

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.

Case No. PGR2023-00023
Patent No. 11,373,058 B2

DECLARATION OF DR. ROBERT A. DURHAM

TABLE OF CONTENTS

I.	INTRODUCTION.....	6
II.	EXPERIENCE AND QUALIFICATIONS.....	6
III.	TASK SUMMARY AND MATERIALS REVIEWED	11
IV.	LIST OF EXHIBITS.....	11
V.	CHALLENGED CLAIMS	15
VI.	LEGAL STANDARDS	16
	A. Level of Ordinary Skill in the Art.....	16
	B. Legal Standard for Claim Construction	17
	C. Obviousness	19
	D. Subject Matter Eligibility.....	22
VII.	OVERVIEW OF THE CHALLENGED PATENT	24
	A. The Subject Matter of the '058 Patent	24
	B. Prosecution History.....	32
	C. Level of Ordinary Skill in the Art.....	33
	D. The Challenged Claims of the '058 Patent	34
VIII.	OVERVIEW OF THE PRIOR ART.....	39
	A. <i>Pankaj</i> (Ex. 1005)	39
	a. Status of <i>Pankaj</i>	39
	b. Overview of the Disclosure of <i>Pankaj</i>	39
	B. <i>Payne</i> (Ex. 1006).....	43
	a. Status of <i>Payne</i>	43
	b. Overview of the Disclosure of <i>Payne</i>	43
	C. <i>Dawson</i> (Ex. 1024)	44
	a. Status of <i>Dawson</i>	44
	b. Overview of the Disclosure of <i>Dawson</i>	45
IX.	GROUND 1: Claims 1-4, 6-7, 9-12, 14, & 16-19.....	46
	A. Independent Claim 1	46
	a. Claim 1[A]: “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;”	46
b. Claim 1[C]: “selecting a representative system model based on the received formation response data and sequence of stimuli; and”	50
c. Claim 1[D]: “controlling an electrical fracturing pump based on the representative system model.”	59
B. Independent Claim 9	64
a. 9[C]: “generate 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;”	65
b. 9[E]: “select a representative system model based on the received formation response data and sequence of stimuli; and”	65
c. 9[F]: “control an electrical fracturing pump based on the representative system model.”	65
C. Independent Claim 16	66
a. 16[A]: “generate 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;”	66
b. 16[C]: “select a representative system model based on the received formation response data and sequence of stimuli; and”	66
c. 16[D]: “control an electrical fracturing pump based on the representative system model.”	67
D. Dependent Claims 2 ,10, 17	67
a. Claim 2: “2. The method of claim 1, wherein the representative system model is retrieved from a data store based on the received formation response data.”	67
b. Claim 10: “10. The system of claim 9, wherein the representative system model is retrieved from a data store based the received formation response data.”	70
c. Claim 17: “17. The non-transitory computer readable medium of claim 16, wherein the representative system model is	

retrieved from a data store based the received formation response data.	70
E. Dependent Claims 3, 11, 18.....	71
F. Dependent Claims 4, 12, 19.....	71
a. Claim 4[pre]: “The method of claim 1, wherein selecting the representative system model further comprises:”	71
b. 4[A]: “determining one of a linear or a non-linear relationship between the sequence of stimuli and received formation response data; and”	72
c. 4[B]: “updating the one of the linear or the non-linear relationship based on multiple iterations of the generated sequence of stimuli.”	77
G. Dependent Claim 6: “The method of claim 1, wherein the one or more downhole sensors or surface sensors comprises one or more of a single-point electrical sensors, an optical sensor, or a fiber optic sensor.”	79
H. Dependent Claims 7, 14.....	80
a. Claim 7: “The method of claim 1, wherein the formation response data comprises measurements of one or more of pressure, temperature, flow, dynamic strain, static strain, acoustic intensity, resistivity, or electromagnetic signals or frequency, amplitude or phase of any of the electromagnetic signals.”	80
X. Ground 2: Claims 5, 6, and 13 are not obvious over <i>Pankaj</i> in view of <i>Payne</i>, further in view of <i>Dawson</i>	80
A. Motivation to Combine	81
XI. Ground 3: Claims 8, 15, and 20 are not obvious over <i>Pankaj</i> in view of <i>Payne</i>, further in view of <i>Lecerf</i>.....	84
A. Claim 8: “The method of claim 1, wherein the representative system model predicts a proxy value comprising one or more of a cluster efficiency, a complexity factor, or a proximity index, and the predicted proxy value is used to control one or more of a uniform flow across perforation clusters, a formation complexity, or interference in a neighboring well.	84

XII. Ground 4: Claims 3, 11, and 18 are not obvious over <i>Pankaj</i> in view of <i>Payne</i> further in view of <i>Klumpen</i>	84
XIII. Ground 5: The Claimed Techniques Were Not Well Understood, Routine, or Conventional.....	85
A. The '058 Patent Improves on the Prior Art.....	85
B. The Independent Claims Recite More Than Well-Understood, Routine, and Conventional Activity	87
C. The Dependent Claims Recite More Than Well-Understood, Routine, and Conventional Activity	91
a. Dependent Claims 2, 10 and 17	91
b. Dependent Claims 4, 12 and 19	92
c. Dependent Claims 5 and 13	93
XIV. SECONDARY CONSIDERATIONS.....	93
XV. CONCLUSION.....	94

I. INTRODUCTION

1. My name is Dr. Robert A. Durham. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

2. I have been asked to provide technical assistance in the post-grant review of U.S. Patent No. 11,373,058, which I may abbreviate as “the ’058 Patent” or refer to as the “Challenged Patent.” This declaration is a statement of my opinions on issues related to the alleged unpatentability of claims of the ’058 Patent. I am being compensated at my normal hourly rate of \$305 per hour for my analysis, plus reimbursement for expenses. My compensation does not depend on the content of my opinions or the outcome of this proceeding.

II. EXPERIENCE AND QUALIFICATIONS

3. In formulating my opinions, I have relied upon my knowledge, training, and experience in the relevant art. My qualifications are stated more fully in my curriculum vitae, which has been provided as Appendix A. My CV also lists publications on which I am a named author and identifies parties on behalf of whom I have previously provided expert testimony within the past four years. Here, I provide a brief summary of my qualifications.

4. I am a consulting engineer with experience in a number of technical areas. I have expertise in the electrification of the oil and gas industry from drilling and

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

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

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

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

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

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

9. After a brief stint as Vice President for EDG Power Group, responsible for Engineering and Project Management of generation and co-generation facilities across the U.S., I transitioned to the role of consulting engineer. In that role I have served as consulting engineer relating to the design, construction, and analysis of all kinds of power systems, especially those in the oil and gas industry. This has included not only design and selection of equipment but also analysis of failures of equipment in the oil and gas field from drilling / completion sites to production facilities, midstream and downstream (refinery) locations.

10. In addition, I am a principal of PEDOCS, Inc., an oil and gas production company operating over 50 oil and gas production wells in Oklahoma. As such, I am familiar with operations of oil and gas wells including well stimulation, completion, hydraulic fracturing and production.

11. I have been familiar with oil and gas drilling, fracturing (fracking) and completion operations for nearly twenty years. In addition to being responsible for interfacing with drilling and fracturing operations with regards to electrical needs as an employee of New Dominion, LLC, I have been further educated about drilling, fracturing and operations as I have consulted and investigated incidents on multiple well drilling, fracturing and completion pad sites over my engineering consulting engagements.

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

13. I have been familiar with models and modeling in many arenas including system models, production models and control models. I have developed and used models for calculations, predictions as well as control systems, including models designed for process control in applications including water handling, steam handling, liquid oil handling and natural gas handling. I have studied the operation of models and control systems for over 30 years.

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

15. Therefore, based on my education, professional experience of over 30 years, and scholarly books and publications, I am an expert in the relevant field of

the '058 Patent at issue here and have been an expert in this field since before the '058 Patent was filed with the United States Patent and Trademark Office ("USPTO"). I am familiar with how a person having ordinary skill in the art would have understood and used the terminology found in the '058 Patent at the time of its filing.

III. TASK SUMMARY AND MATERIALS REVIEWED

16. I have been asked to review the '058 Patent and its prosecution history, to provide an understanding of the technology relevant to the '058 Patent, to review certain prior-art references that Petitioners allege render obvious various claims of the '058 Patent, and to analyze whether or not those references disclose or teach limitations of claims from the '058 Patent. The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art (POSITA).

IV. LIST OF EXHIBITS

17. In forming my opinions, I have reviewed the '058 Patent, its prosecution history and references cited by the Examiner, the materials cited in the List of Exhibits below, and the materials cited throughout my declaration.

Ex.	Description
1001	U.S. Patent No. 11,373,058 by Mikko Jaaskelainen <i>et al.</i> entitled "System and Method for Treatment Optimization" (the "'058 Patent")
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 <i>Pankaj et al.</i>
1006	U.S. Patent App. Pub. No. 2016/0258267 to <i>Payne 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>
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 <i>Klumpen 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
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
2001	Memorandum from Director Katherine K. Vidal on Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (June 21, 2022).

Declaration of Dr. Robert A. Durham
PGR of USP 11,373,058 B2

2002	U.S. District Courts – Federal Court Management Statistics (March 31, 2023) (W.D. Texas), available at https://www.uscourts.gov/sites/default/files/data_tables/fcms_na_distprofile0331.2023.pdf
2003	Dkt. 79, Agreed Amended Scheduling Order, <i>Halliburton Energy Servs., Inc. v. U.S. Well Servs., LLC</i> , No. 6:22-cv-00906-ADA-DTG (W.D. Tex. May 31, 2023)
2004	Dkt. 64, Order Setting <i>Markman</i> Hearing, <i>Halliburton Energy Servs., Inc. v. U.S. Well Servs., LLC</i> , No. 6:22-cv-00906-ADA-DTG (W.D. Tex. Mar. 27, 2023)
2005	Defendants’ Preliminary Invalidity Contentions, <i>Halliburton Energy Servs., Inc. v. U.S. Well Servs., LLC</i> , No. 6:22-cv-00906-ADA-DTG (W.D. Tex. Jan. 17, 2023)
2006	2019 Revised Subject Matter Eligibility Guidance, 84 Fed. Reg. 50 (Jan. 7, 2019)
2007	USPTO, <i>October 2019 Update: Subject Matter Eligibility</i> (Oct. 17, 2019), published at https://www.uspto.gov/sites/default/files/documents/peg_oct_2019_update.pdf
2008	USPTO, <i>Appendix 1 to the October 2019 Update: Subject Matter Eligibility Life Sciences & Data Processing Examples</i> (Oct. 17, 2019), available at https://www.uspto.gov/sites/default/files/documents/peg_oct_2019_app1.pdf
2009	Website Printout from the Internet Archive – <i>Hydraulic fracturing</i> , SCHLUMBERGER OILFIELD GLOSSARY (Jul. 11, 2018), https://web.archive.org/web/20180711054502/http://www.glossary.oilfield.slb.com/Terms/h/hydraulic_fracturing.aspx
2010	Website Printout from the Internet Archive – <i>Stimulation</i> , SCHLUMBERGER OILFIELD GLOSSARY (Jul. 9, 2018), https://web.archive.org/web/20180703103747/http://glossary.oilfield.slb.com/en/Terms/s/stimulation.aspx

2011	Excerpts (pdf) of <i>Sequence</i> , NEW OXFORD AMERICAN DICTIONARY (3d ed. 2010).
2012	Excerpts (pdf) of <i>Sequence</i> , AMERICAN HERITAGE DICTIONARY OF THE ENGLISH LANGUAGE (5th ed. 2016).
2014	Transcript of Deposition of Dr. Michael Nikolaou (January 10, 2024)
2016	Excerpts (pdf) of <i>Select</i> , MERRIAM-WEBSTER'S COLLEGIATE DICTIONARY (11th ed. 2014).
2017	Excerpts (pdf) of <i>Select</i> , THE AMERICAN HERITAGE DICTIONARY OF THE ENGLISH LANGUAGE (5th ed. 2016).
2018	Cambridge Dictionary, "Linear Equation," available at https://dictionary.cambridge.org/dictionary/english/linear-equation (last visited February 12, 2024)
2019	Cambridge Dictionary, "Partial Differential Equation," available at https://dictionary.cambridge.org/dictionary/english/partial-differential-equation (last visited February 12, 2024)
2020	Cambridge Dictionary, "Integral," available at https://dictionary.cambridge.org/dictionary/english/integral (last visited February 12, 2024)

V. CHALLENGED CLAIMS

18. I have been informed that the Petitioners in the post-grant review, Profrac Holding Corporation and U.S. Well Services, LLC (collectively, "Petitioners") have claimed that certain claims of the '058 Patent are disclosed or rendered obvious by certain alleged prior art. Additionally, I understand that Petitioners allege that all claims of the '058 Patent are unpatentable as allegedly being directed to ineligible

subject matter. The following table lists the Challenged Claims and the grounds Petitioners have argued invalidate the claims.

Ground	Claims	Argument
1	1-4, 6-7, 9-12, 14, 16-19	Obvious over U.S. Patent App. Pub. No. 2018/0230782 (“ <i>Pankaj</i> ”) (Ex. 1005) in view of U.S. Patent App. Pub. No. 2016/0258267 (“ <i>Payne</i> ”) (Ex. 1006)
2	5, 6, 13	Obvious over <i>Pankaj</i> in view of <i>Payne</i> further in view of U.S. Patent No. 10,378,333 (“ <i>Dawson</i> ”) (Ex. 1024)
3	8, 15, 20	Obvious over <i>Pankaj</i> in view of <i>Payne</i> further in view of U.S. Patent No. 10,087,722 (“ <i>Lecerf</i> ”) (Ex. 1027)
4	3, 11, 18	Obvious over <i>Pankaj</i> in view of <i>Payne</i> further in view of U.S. Patent No. 8,352,227 (“ <i>Klumpen</i> ”) (Ex. 1019)
5	1-20	Ineligible Subject Matter

VI. LEGAL STANDARDS

A. LEVEL OF ORDINARY SKILL IN THE ART

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

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

B. LEGAL STANDARD FOR CLAIM CONSTRUCTION

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

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

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

24. I understand that to determine how a person of ordinary skill would understand a claim term, one should look to those sources available that show what a person of skill in the art would have understood the disputed claim language to mean. I understand that, in construing a claim term, one looks primarily to the intrinsic patent evidence, including the words of the claims themselves, the remainder of the patent, and the patent’s prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient.

25. I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else. In making this determination, the claims, the remainder of the patent, and the prosecution history are of paramount importance. Additionally, the patent and its prosecution history must be consulted to confirm whether the patentee has

acted as its own lexicographer (*i.e.*, provided its own special meaning to any disputed terms), or intentionally disclaimed, disavowed, or surrendered any claim scope.

26. In comparing the claims of the '058 Patent to the prior art, I have considered the '058 Patent and its file history in light of the understanding of a POSITA at the time of the alleged invention.

C. OBVIOUSNESS

27. I understand that the prior art may render a patent claim “obvious.” I understand that two or more prior art references (*e.g.*, prior art articles, patents, or publications) that each disclose fewer than all elements of a patent claim may nevertheless be combined to render a patent claim obvious if the combination of the prior art collectively discloses all elements of the claim and one of ordinary skill in the art at the time would have been motivated to combine the prior art in such a way. I understand that this motivation to combine need not be explicit in any of the prior art but may be inferred from the knowledge of one of ordinary skill in the art at the time the patent was filed. I also understand that one of ordinary skill in the art is not an automaton but is a person having ordinary creativity. I further understand that one or more prior art references, articles, patents or publications that disclose fewer than all of the elements of a patent claim may render a patent claim obvious if including the missing element would have been obvious to one of skill in the art (*e.g.*, the

missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system).

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

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

30. I understand that any evidence of secondary indicia of non-obviousness should be considered when evaluating whether a claimed invention would have been obvious to one of ordinary skill at the time of invention. These secondary indicia of non-obviousness may include, for example:

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

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

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

- the claimed subject matter is simply a combination of prior art elements according to known methods to yield predictable results;
- the claimed subject matter is a simple substitution of one known element for another to obtain predictable results;
- the claimed subject matter uses known techniques to improve similar devices or methods in the same way;
- the claimed subject matter applies a known technique to a known device or method that is ready for improvement to yield predictable results;
- the claimed subject matter would have been “obvious to try” choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- there is known work in one field of endeavor that may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to a POSITA;
- there existed at the time of the invention a known problem for which there was an obvious solution encompassed by the patent’s claims; and
- there is some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed subject matter.

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

D. SUBJECT MATTER ELIGIBILITY

34. I understand that whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to certain conditions and requirements. I understand that laws of nature, natural phenomena, and abstract ideas are not patent-eligible. I understand that a patent may be invalid for claiming subject matter that is ineligible for patent protection.

35. I understand that courts have developed a two-step test for determining whether a claim is directed to eligible subject matter. The first step is to determine if the claim is directed to a patent-ineligible concept, such as an abstract idea. I understand that at the first step of the eligibility analysis, the claim as a whole is considered in light of the specification to determine whether the character of the claim as a whole is directed to an abstract idea. I understand that this involves examining the patent's claimed advance to determine whether the claims are directed to an abstract idea. This can involve looking to the specification to understand the problem facing the inventor and, ultimately, what the patent describes as the

invention. I understand that claims should not be overgeneralized. I understand that if the claims are directed to a patent-eligible concept, and not an abstract idea, there is no need to proceed to the second step. I understand that if the focus of the claim is a specific and concrete technological advance, for example an improvement to a technological process or in the underlying operation of a machine, the inquiry ends and the claim is eligible.

36. I understand that if a claim is found to be directed to an abstract idea (or other judicial exception) at step one, the eligibility inquiry proceeds to the second step. I understand that the second step considers the elements of each claim both individually and as an ordered combination to determine whether the elements transform the nature of the claim into a patent-eligible application. I understand that the second step is often referred to as the search for an inventive concept. I understand that a claim recites an inventive concept when the claim limitations involve more than performance of well-understood, routine, and conventional activities previously known to the industry. I understand that the question of whether a claim element or combination of elements is well understood, routine, and conventional to a skilled artisan in the relevant field is a question of fact. I understand that whether a particular technology is well understood, routine, and conventional goes beyond what was simply known in the prior art. I understand that the mere fact

that something is disclosed in a piece of prior art, for example, does not mean that it is well understood, routine, and conventional.

VII. OVERVIEW OF THE CHALLENGED PATENT

37. I have reviewed the '058 Patent, which is entitled "System and Method for Treatment Optimization."¹ I understand that the application which led to the '058 Patent (U.S. Patent Application No. 16/573,448) was filed on September 17, 2019, and that it was issued on June 28, 2022.²

A. THE SUBJECT MATTER OF THE '058 PATENT

38. The '058 Patent discloses a treatment optimization system for improved control of electric fracturing pumps at a well location. The technique of the '058 Patent enables the selection of a representative system model that is a more accurate representation of the well being fractured. This more accurate representative system model is used "to control the electric frac pump" in a more effective manner.³

39. The '058 Patent recognizes that a representative system model "may be a static construct and may not accurately reflect the well to which it has been

¹ Ex. 1001, Cover.

² Ex. 1001, Cover.

³ Ex. 1001, Abstract.

deployed.”⁴ To combat this, the ’058 Patent “provides techniques for optimizing well treatments using representative system models selected according to formation responses to stimuli indicated by sensor data.”⁵ I have adopted the following description of the subject matter of the ’058 Patent from the Patent Owner’s Preliminary Response (“POPR”). The following description accurately describes the subject matter of the ’058 Patent.

40. The ’058 Patent, entitled “System and Method for Treatment Optimization,” was issued by the USPTO on June 28, 2022.⁶ As the title suggests, the ’058 Patent discloses “techniques for optimizing well treatments using representative system models selected according to formation responses to stimuli indicated by sensor data.”⁷ The patent explains that a representative system model may be used to, for example, determine pump settings of an electric fracturing pump.⁸ One problem with prior approaches to using representative system models during well treatment, however, is that “the representative system model may be a

⁴ Ex. 1001, 1:23-26.

⁵ Ex. 1001, 2:12-16.

⁶ Ex. 1001, Cover.

⁷ Ex. 1001, 2:12–15.

⁸ Ex. 1001, 1:19–23.

static construct and may not accurately reflect the well to which it has been deployed.”⁹ The techniques described and claimed in the ’058 Patent address this problem by generating a sequence of stimuli for application to a well environment in order to produce a response from the formation.¹⁰ Sensor data in response to the generated sequence of stimuli can then be received from sensors deployed throughout the well (e.g., surface sensors, downhole sensors, wireline sensors, etc.).¹¹ The stimuli and response combination “can be mapped to respective system models maintained in an accessible data store.”¹² The representative system model is then used to “control fracturing operations,” such as the settings on an electric fracturing pump.¹³

41. Figure 1B, reproduced below, illustrates a “diagrammatic view of a surface electric frac pump and environment,” according to various embodiments.¹⁴ Figure 1B depicts a “wellbore 155” that “extends from the surface 160 of the earth

⁹ Ex. 1001, 1:23–26.

¹⁰ Ex. 1001, 7:12–22.

¹¹ Ex. 1001, 7:12–22.

¹² Ex. 1001, 3:44–49.

¹³ Ex. 1001, 4:8–12, 8:45–49.

¹⁴ Ex. 1001, 1:46–48.

through the formation 165 formed by a drilling device from a previous drilling operation[.]”¹⁵ “A plurality of sensors 162 may be provided along the length of the wellbore to detect temperature, pressure, strain, vibration, or flow rate.”¹⁶ Pump equipment 172 (*i.e.*, electrical pumps) are used to pump a treatment fluid (*i.e.*, a combination of a carrier fluid and a proppant) through a line 192 into the entrance 185 of the wellbore 155 via fracturing tree 194.¹⁷

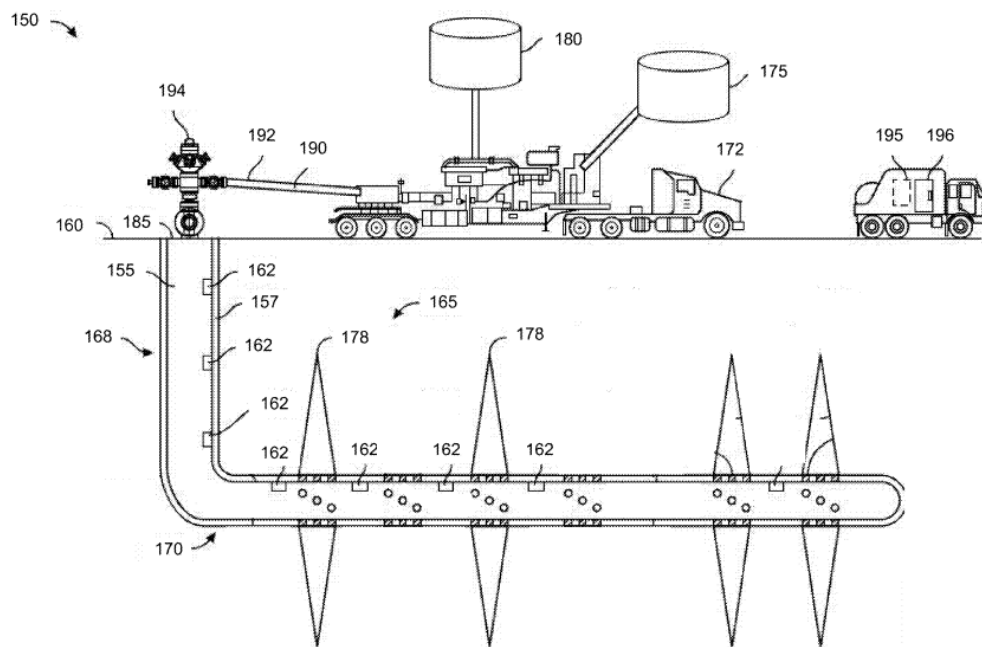


FIG. 1B

Ex. 1001, Fig. 1B.

¹⁵ Ex. 1001, 5:37–42.

¹⁶ Ex. 1001, 5:46–48.

¹⁷ See Ex. 1001, 5:52–66.

42. Figure 3 illustrates “a block diagram of an operating environment 300 in which a treatment optimization system 302 may be deployed.”¹⁸ The treatment optimization system 302 is communicatively coupled to a model store 304, an electric frac pump system 306, and well sensors 310 in well environment 308.¹⁹ Treatment optimization system 302 sends commands to electric frac pump system 306 (e.g., to adjust settings such as pressure levels, flow rates, composition and/or presence of proppant, diverter, or other chemicals within a pumped fluid) and receives sensor data from values from sensors 310.²⁰

¹⁸ Ex. 1001, 7:1–3.

¹⁹ Ex. 1001, 7:15–17.

²⁰ Ex. 1001, 7:22–34.

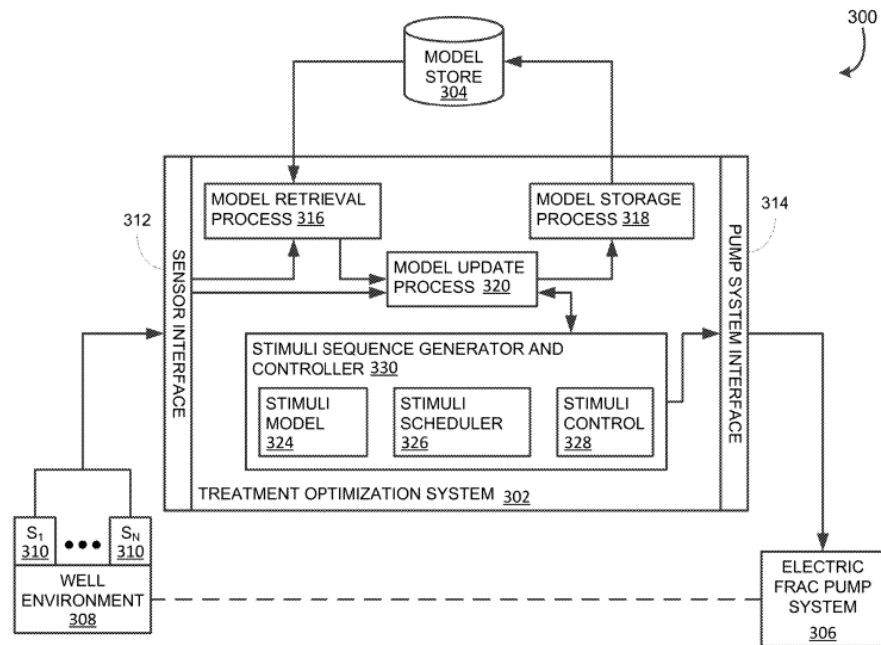


FIG. 3

Ex. 1001, Fig. 3. The system includes a stimuli sequence generator and controller that generates “a sequence of stimuli which are provided as commands to electric frac pump system 306” that is used to “produce a response, and resulting sensor data from sensors 310, from well environment 308.”²¹ A model retrieval process 316 retrieves a system model based on the response information from well environment 308 as a result of stimuli sequence generator and controller 330.²²

43. Figure 4 “is a flowchart of a method 400 for selecting and executing a representative system model” that may be performed by treatment optimization

²¹ Ex. 1001, 7:52–57.

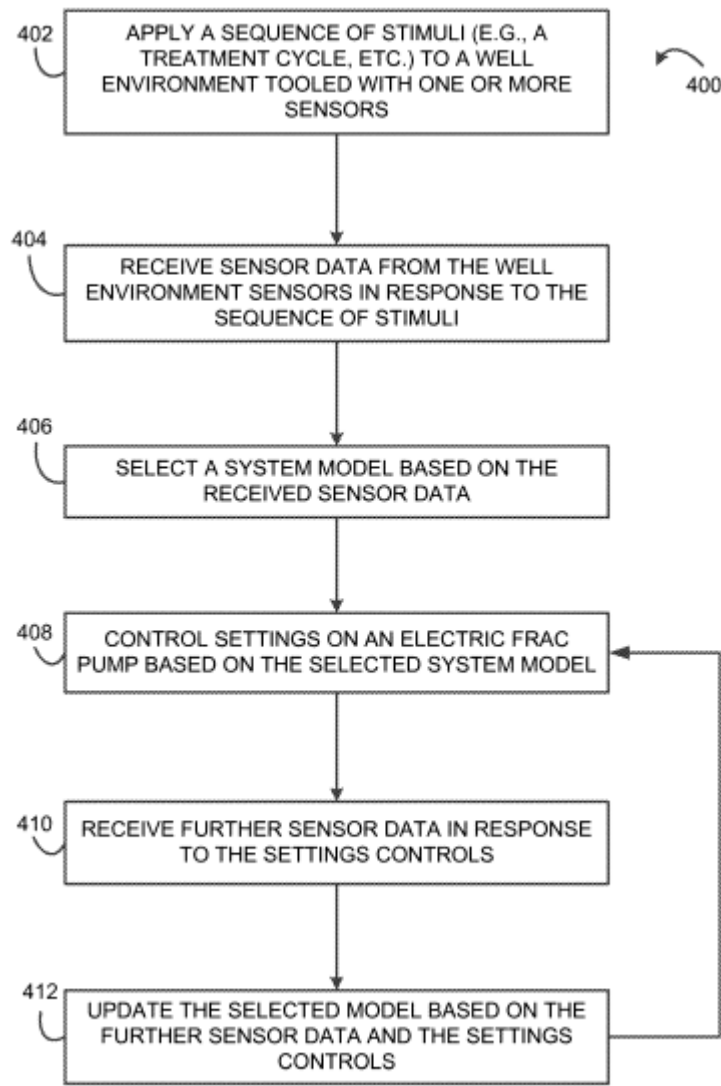
²² Ex. 1001, 7:58–61.

system 302.²³ In step 402, “a sequence of stimuli, such as a treatment cycle or the like, is applied to a well environment tooled with one or more sensors.”²⁴ “At step 404, sensor data is received from the well environment sensors in response to the sequence of stimuli.”²⁵

²³ Ex. 1001, 8:22–25.

²⁴ Ex. 1001, 8:26–28.

²⁵ Ex. 1001, 8:29–30.



Ex. 1001, Fig. 4. “At step 406, a representative system model is selected based on the received sensor data.”²⁶ Then, “[a]t step 408, setting on an electric frac pump are controlled based on the selected representative system model.”²⁷ The settings may

²⁶ Ex. 1001, 8:37–39.

²⁷ Ex. 1001, 8:45–46.

include, for example, pressure, flow rate, chemical (e.g., proppant, diverter, etc.) composition of a pumped fluid.²⁸ In some embodiments, at step 410 further sensor data is received in response to the setting controls and at step 412, the selected model can be updated based on the further sensor data and the sensor controls.²⁹

44. The techniques for optimizing well treatments described and claimed in the '058 Patent, which select a representative system model based on the sequence of stimuli and formation response data, advantageously provide for selection of a representative system model that more accurately reflects the well to which it has been deployed.

B. PROSECUTION HISTORY

45. The '058 Patent issued from U.S. Patent Application No. 16/573,448 filed on September 17, 2019.³⁰ The Examiner did not issue any office action rejecting the claims during prosecution of the '058 Patent.

46. On May 9, 2022, the Examiner issued a Notice of Allowance indicating that “[a]fter a thorough search, and in light of the prior art of record, claims 1-20 are

²⁸ Ex. 1001, 8:47–49.

²⁹ Ex. 1001, 8:49–52.

³⁰ Ex. 1001, Cover.

allowed.”³¹ The Examiner’s reasons for allowance stated:

The cited references do not disclose 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, selecting a representative system model based on the received formation response data from downhole or surface sensors and sequence of stimuli, and controlling an electrical fracturing pump based on the representative system model.³²

Furthermore, the notice of allowance identified “prior art of record” and, for each reference, noted the following: “No selection of a model based on the claimed response data and sequence of stimuli, not controlling of an electrical fracturing pump based upon the selected model.”³³ Thereafter, the ’058 Patent issued on June 28, 2022.³⁴

C. LEVEL OF ORDINARY SKILL IN THE ART

47. The Petition alleges that a POSITA would have had a B.S. in Chemical Engineering, Mechanical Engineering, Materials Science, or Metallurgical

³¹ Ex. 1002, 18, 24.

³² Ex. 1002, 24.

³³ Ex. 1002, 25-27.

³⁴ Ex. 1001, Cover.

Engineering or an equivalent field and at least two years of academic or industry experience in the oil and gas industry, including experience with process control systems.³⁵ The Petition also alleges that “a person with additional education but less professional experience, and vice versa, may qualify.”³⁶ For purposes of rendering the opinions in this Declaration, I have applied Petitioners’ definition of the level of skill in the art.

48. Based on my education and experience, I meet this definition of one of ordinary skill in the art, and I believe that I am qualified to provide opinions about how a POSITA at the relevant time would have interpreted and understood the ’058 Patent and the alleged prior art relied upon in the Petition. Although my qualifications and experience exceed those of a POSITA, both in September 2019 and today, I have nevertheless applied the perspective of a POSITA in rendering my opinions herein.

D. THE CHALLENGED CLAIMS OF THE ’058 PATENT

49. The Challenged Claims of the ’058 Patent, which are Claims 1-20, are set forth below. Some of the claim elements have been further sub-divided for ease of reference.

³⁵ Petition, 23-24.

³⁶ Petition, 23-24.

Claim Element	Claim Language from '058 Patent
1[pre]	1. A computer-implemented method for controlling electrical fracturing equipment for fracturing a well, the method comprising:
1[A]	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;
1[B]	receiving formation response data comprising data from one or more downhole sensors or surface sensors;
1[C]	selecting a representative system model based on the received formation response data and sequence of stimuli; and
1[D]	controlling an electrical fracturing pump based on the representative system model.
2	2. The method of claim 1, wherein the representative system model is retrieved from a data store based the received formation response data.
3	3. The method of claim 1, wherein the representative system model is generated based on data created through simulation with uncertainty parameters.
4[pre]	4. The method of claim 1, wherein selecting the representative system model further comprises:
4[A]	determining one of a linear or a non-linear relationship between the sequence of stimuli and received formation response data; and
4[B]	updating the one of the linear or the non-linear relationship based on multiple iterations of the generated sequence of stimuli.
5	5. The method of claim 1, wherein the data from the one or more downhole sensors or surface sensors is used to determine changes in flow distribution in response to a diverter drop, the changes in flow distribution used to determine the representative system model.

Claim Element	Claim Language from '058 Patent
6	6. The method of claim 1, wherein the one or more downhole sensors or surface sensors comprises one or more of a single-point electrical sensors, an optical sensor, or a fiber optic sensor.
7	7. The method of claim 1, wherein the formation response data comprises measurements of one or more of pressure, temperature, flow, dynamic strain, static strain, acoustic intensity, resistivity, or electromagnetic signals or frequency, amplitude or phase of any of the electromagnetic signals.
8	8. The method of claim 1, wherein the representative system model predicts a proxy value comprising one or more of a cluster efficiency, a complexity factor, or a proximity index, and the predicted proxy value is used to control one or more of a uniform flow across perforation clusters, a formation complexity, or interference in a neighboring well.
9[pre]	9. A system for controlling electrical fracturing equipment for fracturing a well, the system comprising:
9[A]	one or more processors; and
9[B]	a memory comprising instructions to:
9[C]	generate 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;
9[D]	receive formation response data comprising data from one or more downhole sensors or surface sensors;
9[E]	select a representative system model based on the received formation response data and sequence of stimuli; and
9[F]	control an electrical fracturing pump based on the representative system model.

Claim Element	Claim Language from '058 Patent
10	10. The system of claim 9, wherein the representative system model is retrieved from a data store based the received formation response data.
11	11. The system of claim 9, wherein the representative system model is generated based on data created through simulation with uncertainty parameters.
12[pre]	12. The system of claim 9, wherein selecting the representative system model further comprises:
12[A]	determining one of a linear or a non-linear relationship between the sequence of stimuli and received formation response data; and
12[B]	updating the one of the linear or the non-linear relationship based on multiple iterations of the generated sequence of stimuli.
13	13. The system of claim 9, wherein the data from the one or more downhole sensors or surface sensors is used to determine changes in flow distribution in response to a diverter drop, the changes in flow distribution used to determine the representative system model.
14	14. The system of claim 9, wherein the formation response data comprises measurements of one or more of pressure, temperature, flow, dynamic strain, static strain, acoustic intensity, resistivity, or electromagnetic signals or frequency, amplitude or phase of any of the electromagnetic signals.
15	15. The system of claim 9, wherein the representative system model predicts a proxy value comprising one or more of a cluster efficiency, a complexity factor, or a proximity index, and the predicted proxy value is used to control one or more of a uniform flow across perforation clusters, a formation complexity, or interference from a neighboring well.
16[pre]	16. A non-transitory computer readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to:

Claim Element	Claim Language from '058 Patent
16[A]	generate 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;
16[B]	receive formation response data comprising data from one or more downhole sensors or surface sensors.
16[C]	select a representative system model based on the received formation response data and sequence of stimuli; and
16[D]	control an electrical fracturing pump based on the representative system model.
17	17. The non-transitory computer readable medium of claim 16, wherein the representative system model is retrieved from a data store based on the received formation response data.
18	18. The non-transitory computer readable medium of claim 16, wherein the representative system model is generated based on data created through simulation with uncertainty parameters.
19[pre]	19. The non-transitory computer readable medium of claim 16, wherein selecting the representative system model further comprises:
19[A]	determining one of a linear or a non-linear relationship between the sequence of stimuli and received formation response data; and
19[B]	updating the one of the linear or the non-linear relationship based on multiple iterations of the generated sequence of stimuli.
20	20. The non-transitory computer readable medium of claim 16, wherein the formation response data comprises measurements of one or more of pressure, temperature, flow, dynamic strain, static strain, acoustic intensity, resistivity, electromagnetic signals, or frequency, amplitude or phase of any of the signals, and the representative system model predicts a proxy value comprising one or more of a cluster efficiency, a complexity factor, or a

Claim Element	Claim Language from '058 Patent
	proximity index, and the predicted proxy value is used to control one or more of a uniform flow across perforation clusters, a formation complexity, or interference from a neighboring well.

VIII. OVERVIEW OF THE PRIOR ART

A. PANKAJ (EX. 1005)

a. Status of Pankaj

50. *Pankaj* is a publication of a United States patent application, U.S. Patent Application Publication No. 2018/0230782. *Pankaj* is titled “Method of Performing Integrated Fracture and Reservoir Operations for Multiple Wellbores at a Wellsite.”³⁷ *Pankaj* was filed on August 8, 2016, and published on August 16, 2018.³⁸ *Pankaj* claims priority to U.S. Provisional Application No. 62/202,475, filed on August 7, 2015.

b. Overview of the Disclosure of Pankaj

51. *Pankaj* describes “a method of performing oilfield operations at a wellsite” which is “positioned about a subterranean formation having multiple

³⁷ Ex. 1005, Cover.

³⁸ Ex. 1005, Cover.

wellbores therethrough and a fracture network therein.”³⁹ According to *Pankaj* “[t]he fracture network includes natural fractures,” as is common in many formations.⁴⁰

52. *Pankaj*’s method includes, first, “collecting wellsite data comprising microseismic events and a mechanical earth model[.]”⁴¹ The microseismic events are depictions of movement of portions of the formation due to “interaction between the hydraulic fractures with the natural fractures [] when the hydraulic fracture treatment is pumped into the reservoir.”⁴² The mechanical earth model, according to *Pankaj*, is “a numerical representation of the geomechanical state of the wellsite (e.g. reservoir, field and/or basin).”⁴³ The geomechanical state of the wellsite is calculated from factors such as density and porosity of the geological formation and may incorporate “wellsite parameters, such as pore pressures, state of stress, rock

³⁹ Ex. 1005, Abstract.

⁴⁰ Ex. 1005, Abstract.

⁴¹ Ex. 1005, [0008].

⁴² Ex. 1005, [0081].

⁴³ Ex. 1005, [0099].

mechanical properties, etc.”⁴⁴ The wellsite data are then used to develop “fracture parameters for each of the multiple wellbores based on the wellsite data[.]”⁴⁵

53. *Pankaj*’s method includes “generating *fracture parameters* [] and a mechanical earth model[.]”⁴⁶ The fracture parameters comprise “a hydraulic fracture network of a fracture grid for each of the multiple wellbores[.]”⁴⁷ These fracture parameters are “based on *wellsite data* comprising microseismic events and a *mechanical earth model*[.]”⁴⁸ The mechanical earth model represents “a reservoir grid based on the wellsite data and the fracture parameters.”⁴⁹

54. The mechanical earth model, based on wellsite parameters, from each wellsite are combined with *reservoir parameters* to create “integrated wellsite parameters comprising an integrated earth model[.]”⁵⁰ The reservoir parameters are made up of “an updated mechanical earth model of a reservoir grid based on the

⁴⁴ Ex. 1005, [0099].

⁴⁵ Ex. 1005, [0009].

⁴⁶ Ex. 1005, Abstract; *see also* Ex. 1005, [0007].

⁴⁷ Ex. 1005, Abstract; *see also* Ex. 1005, [0007].

⁴⁸ Ex. 1005, [0007] (emphasis added).

⁴⁹ Ex. 1005, [0007].

⁵⁰ Ex. 1005, [0007].

wellsite data and the fracture parameters[.]”⁵¹ Once this is completed, the integrated wellsite parameters are used to perform “production operations at the multiple wellbores based on the integrated wellsite parameters.”⁵² Despite the sometimes circular descriptions, *Pankaj* teaches the models and parameters are related to subterranean geological formations and information regarding the fractures in those formations.

55. *Pankaj* teaches that “[w]ellsite data may be input into the reservoir to define the reservoir model 600.1. For example, surface outcrop observations, seismic surveys, wireline logs, and logging-while-drilling logs, may collectively contribute in the hydrocarbon reservoir characterization process. Initial steps may involve identifying subsurface structures, such as seismic or geological surfaces and faults.”⁵³ *Pankaj* teaches the use of hydraulic fracture models “such as UFM™, to predict geometry of fractures in the hydraulic fracture networks and the distribution of fluids and proppants therein.”⁵⁴ These two sets of data are integrated by

⁵¹ Ex. 1005, [0007].

⁵² Ex. 1005, [0007].

⁵³ Ex. 1005, [0085].

⁵⁴ Ex. 1005, [0086].

“combining inputs from the fracture simulator and the reservoir simulator[.]”⁵⁵

Results from multiple wellbores are combined to create a model of the formation and reservoir across a geographic area. The result is a combined model used primarily “to estimate production” from the geographic area.⁵⁶

B. PAYNE (EX. 1006)

a. Status of *Payne*

56. U.S. Patent Application Publication No. 2016/0258267 by Payne et al. (“*Payne*”) was filed on March 3, 2016 and published on September 8, 2016.⁵⁷ It claims priority to U.S. Provisional Application No. 62/128,291, filed on March 4, 2015.⁵⁸

b. Overview of the Disclosure of *Payne*

57. *Payne* involves “a system for stimulating oil or gas production” that “includes a hydraulic fracturing pump unit having two or more fluid pumps,” where each pump is “driven by an alternating current (AC) electrical pump motor coupled to the fluid pump, and a variable frequency drive (VFD) controlling the electrical

⁵⁵ Ex. 1005, [0089].

⁵⁶ Ex. 1005, [0010].

⁵⁷ Ex. 1006, Cover.

⁵⁸ Ex. 1006, Cover.

pump motor[.]”⁵⁹ *Payne* explains that the VFD may be a “Toshiba GX7 Rig Drive 1750 HP,” among other options, and in a “preferred embodiment, there is one (1) Toshiba GX7 VFD per pump system[.]”⁶⁰ The fracturing system also includes additional units, such as a hydraulic blender unit and a system control unit.⁶¹

C. DAWSON (Ex. 1024)

a. Status of Dawson

58. *Dawson* is U.S. Patent No. 10,378,333 entitled “Determining Diverter Effectiveness in a Fracture Wellbore.”⁶² U.S. Patent Application No. 15/192,218, which led to *Dawson*, was filed June 24, 2016 and published on December 28, 2017.⁶³ *Dawson* was issued on August 13, 2019.⁶⁴

⁵⁹ Ex. 1006, [0014].

⁶⁰ Ex. 1006, [0122].

⁶¹ Ex. 1006, [0014].

⁶² Ex. 1024, Cover.

⁶³ Ex. 1024, Cover.

⁶⁴ Ex. 1024, Cover.

b. Overview of the Disclosure of *Dawson*

59. *Dawson* describes “[s]ystems and methods for using pressure signals to assess effectiveness of a diverter in a stimulation wellbore[.]”⁶⁵ *Dawson* describes using “[a] pressure signal in an observation wellbore” to measure “a pressure change that is induced by a fracture [] in the subsurface formation.”⁶⁶ By measuring “[t]he slope in the pressure signal before and after the diverter” *Dawson*’s system can “determine the effectiveness of the diverter.”⁶⁷

60. *Dawson* teaches that “[d]iverters are used to divert the flow of well treatment fluids (e.g. injection fluids) from perforations taking more fluid to perforations taking less fluid.”⁶⁸ Though there are “many types of commercial diverters,”⁶⁹ *Dawson* teaches “[d]iverters, however, may be unreliable due to uncertainty in whether a diverter is going to work or not.”⁷⁰ *Dawson* purports to

⁶⁵ Ex. 1024, Abstract.

⁶⁶ Ex. 1024, Abstract.

⁶⁷ Ex. 1024, Abstract.

⁶⁸ Ex. 1024, 1:31-33.

⁶⁹ Ex. 1024, 1:38-39.

⁷⁰ Ex. 1024, 1:44-45.

provide “[m]ore effective assessment of the diverter” which “may be used to improve the use of diverters.”⁷¹

IX. GROUND 1: CLAIMS 1-4, 6-7, 9-12, 14, & 16-19

61. Petitioners cite the combination of *Pankaj* and *Payne* as allegedly rendering Claims 1-4, 6-7, 9-12, 14, and 16-19 of the '058 Patent obvious. For the reasons set forth below, I disagree. In my opinion, the *Pankaj-Payne* combination fails to disclose, teach, or suggest every claimed element.

A. INDEPENDENT CLAIM 1

62. *Pankaj*, considered alone or in combination with *Payne*, does not disclose, teach, or suggest each and every limitation of Claim 1, as discussed in the sections below. As a result, Claim 1 is not rendered obvious by the combination of *Pankaj* and *Payne*.

- a. **Claim 1[A]: “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;”**

63. *Pankaj* does not disclose “generating a sequence of stimuli for application to a well environment” as claimed by the '058 Patent. Dr. Nikolaou points to several locations in *Pankaj* where fracturing is generally described (*e.g.*, [0055], [0059],

⁷¹ Ex. 1024, 2:1-2.

[0061], [0086], [0100]).⁷² However, none of these portions describes “generating a sequence of stimuli for application to a well environment.” Each of these portions of *Pankaj* only contain a general description of fracturing operations.⁷³ Dr. Nikolaou then finishes the listing of these parts of *Pankaj* with the conclusory statement: “A POSITA would have thus understood these teachings in *Pankaj* to disclose (or render obvious) ‘*generating a sequence of stimuli ... comprising one or more of particulate concentrations, chemical concentrations or a pump control.*’”⁷⁴ However none of these portions of *Pankaj* disclose, or suggest, the entirety of the claim limitation.

64. The '058 Patent describes the sequence of stimuli as a series of events that are generated in advance of the actual stimulation and then applied to a well environment. The '058 Patent teaches that the sequence of stimuli is a schedule of multiple events to occur over time. For example, the '058 Patent teaches “stimuli may be modified over a span of time as part of a sequence of stimuli.”⁷⁵ Further, the '058 Patent teaches “a sequence can include a particular stimulus (e.g., injection

⁷² Ex. 1003, ¶¶ 82-84.

⁷³ Ex. 1003, ¶¶ 82–83.

⁷⁴ Ex. 1003, ¶ 83 (emphasis and deletions in original).).

⁷⁵ Ex. 1001, 3:26-31.

rate) being stepped through a sequence of various amplitudes (e.g., high, medium, low, etc.).”⁷⁶

65. The discussion of a sequence of stimuli in the ’058 Patent is consistent with an ordinary meaning of the term “sequence.” For example, dictionary definitions of “sequence” include “a particular order in which related events, movements, or things follow each other” and a “following of one thing after another; succession.”⁷⁷

66. Moreover, limitation [1A] requires generating a sequence of stimuli **for application** to a well environment. The plain reading of this limitation requires that a **sequence** of stimuli be generated before it is applied to a well environment. This is consistent with the specification. In the sentence immediately following the statement that “stimuli may be modified over a span of time as part of a sequence of stimuli,” the ’058 Patent states:

For example, concentrations of particulates and/or chemicals can be periodically varied **in predetermined patterns over time** to induce various formation responses detectable via deployed sensors.⁷⁸

⁷⁶ Ex. 1001, 2:30-33.

⁷⁷ Ex. 2011; Ex. 2012.

⁷⁸ Ex. 1001, 3:31-34.

67. The patent's statement that the concentrations of particulates or chemicals can be varied in ***predetermined*** patterns over time is consistent with the claim language requiring that the sequence of stimuli must first be generated before the sequence is applied to a well environment.

68. Further, when describing the apparatus used to execute the method of Claim 1, the '058 Patent discloses: "[s]timuli scheduler 326 may generate a stimuli sequence based on the stimuli determined by stimuli model 324. Stimuli control 328 may execute the generate stimuli sequence by generating respective commands, based on the scheduled sequence, to provide to pump system interface 314."⁷⁹

69. The Petition's discussion of limitation [1A] does not explain how *Pankaj* discloses generating a sequence of stimuli for application to a well environment, nor does *Pankaj* disclose the limitation. The Petition references *Pankaj*'s disclosure that "[i]n particular, injection may be manipulated by adjusting the material being injected and/or the way it is injected to achieve the fractures which draws fluid from formations into the wellbore and up to the surface."⁸⁰ A POSITA would, however, understand that this disclosure in *Pankaj* at best relates to starting the fracturing process and making adjustments based on how the fracturing process is proceeding

⁷⁹ Ex. 1001, 8:16-21.

⁸⁰ Ex. 1005, [0061].

as opposed to generating a sequence of stimuli for subsequent application. For example, it discusses manipulating by “adjusting” the material being injected and/or the way it is injected, steps that are taken during a fracturing process or while the fracturing process is being conducted. Moreover, the *Pankaj* disclosure specifically states material “being injected” and the way it “is injected” as opposed to “to be injected.” The claim language of the ’058 Patent, however, is consistent with “to be injected” (*i.e.*, “for application to a well environment”). There is no disclosure in *Pankaj* of generating a sequence of stimuli for application to a well environment.

b. Claim 1[C]: “selecting a representative system model based on the received formation response data and sequence of stimuli; and”

70. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, this claim limitation. Dr. Nikolaou concludes that *Pankaj* discloses “the updated mechanical earth model is selected (*‘selecting a representative system model’*) based on both the wellsite data (*‘the received formation response data’*) and fracture parameters/stimulating step (*‘sequence of stimuli’*).”⁸¹ However, a careful reading of *Pankaj* shows that such a conclusory statement is not supported by the specification of *Pankaj*.

⁸¹ Ex. 1003, ¶ 93.

71. Initially, neither the Unconventional Fracture Models (UFM) nor the Mechanical Earth Model (MEM) are a representative system model. The MEM, according to *Pankaj*, “is a numerical representation of the geomechanical state of the wellsite (e.g., reservoir, field, and/or basin). In addition to property distribution (e.g., density, porosity) and fracture system, the model may incorporate wellsite parameters, such as pore pressures, state of stress, rock mechanical properties, etc.”⁸² Accordingly, the MEM is simply a model of the characteristics of the subterranean formation. Further, the UFM is described by *Pankaj* as “a static (fracture) simulator”⁸³ and is used “to take into account the rock geomechanics and interaction of natural fractures[.]”⁸⁴ The “representative system model” of the ’058 Patent is more.

72. When describing the “representative system model,” the ’058 Patent teaches “a representative system model may be defined based on a multitude of models using parameter uncertainty techniques[.]”⁸⁵ “Sensors may be deployed to a treatment or monitoring well on surface or downhole. Surface sensor data may be

⁸² Ex. 1005, [0099].

⁸³ Ex. 1005, [0031].

⁸⁴ Ex. 1005, [0075].

⁸⁵ Ex. 1001, 2:49-51.

used to project subsurface parameters to downhole positions. For example, a measured surface pressure can be projected to a downhole location based on a model accounting for friction induced pressure drop and/or hydrostatic pressure changes due to gravity.”⁸⁶ Further, the ’058 Patent teaches that the “representative system model may be used to achieve uniform flow across perforation clusters by adjusting pressure, flow rates, diverter composition, proppant composition, and/or chemical composition at one or more relevant electric frac pumps[.]”⁸⁷ Further still, the ’058 Patent teaches that the representative system model is a “pre-defined representative system model for stage and/or well treatment schedules[.]”⁸⁸ emphasizing that it contains more than the geomechanical conditions. Accordingly, the representative system model is made up of much more than the relatively simple geomechanical conditions contained in the mechanical earth model.

73. Secondly, *Pankaj* does not teach “selecting” an alleged representative system model, much less selecting the representative system model based on the received sensor data *and* the sequence of stimuli. Dr. Nikolaou does not even attempt to show that a model is “selected” based on any parameter. Instead, he describes how

⁸⁶ Ex. 1001, 2:54-60.

⁸⁷ Ex. 1001, 4:12-16.

⁸⁸ Ex. 1001, 2:38-40.

the MEM in *Pankaj* is “updated” based on the sensor data.⁸⁹ Updating is not the same process as selecting. Selecting a model requires choosing a model out of a number or group of models. Updating would be part of constructing the MEM, which is a separate process in the ’058 Patent. For example, the ’058 Patent distinguishes “selecting” a model from “defining” or “constructing” a model when it teaches:

Response variables (e.g., responsive sensor data values) and respective stimuli (e.g., experimental data) can be used to select, define, and/or construct a representative system model. For example, stimuli and response combination can be mapped to respective system models maintained in an accessible data store. In some examples, a partial model can be generated based on stimuli and response combinations in order to select a pre-constructed representative system model most similar to the partial model.⁹⁰

The specification also describes a model store 304 that stores representative system models available for selection: “[t]reatment optimization system 302 includes a model retrieval process 316 for retrieving representative systems models from model store 304.”⁹¹ This is consistent with dictionary definitions of “select,” which include

⁸⁹ Ex. 1003, ¶ 93.

⁹⁰ Ex. 1001, 3:44 – 52.

⁹¹ Ex. 1001, 7:46-61.

“to choose (as by fitness or excellence) from a number or group” and “[t]o take as a choice from among several”.⁹² *Pankaj* does not teach any process whereby a representative system model is selected or chosen out of a number or group of models. Integrating parameters into a single updated earth model does not teach the required “selecting.”

74. Further, Dr. Nikolaou introduces confusion where none should exist. In describing the “selection” process, Dr. Nikolaou quotes a section of *Pankaj* referring to Unconventional Fracture Models (UFMs) which states “[e]xisting models may be used to simulate the governing equations for cases involving smooth fractures.”⁹³ Dr. Nikolaou then points to *Pankaj*’s disclosure that “[t]he generating 1176 may involve modeling the smooth fracture behavior to solve the governing equations and determine the smooth fracture parameters.”⁹⁴ Finally, Dr. Nikolaou points to a section of *Pankaj* that states “[UFM]s have been developed to understand subsurface fracture networks. Existing models may be used to simulate the governing equations

⁹² Ex. 2016; Ex. 2017

⁹³ Ex. 1003, ¶ 91 (quoting Ex. 1005, [0112]).

⁹⁴ Ex. 1003, ¶ 91 (quoting Ex. 1005, [0112]).

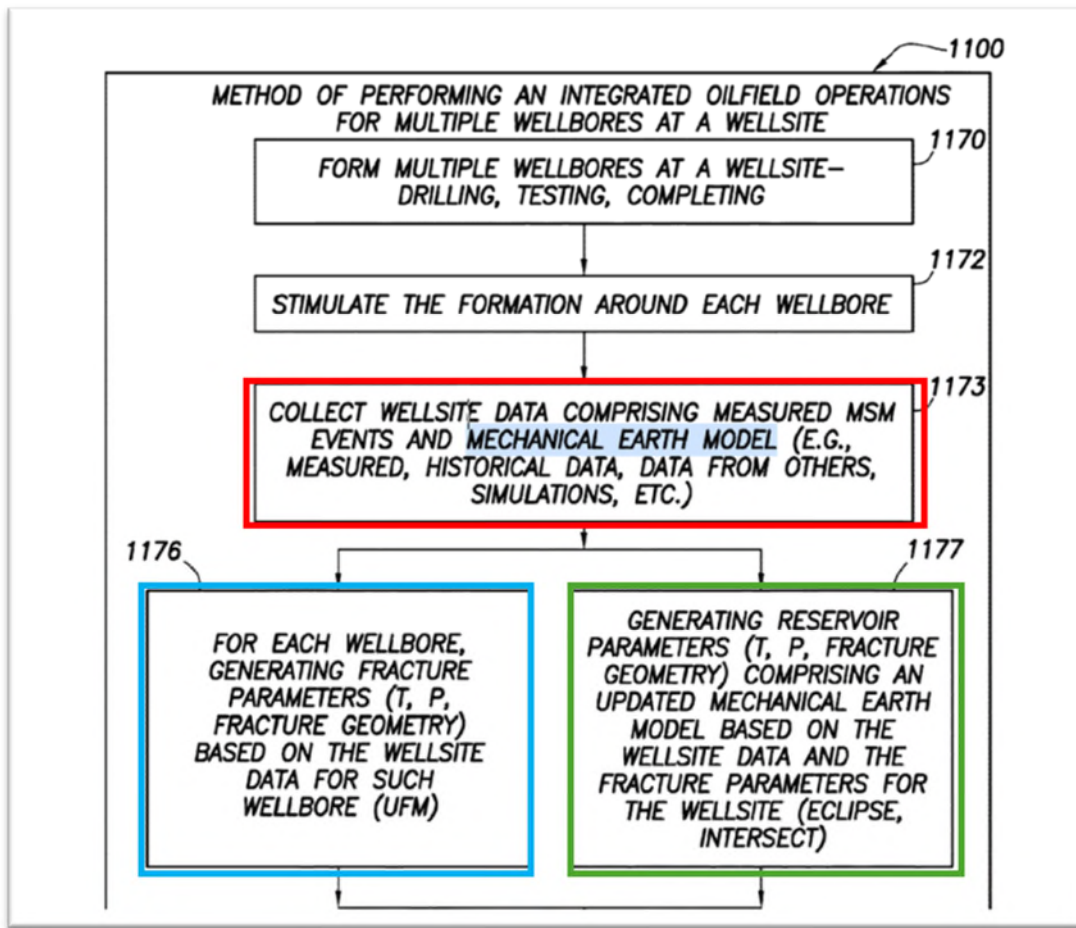
for cases involving smooth fractures.”⁹⁵ As pointed out above, the UFM_s are not representative system models.

75. Further, there is no teaching in *Pankaj* that the smooth fracture models are part of the Mechanical Earth Model. In fact, the fracture models (sometimes referred to as fracture parameters and sometimes as fracture geometry) are determined *based on* the MEM and other wellsite data, not the other way around. *Pankaj* teaches, for example, “[t]he method involves collecting wellsite data comprising microseismic events and a mechanical earth model, generating fracture parameters . . . based on the wellsite data” as a step in its process.⁹⁶ Thus, the “fracture parameters” are based on the wellsite data and the MEM, the MEM is not selected based on the fracture parameters, as Dr. Nikolaou suggests. Accordingly, the UFM_s are not part of the MEM, and cannot be used to show the selecting process.

76. Figure 11, which Dr. Nikolaou points to as teaching the selecting process, makes this relationship clear. The relevant portion of Figure 11 is duplicated below.

⁹⁵ Ex. 1003, ¶ 91 (quoting Ex. 1005, [0112]).

⁹⁶ Ex. 1005, [0008], [0009].



Ex. 1001, Figure 11 (excerpted and annotated).

77. Dr. Nikolaou states, “fracture parameters in step 1176 [annotated in blue] are ‘based on wellsite data’ collected from sensors.”⁹⁷ Dr. Nikolaou also states that “reservoir parameters in step 1177 [annotated in green] are likewise ‘based on wellsite data[.]’”⁹⁸ Further, in an attempt to tie in the UFM’s to the alleged selection

⁹⁷ Ex. 1003, ¶ 86 (quoting Ex. 1005, [0100]).

⁹⁸ Ex. 1003, ¶ 88.

process, Dr. Nikolaou states “[u]sing the received parameters, step 1176 also involves simulation techniques, such as an Unconventional Fracture Model[.]”⁹⁹ However, there is no discussion of how the MEM (as part of step 1173, annotated in red) is selected or is based at all on the sensor data. As discussed above, the fracture and reservoir parameters (steps 1176 and 1177) are generated based on the sensor data *and* the mechanical earth model, the model is not “selected” based on the parameters.

78. Further, claim limitation 1[C] requires that the representative system model be selected “based on the received formation response data *and* sequence of stimuli[.]” This limitation requires the selecting step to have knowledge of both the formation response data and the sequence of stimuli in order to make the selection of the representative system model. There is no teaching in *Pankaj* that even suggests the alleged selecting step is based on both sets of data (*i.e.*, response data and sequence of stimuli). Selecting the representative system model based on both the inputs to the system (*i.e.*, sequence of stimuli) and the outputs of the system (*i.e.*, formation response data) allows the method of the ’058 Patent to select a representative system model that is more representative of the actual system conditions. Having knowledge of only the sensor data, as in *Pankaj*, may allow for

⁹⁹ Ex. 1003, ¶ 91.

development of mechanical earth models, but does not teach selection of a representative system model as claimed.

79. When discussing the selection process, Dr. Nikolaou points again to the discussion of UFM's (not the MEM) and states, in a conclusory manner, "[t]his selection is based on both wellsite data ('received formation response data'), . . . and fracture parameters ('sequence of stimuli')[.]"¹⁰⁰ In making this statement, Dr. Nikolaou points to a portion of paragraph [0105] of *Pankaj*, which states "the hydraulic fracture geometry and the fracture parameters, such as conductivity, pressure in fractures, temperature, may be modeled from the wellsite data collection."¹⁰¹ The "fracture parameters" referred to here are explicitly downhole conditions (conductivity, pressure in fractures, temperature) and *not* the sequence of stimuli. Further, there is not any discussion about selecting a model based on these parameters, but simply using the UFM techniques to calculate the fracture geometry and the downhole fracture parameters. This has nothing to do with selecting a representative system model.

¹⁰⁰ Ex. 1003, ¶ 91.

¹⁰¹ Ex. 1003, ¶ 91 (quoting Ex. 1005, [0105]).

c. **Claim 1[D]: “controlling an electrical fracturing pump based on the representative system model.”**

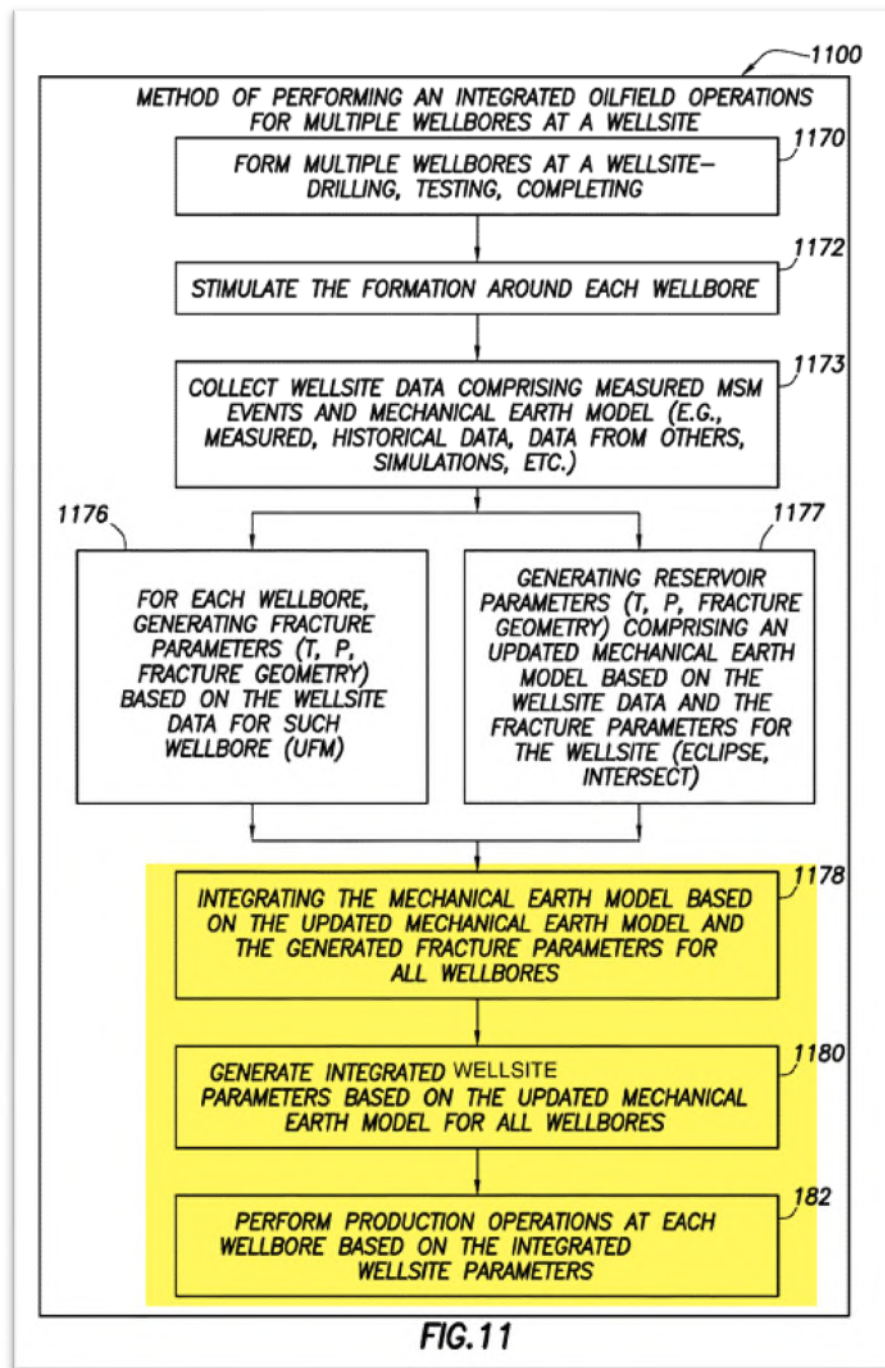
80. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, this claim limitation. Dr. Nikolaou points to Fig. 11 of *Pankaj* and a general statement regarding “performing fracture and/or production operations” as disclosure of “controlling an electrical fracturing pump based on the representative system model.”¹⁰² However, these broad generalizations do not show controlling a fracturing pump based on the representative system model, as Dr. Nikolaou claims.¹⁰³

81. Dr. Nikolaou points to a portion of Figure 11 in his analysis of this claim limitation.¹⁰⁴ I have duplicated Dr. Nikolaou’s reference to Figure 11 below.

¹⁰² Ex. 1003, ¶ 96 (quoting Ex. 1005, [0140]).

¹⁰³ I recognize that Dr. Nikolaou points to *Payne* as providing the “electrical” description of the fracturing pump. However, Dr. Nikolaou does not point to any other portion of *Payne* for the “controlling” portion of the claim limitation, so I direct my comments regarding controlling the pump to the portions of *Pankaj* that Dr. Nikolaou addresses.

¹⁰⁴ Ex. 1003, ¶ 96.



82. Dr. Nikolaou only addresses steps 1178, 1180 and 1182 in Figure 11, and ignores the teachings of the rest of Figure 11, which contradict his analysis. Dr. Nikolaou points to step 1182 as the “controlling a fracture pump” step, based solely

on the general statement in *Pankaj* that step 1182 “may involve performing fracture and/or production operations at one or more of the wellbores of the wellsite based on the integrated wellsite parameters.”¹⁰⁵ However, this broad statement does not support Dr. Nikolaou’s contentions that step 1182 teaches “controlling a fracturing pump based on the representative system model.”

83. Initially, *Pankaj* discloses that the “fracture operations” are “based on the integrated wellsite parameters.”¹⁰⁶ These integrated wellsite parameters are explicitly defined in *Pankaj*: “[t]he integrated dynamic wellsite parameters may include, for example, production forecasts of production parameters (e.g., pressure, flow rate, permeability, etc.) using the validated geomechanical parameters as inputs to a reservoir simulator[.]”¹⁰⁷ As discussed above, neither the integrated wellsite parameters nor the reservoir simulator are the “representative system model” claimed in the ’058 Patent. *Supra*, §IX.A.b. The “representative system model” contains more than just the geomechanical properties of the formation. Accordingly, step 1182 does not perform fracture operations “based on the representative system model” but, instead, based on productions forecasts, etc.

¹⁰⁵ Ex. 1003, ¶ 96 (quoting Ex. 1005, [0141]).

¹⁰⁶ Ex. 1005, [0141], Fig. 11.

¹⁰⁷ Ex. 1005, [0140].

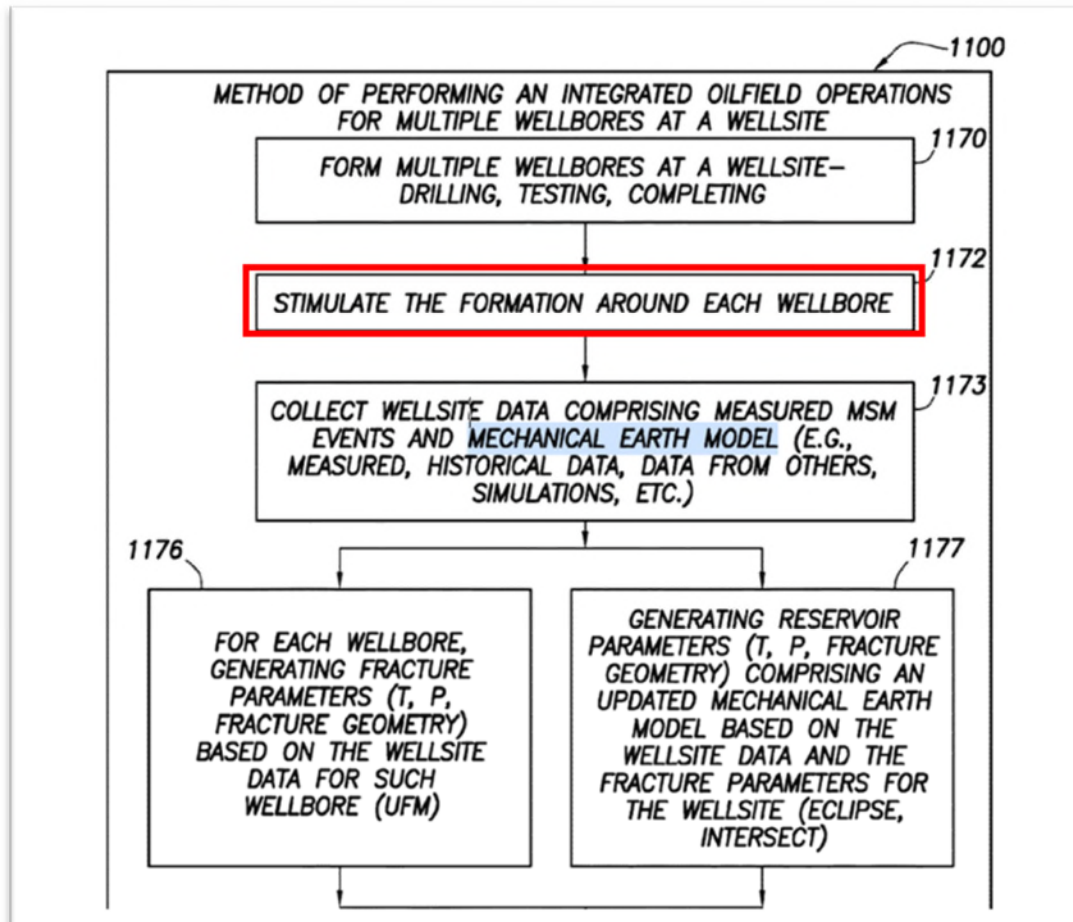
84. Secondly, *Pankaj*'s broad statement of "performing fracture operations" does not disclose "controlling a fracturing pump" as claimed. Dr. Nikolaou points to a separate section of *Pankaj* which teaches updating the geomechanical model, and that this updating includes "changing the reservoir properties in the geological model and/or changing the fracture design parameters and fluid properties"¹⁰⁸ and then makes the conclusory statement, "[a] POSITA would have recognized that a fracturing pump is controlled via these updated fracture parameters from using the model."¹⁰⁹ However, even taking Dr. Nikolaou's arguments at face value, at most these sections of *Pankaj* teach changing the *design* of the fracturing treatment, not the *control* of the pump. In other words, *Pankaj* may teach a POSITA *what* you are targeting (*i.e.*, pressure, flowrate, fluid composition, etc.) but not *how* the various components, including the pump, are controlled. There are no teachings in *Pankaj* regarding how to control a pump.

85. Finally, it is not at all clear from a careful reading of *Pankaj* that step 1182 involves pumping fluid downhole at all. A close examination of Figure 11 shows that step 1172, executed before any reference to a "model," is "stimulate the

¹⁰⁸ Ex. 1003, ¶ 97 (quoting Ex. 1005, [0076]).

¹⁰⁹ Ex. 1003, ¶ 97.

formation around each wellbore[.]”¹¹⁰ *Pankaj* teaches that this step is “perforating, injecting[.]”¹¹¹ This is the step that involves pumping fluid downhole (*i.e.*, injecting). As seen below, this step occurs before the geomechanical models of *Pankaj* are generated (not selected) and thus cannot be controlled based on the models.



¹¹⁰ Ex. 1005, Fig. 11.

¹¹¹ Ex. 1005, [0097].

86. Dr. Nikolaou appeared to recognize this in his deposition. When questioned regarding step 1182, Dr. Nikolaou testified that step 1182 was about production operations, not about controlling a fracturing pump.¹¹²

87. Even when questioned by counsel for Petitioner, Dr. Nikolaou re-emphasized that step 1182 is about productions operations and not about controlling a fracturing pump because “the fracturing pump is no longer in play.”¹¹³

88. Accordingly, it would not have been at all clear to a POSITA that step 1182 teaches “controlling a fracturing pump” much less controlling the fracturing pump “based on the representative system model.”

B. INDEPENDENT CLAIM 9

89. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne*, does not teach or suggest each and every limitation of Independent Claim 9, as discussed in the sections below. As a result, Claim 9 is not rendered obvious by the combination of *Pankaj* and *Payne*.

¹¹² Ex. 2014, 56:7-22; 54:16-55:22.

¹¹³ Ex. 2014, 82:21-84:24.

- a. **9[C]: “generate 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;”**

90. Other than being rewritten as part of a system claim, claim limitation 9[C] is identical to limitation 1[A]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 9[C] for the same reasons as those discussed regarding limitation 1[A] above in Section IX.A.a.

- b. **9[E]: “select a representative system model based on the received formation response data and sequence of stimuli; and”**

91. Other than being rewritten as part of a system claim, claim limitation 9[E] is identical to limitation 1[C]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 9[E] for the same reasons as those discussed regarding limitation 1[C] above in Section IX.A.b.

- c. **9[F]: “control an electrical fracturing pump based on the representative system model.”**

92. Other than being rewritten as part of a system claim, claim limitation 9[F] is identical to limitation 1[D]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 9[F] for the same reasons as those discussed regarding limitation 1[D] above in Section IX.A.c.

C. **INDEPENDENT CLAIM 16**

93. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not teach or suggest, each and every limitation of Independent Claim 16, as discussed in the sections below. As a result, Claim 16 is not rendered obvious by the combination of *Pankaj* and *Payne*.

- a. **16[A]: “generate 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;”**

94. Other than being rewritten as part of a computer readable medium claim, claim limitation 16[A] is identical to limitation 1[A]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 16[A] for the same reasons as those discussed regarding limitation 1[A] above in Section IX.A.a.

- b. **16[C]: “select a representative system model based on the received formation response data and sequence of stimuli; and”**

95. Other than being rewritten as part of a computer readable medium claim, claim limitation 16[C] is identical to limitation 1[C]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 16[C] for the same reasons as those discussed regarding limitation 1[C] above in Section IX.A.b.

c. **16[D]: “control an electrical fracturing pump based on the representative system model.”**

96. Other than being rewritten as part of a computer readable medium claim, claim limitation 16[D] is identical to limitation 1[D]. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, limitation 16[D] for the same reasons as those discussed regarding limitation 1[D] above in Section IX.A.c.

D. **DEPENDENT CLAIMS 2,10, 17**

97. Claims 2, 10 and 17 depend from Claims 1, 9 and 16 respectively and each contains all of the limitations of the independent claim from which they depend. As discussed above in Sections IX.A-IX.C, the combination of *Pankaj* and *Payne* does not disclose or render obvious Independent Claims 1, 9, or 16. As a result, Claims 2, 10 and 17 are not obvious for the same reasons as those discussed regarding Claims 1, 9 and 16 above.

98. In addition to missing the limitations of Claims 1, 9 and 16, respectively, Claims 2, 10, and 17 are not rendered obvious by the combination of *Pankaj* and *Payne* for the additional reasons discussed below. Claim 2 is representative.

a. **Claim 2: “2. The method of claim 1, wherein the representative system model is retrieved from a data store based on the received formation response data.”**

99. With regard to the UFM, Dr. Nikolaou points to a single portion of *Pankaj*:

UFMs have been developed to understand subsurface fracture networks. Existing models may be used to simulate the governing equations for cases involving smooth fractures. These models may be used, for example, to simulate complex fracture network propagation in a formation with pre-existing natural fractures.¹¹⁴

100. Dr. Nikolaou then states, in a conclusory manner without support:

Based on these disclosures, a POSITA would have understood that Pankaj's pre-existing UFMs were stored in a data store, e.g., computer memory, so that they can be used, if needed. . . . [A] POSITA would have understood that *Pankaj* discloses that its UFM (a "*representative system model*") is selected from a group of pre-existing UFMs based on which model best represents wellsite data ("*retrieved from a data store based the received formation response data.*")¹¹⁵

101. There is nothing in the quote, nor in Dr. Nikolaou's analysis, that suggests that the "UFMs" are stored in a data store or that the UFMs are selected based on anything, much less based on the received formation response data. UFMs may use wellsite data, but there is no teaching that a particular UFM is "selected" based on the formation response data.

102. Further, with respect to the MEM, there is no teaching that the MEM is a "representative system model," or that there is any "selecting" step with regard to

¹¹⁴ Ex. 1003, ¶ 0101 (quoting Ex. 1005, [0112]).

¹¹⁵ Ex. 1003, ¶ 0101.

the MEM. Dr. Nikolaou points to a single portion of *Pankaj* in paragraph [0099] describing that the MEM “is provided or may be calculated from other wellsite data” as teaching that the MEM is retrieved from a data store based on formation response data.¹¹⁶ But the Petition alleges that it is the “updated mechanical earth model” that is selected based on integrating fracture parameters at step 1178 of *Pankaj*.¹¹⁷ Dr. Nikolaou fails to explain how paragraph [0099] of *Pankaj* and its disclosure that an existing MEM may be “provided” relates in any way to *Pankaj*’s disclosure at step 1178, let alone how providing an existing MEM teaches that the updated mechanical earth model in step 1178 is retrieved from a data store based on the received formation response data.

103. Further still, Dr. Nikolaou points to a single section of *Pankaj* generally describing “computer facilities for receiving, storing, processing, and/or analyzing data from the operation”¹¹⁸ as teaching “retrieving the model from a data store based on the received formation response data” as claimed. However, there is no support for Dr. Nikolaou’s conclusory statement. There is no retrieving step in *Pankaj*. Further, Dr. Nikolaou does not even attempt to explain how this statement teaches

¹¹⁶ Ex. 1003, ¶ 102 (quoting Ex. 1005, [0099]).

¹¹⁷ Petition, 48.

¹¹⁸ Ex. 1003, ¶ 102.

retrieving “based [on] the received formation response data.” This is no surprise since there is no disclosure in *Pankaj* teaching this claim element.

104. Dr. Nikolaou’s analysis of Claim 2 seems to be that there is a computer in *Pankaj*, and therefore a POSITA would understand that there is disclosure of each of the elements of Claim 2. Claim 2 requires more than just a computer, it requires retrieving the representative system model from a data store based on the received formation response data. Neither *Pankaj* nor *Payne* suggest this limitation.

b. **Claim 10: “10. The system of claim 9, wherein the representative system model is retrieved from a data store based the received formation response data.”**

105. Except for depending from Claim 9 and being rewritten as a system claim, Claim 10 is identical to Claim 2. Accordingly, Claim 10 is not rendered obvious by the combination of *Pankaj* and *Payne* for the same reasons as those discussed above regarding Claim 2.

c. **Claim 17: “17. The non-transitory computer readable medium of claim 16, wherein the representative system model is retrieved from a data store based the received formation response data.”**

106. Except for depending from Claim 16 and being rewritten as part of the “computer readable medium of Claim 16,” Claim 17 is identical to Claim 2. Accordingly, Claim 17 is not rendered obvious by the combination of *Pankaj* and *Payne* for the same reasons as those discussed above regarding Claim 2.

E. DEPENDENT CLAIMS 3, 11, 18

107. Claims 3, 11 and 18 depend from Claims 1, 9 and 16 respectively and each contains all of the limitations of the independent claim from which it depends. As discussed above in Sections IX.A-IX.C, the combination of *Pankaj* and *Payne* does not disclose or render obvious Independent Claims 1, 9, or 16. As a result, Claims 3, 11 and 18 are not obvious for the same reasons as those discussed regarding Claims 1, 9 and 16 above.

F. DEPENDENT CLAIMS 4, 12, 19

108. Claims 4, 12 and 19 depend from Claims 1, 9 and 16 respectively and each contains all of the limitations of the independent claim from which it depends. As discussed above in Sections IX.A-IX.C, the combination of *Pankaj* and *Payne* does not disclose or render obvious Independent Claims 1, 9, or 16. As a result, Claims 4, 12, and 19 are not obvious for the same reasons as those discussed regarding Claims 1, 9 and 16 above.

109. In addition to missing the limitations of Claims 1, 9 and 16, Claims 4, 12, and 19 are not rendered obvious by the combination of *Pankaj* and *Payne* for the additional reasons discussed below. Claim 4 is representative and discussed below.

a. Claim 4[pre]: “The method of claim 1, wherein selecting the representative system model further comprises:”

110. *Pankaj* does not disclose, and the combination of *Pankaj* and *Payne* does not render obvious, this limitation. As discussed above regarding claim

limitation 1[C], *Pankaj* does not teach or suggest selecting a representative system model. For the same reasons, preamble 4[pre] is not disclosed or rendered obvious by the combination of *Pankaj* and *Payne*.

b. **4[A]: “determining one of a linear or a non-linear relationship between the sequence of stimuli and received formation response data; and”**

111. *Pankaj* does not disclose this limitation, and the combination of *Pankaj* and *Payne* does not render this limitation obvious.

112. As an initial matter, despite Dr. Nikolaou’s unsupported assertion, *Pankaj* does not disclose or suggest *any* linear equations, much less linear relationships between the sequence of stimuli and the received formation response data. Dr. Nikolaou, referencing equations 1-5 discussed in paragraphs [0106] – [0110] of *Pankaj*, asserts, “[a] POSITA would have understood that each of equations 1-5 is a linear equation that represents a mathematical relationship between fracture parameters (*‘sequence of stimuli’*) and modeled wellsite data (*‘formation response data’*).”¹¹⁹ However, a careful examination of the teachings of *Pankaj* shows this is not correct.

¹¹⁹ Ex. 1003, ¶ 110.

113. A linear equation is “an equation (= a mathematical statement) with a result that, when it is put on a graph, forms a straight line”.¹²⁰ A linear equation would have the form

$$a_1x_1 + a_2x_2 + \cdots a_nx_n + C = 0$$

Where

$a_1, a_2, \dots, a_n, C$ are coefficients comprised primarily of real numbers
 $x_1, x_2, \dots, x_n$ are variables or unknowns

114. Equation 1 is a partial differential equation (PDE) relating flow rate *inside* the fracture to the dimensions of the fracture.¹²¹ A partial differential equation is not a linear equation. Equation 2 is another partial differential equation describing laminar flow *inside* the fracture. Equation 3 is a definition of one of the terms in Equation 2 and is an integral equation specifically addressing laminar flow *inside* the fracture.¹²² An integral equation is not a linear equation. Equation 4 is not a true

¹²⁰ See Ex. 2018, 1 (<https://dictionary.cambridge.org/dictionary/english/linear-equation>).

¹²¹ A PDE is “an equation (= a mathematical statement) that expresses a relationship between a function (= a changing mathematical value) and two or more of its derivatives (= measures of the rate at which the function is changing) in which one variable (= value) changes and others stay the same:” Ex. 2019 at 1 (<https://dictionary.cambridge.org/dictionary/english/partial-differential-equation>).

¹²² An integral is “a number or function that gives the area under a curve on a graph between two points:” Ex. 2020 at 1 (<https://dictionary.cambridge.org/dictionary/english/integral>).

equation, but a relationship showing that the width *inside* the fracture is a function of (can be determined using) the height of the fracture, its location and depth. Equation 5 is an integral equation representing a volume balance of the fluid *inside* the fracture. Neither a partial derivative nor an integral are or can be included in any definition of a linear equation.

115. Each of the equations referenced by Dr. Nikolaou address fluid conditions inside the fracture, and do not show the relationship between the sequence of stimuli and the formation response data, as claimed. Dr. Nikolaou states, without support, “[s]uch a person would typically consider q (flow rate) at the injection point $n(s=0)$ as an input (*‘sequence of stimuli’*) and derive as outputs, including *‘formation response data,’* from solution of eqns. (1)-(5) the remaining variables[.]”¹²³ Dr. Nikolaou appears to be trying to say that the flowrate at the “injection point” is somehow output of the pump, or the beginning of the wellsite, or some other location which may be related to the “sequence of stimuli.” However, *Pankaj* does not teach that “ $s=0$ ” is the injection point. Rather, *Pankaj* teaches, for example with respect to Equation 1, “ q is the *local flow rate inside the hydraulic fracture* along the length, w is an average width or opening at the cross-section of the fracture at position $s=s(x,y)$, H_a is the height of the fluid *in the fracture*, and q_L is the leak-off volume

¹²³ Ex. 1003, ¶ 110.

rate *through the wall of the hydraulic fracture* into the matrix per unit height (velocity at which fracturing fluid infiltrates into surrounding permeable medium)[.]”¹²⁴ The only parameters calculated, as described, are *inside* the fracture, not at an “injection point.” Thus, Equation 1 represents a relationship between flow rate inside the fracture and other quantities measured or calculated inside the fracture. There is no relationship between the sensor data and the sequence of stimuli described in Equation 1. The same holds true of the other equations. Equation 2 is related to 1D (*i.e.*, one dimensional) laminar flow *inside* the fracture.¹²⁵ Equation 3 is related to the “width profile” of the fracture (*i.e.*, how width changes inside the fracture), and Equation 4 determines the “volume balance condition” inside the fracture.¹²⁶ For these equations, *Pankaj* teaches “[t]he boundary conditions may use the flow rate, net pressure and fracture width to be zero at all fracture tips.”¹²⁷

116. Dr. Nikolaou goes on to point to a portion of *Pankaj* teaching “[c]ombining these equations and discretizing the fracture network into small elements may lead to a nonlinear system of equations” and solving “using a damped

¹²⁴ Ex. 1005, [0106] (emphasis added).

¹²⁵ Ex. 1005, [0107].

¹²⁶ See Ex. 1005, [0107] – [0110].

¹²⁷ Ex. 1005, [0110].

Newton-Raphson method” as somehow teaching the claimed limitation.¹²⁸ However, the entire sentence from *Pankaj* reads “[c]ombining these equations and discretizing the fracture network into small elements may lead to a nonlinear system of equations in terms of fluid pressure *p* in each element, simplified as $f(p)=0$, which may be solved by using a damped Newton-Raphson method.”¹²⁹ The portion that Dr. Nikolaou left out makes it clear that even the combined equations represent parameters *inside* the fractures and fracture network.

117. Accordingly, the equations referenced by Dr. Nikolaou represent relationships between fluid conditions inside the fracture and the location and dimensions of the fracture, but do not teach a relationship, linear or otherwise, between the alleged sequence of stimuli and the formation response data.

118. There is also no disclosure in *Pankaj* of any relationship (whether linear or non-linear) between formation response data and the sequence of stimuli as required. Equations 1-5 do not represent any relationship (let alone a linear one) between formation response data and the sequence of stimuli. Dr. Nikolaou suggests “fracture parameters” are the sequence of stimuli.¹³⁰ But as discussed above with

¹²⁸ Ex. 1003, ¶ 110 (quoting Ex. 1005, [0111]).

¹²⁹ Ex. 1005, [0111] (emphasis added).

¹³⁰ Ex. 1003, ¶ 110.

respect to limitation 1[C], the “fracture parameters” referenced are explicitly downhole conditions (*e.g.*, conductivity, pressure in fractures, temperature) and are not the sequence of stimuli. Moreover, instead of showing a relationship between the sequence of stimuli applied to the well and the received formation data, as discussed above, Equations 1-5 show the relationship between the wellsite data (alleged by Dr. Nikolaou to be the formation response data) and the physical characteristics of the fractures. *Pankaj* states with respect to step 1176 utilizing Equations 1-5 that the method involves for each wellbore “generating fracture parameters ***based on wellsite data.***”¹³¹ The equations do not show a relationship between formation response data ***and the sequence of stimuli.*** In addition, as discussed above, the mere allegation that *Pankaj*’s reference to a “nonlinear system of equations” somehow discloses a nonlinear relationship between formation response data and the sequence of stimuli is just that – a mere allegation without any explanation or support. There is no such disclosure in *Pankaj*.

c. **4[B]: “updating the one of the linear or the non-linear relationship based on multiple iterations of the generated sequence of stimuli.”**

119. As *Pankaj* does not teach a linear or non-linear relationship as described above it cannot teach updating the relationship. Further, assuming in arguendo that

¹³¹ Ex. 1005, [0100] (emphases added).

the equations discussed by Dr. Nikolaou do teach a relationship between the sequence of stimuli and the formation response data (which they do not), *Pankaj* does not discuss or suggest updating the relationship based on multiple iterations of the generated sequence of stimuli.

120. Even accepting Dr. Nikolaou's analysis of linear or non-linear relationships at face value, there is no discussion whatsoever of updating the relationship "based on multiple iterations of the generated sequence of stimuli". Dr. Nikolaou points to the method described in Figure 11 and points to generating (not selecting) integrated dynamic wellsite parameters.¹³² Dr. Nikolaou then states, in a conclusory manner without explanation, "[a] POSITA would have understood that this means the updated parameters are both (i) used for fracture and/or production operation and (ii) factored into the linear (or nonlinear) mathematical relationship mentioned above for future models."¹³³ At most, what *Pankaj* is teaching is *using* the relationships described by *Pankaj* (*i.e.*, the equations) at different locations in the fracture, and perhaps at different times, to calculate the size and location of the fractures. There is no explanation of how the "relationships" (*i.e.*, equations) change

¹³² Ex. 1003, ¶ 114.

¹³³ Ex. 1003, ¶ 114.

(they do not), they are just calculated using different values for the inputs. Thus, there is no updating of the relationships disclosed or suggested.

121. Further, the “wellsite parameters” pointed to by Dr. Nikolaou are “production forecasts of production parameters (e.g., pressure, flowrate permeability, etc.)[.]”¹³⁴ *Pankaj* uses the term “parameters” in a variety of ways throughout the specification. The wellsite parameters are not parameters of the sequence of stimuli and are not sensor data. These parameters are predictions of what the produced well will generate, and what downhole conditions will exist at points in the future throughout the life of the well. The “wellsite parameters” may get an update, but the relationships that lead to the wellsite parameters do not.

122. Accordingly, neither *Pankaj* nor *Payne* discloses or suggests the elements of limitation 4[B].

G. DEPENDENT CLAIM 6: “THE METHOD OF CLAIM 1, WHEREIN THE ONE OR MORE DOWNHOLE SENSORS OR SURFACE SENSORS COMPRISES ONE OR MORE OF A SINGLE-POINT ELECTRICAL SENSORS, AN OPTICAL SENSOR, OR A FIBER OPTIC SENSOR.”

123. Claim 6 depends from Claim 1 and contains all of the limitations of Claim 1. As discussed above in Section IX.A, the combination of *Pankaj* and *Payne*

¹³⁴ Ex. 1005, [0140].

does not disclose or render obvious Independent Claim 1. As a result, Claim 6 is not obvious for the same reasons as those discussed regarding Claim 1 above.

H. DEPENDENT CLAIMS 7, 14

- a. **Claim 7: “The method of claim 1, wherein the formation response data comprises measurements of one or more of pressure, temperature, flow, dynamic strain, static strain, acoustic intensity, resistivity, or electromagnetic signals or frequency, amplitude or phase of any of the electromagnetic signals.”**

124. Claims 7 and 14 depend from Claims 1 and 9 respectively and each contains all of the limitations of the independent claim from which it depends. As discussed above in Sections IX.A-IX.B, the combination of *Pankaj* and *Payne* does not disclose or render obvious Independent Claims 1 or 9. As a result, Claims 7 and 14 are not obvious for the same reasons as those discussed regarding Claims 1 and 9 above.

X. GROUND 2: CLAIMS 5, 6, AND 13 ARE NOT OBVIOUS OVER PANKAJ IN VIEW OF PAYNE, FURTHER IN VIEW OF DAWSON

125. Claims 5 and 6 depend from Claim 1 and contain all of the limitations of Claim 1. As discussed above in Section IX.A, the combination of *Pankaj* and *Payne* does not disclose or render obvious Claim 1. There is no additional teaching in *Dawson* that discloses or suggests the limitations not disclosed or rendered obvious by *Pankaj* and *Payne* and Dr. Nikolaou does not argue otherwise. As a

result, Claims 5 and 6 are not obvious for the same reasons as those discussed regarding Claim 1.

126. Claim 13 depends from Claim 9 and contains all of the limitations of Claim 9. As discussed above in Section IX.B, the combination of *Pankaj* and *Payne* does not disclose or render obvious Claim 9. There is no additional teaching in *Dawson* that discloses or suggests the limitations not disclosed or rendered obvious by *Pankaj* and *Payne* and Dr. Nikolaou does not argue otherwise. As a result, Claim 13 is not obvious for the same reasons as those discussed regarding Claim 1.

127. In addition to missing the limitations of Claims 1 and 9, respectively, Claims 5 and 13 are not rendered obvious by the combination of *Pankaj*, *Payne* and *Dawson* at least because there is no motivation for a POSITA to combine the teachings of *Pankaj* and *Payne* with *Dawson* absent the roadmap provided by the '058 Patent.

A. MOTIVATION TO COMBINE

128. Without the disclosure of the '058 Patent, a POSITA would not have been motivated to combine the teachings of *Pankaj* and *Payne* with those of *Dawson* to arrive at Claims 5 and 13. Dr. Nikolaou discusses two reasons that, in his opinion, a POSITA would have combined the teachings of *Dawson* with those of *Pankaj* and *Payne*. Each of these reasons depend on using the teachings of the '058 Patent as a roadmap for the combination.

129. First, Dr. Nikolaou states:

First, a POSITA would have been motivated to use Dawson’s technique to allow for a “more effective assessment of the diverter,” which may be used to “improve the use of diverters.” EX-1024, [2:1–2]. A POSITA would have understood that fracturing operations, such as the one described in *Pankaj*, commonly use diverter drops. *See* EX-1024, [1:16–50]. Such a person would have been motivated to use Dawson’s technique to improve diverters in *Pankaj* for the express reason provided in Dawson—that is, Dawson’s technique allows for a “[m]ore effective assessment of the diverter [that] may be used to improve the use of diverters.” EX-1024, [2:1–2].¹³⁵

130. However, there are no “diverters in *Pankaj*.” Neither *Pankaj* nor *Payne* contain a single reference to the use of diverters. Further, *Pankaj* specifically describes the fluid being sent downhole as gel mixed with a proppant, or “fluid and proppant.”¹³⁶ Nowhere is a diverter, or any process for diverting fluid, mentioned, or suggested by *Pankaj*. In addition, *Payne* describes its use of “fracturing fluid” to be “fracking fluid” (primarily water, containing sand or other proppants suspended with the aid of thickening agents).¹³⁷ *Payne* further teaches fracturing fluid may also

¹³⁵ Ex. 1003, ¶ 154.

¹³⁶ Ex. 1005, [0055]; *see also* Ex. 1005, [0060], [0065], [0066], [0074], [0076], [0087], [0104].

¹³⁷ Ex. 1006, [0005].

contain “chemical additives, such as guar gum (also found in many foods)” to help the water gel.¹³⁸ No mention, teaching or suggestion of the use of a diverter is found in *Payne*.

131. It is not obvious to “improve” something that does not already exist in the teachings of *Pankaj* or *Payne*.

132. Second, Dr. Nikolaou states “using Dawson’s effectiveness technique in Pankaj’s fracturing operation would result in a more accurate representation of any well with a diverter.”¹³⁹ In a similar vein, Dr. Nikolaou states a POSITA “would further recognize that Pankaj would improve fracturing operations by having a more accurate model of a well that uses a diverter.”¹⁴⁰ This conclusory statement is unsupported. Further, as discussed above, there is no diverter in either *Pankaj* or *Payne*. Further still, there is no suggestion in any of the three references of how such a system would be accomplished, or if the techniques in *Pankaj* could be adapted to a well with diverters as described in *Dawson*. The only teachings in any reference that suggest such a combination come from the ’058 Patent.

¹³⁸ Ex. 1006, [0088].

¹³⁹ Ex. 1003, ¶ 155.

¹⁴⁰ Ex. 1003, ¶ 155.

133. Accordingly, a POSITA would not have been motivated to combine *Dawson* with *Pankaj* and *Payne* absent the roadmap provided by the '058 Patent.

XI. GROUND 3: CLAIMS 8, 15, AND 20 ARE NOT OBVIOUS OVER PANKAJ IN VIEW OF PAYNE, FURTHER IN VIEW OF LECERF

A. CLAIM 8: “THE METHOD OF CLAIM 1, WHEREIN THE REPRESENTATIVE SYSTEM MODEL PREDICTS A PROXY VALUE COMPRISING ONE OR MORE OF A CLUSTER EFFICIENCY, A COMPLEXITY FACTOR, OR A PROXIMITY INDEX, AND THE PREDICTED PROXY VALUE IS USED TO CONTROL ONE OR MORE OF A UNIFORM FLOW ACROSS PERFORATION CLUSTERS, A FORMATION COMPLEXITY, OR INTERFERENCE IN A NEIGHBORING WELL.

134. Claims 8, 15 and 20 depend from Claims 1, 9 and 16 respectively and contain all of the limitations of the independent claim from which they depend. As discussed above in Sections IX.A-IX.C, the combination of *Pankaj* and *Payne* does not disclose or render obvious Claims 1, 9, and 16. There is no additional teaching in *Lecerf* that discloses or suggests the limitations not disclosed or rendered obvious by *Pankaj* and *Payne* and Dr. Nikolaou does not argue otherwise. As a result, Claims 8, 15 and 20 are not obvious for the same reasons as those discussed above regarding Claim 1, 9 and 16.

XII. GROUND 4: CLAIMS 3, 11, AND 18 ARE NOT OBVIOUS OVER PANKAJ IN VIEW OF PAYNE FURTHER IN VIEW OF KLUMPEN

135. Claims 3, 11 and 18 depend from Claims 1, 9 and 16 respectively and each contains all of the limitations of the independent claim from which it depends. As discussed above in Sections IX.A-IX.C, the combination of *Pankaj* and *Payne*

does not disclose or render obvious Independent Claims 1, 9, or 16. As a result, Claims 3, 11 and 18 are not obvious for the same reasons as those discussed regarding Claims 1, 9 and 16 above.

XIII. GROUND 5: THE CLAIMED TECHNIQUES WERE NOT WELL UNDERSTOOD, ROUTINE, OR CONVENTIONAL

A. THE '058 PATENT IMPROVES ON THE PRIOR ART

136. I have been asked to consider and provide my opinions regarding the claimed advance of the '058 Patent. I disagree with the Petition's assertion that, with respect to the '058 Patent, "the 'focus of the claimed advance' is the automated selection of the system model and controlling the pump based on the system model[.]"¹⁴¹ Rather, as discussed above in Section VII.A, the '058 Patent contains an improvement over the prior art, particularly in the process of selecting a representative system model to use for controlling electrical fracturing pumps. According to the '058 Patent, a representative system model was typically a "static construct and may not accurately reflect the well to which it has been deployed."¹⁴² It is more desirable, as taught by the '058 Patent, to "find models that represent the observed data more accurately" to allow for "optimizing well treatments using

¹⁴¹ Petition, 92, n.6.

¹⁴² Ex. 1001, 1:23–26.

representative system models selected according to formation responses to stimuli indicated by sensor data.”¹⁴³

137. The '058 Patent teaches “a sequence of stimuli, such as a treatment cycle or the like, is applied to a well environment.”¹⁴⁴ Once the sequence of stimuli has been applied (e.g., pumped), “sensor data in response to the generated sequence of stimuli can then be received from sensors deployed throughout the well.”¹⁴⁵ The sensor data, which indicates how the well responds to the sequence of stimuli, is used along with the sequence of stimuli to select a representative system model which more accurately describes the well and location. This improves fracturing operations by providing more effective control of the fracturing pumps for a given formation being fractured.

138. For example, the '058 Patent teaches that “[r]esponse variables (e.g., responsive sensor data values) and respective stimuli (e.g., experimental data) can be used to select, define, and/or construct a representative system model.”¹⁴⁶ Selecting the representative system model based on *both* the sequence of stimuli

¹⁴³ Ex. 1001, 2:12-16.

¹⁴⁴ Ex. 1001, 8:36-28.

¹⁴⁵ Ex. 1001, 2:19-21; *see also* Ex. 1001, 8:29-30.

¹⁴⁶ Ex. 1001, 3:44-47; *see also* Ex. 1001, 10:21-23, 11:1-2.

applied to the well and the formation response data enables the selection of a more accurate representative system model, improving fracturing operations conducted based on the selected representative system model. The '058 Patent further discloses that “settings on an electric frac pump are controlled based on the selected representative system model.”¹⁴⁷

139. By stimulating the well with a sequence of stimuli, and then selecting a representative system model based on sensor data *and* the sequence of stimuli, the process of the '058 Patent improves fracturing operations by enabling the selection of a more accurate representative system model to use for controlling an electrical fracturing pump. Using a representative system model that more accurately reflects the well to which it is applied, in turn, results in improved control of the electrical fracturing pump to generate subsurface fractures that are favorable for enhancing the productivity of the well.

B. THE INDEPENDENT CLAIMS RECITE MORE THAN WELL-UNDERSTOOD, ROUTINE, AND CONVENTIONAL ACTIVITY

140. I have been asked to consider whether the independent claims of the '058 Patent recite more than well-understood, routine, and conventional activity previously known in the hydraulic fracturing industry. In my opinion, the

¹⁴⁷ Ex. 1001, 10:45-46.

independent claims recite a number of unconventional elements. For example, at a minimum Claim 1 recites the unconventional steps of “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;” “receiving formation response data comprising data from one or more downhole sensors or surface sensors;” and “selecting a representative system model based on the received formation response data and sequence of stimuli” that is used to control an electrical fracturing pump.¹⁴⁸ As discussed above, these claim elements are not shown in Petitioner’s combination of *Pankaj* and *Payne* which, at most, teach updating a model based on response data alone. Claims 9 and 16 contain essentially the same elements as Claim 1.

141. Dr. Nikolaou relies on Gottumukkala¹⁴⁹ as an additional reference in an attempt to show that the elements of the independent claims were routine and conventional.¹⁵⁰ However, Gottumukkala equally fails to disclose or suggest the specific elements of the claims. For example, in comparing the claim elements to

¹⁴⁸ Ex. 1001, claim 1.

¹⁴⁹ Ex. 1014.

¹⁵⁰ Ex.1003, ¶ 193.

Gottumukkala, Dr. Nikolaou simplifies the requirements of limitation 1[A], as shown below:

Actual Claim Limitation	Dr. Nikolaou's simplification
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;	a sequence of stimuli ... comprising one or more of particulate concentrations, chemical concentrations, or pump rate control

142. The sections of Gottumukkala that Dr. Nikolaou cites (paragraphs [0029] and [0031]) do not at all discuss generating a sequence of stimuli for application to a well environment (*i.e.*, a predetermined sequence). Further, these paragraphs discuss manipulation and actuation of control valves and measuring flow responses. This is not at all teaching “particulate concentrations, chemical concentrations, or a pump rate control” as recited in the independent claims of the ’058 Patent. There is no mention of either chemical concentration or particulate concentrations in these paragraphs. Further, manipulating flow rate control valves is not the same as pump rate control. Gottumukkala’s control valves control the rate of flow into the well, and between different well zones of a lateral bore, but does not

impact the rate of the pump. Fracturing pumps are known to be positive-displacement (*i.e.*, plunger) pumps. The flowrate of the pump is directly proportional to the speed (*i.e.*, rate) of the pump, regardless of downstream conditions. Manipulating a valve downstream may cause the flow to go different places in the well, or may change the pressure conditions, but will not affect either the speed or the flowrate of the pump. Thus, while pump rate can influence fluid flow rate in different portions of the wellsite or well, the manipulation of flow control valves in the wellbore does not impact pump rate. A “pump rate control” would have been understood by a POSITA to mean controlling the rate that the pump is operating. Actuating flow control valves is not the same as controlling the rate the pump is operating.

143. Further, Dr. Nikolaou points to no additional reference for the limitation of “selecting a representative system model based on the received formation response data and sequence of stimuli” as claimed in the independent claims. As discussed above, *Pankaj* and *Payne* do not disclose or suggest such a selection process. There is, therefore, no showing at all that this step was well understood, routine and conventional.

144. These claim elements, as a whole and individually, amount to more than well-understood, routine, and conventional activity previously known in the hydraulic fracturing industry.

C. THE DEPENDENT CLAIMS RECITE MORE THAN WELL-UNDERSTOOD, ROUTINE, AND CONVENTIONAL ACTIVITY

145. I have been asked to review the evidence that the Petition and Dr. Nikolaou rely on to allege that limitations of certain dependent claims of the '058 Patent recite only well-understood, routine, and conventional activities previously known in the hydraulic fracturing industry. For the reasons set forth below, in my opinion the relied-upon evidence fails to show that the elements of the dependent claims were well-understood, routine, or conventional in the industry.

a. Dependent Claims 2, 10 and 17

146. Like with the Independent claims, Dr. Nikolaou's analysis of Claims 2, 10, and 17 focuses on a single piece of the claim limitation, the "data store" while ignoring the "retrieved...based on the received formation response data." As discussed above, neither *Pankaj* nor *Payne* discloses this limitation. Further, Dr. Nikolaou's additional reference, *Rashid*,¹⁵¹ fails to disclose the limitation as well. Dr. Nikolaou points to paragraph 67 and Fig. 6 of *Rashid*.¹⁵² Neither Figure 6 nor paragraph 67 of *Rashid* provides any information regarding "how" or on what basis the model is retrieved, and Dr. Nikolaou provides no additional explanation. The references only show that there exists memory in which a model is stored, and do

¹⁵¹ Ex. 1018.

¹⁵² Ex. 1003, ¶, 193.

not provide support that the model is retrieved “based [on] the received formation response data” as claimed.

b. Dependent Claims 4, 12 and 19

147. Similar to the independent claims and Claims 2, 10 and 17, Dr. Nikolaou’s analysis oversimplifies the claim and ignores the requirement that the updating is “based on multiple iterations of the generated sequence of stimuli.” As discussed above, neither *Pankaj* nor *Payne* disclose this limitation. Similar to the above sections, Dr. Nikolaou simplifies the claim and ignores the requirement that “the linear or the non-linear relationship between the sequence of stimuli and received formation response data” is updated “based on multiple iterations of the generated sequence of stimuli.” Dr. Nikolaou points to Husen¹⁵³ as allegedly teaching that the claims are well understood, routine and conventional.¹⁵⁴ The sections of Husen referenced by Dr. Nikolaou, however, merely disclose that “the model is modified” using a “reiterative loop.” However, Dr. Nikolaou provides no explanation of how those teachings disclose updating the linear and non-linear relationship between the sequence of stimuli and received formation response data based on multiple iterations of the sequence of stimuli as the claims require.

¹⁵³ Ex. 1013.

¹⁵⁴ Ex. 1003, ¶ 193.

c. Dependent Claims 5 and 13

148. Dr. Nikolaou provides no additional explanation for how the limitations of Claims 5 and 13 are purportedly well understood, routine and conventional other than pointing back to the *Dawson* reference he used in his obviousness analysis.¹⁵⁵ As discussed above, a POSITA would not have been motivated to combine *Dawson*'s "effectiveness of a diverter" technique with *Pankaj* and *Payne*, particularly because neither *Pankaj* nor *Payne* contains any reference to a diverter. Further, it is telling that Dr. Nikolaou relied on a combination of references and an "obviousness" analysis to teach the elements. A practice that is only alleged to be "obvious" in light of multiple references does not support Dr. Nikolaou's assertion that such a practice is "well understood, routine and conventional".

XIV. SECONDARY CONSIDERATIONS

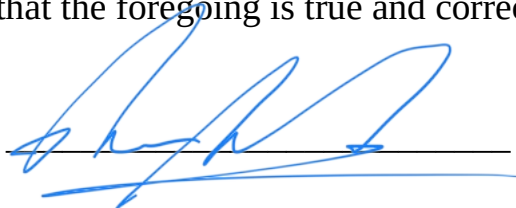
149. I am not currently aware of any secondary considerations evidence with respect to the claims of the '058 Patent. Should the Patent Owner put forth any evidence of secondary considerations in this proceeding or the related litigation, I reserve the right to consider such evidence, to consider whether any such evidence has a nexus to any claims of the Challenged Patent, and to update my analysis.

¹⁵⁵ Ex. 1003, ¶ 193.

XV. CONCLUSION

150. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. I further understand that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code. I declare under penalty of perjury that the foregoing is true and correct.

Executed on February 16, 2024.



Dr. Robert A. Durham

Appendix A

Dr. ROBERT A DURHAM, PhD, FIEEE

Resume
Specialization
Honors & Awards
Publications

Dr ROBERT A DURHAM, PhD, FIEEE

Robert A Durham is the Principal of D² Tech Solutions, a technology related firm concentrating on Mechanical and Electrical systems and energy conversions. He also serves as a Principal Scientist of THEWAY LABs, Tulsa, OK, an engineering and energy consulting firm that provides design and failure analysis of facilities and system installations.

Dr. Durham's work experience is broad and encompasses all areas of the energy industry. Dr. Durham spent 11 years with AEP/CSW, at the time the country's largest utility, in electrical engineering positions in the power generation and transmission planning departments. He then accepted a position as Manager of Electric Infrastructure for New Dominion, LLC., a major independent energy producer in Oklahoma. Dr. Durham then moved on to hold the position of Vice President of Engineering and Project Management for EDG Power Group, an Engineering Procurement and Construction company specializing in design and construction of small to medium size power generating facilities. Dr. Durham left EDG Power Group to accept his current positions. Dr. Durham has been accepted as an expert and offered testimony in several jurisdictions.

Dr. Durham's extensive client list includes the development of a broad spectrum of forensic, electrical and facilities projects for many companies. He has also taught University offered courses in electrical engineering review for board licensure. He has published five books, six magazine articles and over 40 other technical papers and articles. Dr. Durham's extensive work on standards and electrical systems has resulted in his elevation to Fellow of the IEEE, the highest grade of recognition in the electrical technology industry.

Dr. Durham received the B.S. in electrical engineering from the University of Tulsa in 1992 and the M.E. in Technology Management from The University of Tulsa in 1997. Tulsa, OK. In 2004, Dr. Durham received a PhD in Engineering Management from Kennedy Western University.

Degrees Earned

BSEE, with Honors, The University of Tulsa
Master of Engineering, The University of Tulsa
PhD , Kennedy Western University

Area of Specialization

lightning & grounding
failure analysis & forensic engineering
electrical power systems & safety
power generation
utility industry competition
economics & management
petroleum & chemical industry
electrical / mechanical energy conversion

Registration

Professional Engineer - Oklahoma
Professional Engineer – Texas
Professional Engineer – California
Professional Engineer – New Hampshire (Inactive)
Professional Engineer – Kansas
Professional Engineer – North Carolina (Inactive)
Professional Engineer – Missouri
Professional Engineer – Arkansas
Professional Engineer – Virginia (Inactive)
Professional Engineer – Illinois (Inactive)
Electrical Contractor - Oklahoma

Work History

D² Tech Solutions, Inc. 2002 - 2022
Principal

THEWAY Corp. 2004 - 2022
Principal Scientist

EDG Power Group, Inc. 2002 - 2004
Vice President Engineering & Project Management

New Dominion, LLC 2000 - 2002
Mgr Electric Infrastructure

Central & Southwest, Inc 1989 - 2000
Electrical Engineer

Professional Memberships

Fellow	Institute of Electrical and Electronic Engineers
Diplomate	American College of Forensic Examiners, International
Member	National Association of Fire Investigators
Voting Member	National Fire Protection Institute, Electrical Section
Executive Member	Petroleum and Chemical Industry Committee, IEEE
Diplomate,	
Past Board Member	American Board of Forensic Engineering and Technology
Member	IEEE Standards Association
Past Chair	Production Subcommittee, IEEE IAS/PCIC
CFC	American College of Forensic Examiners
Member	International Association of Arson Investigators
CFEI, CVFEI	National Association of Fire Investigators
Past Chair	Tulsa Section IEEE
Chair	IEEE RP1017.1 Working Group
Chair	IEEE RP1017.2 Working Group
Chair	IEEE RP1017.3 Working Group
Chair	IEEE RP1017.4 Working Group
Past Chair	IEEE PCIC Standards Subcommittee
Secretary	IEEE Petroleum and Chemical Industry Committee

Honors and Awards

Fellow of the IEEE

For contributions to submersible electrical equipment analysis and multi-point ground method in hazardous petroleum and chemical environments.

Honor Societies

Tau Beta Pi, national engineering honors
Eta Kappa Nu, national electrical engineering honors

Dr. Durham's publications have often successfully competed for outstanding paper awards from journals of the Institute of Electrical and Electronic Engineers (PCIC and IAS). This is an

international competitive peer review and evaluation of papers that provide a significant contribution to the advancement and understanding of electrical applications.

IEEE Industry Applications Society, New Orleans, LA: Prize Article for “Data Quality and Grounding: Considerations in a Mixed Use Facility”

PCIC, Cincinnati, OH: Prize Paper for “Grounding and Bonding Conductors: Solid, Stranded, Bare or Insulated”

PCIC, New Orleans, LA: Prize paper for "Industrial Design Application for Power Distribution over Extra-Long Distances"

PCIC, Philadelphia, PA: Prize paper for "Paradigm Shifts and Impact on Engineers and Industry"

Transactions on Industry Applications, Orlando, FL: Prize Paper for "Lightning, Grounding, and Protection for Control Systems”.

PCIC, Denver, CO: Prize Paper for “Grounding System Design for Isolated Locations and Plant Systems”

PCIC, St. Louis, MO: First place for "Lightning, Grounding, and Protection for Distributed Control and Communications Systems: A Retrofit".

Publications

Electrical Engineering in a Nutshell, Dr. Robert A Durham, Dr. Marcus O. Durham, ISBN 978-1466236795, 2011

Electrical Failure Analysis for Fire and Incident Investigations, Marcus O. Durham, Robert A. Durham, Rosemary Durham, Jason Coffin, ISBN 978-1463773472, 2011

Leadership and Success in Relationships and Communication, Marcus O. Durham and Robert A Durham, ISBN 978-1463758769, 2011

Leadership and Success in Organizations, Culture & Ethics: Group or Horizontal Interactions, Marcus O. Durham and Robert A Durham, ISBN 978-1466250338, 2011

Leadership and Success in Economics, Law & Technology: Society or External Influence, Marcus O. Durham and Robert A Durham, OK, ISBN 978-1466250461, 2011

How Should Generating Asset Acquisitions by Regulated, Vertically Integrated Utilities be Overseen in Today's Quasi-Regulated Electric Utility Environment? A Dissertation Presented to the Faculty of the School of Engineering Kennedy-Western University, KWU Press, Thousand Oaks, CA, 2004

R. A. Durham, M. O. Durham and T. W. Gillaspie, "Lightning Protection at Petrochemical Facilities - Part 3 Alternative Systems," *2022 IEEE Petroleum and Chemical Industry Committee Conference (PCIC)*, Denver, CO 2021.

R. A. Durham, M. O. Durham and T. W. Gillaspie, "Lightning Protection at Petrochemical Facilities - Part 2 Standards Requirements," *2021 IEEE Petroleum and Chemical Industry Committee Conference (PCIC)*, San Antonio, TX, 2021.

R. A. Durham, M. O. Durham and T. W. Gillaspie, "Petrochemical Facility Lightning Protection Primer: Part 1: History and Basic Science," in *IEEE Industry Applications Magazine*, vol. 27, no. 2, pp. 47-56, March-April 2021, doi: 10.1109/MIAS.2020.3024492.

R. A. Durham, S. J. Szczecinski and M. O. Durham, "Factors Impacting Selection of Grounding and Bonding Conductors," in *IEEE Transactions on Industry Applications*, vol. 56, no. 5, pp. 4652-4661, Sept.-Oct. 2020, doi: 10.1109/TIA.2020.3005637.

R. A. Durham, M. O. Durham and T. W. Gillaspie, "Lightning Protection at Petrochemical Facilities - Part 1 History and Background Science," *2019 IEEE Petroleum and Chemical Industry Committee Conference (PCIC)*, Vancouver, BC, Canada, 2019, pp. 205-214, doi: 10.1109/PCIC30934.2019.9074531.

R. A. Durham, S. J. Szczecinski and M. O. Durham, "Grounding and Bonding Conductors: Solid, Stranded, Bare or Insulated?: Copyright Material IEEE, Paper No. PCIC-2018-03," *2018 IEEE Petroleum and Chemical Industry Technical Conference (PCIC)*, Cincinnati, OH, USA, 2018, pp. 19-28, doi: 10.1109/PCIC31437.2018.9080442.

F. P. Feletto, R. Durham, E. Bortoni and J. Costa, "IMPROVENT OF MV CASCADED H BRIDGE INVERTER (CHBI) VFD AVAILABILITY FOR HIGH POWER ESP OIL WELLS," in *IEEE Transactions on Industry Applications*.
doi: 10.1109/TIA.2018.2866481

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8443149&isnumber=4957013>

F. Feletto, R. A. Durham, E. da Costa Bortoni and J. G. C. Costa, "Techniques to improve MV cascaded H bridge inverter (CHBI) VFDs availability applied to drive high power esp oil wells," *2017 Petroleum and Chemical Industry Technical Conference (PCIC)*, Calgary, AB, Canada, 2017, pp. 363-370.

doi: 10.1109/PCICON.2017.8188756

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8188756&isnumber=8188605>

R. A. Durham, M. Azambuja, F. P. Feleto and M. O. Durham, "PD testing of motors for hostile environments," *2015 IEEE Petroleum and Chemical Industry Committee Conference (PCIC)*, Houston, TX, 2015, pp. 1-8.

doi: 10.1109/PCICON.2015.7435106

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=7435106&isnumber=7435079>

Durham, Robert A.; Brinner, Thomas R., "Oilfield electric power distribution," *Petroleum and Chemical Industry Technical Conference (PCIC)*, 2014 IEEE , vol., no., pp.429,442, 8-10 Sept. 2014 doi: 10.1109/PCICon.2014.6961908

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6961908&isnumber=6961868>

Durham, Robert; Durham, M.O. "What Does Grounding Have To Do with Fire & Injury", *Fire Protection* vol 40 no 2, Fire Protection Association of Southern Africa, June 2014.

Durham, M.O.; Durham, R.A., "Does a Unified Energy Equation Contain the Higgs Field?," *Access*, IEEE , vol.1, no., pp.505,508, 2013

doi: 10.1109/ACCESS.2013.2276623

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6574202&isnumber=6336544>

Durham, R.A.; Durham, M.O.; , "Does Corrugated Tubing +Lightning =Catastrophic Failure?," *Industry Applications, IEEE Transactions on* , vol.48, no.4, pp.1243-1250, July-Aug. 2012

doi: 10.1109/TIA.2012.2200069

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6202685&isnumber=6238414>

Durham, R.A.; Durham, M.O.; , "Lightning, grounding, and protection for control and communications systems: Re-evaluated," *Petroleum and Chemical Industry Conference Europe Conference Proceedings (PCIC EUROPE)*, 2011 , vol., no., pp.1-11, 7-9 June 2011

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5936962&isnumber=5936950>

Durham, M.O.; Durham, R.A.; , "Lightning dangers on corrugated tubing carrying hydrocarbons," *Petroleum and Chemical Industry Conference (PCIC)*, 2010 *Record of Conference Papers Industry Applications Society 57th Annual* , vol., no., pp.1-9, 20-22 Sept. 2010 doi: 10.1109/PCIC.2010.5666860

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5666860&isnumber=5666816>

Brinner, T. R.; Durham, R. A.; , "Transient-Voltage Aspects of Grounding," *Industry Applications, IEEE Transactions on* , vol.46, no.5, pp.1796-1804, Sept.-Oct. 2010

doi: 10.1109/TIA.2010.2059551

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5523987&isnumber=5577442>

"CSST Response to Lightning and Transients – A Technical Analysis", Marcus O Durham and Robert A Durham, *Fire & Arson Investigator*, July 2009 Vol 60, No 1.

Brinner, T.R.; Durham, R.A.; , "Transient voltage aspects of grounding," *Petroleum and Chemical Industry Technical Conference, 2008. PCIC 2008. 55th IEEE* , vol., no., pp.1-9, 22-24

Sept. 2008

doi: 10.1109/PCICON.2008.4663969

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4663969&isnumber=4663961>

Durham, M.O.; Durham, R.A.; Hulett, R.H.; , "History and Development of IEEE Standards for Downhole Cable," *Industry Applications, IEEE Transactions on* , vol.43, no.2, pp.436-443, March-april 2007

doi: 10.1109/TIA.2006.890022

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4132867&isnumber=4132857>

Durham, R.A.; Durham, M.O.; , "What to do when Things go Wrong an Ethical Solution," *Petroleum and Chemical Industry Technical Conference, 2007. PCIC '07. IEEE* , vol., no., pp.1-7, 17-19 Sept. 2007

doi: 10.1109/PCICON.2007.4365790

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4365790&isnumber=4365767>

Durham, M.O.; Durham, R.A.; , "Data quality and grounding," *Industry Applications Magazine, IEEE* , vol.12, no.3, pp. 67- 73, May-June 2006

doi: 10.1109/MIA.2006.1628848

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1628848&isnumber=34165>

Durham, M.O.; Durham, R.A.; Hulett, R.; , "Submersible cable standards history newly revised," *Petroleum and Chemical Industry Conference, 2005. Industry Applications Society 52nd Annual* , vol., no., pp. 189- 197, 12-14 Sept. 2005

doi: 10.1109/PCICON.2005.1524554

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1524554&isnumber=32590>

Durham, M.O.; Durham, R.A.; , "Cathodic Protection: Consequences and Standards From Using CP Systems to Prevent Corrosion"

Industry Applications Magazine, IEEE , vol.11, no.1, pp. 41- 47, Jan-Feb 2005

doi: 10.1109/MIA.2005.1380326

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1380326&isnumber=30100>

Durham, M.O.; Durham, R.A.; , "Data quality and grounding considerations in a mixed-use facility," *Petroleum and Chemical Industry Technical Conference, 2004. Fifty-First Annual Conference 2004* , vol., no., pp. 1- 7, 13-15 Sept. 2004

doi: 10.1109/PCICON.2004.1352768

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1352768&isnumber=29719>

Durham, R.A.; Durham, M.O.; , "Covering all the bases - industrial power system design in a utility environment," *Industry Applications Magazine, IEEE* , vol.9, no.6, pp. 14- 20, Nov.-Dec. 2003

doi: 10.1109/MIA.2003.1245791

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1245791&isnumber=27919>

Durham, R.A.; Durham, M.O.; , "Corrosion impact of cathodic protection on surrounding structures," *Petroleum and Chemical Industry Conference, 2003. Record of Conference Papers. IEEE Industry Applications Society 50th Annual* , vol., no., pp. 303- 309, 15-17 Sept. 2003
doi: 10.1109/PCICON.2003.1242626

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1242626&isnumber=27844>

Durham, M.O.; Durham, K.D.; Durham, R.A.; , "TVSS designs," *Industry Applications Magazine, IEEE* , vol.8, no.5, pp. 31- 36, Sep/Oct 2002
doi: 10.1109/MIA.2002.1028388

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1028388&isnumber=22082>

Durham, M.O.; Durham, R.A.; Durham, K.D.; , "Applications engineering approach to Maxwell and other mathematically intense problems," *Petroleum and Chemical Industry Conference, 2002. Industry Applications Society 49th Annual* , vol., no., pp. 31- 38, 2002
doi: 10.1109/PCICON.2002.1044982

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1044982&isnumber=22397>

Durham, M.O.; Durham, R.A.; , "Ground systems design considerations for vessels [in petroleum industry]," *Industry Applications Magazine, IEEE* , vol.7, no.6, pp.41-49, Nov/Dec 2001
doi: 10.1109/2943.959115

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=959115&isnumber=20727>

Durham, R.A.; Durham, M.O.; , "Industrial design application for power distribution over extra-long distances," *Petroleum and Chemical Industry Conference, 2001. IEEE Industry Applications Society 48th Annual* , vol., no., pp.217-224, 2001
doi: 10.1109/PCICON.2001.960556

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=960556&isnumber=20752>

Durham, M.O.; Durham, R.A.; Durham, K.D.; , "2," *Petroleum and Chemical Industry Conference, 2000. Record of Conference Papers. Industry Applications Society 47th Annual* , vol., no., pp.207-215, 2000
doi: 10.1109/PCICON.2000.882777

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=882777&isnumber=19100>

Durham, R.A.; Durham, M.O.; , "Electric re-regulation impact," *Industry Applications Magazine, IEEE* , vol.5, no.5, pp.47-56, Sep/Oct 1999
doi: 10.1109/2943.783122

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=783122&isnumber=16987>

Durham, M.O.; Durham, R.A.; , "Interaction and design of grounded systems for tanks and vessels ," *Petroleum and Chemical Industry Conference, 1999. Industry Applications Society 46th Annual* , vol., no., pp.195-202, 1999
doi: 10.1109/PCICON.1999.806437

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=806437&isnumber=17478>

Durham, M.O.; Durham, R.A.; Anderson, D.; , "What are standardized equations for acceptance of hi-pot tests and for voltage drop?," *Petroleum and Chemical Industry Conference, 1998. Industry Applications Society 45th Annual* , vol., no., pp.281-287, 28-30 Sep 1998
doi: 10.1109/PCICON.1998.727989
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=727989&isnumber=15690>

Durham, M.O.; Durham, R.A.; , "Changing paradigms for engineering," *Industry Applications Magazine, IEEE* , vol.4, no.2, pp.52-60, Mar/Apr 1998
doi: 10.1109/2943.655661
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=655661&isnumber=14297>

Durham, R.A.; Durham, M.O.; , "Electric re-regulation and effects on industrial customers," *Petroleum and Chemical Industry Conference, 1997. Record of Conference Papers. The Institute of Electrical and Electronics Engineers Incorporated Industry Applications Society 44th Annual* , vol., no., pp.69-78, 15-17 Sep 1997
doi: 10.1109/PCICON.1997.648168
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=648168&isnumber=14127>

Durham, M.O.; Durham, R.A.; , "Grounding system design for isolated locations and plant systems ," *Industry Applications, IEEE Transactions on* , vol.33, no.2, pp.374-382, Mar/Apr 1997
doi: 10.1109/28.567998
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=567998&isnumber=12339>

Durham, M.O.; Durham, R.A.; , "Paradigm shifts and impact on industry and technology [R&D management]," *Petroleum and Chemical Industry Conference, 1996, Record of Conference Papers. The Institute of Electrical and Electronics Engineers Incorporated Industry Applications Society 43rd Annual* , vol., no., pp.27-35, 23-25 Sep 1996
doi: 10.1109/PCICON.1996.564859
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=564859&isnumber=12267>

Durham, M.O.; Durham, R.A.; , "Grounding system design for isolated locations and plant systems ," *Petroleum and Chemical Industry Conference, 1995. Record of Conference Papers., Industry Applications Society 42nd Annual* , vol., no., pp.145-153, 11-13 Sep 1995
doi: 10.1109/PCICON.1995.523949
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=523949&isnumber=11530>

Durham, M.O.; Durham, R.A.; , "Lightning, grounding and protection for control systems," *Industry Applications, IEEE Transactions on* , vol.31, no.1, pp.45-54, Jan/Feb 1995
doi: 10.1109/28.363051
URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=363051&isnumber=8319>.

Durham, M.O.; Durham, R.A.; , "Lighting, grounding, and protection for distributed control and communications systems: a retrofit," *Petroleum and Chemical Industry Conference, 1993, Record of Conference Papers. The Institute of Electrical and Electronics Engineers*

Incorporated. Industry Applications Society 40th Annual , vol., no., pp.293-302, 13-15 Sep 1993
doi: 10.1109/PCICON.1993.337392

URL: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=337392&isnumber=7922>

“Generalized Electrical Failures”, Durham, R.A., Durham, M.O., Coffin, J.A. *Proceedings of 46th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2013.

“Common Ways your Electrical Installation does you Harm”, Durham, R.A., Durham, M.O., Coffin, J.A. *Proceedings of 44th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2011.

“Ignition or Shock, is Grounding the Culprit?”, Marcus O Durham, Robert A Durham, Rosemary Durham, Jason A. Coffin, *Proceedings of 43rd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2010.

“Unraveling the Myths of Low Energy Ignition”, Marcus O Durham, Robert A Durham, Curtis L. Ozment, Jason A. Coffin, *Proceedings of 42nd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2009.

“Lightning, Transient & High Frequency Impact on Material Such As Corrugated Tubing”, Marcus O. Durham & Robert Durham, *Proceedings of 41st Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2008.

“Lightning Damage an Act of God, or Act of Negligence?”, Marcus O. Durham, Robert Durham, Randall Overton, Curtis Ozment, *Proceedings of 40th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2007.

“The Flat Earth Society Perception of Grounding”, Marcus O. Durham & Robert Durham, *Proceedings of 39th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2006.

"The IEEE Standards Process, A Case Study", Marcus O. Durham & Robert Durham, *Proceedings of 38th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2005.

"Engineering Management: A Course For Survival", Marcus O. Durham, Robert A. Durham, & Rosemary Durham, *American Society of Engineering Educators*, Pittsburg, KS 2004.

"Eleven Ground Systems and Connections", Marcus O. Durham & Robert Durham, *Proceedings of 37th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2004.

"Engineering Management, An Oxymoron?", Marcus O. Durham, Robert Durham & Rosemary Durham, *Proceedings of 37th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2004.

"Corrosion and Electrical Safety", Marcus O. Durham & Robert Durham, *Proceedings of 36th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2003.

"Applications Engineers Don't Do Hairy Math", Marcus O. Durham, Robert A. Durham, and Karen D. Durham, *Proceedings of 35th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2002.

"Tests and Correlations for TVSS", Marcus O. Durham, Karen Durham, and Robert Durham, *Proceedings of 34th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2001.

"Grounding Systems Interaction," Robert A. Durham and Marcus O. Durham, *Proceedings of 33rd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2000.

"A Cost Effective, Numeric Technique for Projecting Quality of Insulation and Impending Failures," Marcus O. Durham and Robert A. Durham, *Proceedings of 33rd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2000.

"An Engineering Selection for Size of Long Conductors Considering Factors in Addition to NEC," Marcus O. Durham and Robert A. Durham, *Proceedings of 33rd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 2000.

"Grounding Systems Interaction," Robert A. Durham and Marcus O. Durham, *Proceedings of 32nd Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 1999.

"Can Electrical Insulation and Conductor Performance Be Predicted?" Marcus O. Durham and Robert A. Durham, *Proceedings of Production Operations Symposium*, SPE 52161, Oklahoma City, OK, March 1999

"Engineering Paradigms: Change, Opportunity and Benefit," Robert A. Durham and Marcus O. Durham, *Proceedings of 31st Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 1998.

"Electric Re-regulation and Impact on Users," Robert A. Durham and Marcus O. Durham, *Proceedings of 30th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 1997.

"Remote Transmitter and Distributed Control Grounding and System Protection," Robert A. Durham and Marcus O. Durham, *Proceedings of 27th Annual Frontiers in Power Conference*, OSU, Stillwater, OK, October 1994.

Robert A Durham, PhD, PE
Expert Witness
Previous Four Years from February 14, 2023

Attorney	Case	Location	Issue	
Denton Law	Robbins v. Madewell	Mayes County, OK	Fire / injury	Trial
Baker Botts	IPR 2023-00558	USPTA PTAB	Intellectual Property	Depo
Haynes Boone	Nabors v. Helmerich & Payne et al	Northern District, TX	Intellectual Property	Trial
McDermott Will & Emery LLP	Halliburton V. U.S. Well Services	Western District, TX	Intellectual Property	Trial
Jones, Oten & Jewell	Davis v. Tapp	Garfield County, OK	Fire / Injury	Trial
Haynes & Boone	Nabors Driling v. Helmerich & Payne et al	Northern District, TX	Intellectual Property	Depo
Mattingly Law	Fulton v. Aviagen et al	Muskogee County, OK	Building Codes	Trial
Baker Botts	US Well Services v. Halliburton	Western District, TX	Intellectual Property	Depo
Kelly, Morgan	Montanez v. Deepwell Energy Svcs	Ector County, TX	Flash Fire / Injury	Depo
Baker Botts	IPR 2021-01316	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01238	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01315	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01065	USPTO PTAB	Intellectual Property	Depo
Clancy & Thompson	Borth v. Phillips & Sons Trucking et al	Canadian County, OK	Injury	Depo
Baker Botts	IPR 2021-01034	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01033	USPTO PTAB	Intellectual Property	Depo
Baker Botts	IPR 2021-01032	USPTO PTAB	Intellectual Property	Depo
Stephen Jones	Davis v. Tapp	Garfield County	Fire / Injury	Depo

Kelly, Morgan	Calvillo v. On Point	Travis County, TX	Flash Fire / Injury	Depo
Hartline Barger	Ramirez v. Home Depot	Southern District, TX	Electrical Failure / Fire	Depo
Mcafee & Taft	Hale v. Southeast Colorado Power Association	Baca County, CO	Electrical Failure / Fire	Depo
Hartline Barger	Siqueros v. Templo Monte Horeb et al	El Paso County, TX	Injury	Depo
Naman, Howell	Lentz v Brenntag Pacific et al	Upton County, TX	Flash Fire / Injury	Depo
Craft Law Firm	Cason v. Cimarex et al	Victoria County, TX	Flash Fire / Injury	Depo
Naman, Howell	Lentz v Brenntag Pacific et al	Upton County, TX	Flash Fire / Injury	Depo