydraulic passages, particularly considering *Liu*'s abrasion teachings. EX1002, ¶¶419-420. A POSITA would have been motivated to obtain the benefits of avoiding excessive erosion, which would damage the pipe and equipment. *Id*. It would have been obvious to apply such teachings to the hoses because the same slurry passes through the pump and hoses. *Id.*

A POSITA would have understood, based on these combined teachings, that slurry velocities should be maintained between 1.8-3.6 m/s (6 to 12 ft/s) to minimize slurry drop out and wear/abrasion/erosion. *Id*., ¶422. For any given hose diameter, there is a maximum flow rate above which velocity would exceed 12 ft/s, leading to unacceptable pressure drop or wear. *Id*. Further, for any given hose diameter, there is a minimum flow rate above which velocity would be below 6 ft/s, leading to unacceptable slurry drop-out. *Id*. Accordingly, it would have been obvious that the third diameter is associated with a second threshold that corresponds to a maximum suggested flow rate, which would limit pressure drop and wear to acceptable levels. *Id*.

Applying *Liu*'s formula, it would have been obvious to calculate minimum and maximum flowrates applying *ANSI/HI 6.1*'s limits for certain hose sizes, as shown below:

Hose Diameter (inches)	Minimum Flowrate (BPM)	Maximum Flow Rate (BPM)
3	3.15	6.29
4	5.60	11.19
5	8.74	17.49

EX1002, ¶423; *supra*, §VII.A.2(g).

Gardner-Denver describes operation ranges for its pump, teaching that the "operating window" for each pump is between 191 GPM (4.5 BPM, red) and 2,044 GPM (48.66 BPM), depending on the design, speed, and specific well conditions. EX1010, 20; *supra*, §VII.B.4. For *Cicci*'s conditions ("5,000 PSI to 15,000 PSI, or more"), each pump's range is 191 GPM (4.5 BPM, red) to 734 GPM (17.5 BPM, blue). EX1004, 2:39-42; EX1005, ¶[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	

EX1010, 20. Comparing the *Gardner-Denver* pump's operating range with *ANSI/HI 6.1*'s maximum flowrate thresholds, applying *Liu*'s principles, shows that the operating window exceeds the maximum suggested flowrate threshold of the hose sizes which would have been obvious. EX1002, ¶¶424-425.

3. Claim 17

Supra, §VII.D.2; EX1002, ¶426.

VIII. CONCLUSION

Petitioners respectfully request *inter partes* review of the '420 Patent be instituted and that the challenged claims be canceled as unpatentable under 35 U.S.C. §318(b).

Respectfully submitted,

BAKER BOTTS L.L.P.



Chad C. Walters (Reg. No. 48,022)

Lead Counsel for Petitioners

Date: October 06, 2025

2001 Ross Ave., Suite 900
Dallas, TX 75201-2980
Phone: (214) 953-6511
Fax: (214) 661-4511
chad.walters@bakerbotts.com

CERTIFICATE OF SERVICE

The undersigned hereby certifies on this 6th day of October 2025, that true and correct copies of the foregoing PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 11,668,420, Exhibits 1001-1059, and Petitioner's power of attorney were served in their entirety to Patent Owner via FedEx Express® or Express Mail:

Hogan Lovells US LLP

609 Main Street, Suite 4200

Houston, Texas 77002

BAKER BOTTS L.L.P.



Chad C. Walters (Reg. No. 48,022)

Lead Counsel for Petitioners

Date: October 6, 2025

2001 Ross Ave., Suite 900
Dallas, TX 75201-2980
Phone: (214) 953-6511
Fax: (214) 661-4511
chad.walters@bakerbotts.com

CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME LIMITATION, TYPEFACE REQUIREMENTS, AND TYPE STYLE REQUIREMENTS

1. This Petition complies with the type-volume limitation of 14,000 words, comprising 13,793 words, excluding the parts exempted by 37 C.F.R. § 42.24(a).

2. This Petition complies with the general format requirements of 37 C.F.R. § 42.6(a) and has been prepared using Microsoft® Word in 14-point Times New Roman.

Respectfully submitted,

BAKER BOTTS L.L.P.



Chad C. Walters (Reg. No. 48,022)

Lead Attorney for Petitioners

Date: October 6, 2025

2001 Ross Ave., Suite 900
Dallas, TX 75201-2980
Phone: (214) 953-6511
Fax: (214) 661-4511
chad.walters@bakerbotts.com