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. IPR2025-01445
Patent 11,009,162

PETITION FOR *INTER PARTES* REVIEW OF CLAIMS 1-14 OF U.S. PATENT NO. 11,009,162

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LIST OF EXHIBITS

Ex. No.[1]	Description
1001	U.S. Patent No. 11,009,162 to Jared Oehring *et al.*(the "'162 Patent")
1002	Declaration of Dr. Robert Durham
1003	File History for U.S. Patent No. 11,009,162 ("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 *et al.* ("*Coli*")
1007	Henry Liu, *Pipeline Engineering*, CRC Press, 2003 ("*Liu*")
1008	Kemper Valve & Fittings Corp. – Union Swages, available at https://web.archive.org/web/20190405051213/http://www.kempervalve.com:80/unionswages.php
1009	2018 Australia Dixon Product Catalog, available at https://australia.dixonvalve.com/sites/default/files/downloadable_resources/product_literature/ADPL718%20Catalog_optimized_0.pdf
1010	Gardner Denver, Inc., Well Servicing Pump, Model GD-2500Q, Quintuplex, Operating and Service Manual, 300FWF996 Revision C, ("*Gardner*") published in April 2005, Tulsa, OK, USA.
1011	American National Standard for Reciprocating Power Pumps, ANSI/HI 6.1 (2015)
1012	2018 U.S. Dixon Product Catalog
1013	Declaration of Holly Lagenfelder
1014	Declaration of Dr. Sylvia Hall-Ellis
1015	Michael Morton, "*Unlocking the Earth: A Short History of Hydraulic Fracturing*," GEO ExPro, Vol. 10, No. 6, December 2013

[1] Citations to patents are made by column and line number. Citations to patent publications are made by paragraph number. Citations to Ex. 1003, Ex. 1010, and Ex. 1011 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 are added unless otherwise indicated.

	https://geoexpro.com/unlocking-the-earth-a-short-history-of- hydraulic-fracturing/ (last accessed November 30, 2023)
1016	B.A. Wells and K.L. Wells, "Shooters – A "Fracking" History." American Oil & Gas Historical Society, https://aoghs.org/technology/hydraulic-fracturing (last accessed November 30, 2023)
1017	Carl T. Montgomery and Michael B. Smith, "Hydraulic Fracturing: History of an Enduring Technology," *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	Gardner Denver, *Operating and Servicing Manual: Well Servicing Pump Model GD-2500Q QUINTUPLEX*, August 2005, available at, https://web.archive.org/web/20120917102614/http:/www.quincieoilfield.com/pdf/3.0%20Gardner%20Denver/2500/GD2500Q%20Op%20&%20Service%20Manual.pdf
1045	Socket Weld Fittings Types and Applications – Complete Specification, ASME B16.11-2004 available at: https://web.archive.org/web/20180210052553/https://www.octalsteel.com/socket-weld-pipe-fittings/.
1046	Cambridge English Dictionary, definition of "weld," https://web.archive.org/web/20170709094317/https://dictionary.cambridge.org/dictionary/english/weld
1047	Collin's English Dictionary definition of "quintuplex": https://www.collinsdictionary.com/dictionary/english/quintuplex

1048	Jacobs, Trent. "*The Shale Evolution: Zipper Fracture Takes Hold*," JPT Technology Writer, October 2014, (2014): 60–67
1049	Turbines: Solar Mobile Turbomachinary, available at https://www.solarturbines.com/en_US/solutions/oil-and-gas/solar-mobile-turbomachinery.html
1050	CNC Flow Control, Oilfield Solutions: Valves, Fittings, & Flow Lines
1051	GTS Admiral W.M. Callaghan, available at https://www.maritime.dot.gov/multimedia/gts-admiral-wm-callaghan
1052	Caterpillar Acquires Kemper Valve & Fittings Corp. Press Release, available at: https://www.cat.com/en_US/news/engine-press-releases/caterpillaracquireskempervalvefittingscorporationexpandingcatwel.html
1053	Affidavit of Duncan Hall, dated June 7, 2021
1054	MARC record for ANSI/HI 6.1-6.5 (2015), available at: https://catalog.lindahall.org/discovery/sourceRecord?vid=01LINDAHALL_INST:LHL&docId=alma999258734905961&recordOwner=01LINDAHALL_INST
1055	Hydraulic Fracturing Institute Reciprocating Pump Standards: available at https://web.archive.org/web/20150808112714/http://estore.pumps.org/Standards/Reciprocating/Hardcopy.aspx
1056	Claim Listing
1057	Variable Speed Pumping: A Guide to Successful Applications
1058	Langewis, C. et al., "Practical Hydrualics for Positive Displacement Pumps for High-Pressure Waterflood Installations," Journal of Petroleum Engineering 173 (1971)_

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: U.S. Patent No. 11,009,162 ("the '162 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.* (E.D. Tex.) ("Liberty Litigation").

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).

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II. STANDING AND FEES

Standing: Petitioners certify under 37 C.F.R. §42.104(a) that the '162 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 '162 PATENT

A. Subject Matter

The '162 Patent describes a conventional fracturing system, as illustrated in Figure 1:

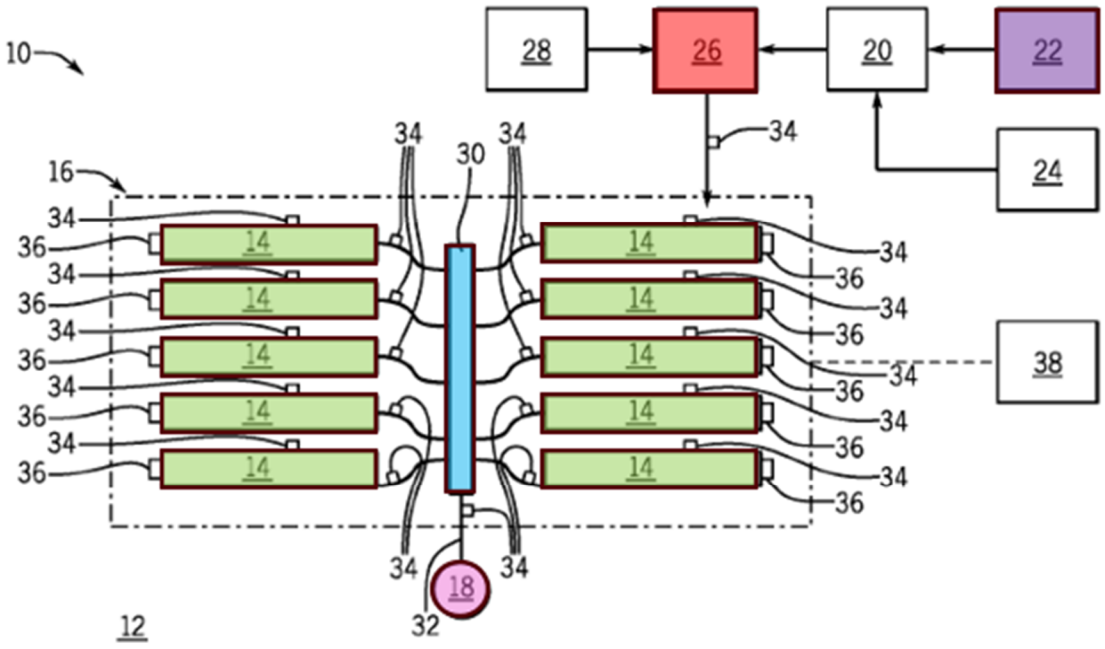


FIG. 1

EX1001, Fig. 1, 4:17-49. The blender 26 (red) receives fluid from the fluid source 22 (purple) and adds proppant to form a slurry. EX1001, 4:24-28. The pumps 14 (green) pressurize the slurry. *Id.*, 4:19-21. The distribution system 30 (blue), such as a missile, receives the slurry from the pump for injection into the wellhead. *Id.*, 4:34-36. 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 electric powered pump with "a first end for receiving the hose at the first diameter and a second end for coupling to the electric powered pump at a second diameter," illustrated below:

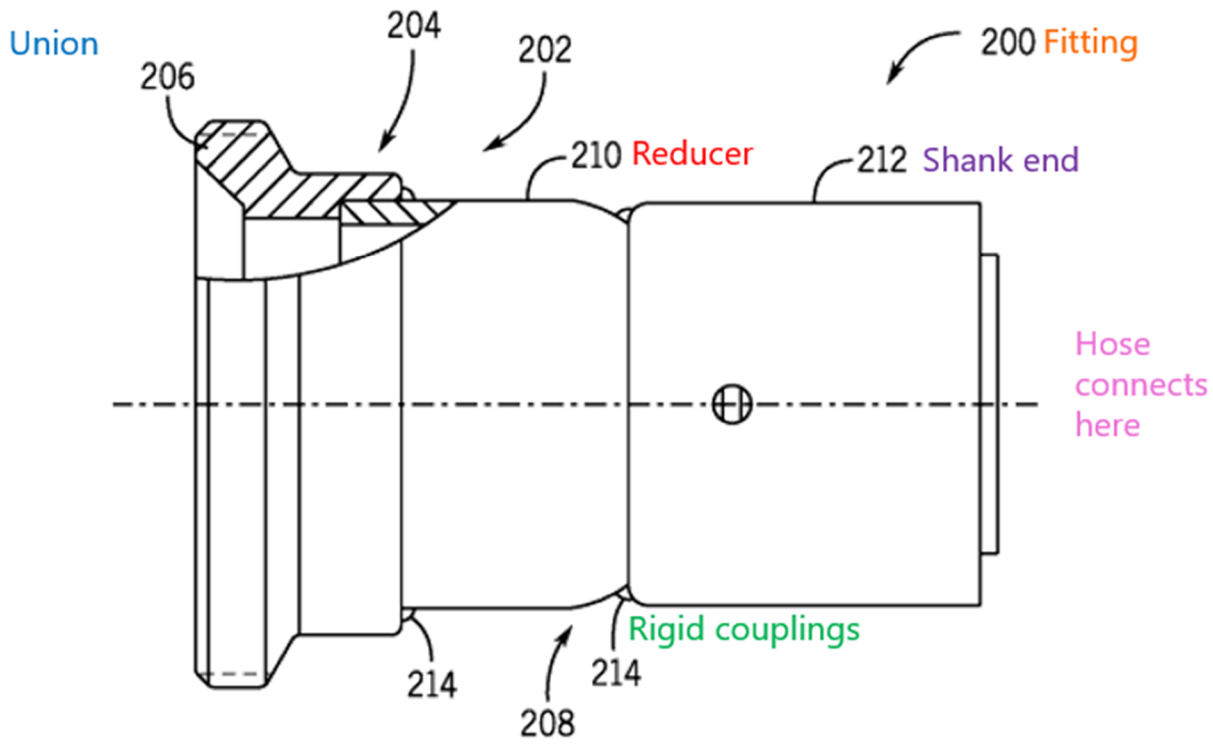


FIG. 2

Id., Abstract, Fig. 2. The patent describes embodiments in which the first and second diameters have different relative sizes. *Id.*, 6:18-38.

B. Prosecution History

The '359 Application that ultimately issued as the '162 Patent was filed on December 27, 2019. The Examiner allowed the claims without commenting on the alleged points of novelty. EX1003, 280-285.

C. Priority Date

For purposes of this Petition, Petitioner assumes that the earliest possible priority date for the Challenged Claims would be no earlier than December 27, 2019, when U.S. Patent App. No. 16/728,359, issued as the '162 Patent, 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 62/941,549 ("*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 co-pending 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, 5:25-29; EX1005, ¶[23]; EX1004, 1:9-19; EX1005, ¶[1].

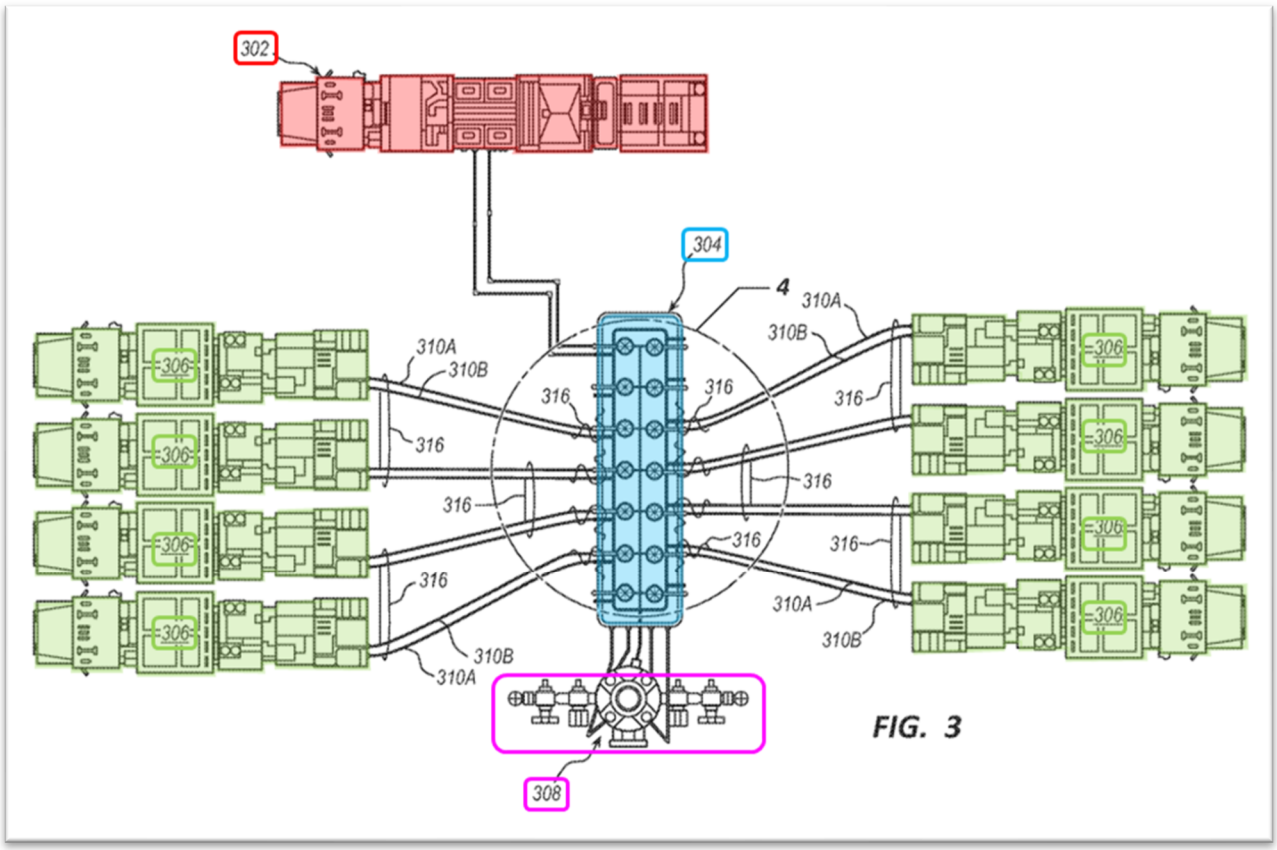


FIG. 3

EX1004, Fig. 3; EX1005, Fig 3; EX1002, ¶¶95-96.

B. Coli (EX1006)

U.S. Patent Application Publication 2012/0255734 ("*Coli*") was filed on April 6, 2012, and published on October 11, 2012. *Coli* qualifies as prior art under §§102(a)(1)-(2).

Coli involves a "fracturing system" for "delivering fracturing fluid to a wellbore at a fracturing operation." EX1006, ¶[0034]. *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[.]" *Id*., ¶¶[0046], [0049]; EX1002, ¶¶97-101.

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, ¶50. *Liu* qualifies as a prior art printed publication under §102(a)(1).

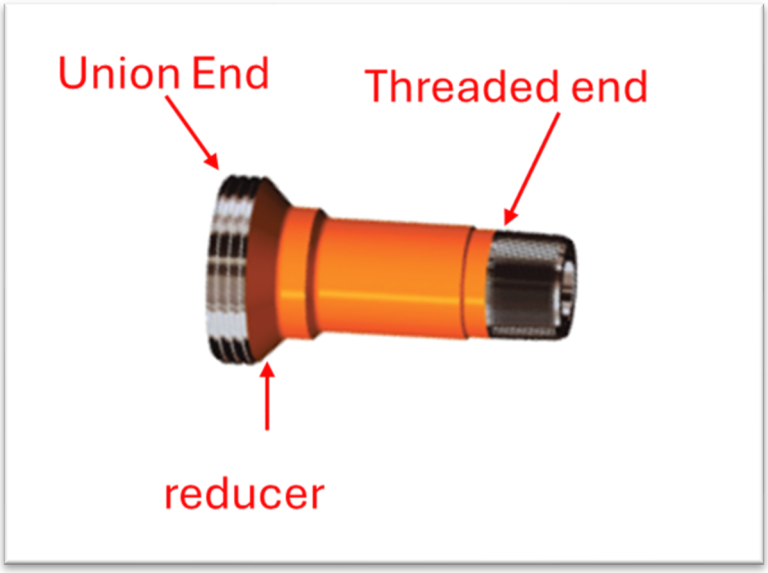
Liu contains well-known scientific principles regarding fluid flow, including slurries, through pipelines. EX1002, ¶¶102-103; EX1007, Preface. *Liu* contains a "review of fluid mechanics pertinent to pipe flow" and "more advanced subjects," including "flow of solid/liquid mixtures" (slurries). *Id*.

Chapter 5 discusses "the flow of solid particles transported by liquid in pipelines, namely, slurry pipelines[,]" (EX1007, 131) 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. EX1002, ¶104.

D. Kemper (EX1008)

Kemper is the webpage for Kemper Valve. Kemper was publicly accessible since at least April 5, 2019. EX1002, ¶105; EX1053, ¶5. *Kemper* is a prior art under §102(a)(1).

Kemper discloses hammer union swages for fracturing applications, where the swage includes a reducer:



EX1008, 1; EX1002, ¶¶105-107.

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, ¶¶108-113; EX1013, ¶¶1-13.

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":



Id.

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

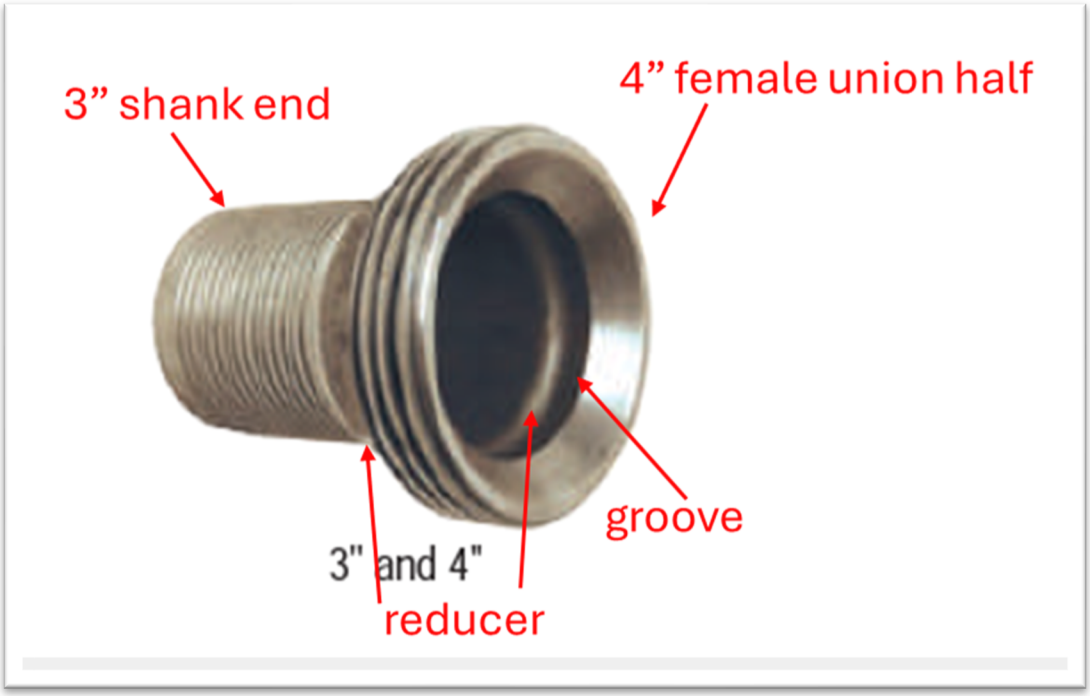
[2] References to "*Dixon*" refer to both catalogs because the catalogs have the same disclosure of the claim limitations as applied in this Petition.

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, 995. The catalogs also list "New Products for 2018." EX1009, 10; EX1012, 4-5. 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, ¶112; EX1013. Dixon would have been a well-known company to a POSITA. EX1002, ¶113; 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, ¶¶114-115.

F. Gardner-Denver (EX1010)

Gardner-Denver is an operating and service manual for Gardner Denver's GD-2500Q Quintuplex pump (300FWF996 Rev C) that was originally published in 2001, and revised in 2005 (EX1010, 1, 46), and a GD-2500Q Fluid End Parts list published in September 2011 (EX1010, 47). *Gardner-Denver* was publicly accessible on the internet by at least September 2012. EX1053, 1, 4, 51. 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, ¶¶116-117. *Gardner-Denver* thus qualifies as a prior art printed publication 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, ¶118. The public accessibility of *Gardner-Denver* by at least 2012 is further confirmed by this express reference in *Coli*, which was also filed and published in 2012. *Id.*, ¶¶118-122.

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

ANSI/HI 6.1 is the "American National Standard for Reciprocating Power Pumps," published in 2015. EX1011, 1, 3. *ANSI/HI 6.1* bears a copyright date of 2015 and was "approved" on March 5, 2015. *Id*., 2. *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, ¶¶126-127. For example, *ANSI/HI 6.1* was publicly accessible from the Hydraulic

[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, ¶118.

Institute by at least August 8, 2015. *Id*., ¶¶128-129; EX1055. *ANSI/HI 6.1* also was cataloged, indexed, and publicly accessible at a library by at least October 31, 2016. EX1002, ¶¶130-132; EX1054. *ANSI/HI 6.1* therefore is prior art under §102(a)(1).

ANSI/HI 6.1 describes the use of reciprocating power pumps to pump slurry, such as would have been used in hydraulic fracturing systems. *Id*., 66; EX1002, ¶125. *ANSI/HI 6.1* teaches ranges of fluid velocities to avoid excessive corrosion. EX1011, 11; EX1002, ¶¶123-125.

H. Grounds

Ground	Claims	Basis (35 U.S.C. §)	Prior Art
1	1-4, 8-10, 14	103	*Cicci, Coli,* and *Dixon*
2	1-6, 8-12, 14	103	*Cicci, Coli, Dixon*, and *Liu*
3	1-14	103	*Cicci, Coli, Dixon*, *Liu,* and *Gardner-Denver*
4A	1-14	103	*Cicci, Coli, Dixon*, *Liu,* and *Kemper*
4B	1-14	103	*Cicci, Coli, Dixon*, *Liu, Gardner-Denver,* and *Kemper*
5A	7	103	*Cicci, Coli, Dixon*, *Liu, Gardner-Denver,* and *ANSI/HI 6.1*
5B	7	103	*Cicci, Coli, Dixon*, *Liu, Gardner-Denver, Kemper*, and *ANSI/HI 6.1*

EX1002, ¶19; EX1056.

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, ¶46.

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, ¶47.

VII. THE CHALLENGED CLAIMS ARE UNPATENTABLE

A. Ground 1

The *Cicci-Coli-Dixon* combination renders obvious claims 1-4, 8-10, and 14. EX1002, ¶¶133-266.

1. Motivation to Combine

A POSITA would have been motivated to combine *Cicci*, *Coli*, and *Dixon*, and would have a reasonable expectation of success. EX1002, ¶¶134-158.

A POSITA would have been motivated to combine *Coli* with *Cicci*. EX1002, ¶135. Both *Coli* and *Cicci* are in the same field of endeavor as the '162 Patent of hydraulic fracturing systems. *Id.*; EX1001, Abstract, 1:8-10; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, Abstract, ¶¶[0003], [0009].

Coli and *Cicci* disclose similar and compatible hydraulic fracturing systems. EX1002, ¶¶135-139. 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, ¶139; 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, ¶¶140-141; 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, ¶142. *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, ¶¶143-148. 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 as would have been well-known to a POSITA. *Id.*; EX1006, ¶¶[0046], [0049]. As *Coli* discloses, electric-powered pumps "obviate 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 have made the system more efficient. EX1002, ¶148. Reduced numbers of pieces of equipment would have resulted in lower maintenance requirements, as there would be fewer pieces of equipment to maintain. *Id*. A reduced footprint would have allowed the system to be configured in a smaller space and/or arranged more easily. *Id*. Reduced weight would have made it easier to transport the pumps. *Id*. It additionally would have been well-known to a POSITA that an electric motor would have reduced 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, ¶149. 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, ¶149; *see also* EX1021, 1:46-65 (electric powered pumps were well known); *see generally* EX1038 (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 traditional, diesel-powered systems. *Id*.

A POSITA would have been further motivated to incorporate *Dixon* into the *Cicci-Coli* system. *Id*., ¶¶150-158. *Dixon* is analogous art to the '162 Patent as it is in the same field of endeavor as the '162 Patent of hydraulic fracturing system. *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 '162 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, 1:14-45; EX1003, 433.

A POSITA would have been motivated by *Cicci*'s disclosure of fittings to look to references that teach about fittings and hoses. *Id*., ¶¶151-152. 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, ¶153. *Dixon* contains information about commercially available hoses and fittings for "slurry" systems and hydraulic fracturing applications.

EX1002, ¶¶153-156; 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 designing 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, ¶157. 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, ¶157. 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.B.6-7.

A POSITA would have had a reasonable expectation of success in combining *Dixon* with *Cicci-Coli*. EX1002, ¶158. 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.

2. Claim 1

a) 1[p]

To the extent the preamble is limiting, the *Cicci-Coli-Dixon* combination discloses the preamble. EX1002, ¶¶160-165.

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, ¶164.

b) 1[a]

The *Cicci-Coli-Dixon* combination discloses limitation 1[a]. EX1002, ¶166-174.

Cicci and *Coli* each disclose a hydraulic fracturing pump. *Id*., ¶¶167-169; EX1004, 1:7-19; EX1005, ¶[1]; EX1006, Abstract.

Coli discloses an electric-powered multi-plunger hydraulic fracturing pump. EX1002, ¶¶167-169. *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].

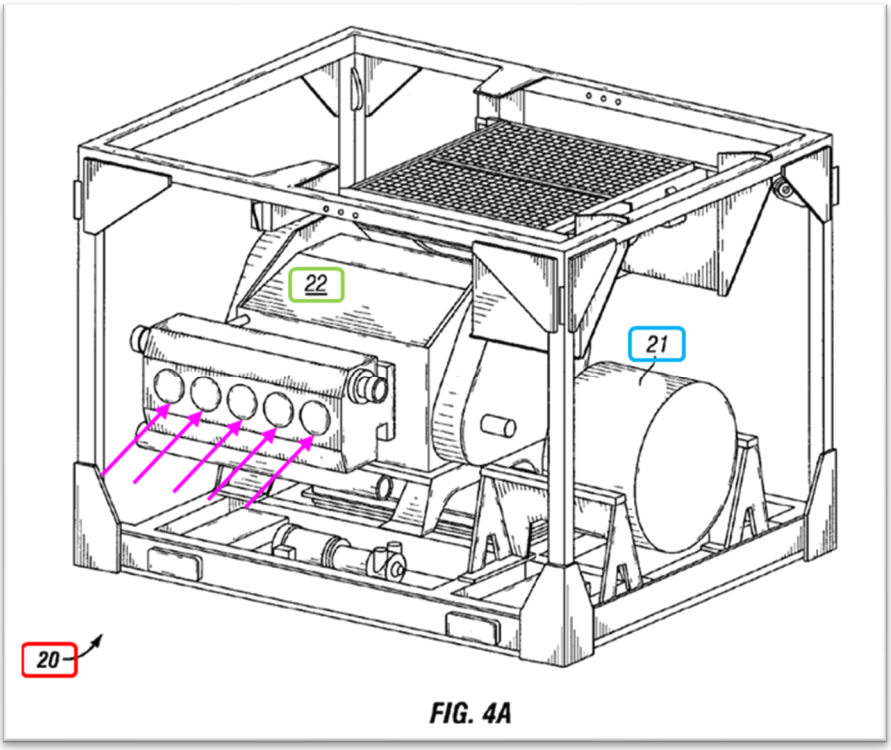


FIG. 4A

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, ¶¶53-63, 141, 168. Fig. 4A illustrates a quintuplex (5-plunger) pump, with magenta arrows identifying each plunger. EX1002, ¶168.

Coli's electric-powered pump is powered by at least one electric motor. EX1002, ¶160. *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, ¶¶141-148, 169.

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, ¶¶170-171.

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

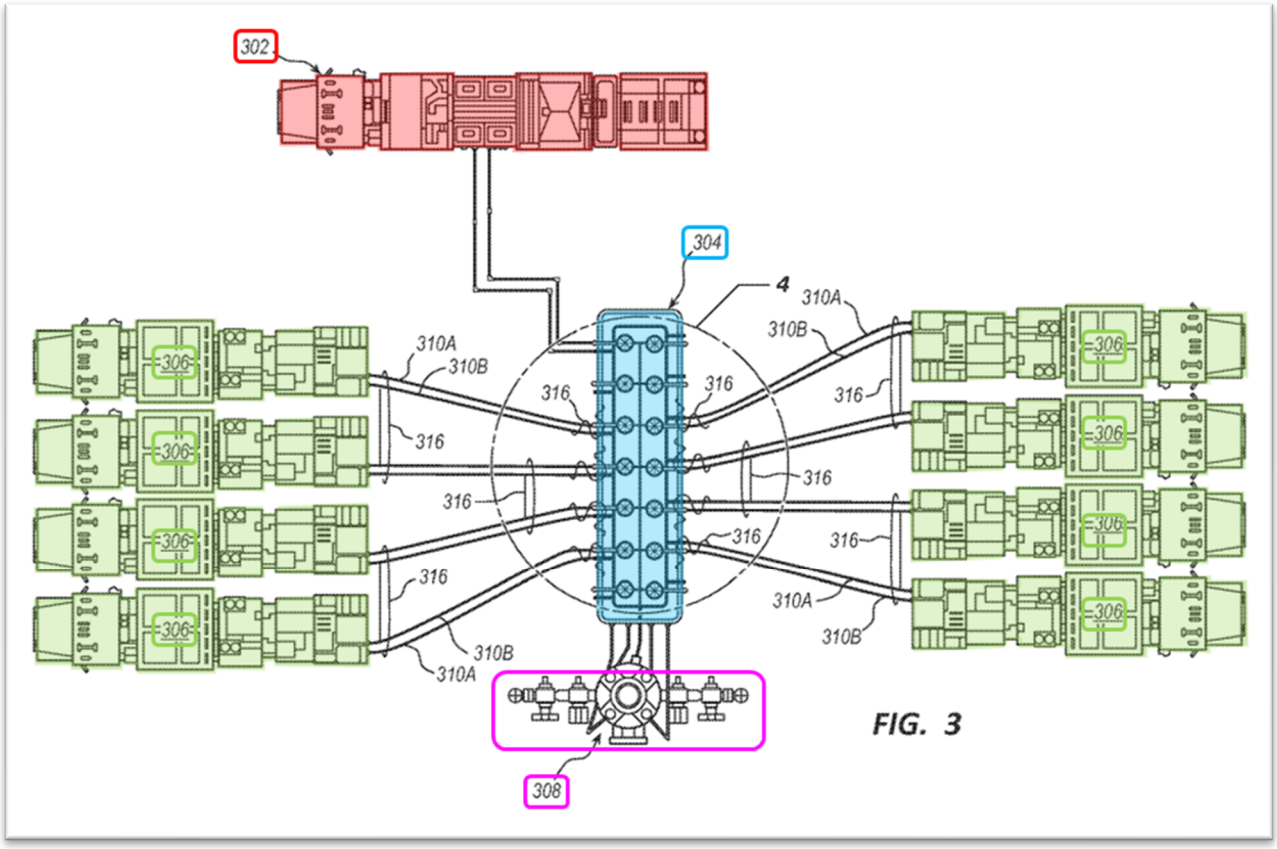
the fluid into steel casing in the wellbore (not shown)," which a POSITA would have understood meant that *Cicci*'s pump's outlet is coupled to the wellbore. EX1004, 5:23-26; EX1005, ¶[23]; EX1002, ¶171. *Cicci* also discloses that "[w]hen distributed into a wellbore, the highly pressurized fluid generates 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. EX1004, 5:23-26; EX1005, ¶[23]; EX1002, ¶172.

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, ¶173; EX1004, 1:7-19; EX1005, ¶[1].

c) 1[b]

The *Cicci-Coli-Dixon* combination discloses limitation 1[b]. EX1002, ¶¶175-178.

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]."



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 pumps (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, 1:13-15, EX1005, ¶[1]; EX1006, ¶¶[0003], [0035]; *supra*, §VII.A.2(b).

d) 1[c]

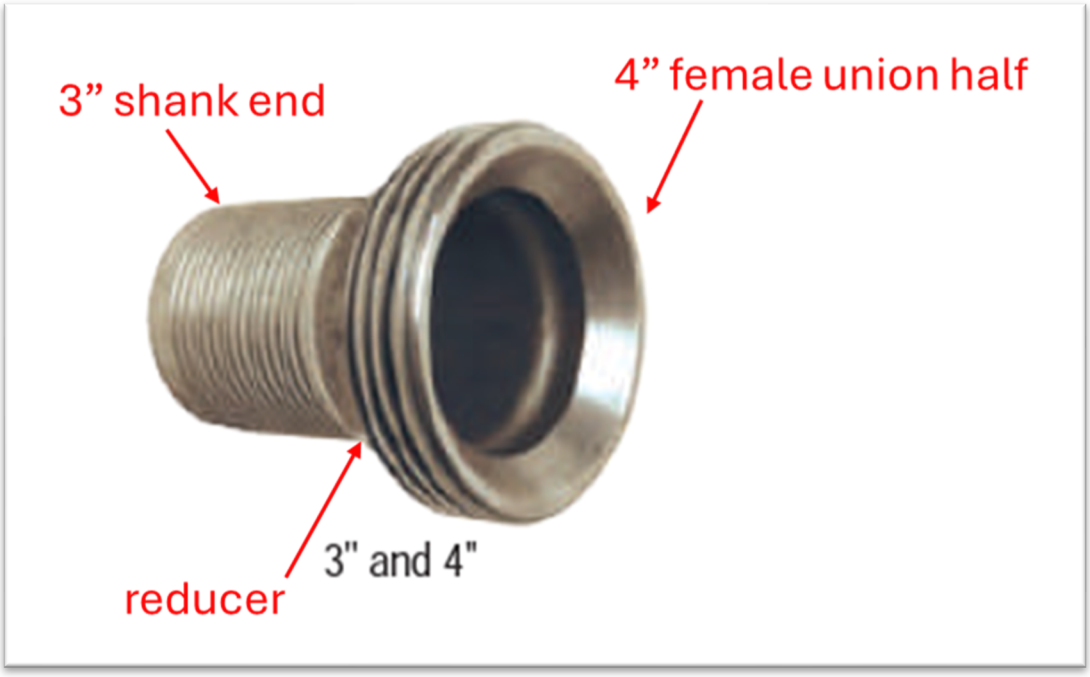
The *Cicci-Coli-Dixon* combination discloses limitation 1[c]. EX1002, ¶¶179-182. *Cicci* discloses a flexible hose extending between the fluid source (missile 304) and the pump. *Id*.; *supra*, §VII.A.2(b). *Cicci* discloses "a flexible pipe or hose (i.e., a flexible flow line) . . . used to connect a pump to the manifold." EX1004, 3:42-26; EX1005, ¶[15]. Further, *Cicci* 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]. *Cicci* therefore discloses the hose having a first diameter. EX1002, ¶181.

e) 1[d]

The *Cicci-Coli-Dixon* combination discloses and renders obvious limitation 1[d]. EX1002, ¶¶183-197.

Cicci discloses a fitting between the hose and the pump, the fitting having a first end for receiving the hose and a second end for coupling to the electric-powered pump. *Id*., ¶184. *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]." EX1004, 5:30-34; EX1005, ¶[24]. A POSITA would have understood from this disclosure that the fitting has two ends—one end for receiving the hose (a first end), and another end for coupling to the pump (a second end). EX1002, ¶184. In combination with *Coli*, the "pump" is electric-powered. *Supra*, §VII.A.2(b).

Dixon also discloses fittings for fracturing operations that connect larger-diameter unions with smaller-diameter hoses. EX1009, 149; EX1012, 78; EX1002, ¶185. For example, *Dixon* discloses a 3-inch shank end fitting with a 4-inch female union half:

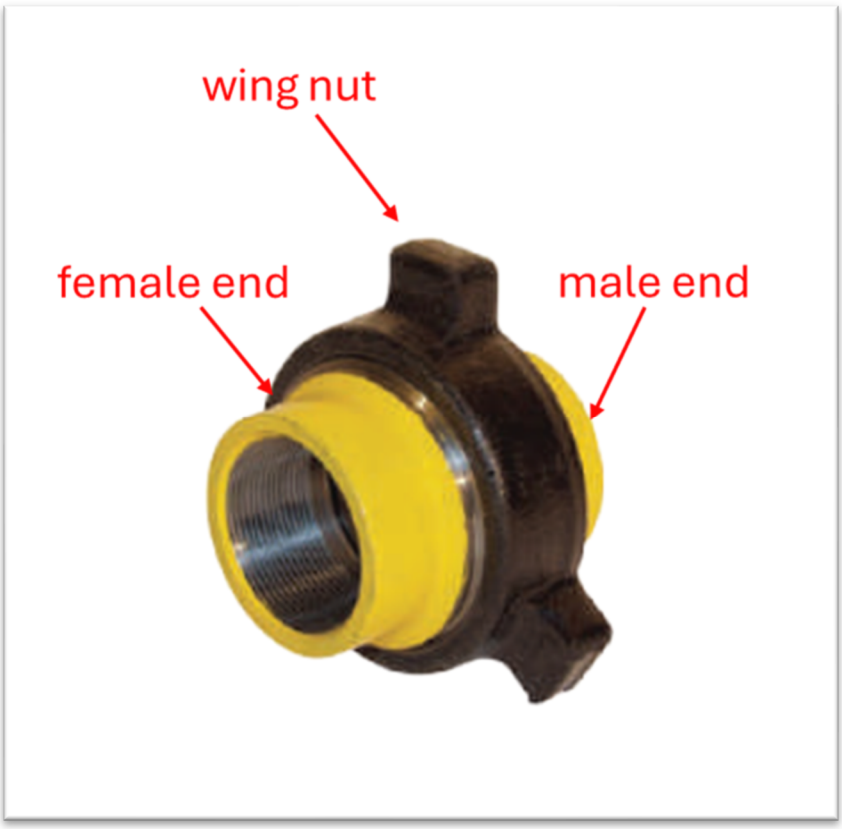


EX1009, 149; EX1012, 78. A POSITA would have recognized the 3-inch end to be a “shank end,” at least because *Dixon* uses the term “shank” to name that type of hose connection. EX1009, 85, 91-96, 98-100; EX1012, 33-34, 67, 71, 74, 101, 104-106, 109-110; EX1002, ¶¶186, 191. A POSITA would have understood that *Dixon*’s fitting has two ends—a first end (3-inch shank end) for receiving the hose and a second end (4-inch female union) for coupling to the pump. EX1002, ¶186.

With respect to the second end, *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 the fitting has a second end for coupling to the pump. EX1002, ¶187.

A hammer union, as disclosed by *Dixon*, is a three-piece system for connecting piping, including hoses, to other fluid connections, such as a pump intake, as described by *Cicci*. EX1002, ¶188; EX1009, 149-151; EX1012, 78-79, 118. *Dixon* discloses hammer unions for fracturing suction operations:

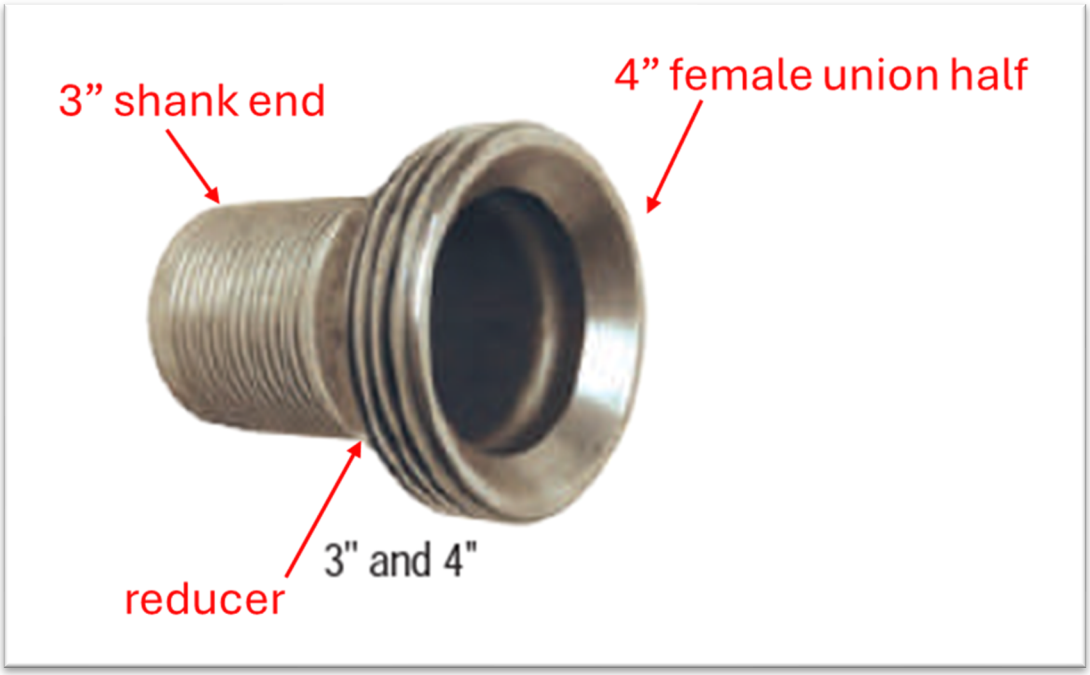


EX1009, 150, 154; EX1012, 681-83; EX1002, ¶¶188-190.

A POSITA would have understood that each end of *Cicci*'s fitting would have a diameter (a first and second diameter), at which the fitting would receive the hose and couple to the pump, respectively. EX1002, ¶192. *Cicci* discloses that "the

plurality of flexible hoses can have an inner diameter of one to eight inches." EX1004, 1:64-65; EX1005, ¶[4]. A POSITA would have understood from *Cicci's* disclosure of a hose "inner diameter" and that an "end" of the hose and the fittings coupled to the hose would have a diameter (first diameter). EX1002, ¶192. Similarly, a POSITA would have understood that the end of the fitting coupled to the pump would also have a diameter (second diameter). *Id*.

Additionally, the first and second ends of *Dixon*'s fittings also have a first diameter (3-inch diameter) and a second diameter (4-inch diameter):



EX1009, 149; EX1012, 78; EX1002, ¶¶193-194.

Dixon's fitting has a second diameter (4-inch female union) that is larger than the first diameter (3-inch shank end). EX1009, 149; EX1012, 78. *Dixon* shows

examples of various fitting sizes, including combinations of Male/Female assemblies that would have connected a larger union to a smaller hose. EX1009, 149; EX1012, 78.

A POSITA would have used *Dixon*'s teachings to connect a smaller-diameter hose to a larger-diameter union, as such fittings were well-known. EX1002, ¶195; *supra*, §VII.A.1; *see, e.g.*, EX1009, 149; EX1012, 78; EX1008, 1; EX1050, 7.

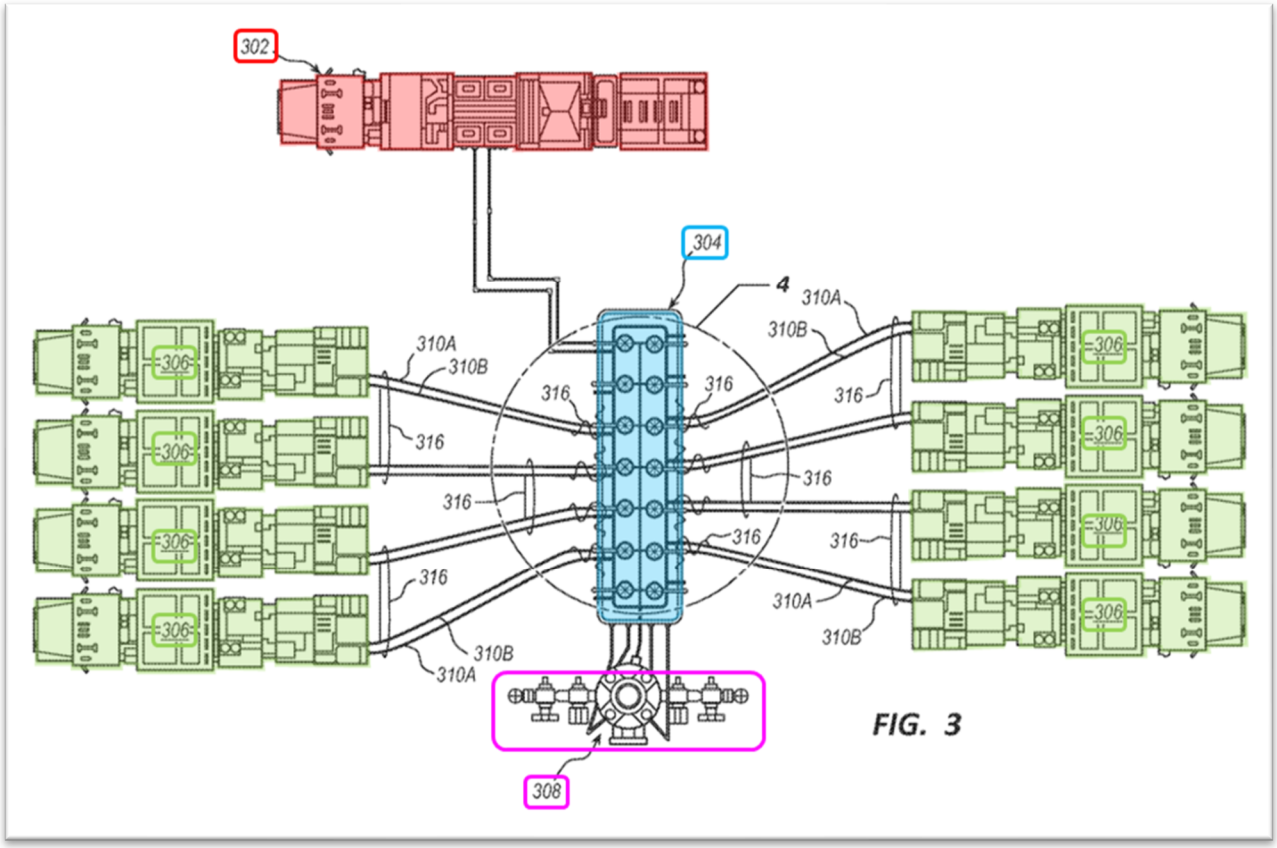
Further, the '162 Patent reveals that multiple-diameter fittings, such as *Dixon's* Frac Fittings, would have been obvious. EX1002, ¶196. The '162 Patent admits that 6-inch fittings, such as "hammer unions, butterfly valves and other 6" steel pipe components" were "standard" in the fracturing industry. EX1001, 3:67-42. This is consistent with the pump in *Coli* (Gardner-Denver SWGS-2500), which had 6-inch standard fittings. EX1002, ¶196. Further, the '162 Patent admits that 4-inch supply hoses were "standard" in fracturing systems. EX1001, 4:6-10. And during the prosecution of the '162 Patent, the applicant also admitted that "[t]raditional fracturing systems typically use 6" connections for equipment and 4" hoses for fluid flow." EX1003, 433. *Dixon's* frac fittings to connect a larger-diameter pump fitting (*e.g.*, "standard" 6" pump connection) and a smaller-diameter hose (*e.g.*, "standard" 4" hose) would have been useful in connecting standard parts. EX1002, ¶196. Such a solution would have been obvious based on the *Cicci-Coli-Dixon* combination. *Id.*

f) 1[e]

The *Cicci-Coli-Dixon* combination discloses limitation 1[e]. EX1002, ¶¶198-200.

Cicci discloses a distribution system (including high pressure hoses 310A and manifold/missile 304)[4] 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, ¶199. *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, 5:25-29; EX1005, ¶[23]; *see also* EX1004, 1:9-19, 6:58-60; EX1005, ¶¶[1], [27].

[4] The "missile" contains manifolds for both the low-pressure and high-pressure connections of the pumps, consistent with *Cicci*'s disclosure regarding missile 304 connecting both suction and discharge lines of the pump. EX1002, ¶199 n.232; EX1004, 5:22-29; EX1005, ¶[23].



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

3. Claim 2

The *Cicci-Coli-Dixon* combination renders obvious Claim 2. EX1002, ¶¶201-210; *supra*, §VII.A.2.

A first diameter (hose end) of approximately 5 inches and a second diameter (pump end) of approximately 6 inches would have been obvious in view of *Cicci.* EX1002, ¶202. *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 flexible hose diameters, including 5 inches. *See id*.; EX1002, ¶202.

First diameter is approximately 5 inches. A POSITA would have found it obvious to modify *Dixon* for the first diameter to be approximately five inches, because it would have been obvious to use a 5-inch hose in light of *Dixon* and *Cicci*'s disclosures. EX1002, ¶203. *Dixon* discloses "Suction Service Fittings" for hydraulic fracturing that have a 5-inch diameter. EX1009, 150; EX1012, 79. A POSITA would have found it obvious to use a 5-inch hose based on this teaching and *Cicci*'s disclosure of hose diameters between 1 and 8 inches. EX1002, ¶203. It would have been obvious to a POSITA for the end of the fitting that connects to the hose to have a diameter (the first diameter) of approximately five inches, to correspond to a hose diameter of five inches, to which it connects. *Id*. A POSITA would have been motivated to use a 5-inch hose and first diameter when flow velocity calculations indicate a 5-inch hose would keep the velocity in the proper range and avoid drop-out,. EX102, ¶204; *infra*, §§VII.B.6-7, VII.C.5.

Second diameter is approximately 6 inches. It would have been obvious to a POSITA for the second diameter to be approximately 6 inches, as 6 inches was a well-known fracturing pump connection size. EX1002, ¶205. For example, the '162 Patent admits that "6" (0.1524 m) components," including hammer unions, were "standard." EX1001, 3:65-4:2. And a POSITA would have understood from *Dixon*

that combinations of sizes other than those specifically disclosed 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, ¶209.

For example, *Coli* discloses a "SWGS-2500 Well Service Pump sold by Gardner Denver[.]" EX1006, ¶[0046]. A POSITA would have understood *Coli*'s disclosure refers to 6-inch inlet connections with both threaded (for hammer union) and Victaulic style inlet connections. EX1002, ¶¶206-207; EX1010, 76-79. 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. EX1002, ¶208; EX1001, 3:65-4:2. It would have been obvious to a POSITA to select a fitting diameter consistent with this disclosure. EX1002, ¶206.

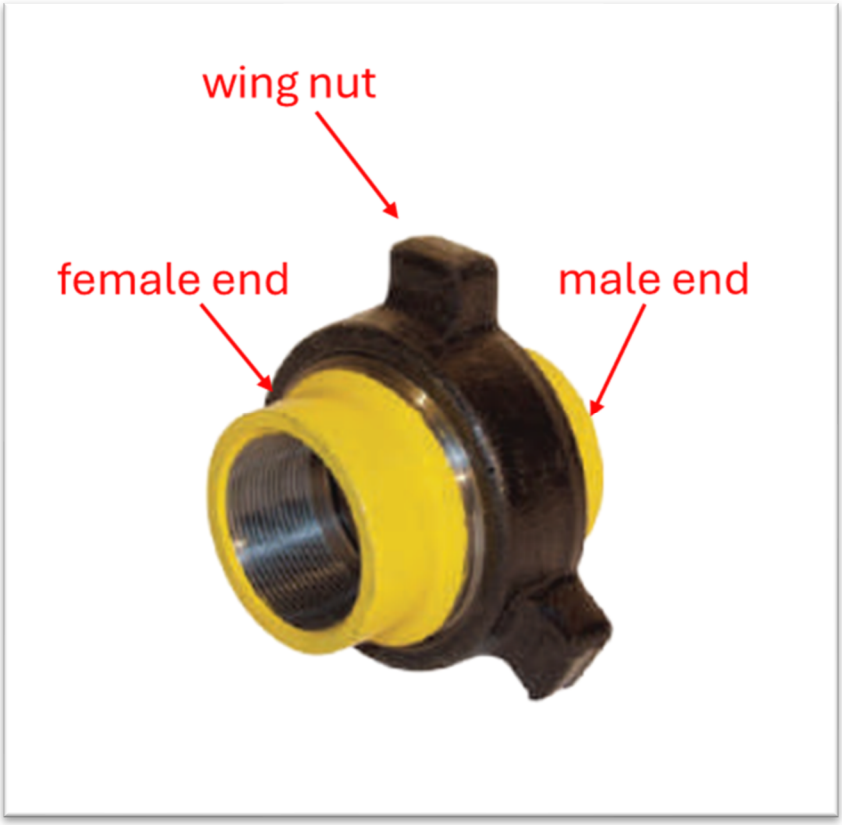
4. Claim 3

The *Cicci-Coli-Dixon* renders obvious Claim 3. EX1002, ¶¶211-224; *supra*, §VII.A.2.

a) 3[a]

The *Cicci-Coli-Dixon* combination discloses a fitting comprising a union at the second end. *Supra*, §VII.A.2.e; EX1004, 7:40-47; EX1005, ¶[30]; EX1002, ¶¶212-213. The hammer union disclosed in *Cicci* is shown by *Dixon* as a three-piece

system for connecting piping, including hoses, to other fluid connections, such as a pump intake, as described by *Cicci*. *Id*.; EX1009, 150, 154; EX1012, 79, 681.



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, ¶213. Accordingly, the 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 the examples of the Frac Fittings from Dixon, 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 other half (female half) of the hammer union would have been attached to the pump. EX1002, ¶213.

b) 3[b]

Dixon discloses a shank end at the first end. *Supra*, §VII.A.2(e); EX1002, ¶¶214-218. A POSITA would have understood this shank end receives at least a portion of the hose. *See id. Dixon* teaches that the shank is coupled with a ferrule that is crimped over at least the portion of the hose. EX1002, ¶216. 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. *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.

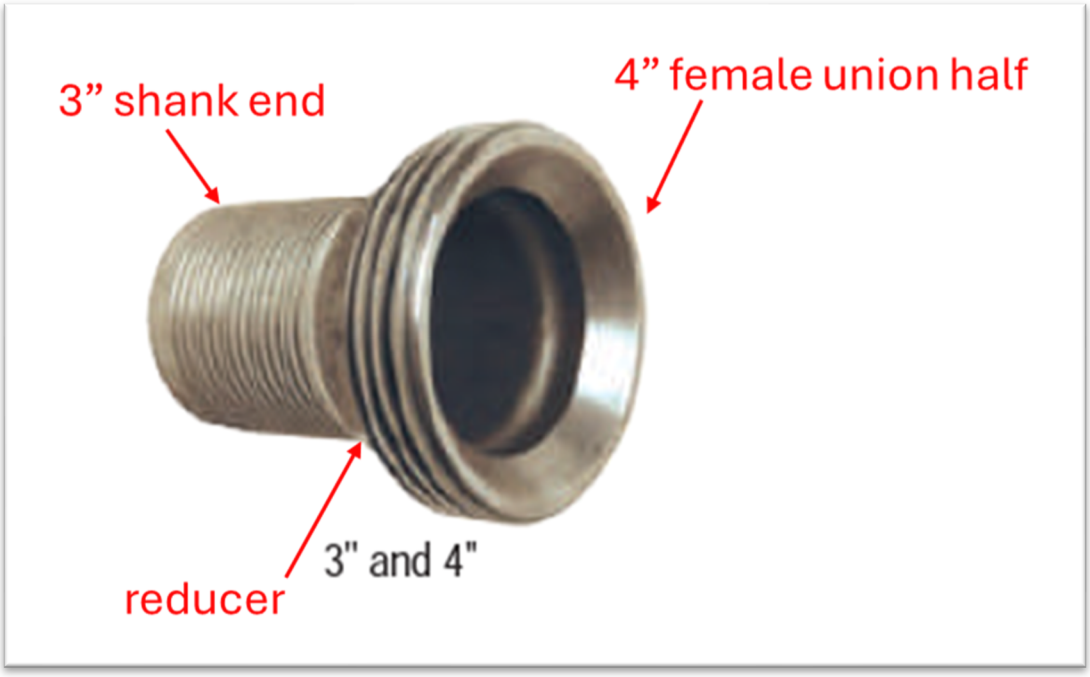


Hose ID (inch)	Hose OD (mm)		Carbon Steel		Ferrule ID (inch)	Ferrule Wall Thickness (mm)	Ferrule Overall Length (mm)
	From	To	Heavy Duty (HD) Part No.	Price $			
4	114.70	115.90	CF400-6CSHD	81.80	4.625	3.05	102
	116.30	117.50	CF400-7CSHD	97.11	4.688	3.05	102
	117.90	119.10	CF400-8CSHD	97.11	4.750	3.05	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. EX1002, ¶217.

c) 3[c]

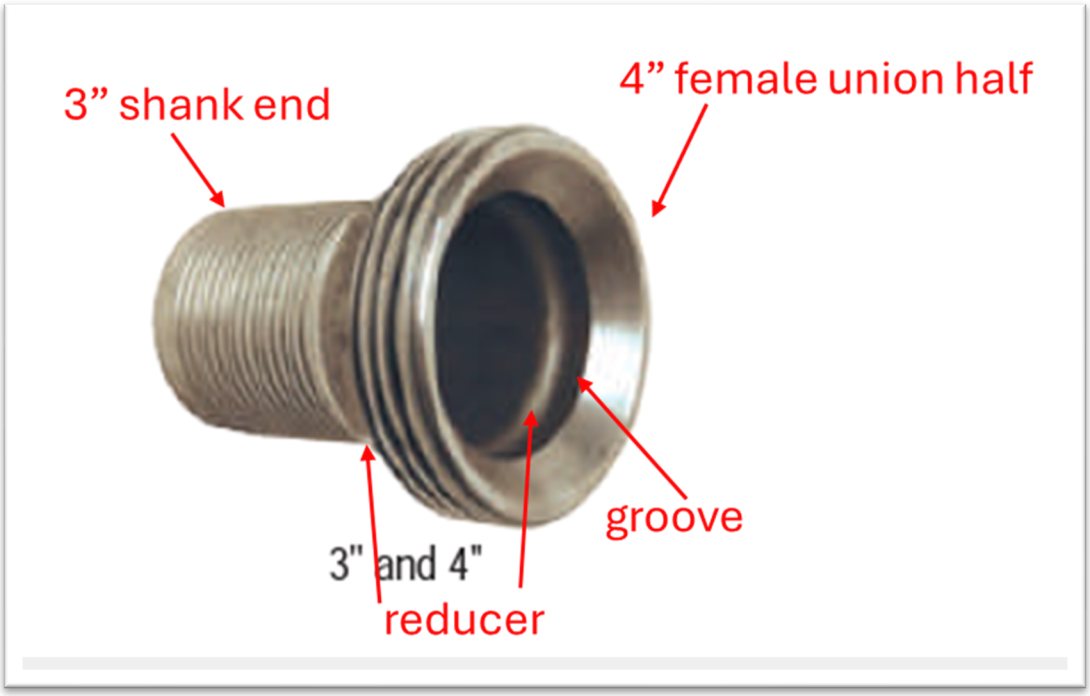
Dixon discloses and renders obvious a reducer between the union and the shank end. EX1002, ¶¶219-224. *Dixon* shows a fitting with a 3" shank end and a 4" union end:



EX1009, 149; EX1012, 78. *Dixon*’s reducer is in the claimed location to enable the connection of the disparate-sized parts, and to allow for a smooth transition of the fluid flow. EX1002, ¶219.

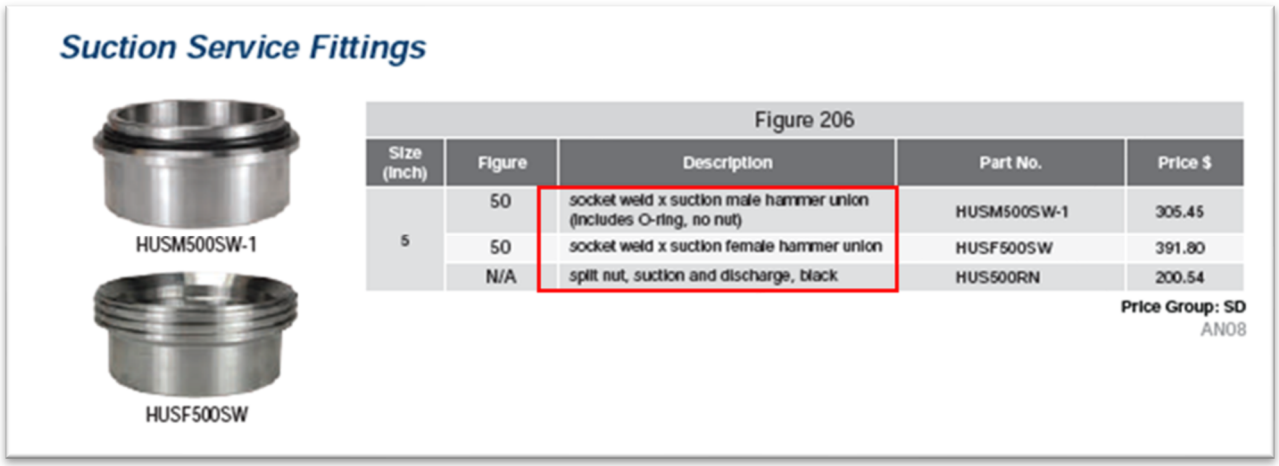
Dixon further teaches individual components of “weld” hammer unions and reducers. EX1009, 150; EX1012, 79. A POSITA would have found it obvious to take *Dixon*’s weld unions and combine them with *Dixon*’s weld reducers (EX1009, 359; EX1012, 608) and weld such fittings together to form a reducing fitting, such as the “frac fittings” disclosed by *Dixon*. EX1002, ¶220. This would have been combined with *Dixon*’s hose shank to create a fitting that would enable a smaller hose size. *Id*.; *see, e.g.*, EX1009, 85, 91-96, 98-100; EX1012, 33-34, 67, 71, 74, 101, 104-106, 109-110.

Dixon discloses at least a portion of the reducer extends into a groove formed in the union. EX1002, ¶221. 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 a least a portion of the reducer extending into it. *See id.*; EX1002, ¶222. 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, ¶223. 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 of the appropriate size, and a hose shank. EX1002, ¶223. In such a combination, a portion of the reducer would extend into a groove formed in the union, and the union would extend farther laterally than the reducer, as a portion of the reducer is inside the union. *Id.*

5. Claim 4

The *Cicci-Coli-Dixon* combination renders obvious Claim 4. EX1002, ¶¶225-229; *supra*, §VII.A.4.

Dixon discloses fittings formed as an integral piece. EX1002, ¶226. A POSITA would have been motivated to have the fittings as an integral piece, as

taught by *Dixon,* because, as *Dixon* teaches, a "[o]ne-piece design eliminates leak path experienced with two-piece threaded systems." 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, ¶226.

Dixon discloses the fitting with at least one "rigid coupling" between at least the union and the reducer. EX1002, ¶¶227-228. One example of a "rigid coupling" is a weld or weld bead. *Id.*, ¶227. The weld, once cooled, forms a rigid piece of metal that couples the pieces of metal (such as the socket weld union and reducer) together. *Id.*; EX1046. This is consistent with the '162 Patent's usage of "rigid coupling 214" (red), which a POSITA would have recognized as a weld bead.

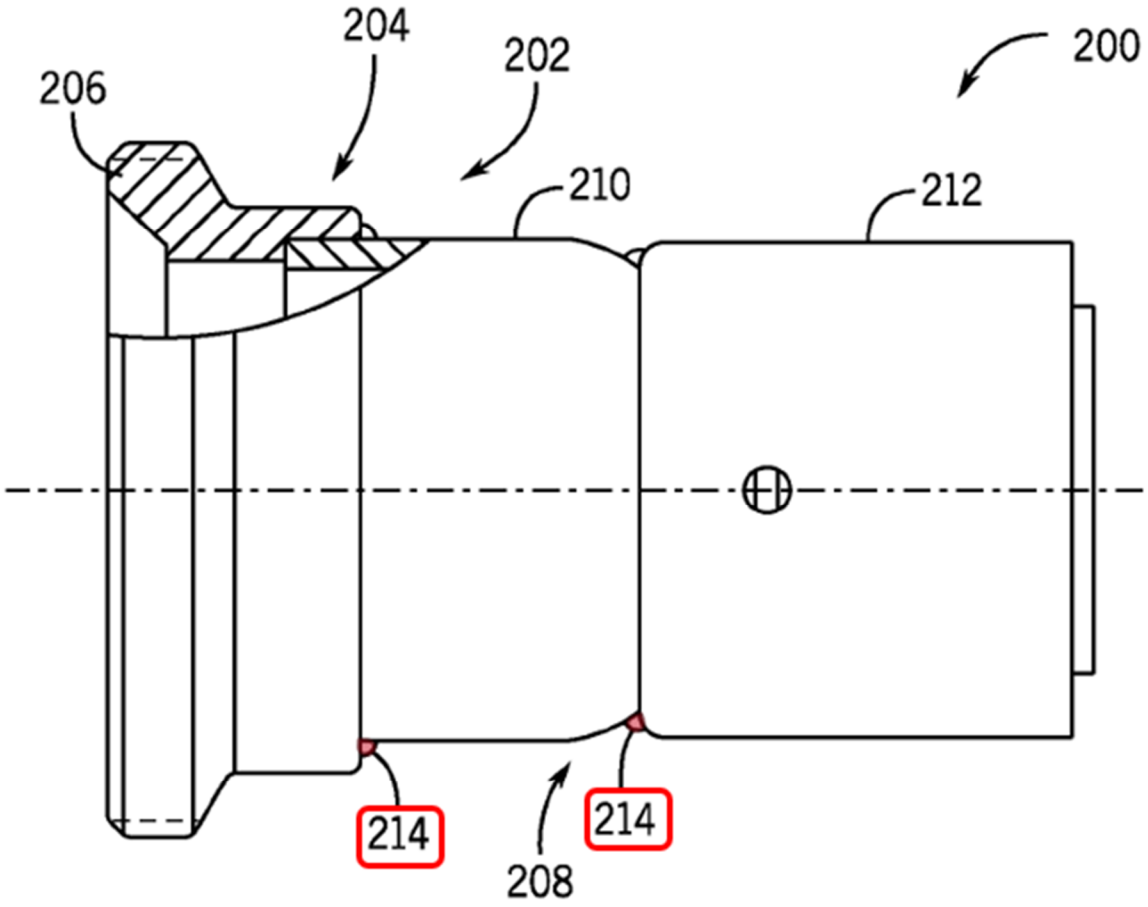


FIG. 2

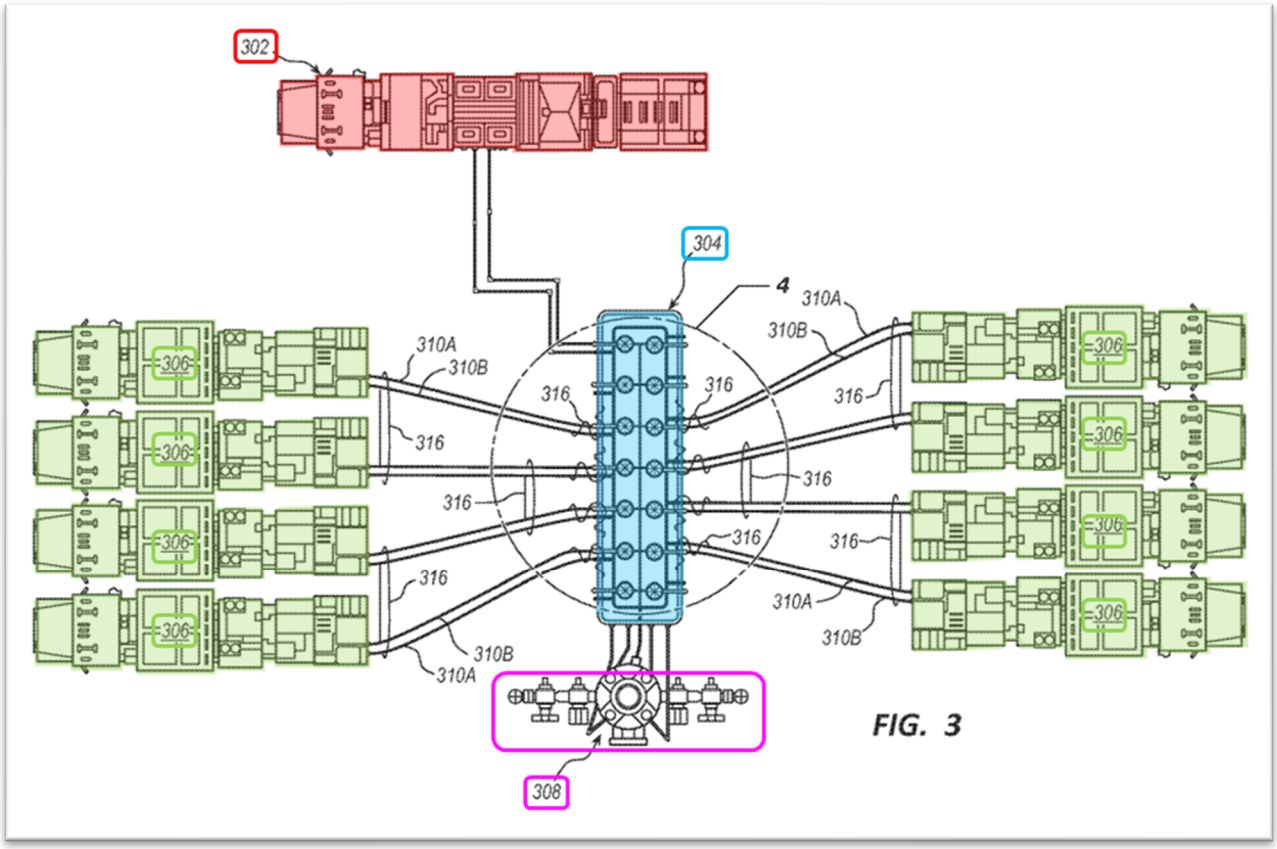
EX1001, Fig. 2; EX1002, ¶227. *Dixon*'s "socket weld" union is a "rigid coupling" between at least the union and the reducer. EX1002, ¶228; *supra*, VII.A.4(c). A "weld bead" as a rigid coupling thus would have been obvious to a POSITA. EX1002, ¶228.

6. Claim 8

The *Cicci-Coli- Dixon* combination renders obvious Claim 8. EX1002, ¶¶230-243; *supra*, §VII.A.2.

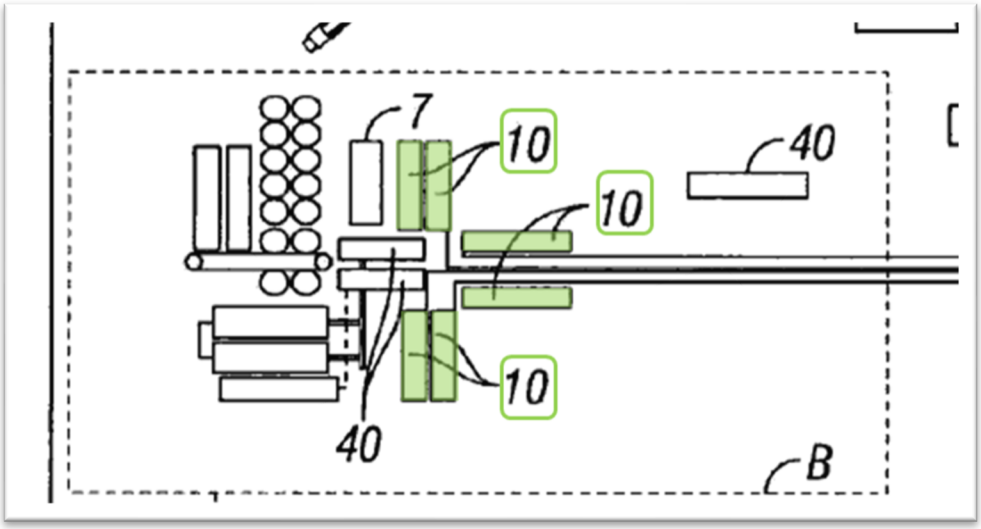
a) 8[a]

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 use of any number of pumps. EX1002, ¶¶231-232; EX1004, 1:26, 5:17-29; EX1005, ¶¶[2], [12].



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, ¶233. *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].

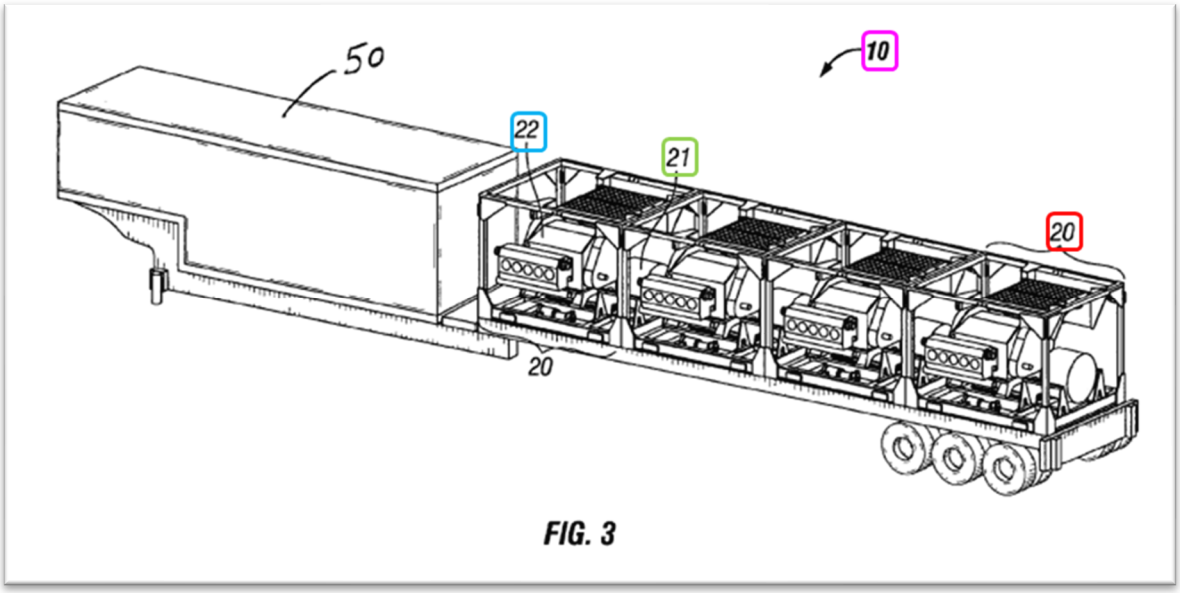


FIG. 3

EX1006, Fig. 3.Accordingly, *Coli* at least discloses 24 pumps. EX1002, ¶234. *Coli* also discloses "providing one or more electric fracturing modules at the site." EX1006, ¶[0009].

Coli discloses "electric powered multi-plunger hydraulic fracturing pumps." *Supra*, §VII.A.2(b). The *Cicci-Coli-Dixon* 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." EX1004, 5:30-31; EX1005, ¶[24]. Further, *Cicci* teaches "[t]he missile 304 delivers the fracturing fluid to the pumps 306." EX1004, 5:22-23; EX1005, ¶[23]. Accordingly, each pump receives fluid from the fluid source (missile 304). EX1002, ¶¶235-236.

b) 8[b]

The combination discloses and renders obvious a plurality of hoses having the first diameter. *Supra*, §§VII.A.2(d)-(e); EX1004, 1:64-65, 5:30-31, Claim 7; EX1005, ¶¶[4], [24]; EX1002, ¶¶238-240. *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 flow conditions at the pumps. EX1002, ¶238; *infra*, §§VII.B.5-6. Furthermore, it would have been obvious to a POSITA that each hose would have the first diameter, allowing the hoses to be interchangeable. *Id*., ¶239. And it would have been obvious

to a POSITA for that diameter to be the first diameter, as that is the diameter of the fitting end connected to the hose. *Id.*; *supra*, §§VII.A.2(d)-(e).

c) 8[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 would have its own hose, resulting in a plurality of fittings between the respective hoses of the plurality of hoses and respective pumps of the plurality of pumps. EX1002, ¶241.

It would have been obvious to a POSITA for each of the pumps to have a connection having the second diameter, as that is the diameter of the fitting end connected to the pump. *Supra*, §VII.A.2(e). A POSITA would have been motivated for the pumps to have a connection having the second diameter to obtain the benefits of interchangeability. EX1002, ¶242. It therefore would have been obvious to a POSITA to use pumps with the same diameter connection of the limited number of connections available. *Id.*; *supra*, §VII.A.3.

7. Claim 9

a) 9[p]

Supra, §VII.A.2(a); EX1002, ¶245.

b) 9[a]

Supra, §VII.A.2(b); EX1002, ¶246.

c) 9[b]

Supra, §VII.A.2(c); EX1002, ¶247.

d) 9[c]

Supra, §VII.A.2(d); EX1002, ¶248.

e) 9[d]

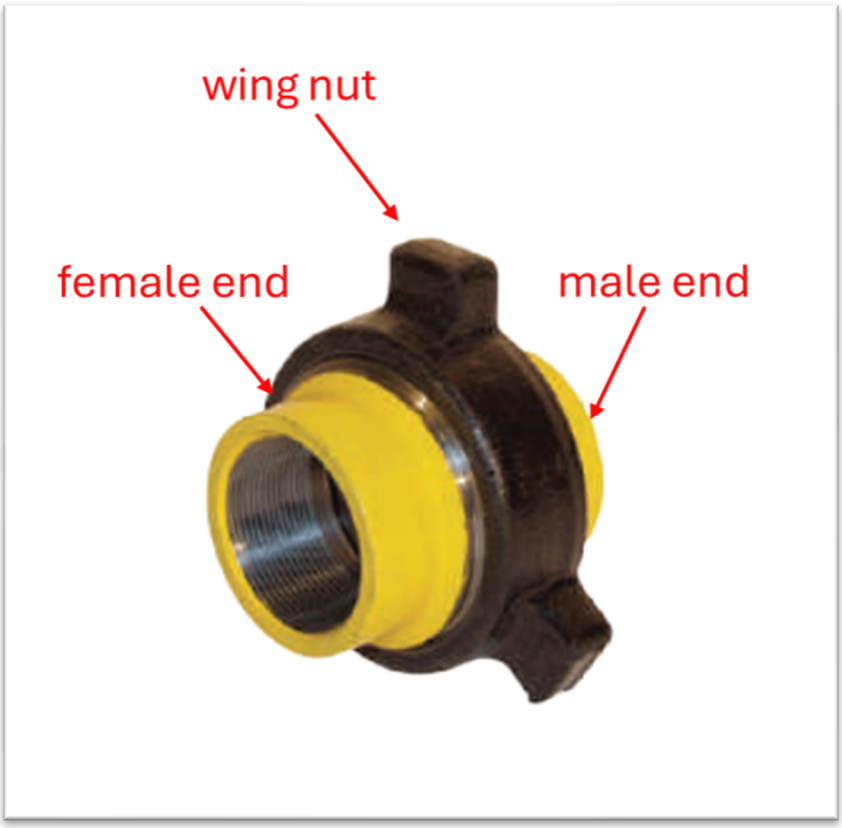
Supra, §VII.A.2(e); EX1002, ¶249.

f) 9[e]

The *Cicci-Coli-Dixon* combination renders obvious limitation 9[e]. EX1002, ¶¶250-253; *supra*, §§VII.A.2(e), VII.A.4(a).

Cicci discloses a union arranged at a first end and configured to couple to the pump. EX1002, ¶250. *Cicci* discloses "coupling a first end of a first flexible hose to one of the respective pump connections. The flexible hose can be connected to the pump connections by any number of connection methods currently known or developed in the future,[] including threading wings onto a threaded connection, such as a hammer union." EX1004, 7:40-47; EX1005, ¶[30]. A hammer union, as shown by *Dixon*, is a three-piece system for connecting piping, including hoses, to

other fluid connections, such as a pump intake, as described by *Cicci*. EX1002, ¶250. *Dixon* teaches hammer unions in various sizes, including hammer unions for fracturing suction operations. EX1009, 79, 150, 154, 681. *Dixon* shows a typical hammer union with the three components identified.



EX1009, 154; EX1012, 681; EX1002, ¶250.

A POSITA would have understood from *Dixon* that one half of the hammer union (*e.g.*, the male end) would be connected to the hose and the second half (*e.g.*, the female end) would be connected to the pump, or vice versa. EX1002, ¶251. Accordingly, the 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), as further described in limitation 1[d]. EX1002, ¶251; *supra*, §VII.A.2(e).

The union would have a second diameter larger than the first diameter (hose diameter). *Supra*, §VII.A.2(e). As fracturing pumps have manufacturer-supplied headers with inlet connections of fixed sizes,[5] a POSITA would have recognized that it is easier to combine well-known, commercially available components, to allow for a smaller hose size in order to increase velocity and minimize proppant drop out, than to obtain custom inlet headers for the pumps from the manufacturer. EX1002, ¶252; *supra*, §VII.A.2(e); *infra*, §VII.B.6-7. Therefore, the *Cicci-Coli-Dixon* combination would have renders Limitation 9[e] obvious. *Id.*

g) 9[f]

The *Cicci-Coli-Dixon* combination renders obvious limitation 9[f]. EX1002, ¶¶254-257. The fitting comprises a shank end configured to receive at least a portion of the hose. *Supra*, §VII.A.2(e). The shank end comprises a shank that is inserted into the hose and a ferrule that is crimped over the hose to engage the barbs/ridges on the shank end. *Supra*, §VII.A.4(b); EX1002, ¶254. *Dixon* discloses that the shank end is securable to at least the portion of the hose, for example by crimping it to the

[5] For example, the Gardner Denver 2500 referenced by *Coli* has 6" or 8" headers. *Supra*, VII.A.3.

hose. *See id*. The combination of the ferrule and the ribs or barbs on the shank makes the shank end securable to the hose, such as when the ferrule is crimped. *Id*. *Dixon* discloses that its 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*'s disclosure that when the shank end of the ferrule is crimped over at least a portion of the hose, it is securable to at least the portion of the hose. EX1002, ¶255.

The shank end includes an opening to receive the shank end. *Id*., ¶256. 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 '162 Patent, which describes "an end of the hose may be inserted into the shank end 212 and crimped, thereby joining the hose to the fitting 200." EX1001, 5:16-18.

h) 9[g]

The *Cicci-Coli-Dixon* combination renders obvious limitation 9[g]. EX1002, ¶¶258-263. *Dixon* discloses a reducer positioned between the union and the shank end, and the reducer extending at least partially into the union. *Supra*, §§VII.A.2(e), VII.A.4(c), VII.A.5.

It would have been obvious to weld the reducer to the union at one end. *Supra*, §VII.A.5. It further would have been obvious to weld the reducer to the shank end at the other end. EX1002, ¶258. *Dixon* teaches 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, ¶258. 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. *Infra*, §VII.B.6-7; EX1002, ¶258.

A POSITA would have understood that *Dixon*'s integral fittings would have been either machined as a single part or welded together from the individual components. EX1002, ¶259. 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 only a limited number of connection options to create an integral frac fitting. *Id*., ¶260 Accordingly, there was a finite number of ways to construct *Dixon*'s "Frac Fittings," and it would have been obvious to construct the part by welding known parts together. *Id.*

Dixon discloses that its reducer has an increasing diameter along its axial length, consistent with the well-known construction of reducers. EX1002, ¶261; *see, e.g.*, EX1009, 359, 360, 460, 469 (illustrating reducers with increasing diameters along their axial length); EX1012, 575, 592, 608, 613, 628.

i) 9[h]

Supra, §VII.A.2(f); EX1002, ¶264.

8. Claim 10

Supra, §VII.A.3; EX1002, ¶265.

9. Claim 14

a) 14[a]

Supra, §VII.A.6(a); EX1002, ¶266.

b) 14[b]

Supra, §VII.A.6(b); EX1002, ¶266.

c) 14[c]

Supra, §VII.A.6(c); EX1002, ¶266.

B. Ground 2

The *Cicci-Coli-Dixon-Liu* combination renders obvious claims 1-6, 8-12, and 14. EX1002, ¶¶267-346.

1. Motivation to Combine

A POSITA would have been motivated to combine the *Cicci-Coli-Dixon* combination with *Liu*. EX1002, ¶¶267-276; *supra*, §VII.A.1. 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.*, ¶268. *Liu* compiles established scientific principles into a single reference. *Id.*

Liu is analogous art to the '162 Patent because it is reasonably pertinent to the problem with which the inventor was involved. EX1002, ¶269. The '162 Patent is directed to the problem of fluid flow rates for fracturing operations. For example, the '162 Patent describes "problems with flow rates, as flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site." EX1001, 1:14-45. Similarly, during prosecution, the applicant distinguished prior art by arguing that it did not "identify the problem associated with efficient fluid flow rates for fracturing operations." EX1003, 433. *Liu* teaches scientific principles directly applicable to the'162 Patent's hydraulic fracturing systems and pertinent to the problem of efficient fluid flow rates for fracturing operations to which the inventor was involved. EX1002, ¶269.

A POSITA would have been motivated to look to *Liu* because *Liu* discloses scientific principles applicable to the *Cicci-Coli-Dixon* system. EX1002, ¶270. *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, ¶270.

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*.[6] *Id*. *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. EX1007, Preface; EX1002, ¶271. 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, ¶¶273, 279; EX1007, 131. For example, Chapter 5

[6] *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, ¶272.

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 established scientific principles to understand the *Cicci-Coli-Dixon* system's fluid dynamics and to size equipment within the system. EX1002, ¶274. *Liu* teaches that its principles apply to piping systems, including hose systems, at least because *Cicci* teaches piping and hoses interchangeably. *Id*. Furthermore, *Liu* dedicates an entire chapter to explaining the scientific principles behind slurry flow, which apply to the slurry used 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 in order to gain the benefits of maintaining sufficient fluid velocity and flow, and thus reducing the possibility of slurry drop-out, plugging the hoses, damaging cavitation, as taught by *Liu*. EX1002, ¶275; 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, ¶276. 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. EX1002, ¶276, *infra*, §§VII.B.6-7, VII.C.5.

2. Claim 1

a) 1[p]-1[c], 1[e]

Limitations 1[p]-[c], 1[e] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu* combination for the same reasons as Ground 1. *Supra*, §§VII.A.2(a)-(d), VII.A.2(f); EX1002, ¶277.

b) 1[d]

The *Cicci-Coli-Dixon* combination discloses and renders obvious element 1[d] for the same reasons as Ground 1. *Supra*, §VII.A.2(e). Further, a POSITA would have found it obvious for the second diameter to be larger than the first diameter, based on *Liu*'s teachings of fluid dynamics. EX1002, ¶¶278-292. It would have been obvious, and a POSITA would have been motivated, for the second diameter to be larger than the first diameter to maintain a velocity of fluid flow high enough to avoid drop out in light of *Liu*'s disclosure detailed in Claims 5-7. EX1002, ¶¶278-289; *infra*, §VII.B.6-7. Once a POSITA realized, based on the well-known

principles taught by *Liu*, that the hose diameter would need to be smaller to reduce the risk of damaging cavitation, fluid starving the pumps or screen-out of the hoses, a POSITA would have looked to commercially available fittings, such as *Dixon*'s, to allow the smaller hose to connect to the larger pump coupling. EX1002, ¶¶290-291.

3. Claim 2

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 2 for the same reasons as Ground 1. *Supra*, §VII.A.3. Additionally, it would have been obvious for the first diameter to be approximately 5 inches when the flow calculations disclosed by *Liu* indicate that 5 inches is an appropriate size. EX1002, ¶293; *infra*, §§VII.B.6-7, VII.C.5.

4. Claim 3

Supra, §VII.A.4; EX1002, ¶346.

5. Claim 4

Supra, §VII.A.5; EX1002, ¶346.

6. Claim 5

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 5. EX1002, ¶¶294-316; *supra*, §VII.A.2.

It would have been obvious for the first diameter (at the end receiving the hose) to be particularly selected based at least in part on a threshold, the threshold

corresponding to a drop-out rate for the slurry, where the diameter is selected to maintain velocity high enough to prevent slurry drop-out. EX1002, ¶296.

It would have been well-known to a POSITA that the velocity of the pipe is based on both the flow rate and the pipe diameter. EX1002, ¶295. As *Liu* also teaches maintaining velocity (and flow) in the pipe high enough to prevent the drop-out of solids (proppant) into a bed, *Liu* makes it obvious to select the pipe based on the flow rate. *Id.*

It would have been obvious, and a POSITA would have been motivated, to select the first diameter to maintain a velocity of the fluid flow high enough to avoid drop out in light of the *Liu*'s disclosure. EX1002, ¶¶297-298. *Liu* discloses selecting the diameter of a slurry piping system (including the fitting diameter in the *Cicci-Coli-Dixon* combination), to maintain velocity high enough to suspend the slurry in the pipe and prevent "moving bed flow" or "stationary bed flow." *Id.*, ¶¶299-300; EX1007, 132. *Liu* discloses "moving-bed flow" and "stationary bed flow" to refer to drop out of the slurry. EX1002, ¶301. For example, *Liu* describes "moving-bed flow" as when "particles settle out of the flow and form a bed," when there is insufficient velocity. *Id*. *Liu* further describes "stationary-bed flow" as when "particles settle out of the bed, and they do not move in the bed," occurring at "very low velocity[.]" *Id*. This is consistent with the '162 Patent, which describes "drop out" as particulates "drop[ping] out of the flow" when there is insufficient flow rate.

EX1001, 1:43-45 (describing "flow rates that drop below a threshold may experience drop out of particulates, leading to blockages and other problems at the well site."); *id*., 5:37-46 (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 in the piping system is avoided. *Id*., 133, Fig. 5.1; EX1002, ¶¶302-304.

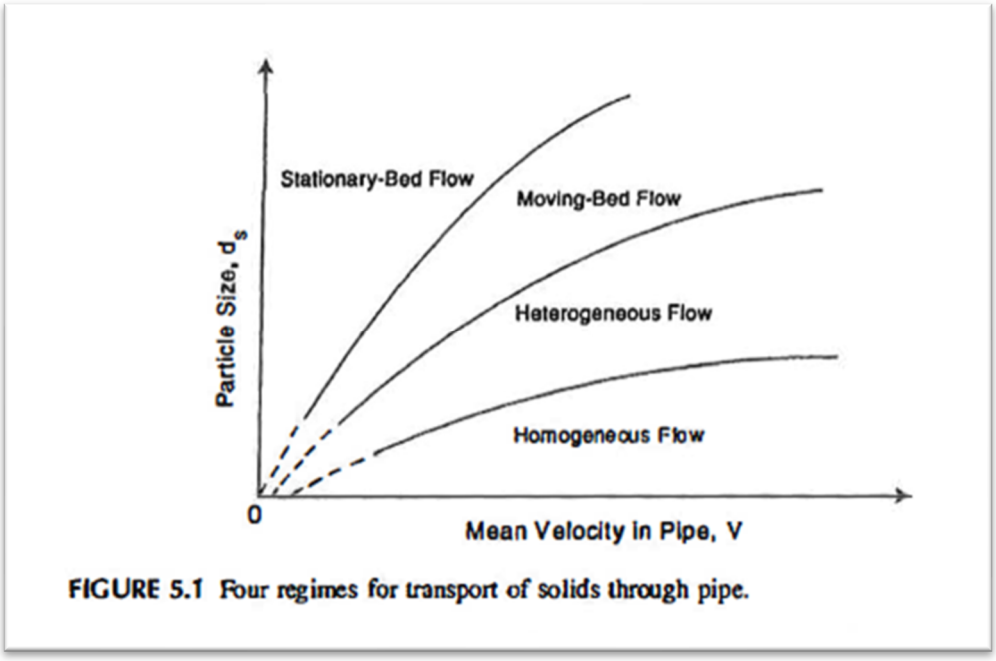


FIGURE 5.1 Four regimes for transport of solids through pipe.

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, ¶¶64-70, 305-306; EX1007, 133, 269. As velocity drops, the slurry enters Moving-Bed Flow or Stationary-Bed Flow,

resulting in proppant settling at the bottom of the hose, or even cause 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, ¶¶64-70, 304-306. Accordingly, a POSITA would have known and been motivated to avoid moving-bed or stationary-bed flow regimes when designing a piping system, and would have selected a hose diameter that keeps velocity high enough to avoid these flow regimes. EX1002, ¶307.

A POSITA would have understood that the first diameter affects the fluid flow velocity, and accordingly the drop-out threshold, based on *Liu*. *Id.*, ¶308. *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, 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, ¶309. 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 pipe'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:

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

EX1002, ¶¶310-311.

Liu also teaches that the pressure drop in the piping system is a function of pipe size and flow rate. EX1002, ¶312. *Liu* teaches that "head loss" (pressure drop) in a pipe (including hoses) is calculated using 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, ¶312.

Liu is just one example of scientific principles known to a POSITA regarding fluid and slurry flow in piping systems. EX1002, ¶311. Accordingly, a POSITA

would have known to perform the well-known calculations described in *Liu* and design the piping system, including the first diameter, to maintain flow in a homogeneous or, at the very least, a heterogeneous flow regime. *Id*.

The velocity in the pipe is based on both the flow rate and the pipe's diameter. EX1007, 21; EX1002, ¶295. As *Liu* also teaches maintaining velocity in the pipe high enough to prevent the drop-out of solids (proppant), *Liu* makes it obvious to select the diameter based on the flow rate. *Id*.

As discussed above, the fluid velocity is a function of the hose diameter and flow rate. EX1002, ¶¶313. A smaller diameter increases velocity and pressure drop. *Id*. A larger diameter reduces velocity, and if reduced too far, 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 first diameter while slurry drop-out considerations place an upper limit on the first diameter. *Id*., ¶314.

Therefore, sizing a hose, and the diameter for the fitting end receiving the hose, is a standard engineering tradeoff. EX1002, ¶315. For a given flow rate, increasing the diameter of the hose reduces velocity, which in turn reduces the pressure drop in the hose, thereby reducing the 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 the *Cicci-Coli-Dixon-Liu* combination. *Id*. Accordingly, it would have been obvious to have a first diameter (hose) particularly selected based at least in part on a threshold, the threshold corresponding to a drop-out rate for the slurry. *Id*.

7. Claim 6

The *Cicci-Coli-Dixon-Liu* combination renders obvious Claim 6. EX1002, ¶¶317-324; *supra*, §VII.A.2. *Liu* teaches particularly selecting the first diameter to maintain the suggested flow rate or velocity, and avoid increased pressure drop, reduced flow, and cavitation. *Supra*, §VII.B.6. *Liu* further teaches that pressure drop is a function of the hose diameter, and accordingly the first diameter (the fitting end receiving the hose). *See id*.; EX1007, 26-29, 37, Eq. 2.33; EX1002, ¶320.

Liu also teaches an additional upper limit on slurry velocity, and the associated lower limit on the first diameter. EX1002, ¶322. *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 first diameter, as a smaller pipe would increase velocity and increase wear. EX1002, ¶¶64-70, 322. A

POSITA would have understood the '162 Patent's "damage accumulation rate" to include such "wear" or abrasion taught by *Liu*. *Id*.

Accordingly, it would have been obvious that the first diameter is particularly selected based at least in part on a pressure drop rate, a damage accumulation rate, or a suggested flow rate. EX1002, ¶323.

8. Claim 8

a) 8[a]

Supra, §VII.A.6(a); EX1003, ¶325.

b) 8[b]

Element 8[b] is disclosed and rendered obvious by the *Cicci-Coli-Dixon-Liu* combination. *Supra*, §VII.A.6(b). Additionally, for the same reasons as Claims 5–7 and Limitation 1[d], it would have been obvious based on *Liu*'s disclosure to size each of the hoses with the same diameter based on the flow conditions at the pumps. EX1002, ¶326; *supra*, §VII.B.2(b), VII.B.6-7.

c) 8[c]

Supra, §VII.A.6(c); EX1003, ¶325.

9. Claim 9

a) 9[p]-[d], 9[f]-[h]

Elements 9[p]-[d] and 9[f]-[h] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu* combination for the same reasons as Ground 1. *Supra*, §§VII.A.7(a)-(e), VII.A.7(g)-(i); EX1002, ¶327.

b) 9[e]

Element 9[e] is rendered obvious by the *Cicci-Coli-Dixon-Liu* combination. *Supra*, §VII.A.7(f). Additionally, it would have been obvious to use a union with a diameter larger than the hose diameter, based on *Liu*'s teachings, for the same reasons as Limitation 1[d] and Claims 5-6. EX1002, ¶¶328-342; *supra*, §§VII.B.2(b), VII.B.6-7.

10. Claim 10

Supra, §VII.B.3; EX1002, ¶343.

11. Claim 11

Supra, §VII.B.6; EX1002, ¶344.

12. Claim 12

Supra, §VII.B.7; EX1002, ¶345.

13. Claim 14

Supra, §VII.B.8; EX1002, ¶346.

C. Ground 3

The *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination renders obvious Claims 1-14. EX1002, ¶¶247-284.

1. Motivation to Combine

A POSITA would have been motivated to combine *Gardner-Denver* with the *Cicci-Coli-Dixon-Liu* combination. EX1002, ¶¶347-352; *supra*, §VII.B.1.

Gardner-Denver is analogous art to the '162 Patent because it is in the same field of endeavor regarding hydraulic fracturing systems. EX1010, 15; EX1002, ¶¶348-351.

Coli contains an express motivation to combine the references. *Id*. *Coli* teaches that "[a] suitable pump is a quintuplex or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver[.]" EX1006, ¶[0046]. 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, ¶347.

A POSITA would have been motivated to look to *Gardner-Denver* for the implementation details and operating parameters of incorporating the Gardner-Denver pump disclosed in *Coli*, such as the below:

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; EX1002, ¶348.

GD-2500Q PERFORMANCE RATING

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

Id.

A POSITA would have found *Gardner-Denver* helpful for understanding *Coli's* teachings regarding applicable fracturing pumps, their characteristics, and the connections. EX1002, ¶350. A POSITA would have found the operating data to be valuable in evaluating, for example, how many pumps would be necessary to pump the fracturing fluid at the suggested rate and pressure. *Id*. Furthermore, a POSITA would have found the connection data valuable in understanding what kind of fittings would have been appropriate to connect to an applicable 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* as it is merely applying a known technique (applying a known pump) to a known device (*Cicci-Coli-Dixon-Liu*'s fracturing system) ready for improvement (the practical design of the system) to yield predictable results (a system with an applicable pump, *e.g.*, GD SGWS-2500). EX1002, ¶352.

2. Claim 1

a) 1[p]-[c], 1[e]

Limitations 1[p]-[c] and 1[e] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* for the same reasons as in Grounds 1 and 2. *Supra*, §§VII.A.2(a)-(d), VII.A.2(f), VII.B.2(a); EX1002, ¶354.

b) 1[d]

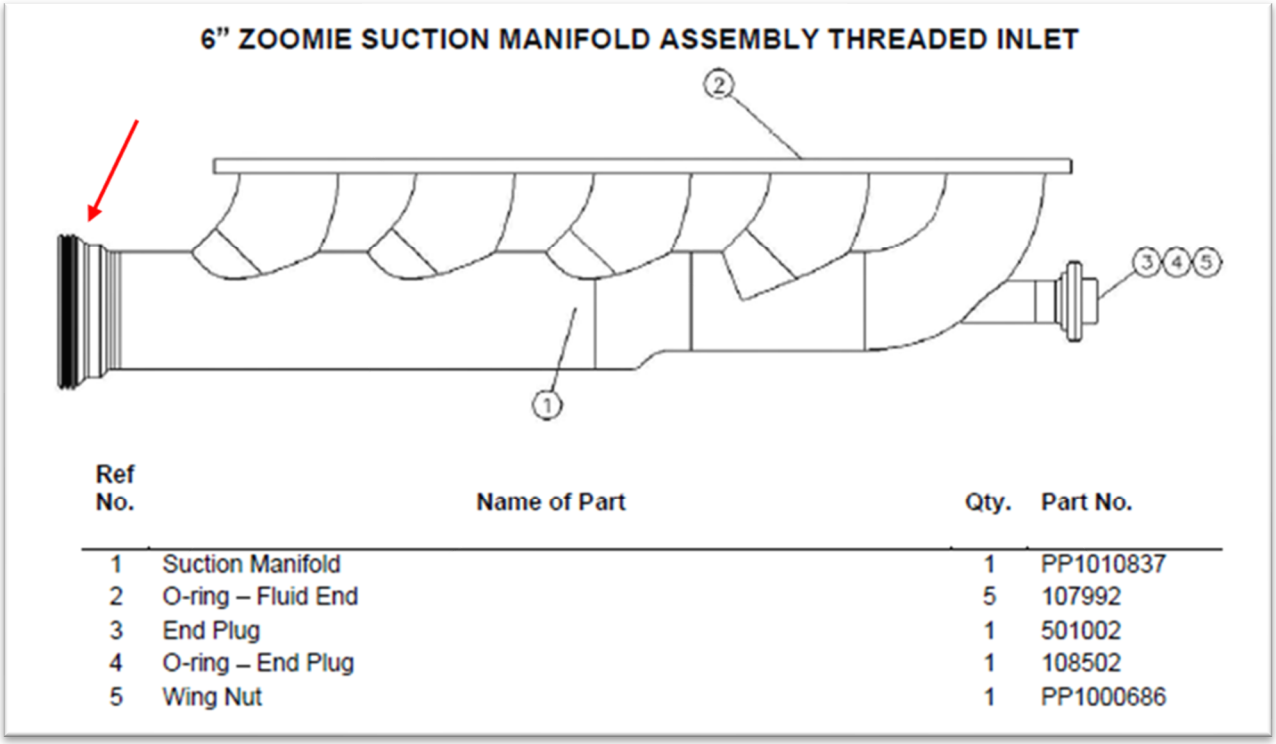
Supra, §§VII.A.2(e), VII.B.2(b). The addition of *Gardner-Denver* renders limitation 1[d] obvious, as *Gardner-Denver* discloses commercially available fracturing pumps, for example, the Gardner Denver SGWS-2500 referenced by *Coli*, with 6" or 8" headers. *Infra*, §VII.C.3; EX1002, ¶¶355-356. This would 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. *Id.*

3. Claim 2

Supra, §§VII.A.3, VII.B.3. It would have further been obvious for the second diameter to be approximately six inches in light of *Gardner-Denver*. EX1002, ¶357. *Coli* discloses a "SWGS-2500 Well Service Pump sold by Gardner Denver[.]" EX1006, ¶[0046]. It would have been obvious to use a fitting diameter consistent with this disclosure. EX1002, ¶¶357-359.

A POSITA would have understood that *Coli* refers to 6" inlet connections with both threaded (for hammer union) and Victaulic style inlet connections. EX1002, ¶358. *Gardner-Denver* discloses suction manifolds with various connection types, including Victaulic and threaded inlets (for hammer unions), and fixed sizes, such as 6" and 8" inlet 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. *Id*., 77. A POSITA would have understood this to be a 6" threaded inlet (hammer union half). EX1002, ¶358.



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

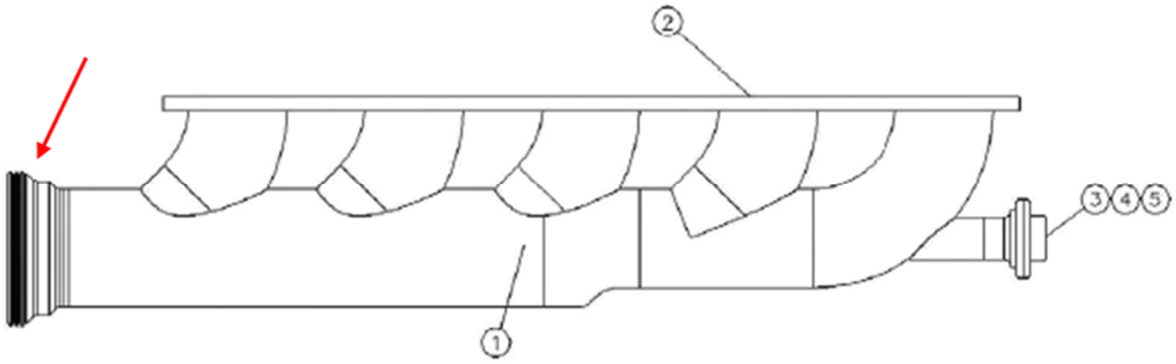
EX1010, 77.

Other connections and sizes include 6" Victaulic, 8" threaded (hammer union) and 8" Victaulic. EX1010, 76-79. Accordingly, *Gardner-Denver*, which contains information about the GD-2500 pump specifically referenced by *Coli,* discloses a 6" suction end (2nd diameter) for connection to the pump. *Id*. Moreover, it would have been obvious to use a 6" hammer union to connect to the 6" inlet manifold disclosed by *Coli* as hammer unions were well known. EX1002, ¶359; EX1001, 3:55-4:2.

4. Claim 3

Supra, §VII.A.4. The addition of *Gardner-Denver* further renders obvious limitation 3[a], as a POSITA would have understood from *Gardner-Denver* that the other half (female half) of the hammer union would have been attached 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, ¶360.

5. Claim 7

The *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination renders obvious Claim 7. EX1002, ¶¶363-378; *supra*, §VII.C.2. *Liu* discloses that pressure drop and damage accumulation rate (e.g., wear or abrasion on the hose) would have impacted the selection of the first diameter. *Supra*, VII.B.7. Pressure drop and wear are both directly related to velocity. *See id.*; EX1002, ¶364. Velocity (V), in turn, is related to both flowrate (Q) and diameter (D) of the hose as shown below.

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

Id. The first diameter would have been selected based on an upper limit on velocity, above which pressure drop and/or wear would have been unacceptable. *Id.*, ¶365.

In a similar manner, for any given diameter of hose, there is a maximum flowrate above which velocity would be too high, leading to unacceptable pressure drop or wear. EX1002, ¶366. Accordingly, it would have been obvious that for any given first diameter, there is a second threshold that corresponds to a maximum suggested flowrate which would limit pressure drop and wear to acceptable levels. *Id*. The first diameter is therefore associated with this second threshold. *Id.*

For example, *Coli* teaches blenders with outputs of approximately 100 bbl/min or 240 bbl/min. EX1006, ¶[0060]. As the fluid supplied by the blender would have the same rate as the fluid entering the wellbore, *Coli* teaches a range of maximum flow rates for the entire system between 100 bbl/min and 240 bbl/min (4200 GPM to 10,080 GPM). *See, e.g*., EX1004, 5:17-29; EX1005, ¶[12]; EX1002, ¶367. This total would be divided by the total number of pumps available in the system to provide the flowrate required by each pump. EX1002, ¶367. It would have been well-known to a POSITA to select the proper number of pumps to perform the fracturing job according to the fracturing design. *Id*., ¶368; *supra*, §VII.A.6(a).

Gardner-Denver, which contains information regarding the GD-2500 pump specifically 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 specified in *Cicci* ("5,000 PSI to 15,000 PSI or more"), the range of each pump is 191 GPM (red) to 734 GPM (blue). *Id.*; EX1004, 2:39-42; EX1005, ¶[12]; EX1002, ¶372; *supra*, §VII.A.2(b).

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 bbl/min to 240 bbl/min), in *Cicci*'s system, with 8 pumps would require a maximum flow rate between 12.5 bbl/min (525 GPM) and 30 bbl/min (1,260 GPM) per pump, respectively. EX1002, ¶373. However, in *Coli*'s system with as many as 24 pumps,

each pump would require a maximum flow rate between 4.2 bpm (175 GPM) and 10 bbl/min (420 GPM). *Id*. A POSITA would have understood to select or operate the proper number of pumps (at least between 8 and 24, or any number based on *Cicci* and *Coli*) so that the maximum flow rate, as determined by pressure drop and damage accumulation considerations, for each pump falls within the operating window of the pumps, 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, ¶374. It would have been obvious that the operating window for the pump would exceed the maximum flowrate determined by the pipe size, based on pressure drop and/or wear (damage accumulation). *Id*.

Further, as there are a finite number of sizes of piping systems available (such as the approximately 4-8 inch sizes shown in *Dixon*'s "frac hose" disclosure), and the operating window for pumps is so large (*e.g.*, 4.5–48.66 BPM shown in *Gardner-Denver*), it would have been obvious that the operating window of the pump would exceed the second threshold. *Id*., ¶375.

Accordingly, the *Coli-Cicci-Dixon-Liu-Gardner-Denver* combination render obvious a maximum suggested flow rate, an operating window for the electric powered pump exceeding the maximum suggested flow rate. *Id.*, ¶376. Because the

maximum suggested flowrate depends on the first diameter, the second threshold, corresponding to a maximum suggested flowrate, is associated with the first diameter. *Id.*, ¶377; *supra* §§VII.B.6-7.

6. Claim 9

a) 9[p]-[d], 9[f]-[h]

Limitations 9[p]-[d] and 9[f]-[h] are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination for the same reasons as Grounds 1 and 2. *Supra*, §§VII.A.7(a)-(e), VII.A.7(g)-(i), VII.B.9(a); EX1002, ¶380.

b) 9[e]

Supra, §§VII.A.7(f), VII.B.9(b), VII.C.(b); ¶EX1002, 381.

7. Claim 10

Supra, §VII.C.3; EX1002, ¶382.

8. Claim 13

Supra, §§VII.C.5; EX1002, ¶384.

9. Claims 4-6, 8, 11-12, and 14

Claims 4-6, 8, 11-12, and 14 are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Gardner-Denver* combination for the same reasons as Grounds 1 and 2. *Supra*, §§VII.A.4-6, VII.A.9, VII.B.4-8, VII.B.11-13; EX1002, ¶¶361-362, 383.

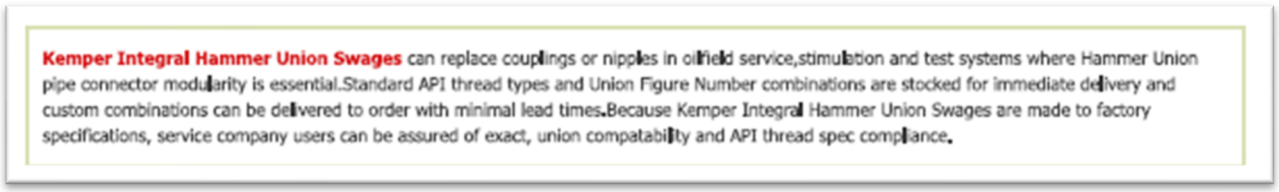
D. Grounds 4A and 4B

1. Motivation to Combine

A POSITA would have been motivated to combine *Kemper* with the *Cicci-Coli-Liu-Dixon* combination, with or without *Gardner-Denver*. EX1002, ¶¶386-394; *supra*, §VII.A.1, VII.B.1, VII.C.1.

Kemper is analogous art to the '162 Patent as it relates to the same field of endeavor of hydraulic fracturing systems. EX1002, ¶392; EX1008, 1.

A POSITA would have been motivated to incorporate *Kemper*, as *Kemper* discloses integral fittings that contain a hammer union, reduced to connect to an additional fitting. EX1002, ¶¶387-391; EX1008, 1. *Kemper* describes "Union Swages," which have a union on one end that reduces to a different type of connection on the other end. EX1008, 1. *Kemper* describes union swages for use in "oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential." EX1008, 1.


Kemper Integral Hammer Union Swages can replace couplings or nipples in oilfield service,stimulation and test systems where Hammer Union pipe connector modularity is essential.Standard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times.Because Kemper Integral Hammer Union Swages are made to factory specifications, service company users can be assured of exact, union compatability and API thread spec compliance.

Kemper also discloses the availability of "custom combinations." EX1008, 1. A POSITA would have recognized that *Kemper*'s configurations had threaded connections, instead of connectors to connect to hoses (shanks or barbs), and would have been motivated to design and construct a "custom combination" of union swage with a barb or shank fitting, based on *Dixon*. EX1002, ¶391.

A POSITA would have had a reasonable expectation of success in incorporating *Kemper* into the *Cicci-Coli-Dixon-Liu* system, with or without *Gardner-Denver*, because it uses a known technique (commercial fittings including union swages) to a known system (the *Cicci-Coli-Dixon-Liu* fracturing system incorporating *Dixon's* reducing Frac Fittings) ready for improvement (reducing the size between the union and the fitting's other end) to yield predictable results (reducing the size between the union and the fitting's other end). EX1002, ¶393.

2. Claim 1

a) 1[p]

Supra, §VII.A.2(a); EX1002, ¶396.

b) 1[a]

Supra, §VII.A.2(b); EX1002, ¶396.

c) 1[b]

Supra, §VII.A.2(c); EX1002, ¶396.

d) 1[c]

Supra, §VII.A.2(d); EX1002, ¶396.

e) 1[d]

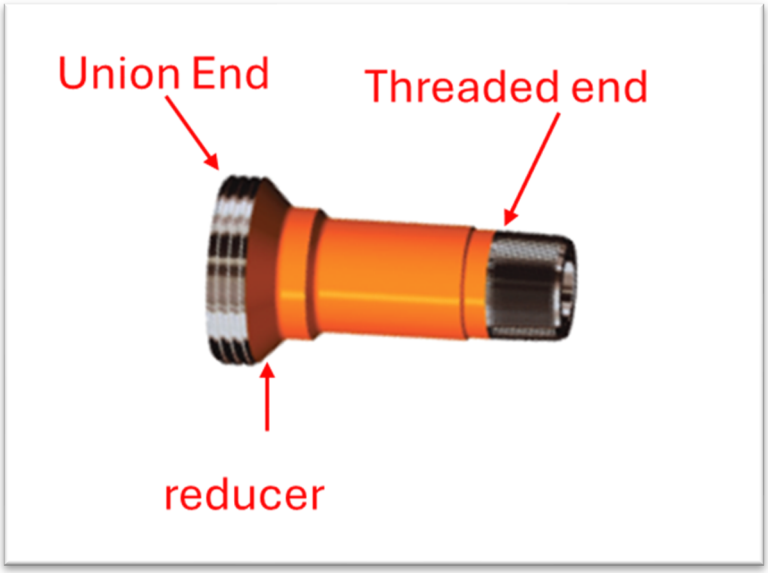
Supra, §§VII.A.2(e), VII.B.2(b), VII.C.2(b). *Kemper* also discloses the fitting in Limitation 1[d]. EX1002, ¶¶397-403. *Kemper* discloses fittings referred to as "union swages," which have a union on one end that reduces to a different type of

connection on the other end, with a smaller diameter than the first end's diameter. *Id.*; EX1008, 1.

Kemper describes union swages for use in "oilfield service, stimulation and test systems where Hammer Union pipe connector modularity is essential." EX1008, 1.

Kemper Integral Hammer Union Swages can replace couplings or nipples in oilfield service,stimulation and test systems where Hammer Union pipe connector modularity is essential.Standard API thread types and Union Figure Number combinations are stocked for immediate delivery and custom combinations can be delivered to order with minimal lead times.Because Kemper Integral Hammer Union Swages are made to factory specifications, service company users can be assured of exact, union compatability and API thread spec compliance.

Kemper illustrates union swages, which shows the end connecting to the pump (second end) having a larger diameter (second diameter) than the diameter (first diameter) of the end connecting to the pipe or hose (first end):



EX1008, 1. *Kemper* illustrates what a POSITA would have understood as a reducer between the pipe thread end and the union end. EX1002, ¶¶399-400.

Kemper shows various union swages that couple a larger union to a smaller connection, such as, for example, a 4" female union to a 3" line pipe thread and a 3" female union to a 2 7/8" EUE 8 round thread.



2" 1502 FEMALE X 5 ½" 8RD SC	1515SW2X55SC	10,000	21.2
3" 1502 FEMALE X 2" LPTL	1503SW2X2L	10,000	12.8
3" 1502 FEMALE X 2 3/8" EUE 8RD	1503SW2X2375E	10,000	12
3" 1502 FEMALE X 2 7/8" EUE 8RD	1503SW2X2875E	10,000	12.6
3" 1502 FEMALE X 3" LPT	1503SW2X3L	10,000	13.8
3" 1502 FEMALE X 3 ½" EUE 8RD	1503SW2X35E	10,000	14.4
3" 1502 FEMALE X 4" LPT	1503SW2X4L	10,000	17.3
3" 1502 FEMALE X 4" 8RD SC	1503SW2X4SC	10,000	-
3" 1502 FEMALE X 4" 8RD LC	1503SW2X4LC	10,000	-
3" 1502 FEMALE X 5 ½" 8RD SC	1503SW2X55SC	10,000	23.2
3" 1502 FEMALE X 7" 8RD SC	1503SW2X7SC	10,000	28.5
4" 1002 FEMALE X 2" LPT	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 3/8" EUE 8RD	1204SW2X2375E	10,000	18.5
4" 1002 FEMALE X 2 7/8" EUE 8RD	1204SW2X2875E	10,000	18.8
4" 1002 FEMALE X 3" LPT	1204SW2X3L	10,000	-
4" 1002 FEMALE X 3 ½" EUE 8RD	1204SW2X35E	10,000	19.6

EX1008, 1; EX1002, ¶401.

A POSITA would have recognized that *Kemper*'s specific configurations had threaded connections, instead of connectors to connect to hoses (shanks or barbs), and would have been motivated to design and construct a "custom combination" of union swage with a barb or shank fitting, based on *Dixon*. EX1008, 1 (disclosing "custom combinations"); EX1002, ¶402.

f) 1[e]

Supra, §VII.A.2(f); EX1002, 396.

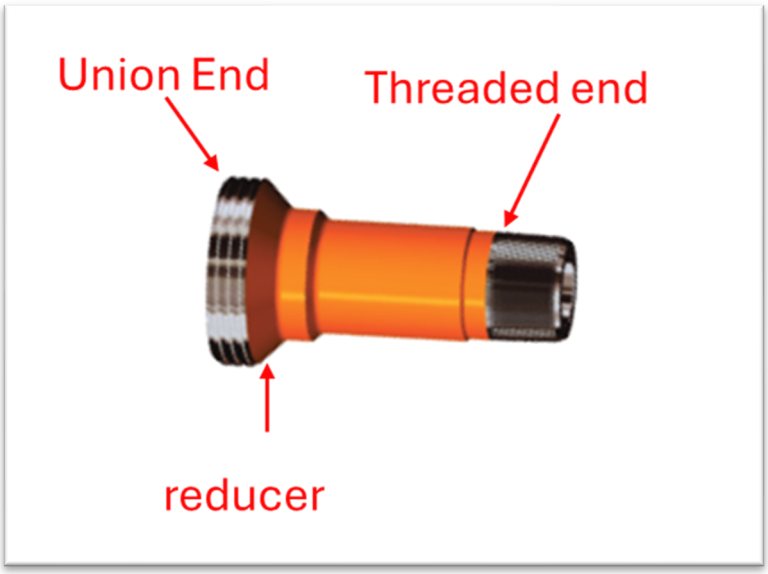
3. Claim 2

Claim 2 would have further been obvious in view of *Kemper*. EX1002, ¶¶404-407; *supra*, §§VII.A.3, VII.B.3, VII.C.3, VII.D.2. A POSITA would have understood from *Dixon* and *Kemper* that combinations of sizes other than those

specifically disclosed would have been available. EX1002, ¶405; EX1008, 1 (disclosing "custom combinations"). A POSITA would have ordered custom combinations to connect standard pump connection sizes (e.g., 6") to a smaller, 5" connection, when a 5" hose is desired, either based on *Cicci*'s 1-8 inch hose diameters, and/or when *Liu*'s calculations indicate that 5" is the appropriate size, based on the balanced velocity considerations. EX1002, ¶¶405-406; EX1001, 3:65-4:2.

4. Claim 3

Supra, §VII.A.4, VII.B.4, VII.C.4, VII.D.2. *Kemper* additionally discloses a reducer, as recited in 3[c]:



EX1008, 1; EX1002, ¶¶408-409.

5. Claim 9

a) 9[p]-[d], 9[f]-[h]

Limitations 9[p]-[d] and 9[f]-[h] are disclosed or rendered obvious by the *Cicci-Coli-Dixon-Liu-Kemper* combination, with or without *Gardner-Denver*, for the same reasons as Grounds 1-3. *Supra*, §§VII.A.7(a)-(e), VII.A.7(g)-(i), VII.B.9(a), VII.C.6(a); EX1002, ¶411.

b) 9[e]

Supra, §§VII.A.7(f), VII.B.9(b), VII.C.6(b), VII.D.2(e); EX1002, ¶412.

6. Claim 10

Supra, §VII.D.3; EX1002, ¶413.

7. Claims 4-8, 11-14

Claims 4-8 and 11-14 are disclosed and/or rendered obvious by the *Cicci-Coli-Dixon-Liu-Kemper* combination, with or without *Gardner-Denver*, for the same reasons as Grounds 1-3. *Supra*, §§VII.A.5-6, VII.A.9, VII.B.5-8, VII.B.11-13, VII.C.7. Adding *Kemper* renders these claims obvious for the same reasons as 1[d] and 9[d], from which they respectively depend. *Supra*, §§VII.D.2(e), VII.D.5(b); EX1002, ¶¶410, 414.

E. Grounds 5A and 5B

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, with or without *Kemper*, and would have had a reasonable expectation of success in doing so. EX1002, ¶¶415-424; *supra*, §§VII.C.1, VII.D.1.

ANSI/HI 6.1 is analogous art to the '162 Patent because it is directed to the same field of endeavor of hydraulic fracturing systems. EX1002, ¶416; EX1011, 11. *ANSI/HI 6.1* also would have been reasonably pertinent to the problem with which the '162 Patent is concerned—fluid flow rates for fracturing operations—as *ANSI/HI 6.1* relates to sizing hydraulic pumps and piping to maintain sufficient fluid velocity or flow. EX1011, 11. *ANSI/HI 6.1* is a standard approved by the American National Standard when consensus is established. EX1011, 3; EX1002, ¶¶417-418.

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, ¶419; EX1011, 9-11. 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, ¶419. 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, with or without *Kemper*. EX1002, ¶419.

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, with or without *Kemper.* EX1002, ¶420; *supra*, §§VII.A.1, 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, 11. 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, with or without *Kemper*. EX1002, ¶420.

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* teaches sizing pumps' hydraulic passages within operating carrying velocities, and below a highest velocity which would otherwise cause "excessive erosion." EX1011, 11. A POSITA would have been motivated to apply these teachings to slurry passages of pumps and hoses in the *Cicci-Coli-Dixon-Liu-Gardner-Denver* system, with or without *Kemper*, to obtain the benefits of avoiding such excessive erosion, which would damage the pipe and equipment. EX1002, ¶421. A POSITA would have had a reasonable expectation of success in doing so because the same slurry passes through the passages of the pump and the hoses, and the same scientific principles apply. *Id*.

Liu discloses wear (abrasion) at high velocities. *Supra*, §VII.C5. A POSITA would have been motivated to look to *ANSI/HI 6.1* for implementation details of how to avoid 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, 10. 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, ¶¶421-422. Accordingly, *ANSI/HI 6.1* and *Liu*'s teachings are complimentary. *Id*., ¶422.

ANSI/HI 6.1 provides real-world examples of numbers, applying *Liu*'s principles. *Id*., ¶423. 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, with or without *Kemper*. *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, with or without *Kemper*, because the combination merely applies a known technique (practical limits on slurry velocity) to a known system (hydraulic fracturing system) ready for improvement (the practical application of *Liu*'s principles) to yield predictable results (minimizing proppant drop out and wear/abrasion/erosion). EX1002, ¶424.

2. Claim 7

Supra, §VII.C.5. *ANSI/HI 6.1* further renders Claim 7 obvious. EX1002, ¶¶425-432. For example, *ANSI/HI 6.1* teaches that, when pumping a slurry, "hydraulic passages should be sized to that the lowest velocity of the liquid will be above the critical carrying velocity of 1.2 to 1.8 m/s (4 to 6 ft/s) as an average. The highest velocity should be below that which causes excessive erosion. Typical

average operating velocities through a reciprocating slurry pump's passages are 1.8 to 3.6 m/s (6 to 12 ft/s).” EX1011, 11. A POSITA would have recognized that this applies to the *Cicci-Coli-Dixon-Liu-Garder-Denver* hoses’ hydraulic passages, particularly considering *Liu*’s abrasion teachings. EX1002, ¶¶427-428. 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*., ¶429. 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 first diameter is associated with a second threshold that corresponds to a maximum 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:

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

EX1002, ¶430; *supra*, §VII.C.5.

Gardner-Denver describes that its pump has a range of operations, teaches that the "operating window" for each pump is between 191 GPM (4.5 BPM, red) and 2,044 GPM (48.66 BPM), depending on the design, speed and specific well conditions. EX1010, 20; *supra*, §VII.C.5. For *Cicci*'s conditions ("5,000 PSI to 15,000 PSI or more"), the range of each pump 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. A comparison of the operating range of the *Gardner-Denver* pump with the practical maximum flowrate thresholds described by *ANSI/HI 6.1*, applying the principles of *Liu*, shows that the operating range exceeds the maximum flowrate threshold of the hose sizes which would have been obvious. EX1002, ¶431.

VIII. CONCLUSION

Petitioners respectfully request *inter partes* review of the '162 Patent be instituted and that the challenged claims be canceled as unpatentable under 35 U.S.C. §318(b).

Respectfully submitted,

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CERTIFICATE OF SERVICE

The undersigned hereby certifies on this August 29, 2025, that true and correct copies of the foregoing PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 11,009,162, Exhibits 1001-1058, and Petitioner's power of attorney were served in their entirety to Patent Owner via FedEx Express® or Express Mail:

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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 13,972 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,

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