

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PROFRAC HOLDING CORPORATION
and
U.S. WELL SERVICES, LLC,
Petitioners,

v.

HALLIBURTON ENERGY SERVICES, INC.,
Patent Owner

PGR2023-00023
U.S. PATENT NO. 11,373,058 B2

PETITIONERS' REPLY BRIEF

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PETITIONERS' EXHIBIT LIST

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1001	U.S. Patent No. 11,373,058
1002	File History of U.S. Patent No. 11,373,058
1003	Declaration of Dr. Michael Nikolaou
1004	Curriculum Vitae of Dr. Michael Nikolaou
1005	U.S. Patent App. Pub. No. 2018/0230782 to Pankaj <i>et al.</i>
1006	U.S. Patent App. Pub. No. 2016/0258267 to Payne <i>et al.</i>
1007	S. Dalvi, <i>Fundamentals of Oil & Gas Industry for Beginners</i> (Notion Press 2015) (excerpts)
1008	U.S. Patent App. Pub. No. 2013/0306322 to Sanborn <i>et al.</i>
1009	U.S. Patent No. 9,410,410 to Broussard <i>et al.</i>
1010	U.S. Patent App. Pub. No. 2012/0255734 to Coli <i>et al.</i>
1011	U.S. Patent No. 10,020,711 to Oehring <i>et al.</i>
1012	U.S. Patent App. Pub. No. 2008/0236818 to Dykstra <i>et al.</i>
1013	U.S. Patent App. Pub. No. 2006/0015310 to Husen <i>et al.</i>
1014	U.S. Patent App. Pub. No. 2016/0061003 to Gottumukkala <i>et al.</i>
1015	U.S. Patent No. 10,280,722 to Bello <i>et al.</i>

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1016	Website Printout from the Internet Archive concerning the Mayo Clinic allergy test procedures, accessed at: https://web.archive.org/web/20180728025208/https://www.mayoclinic.org/tests-procedures/allergy-tests/about/pac-20392895
1017	U.S. Patent No. 5,809,428 to Garahi <i>et al.</i>
1018	U.S. Patent App. Pub. No. 2016/0153266 to Rashid <i>et al.</i>
1019	U.S. Patent No. 8,352,227 to Klumpen <i>et al.</i>
1020	U.S. Patent No. 7,953,585 to Gurpinar <i>et al.</i>
1021	U.K. Patent App. GB 2443051 to Varadarajan <i>et al.</i>
1022	Federal Court Management Statistics for the Western District of Texas (Dec. 31, 2022)
1023	PCT International Pub. No. WO 2018/084871 to Madasu <i>et al.</i>
1024	U.S. Patent No. 10,378,333 to Dawson <i>et al.</i>
1025	Website Printout from Amazon.com (Dalvi Book), accessed at: https://www.amazon.com/Fundamentals-Oil-Gas-Industry-Beginners/dp/9352064194/ref=sr_1_1?crid=2OJL05AXX8XSF&keywords=Dalvi+oil+gas+industry&qid=1679761993&srefix=dalvi+oil+gas+industry%2Caps%2C182&sr=8-1

Exhibit No.	Description
1026	Website Printout from the Internet Archive (Dalvi Book), accessed at: https://web.archive.org/web/20161108121245/https://notionpress.com/store/categories/technology-engineering
1027	U.S. Patent No. 10,087,722 to Lecerf <i>et al.</i>
1028	T. Jacobs, These Five Companies are Reinventing the U.S. Frac Fleet, <i>Journal of Petroleum Technology</i> (July 31, 2019)
1029	Website Printout from the Internet Archive (U.S. Well Services) accessed at: https://web.archive.org/web/20151121102607/http://uswellservices.com/
1030	Website Printout from Amazon.com – D. Tiab, <i>Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties</i> , 4 th Ed. (Gulf Professional Pub. 2015), accessed at: https://www.amazon.com/dp/0128031883?psc=1&smid=AZOLNCI5GS0EX&ref_=chk_typ_imgToDp
1031	September 18, 2023 Letter from Petitioners’ Counsel to Patent Owner’s Counsel

Exhibit No.	Description
1032 New	A. Shchipanov <i>et al.</i> , <i>Step Rate Test as a Way to Understand Well Performance in Fractured Carbonates</i> , SPE-185795-MS (June 2017)
1033 New	United States Environmental Protection Agency, Region VIII, <i>Step Rate Test Procedure</i> (Jan. 12, 1999)
1034 New	European Patent EP 1 393 136, <i>Method for Monitoring and Detecting Sensor Failure in Oil and Gas Production System</i> , published Feb. 18, 2009
1035 New	PCT WO 2011/041794 A1, <i>Method and Apparatus for Differential Pressure Measurement</i> , published April 7, 2011
1036 New	U.S. Patent Application Publication No. US 2015/0377716 A1, <i>Pipeline Constriction Detection</i> , published Dec. 31, 2015
1037 New	PCT WO 2016/025672 A1, <i>Method of Treating an Underground Formation Featuring Single-Point Stimulation</i> , published Feb. 18, 2016
1038 New	U.S. Patent Application Publication No. US 2015/0075778A1, <i>Controlling an Injection Treatment of a Subterranean Region Based on Stride Test Data</i> , published March 19, 2015

Exhibit No.	Description
1039 New	PCT WO 2015/057242 A1, <i>Managing a Wellsite Operation With a Proxy Model</i> , published April 23, 2015
1040 New	PCT WO 2014/039036 A1, <i>Wellbore Completion and Hydraulic Fracturing Optimization Methods and Associated Systems</i> , published March 13, 2014
1041 New	U.S. Patent App. Pub. No. US 2014/0262232, <i>Controlling Net Treating Pressure in a Subterranean Region</i> , published Sept. 18, 2014
1042 New	U.S. Patent No. 7,806,182, <i>Stimulation Method</i> , issued Oct. 5, 2010
1043 New	U.S. Patent No. 7,788,037, <i>Method and System for Determining Formation Properties Based on Fracture Treatment</i> , issued Aug. 31, 2010
1044 New	U.S. Patent No. 7,516,793, <i>Methods and Systems for Fracturing Subterranean Wells</i> , issued April 14, 2009
1045 New	U.S. Patent App. Pub. No. US 2017/0175484, <i>Hydraulic Fracturing with Strong, Lightweight, Low Profile Diverters</i> , published June 22, 2017
1046 New	M. Van Domelen, <i>A Practical Guide to Modern Diversion Technology</i> , SPE-185120-MS (March 2017)

Exhibit No.	Description
1047 New	<i>Reservoir Modeling</i> , Wikipedia Webpage from Internet Archive (April 1, 2019)
1048 New	<i>Nexus® User Guide</i> , Halliburton Landmark Software & Services (December 2009)
1049 New	May 2, 2024 Deposition Transcript of Dr. Robert A. Durham
1050 New	Supplemental Declaration of Dr. Michael Nikolaou
1051 New	May 9, 2024 Affidavit of Internet Archive Records Request Processor Nathaniel E. Frank-White

TABLE OF ABBREVIATIONS

ProFrac or Petitioner	Petitioners ProFrac Holding Corp. and U.S. Well Services, LLC
Halliburton or PO	Patent Owner Halliburton Energy Services, Inc.
058 patent	U.S. Patent No. 11,373,058
ID	Institution Decision, Paper 9
Petition	Petition for Post-Grant Review, Paper 2
POR	Patent Owner Response, Paper 14
POSITA	Person of Ordinary Skill in the Art
Emphasis	All emphasis added herein except if noted otherwise
Page Cites	All exhibit cites are to the PDF page number

I. INTRODUCTION

None of PO's arguments change what the petition demonstrated—the challenged claims are invalid under 35 U.S.C. §§ 101, 103.

II. THE CLAIMS ARE UNPATENTABLE

A. GROUND 5: 35 U.S.C. § 101

Alice Step One. Whether the claims are directed to an abstract idea requires considering ‘the focus of the claimed advance over the prior art to determine if the claim’s character as a whole is directed to excluded subject matter.’ *Affinity Labs of Texas v. DIRECTV*, 838 F.3d 1253, 1257 (Fed. Cir. 2016). The focus of the 058 claims is automating fracturing steps. But prior art confirms that each step was well-known and conventional.

PO argues that Claim 1’s “generating a sequence of stimuli for application to a well environment, the sequence of stimuli comprising one or more of particulate concentrations, chemical concentrations, or a pump rate control” (“step one”) represents a patentable advance. Wrong. Altering pump rates and determining a well’s response thereto has been done for decades. EX-1050, ¶¶6-18.

“Step-rate” tests were industry-standard. EX-1032 (“Step Rate Test (SRT) is commonly used to estimate formation parting (or fracture opening) pressure for stimulated wells. SRTs may also focus on changes of well performance at different rates/pressures....”); *Id.*, .002 (“SRTs may be used for evaluating any changes in

well and reservoir parameters with changing pressure and rate.”). Using SRTs, a “series of successively higher injection rates should be determined” and the “elapsed time and pressure values” read and recorded “for each time and rate-step.” EX-1033.001. See below:

STEP RATE TEST DATA

Well: Anywell #1 Date: April 15, 2000 Operator: Lotya Oil

STEP #1 Test Rate (5% of maximum rate) .2 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	0	90	95	98	99	100	100

STEP #2 Test Rate (10% of maximum rate) .4 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	80	170	185	195	199	201	202

STEP #3 Test Rate (20% of maximum rate) .8 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	190	320	385	392	398	403	404

STEP #4 Test Rate (40% of maximum rate) 1.6 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	380	700	790	792	798	803	805

STEP #5 Test Rate (60% of maximum rate) 2.4 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	751	990	1032	1093	1155	1188	1202

STEP #6 Test Rate (80% of maximum rate) 3.2 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	1133	1250	1326	1370	1397	1399	1403

STEP #7 Test Rate (100% of maximum rate) 4.0 (bbl/min)

Time (min)	0	5	10	15	20	25	30
Pressure (psi)	1350	1448	1503	1530	1571	1590	1600

EX-1033.005; EX-1050, ¶¶8-10.

SRTs are a “sequence of stimuli” comprising a “pump rate control” as claimed. *Id.*, ¶¶11-12. SRTs incrementally change the pump rate (a “sequence”) and measure the well pressure response.¹ *Id.*; *see* EX-1037 [0041] (disclosing “diagnostic tests” including “step-up rate test, step down tests...”); [0057].²

“Mini-frac” testing was also well-known and conventional. EX-1050, ¶¶14-17. These too were “used to determine formation properties and residual fracture properties before a regular or full fracture treatment.” EX-1043 [3:5-9]. These tests controlled pump rates and measured the response. *Id.* [5:37-42]; [9:30-38] (noting that the system may “modify pump times, [and] pump pressures”); [10:67-11:8] (“[D]ata is collected” from the mini-frac test); EX-1013, [0024] (same).

SRTs and mini-frac tests also show claim 1’s limitation “receiving formation response data comprising data from one or more downhole sensors or surface sensors” (“step two”) was well-known and conventional. EX-1050, ¶¶10, 15-17; EX-1032.001 (describing “downhole gauges”); EX-1033.002 (disclosing

¹ *See* EX-1001 [2:30-36].

² SRTs meet step one even under PO’s incorrect construction because they are predetermined tests for application to a well. EX-1033; EX-1050, ¶11.

“downhole pressure bomb[s]” and “surface gauge[s]”).³ EX-1043 explains that “surface and down-hole sensors” were used to collect mini-frac test data. *Id.* [3:57-60] [10:67-11:8]; EX-1044 [2:8-27]; Petition, 94-95.

PO’s representation that steps one and two were unconventional is therefore false. Indeed, PO’s *own prior art* confirms this. A 2015 Halliburton publication (EX-1038) exactly describes steps one and two (*see* EX-1050, ¶18):

Step One:

- “Injection tests are sometimes performed before a fracture treatment.

Conventional injection tests include *step-rate tests, mini-fracture tests....*” EX-1038 [0002].

- “*Data from the injection test* ... can be used [] to modify or otherwise design an ongoing or future injection treatment.” [0010].

- “[A]n injection test includes a *controlled injection sequence that is calibrated* to induce a measurable response [from the well].” [0018]; *see* [0017],

³ POSITAs understood that “gauges” and “sensors” were used interchangeably. EX-1050, ¶¶15-17; EX-1034.004; EX-1035.003 (identifying a “differential pressure sensor/gauge”); EX-1036 [0041] (identifying “pressure measurement device[s]” including “pressure sensor, gauge”).

[0030] (identifying an “*injection test sequence*, a pumping stage sequence, etc.” that “specifies parameters (e.g., *injection rate and material*) of an injection test....”); [0066] (“[T]he *injection rate 420 is increased over time across different injection periods....*”).

- “The injection test can employ *various injection rates and injection materials to test and measure the [well] response*]....” [0037].

Step Two:

- “[A] *measurement system can acquire pressure data* from the wellbore 102 during the injection test, and the pressure data can be analyzed to determine ... [well] properties....” [0017]; [0019] (pressure response to an injection test is measured by “*pressure sensors*”); [0027] (disclosing “*surface and down-hole sensors*”); [0037].

Fig. 6 shows steps one and two highlighted below:

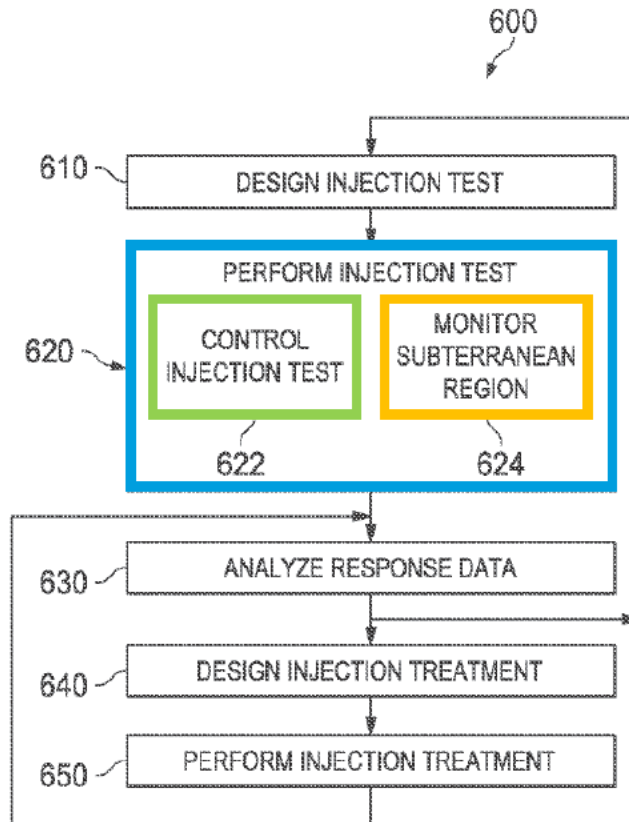


FIG. 6

EX-1038, Fig. 6 (annotated)

Steps one and two were thus well-known and conventional before the 058 patent. EX-1050, ¶¶7-18.

Step Three requires “selecting a representative system model based on the received formation response data and sequence of stimuli.” Selecting models based

on response data from an injection test was also well-known and conventional. EX-1050, ¶¶20-30.⁴

PO's 2015 publication discloses this. EX-1038 [0010] (analysis of the injection test data “can be used to *design or control an ongoing injection treatment*....”); [0031] (“[T]he injection control subsystem 111 may process the [injection test] data ... *to select* or modify ... *treatment to be applied*” to the well); [0043], [0045]; [0055] (“The analysis and design systems ... can include ... *models* ... for analyzing the subterranean data and designing injection tests and treatments.”); [0091] (“[T]he injection treatment can be designed *based on the analysis of the response data of the subterranean region to the injection test*.”).

Other prior art disclosed step three. See EX-1039 [0029] (disclosing “techniques for managing ... a hydraulic fracture operation, by *using one or more proxy models to determine setpoint controls for operational equipment*....”);⁵

⁴ Software for generating treatment models was used for years before 2019. EX-1050, ¶¶22-24. PO's expert testified he was aware of models used for well treatment schedules before the 058 patent. EX-1049, 25:17-26:18; 22:6-19

⁵ Published in 2013, EX-1039 identifies commercially-available modeling software. *Id.* [0030]; see EX-1042 (2008 patent) (disclosing “widely-used”

[0070] (“[A] model selection algorithm 608 *chooses a particular proxy model* 610.”).

EX-1039 discloses selecting the model using sensor data. *Id.* [0046] (“sensors 202 ... gather measured or observed data (measurements) 204....”); [0047] (disclosing a “Proxy Model Generator (PMG) 206 that receives, as inputs, *the measured properties 204 from the sensors* 202. The PMG 206 includes *one or more proxy models that can be updated based on the measure properties 204.*”).

Model selection based on sensor data is shown in Fig. 3:

“commercial fracture simulation model ... known as FracCADETM.”); *id.* [14:20-28].

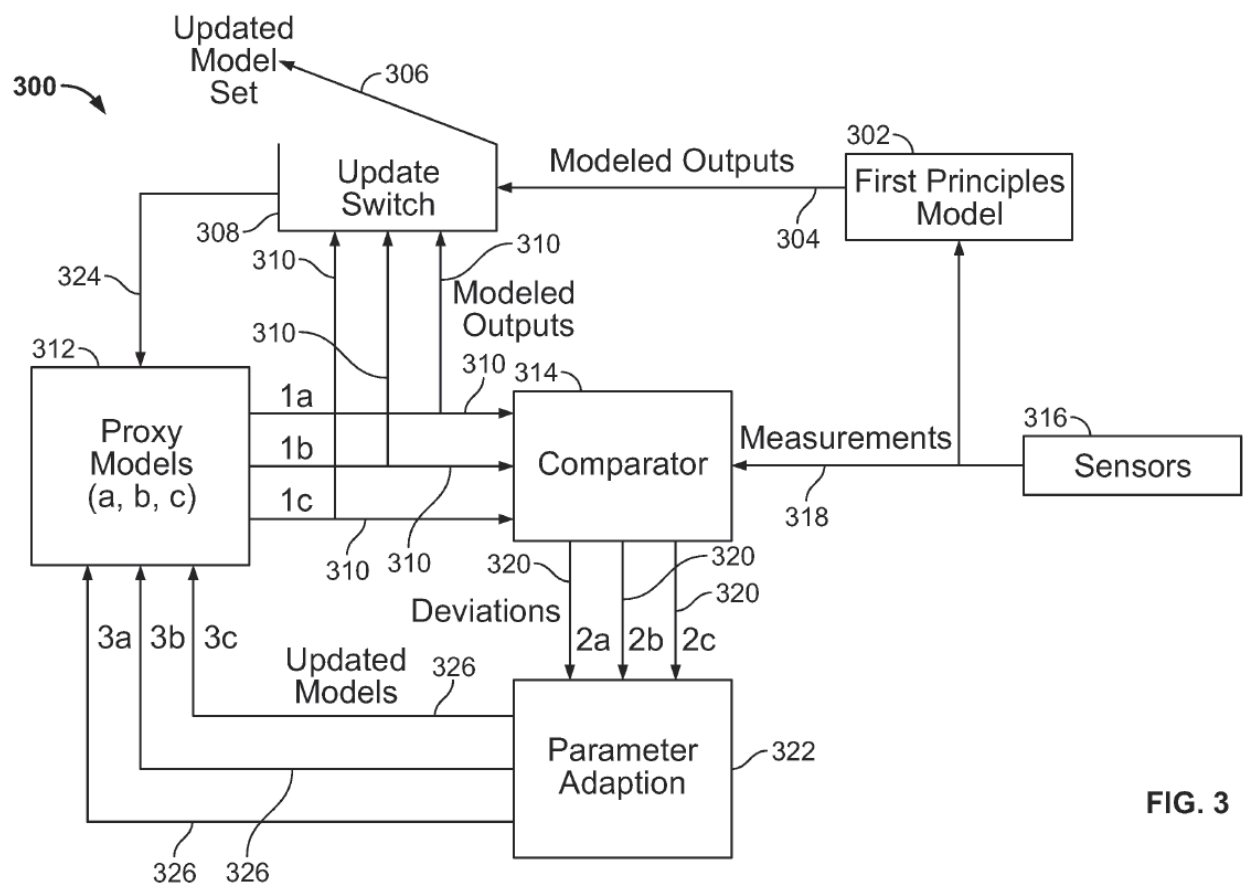


FIG. 3

EX-1039, Fig. 3

Other prior art similarly discloses this. See EX-1040, Figs. 3, 4:

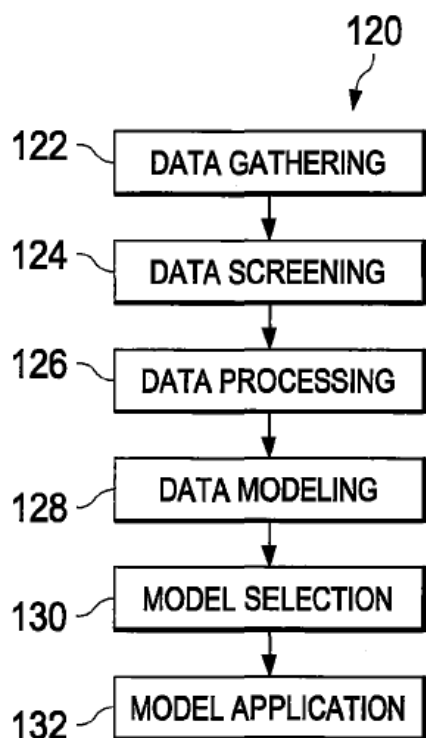


Fig. 3

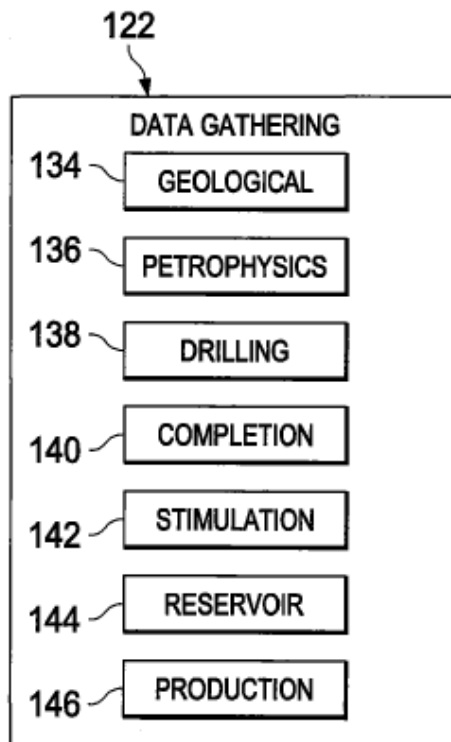


Fig. 4

EX-1040, Figs. 3, 4

Data gathering includes determining well pressure values used “in a predictive model to estimate the effects of various stimulation options (e.g., hydraulic fracturing parameters) on well production.” EX-1040.012-13. In Fig. 3, the method includes “*model selection* at step 130 and then model application at step 132.” *Id.*, .0023; *see* .0026 (teaching selecting “*a best or final model from a plurality of available models.*”). *See* EX-1018, Fig. 6 (showing “well models 626” in “mass storage 610”).

Step Four requires “controlling an electrical fracturing pump based on the representative system model.” This too was commonplace years before 2019. EX-

1050, ¶¶32-38. *See* EX-1038 [0027]: “The injection system 108 may include ***pump controls*** ... for ... ***controlling pumping*** ... during the injection treatment.” These pumps are computer-controlled. *Id.* (“The injection control subsystem 111 may communicate with such equipment to ... control the injection treatment.”); [0060] (“[T]he injection treatment can be ... ***controlled automatically by an injection control system....***”).⁶

EX-1039 teaches automated pump control using well models. *Id.* [0027] (“[A] control system ... may automate a wellsite operation.... [C]ontrol optimization may be performed ... through one or more proxy models.”); [0029] (disclosing managing “a hydraulic fracture operation, by ***using one or more proxy models to determine setpoint controls for operational equipment***. The operational equipment ... include[s] ... ***pumps....***”); [0041] (“[T]he computing environment 250 may ... ***control one or more pumps....***”); [0044]; claim 11.

EX-1041 shows an automated system that analyzes well data, selects models, and controls pumps:

⁶ The injection treatment is determined “***based on response data from an injection test.***” EX-1038 [0094].

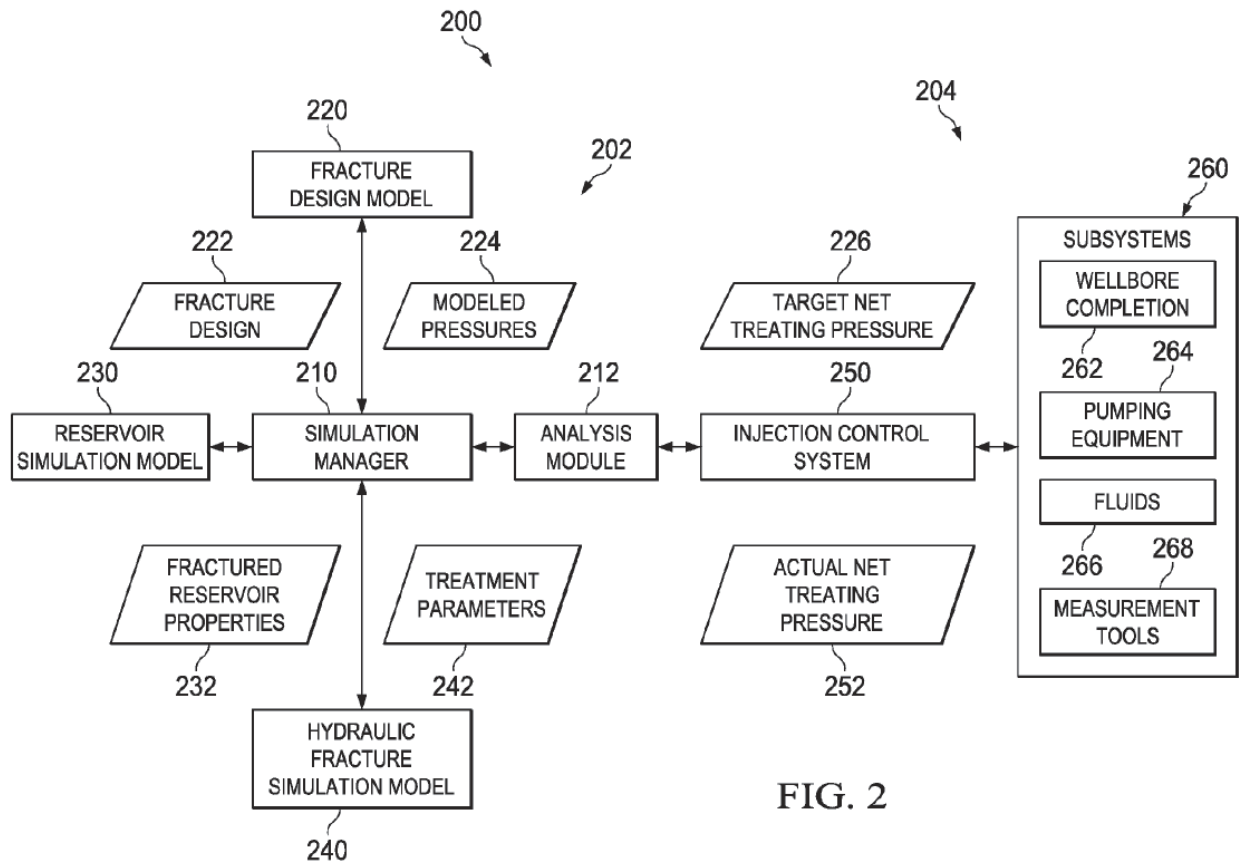


FIG. 2

EX-1041, FIG. 2

“The injection treatment control subsystem [] may receive, generate or modify an injection treatment plan (e.g., a *pumping schedule*) that specifies properties of an injection treatment to be applied [to the well].” *Id.* [0030]; [0031]; [0032]

(“Controlling the net treating pressure may include modifying pumping pressures, modifying pumping rates...”); [0046] (the control system selects well models); [0053], [0054]; [0027]; [0028] (the system includes “*pump controls* The [control system] may *communicate with such equipment to monitor and control the injection treatment.*”); [0068] (disclosing “computer-implemented algorithms

that can *automatically* control the subsystems” including pumps); [0073]; claims 14-22; *see* EX-1012 [0021]; [0028] (“[T]he pump drive signal 350 can control the ... pumping rate of the pumps driving the well treatment fluid into a well.”); EX-1042 [14:30-35] (models were used to generate “a pumping schedule that is used to pump the fracture stimulation fluids into the wellbore.”).

Each claim 1 step was thus well-known and conventional. The “focus of the claimed advance” is therefore claim 1’s method being “computer-implemented.” This is consistent with the specification explaining that “typically” pump settings were “performed manually based on manually appraised information.... [A] technician may review sensor data and ... adjust various settings... [A] representative system model may be used for determining pump settings based on sensor information; however, the ... model is typically manually selected by a technician.” EX-1001 [1:14-22].

Claim 1’s focus on automating this process makes it an abstract idea. *Chamberlain Grp. v. Techtronic Indus. Co.*, 935 F.3d 1341, 1346 (Fed. Cir. 2019); *cxLoyalty, Inc. v. Maritz Holdings Inc.*, 986 F.3d 1367, 1377 (Fed. Cir. 2021) (claims abstract when the “GUI in claim 1 takes the place of the human acting as an intermediary”). In claim 1, the “computer-implemented method” replaces a human interpreting the sensor data, selecting the model, and controlling the pump.

Nor are the claims saved by being directed to well fracturing. “[M]erely limiting the field of use of the abstract idea to a particular existing technological environment does not render the claims any less abstract.” *Chamberlain*, 935 F.3d at 1347. “[T]he claimed advance is directed to the wireless communication of status information ***using off-the-shelf technology*** for its intended purpose.” *Id.* Here too, the claimed steps identify “off-the-shelf technology” used in their intended way. *In re TLI Communs. LLC Patent Litig.*, 823 F.3d 607, 611 (Fed. Cir. 2016) “[N]ot every claim that recites concrete, tangible components escapes the reach of the abstract-idea inquiry.”).

PO’s arguments against abstractness fail, and its case law is distinguishable. In *Adasa Inc. v. Avery Dennison Corp.*, 55 F.4th 900, 908 (Fed. Cir. 2022), the claim was directed to a “specific, hardware-based RFID serial number data structure designed to enable technological improvements to the commissioning process.” The 058 claims are not comparable.

Diamond v. Diehr, 450 U.S. 175 (1981) is also inapt. The claims required “precision molded compounds” and no one in the industry knew how to obtain accurate cured compounds on a uniform basis. The claims transformed uncured synthetic rubber into a different state and thus were directed to “an improved process for molding rubber articles by solving a practical problem which had arisen” in the field. *Id.* at 181, 184. The 058 claims require no such transformation.

Mentone Sol. LLC v. Digi Int'l Inc., 2021 WL 5291802 (Fed. Cir. Nov. 15, 2021) contained claims directed to permitting additional multislot configurations for mobile stations using extended bandwidth allocation. The specification disclosed that the solution to the technological problem required a “shifted USF” that was unknown in the industry. The Federal Circuit held the district court’s abstract idea failed to mention a shifted USF and was thus untethered from the invention.

TecSec, Inc. v. Adobe Inc., 978 F.3d 1278, 1296 (Fed. Cir. 2020) contained claims directed to “improving a basic function of a computer data-distribution network, namely, network security.” The Court rejected Adobe’s abstract idea because it disregarded a key claim limitation that was emphasized during prosecution.

In contrast, Petitioners tied their abstract idea to the claim language:

Claim 1 is thus directed to the abstract idea of selecting a plan (“representative system model”) for a desired result (“controlling” a pump) based on information received (“response data”) in response to one or more inquiries (“sequence of stimuli”).

Petition, 87. The parenthetical language matches the claimed steps and is thus not “untethered” from the claims. Moreover, the Federal Circuit has repeatedly endorsed characterizing abstract ideas broadly. *See Plotagraph Inc. v. Lightricks*

Ltd., 2024 U.S. App. LEXIS 1367, *6-7 (Fed. Cir. Jan. 22, 2024) (accepting district court’s abstract idea of an “animation” providing the illusion of movement, even when “the claims do not include any form of the word ‘animation,’ or the phrase ‘illusion of movement....’”); *In re Killian*, 45 F.4th 1373, 1378 (Fed. Cir. 2023) (boiling down verbose claims to “a search algorithm for identifying people who may be eligible for SSDI benefits they are not receiving....”).

EcoServices v. Certified Aviation Services, 830 F. App’x 634, 641 (Fed. Cir. 2020) is also off-point. The majority found the claims directed to a “system for washing turbine engines” using “hardware in a ***non-conventional manner*** to reduce errors and create a technologically improved turbine engine washing system.” Claim 1 here, in contrast, is directed to a method, not a system, and any identified hardware is used in its conventional manner as explained *supra*. The claims here are directed to mere automation of known fracturing steps.

More on-point is *Ficep Corp. v. Peddinghaus Corp.*, 2023 U.S. App. LEXIS 21842 (Fed. Cir. Aug. 21, 2023), *cert. denied*, 2024 U.S. LEXIS 1485 (April 1, 2024). The patent taught that a human was typically required to manually program machines used for manufacturing a component from a CAD model. “The patent’s proposed solution to improve efficiency and accuracy, ... is to ***remove the human operator*** ... and instead ***automatically*** extract and transfer information from the design model to the manufacturing machine.” *Id.* at *2-3. The claim thus was

directed to an “apparatus for automatic manufacture of an object” from a CAD model. Notably, the claim required a machine automatically manufacturing a component from computer-generated dimensions and parameters. *Id.*

The Court found the claim patent-ineligible. *Id.* at *6. “[T]he focus of the claimed advance ... is **automating** a previously manual process of transferring information from a CAD design model to a manufacturing machine” which is “not sufficient for patent eligibility.” *Id.* at *7-8. And, just like the automated pump control here, the “generic manufacturing machine that manufactures the component based on received data is no different than the conventional machine and ... is **merely post-solution activity**.” *Id.* at *16.

The ID identifies *Automation Middleware Solutions v. Invensys Sys.*, 737 F. App’x 1005 (Fed. Cir. 2018). ID, 21. The Court affirmed a finding that method claims directed to moving an object via a motion control device were invalid. *Automation Middleware Solutions v. Invensys Sys.*, 2017 U.S. Dist. 23266, *20-32 (E.D. Tex. 2017). The claims are like those here because they required generating a “control command” and “operating [a] ... motion control device in accordance with the control command to move the object.” *Id.* at *26-27. That is akin to claim 1’s steps of selecting a “system model” and “controlling” a fracturing pump based on the model.

Alice Step Two. The claims do not survive step two because the limitations were well-known and conventional. *See* pp. 1-13 *supra*. PO’s reliance on step one is misplaced because SRTs and mini-frac tests were conventionally used for years and disclose steps one and two. PO’s emphasis on step three’s requirement that the system model is selected based on the sensor response data **and** the sequence of stimuli is rebutted by the myriad art showing that models are selected exactly this way. *See* pp. 6-10. And having computer systems control fracturing pumps was likewise well-known and conventional. *See* pp. 10-13; *Chamberlain*, 935 F.3d at 1349 (finding limitations were “well-understood, routine and conventional” and not directed to ‘inventive concepts”).

The PTO Guidance. PO argues that petitioners did not sufficiently address Guidance step 2A Prong 2, but the Guidance does not control. *cxLoyalty*, 986 F.3d at 1375, n. 1; *In re Rudy*, 956 F.3d 1379, 1382 (Fed. Cir. 2020) (the Guidance “is not, itself, the law of patent eligibility, does not carry the force of law, and is not binding on our patent eligibility analysis”); *In re Abel*, 838 F. App’x 558, 561 (Fed. Cir. Jan. 7, 2021) (same). It is confirmed in the Guidance that it “does not constitute substantive rulemaking and does not have the force and effect of law....” 2019 Revised Patent Subject Matter Eligibility Guidance, Fed. Reg. Vol. 84, No. 4 (Jan. 7, 2019).

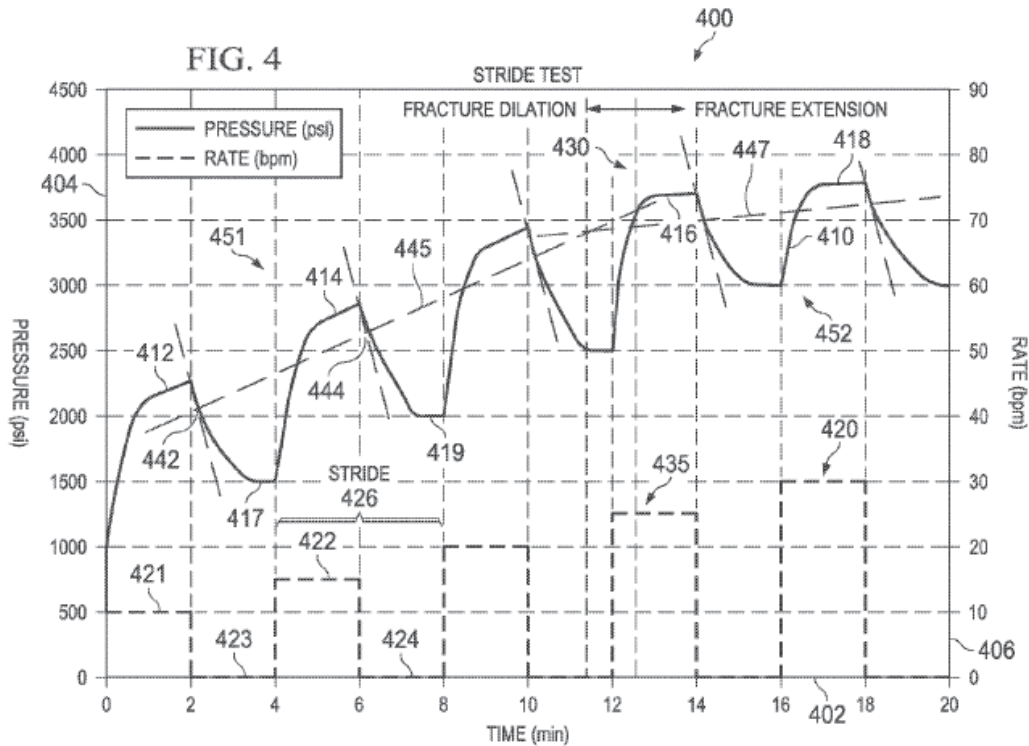
Regardless, Step 2A, Prong 2 does not save PO. The limitations do not improve computer performance, nor do they improve another technical field because the limitations were well-known and used in their conventional manner. *Ex Parte Fung*, 2019 Pat. App. LEXIS 3189, *31 (PTAB May 1, 2019). Rather, the limitations “merely (1) apply the abstract idea on a computer; (2) include instructions to implement the abstract idea on a computer; or (3) use the computer as a tool to perform the abstract idea.” *Id.* (citing Guidance). The limitations are ancillary to the claim’s automation focus, and the outcome—controlling a fracturing pump—is “insignificant post-solution activity and, therefore, does not integrate the exception into a practical application.” *Id.* at *33; *Ex Parte Allen*, 2022 Pat. App. LEXIS 2811, *16 (PTAB May 26, 2022) (finding the relevant limitations did not “apply the abstract idea in a meaningful way beyond linking its use to a particular technological environment”) (citing Guidance).

The Dependent Claims. PO does not raise separate arguments for claims 3, 6-8, 11, 14-15, 18, and 20; they therefore stand or fall with claim 1.

Claims 2, 10, 17 add that the system model is retrieved “from a data store” based on the response data. A “data store” is merely computer memory. EX-1001 [7:19-21]. The references discussed herein confirm that retrieving models from memory “based on” sensor data was known and conventional. *See* pp. 6-10; EX-1050, ¶¶39-43 (collecting prior art).

Claims 4, 12, 19 require determining a linear or non-linear relationship between the sequence of stimuli and response data and updating the linear or non-linear relationship based on multiple iterations of the sequence of stimuli.

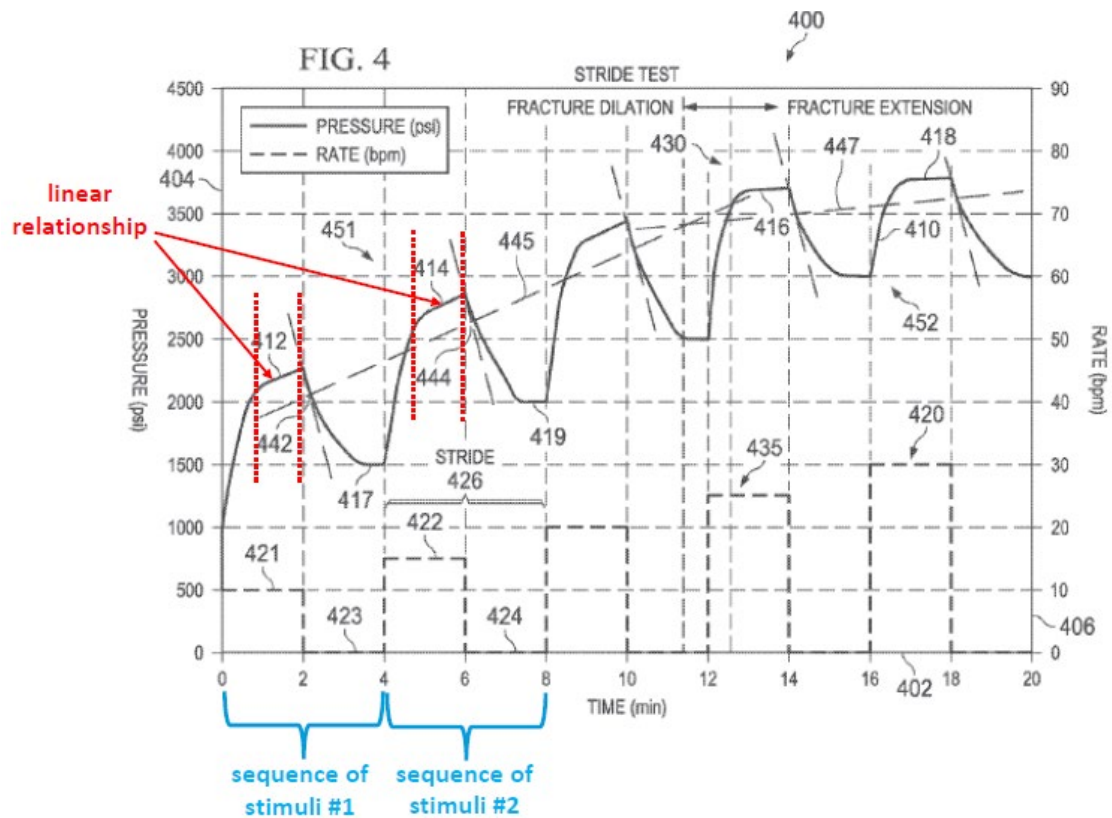
This is what SRTs do. EX-1050, ¶¶44-48. Injection tests plot the relationship between pump rate(s) and the measured pressure, and repeatedly update the relationship based on multiple changes (“iterations”) of the pump rate. EX-1038 [Abstract] (“[R]esponse data from an injection test ... are received.... [T]he response data are acquired during a *series* of injection periods.”); [0053] (“[T]he control subsystem 312 can interact with the monitoring subsystem 314 to *control the injection test based on the formation response* obtained from the monitoring subsystem 314”); [0055]; [0056]; [0063] (“FIG. 4 is a plot illustrating the injection rate 420 and a pressure response 410 of an example injection test.”):



EX-1038, Fig. 4

EX-1038 explains that the injection test “includes a *succession* of injection periods (e.g., injection periods 421 and 422) and shut-in intervals (e.g., shut-in intervals 423 and 424)” *Id.* [0064]; [0065]; [0066] (“the injection rate 420 is increased over time across different injection periods”). Moreover, “each injection period may last at least to a point where the pressure curve 410 *reaches a steady slope* such as the constant slope at 412 and 414.” [0067]; *see* [0071]; [0073]; [0075]; [0077]; [0080]; [0088] (“[T]he injection rate and the duration of each injection period *can be controlled such that the pressure reaches a stabilized slope* such as the constant slopes 412 and 414”); [0089]-[0090].

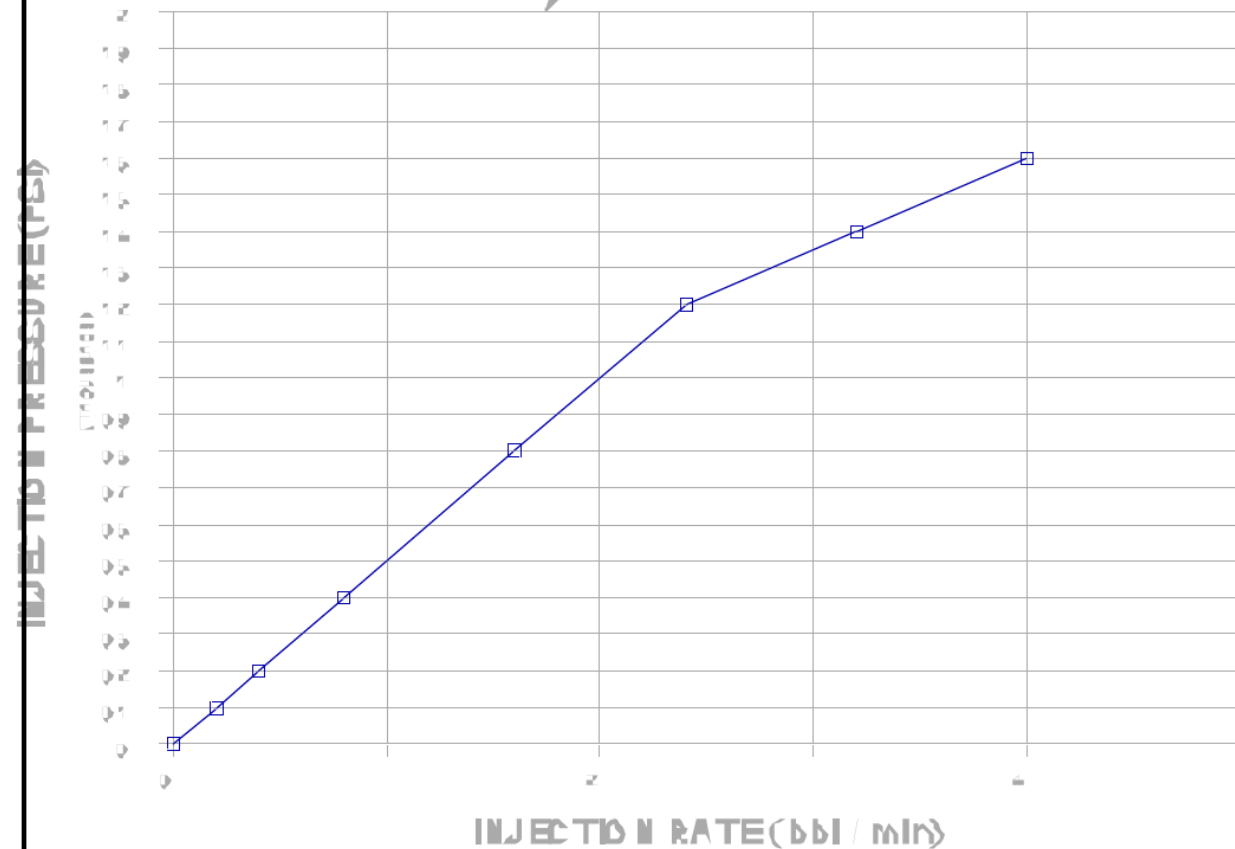
EX-1038 therefore shows and describes these claims. *See* EX-1050, ¶46:



EX-1038, Fig. 4 (annotated)

This was industry standard for years, as EX-1033 also proves:

Plot the injection rates and the corresponding stabilized pressure values. These are graphically represented as a constant slope straight line to a point at which the formation fracture, or breakdown pressure is exceeded. The slope of this subsequent straight line should be less than that of the before-fracture straight line (see example).



EX-1033.002, .006.

Other prior art also teaches this. *See* EX-1043, [9:39-54, Figure 4A] (showing and describing a non-linear relationship between pressure and pump rate across an injection test); *see* EX-1050, ¶14 (discussing EX-1043). Thus, these claims are also directed to known and conventional technology.

Claim 5, 13 require that sensor data is used to “determine changes in flow distribution in response to a diverter drop, the changes in flow distribution used to determine” the system model. This too was conventional. EX-1050, ¶¶49-53.

Using diverters to change flow distribution is the conventional use of diverters. EX-1024 [1:31-33] (explaining that diverters will “divert the flow of well treatment fluids (e.g., injection fluids) from perforations taking more fluid to perforations taking less fluid”); EX-1046.001 (“The diversion process is used to help ensure that stimulation fluids are distributed across the entire interval to be treated....”); *see* EX-1046.002; EX-1045 [0013] (“[D]iverters are introduced into the frac fluid entering the wellbore.... to obstruct and temporarily seal [the perforations], thereby causing frac fluid to flow toward the remaining ones of the ... perforations not being obstructed....”). *See* figs. 4-6:

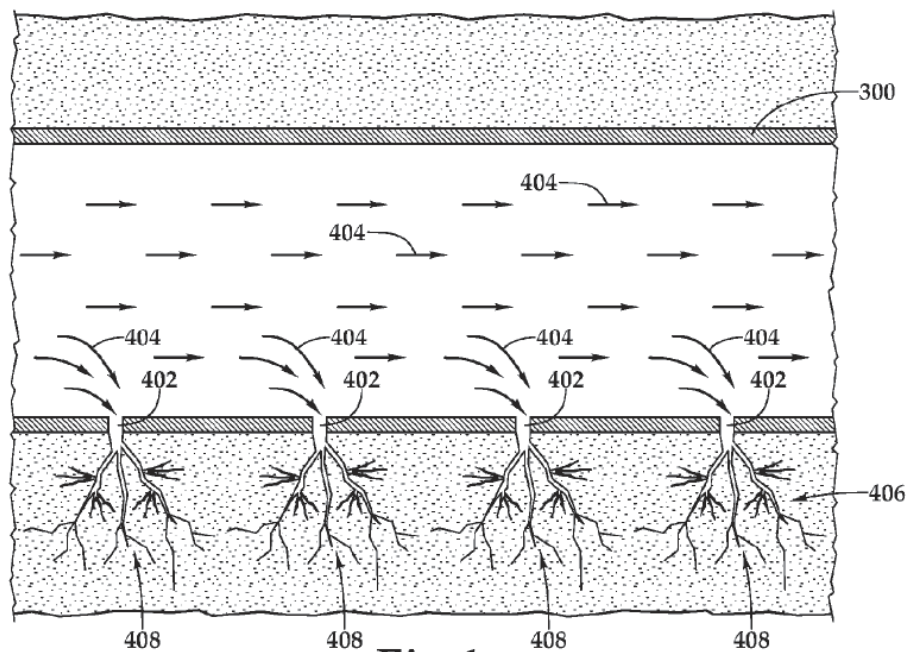
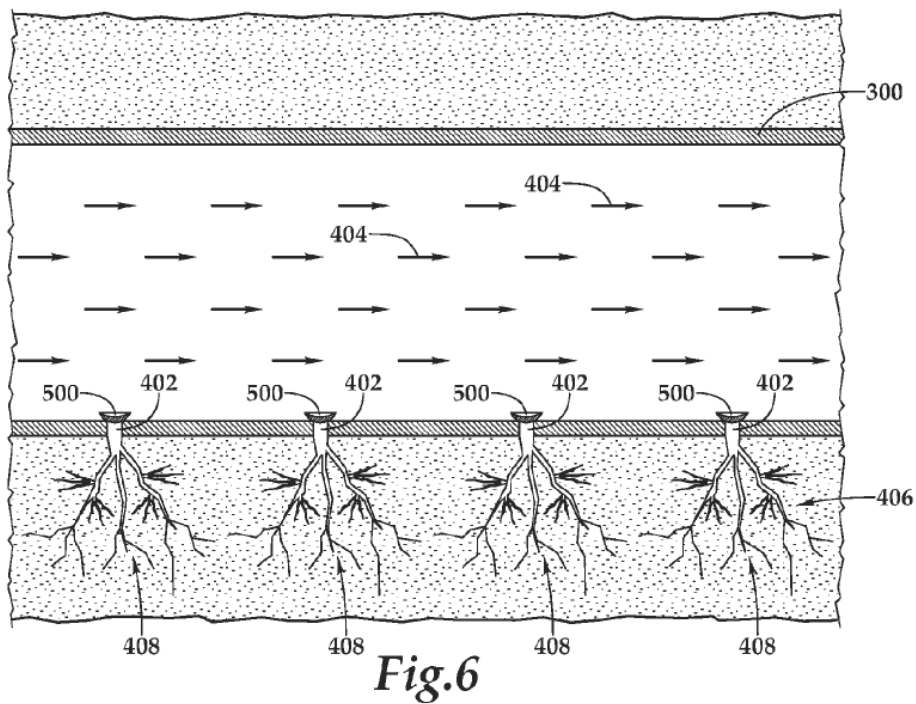
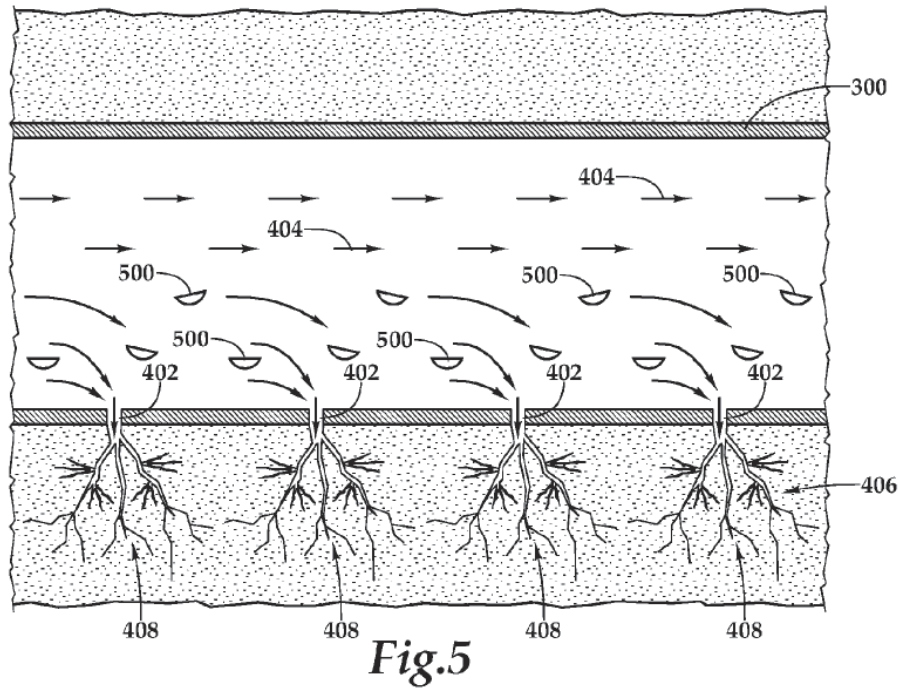


Fig.4



EX-1045, Figs. 4-6

“FIG. 4 shows multiple perforations 402.... The pressurized frac fluid flows into the perforations ... as shown by directional lines 404.” EX-1045 [0041]. “In

FIG. 5 ... diverters 500 ... are shown ... being moved toward perforations 402 by the flow of the frac fluid....” *Id.*, [0042]. “In FIG. 6, the ... diverters are shown seated on the [perforation] openings ... thus temporarily sealing the perforations against substantial frac fluid flow.... The high pressure of the frac fluid within the wellbore pushes against the seated diverters with sufficient force to keep them in place *while the frac fluid flows past them....*” *Id.*

It was also commonplace to measure the pressure response to diverters. EX-1046.016 (“[M]onitoring of the treatment is critical for real-time optimization of the diversion process.... [T]he ... *most common way to monitor diversion effectiveness* is to evaluate the pressure responses during pumping....”); *id.*, .017; *id.*, .018 (showing in Fig. 17 estimating diverter effectiveness by looking for an “increase in net pressure from the beginning to the end of the stimulation treatment.”).

It was also conventional to use diverters in injection tests, and, as explained above, use the measured response from the injection tests (including with diverters) as part of selecting a system model. *See* pp. 1-10; EX-1038 [0067] (“During each injection period, ... diverters can be used to test and determine the subterranean response....”); [0054]-[0056]; [0077]; [0082]-[0083]; [0086]; [0088]-[0089]; [0091]; Fig. 6.

None of the dependent claims add anything other than “trivial variations” of the abstract idea. *Trinity Info Media v. Covalent, Inc.*, 72 F.4th 1355, 1362 (Fed. Cir. 2023). All claims are invalid under § 101.

B. GROUNDS 1-4: 35 U.S.C. § 103

1. Pankaj-Payne Render Step One Obvious

The Board correctly noted the petition showed that Pankaj’s step 1172 describes “stimulating the formation around each wellbore” and, during such stimulation, the “injection may be manipulated by adjusting the material being injected and/or the way it is injected. . .” ID, 10 *citing* Petition, 41-42. PO admits as much. POR, 62 (“Pankaj “start[s] the fracturing process and mak[es] adjustments based on how the fracturing process is proceeding.”); EX-1049, 50:3-53:14; 60:3-61:13; 72:4-8. Pankaj further discloses optimizing fracturing parameters, *see* Petition, 51 *citing* EX-1005, [0141]; *id.*, [0061] (describing the injection manipulation).

Pankaj therefore satisfies step one by changing these fracturing parameters (including pump rates) over time. That is consistent with the 058’s description of a “sequence of stimuli.” EX-1001, 3:29-31 (“[S]timuli may be modified over a span of time as part of a sequence of stimuli.”).

PO argues an incorrect claim construction, asserting that the claims require a sequence of stimuli be generated “before it is applied.” POR, 61. PO’s construction

is predicated on intended use language (i.e., for application to a well environment), which should be given no patentable weight. *Bristol Myers Squibb Co. v. Ben Venue Labs., Inc.*, 246 F.3d 1368, 1376 (Fed. Cir. 2001) (certain claim language was properly understood as “only a statement of purpose and intended result” and thus not limiting); *Catalina Mktg. Int’l, Inc. v. Coolsavings.com, Inc.*, 289 F.3d 801, 810 (Fed. Cir. 2002) (“[T]he applicants did not rely on this intended use to distinguish their invention over the prior art . . . [so the] language does not limit Claim 1”).

Moreover, the claims do not include any temporal requirement. *See Apple Inc. v. Fintiv, Inc.*, IPR2022-00976, Paper 27 at 18-19 (PTAB Nov. 8, 2023) (declining to import a temporal requirement in construing claim term). And the specification confirms the portions PO cites disclose illustrative, not limiting, embodiments. EX-1001 [11:39-42]; *Hill-Rom Servs. v. Stryker Corp.*, 755 F.3d 1367, 1371 (Fed. Cir. 2014) (declining to “read limitations from the embodiments in the specification into the claims.”). The Board should reject PO’s unduly narrow construction.

Regardless, Pankaj discloses, or at least renders obvious, step one even under PO’s construction. EX-1050, ¶¶61-63. Pankaj teaches that as the “fracturing fluid pumping treatment continues for some duration . . . the fluid and proppant flow in the fractures is determined from simulation on the collected wellsite

information. The *sequence of increasing the proppant concentration* on the surface is also a parameter that may be recorded while pumping.” EX-1005 [0104].

Table 1 shows a “pumping schedule” as input for the simulator:

TABLE I

Pump rate (bbl/min)/ (kL/min)	Fluid name	Fluid volume (gal)/(kL)	Proppant	Proppant concentration (PPA)
90/(14.3)	Fracturing fluid	20000 (75.7)	None	0
90/(14.3)	Fracturing fluid	15000 (56.8)	Proppant type 1	0.5
90/(14.3)	Fracturing fluid	15000 (56.8)	Proppant type 1	1
90/(14.3)	Fracturing fluid	15000 (56.8)	Proppant type 2	1.5
90/(14.3)	Fracturing fluid	15000 (56.8)	Proppant type 3	2
90/(14.3)	Fracturing fluid	15000 (56.8)	Proppant type 4	2.5
90/(14.3)	Fracturing fluid	10000 (37.9)	Proppant type 5	3
90/(14.3)	Fracturing fluid	10000 (37.9)	Proppant type 6	3.5
90/(14.3)	Fracturing fluid	5000 (18.9)	Proppant type 7	4

EX-1005, Table I

A POSITA would have understood that Table 1 shows a “predetermined” pumping schedule that meets step one even if PO’s construction were accepted. The proppant concentration, which reads on a sequence of stimuli comprising a “particulate concentration,” is varied over time. EX-1050, ¶62. While Table I refers to an “input for the simulator,” a POSITA would have understood that Table

I would also be used to apply to the well. As explained above, step-rate tests and mini-frac tests were commonplace in the industry and were applied to wells, and a POSITA would have understood that Table I is an example of such a test. EX-1050, ¶63; *see* EX-1049, 58:13-59:18 (PO’s expert testifying that Table I may be interpreted as “probably for injection application to the well environment”).

2. Pankaj-Payne Render Step Three Obvious

Pankaj selects a model based on wellsite data (“*the received formation response data*”), reservoir parameters, and fracture parameters (“*sequence of stimuli*”). Petition, 45-47. Pankaj explains that the “generating [step] 1176” “involve[s] modeling fracture parameters,” EX-1005 [0103], which include pump rate, proppant, and injection fluid parameters, EX-1005 [0100], from a “wellsite data collection” [0105]. Pankaj also describes varying fracture parameters over time. EX-1005 [0104]; [0061]. The Board correctly noted that the petition’s explanation of the selection of a representative model refers to this teaching of manipulating fracture parameters. ID, 12 *citing* EX-1005, [0061]; *see* Petition, 47. After updating those parameters, the fracture and reservoir parameters are integrated into the model in step 1178, thus making it the “*selected representative model.*” Petition, 48 *citing* EX-1005 [0126] (“The integrating may involve selecting aspects from the fracture parameters....”).

PO's rebuttal argument is based on another incorrect claim construction—requiring the claimed model be selected from a number or group of models. POR, 65. PO again reads in limitations from the specification. *Id.*; *Hill-Rom*, 755 F.3d at 1371-1372. The claims do not require selecting the models from multiple predetermined ones.⁷ Pankaj discloses selecting fracturing parameters that are integrated into a model to best represent a well. EX-1005 [0126]. Determining fracturing parameters for a model satisfies the “*selection of a representative model.*”

PO also argues that Pankaj's selection is not “*based on received formation data and sequence of stimuli data.*” POR, 66-68. But Pankaj selects a “*representative model*” by integrating fracture parameters into models, such as an Unconventional Fracture Model (“UFM”), that are modeled from wellsite data. *See* Petition, 45-48. PO's arguments misstate Pankaj's disclosure that its fracturing parameters refer only to down-hole measurements. POR, 67 *citing* EX-1005

⁷ Even if the claims have such a requirement, the petition explains the claim would have been obvious. For example, Pankaj's models are “built-in,” *see* Petition, 53-54, showing that the models are predetermined.

[0105]. Thus, Pankaj selects a model based on both fracture parameters (“*sequence of stimuli*”) and wellsite data (“*the received formation response data*”).

3. Pankaj-Payne Render Step Four Obvious

Pankaj discloses, in step 1182, that the method “optimize[s]” “fracturing treatment parameters,” thereby controlling a fracturing pump. Petition, 51 *citing* EX-1005 [0141]. Despite noting that the petition both cites and quotes language from three paragraphs in Pankaj, PO does not address this language.

Rather, PO’s arguments are based on a misstatement by Dr. Nikolaou during his deposition. Dr. Nikolaou addresses this in his supplemental declaration and explains the error. EX-1050, ¶¶54-59. Ultimately, what matters is what Pankaj discloses.

Moreover, Pankaj confirms this limitation is met. Pankaj explains that fracturing “is performed by pumping fluid into the formation using a pump system 329.” EX-1005 [0055]; Fig. 3.1; [0015]. Pump system 329 pumps fracturing fluid into the well. *Id.* [0056]. Pankaj teaches that a “computerized control system may be employed to direct the entire pump system 329 during the fracturing operation,” [0058], which a POSITA would have understood to mean includes using the computer system to control the pumps, e.g. without human intervention. EX-1050, ¶60. PO’s expert agreed. EX-1049, 64:7-65:9.

4. Claims 2, 10, 17

In Pankaj, the model is provided (“*retrieved*”) based on wellsite data (“*received formation response data*”). Petition, 53; *id.*, 47 *citing* EX-1005 [0099], [0105] (describing a UFM as being modeled from wellsite data). The model may be “built-in,” Petition, 53-54, which a POSITA would have understood means stored in a data store (computer memory). EX-1003, ¶¶101-103; EX-1050, ¶¶40-43.

PO mischaracterizes the petition in stating that Pankaj’s updated mechanical earth model is selected based solely on integrating fracture parameters. Pankaj’s MEM is selected based on wellsite data (“*received formation data*”), which PO never addresses. *See* Petition, 45-47. Moreover, petitioners explained how Pankaj’s built-in MEMs are selected based on wellsite data from a data store. Petition, 53-54, *citing* EX-1003, ¶¶101-102.

5. Claims 4, 12, 19

The petition identifies five linear equations used by Pankaj’s models (UFMs) to satisfy the relationships in these claims. *See* Petition, 57; EX-1005, [0106] (“[E]quations governing the underlying physics of the fracture process may

be used.”). The petition further identifies these equations⁸ as showing the relationship between the input q (flow rate) (“*sequence of stimuli*”) and outputs (“*formation response data*”). Petition, 57-58; EX-1005 [0106], [0104] (showing flow rate is calculated from pump rate, which adjusts over time). Pankaj discloses a feedback control system—fracture parameters are updated by using such UFM’s and their equations, and the models are then recalibrated with the updated parameters. Petition, 59 *citing* EX-1005 [0076] (“[T]he treatment data (e.g., treatment pressure, proppant concentration, [and] pumping rates ...) can be used to re-calibrate the stimulation design model by matching the observed parameters against the predicted parameters from the simulation run. The matching exercise may require. . . changing the fracture design parameters and fluid properties.”); [0104], [0141] (optimizing fracture treatment parameters based on updated model). Thus, Pankaj discloses these claims.

⁸ The Petition alternatively identified using non-linear relationships—e.g., damped Newton-Raphson method—as well. Petition, 58 *citing* EX-1005 [0111] (describing a nonlinear system of equations in terms of fluid pressure).

PO's contrary arguments fail. First, PO disputes that Pankaj's equations are linear, but PO's expert concedes that an equation that is not linear is a non-linear equation and thus falls within the claim language. EX-1049, 70:7-71:14.

PO next argues that Pankaj's equations do not make the requisite determination "between the sequence of stimuli and received formation response data." POR, 75-76. But these equations define (or "*determine*") the relationship between a flow rate ("*sequence of stimuli*") and wellsite data ("*formation response data*"), EX-1005 [0105]-[0106], and use these equations to update/optimize parameters (e.g., pump rate) which are then fed back into the equations to recalibrate the system, *id.*, [0076], [0078], [0141]. PO does not dispute that these equations include "*formation response data*." POR, 75-76. Thus, Pankaj discloses equations that define the claimed "*relationship*" between the "*sequence of stimuli*" and "*formation response data*."

PO also argues that the petition's explanation for Pankaj teaching the "updating" step is insufficient. POR, 76-77. But Pankaj explains that step 1182 includes optimizing fracture treatment parameters. EX-1005, [0141]; *see* Petition, 58-59. Based on the updated representative model, Pankaj selects new fracture parameters which are used to recalibrate the representative model. EX-1005 [0076]. Pankaj's fracture design parameters are changed until they are optimized. EX-1005 [0078]. This feedback system is depicted in Figure 4.2, showing such

changes—that is, a loop of multiple iterations that tries to match the observed parameters against the predicted parameters from the simulation run. EX-1005 [0076]. Pankaj’s optimization of fracture parameters (“*generated sequence of stimuli*”) includes changing those parameters at different stages (“*updating. . . based on multiple iterations*”) until those parameters are optimized. *See* EX-1005 [0076], [0078], [0141].

6. Claims 5, 13

Pankaj measures changes in flow distribution and uses such changes to determine a representative model. Petition, 64. While Pankaj does not disclose that these changes are “*in response to a diverter drop,*” such changes would have been obvious over Dawson (EX-1024), which PO admits is “directed to a system for determining an effectiveness of a diverter.” POR, 78. The Pankaj-Payne-Dawson combination thus renders obvious these claims. Petition, 63-68.

PO argues that a POSITA would not combine the references because Pankaj never mentions a diverter. POR, 78-79. That is not the law. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 415 (2007) (reversing test requiring an express teaching, suggestion, or motivation to modify a reference). Rather, it is the combined teachings of both references that is relevant. *Id.* at 416-17. Dawson teaches the benefits of using a diverter in well-site operations. PO does not dispute that diverters could be used in Pankaj’s fracturing operation. Whether Pankaj

mentions a diverter is irrelevant to whether incorporating a diverter's effectiveness in the combined Payne-Pankaj system was obvious, especially given that PO admits Dawson "determin[es] an effectiveness of a diverter," which is a well-known feature commonly used in fracturing operations.

III. CONCLUSION

Petitioners respectfully request that the Board cancel all challenged claims.

Date: May 10, 2024

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CERTIFICATE OF COMPLIANCE

The undersigned certifies that this Brief complies with the word-count limitations of 37 C.F.R. § 42.24(a)(1)(ii). This Brief contains 5,591 words as calculated by the Word Count feature of Microsoft Word, the word processing program used to create it.

The undersigned further certifies that this Brief complies with the typeface requirements of 37 C.F.R. § 42.6(a)(2)(ii) and typestyle requirements of 37 C.F.R. § 42.6(a)(2)(iii). This Brief has been prepared in a proportionally spaced typeface using Microsoft Word in Times New Roman 14-point font.

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CERTIFICATE OF SERVICE

Pursuant to 37 C.F.R. § 42.205 and § 42.6(e), the undersigned certifies that on May 10, 2023, a complete and entire copy of this Reply Brief and all new supporting exhibits were served on Patent Owner's counsel of record as follows:

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