

UNITED STATES PATENT AND TRADEMARK OFFICE
PATENT TRIAL AND APPEAL BOARD

HALLIBURTON ENERGY SERVICES, INC.
Petitioner

v.

U.S. WELL SERVICES, LLC
Patent Owner

Case No. IPR2023-00557
Patent No. 9,650,871

DECLARATION OF DR. ROBERT DURHAM

TABLE OF CONTENTS

INTRODUCTION.....	14
I. EXPERIENCE AND QUALIFICATIONS.....	14
II. TASK SUMMARY AND MATERIALS REVIEWED	19
III. LIST OF EXHIBITS.....	20
IV. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE	25
V. LEGAL STANDARDS	26
A. Level of Ordinary Skill in the Art.....	26
B. Legal Standard for Claim Construction	27
C. Anticipation.....	29
D. Obviousness	29
E. Priority Date	32
VI. OVERVIEW OF THE CHALLENGED PATENT	34
A. The Subject Matter of the Challenged Patent	34
B. The Challenged Claims of the '871 Patent	37
C. Prosecution History of the '871 Patent	41
a. Originally Filed Claims on July 22, 2016	41
b. USPTO Examiner Issues Office Action on November 29, 2016.....	46
c. Response to Office Action on February 28, 2017.....	47
d. Notice of Allowance on March 28, 2017	48
D. Priority Date of the '871 Patent	48
E. Comparison of Asserted References to Prior Art Discussed During Prosecution.....	50
VII. LEVEL OF ORDINARY SKILL IN THE ART	51
VIII. CLAIM CONSTRUCTION	51
A. "Frequently Performs" (Claim 1).....	51
IX. TECHNOLOGY BACKGROUND AND STATE OF THE ART	52
A. Exemplary References Corroborating the General Engineering Knowledge	52

a. Roe (Ex. 1010)	52
b. EE-Reference (Ex. 1009)	55
B. Basic Electric Systems	56
C. Alternating Current (AC) systems	61
D. Electric Motors.....	64
E. Adjustable Speed Drives / Variable Frequency Drives	65
F. Electric Motor Diagnostics to Prevent Damage to the Electric Motor.....	67
a. NEMA ICS-61800-4 (Ex. 1012) corroborates general engineering knowledge regarding ASDs/VFDs.....	67
b. Horikoshi (Ex. 1011) corroborates general engineering knowledge regarding ASDs/VFDs.....	73
G. Signal Assemblies	75
H. Background on E-Kill	88
X. OVERVIEW OF THE PRIOR ART.....	92
A. <i>Payne</i> (Ex. 1004).....	92
a. Status of <i>Payne</i>	92
b. Overview of the Disclosure of <i>Payne</i>	93
B. Toshiba Manual (Ex. 1005)	94
a. Prior Art Status of Toshiba Manual	94
b. Overview of the Disclosure of Toshiba Manual	96
C. Broussard (Ex. 1006)	109
a. Status of <i>Broussard</i>	109
b. Overview of the Disclosure of <i>Broussard</i>	109
D. Feller (Ex. 1008)	110
a. Status of <i>Feller</i>	110
b. Overview of the Disclosure of <i>Feller</i>	110
E. Wiemers (Ex. 1009)	112
a. Status of <i>Wiemers</i>	112
b. Overview of the Disclosure of <i>Wiemers</i>	112

F.	Carlson (Ex. 1010)	114
a.	Status of <i>Carlson</i>	114
b.	Overview of the Disclosure of <i>Carlson</i>	114
G.	Randle (Ex. 1011)	115
a.	Status of <i>Randle</i>	115
b.	Overview of the Disclosure of <i>Randle</i>	115
XI.	GROUND 1-2: ANTICIPATION BY PAYNE AND OBVIOUSNESS OVER PAYNE	116
A.	Independent Claim 1	117
a.	1[pre]: A hydraulic fracturing system for fracturing a subterranean formation comprising:	117
b.	1[a] a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor, and configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation, and fractures the formation;	117
c.	1[b] a variable frequency drive connected to the electric motor to control the speed of the motor, ...	119
d.	1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;	120
e.	1[d] a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.	124
B.	Dependent Claim 2	131
a.	2. The hydraulic fracturing system of claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack.	131
C.	Dependent Claim 3	132
D.	Dependent Claim 4	132
a.	4. The hydraulic fracturing system of claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.	132

E.	Dependent Claim 5.....	135
a.	5. The hydraulic fracturing system of claim 1, wherein the operational states of the hydraulic fracturing system comprise, [i] no electricity to the system, [ii] a supply of electricity to all electrically powered devices in the system, [iii] a supply of electricity to some of the electrically powered devices in the system, and [iv] a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.....	135
F.	Dependent Claim 6.....	140
a.	6. The hydraulic fracturing system of claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of one of the pumps, and the signal assembly.	140
G.	Dependent Claim 7.....	143
a.	7. The hydraulic fracturing system of claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.....	143
H.	Dependent Claim 8.....	144
a.	8. The hydraulic fracturing system of claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.....	144
I.	Independent Claim 9	146
a.	9[pre] A hydraulic fracturing system for fracturing a subterranean formation comprising:	146
b.	9[a] a pump having a discharge in communication with a wellbore that intersects the formation;	147
c.	9[b] an electric motor coupled to and that drives the pump;	147
d.	9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;	148

e. 9[d] a signal assembly that selectively emits different visual signals that are distinctive of an operational state of the system; and	148
f. 9[e] a controller in communication with the signal assembly, and that selectively transmits a command signal to the signal assembly in response to a monitoring signal received by the controller and transmitted from a device in the system.	148
J. Dependent Claim 10.....	149
a. The hydraulic fracturing system of claim 9, wherein the device in the system that transmits the monitoring signal to the controller comprises one of the variable frequency drive, and a pressure monitor in fluid communication with the discharge of the pump.	149
K. Dependent Claim 11.....	149
a. 11. The hydraulic fracturing system of claim 9, wherein the signal assembly comprises a stack of light assemblies.....	149
L. Dependent Claim 12.....	149
a. 12. The hydraulic fracturing system of claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.	149
M. Dependent Claim 13.....	150
a. 13[a] The hydraulic fracturing system of claim 9 further comprising a pump controller and auxiliary equipment, and	150
b. 13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.	152
N. Dependent Claim 14.....	155
a. 14. The hydraulic fracturing system of claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for	

operations personnel, and when the system is currently unsafe for operations personnel.	155
O. Independent Claim 15	159
a. 15[pre] A method of fracturing a subterranean formation comprising:	159
b. 15[a] pressurizing fracturing fluid with a pump	159
c. 15[b] driving the pump with a motor that is powered by electricity	160
d. 15[c] controlling the speed of the motor with a variable frequency drive, ...	160
e. 15[d] the variable frequency drive further performing electric motor diagnostics;	160
f. 15[e] monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and	160
g. 15[f] selectively emitting a visual signal that is indicative of the monitored operational state.	162
P. Dependent Claim 16.....	162
a. 16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.	162
Q. Dependent Claim 17.....	163
a. 17. The method of claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.	163
R. Dependent Claim 18.....	164
a. 18[a] The method of claim 15, further comprising monitoring electricity to a variable frequency drive, ...	164
b. 18[b] wherein the variable frequency drive controls electricity to the motor.	164

S.	Dependent Claim 19.....	166
a.	19. The method of claim 15, further comprising monitoring a fluid pressure of discharge of the pump.....	166
XII.	GROUND 3A: OBVIOUSNESS OVER PAYNE IN VIEW OF TOSHIBA MANUAL	166
A.	Reasons to Combine <i>Payne</i> with <i>Toshiba Manual</i>	166
B.	Independent Claim 1	169
a.	1[b] a variable frequency drive connected to the electric motor to control the speed of the motor,.....	169
b.	1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;.....	170
c.	1[d] a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.....	171
C.	Dependent Claim 6.....	172
a.	6. The hydraulic fracturing system of claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of one of the pumps, and the signal assembly.	172
D.	Dependent Claim 7.....	172
a.	7. The hydraulic fracturing system of claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.....	172
E.	Independent Claim 9	173
a.	9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;.....	174
F.	Independent Claim 15	174
a.	15[c] controlling the speed of the motor with a variable frequency drive,.....	174

b. 15[d] the variable frequency drive further performing electric motor diagnostics;	175
c. 15[e] monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and	175
G. Dependent Claim 18.....	176
a. 18[a] The method of claim 15, further comprising monitoring electricity to a variable frequency drive,.....	176
XIII. GROUND 3B: OBVIOUSNESS OVER PAYNE IN VIEW OF BROUSSARD	177
A. Reasons to Combine <i>Payne</i> with <i>Broussard</i>	178
B. Independent Claim 1	179
a. 1[b] a variable frequency drive connected to the electric motor to control the speed of the motor,.....	179
b. 1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;.....	179
C. Independent Claim 9	179
a. 9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;	180
D. Independent Claim 15	180
a. 15[c] controlling the speed of the motor with a variable frequency drive,.....	180
b. 15[d] the variable frequency drive further performing electric motor diagnostics;	180
XIV. GROUND 4: OBVIOUSNESS OVER PAYNE IN VIEW OF FELLER.....	180
A. Reasons to Combine <i>Payne</i> with <i>Feller</i>	181
B. Dependent Claim 2.....	182
a. 2. The hydraulic fracturing system of claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack.....	182
C. Dependent Claim 3.....	184

a. 3. The hydraulic fracturing system of claim 2, wherein each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies.	184
D. Dependent Claim 4.....	184
a. 4. The hydraulic fracturing system of claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.	184
E. Dependent Claim 11.....	187
a. 11. The hydraulic fracturing system of claim 9, wherein the signal assembly comprises a stack of light assemblies.	187
F. Dependent Claim 12.....	187
a. 12. The hydraulic fracturing system of claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.	187
G. Dependent Claim 17.....	187
a. 17. The method of claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.	187
XV. GROUND 4A AND 4B: OBVIOUSNESS OVER PAYNE IN VIEW OF TOSHIBA MANUAL AND FELLER; AND OBVIOUSNESS OVER PAYNE IN VIEW OF BROUSSARD AND FELLER.....	188
A. Reasons to Combine <i>Payne</i> with <i>Toshiba Manual</i> and <i>Feller</i>	188
B. Reasons to Combine <i>Payne</i> with <i>Broussard</i> and <i>Feller</i>	188
C. Dependent Claims 2, 3, 4, 11, 12, 17	189
XVI. GROUND 5: OBVIOUSNESS OVER PAYNE IN VIEW OF WIEMERS	189
A. Reasons to Combine <i>Payne</i> with <i>Wiemers</i>	189
B. Dependent Claim 5.....	191

a. 5. The hydraulic fracturing system of claim 1, wherein the operational states of the hydraulic fracturing system comprise, [i] no electricity to the system, [ii] a supply of electricity to all electrically powered devices in the system, [iii] a supply of electricity to some of the electrically powered devices in the system, and [iv] a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.....	191
C. Dependent Claim 13.....	194
a. 13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.	194
D. Dependent Claim 16.....	194
a. 16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.	194
XVII. GROUNDS 5A AND 5B: OBVIOUSNESS OVER PAYNE IN VIEW OF TOSHIBA MANUAL AND WIEMERS; AND OBVIOUSNESS OVER PAYNE IN VIEW OF BROUSSARD AND WIEMERS	195
A. Reasons to Combine <i>Payne</i> with <i>Toshiba Manual</i> and <i>Wiemers</i>	195
B. Reasons to Combine <i>Payne</i> with <i>Broussard</i> and <i>Wiemers</i>	196
C. Dependent Claim 5.....	196
XVIII.GROUND 6: OBVIOUSNESS OVER PAYNE IN VIEW OF CARLSON.....	196
A. Reasons to Combine <i>Payne</i> with <i>Carlson</i>	197
B. Dependent Claim 8.....	198
a. 8. The hydraulic fracturing system of claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone	

that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.....	198
C. Dependent Claim 14.....	199
a. 14. The hydraulic fracturing system of claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for operations personnel, and when the system is currently unsafe for operations personnel.	199
XIX. GROUNDS 6A AND 6B: OBVIOUSNESS OVER PAYNE IN VIEW OF <i>TOSHIBA MANUAL</i> AND <i>CARLSON</i>; AND OBVIOUSNESS OVER PAYNE IN VIEW OF <i>BROUSSARD AND CARLSON</i>	200
A. Reasons to Combine <i>Payne</i> with <i>Toshiba Manual</i> and <i>Carlson</i>	200
B. Reasons to Combine <i>Payne</i> with <i>Broussard</i> and <i>Carlson</i>	201
C. Dependent Claims 8 and 14	201
XX. GROUND 7: OBVIOUSNESS OVER PAYNE IN VIEW OF <i>RANDLE</i>	201
A. Reasons to Combine <i>Payne</i> with <i>Randle</i>	202
B. Dependent Claim 13.....	204
a. 13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.	204
C. Dependent Claim 16.....	205
a. 16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.	205
XXI. GROUNDS 7A AND 7B: OBVIOUSNESS OVER PAYNE IN VIEW OF <i>TOSHIBA MANUAL</i> AND <i>RANDLE</i>; AND	

OBVIOUSNESS OVER <i>PAYNE</i> IN VIEW OF <i>BROUSSARD</i> AND <i>RANDLE</i>	205
A. Reasons to Combine <i>Payne</i> with <i>Toshiba Manual</i> and <i>Randle</i>	205
B. Reasons to Combine <i>Randle</i> with <i>Broussard</i> and <i>Carlson</i>	206
C. Dependent Claims 13 and 16	206
XXII. SECONDARY CONSIDERATIONS	206
XXIII.CONCLUSION	207

INTRODUCTION

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

2. I have been asked to provide technical assistance in the inter partes review of U.S. Patent No. 9,650,871, which I may abbreviate as “the ’871 Patent” or refer to as the “Challenged Patent.” This declaration is a statement of my opinions on issues related to the unpatentability of claims of the ’871 Patent. I am being compensated at my normal 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.

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

13. I have been familiar with 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, including establishing policies and procedures commensurate with OSHA requirements at all locations, including requirement for oil and gas sites.

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 30 years, and scholarly books and publications, I am an expert in the relevant field of the Challenged Patent at issue here and have been an expert in this field since before the Challenged 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 ’871 Patent at the time of its filing.

II. TASK SUMMARY AND MATERIALS REVIEWED

16. I have been asked to review the Challenged Patent and its prosecution history, to provide an understanding of the technology relevant to the Challenged

Patent, to review certain prior-art references, and analyze whether or not those references disclose or teach limitations of claims from the Challenged Patent. The opinions stated in this declaration are from the perspective of a person of ordinary skill in the art (POSITA).

III. LIST OF EXHIBITS

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

Ex.	Description
1001	U.S. Patent No. 9,650,871 by Jared Oehring <i>et al.</i> entitled “Safety Indicator Lights for Hydraulic Fracturing Pumps” (the “’871 Patent”)
1002	Declaration of Dr. Robert Durham
1003	File History for U.S. Patent No. 9,650,871
1004	U.S. Patent Publication No. 2016/0258267, Payne, <i>et al.</i> , “Well Fracturing Systems with Electrical Motors and Methods of Use,” (“Payne”) filed on March 3, 2016, and published on September 8, 2016
1005	Toshiba International Corporation, “G7 Adjustable Speed Drive Operation Manual,” Document No. 51546-009 (March 2005) (“Toshiba”), available at: https://web.archive.org/web/20101207173900/http://www.toshiba.com/ind/data/tag_files/GX7%20Operation%20Manual_3886.pdf
1006	Declaration of Nathaniel E. Frank-White, custodian of records for Internet Archive regarding Toshiba documents (May 27, 2022)

1007	U.S. Patent Publication No. 2014/0138079, Broussard, <i>et al.</i> , “System for Pumping Hydraulic Fracturing Fluid Using Electric Pumps,” (“ <i>Broussard</i> ”) filed on November 16, 2012 and published on May 22, 2014
1008	U.S. Patent Publication No. 2015/0198316 by Feller <i>et al.</i> , “Stack Light with Modular Function Generator,” (“ <i>Feller</i> ”) filed on January 13, 2014 and published on July 16, 2015
1009	U.S. Patent Publication No. 2015/0001161 by Wiemers <i>et al.</i> , “Liquid Treatment Station Including Plural Mobile Units and Methods for Operation Thereof,” (“ <i>Wiemers</i> ”) filed on July 1, 2013 and published on January 1, 2015
1010	U.S. Patent No. 6,006,227 by Carlson, “Blender Control System,” (“ <i>Carlson</i> ”) issued on December 28, 1999
1011	U.S. Patent Publication No. 2014/0290768 by Randle <i>et al.</i> , “Frac Pump Isolation Safety System,” (“ <i>Randle</i> ”) filed on March 27, 2013 and published on October 2, 2014
1012	U.S. Provisional Application No. 62/196,350 (“’350 Provisional”)
1013	U.S. Patent No. 9,410,410 by Broussard <i>et al.</i> entitled “System for Pumping Hydraulic Fracturing Fluid Using Electric Pumps” (the “’410 Patent”)
1014	U.S. Patent No. 5,865,247 by Paterson <i>et al.</i> entitled “Cellulose Injection System and Method” (“ <i>Paterson</i> ”) issued on Feb. 2, 1999
1015	U.S. Patent Publication No. 2008/0137266 by Jensen <i>et al.</i> , “Motor Control Center with Power and Data Distribution Bus,” (“ <i>Jensen</i> ”) filed on Sept. 29, 2006 and published on June 12, 2008
1016	U.S. Patent No. 8,789,601 by Broussard <i>et al.</i> entitled “System for Pumping Hydraulic Fracturing Fluid Using Electric Pumps” (“’610 Patent”) issued on July 29, 2014

1017	File History for U.S. Patent No. 9,410,410
1018	Lionel B. Roe, PRACTICES AND PROCEDURES OF INDUSTRIAL ELECTRICAL DESIGN (McGraw-Hill, New York: 1972), ISBN: 0-07-053390-3 (“Roe”)
1019	John A. Camera, ELECTRICAL ENGINEERING REFERENCE MANUAL, 6th ed. (Professional Publications, Inc., Belmont: 2002), ISBN: 1-888577-56-8 (“Camera”)
1020	Donald G. Fink, STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, 13 th ed. (McGraw-Hill, New York: 1993), ISBN: 0-07-020984-7 (“Fink”)
1021	U.S. Patent Publication No. 2011/0241590, Horikoshi, <i>et al.</i> , “Motor driving apparatus having fault diagnostic function,” (“ <i>Horikoshi</i> ”) filed on February 11, 2011 and published on October 6, 2011.
1022	National Electrical Manufacturers Association (NEMA) Standards Publication ICS 61800-4-2004, <i>Adjustable Speed Electrical Power Drive Systems, Part 4: General Requirements—Rating Specifications for a.c. Power Drive Systems above 1000 V a.c. and Not Exceeding 35 kV</i> (National Electrical Manufacturers Association: 2004) (“ICS-61800-4”)
1023	Turner P. Northern, “Automatic Lease Operations,” <i>Journal of Petroleum Technology</i> , vol. 6, no. 01, pp. 21-24, 1954, doi: 10.2118/283-g (“ <i>Northern</i> ”)
1024	Eugene C. Campbell, “Isolated Waterflood,” <i>PE Production Automation Symposium</i> , 1964, vol. All Days, SPE-856-MS, doi: 10.2118/856-ms (“ <i>Campbell</i> ”)
1025	H.J. Fitzgibbon, “Gas Well Automation,” <i>Journal of Petroleum Technology</i> , vol. 16, no. 08, pp. 873-876, 1964, doi: 10.2118/858-pa (“ <i>Fitzgibbon</i> ”)

1026	R.A. Hinchliffe, "The Solid State Pipeline Gauger," <i>Journal of Canadian Petroleum Technology</i> , vol. 5, no. 04, pp. 171-174, 1966, doi: 10.2118/66-04-03 ("Hinchliffe")
1027	Millard E. Owens & Bret R. Allard, "Installation and Operation Of Hydraulic Pumping Systems On Cook Inlet," <i>Offshore Technology Conference</i> , 1970, vol. All Days, OTC-1194-MS, doi: 10.4043/1194-ms ("Owens")
1028	M.P. Cleary, A.M. Burharali, A.R. Crockett, & I.A. Salehi, "Computerized Field System for Real-Time Monitoring and Analysis of Hydraulic Fracturing Operations," in <i>International Meeting on Petroleum Engineering</i> , 1986, vol. All Days, SPE-14087-MS, doi: 10.2118/14087-ms ("Cleary")
1029	H.L. Tomlinson, A.C. Byrd, & C.F. VanBerg, Jr., "Fracturing process control and automation," in <i>Permian Basin Oil and Gas Recovery Conference</i> , 1988 ("Tomlinson")
1030	S.O. Norris & K.S. Capps, "Reservoir Simulation with Simultaneous Graphic Display on the Macintosh II PC," <i>SPE Computer Applications</i> , vol. 2, no. 06, pp. 24-27, 1990, doi: 10.2118/20362-pa ("Norris")
1031	S.V. Stephenson, E.L. Woodall, C.D Donaghe, & R.E Dant, "Fracturing process control and automation: Phase 2," <i>Petroleum Computer Conference</i> , 1993 ("Stephenson")
1032	D.L. Purvis, R.J Novotny, & B.T Carlson, "Field-Applied Computerized Tracking System: A Practical Approach to On-Site Quality Control," <i>SPE Computer Applications</i> , vol. 3, no. 05, pp. 22-28, 1991 ("Purvis")
1033	Stephen Rassenfoss, "The Keywords for Blowout Preventers Are Trust But Verify," <i>Journal of Petroleum Technology</i> , vol. 64, no. 08, pp. 40-48, 2012, doi: 10.2118/0812-0040-JPT ("Rassenfoss")

1034	IEC 60073 (International Standard), Basic and Safety Principles for Man-Machine Interface, Marking and Identification – Coding Principles for Indicators and Actuators, 6th ed., 2002-05 (“IEC 60073”)
1035	NFPA 79, “Electrical Standard for Industrial Machinery” National Fire Protection Association, Quincy, Mass, 1962-2007 (“NFPA”)
1036	J. Pearson, “Proposed HSE guidelines on emergency shutdown systems,” 1989 A First International Conference on the Use of Programmable Electronic Systems in Safety Related Applications Computers and Safety, 1989, pp. 55-58 (“Pearson”)
1037	Bill Gilson, “Fast Response System for Large-Volume Acid Stimulation,” Paper presented at the Offshore Technology Conference, Houston, Texas, May 1996. doi: https://doi.org/10.4043/8096-MS (“Gilson”)
1038	Rex Burgos; Marc Allcorn; Robin Mallalieu; Jorge Vicens “Eliminating Human Error during Coiled Tubing Operations,” <i>SPE Production & Operations</i> 22 (03) (June 2006): 335–338. DOI: 10.2118/100164-PA (“Burgos”)
1039	J. J. Sammarco, “Programmable electronic and hardwired emergency shutdown systems: a quantified safety analysis,” Fortieth IAS Annual Meeting. Conference Record of the 2005 Industry Applications Conference, 2005., 2005, pp. 210-217 Vol. 1, doi: 10.1109/IAS.2005.1518312 (“Sammarco”)
1040	Kurz, Rainer, and Robert C. White, “Modeling Emergency Shutdowns of Centrifugal Compressors,” Paper presented at the PSIG Annual Meeting, Galveston, Texas, May 2009 (“Kurz”)
1041	[Intentionally Left Blank]
1042	K. Vidal, Memorandum Regarding Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation (June 21, 2022)

1043	<i>Halliburton Energy Servs., Inc. v. U.S. Well Servs., LLC</i> , No. 6:22-cv-00905-ADA, Dkt. 50 (W.D. Tex. Feb. 8, 2023) (Joint Motion for Entry of Scheduling Order)
1044	<i>Halliburton Energy Servs., Inc. v. U.S. Well Servs., LLC</i> , No. 6:22-cv-00905-ADA, Dkt. 50-1 (W.D. Tex. Feb. 8, 2023) (Scheduling Order)
1045	Onyx Industries, Command Tower Standard Configurations, available at https://web.archive.org/web/20150503091137/http://www.onyx-industries.com:80/Products.aspx (last accessed on Feb. 9, 2023)
1046	Onyx Industries, Stack Light Engineering Reference Guide, (Sept. 23, 2012), available at https://web.archive.org/web/20160304080801/http://www.onyx-industries.com/downloads/StackLightEngineeringReferenceGuide.pdf

Other than prosecution histories, Ex. 1003 and Ex. 1017, all citations to exhibits reference original page numbers found in the underlying document, and all emphases are added.

IV. SUMMARY OF CONCLUSIONS AND GROUNDS FOR CHALLENGE

18. After reviewing the materials identified in the List of Exhibits, I have concluded that each of the Challenged Claims of the '871 Patent would have been obvious to a person of ordinary skill in the art, based on the following grounds.

Ground	'871 Claims	Basis for Challenge
1	1-4, 6-7, 9-12, 15-17, 19	Anticipated by Payne
2	1-19	Obvious in view of Payne
3A	1-19	Obvious in view of Payne and Toshiba Manual
3B	1-19	Obvious in view of Payne and Broussard

Ground	'871 Claims	Basis for Challenge
4	2-4, 11-12, 17	Obvious in view of Payne and Feller
4A	2-4, 11-12, 17	Obvious in view of Payne, Toshiba Manual, and Feller
4B	2-4, 11-12, 17	Obvious in view of Payne, Broussard, and Feller
5	5, 13, 16	Obvious in view of Payne and Wiemers
5A	5, 13, 16	Obvious in view of Payne, Toshiba Manual, and Wiemers
5B	5, 13, 16	Obvious in view of Payne, Broussard, and Wiemers
6	8, 14	Obvious in view of Payne and Carlson
6A	8, 14	Obvious in view of Payne, Toshiba Manual, and Carlson
6B	8, 14	Obvious in view of Payne, Broussard, and Carlson
7	13, 16	Obvious in view of Payne and Randle
7A	13, 16	Obvious in view of Payne, Toshiba Manual, and Randle
7B	13, 16	Obvious in view of Payne, Broussard, and Randle

V. 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. *See* Ex. 1004 (Payne).

20. I have been instructed by counsel that the person of ordinary skill in the art (“**POSITA**”) is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor’s skill is not determinative of the level of ordinary skill. I further understand that the factors that may be considered in

determining the level of skill include: the types of problems encountered in the art; prior art solutions to those problems; rapidity with which innovations are made; sophistication of the technology; and educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

B. LEGAL STANDARD FOR CLAIM CONSTRUCTION

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

C. ANTICIPATION

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

D. OBVIOUSNESS

28. 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).

29. 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.

30. 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.

31. 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.

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

33. 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.

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

E. PRIORITY DATE

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

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

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

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

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

VI. OVERVIEW OF THE CHALLENGED PATENT

39. I have reviewed U.S. Patent No. 9,650,871 (“the ’871 Patent”), which is entitled “Safety Indicator Lights for Hydraulic Fracturing Pumps.” Ex. 1001. I understand that the patent was filed on July 22, 2016, and that it was issued on May 16, 2017. The ’871 Patent claims priority to several other documents, but as I discuss below in the “Priority Date of the ’871 Patent” section, those earlier documents do not provide support for all claim limitations of the ’871 Patent.

A. THE SUBJECT MATTER OF THE CHALLENGED PATENT

40. The ’871 Patent generally relates to hydraulic fracturing operations of subterranean formations. The ’871 Patent includes a section entitled “Description of Prior Art,” which is within a larger section entitled “Background of the

Invention.” Ex. 1001 (’871 Patent) at 1:23. The Description of Prior Art section discusses several known aspects of hydraulic fracturing, including known ingredients to form the hydraulic fracturing slurry (e.g., water, proppant (e.g., sand or ceramic), and other chemicals) and various units to manufacture that slurry and applying the slurry downhole to a wellbore:

Hydraulic fracturing is a technique used to stimulate production from Some hydrocarbon producing wells. The technique usually involves injecting fluid into a wellbore at a pressure sufficient to generate fissures in the formation surrounding the wellbore. Typically, the pressurized fluid is injected into a portion of the wellbore that is pressure isolated from the remaining length of the wellbore so that fracturing is limited to a designated portion of the formation. The fracturing fluid slurry, whose primary component is usually water, includes proppant (such as sand or ceramic) that migrate into the fractures with the fracturing fluid slurry and remain to prop open the fractures after pressure is no longer applied to the wellbore. A primary fluid for the slurry other than water, such as nitrogen, carbon dioxide, foam (nitrogen and water), diesel, or other fluids is sometimes used as the primary component instead of water. Typically, hydraulic fracturing fleets include a data van unit, blender unit, hydration unit, chemical additive unit, hydraulic fracturing pump unit, sand equipment, and other equipment.

Ex. 1001 (’871 Patent) at 1:24-42.

41. The ’871 Patent discusses that it was known that hydraulic fracturing is performed by pressurizing a slurry using “high pressure pumps powered by diesel engines.” Ex. 1001 (’871 Patent) at 1:43-45. A known problem with diesel engines, according to the ’871 Patent, was that they generate large amounts of “noise,

emissions, and vibrations.” Ex. 1001 (’871 Patent) at 1:56-59. The ’871 Patent discusses a known solution to on-site diesel engines: “Recently electrical motors controlled by variable frequency drives have been introduced to replace the diesel engines and transmissions, which greatly reduces the noise, emissions, and vibrations generated by the equipment during operation, as well as its size footprint.” Ex. 1001 (’871 Patent) at 1:56-60.

42. The ’871 Patent also describes as part of the prior art that “a closed circuit hydraulic fluid system is often used for operating auxiliary portions of each type of equipment” that is “separate and independent of the main hydraulic fracturing fluid slurry” Ex. 1001 (’871 Patent) at 1:61-63, 2:1-2. According to the ’871 Patent, the system includes “lines carrying the pressurized fluid from the [fracturing] pumps,” which “can fail without warning.” Ex. 1001 (’871 Patent) at 2:3-5. The ’871 Patent further explains:

Metal shrapnel or the high pressure fluid slurry from the failed discharge iron can cause personal injury to any personnel proximate the failure. While the best way to avoid personal injury is for operations personnel to avoid zones proximate the discharge iron, maintenance or inspection requires entry into these zones.

Ex. 1001 (’871 Patent) at 2:5-10.

43. The ’871 purports to improve safety and operation of a known hydraulic fracturing system through a “signal assembly.” Ex. 1001 (’871 Patent) at 2:14-52.

As I describe below, each component of the hydraulic fracturing system, including the “signal assembly” was well-known in the art.

B. THE CHALLENGED CLAIMS OF THE '871 PATENT

44. The Challenged Claims of the '871 Patent, which are Claims 1-19, are set forth below. Some of the claim elements have been further sub-divided for ease of reference.

Claim Element	Claim Language from '871 Patent
1[pre]	1. A hydraulic fracturing system for fracturing a subterranean formation comprising
1[a]	a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor, and configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation, and fractures the formation
1[b]	a variable frequency drive connected to the electric motor to control the speed of the motor,
1[c]	wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor; and
1[d]	a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.
2	2. The hydraulic fracturing system of claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack.

Claim Element	Claim Language from '871 Patent
3	3. The hydraulic fracturing system of claim 2, wherein each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies.
4	4. The hydraulic fracturing system of claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.
5	5. The hydraulic fracturing system of claim 1, wherein the operational states of the hydraulic fracturing system comprise, [i] no electricity to the system, [ii] a supply of electricity to all electrically powered devices in the system, [iii] a supply of electricity to some of the electrically powered devices in the system, and [iv] a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.
6	6. The hydraulic fracturing system of claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of a one of the pumps, and the signal assembly.
7	7. The hydraulic fracturing system of claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.
8	8. The hydraulic fracturing system of claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.
9[pre]	9. A hydraulic fracturing system for fracturing a subterranean formation comprising:

Claim Element	Claim Language from '871 Patent
9[a]	a pump having a discharge in communication with a wellbore that intersects the formation;
9[b]	an electric motor coupled to and that drives the pump;
9[c]	a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;
9[d]	a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;
9[e]	a controller in communication with the signal assembly, and that selectively transmits a command signal to the signal assembly in response to a monitoring signal received by the controller and transmitted from a device in the system.
10	10. The hydraulic fracturing system of claim 9, wherein the device in the system that transmits the monitoring signal to the controller comprises one of the variable frequency drive, and a pressure monitor in fluid communication with the discharge of the pump.
11	11. The hydraulic fracturing system of claim 9, wherein the signal assembly comprises a stack of light assemblies.
12	12. The hydraulic fracturing system of claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.
13[a]	13. The hydraulic fracturing system of claim 9 further comprising a pump controller and auxiliary equipment, and

Claim Element	Claim Language from '871 Patent
13[b]	wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.
14	14. The hydraulic fracturing system of claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for operations personnel, and when the system is currently unsafe for operations personnel.
15[pre]	15. A method of fracturing a subterranean formation comprising:
15[a]	pressurizing fracturing fluid with a pump;
15[b]	driving the pump with a motor that is powered by electricity;
15[c]	controlling the speed of the motor with a variable frequency drive,
15[d]	the variable frequency drive further performing electric motor diagnostics;
15[e]	monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and
15[f]	selectively emitting a visual signal that is indicative of the monitored operational state.
16	16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.

Claim Element	Claim Language from '871 Patent
17	17. The method of claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.
18[a]	18. The method of claim 15, further comprising monitoring electricity to a variable frequency drive,
18[b]	wherein the variable frequency drive controls electricity to the motor.
19	19. The method of claim 15, further comprising monitoring a fluid pressure of discharge of the pump.

C. PROSECUTION HISTORY OF THE '871 PATENT

45. In the subsections below, I summarize the prosecution history of the '871 Patent. As can be seen, all claims of the '871 Patent were allowed after all the independent claims were amended to recite “a variable frequency drive [that] perform[s] electric motor diagnostics.” The Applicant did not dispute that the remaining limitations of the claims were disclosed in the prior art.

a. Originally Filed Claims on July 22, 2016

46. What ultimately issued as the '871 Patent was filed on July 22, 2016 as Application No. 15/217,040. The application was originally filed with 19 claims: independent claim 1, dependent claims 2-8 (depending from claim 1), independent

claim 9, dependent claims 10-14 (depending from claim 9), independent claim 15, and dependent claims 16-19 (depending from claim 15). The text of the claims is copied below:

1. A hydraulic fracturing system for fracturing a subterranean formation comprising:

a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor, and configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation, and fractures the formation;

a variable frequency drive connected to the electric motor to control the speed of the motor, wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor; and

a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.
2. The hydraulic fracturing system of Claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack.
3. The hydraulic fracturing system of Claim 2, wherein each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies.
4. The hydraulic fracturing system of Claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.

5. The hydraulic fracturing system of Claim 1, wherein the operational states of the hydraulic fracturing system comprise, no electricity to the system, a supply of electricity to all electrically powered devices in the system, a supply of electricity to some of the electrically powered devices in the system, and a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.

6. The hydraulic fracturing system of Claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of a one of the pumps, and the signal assembly.

7. The hydraulic fracturing system of Claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.

8. The hydraulic fracturing system of Claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.

9. A hydraulic fracturing system for fracturing a subterranean formation comprising:

a pump having a discharge in communication with a wellbore that intersects the formation;

an electric motor coupled to and that drives the pump;

a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;

a signal assembly that selectively emits different visual signals that are distinctive of an operational state of the system; and

a controller in communication with the signal assembly, and that selectively transmits a command signal to the signal assembly in response to a monitoring signal received by the controller and transmitted from a device in the system.

10. The hydraulic fracturing system of Claim 9, wherein the device in the system that transmits the monitoring signal to the controller comprises one of the variable frequency drive, and a pressure monitor in fluid communication with the discharge of the pump.

11. The hydraulic fracturing system of Claim 9, wherein the signal assembly comprises a stack of light assemblies.

12. The hydraulic fracturing system of Claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.

13. The hydraulic fracturing system of Claim 9 further comprising a pump controller and auxiliary equipment, and wherein the operational state of the system comprises, the system being isolated from electricity, a fluid pressure of the discharge having a value at least as great as a designated value, the pump drive being energized, and the auxiliary equipment being energized but without a one of the motors being energized.

14. The hydraulic fracturing system of Claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for operations personnel, and when the system is currently unsafe for operations personnel.

15. A method of fracturing a subterranean formation comprising:

pressurizing fracturing fluid with a pump;

driving the pump with a motor that is powered by electricity;

monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and

selectively emitting a visual signal that is indicative of the monitored operational state.

16. The method of Claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of the discharge of the pump having a value at least as great as a designated value, the pump controller being energized, and the auxiliary equipment being energized but without a one of the pump motors being energized.

17. The method of Claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.

18. The method of Claim 15, further comprising monitoring electricity to a variable frequency drive, wherein the variable frequency drive controls electricity to the motor.

19. The method of Claim 15, further comprising monitoring a fluid pressure of the discharge of the pump.

Ex. 1003 ('871 Patent File History, Original Claims) at 29-32.

b. USPTO Examiner Issues Office Action on November 29, 2016

47. On November 29, 2016, the USPTO Examiner issued an office action. The USPTO Examiner stated that the application is being examined under AIA provisions.

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Ex. 1003 ('871 Patent File History, 11/29/2016 Office Action) at 84. I understand that this means the Examiner assumed that the priority date for at least one claim in the application did not pre-date March 16, 2013. The Examiner rejected the claims as follows:

- Claims 15, 16, 19: Anticipated by Paterson.
- Claims 17, 18: Obvious over Paterson in view of Jensen.

Ex. 1003 ('871 Patent File History, 11/29/2016 Office Action) at 84-87. The Examiner found (and Patent Owner did not dispute) that Paterson alone disclosed every limitation of claims 15, 16, and 19. Ex. 1003 ('871 Patent File History, 11/29/2016 Office Action) at 84-85. The examiner also found (and Patent Owner did not dispute) that Jensen teaches “use of an electrical motor control system...having a units (66) that selectively emits a visual signal including light

assemblies...that is indicative of the monitored operational state.” Ex. 1003 (’871 Patent File History, 11/29/2016 Office Action) at 85-87.

48. The Examiner also stated that claims 1-14 are allowed because “[t]he prior art of record does not disclose all the claimed subject matter including the variable frequency drive performing electrical motor diagnostics. Ex. 1003 (’871 Patent File History, 11/29/2016 Office Action) at 87.

c. Response to Office Action on February 28, 2017

49. On February 28, 2017, the Applicant responded to the Examiner. The Applicant did not explain any disagreement with the Examiner’s findings as to what the prior art discloses, and instead amended claims 15, 16, and 19:

15. (Currently amended) A method of fracturing a subterranean formation comprising:

pressurizing fracturing fluid with a pump;

driving the pump with a motor that is powered by electricity;

controlling the speed of the motor with a variable frequency drive, the variable frequency drive further performing electric motor diagnostics;

monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and

selectively emitting a visual signal that is indicative of the monitored operational state.

16. (Currently amended) The method of Claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of [[the]] discharge of the pump having a value at least as great as a designated value, [[the]] a pump controller being energized, and [[the]] auxiliary equipment being energized but without a one of the pump motors being energized.

19. (Currently amended) The method of Claim 15, further comprising monitoring a fluid pressure of [[the]] discharge of the pump.

Ex. 1003 ('871 Patent File History, 2/28/2017 Resp. to Office Action) at 125-126.

d. Notice of Allowance on March 28, 2017

50. On March 28, 2017, the Examiner allowed the remaining claims to issue. These are claims 15-19 from the application. The Examiner did not provide further reasons for allowing the claims. Ex. 1003 ('871 Patent File History, 3/28/2017 Notice of Allowance) at 128-130.

D. PRIORITY DATE OF THE '871 PATENT

51. I understand that the '871 Patent (which was filed as U.S. Patent App. No. 15/217,040, or "'040 Application") sought priority from U.S. Provisional Application Ser. No. 62/196,350 (the "Provisional"), filed July 24, 2015. I understand the '871 Patent purports to be a continuation-in-part of Application No. 13/679,689 (the "'689 Application").

52. I have been asked to review the Provisional and to determine whether each limitation of the '871 Patent was disclosed in the Provisional. I have concluded that the Provisional fails to disclose certain limitations from each of the claims of the '871 Patent. For example, there is no disclosure in the Provisional of:

- **Variable Frequency Drive:** The Provisional does not disclose any variable frequency drive, let alone a variable frequency drive that controls the speed of the electric motor and performs electric motor diagnostics, as expressly recited in independent claims 1, 9, and 15.
- **Electric Motor Diagnostics:** In addition to not disclosing any variable frequency drive, the provisional similarly fails to disclose any electric motor diagnostics as expressly recited in independent claims 1, 9 and 15.

Regardless of whether it would or would not have been obvious to include a variable frequency drive, any electric motor diagnostics, or other limitations in view of the Provisional, I understand that for purposes of a priority analysis, the question is not: whether one skilled in the art might have been able to construct the claimed invention from the teachings of the disclosure, or whether a claimed invention is an obvious variant of that which is disclosed in the specification. Rather, I understand that when analyzing priority, the earlier application must itself describe each of the claim limitations of the Challenged Patent.

53. The specification of the '871 Patent also states that it claims priority to the application that issued as the '410 Patent. I understand that when analyzing priority, a claim must be fully supported by a single application. I have concluded

that although the '689 Application discloses a variable frequency drive, it does not disclose the “signal assembly” of the '871 Patent’s independent claims or any of the features of that assembly in the dependent claims. The Provisional also contains no reference to that application.

54. Accordingly, it is my opinion that the earliest possible priority date for the Challenged Claims of the '871 Patent would be no earlier than when the '040 Application was filed—July 22, 2016.

E. COMPARISON OF ASSERTED REFERENCES TO PRIOR ART DISCUSSED DURING PROSECUTION

55. I have been asked to analyze the technical references that I understand Petitioner is asserting as prior art (Payne, Toshiba Manual, Broussard, Feller, Wiemers, Carlson, and Randle) and to compare them to the references cited by the USPTO Examiner during prosecution of the '871 Patent.

56. **Primary references:** I have relied upon Payne as the base (or primary) references. Payne is cited on the cover of the '871 Patent but was not discussed in any office actions or responses during prosecution of the '871 Patent.

57. **Secondary references:** I have relied upon several additional references (secondary references) that are used in combination with the primary references. Two of these references (Toshiba Manual and Broussard), disclose the variable frequency drive found missing by the Examiner and were not discussed during

prosecution of the '871 Patent. In other words, the very limitations that the Examiner found missing from the prior art were disclosed in other references that I discuss, and a POSITA would have been motivated to combine the primary references with the secondary references.

VII. LEVEL OF ORDINARY SKILL IN THE ART

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

VIII. CLAIM CONSTRUCTION

59. In the sections below, I have sought to provide the ordinary and customary meaning of claim terms, using the principles I discuss above in the Legal Standards section.

A. “FREQUENTLY PERFORMS” (CLAIM 1)

60. Independent claim 1 requires a “variable frequency drive” that “frequently performs electric motor diagnostics to prevent damage to the at least one electric motor.” A POSITA would understand that the term “frequently performs” means “e.g., on the application of power, or with each start.” This understanding is

based on extrinsic evidence from other patents assigned to Patent Owner that use the same “frequently performs” term:

Furthermore, with respect to control capabilities, the VFD can provide complete monitoring and protection of drive internal operations while communicating with an operator via one or more user interfaces. For example, motor diagnostics can be performed frequently (e.g., on the application of power, or with each start), to prevent damage to a grounded or shorted electric motor 14. The electric motor diagnostics can be disabled, if desired, when using, for example, a low impedance or high-speed electric motor.

Ex. 1013 ('410 Patent) at 3:62-4:4; Ex. 1016 ('601 Patent) at 4:39-4:48.

IX. TECHNOLOGY BACKGROUND AND STATE OF THE ART

61. In the subsections below, I describe some of the basic principles of engineering that would be used, or at least considered for use, on a hydraulic fracturing site. The principles discussed in the subsections below would have been well-known to a POSITA in the 2015-2016 timeframe, and long before.

A. EXEMPLARY REFERENCES CORROBORATING THE GENERAL ENGINEERING KNOWLEDGE

a. Roe (Ex. 1018)

62. As an example of such general engineering knowledge, Exhibit 1018 (“Roe”) is a textbook published in 1972, entitled *Practices and Procedures of Industrial Electrical Design*. Exhibit 1018 contains true and correct copies of pages from the Roe textbook.

63. Roe is a textbook of basic electrical engineering knowledge that is useful in the design and operation of industrial electrical systems. My first exposure to Roe was as an electrical engineering student in the late 1980s / early 1990s. I “borrowed” Roe from the library of my father (Dr. Marcus O. Durham, PhD, PE, LFIEEE, “Dr. Marc”) as a reference and a teaching tool when I began working at Public Service Company of Oklahoma as a power systems intern in 1989. Dr. Marc had purchased the book from the University of Oklahoma Bookstore as a textbook for a course in industrial electrical design that he took in the mid-1970s while he was pursuing graduate studies as well as licensure as a Professional Engineer. The book passed to me when he downsized his library upon retirement in about 2013.

64. Roe was “written for the whole of the engineering profession, for practicing engineers as well as for students. Thus it is a reference book containing facts which all members of the field may find useful.” Ex. 1018 (Roe) p. xv (Preface). Roe further describes the usefulness of the book: “Project engineers from other fields such as civil, mechanical and chemical engineering should have no difficulty in understanding matters of electrical design after reading this book or a specific chapter of it.” *Id.* p. xvi. Thus, Roe provides evidence of general engineering knowledge, known in the field decades before the priority date of the Challenged Patent.

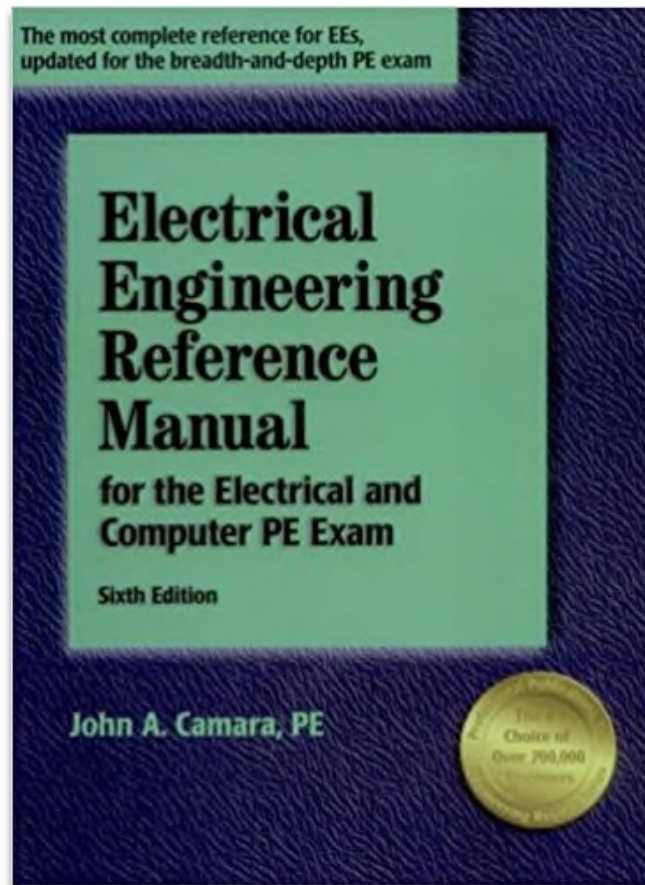
65. As discussed above, Roe contains general engineering knowledge with regards to electrical systems in an industrial environment. A POSITA would have understood that an oil and gas fracturing location is such an industrial environment. Specifically with regards to the subject matter of the Challenged Patent, Roe discusses basic electrical systems including the use of the following:

- Measurement and Control
- Generators
- Circuit breakers
- Step-up transformers
- Circuit breaker locations
- Transmission line
- Step-down transformer
- Distribution System
- Additional transformers
- Protection and Control
- Tie breakers,
- Substations

All of these concepts were within the general knowledge of engineers at the time of the '871 Patent and long before.

b. EE-Reference (Ex. 1019)

66. EE-Reference refers to a textbook authored by John A. Camara, entitled “Electrical Engineering Reference Manual for the Electrical and Computer PE Exam.” This particular version of EE-Reference is the Sixth Edition, was published in 2002 by Professional Publications, Inc., and has ISBN: 1-888577-56-8. Exhibit 1019 contains true and correct copies of pages from EE-Reference. I acquired my copy of EE-Reference around 2005, have used it in my regular practice of engineering since then, and have taught Professional Engineering (PE) Exam courses out of it. The cover of EE-Reference states that it is “[t]he most comprehensive resource available for the electrical PE exam.”

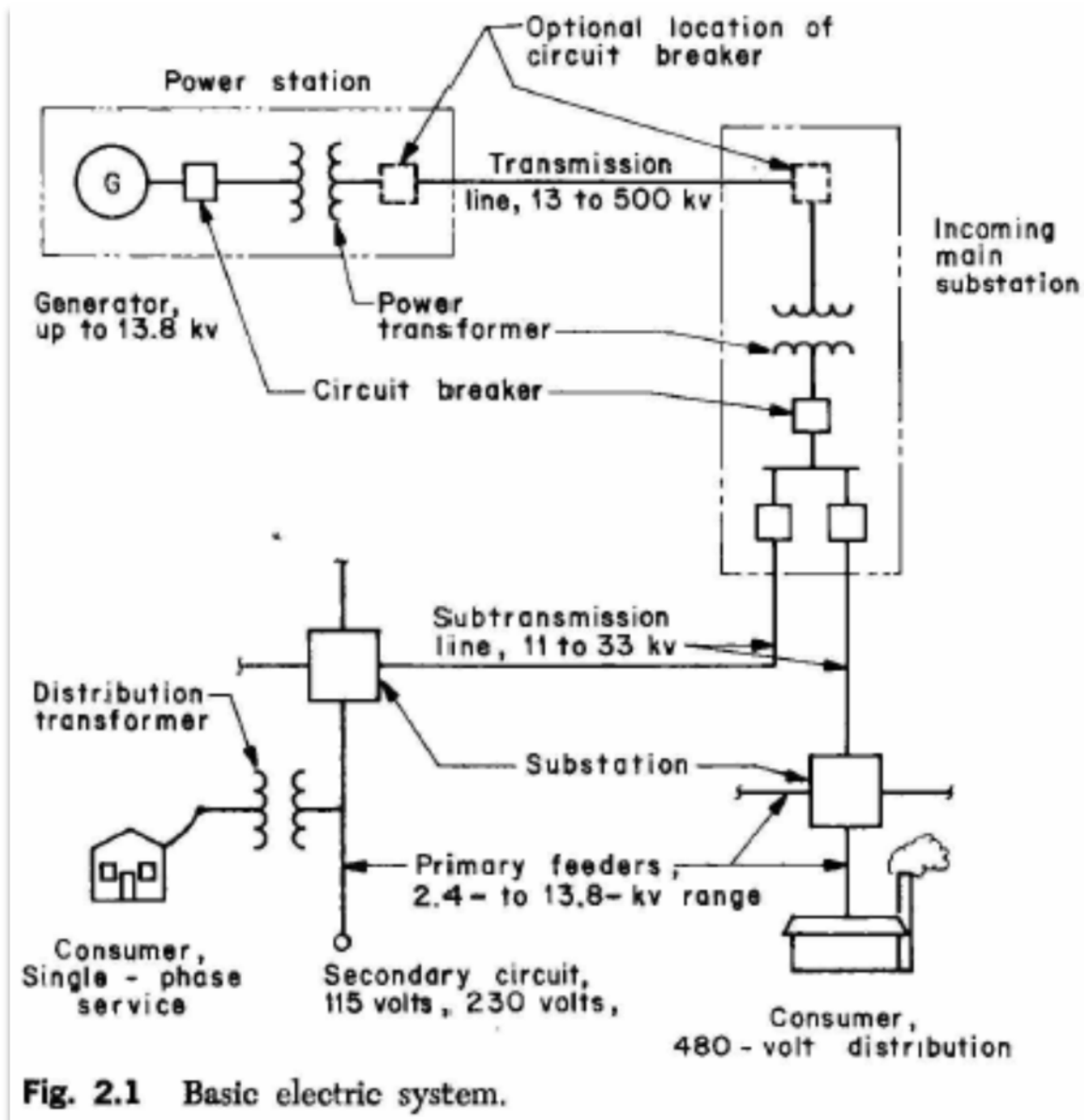


Ex. 1019 (cover) EE-Reference provides evidence of general engineering knowledge, known in the field decades before the priority date of the Challenged Patent. Further discussion of Exhibit 1019, and the well-known and fundamental engineering information it contained, is discussed below in Sections IX.B-.D.

B. BASIC ELECTRIC SYSTEMS

67. The configuration of transmission lines, substations, power generation, and dedicated power generation sub-systems, and how they deliver power to electric motors, was well-known general engineering knowledge.

68. For example, Chapter 2 of Roe is entitled “The Basic Electric System.” The layout of a basic electric system was known at least by 1972 at the time of Roe, and is shown below in Figure 2.1 from Roe:



Ex. 1018 (Roe) p. 9 (Fig. 2.1). Roe then discusses basic components, which I summarize in the subsections below, including generators, transmission lines,

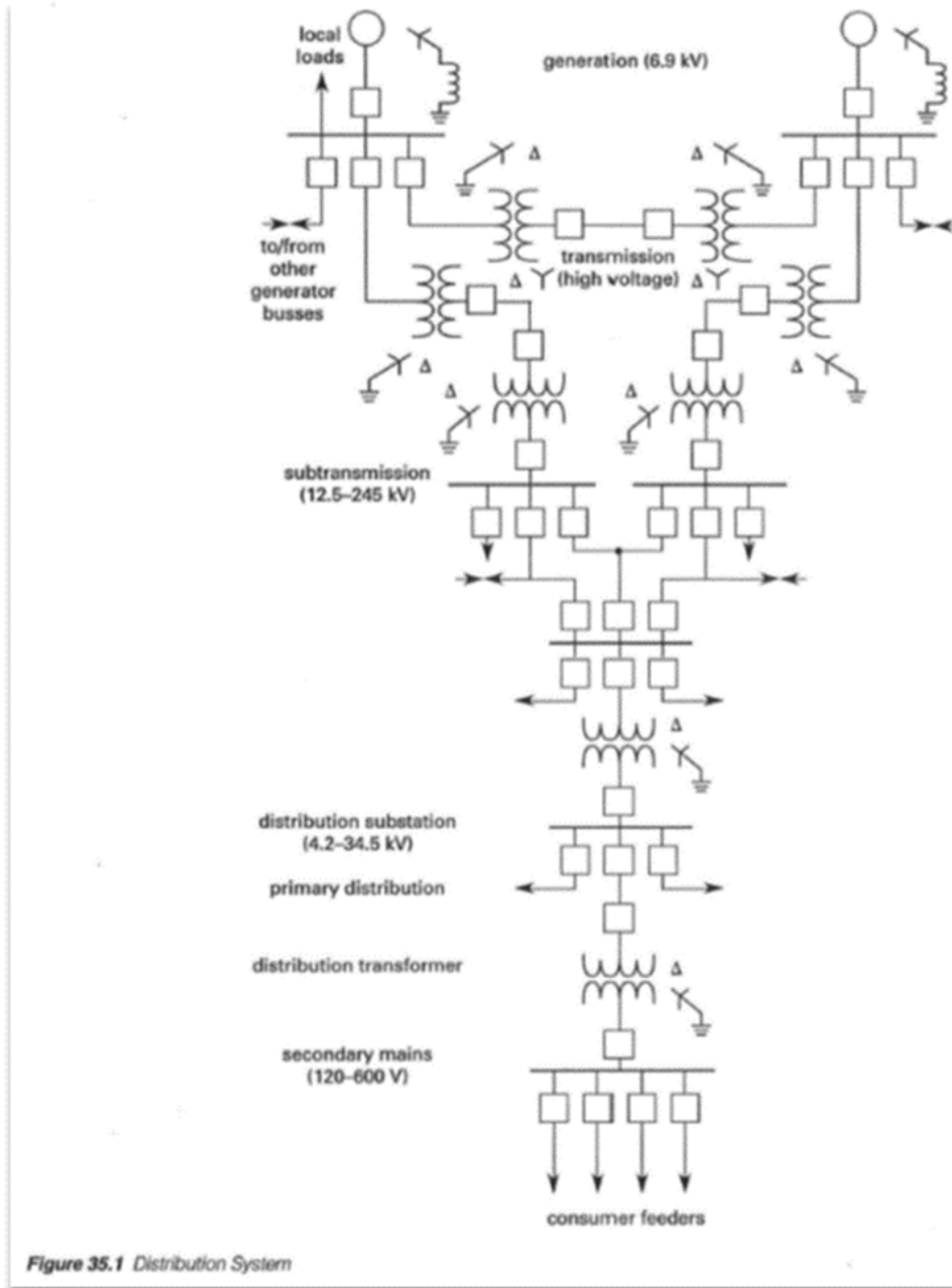
switchgear, step-up transformers, step-down transformers, and other such components.

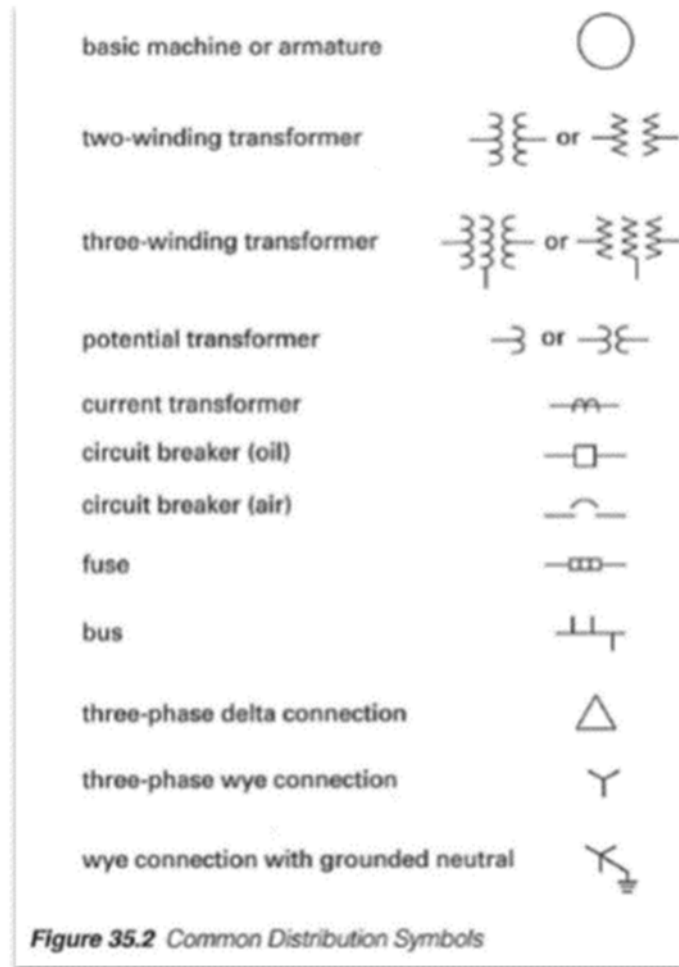
69. Another example of the pervasiveness of the general-engineering knowledge associated with a basic electric system is shown in Exhibit 1019, entitled the *Electrical Engineering Reference Manual for the Electrical and Computer PE Exam* (“EE-Reference”). As implied by the title, this was a basic engineering reference manual that engineers used in 2002 (more than a decade before the priority date of the ’871 Patent), including to study for their Professional Engineer examinations. EE-Reference includes Chapter 35, entitled “Power Distribution.” Within this chapter, EE-Reference includes Section 35.1, entitled “Fundamentals.” The Fundamentals section shows a power distribution system, figure copied below, with components similar to those shown in Exhibit 1018 (Roe).

70. EE-Reference defines an “electric distribution system” as follows:

The *electric distribution system* is the circuitry, high-voltage switchgear, transformers, and related equipment that receives high voltage from the source and delivers it at lower voltages. Its function is to receive power from large bulk sources, that is, generation sources, and distribute it to users at the voltage level and degree of reliability required. A hypothetical distribution system one-line diagram is shown in Fig. 35.1. The electric utility may consider the distribution system as that portion of Fig. 35.1 from the distribution substation to the consumer. The symbols used are explained in Fig. 35.2

Ex. 1019 (EE-Reference) p. 35-1. Figures 35.1 and 35.2 from EE-Reference are shown below.





Ex. 1019 (EE-Reference) p. 35-2, 35-3 (Figs. 35.1, 35.2). Components of the basic electric system are further explained below, each of which would have been well-known in the art and part of general engineering knowledge long before the filing date of the '871 Patent.

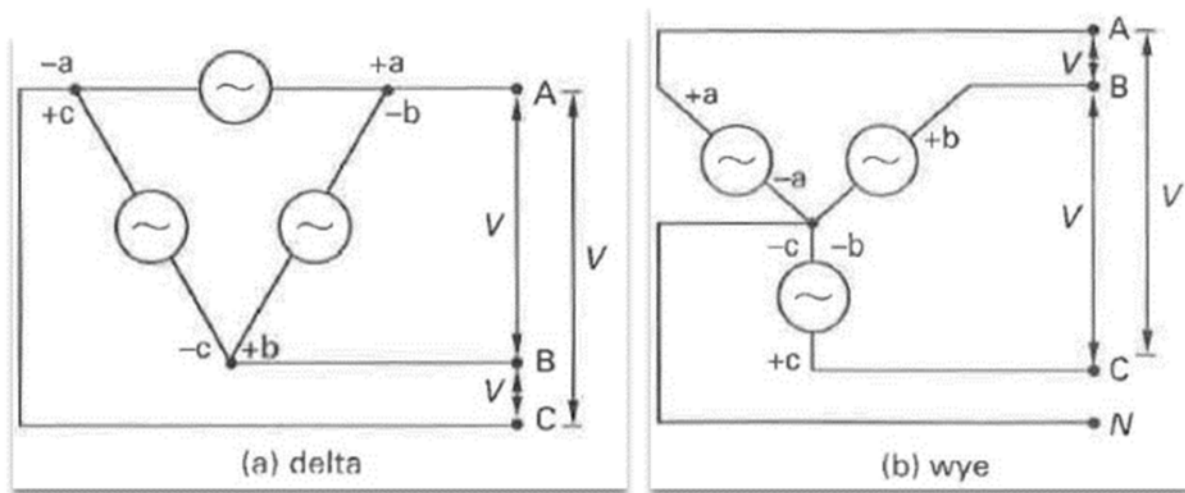
C. ALTERNATING CURRENT (AC) SYSTEMS

71. It was general engineering knowledge that Alternating Current (AC or a.c.) power systems are those in which “Alternating waveforms have currents and voltages that vary with time in a symmetrical manner ... for the most part, the variations are sinusoidal in time.” Ex. 1019 (EE-Reference) p. 27-1. The use of the term alternating current indicates “that the current is produced by the application of a sinusoidal voltage. This means that the flow of electrons changes directions, unlike DC circuits where the flow of electrons is unidirectional” *Id.* p. 27-1.

72. Single-phase AC systems are those in which there is a single voltage source driving the current. For single-phase systems, at least two connections to the load are needed in order for current to flow. These are generally referred to as “hot” and “neutral” connections, or “L1” and “L2” when used with motor connections. A separate ground wire is often used to provide personnel and equipment protection and to allow protective devices to operate effectively.

73. Three-phase AC systems are those in which there are three voltage sources driving current. Those three sources can be provided by a single physical structure such as an “AC generator that produces three equal sinusoidal voltages,” which “are 120° apart in phase.” Ex. 1019 (EE-Reference) p. 34-1. As described in EE-Reference, “a six conductor transmission line could be used to transmit the three

voltages” by treating them as three separate single phase voltages, but “it is more efficient to interconnect the windings.” *Id.* p. 34-2. Two connection types are delta and wye, as shown in Figure 34.2 from *EE Reference*.



Ex. 1019 (EE-Reference) p. 34-2.

74. Delta connected power systems require three phase-wires (plus a ground if required). Wye connected power systems require three phase-wires plus a neutral (plus a ground if required)¹. The neutral wire carries any imbalance from the loads back to the source.

¹ Certain balanced three phase wye connected system are operated with only three wires, though this is limited in application primarily to single loads, such as a three-phase motor.

75. It was general engineering knowledge that there are several benefits to using three-phase systems over single-phase systems, particularly in the context of large electrical loads such as large electric motors.

Three-phase energy distribution systems use fewer and smaller conductors and, therefore are more efficient than multiple single-phase systems providing the same power. Three-phase motors provide a uniform torque, not a pulsating torque as do single-phase motor. Three-phase induction motors do not require additional starting windings or associated switches. When rectified [converted to DC], three-phase voltage has a smoother waveform and less ripple to be filtered out.

Ex. 1019 (EE-Reference) p. 34-1. This is due to the difference in power relationships between single-phase and three-phase systems. The power relationship for single-phase systems is:

$$P = V \cdot I$$

while the power relationship for three-phase systems is:

$$P = \sqrt{3} \cdot V \cdot I^*$$

Thus, for a three-phase system, current is reduced by a factor of $\sqrt{3}$ (~1.73) as compared to a single-phase system. This allows for smaller conductors, decreased losses and increased efficiency. As a result, nearly all larger power systems are configured as three-phase systems.

D. ELECTRIC MOTORS

76. It was general engineering knowledge that electric motors are a subset of rotating electric machinery (rotating machines) in which electric power is converted to rotational mechanical energy.

Rotating machines are broadly categorized as AC and DC machines. Both categories include machines that use [electric] power (i.e. motors) and those that generate [electric] power (alternators and generators). Most machines can be constructed in either single-phase or polyphase [three-phase] configurations, although single-phase machines may be outclassed in terms of economics and efficiency. . . . Large AC motors are almost always three-phase.

Ex. 1019 (EE-Reference) p. 40-1.

77. Electric motors have been manufactured to one or more standards, depending on the application and size. As an example, motors up to 500 horsepower (Hp) are manufactured at least to the specifications of National Electrical Manufacturer's Association (NEMA) Standard MG-1.² Severe duty motors larger than 500 Hp used in oil & gas applications are manufactured to the specifications of American Petroleum Institute (API) standard 541.

78. The National Electrical Manufacturer's Association (NEMA) was founded in the 1920s and is an ANSI- (American National Standards Institute)

² Severe duty motors smaller than 500 Hp used in oil & gas applications are manufactured to the specifications of IEEE 841, one of the IEEE standards for which I am responsible.

accredited Standards Developing Organization (SDO) made up of business leaders, electrical experts, engineers, scientists, and technicians. NEMA convenes a neutral forum for Members to discuss industry-wide concerns and objectives under a legal umbrella by trained NEMA Staff.

79. It is inherent that electric motors have a plurality of connections to the power source in order to operate. As in all electric circuits, there must be a complete path between the power source (e.g., generator) and the load (motor) in order for current to flow and for the electric equipment (motor) to operate. The complete path requires a minimum of two connections for each load, generally designated as L1 and L2 for single phase or DC motors and L1, L2 and L3 for three phase motors.

E. ADJUSTABLE SPEED DRIVES / VARIABLE FREQUENCY DRIVES

80. By way of background, a Variable Frequency Drive (VFD) is another term for and type of Adjustable Speed Drive (ASD). ASD is the preferred term. Nevertheless, based on my experience, the term VFD has been commonly used, so I also use the terms interchangeably in this declaration.

81. *Standard Handbook for Electrical Engineers* from 1993 describes the basic operation of an ASD (VFD) as follows:

In order to supply an adjustable frequency to an ac motor, the incoming constant-frequency [fixed frequency] voltage or current must first be rectified to a dc current or voltage. This dc voltage or current is then

inverted to an adjustable frequency output. This is accomplished by power semi-conductor devices.

These devices allow current to flow in only one direction. They act as electronic switches. Various types can be fired on and off at certain times in the cycle. This selected firing allows control of the resultant voltage or current.

Ex. 1020 (Fink) p. 20-85. Exhibit 1020 contains true and correct copies of pages from the Fink reference. As an additional example, Horikoshi (filed in 2011) describes that such an ASD (VFD) was known for three-phase AC power as well:

Providing a motor driving apparatus, which is connected to a three-phase AC power supply and which comprises an AC/DC converter for converting three-phase AC power supplied from the three-phase AC power supply into DC power and a DC/AC converter for converting the DC power output from the AC/DC converter into three-phase AC power for supply to a motor, is known.

Ex. 1021 (Horikoshi) [0004]. The outgoing DC-AC converter modifies the frequency and/or voltage of the waveform in order to control the speed and torque delivered by the motor.

82. One of the more common ASD topologies, particularly for larger motors is a “pulse-width modulated (PWM)” drive topology. PWM drives have a number of advantages over other drive topologies including “high line-side power factor (near unity),” and the “distortion seen by the electrical network is ... reduced.” Additionally, “high dynamic performance can also be realized. Full torque can be

maintained and controlled throughout the speed range – even at zero speed.”

Ex. 1020 (Fink) p. 20-89.

83. One of the methods of determining the power of a rotating piece of equipment (e.g. a motor) is the well-known relationship: Power = (Torque) x (rotational speed). This formula is expressed as: $P = \tau \cdot \omega$. Thus, by controlling the speed and torque (inherently a function of PWM drives), the drive is also controlling the power of a motor, and maintaining that power within the operating range of the motor.

F. ELECTRIC MOTOR DIAGNOSTICS TO PREVENT DAMAGE TO THE ELECTRIC MOTOR

84. “Electric motor diagnostics” is a function inherent in PWM ASDs (VFDs) that control both torque and speed of the motor. Ex. 1020 (Fink) p. 20-89. It was also routine for ASDs to control the output to be within the motor operating limits.

a. NEMA ICS-61800-4 (Ex. 1012) corroborates general engineering knowledge regarding ASDs/VFDs

85. As another example of general engineering knowledge, standards governing construction of ASD/VFDs specify the types of electric motor diagnostics to perform to prevent damage to the electric motor. For example, NEMA ICS 61800-4 (“61800-4”) is a manufacturing standard for adjustable speed drives

published in 2004. Ex. 1022 (NEMA ICS-61800-4). Exhibit 1022 contains true and correct copies of pages from NEMA ICS-61800-4.

86. NEMA is the National Electrical Manufacturer's Association. NEMA was founded in the 1920s and is an ANSI-accredited Standards Developing Organization (SDO) made up of business leaders, electrical experts, engineers, scientists, and technicians. NEMA convenes a neutral forum for Members to discuss industry-wide concerns and objectives under a legal umbrella by trained NEMA Staff.

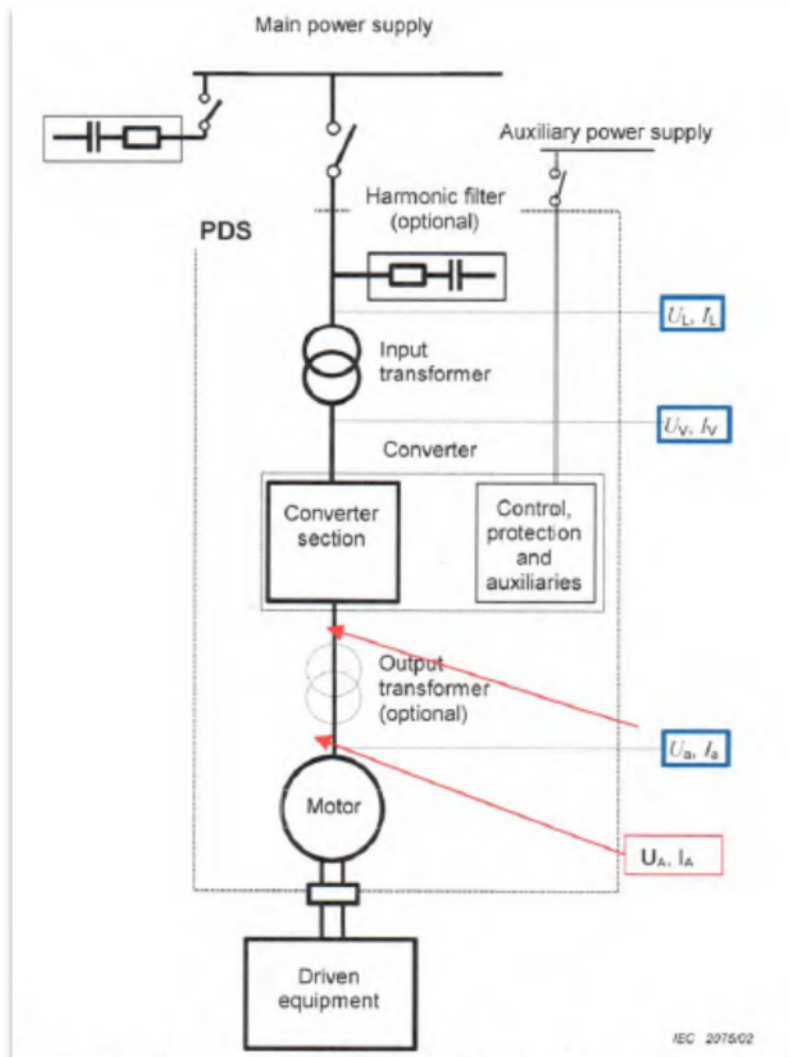
87. One group of standards developed by NEMA are the Industrial Control and Systems ("ICS") family of standards. The ICS standards provide practical general information concerning ratings, construction, testing, performance and manufacture of industrial control and systems equipment and terminal blocks. One of the NEMA ICS Standards is NEMA ICS 61800-4 *Adjustable Speed Electrical Power Drive Systems Part 4: General Requirements – Rating Specifications for a.c. Power Drive Systems above 1000 V a.c. and Not Exceeding 35kV*. Ex. 1022 (ICS-61800-4) (published in 2004). ICS 61800-4 reflects general engineering knowledge of power drive systems, including ASDs/VFDs, known over a decade before the priority date of the '871 Patent.

88. Clause 1.1 of 61800-4 discusses the “Scope and Object” of the standard and contains the following language

This standard gives the characteristics of the converters, their topologies and their relationship with the complete a.c. drive system. It also states their performance requirements with respect to ratings, normal operating conditions, overload conditions, surge withstand capabilities, stability, protection, a.c. line earthing, topologies and testing. Furthermore, it deals with application guidelines, such as control strategies, torsion analysis, recommendations for earthing and drive system component integration.

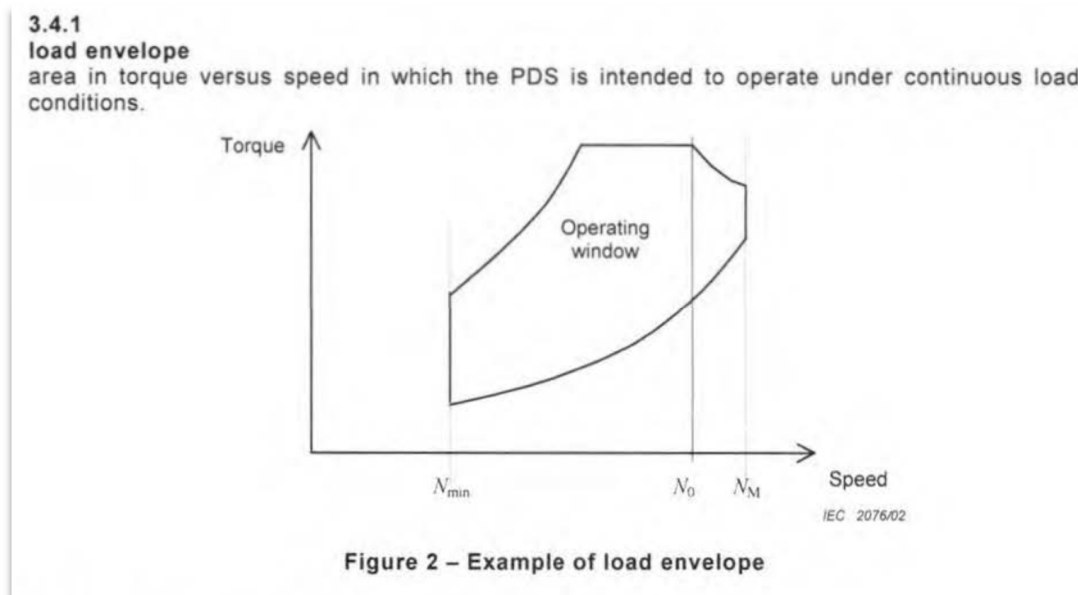
Ex. 1022 (ICS-61800-4) p. 1 (§ 1.1). Thus ICS-61800-4 is a repository of knowledge, and manufacturing requirements, of a.c. power drive systems (PDS).

89. A PDS is defined in this standard as a “system with a voltage above 1kV (see figure 1) is an interconnected combination of equipment with provides a means of adjusting the speed of a mechanical load coupled to a motor.” Ex. 1022 (ICS-61800-4) p. 6 (§3.1.1). Figure 1 further describes the PDS, with annotations in the original.



Ex. 1022 (ICS-61800-4) p. 7 (§ 3.1.1) (coloring in original). A POSITA would have understood ICS-61800-4 to describe adjustable speed drives (ASD or VFD) and requirements of such drives. It should also be noted that Figure 1 shows switchgear (in the form of circuit breakers and fuses), and a transformer between the switchgear and the motor, both of which are common components of an ASD system.

90. Section 3 of 61800-4 defines the output parameters of the drive that are required for operation of the drive / motor system. The “load envelope” is defined in Section 3.4.1 as stated below.



Ex. 1022 (NEMA ICS 61800-4) p. 15.

91. One set of requirements for an ASD are “PDS Integration Requirements,” outlined in Section 9 of ICS-61800-4. One requirement is for the ASD to perform motor protection through diagnostics. These include diagnosing and protecting against: power source irregularities (e.g., voltage surges, over and under voltage, phase reversal, voltage unbalance), overcurrent conditions (e.g., fault currents, ground currents, and internal faults), overloads, overtemperature, motor overspeed, excessive vibration, lost lubrication, and others. Ex. 1022 (ICS-61800-

4) p. 73-74 (§§ 9.5-9.6). ICS-61800-4 summarizes such motor protection and diagnostic steps in Table 8.

Table 8 – PDS protection functions

Line-side supply	Alarm	Trip	Remark
Outage, phase loss	X	X	
Line overvoltages	X	X	
Line under-voltages	X	X	
Line voltage unbalance	X	X	
Line feeder	Alarm	Trip	Remark
Over-current		X	
Overload	X	X	
Transformer	Alarm	Trip	Remark
Gas relay (Buchholz)	X	X	oil-type only
Over-temperature	X	X	
Loss of cooling media	X	X	
Low oil level	X		oil-type only

Converter	Alarm	Trip	Remark
Overcurrent	X	X	commutation failure, short circuit, etc.
Overload	X	(X)	thermal
Overvoltage	X	X	
Ground fault	X	(X)	
Loss of cooling	X	(X)	
Over-temperature	X	(X)	
Loss of auxiliary supply	X	X	
Loss of communication to process control	X	(X)	
Loss of speed feedback	X		

Motor	Alarm	Trip	Remark
Motor over/under-voltage	X	X	
Motor overcurrent	X	X	
Overload	X	(X)	thermal
Over-speed	X	X	
Winding over-temperature	X	X	
Bearing over-temperature	X	X	
High vibrations	X	X	
Loss of cooling	X	(X)	
Loss of lubrication	X	X	

NOTE 1 Vibration protection functions can be taken care of by the driven equipment supplier.

NOTE 2 (X): conditionally applied.

NOTE 3 The impedance of the supply network at the IPC (see 5.1.1.2), and the input impedances of the PDS (see 8.2.3) shall be considered.

Ex. 1022 (ICS-61800-4) p. 75 (Table 8). Thus, ICS-61800-4 reflects the general engineering knowledge that a purpose of an ASD/VFD would be to conduct motor diagnostics in order to protect a motor from such conditions as over/under voltage, overcurrent (e.g., ground fault or short circuit), overload, overspeed, and others.

b. Horikoshi (Ex. 1021) corroborates general engineering knowledge regarding ASDs/VFDs

92. Another example of the general engineering knowledge of VFDs performing motor diagnostics is provided by Horikoshi. Ex. 1021. “Horikoshi” is a publication of a United States patent application, U.S. Patent Publication No. 2011/0241590A1. Horikoshi is entitled “Motor Driving Apparatus Having Fault Diagnostic Function.” Horikoshi was filed February 11, 2011 (claiming priority to a foreign application filed March 31, 2010) and published October 6, 2011. Each of

these dates is before the earliest possible priority date of all Challenged Claims of the '871 Patent.

93. Horikoshi is directed to the configuration and use of a “motor driving apparatus having a fault diagnostic function.” Ex. 1021 (Horikoshi) [0002]. Specifically, Horikoshi is directed to a variable frequency drive that is “capable of detecting during operation a ground fault and a phase-to-phase short circuit by distinguishing one from the other.” *Id.* [0011]; *see also* [0012]. Horikoshi explains that a variable-frequency drive in the form of an AC/DC/AC power converter “is known.” *Id.* [0002]. A POSITA would have understood that one aspect of a motor that needs diagnostics is the potential problem of damage to the motors due to shorting or grounding.

94. Horikoshi teaches the use of a “motor driving apparatus” that includes an “AC/DC converter 18 [that] converts three-phase AC power” into DC power, and an associated “DC/AC converter 10 [that] converts the DC power...into frequency variable three-phase AC power for output.” Ex. 1021 (Horikoshi) [0027]. The apparatus further includes “[c]urrent sensors” to detect current output from the DC/AC converter 10 to an electric motor. *Id.* The current sensors may be used to detect “overcurrent” associated with “the insulation resistance of the motor” connected to the drive apparatus. *Id.* [0004], [0006]. The “overcurrent” can be

caused by a “ground fault or a phase-to-phase short circuit.” *Id.* Thus, Horikoshi discloses a variable frequency drive with diagnostic capabilities that performs the diagnostics to identify ground or short circuit conditions and prevent any subsequent damage to the motor.

95. Horikoshi teaches a system that monitors and performs fault diagnostic functions “during operation.” In fact, Horikoshi describes the system monitoring a fault that occurs momentarily, in operation of only part of a cycle and then clears. Figure 2 and Figure 4 of Horikoshi show these momentary faults as a portion of a single cycle of an AC signal. At 60 Hz (most North American Utility AC Power), and even if the output frequency was as low as 0.1 Hz, the time required for completion of a single cycle of the AC output signal would be 10 Seconds.

G. SIGNAL ASSEMBLIES

96. It was general engineering knowledge that “signal assemblies” have been used to convey information to operators in oil and gas drilling and production and in general industry. A signal assembly is simply a structure that indicates an operational state of a piece of equipment, such as “open or closed”, “energized or de-energized”. A signal assembly could be as simple as a light to show whether a particular valve is opened or closed, may indicate a particular value, such as a flow rate or pressure, or may be a complex human machine interface which shows the

condition of various pieces of equipment, displaying pressure, flowrates, energized state of equipment, etc. all on one screen. A POSITA would have understood that the use of a signal assembly to indicate the operational status of a piece of equipment was a well-known feature of equipment and systems of equipment.

97. One type of signal assembly is an indicating light. The use of indicating lights in oil and gas operations was well known at least since the 1950s and before. In 1954, Northern describes an automated oil and gas production facility in southern Louisiana. Ex. 1023 (Northern) p. 2. As part of this automation “Each tank operating from the switcher has its associated hydraulic valve control relay and indicating lights. These indicate the condition of that particular tank, i.e., empty, filling or full.” Further, Campbell by 1964 described an automated waterflood production field where “oil then goes to the 100 bbl storage tank that is equipped with a high level float switch that will stop the flow of oil and an indicator light will show the operator that he has a full tank of fuel oil. Another indicator light will show low level”. Ex. 1024 (Campbell) p. 1. Campbell’s signal assemblies use different indicators to distinguish one operating condition from another, the two lights representing to the operator at least three states of the system (high level, low level, normal level). Fitzgibbon, also in 1964, describes a “safety shut-in valve” which “light[s] up indicator lamps on the panel to show the open, close, or in-transit

position of this valve. In this way, personnel at the control center can be assured that the safety shut-in valve has actually completed its required function.” Ex. 1025 (Fitzgibbon) p. 3. Further, Fitzgibbon used indicating lights to show incoming communications. *Id.* p. 3. Hinchliffe, by 1966, was using indicating lights to show various tank levels as well as “indicating lights for each component at a specific location are illuminated, thus giving a representation of equipment installed at that particular L.A.C.T. [Lease Automated Custody Transfer]. This representation appears upon selection by the operator of a specific L.A.C.T location.” Ex. 1026 (Hinchliffe) p. 3-4. Hinchliffe’s signal assembly includes a display board. “The display board then presents a visual indication, by means of lights, as to each component’s status, i.e. on or off, normal or not.” *Id.* p. 3. Like Campbell, Hinchliffe uses various lights to represent the operational status of various pieces of equipment.

98. By 1970, Owens described various uses of signal assemblies associated with a hydraulic pumping systems. Ex. 1027 (Owens). Owens describes “An annunciator panel located in the control room on each platform [which] serves as the main source of control and surveillance for the hydraulic pumping systems. This panel contains the shutdown relays and malfunction indicator lights, as well as the hand-off-automatic (H-O-A) control switches for the charge pump and the

triplexes.” *Id.* p. 5-6. Owens also used indicating lights to show the extent of a fire at the facility, should one occur. *Id.* p. 5.

99. In 1986, Cleary et al. were describing the use of a computer system “for the monitoring analysis and potential control of hydraulic fracturing treatments in real-time during the field operation.” This system included “data-acquisition from calibrated sensors, data-processing and storage in the central facility, display of processed data on scrolling windows, simulation of the overall process, using realistic engineering models for analysis, and display of overall states, including model results.” Ex. 1028 (Cleary) p. 1. Cleary’s system “operates in real-time during the job, so that all data-acquisition, retrieval, processing and display is simultaneous”, and “the user-friendly graphics displays improve quality-control and allow the operator to confidently give feedback on equipment operation.” *Id.* p. 2. By 1986, Tomlinson was describing the use of “liquid crystal displays” (LCD) to indicate the operational status of various hydraulic fracturing equipment. These LCDs were mounted on each individual piece of equipment for use in monitoring the status of the associated equipment. Ex. 1029 (Tomlinson) p. 8.

100. By 1990, Norris and Capps described a PC display used to display information about a hydraulic fracturing (stimulation) operation. Ex. 1030 (Norris). The system described contained “simultaneous graphics [] to provide the engineer

with the ability to monitor the simulation as it takes place.” *Id.* p. 2. Further, Norris describes display of a “pressure profile data from a simulation of a horizontal well intercepting a vertical fracture.” *Id.* p. 4. Further, Norris describes the use of “fracture design models [which] frequently have simultaneous graphics that depict the creation of a hydraulic fracture and the transport sand or artificial proppants. Simultaneous graphics is attractive for reservoir simulation because it allows the engineer to “monitor” the run as it is executing.” *Id.* p. 2.

101. By 1993, Stephenson was also describing “data measurement, recording, calculation and display” of a hydraulic fracturing system using a computer-based HMI. Ex. 1031 (Stephenson) p. 2. This system included automated hydraulic pump which comprised an “[i]mproved operating interface panels add a strip chart display. The last two minutes of two selected group rates, including maximum pressure is plotted.” *Id.* p. 4. Further, an “instrument skid provides a gathering point for collecting surface data and displaying those data in a useful format. Information collected includes pressures, flows, temperature and density on pumped-in slurry and gas” *Id.* Stephenson’s HMI allowed that “[a]ll parameters monitored or calculated by the control and engineering center can be accessed anytime during the job. The accessed data can be used for job design an analysis programs or displayed by using various printing, plotting and graphics routines []:

CRT strip chart plot, CRT numeric display, log/log plot, KYPlot and design and analysis programs output.” *Id.* p. 5. Similarly, by 1991 Purvis was describing a computerized control and monitoring system for hydraulic stimulation operations. In Purvis’ system, “[t]he primary operator interface to the analyzer consists of a plasma display panel with an integral touch screen display.” The operator interface displays various data including information gained from “pressure transducers [which] are used to monitor pressure, both tubing and annulus, at the wellhead.” Ex. 1032 (Purvis) p. 5. For simple data, “[a] standard monochrome text board is used to display numerical data.” *Id.* p. 7.

102. By 2002, IEC Standard 60073, Version 2 had been published on “Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators.” Ex. 1034 (IEC).

The scope and application of the standard are included below:

This International Standard establishes general rules for assigning particular meanings to certain visual, acoustic and tactile indications in order to

- increase the safety of persons, property and/or the environment through the safe monitoring and control of the equipment or process;
- facilitate the proper monitoring, control and maintenance of the equipment or process;
- facilitate the rapid recognition of control conditions and actuator positions.

This standard is for general application:

- from simple cases such as single indicator lights, push-buttons, mechanical indicators, light emitting diodes (LEDs) or video display screens to extensive control stations which may include a wide variety of devices for controlling an equipment or process;

NOTE Application of the general coding principles for displays on screens should be carried out without modification.

- where the safety of persons, property and/or the environment is involved, and also where the above-mentioned codes are used to facilitate the proper monitoring and controlling of equipment;
- where a particular kind of coding is to be assigned by a technical committee to a special function.

Ex. 1034 (IEC) at 11

103. IEC 60073 addresses industry standard uses of signal assemblies including “signal lights, [], light emitting diodes (LEDs), or video display screens”. The standard indicates that it applies to situations where “the safety of persons, property and/or the environment is involved.” IEC 60073 contains several definitions which demonstrate the well-known nature of indicating lights and signal assemblies:

3.2

indicator

mechanical, optical or electrical device or a part of device providing visual, acoustic or tactile information

3.2.3

visual signal

message conveyed by means of brightness, contrast, colour, shape, size or position

3.6

signal light

object or apparatus designed to emit a light signal

[IEV 845-11-05]

104. The standard explains that multi-colored light signals may be used to differentiate between dangerous and potentially dangerous situations. Ex. 1034 (IEC) Table 8. For example, Table 6 (below) provides different colors and shapes as visual indicators of different levels of safety, e.g., “danger,” “caution/warning,” “safe,” etc. *Id.* p. 33 (Table 6).

Table 6 – Meaning of indication codes with respect to the safety of persons, property and/or the environment

1	2	3	4	5	6	7	8	9	10
Code Meaning	Visual		Acoustic	Tactile		Explanation	Action by		Examples of application
	Colour	Shape		Vibration force	Position		the operator	other persons*	
Danger	RED		– Sweeping sounds – Bursts of sounds	High	No code assigned	Dangerous situation or imperative order	Immediate response to deal with a dangerous situation	Escape or stop	Prohibited entry
Caution/ warning	YELLOW		Pattern of segments with constant pitch	Medium		– Out of order – Faulty situation – Permanent or temporary risk (e.g. accessibility to hazardous areas)	Intervention to prevent a dangerous situation	Evacuation or restricted access	Restricted access
Safe	GREEN		Continuous sound	Low		– Indication of a safe situation – Safe to proceed – Way clear	No specific action demanded	No specific action demanded	Escape route
Mandatory	BLUE		Alternating sound	No code assigned		Indication of a need for mandatory action	Mandatory action	Mandatory action	Mandatory route
No meaning assigned	WHITE GREY BLACK		Other sounds			General information	No specific action demanded	No specific action demanded	Explanation of a route
* Persons who are in the vicinity of the plant or process, but who are not themselves operators.									

* Persons who are in the vicinity of the plant or process, but who are not themselves operators.

Similarly, Table 8 (below) depicts different indication codes (colors and shapes) with respect to the state of the equipment, e.g., “faulty,” “abnormal,” “normal,” etc. *Id.* p. 37 (Table 8).

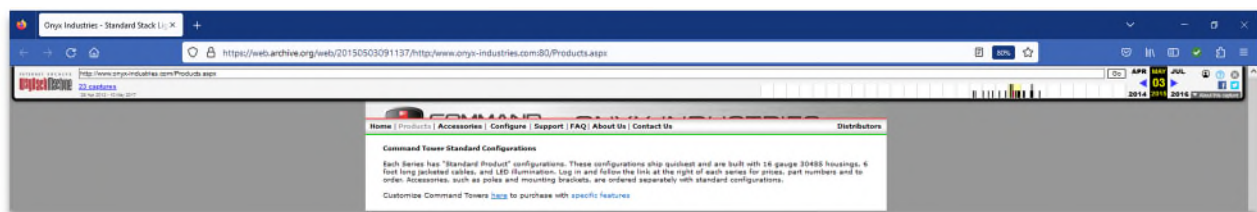
Table 8 – Meaning of indication codes with respect to the state of equipment

1	2	3	4	5	6	7	8	9
Code Meaning	Visual		Acoustic	Tactile		Explanation	Action by the operator	Examples of application
	Colour	Shape		Vibration force	Position			
Faulty	RED		– Sweeping sounds – Bursts of sounds	No code assigned	–	Fault condition	- Immediate action to deal with a dangerous condition, e.g. by – operating emergency stop – opening safety valve – starting cooling pump	– Pressure/temperature of auxiliary systems out of safe limits – Blown fuse – Stoppage of necessary service systems – Over-travelling of a stop position of a hoist
Abnormal	YELLOW		Pattern of segments with constant pitch			Abnormal condition	Monitoring and/or intervention (e.g. by re-establishing the intended function)	– Conveyor overloaded – Overtravelling of a limit switch – Position change of a valve or conveyor belt
Normal	GREEN		Continuous sound			Normal condition	Optional	– Authorization to proceed – Indication of normal working limits
Mandatory	BLUE		Alternating sound			Mandatory significance	Mandatory action	- Indication of a need to enter: – preset values – other mode of control
No meaning assigned	WHITE GREY BLACK		Other sounds			–	–	- Status indication, e.g. – switch OPEN / CLOSE – valve OPEN / CLOSE – motor STOPPED / RUNNING

105. The use of indicating lights continued in oil and gas drilling and stimulation operations, even well after the advent of more complete human machine interface type systems. Even by 2012, Rassenfoss describes “quick monitoring of key BOP components using displays with green, yellow and red lights. The programs were designed to make decision makers aware of the health of the well-control system and help them decide if any problems justify action.” Ex. 1033 (Rassenfoss) p. 3. Further, the system described by Rassenfoss “uses a display with red, yellow and green lights to indicate the status of each key component.” *Id.* p. 6.

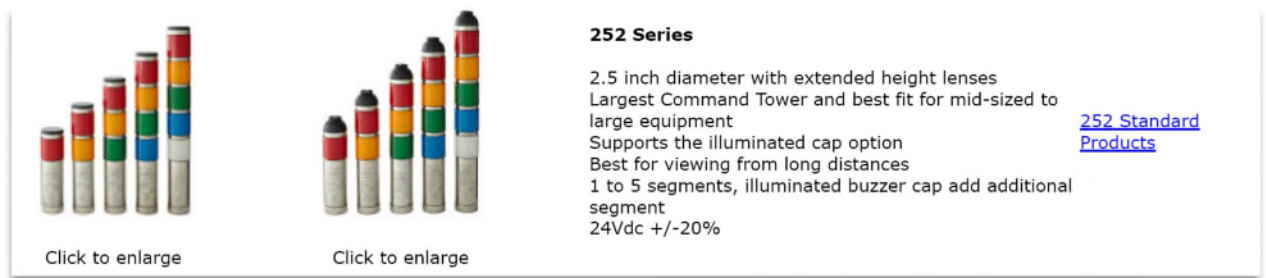
106. Further evidence of the well-known nature of signal assemblies are contained in catalogs regarding signal assemblies which were available prior to the '871 patent. One such catalog is *Onyx*. Ex. 1045. *Onyx* is a webpage from Onyx Industries detailing “Standard product configurations” of “Command Towers” which are stacked light (LED) assemblies used for various types of equipment including "mid-sized to large equipment.”

107. I understand, based on my reading of the web archive URL,³ that *Onyx* was available at least by May 3, 2015, which is before the application which led to the '871 patent. I read the URL portion “201505031137” to mean 11:37 AM on May 03, 2015, indicating the date Onyx Industries website was archived. Additionally, by following the link, the date of May 3, 2015 shows up on the top of the archive header, as shown below. This is consistent with my experience and understanding regarding when this type of information was available to those of skill in the art.



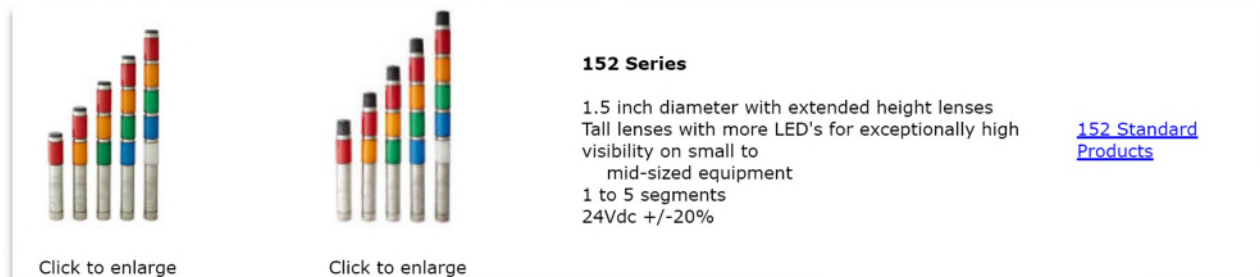
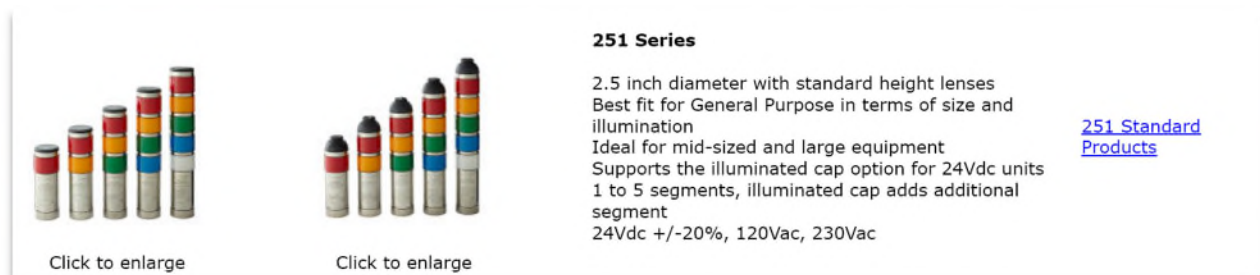
³ Ex. 1045 (*Onyx*), available at <https://web.archive.org/web/20150503091137/http://www.onyx-industries.com:80/Products.aspx>

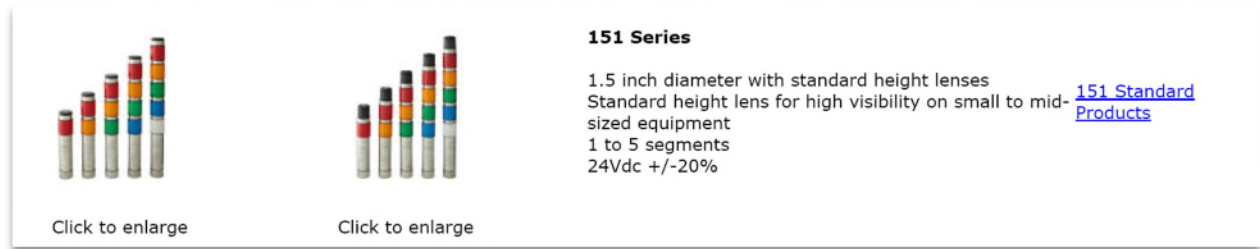
108. *Onyx* contains several examples of signal assemblies, including the 252 series, which are “2.5 inch diameter with extended height lenses.” Ex 1045. The 252 series assemblies are identified as Onyx’s “Largest Command Tower and [is the] best fit for mid-sized to large equipment.”



Id. at 1.

Other examples of signal assemblies from *Onyx* include the 251 Series, 152 series and 151 series:





Id. at 1.

109. The accompanying “Stack Light Engineering Reference Guide” (“*Engineering Guide*”) available from Onyx Industries teaches the purpose of Onyx’s stack lights is to “get the immediate attention of an operator, technician, supervisor or other plant personnel who need to respond to a specific machine condition or event.” Ex. 1046. *Engineering Guide* further teaches “If an operator must tend to the machine away from its console, [] then a high visibility Stack Light provides immediate machine status information across a greater area[]. It is also possible that other plant personnel, not regularly at the equipment, will need machine status information too. This could include maintenance technicians, fork lift drivers supplying raw materials [such as proppant], or a production supervisor as examples.” *Id.* at 1. While examples of colors and purposes are presented in *Engineering Guide*, it also teaches “there are no hard-fast rules about what color represents what function – it is completely up to the system designer to address machine/operator interaction requirements” and “Some engineering thought can identify what the colors will

represent before the units are purchased.” *Id.* at 2. The color selection, accordingly, is a design choice based on a finite number of selections for color.

H. BACKGROUND ON E-KILL

110. An emergency stop or “e-stop” (e-kill) system has long been a common, well-known function of modern industrial systems. Such a system provides for a single human action, such as pressing a button or pulling a cord, to shut down an entire process by removing energy from the system. At least by 2007, the National Fire Protection Association (NFPA) described e-kill in NFPA 79, the “Electrical Standard for Industrial Machinery.” Ex. 1035 (NFPA 79). NFPA 79 defined “Emergency Switching Off” as “[a]n emergency operation intended to switch off the supply of the electrical energy to all or part of an installation.” *Id.* § 3.3.38. NFPA 79 has further taught that modern electrical machines “involve highly complex electrical control systems, including electronic and solid-state devices and equipment.” *Id.* at Origins. This description fairly encompasses an electric fracturing system. NFPA 79 requires that such systems be operated by a single human action using one of a variety of devices:

10.7.2.1 The types of devices for emergency stop shall include, but are not limited to, the following:

- (1) Pushbutton-operated switches in accordance with 10.7.2.2 and 10.7.3
- (2) Pull-cord-operated switches
- (3) Foot-operated switches without a mechanical guard
- (4) Push-bar-operated switches
- (5) Rod-operated switches

Id. § 10.7.2.1. Article 9.2.5.4 of NFPA 79 describes various functions of “Emergency Operations (Emergency Stop, Emergency Switching Off).”

111. Emergency stop systems are sometimes referred to as “Emergency Shutdown Systems” or ESDs. Such systems have been described in the learned literature for decades. For example, in 1989 *Pearson* proposes “HSE Guidelines on Emergency Shutdown Systems” specifically for “the oil, gas and process industries.” Ex. 1036 (Pearson) at 55. *Pearson* discusses that, for such processes that include “complex inter-connected computer based systems...there are advantages from a safety view point in having a dedicated independent protection system or emergency shut down (ESD) system to take action to achieve a safe plant condition in the event of plant or equipment failure or indeed control system failure.” *Id.* at 55 (Introduction). *Pearson* further discusses that such “protection has traditionally been implemented using custom designed and built relay systems or more recently solid state electronic modular systems,” making it clear that such systems had existed long before *Pearson*. *Pearson* further describes that “Emergency Shutdown (ESD)

systems can be applied to any hazardous plant which has a safe state to which the plant can be directed when things go wrong for any reason.” *Id.* at Applications. Pearson’s ESD system is “new,” as of 1989, in that it uses multiple programmable logic controllers (PLCs) to affect the shutdown system. Pearson states, however, “[t]here are many possible configurations of shutdown systems.” *Id.* at Configurations.

112. As another example of an emergency shutdown system being in common use, *Gilson* describes initiating an ESD from a central controller. Ex. 1037 (*Gilson*). *Gilson* describes an “emergency systems activation panel” for use during such stimulation activities as containing “all to neutral,” “emergency kill,” “emergency disconnect [ESD],” and “fixed fire system activation.” *Id.* at Control Cabin. *Gilson* describes that the ESD is part of a “fast response stimulation package (FRSP), and that it is operated “from a central control cabin.” *Id.* at Abstract. *Gilson* describes that “FRSP control hookup is accomplished quickly by centrally locating all connections for all functions to be remotely controlled at one point on each piece of equipment, which enables the use of multi-signal connectors between these single points.” *Id.* at 3.

113. *Burgos* describes using such systems, entitling his paper, “Eliminating Human Error During Coiled-Tubing Operations.” Ex. 1038 (*Burgos*). “The system

also includes an emergency stop.” *Id.* at Modified CS. Based on the well-known aspects of emergency stop systems, a POSITA would understand *Burgos* to be discussing a system to switch off power, or otherwise put into a safe state, the coiled tubing system. Coiled tubing systems are one method of tool placement downhole, analogous to pump down plug and perf operation.

114. Such ESD systems have been regularly used in Oil and Gas applications, but are not limited to them. For example, *Sammarco*, in 2005 quantifies the “safety integrity of a PLC-based ESD and a hardwired ESD” for mining operations using “continuous mining machines and conveyors”, analogous to a fracturing operation. Ex. 1039 (*Sammarco*). *Sammarco* is a result of a study performed by the National Institute for Occupational Safety and Health.

115. It was also known to use ESD in connection with compressors for turbine generators. For example, engineers at Solar (the company that sold turbine generators to USWS) published an article in 2009 about how to handle gas compression during an emergency shutdown. Ex. 1040 (Kurz) at Abstract (“Emergency shutdowns in compressor stations cause fast transients in the operating conditions”). Kurz describes an emergency shutdown to kill fuel flowing to a gas turbine:

During emergency shutdowns, the situation is different from regular, controlled recycle. Emergency shutdowns are initiated to protect the compressor station, and require the immediate shutdown of the compressor and its driver. In gas turbine driven compressors, this is initiated by cutting off the fuel flow into the gas turbine. In electric motor driven stations, the electric power to the motor is turned off.

Id. p. 2 (left column); *see also id.* p. 4 (“After the fuel is shut off, the gas turbine will still produce power due to its thermal inertia”).

116. A POSITA would recognize that at a facility with on-site generation, such as with a gas turbine generator, a shutdown with an ESD system would “switch off the supply of the electrical energy to all or part of an installation.” Ex. 1035 (NFPA 79) at 79-9 (§ 3.3.37). One method of “switching off” the supply of electrical energy to the entire installation would be “by cutting off the fuel flow into the gas turbine.” Ex. 1040 (Kurz) p. 2 (left column). This action, coupled with opening the breakers connecting the generator to the rest of the on-site equipment, would “achieve a safe plant condition” as described by *Pearson* (Introduction). Ex. 1036. Such a configuration would have been well-known to a POSITA.

X. OVERVIEW OF THE PRIOR ART

A. PAYNE (EX. 1004)

a. Status of Payne

117. 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. It claims

the priority to Provisional Application No. 62/128,291, filed on March 4, 2015. *Payne* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Payne*

118. *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 pump motor.” Ex. 1004, [0014]. *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.” *Id.*, [0122]. The fracturing system also includes additional units, such as a hydraulic blender unit and a system control unit. *Id.*, [0014].

119. *Payne* discloses that the hydraulic fracturing pump unit “may be supplied with a multi-color light tower for each pump,” in which the individually colored beacon lights illuminate based on different states of the pump and/or pump motor. *Id.*, [0058], Fig. 10.

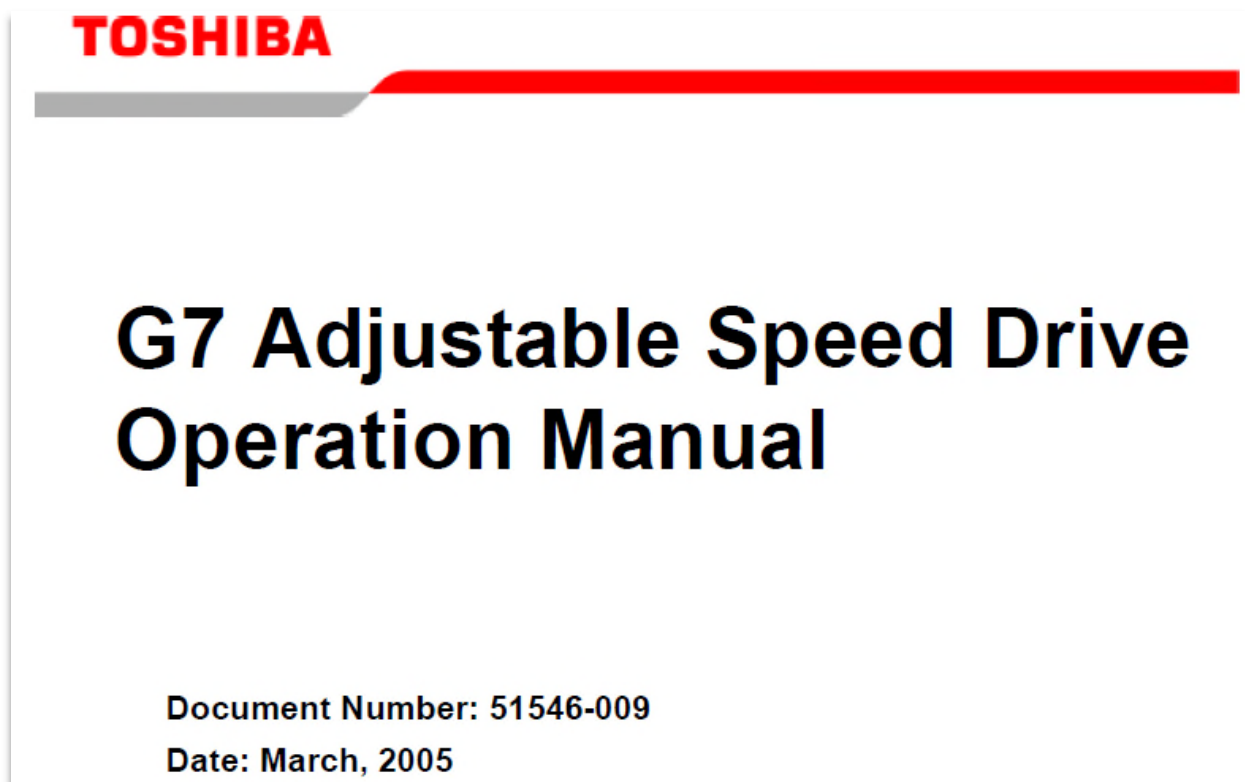
120. Accordingly, in my opinion, a POSITA would have understood that *Payne* discloses an entire fracturing system, including at least the elements of the system claimed in the Challenged Patent, that includes electric pumps and motors

for hydraulic fracturing operations, with associated variable frequency drives, and signal assemblies.

B. TOSHIBA MANUAL (EX. 1005)

a. Prior Art Status of Toshiba Manual

121. Toshiba Manual refers to “G7 Adjustable Speed Drive Operation Manual,” Document No. 51546-009, published by Toshiba International Corporation (“**Toshiba**”) and with a copyright date on the cover of March 2005. A screenshot of the cover is shown below:



Ex. 1005.

122. Toshiba has been a major manufacturer of electric motors and variable frequency drives and has been for decades before the Challenged Patents. Toshiba “entered the North American adjustable speed drives market in 1981 and has continued to grow the market with [its] products.”⁴ Toshiba has actively marketed and participated in the Oil & Gas industry. “Toshiba’s oil and gas product offerings are packages as a complete solution, increasing maximization of system uptime and mean time between failures...With extensive experience in oil and gas applications, including drilling, pumping, [and] production ..., we understand your specific applications and can provide highly reliable solutions to meet your needs.”⁵

123. Toshiba actively participated in industry organizations and activities, such as the Petroleum and Chemical Industry Committee (PCIC) of the IEEE. A POSITA would have been well aware of Toshiba’s expertise and prevalence in the oil and gas market, particularly with motors and drives. A POSITA would have been motivated to look to Toshiba’s products, manual, documentation and brochures for teachings on solutions to problems integrating motors and variable frequency drives.

⁴ <https://web.archive.org/web/20150322063102/https://www.toshiba.com/tic/industrial/adjustable-speed-drives>

⁵ <https://web.archive.org/web/20150912015743/https://www.toshiba.com/tic/industries-served/oil-gas>

124. One such offering was Toshiba's G7 line of drives, in particular the GX7 offering. "Toshiba's GX7 Series PWM adjustable speed drive is a severe duty drive built to handle all conventional applications in the industry, ranging from the simplest to the most complex...This drive maintains astoundingly tight control over both torque and speed with the industry's most user-friendly operator interface." Ex. 1006 at 7. *Toshiba Manual* contains information regarding operation and setup of the G7 family of drives, including the GX7. When a POSITA would access the Toshiba website to obtain the operations manual for the G7 family of drives, one would have found *Toshiba Manual*. The file name of *Toshiba Manual* when accessed from the Toshiba website is "GX7%20Operation%20Manual_3886.pdf." As evidenced by the declaration of the custodian from Internet Archive, *Toshiba Manual* was publicly accessible from the Toshiba website by at least December 7, 2010, corresponding to the date it was archived by the WayBack Machine of Internet Archive. Ex. 1006 at 1, 25 (describing Ex. 1005, *Toshiba Manual*).

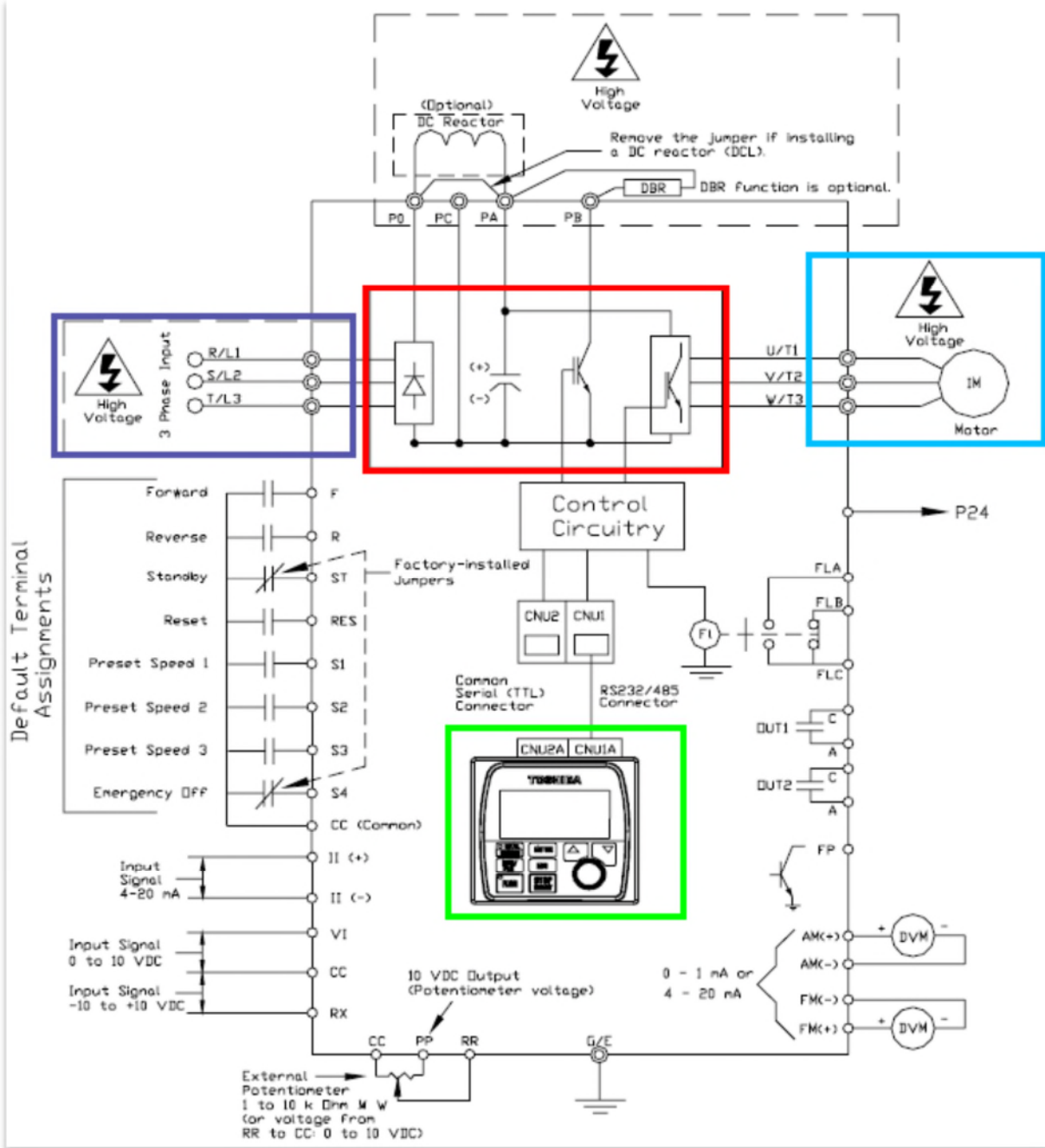
b. Overview of the Disclosure of Toshiba Manual

i. *Variable Frequency Drive*

125. *Toshiba Manual* contains a description of a VFD. The title of *Toshiba Manual* is "G7 Adjustable Speed Drive Operation Manual." As discussed in Section IX.E, "a Variable Frequency Drive (VFD) is another term for an Adjustable Speed Drive (ASD)." Further, *Toshiba Manual* describes that the VFD "uses a sinusoidal

Pulse Width Modulation (PWM) control system. The output current waveform generated by the ASD approaches that of a perfect sine wave” Ex. 1005 at 19. Insulated Gate Bipolar Transistors (IGBTs) are used for the power electronics in *Toshiba Manual*. *Id.* at 145, 180, 183, 207, 209, 211.

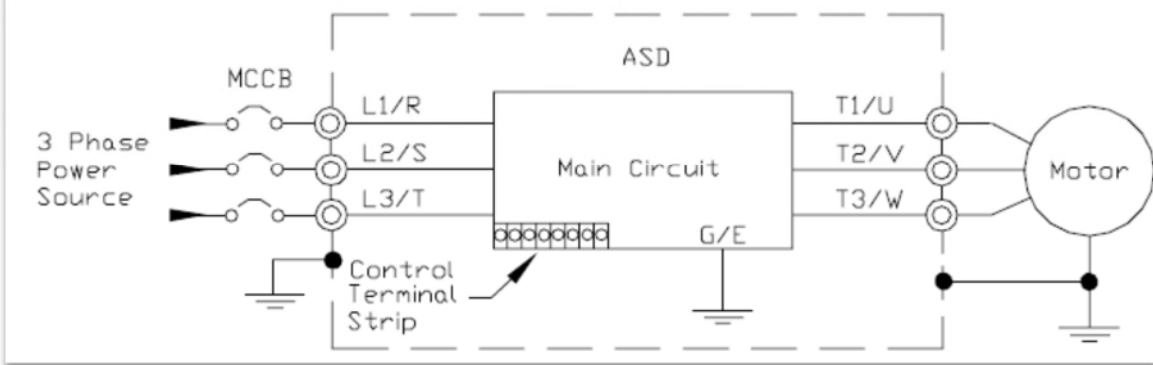
126. *Toshiba Manual* provides a schematic, showing the components of a quintessential VFD, including: “3 Phase Input” of electricity (purple box); an AC/DC/AC converter (including a rectifier circuit and inverter circuit) to convert fixed-frequency input AC electricity to DC and then to variable-frequency AC (red box); and output of that converted AC electricity to an electric motor (blue box). I described such components in Section IX.E. Also shown is an Electronic Operator Interface (“EOI”) (green box) that provides input to control circuitry for the VFD, as well as displaying the operational status of the VFD and associated equipment, including the motor. Ex. 1005 at 36 (Fig. 18, “typical connection diagram”) (annotated below).



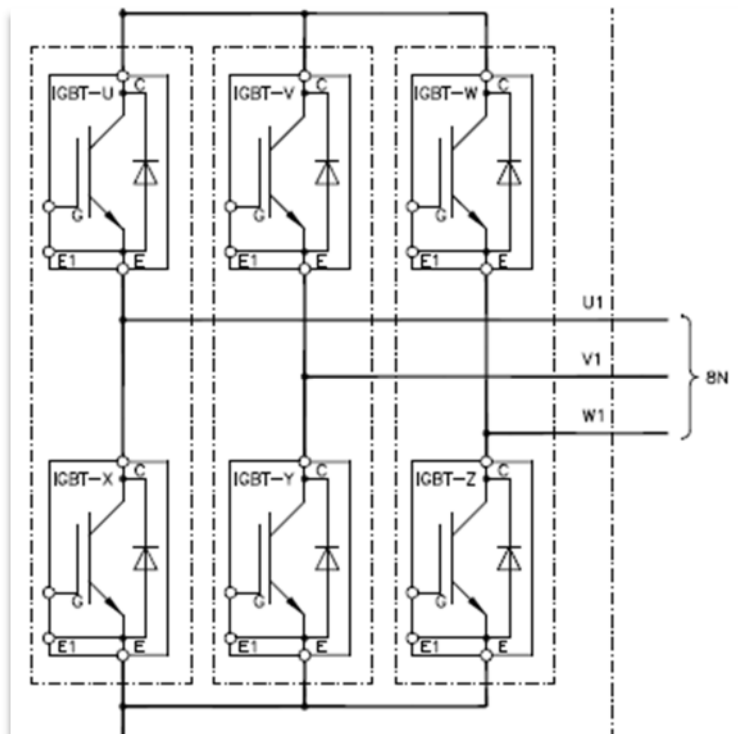
Toshiba Manual shows the inverter circuit using Insulated Gate Bipolar Transistors (IGBTs), the same type of inverter circuit shown in *Horikoshi*. See Section IX.F.b

Toshiba Manual also shows a figure for connecting the VFD (ASD) to the electric motor:

Figure 4. ASD/Motor connection diagram.



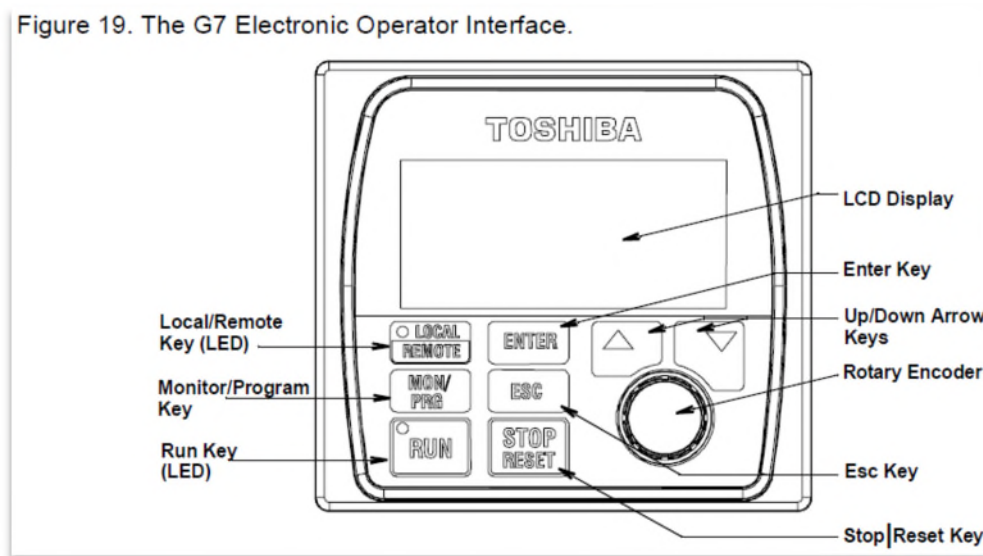
The Toshiba website published schematics of the power electronics to accompany *Toshiba Manual*, and they confirm the presence of an IGBT output converter using the same configuration as in *Horikoshi*.



Ex. 1006 (Internet Archive Declaration) p. 254.

ii. Local / Remote Control

127. *Toshiba Manual* describes that the VFD receives input from the Electronic Operator Interface (EOI) (a touchscreen interface, shown in green above) and a remote host computer. For example, the VFD has a “Local/Remote Key” that toggles between “Local and Remote modes,” allowing “Command and Frequency control functions to be carried out via the EOI” or “via the Control Terminal Strip, LED Keypad, RS232/RS485, Communication Card, or Pulse Input,” respectively. Ex. 1005 at 42 (section describing “EOI Features”). A picture of the EOI is shown below, further including the “Local/Remote” button (key).



Ex. 1005 at 43. The EOI also includes buttons (keys) to “run” or “stop” the electric motor connected to the drive. *Id.* The “EOI is the primary input/output device for

the user. The EOI may be used to monitor system functions, input data into the system, or perform diagnostics” Ex 1005 at 43. The EOI may also be “mounted remotely from the ASD as described in the section EOI Remote Mounting on pg. 190. The interface can operate up to distances of 15 feet from the ASD via the common serial (TTL) Port. For distances beyond 15 feet, the RS232/RS485 port is recommended.” Ex 1005 at 36.

128. A local emergency stop should also be provided, so that any observed failures of the motor or driven equipment, or any other safety condition that may arise, can be immediately addressed by the observer. The EOI provides just such a local emergency stop, including a “Stop” key and other features:

- **Local | Remote Key** – Toggles the system to and from the **Local** and **Remote** modes. The **Local** mode allows the **Command** and **Frequency** control functions to be carried out via the **EOI**. The **Remote** mode enables the **Command** and **Frequency** control functions to be carried out via the **Control Terminal Strip, LED keypad RS232/RS485, Communication Card** or **Pulse Input**.
- **Run Key** – Issues the **Run** command while in the **Local** mode.
- **Stop Key** – Issues the **Off** command if pressed once while in the **Local** mode or initiates an **Emergency Off** (terminates the ASD output and applies the brake if so configured) if pressed twice quickly from the **Local** or **Remote** modes.

Ex 1005 at 42 (section describing “EOI Features”). The *Toshiba Manual* also discloses an “Emergency Off” braking system (accessible from the EOI) to

immediately “remove output power from the drive in the event of the emergency,” and thus shut down the motor (and pump). Ex. 1005 at 12. A POSITA would have been motivated to use the supplied EOI (local control panel) in addition to any remote control to take advantage of local functions such as start / stop, motor jogging and especially emergency stop.

129. “Command control includes instructions such as Stop, Run, Jog,⁶ etc. ... The source of the command control and speed control may be either internal or external.” Ex. 1005 at 37. Toshiba Manual further explains that the “Jog function may be initiated from the EOI or remotely via the Control Terminal Strip or using Communications.” Ex. 1005 at 113. Local control of the jog function is especially useful when checking for mechanical operation of the motor and pump, such as proper direction of rotation. *Toshiba Manual* also describes the EOI can display the “running” or “stopped” condition of the associated pump and motor by changing the color of the “Run Key Status LED”

⁶ “Jog is the term used to describe turning on the motor for small increments of time and is used when precise positioning of motor-driven equipment is required.” Ex. 1005 at 82 (Table 8). Additionally, jogging is used to check phase rotation of the motor, or check mechanical operation of the motor or the driven load (e.g. pump) as part of a diagnostic or troubleshooting exercise.

Run Key Status LED — Illuminates green while stopped or red while running.

Ex. 1005 at 42.

130. In addition to controlling the VFD through the EOI, users could also control the VFD through a remote host computer (such as the PAC or the centralized controller of *Payne*):

The communications network includes other ASDs and Host/Control computers that monitor the status of the ASD(s), transfer commands, and loads or modifies the parameter settings of the ASD.

Ex. 1005 at 173. Accordingly, *Toshiba Manual* discloses both local control and remote control of a pump by controlling the electric motor.

iii. *Performing Electric Motor Diagnostics, and Selectively Disabling the Diagnostics Based on One or More Parameters of the Electric Motors*

131. *Toshiba Manual* discloses numerous examples of electric motor diagnostics. *Toshiba Manual* expressly discloses that the EOI “may be used to monitor system functions, input data into the system, or **perform diagnostics**.” Ex. 1005 at 43. The diagnostics includes a “fault screen” that “identifies the active Fault.” Ex. 1005 at 182-186 (Table 12, containing a list of 5 pages of faults that are diagnosed). Examples of motor diagnostics used to protect the connected motor disclosed in *Toshiba Manual* include:

- Overload protection (Ex. 1005 at 19)

- Over-current protection (Ex. 1005 at 22)
- Electronic Thermal Protection (Ex. 1005 at 160)
- Overcurrent Stall Level (Ex. 1005 at 160)
- Motor 150% OL Time Limit (Ex. 1005 at 161)
- Short Circuit Test (Ex. 1005 at 162)
- Over-torque trip (Ex. 1005 at 163)
- Earth Fault Trip (Ex. 1005 at 166)

These diagnostic functions result in an alarm or trip condition on the ASD. Toshiba

Manual describes alarms and trips:

If a user setting or an ASD parameter has been exceeded, or if a data transfer function produces an unexpected result, a condition that is referred to as a **Fault** is incurred.

An **Alarm** is an indication that a **Fault** is imminent if existing operating conditions continue unchanged. ...

In the event that the condition that caused the **Alarm** does not return to its normal operating level within a specified time, the ASD **Faults** and a **Trip** is incurred (**Fault** and **Trip** are sometimes used interchangeably). A **Trip** is a safety feature, and is the result of a **Fault**, that disables the ASD system in the event that a subsystem of the ASD is malfunctioning, or one or more of the variables listed below exceeds its normal range (time and/or magnitude).

- Current,
- Voltage,
- Speed,

- Temperature,
- Torque, or
- Load.

Ex 1005 at 179.

132. As discussed above, certain diagnostic actions result in a trip. Table 12 from Ex. 1005 shows several trip conditions and possible causes. Included in this table as it relates to preventing damage to an electric motor are the following:

Fault Screen Display	Possible Causes
Earth Fault	Ground Fault at the motor
Load Drooping	Load requirement is in excess of the capabilities of the motor
Motor Overload	Motor is locked Load requirement exceeds ability of the motor Continuous operation at low speed
Overcurrent During Acceleration	Accel time too short Motor/machine jammed Mechanical brake engaged while the ASD is running
Overcurrent During Deceleration	Motor / machine jammed Mechanical brake engaged while the ASD is running
Overtorque	A torque requirement by the load in excess of the setting of the motor (specific settings)
U phase Short Circuit	Low impedance at the U lead of the ASD output (at the motor or in cable to motor)
V phase Short Circuit	Low impedance at the U lead of the ASD output (at the motor or in cable to motor)
T phase Short Circuit	Low impedance at the U lead of the ASD output (at the motor or in cable to motor)

Ex. 1005 at 82-84 (Table 8).

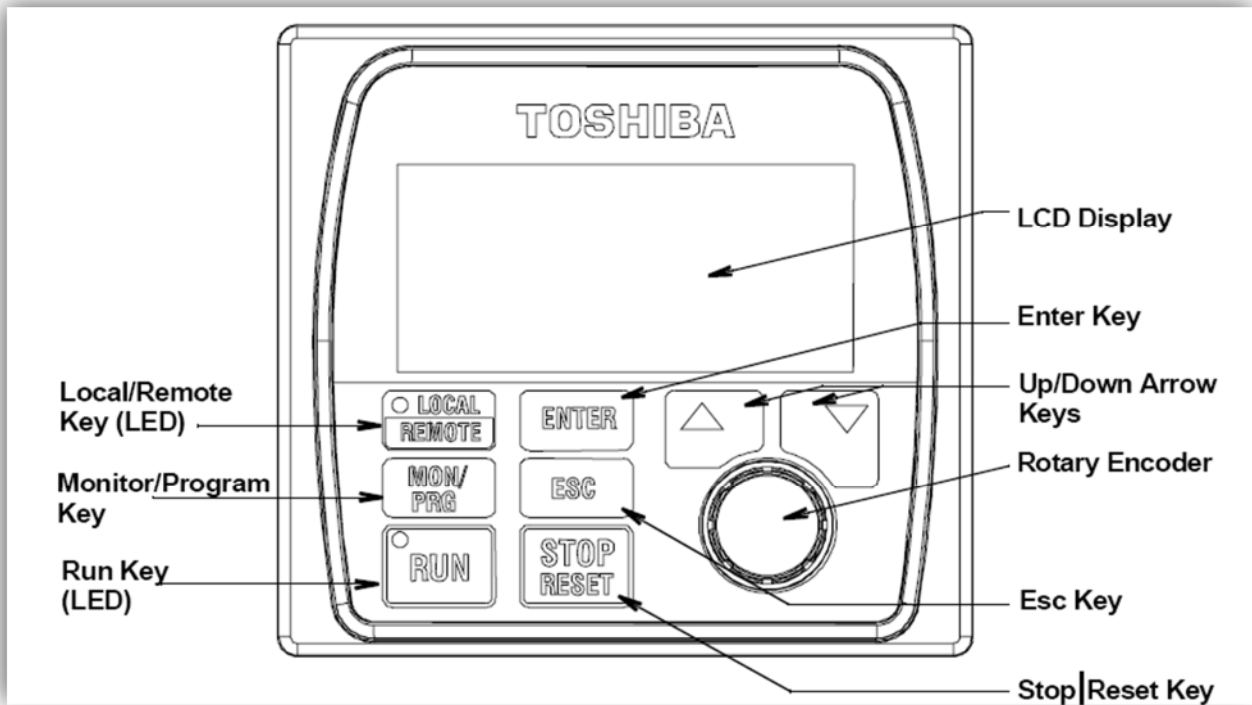
133. Certain of the motor protection diagnostic features can be enabled or disabled, depending on the parameters of the attached motor. For example, for low-speed high torque operation, “When the ASD is used with a VF motor⁷, the **VF Motor** overload protection setting must be enabled.” Ex 1005 at 19. A POSITA would have understood that it follows that if a VF motor is not used, this diagnostic function should be disabled. As another example “the Overcurrent Stall Level may be adjusted to help with nuisance over-current trips,” particularly useful with a low-impedance motor. Ex. 1005 at 22. By adjusting overcurrent stall level higher than would be expected for a particular load, the overcurrent stall level is effectively disabled. Other protective diagnostic functions which can be specifically enabled and disabled (e.g., have “enable/disable” commands) include at least “Overvoltage Stall” (Ex. 1005 at 119), “undervoltage ride-through” (Ex. 1005 at 118, 165), “light load high-speed operation selection” (Ex. 1005 at 84, 123), “Low Current Trip” (Ex. 1005 at 162), “overtorque trip” (Ex. 1005 at 163), “undervoltage trip” (Ex. 1005 at 165). *Toshiba Manual* discloses a series of “Protection Parameters” with “Enable/Disable” functionality (Ex. 1005 at 57-58) and a series of “Motor Parameters” with “Enable/Disable” functionality (Ex. 1005 at 62).

⁷ A VF motor is a Toshiba motor designed for constant Volts / Hertz operation, which is specifically designed for a low speed / high torque operation.

134. The majority of the diagnostics that would result in a trip of the drive to protect the motor are conducted on a continuous basis as the motor is being run. Some diagnostics, such as the “Short Circuit Test,” are specifically conducted “every run” or “every power up” (Ex. 1005 at 162), which meets the definition of frequently, as used in this proceeding.

iv. *Visual Display (Signal Assembly)*

135. As described above, the EOI described in *Toshiba Manual* “is the primary input/output device for the user. The EOI may be used to monitor system functions, input data into the system, or perform diagnostics” Ex. 1005 at 43 The EOI “is comprised of an LCD display, two LEDs, a rotary encoder and eight keys.” Ex. 1005 at 42. The makeup of the EOI is shown in the figure below.



Ex. 1005 Fig. 19.

136. *Toshiba Manual's* EOI, accordingly, not only serves as an input portal to the system, it also is a display of data to inform the operator of the operational state of the system. The EOI performs this function using both the LCD and the LEDs. The LCD “Displays configuration information, performance data (e.g. motor frequency, bus voltage, torque, etc.), and diagnostics information.” Ex. 1005 at 42. The Run Key Status LED “Illuminates green while stopped or red while running”, while the Local|Remote Key LED “is on when the system is in the Local Command Mode” *Id.* at 42.

C. BROUSSARD (EX. 1007)

a. Status of *Broussard*

137. U.S. Patent Application Publication No. 2014/0138079 by Broussard et al. (“*Broussard*”) was filed on November 16, 2012 and published on May 22, 2014. The publication of *Broussard* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Broussard*

138. *Broussard* explains that the prior art includes electric fracturing pumps, i.e., pumps powered by an electric motor, as a replacement for diesel pumps and the “problems associated” with those pumps. Ex. 1007, [0002], [0006]. In particular, *Broussard* describes “pumping fracturing fluid into an oil or gas well using pumps powered by electric motors.” *Id.* [0002]

139. *Broussard* further describes those electric motors are powered with electricity from electric generators, and variable frequency drives control the speed of the motors, and therefore, the speed of the pumps. *Id.* [0008]-[0009], [0019], [0024]. The VFDs “can frequently perform electric motor diagnostics to prevent damage to [an] electric motor if it becomes grounded or shorted.” *Id.*, [0011]; *see also id.* [0021], claim 15.

140. Thus, in my opinion, a POSITA would have understood that *Broussard* discloses an entire fracturing system, similar to the system described in the

Challenged Patent, that includes electric pumps and motors for hydraulic fracturing operations, with associated variable frequency drives, and a signal assembly.

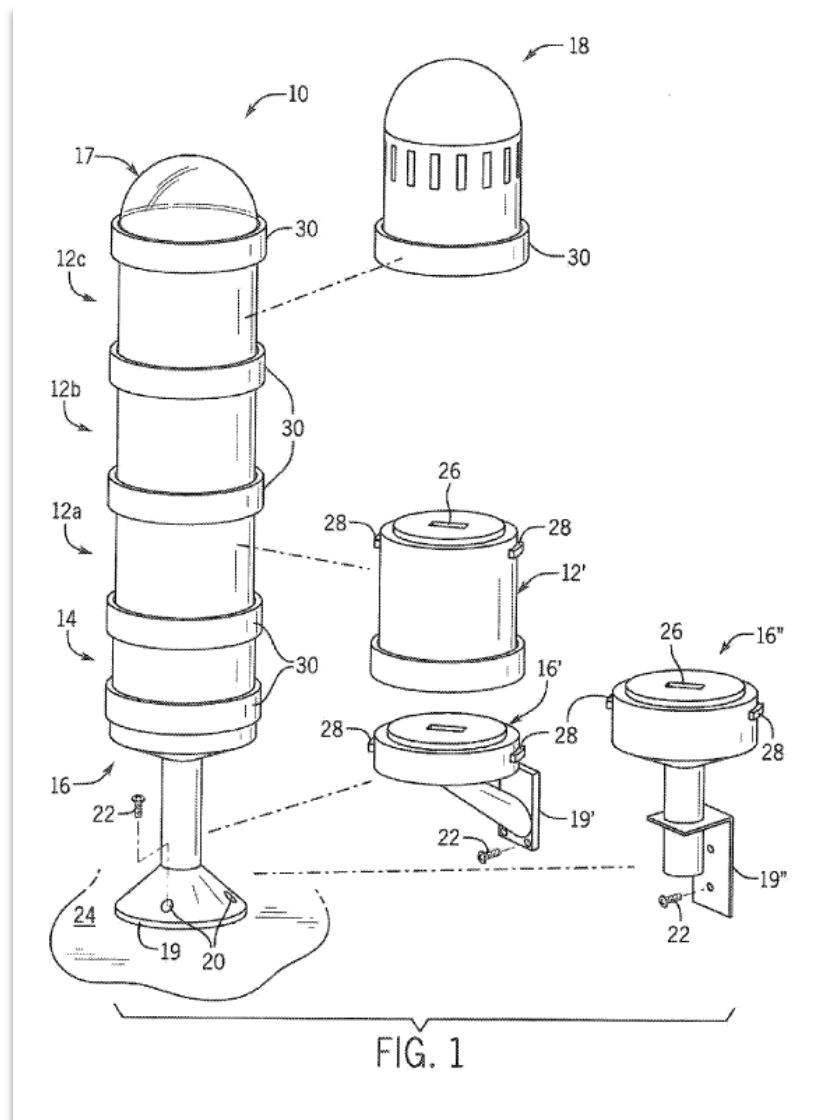
D. FELLER (EX. 1008)

a. Status of *Feller*

141. U.S. Patent Application Publication No. 2015/0198316 by Feller et al. (“*Feller*”) was filed on January 13, 2014 and published on July 16, 2015. The publication of *Feller* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Feller*

142. *Feller* discloses “stack lights” may be used as “visual display” to “convey operation and warning information in an industrial environment.” Ex.1008, [0001]. These stack lights may comprise “a short tower of different colored lamps” that are “attached to, or placed in close proximity to, operating industrial equipment to provide a visible indication of the equipment operating status.” *Id.* [0002]-[0003]; *see also id.* Fig.1. As *Feller* explains, the different colors of the lights “allow multiple types of information to be communicated at a distance in a possibly noisy environment.” *Id.* *Feller* provides additional information and teachings regarding *Payne*’s “multi-color light tower” and a POSITA would recognize *Feller*’s “short tower of different colored lamps” to be substantially similar, if not identical, to *Payne*’s “multi-color light tower.”



Ex.1008, Fig.1.

143. For these reasons, *Feller* is analogous art to *Payne* even though it is not in the fracturing context because it is “reasonably pertinent” to the particular problem at issue in the ’871 Patent—visibly indicating equipment operating status to personnel not standing directly at a machine. Ex. 1001, 2:25-27 (“a signal

assembly that selectively emits a visual signal that is ***indicative of an operational state*** of the hydraulic fracturing system”).

144. Thus, in my opinion, a POSITA would have understood that *Feller* discloses a signal assembly.

E. WIEMERS (EX. 1009)

a. Status of *Wiemers*

145. U.S. Patent Application Publication No. 2015/0001161 by Wiemers et al. (“*Wiemers*”) was filed on July 1, 2013 and published on January 1, 2015. The publication of *Wiemers* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Wiemers*

146. *Wiemers* describes a liquid treatment station and mobile treatment units that may be used at fracking sites to treat flowback liquid at the wellsite. Ex. 1009, Abstract, [0001], [0003]-[0005]. *Wiemers* also explains that the process control of a mobile treatment unit includes the steps of “sensing attributes of liquid to be treated at the treatment unit” and sensing “operational functioning of unit components, such as speed and state attributes (on/off, for example).” *Id.* [0011], [0103].

147. Figure 30 displays a “software controller and training simulator.” *Id.* [0062]. The simulator teaches what an actual controller would do in a deployed system. *Id.* [0107] (“This simulation software is an exact duplication of the process

control software programming onboard at management unit 39....”). As displayed in the figure, “there are status lights, start/stop buttons and speed control potentiometers for each variable frequency drive (VFD) motor in the system.” *Id.* [0110]. Moreover, the lights “show if a VFD motor is currently energized” and contains “switches for each VFD motor that simulate an overheating signal or any other kind of fault.” *Id.*

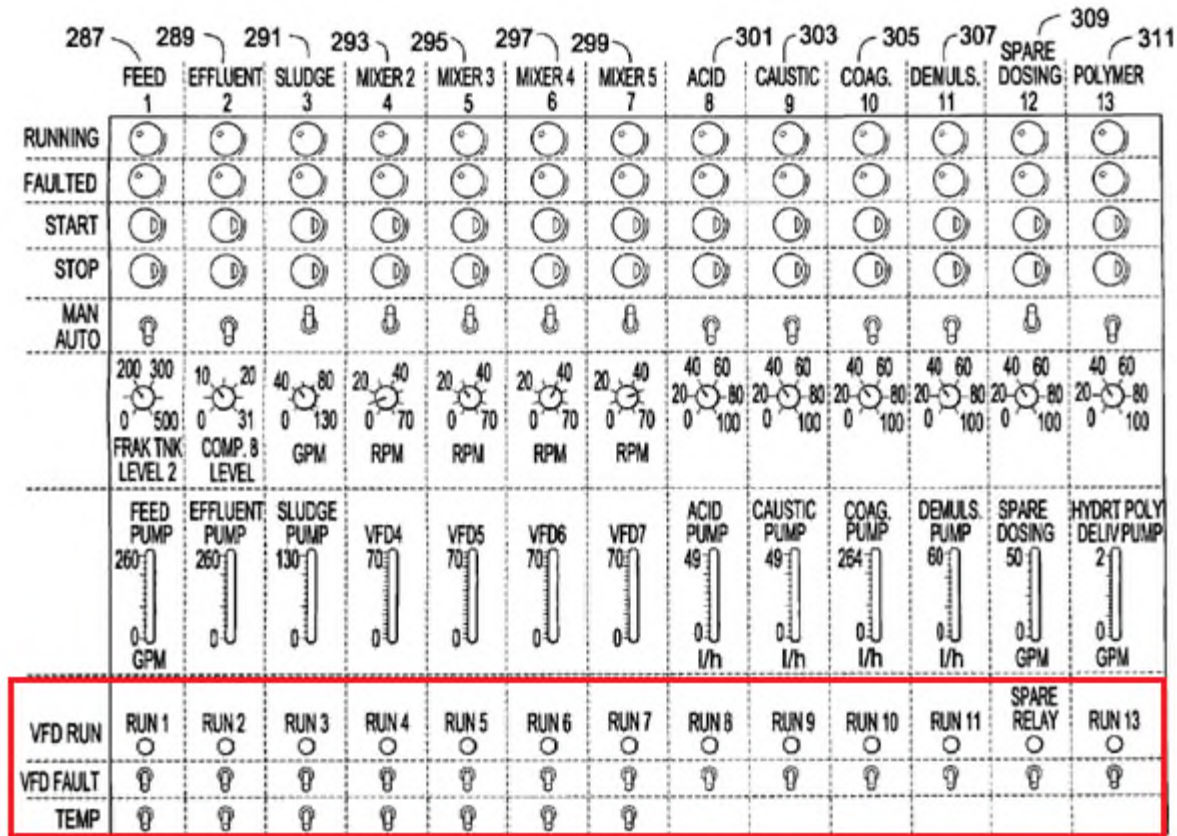


FIG. 30

Ex. 1009, Fig. 30 (annotated).

148. Thus, in my opinion, a POSITA would have understood that *Wiemers* discloses a controller for variable frequency drives, along with a signal assembly depicting the status of the VFDs.

149. *Wiemers* is at least analogous art because it is “reasonably pertinent” to the oil and gas fracturing context, including monitoring and controlling components in the ’871 Patent (*e.g.*, VFDs). Ex.1009, [0001]. *Wiemers* is directed towards “hydraulic fracturing, or hydro-fracturing, commonly known as ‘fracking’” (Ex. 1009, [0003]) and accordingly is analogous to *Payne*.

F. CARLSON (EX. 1010)

a. Status of *Carlson*

150. U.S. Patent No. 6,006,227 by Carlson et al. (“*Carlson*”) was issued on December 28, 1999. The issuance of *Carlson* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Carlson*

151. *Carlson* describes a blender system used to “prepar[e] fluid mixtures for fracturing and propping oil bearing geological formations.” Ex. 1010, 1:15-27. The blender system includes a “blender apparatus,” “control devices,” “sensing devices adapted to transmit a plurality of sensor signals,” “a programmable system controller,” and “control pendants...to receive input commands from an operator and display status conditions of the control devices and sensing devices.” *Id.* The

control pendants may include “light emitting diode (LED) drivers 1255, communication bus 1260, and LED indicators 1265.” *Id.*, 15:9-15. The control pendants may be used “virtually anywhere (e.g., on top of the blender assembly 300, beside the blender assembly 300, in any remote control location, or from two sites simultaneously).” *Id.*, 3:5-10. “This increased mobility enhances the safety of the operator” for several reasons, including because it “eliminates the need for a second person to operate the blender system 100 while the technician performs the service.” *Id.*, 3:5-10, 3:55-60.

152. Thus, in my opinion, a POSITA would have understood that *Carlson* discloses a blender for use in a fracturing system, similar to the system described in the Challenged Patent, that includes a signal assembly associated with the blender.

G. RANDLE (EX. 1011)

a. Status of *Randle*

153. U.S. Patent Application Publication No. 2014/0290768 by Randle et al. (“*Randle*”) was filed on March 27, 2013 and published on October 2, 2014. The publication of *Randle* thus predates the claimed priority date of the Challenged Patent.

b. Overview of the Disclosure of *Randle*

154. *Randle* discloses a “hydraulic fracturing pump isolation safety system.” Ex. 1011, [0017]. *Randle* explains that the fracturing pumps may “include a pump

condition determining means that generates a signal that reflects the condition or operational status of the pump.” Several different conditions are disclosed by *Randle* including “current flow through the motor windings, fluid end pressure, temperature, sound, and/or vibration” *Id.* [0029]. The safety system includes a remote operator control panel that operates with an industrial programmable logic controller, which can “accept[] as inputs the valve condition and the pump condition, and present[] the monitored conditions to the operator control panel for display on the operator graphical interface.” *Id.* [0032].

155. Thus, in my opinion, a POSITA would have understood that *Randle* discloses an entire fracturing system, similar to the system described in the Challenged Patent, that includes electric pumps and motors for hydraulic fracturing operations, and that senses the condition of the fracturing system, including presence of electricity and pressure, and signals the operator regarding this condition using an operator graphical interface (signal assembly).

XI. GROUNDS 1-2: ANTICIPATION BY *PAYNE* AND OBVIOUSNESS OVER *PAYNE*

156. It is my opinion that *Payne* anticipates Claims 1-4, 6-7, 9-12, 15-17, 19 of the '871 Patent (Ground 1). To the extent *Payne* does not anticipate these claims, it is my opinion that *Payne* renders Claims 1-19 obvious (Ground 2).

A. **INDEPENDENT CLAIM 1**

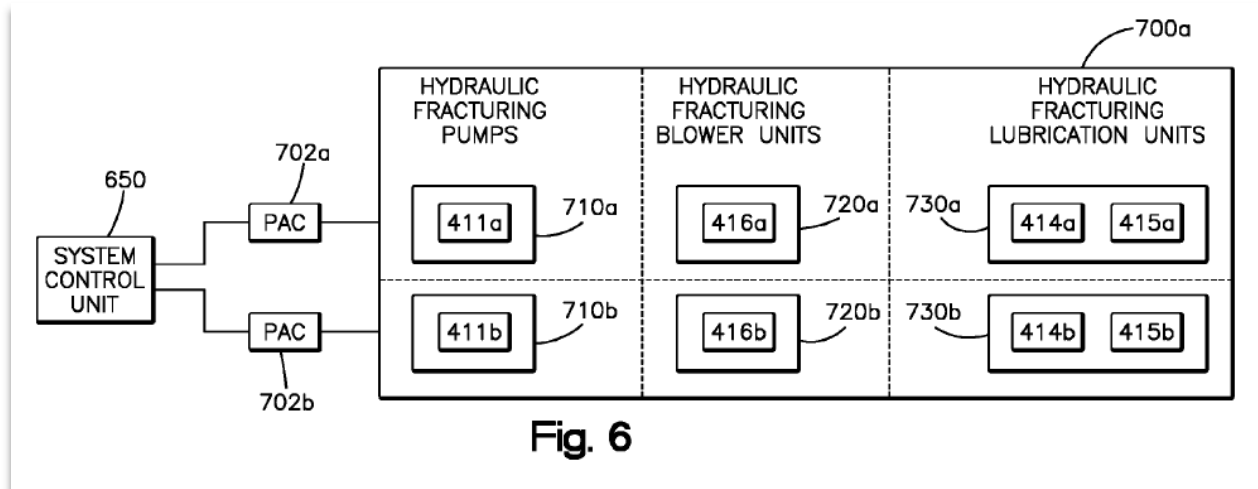
a. **1[pre]: A hydraulic fracturing system for fracturing a subterranean formation comprising:**

157. *Payne* discloses “a system for stimulating oil or gas production for a wellbore” that includes a “hydraulic fracturing pump unit having one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.” Ex. 1004, Abstract, [0015]-[0016].

b. **1[a] a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor, and configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation, and fractures the formation;**

158. *Payne* discloses “one or more hydraulic fracturing pumps driven by one or more electrical fracturing motors.” Ex. 1004, Abstract; *see also* [0051] (“one or more hydraulic fracturing pump units 700, for example eight hydraulic fracturing units”). *Payne*’s hydraulic fracturing pump unit includes “two or more fluid pumps,” where each pump is “driven by an alternating current (AC) electrical pump motor.” *Id.*, claim 1. Figure 6 (below) shows that the hydraulic fracturing pump unit “includes one or more electric motor-driven fracturing pumps 710, for example two

fracturing pumps 710a, 710b.” *Id.*, Fig. 6, [0052]. Accordingly, *Payne* discloses a plurality of pumps powered by at least one electric motor, or “electric pumps”.⁸



159. *Payne* further discloses that the hydraulic fracturing pumps receive treatment fluid from the hydraulic blender unit and deliver the fluid to the wellbore (*i.e.*, a plurality of electric pumps *fluidly connected to the formation*). Ex. 1004, [0015]. *Payne*’s system is used to “inject[] treatment fluids at high pressures into existing oil or gas wells in order to stimulate oil or gas production” *Id.* [0005]. This injection then “create[s] cracks in the deep-rock formations,” *i.e.*, fractures the formation, so that “natural gas, petroleum and brine will flow more freely.” *Id.* A POSITA would thus understand, based on the teaching of *Payne* that a fracturing

⁸ The term “electric pump” is not a term of art in engineering systems. I interpret the use of the term “electric pump” to mean “a pump driven by an electric motor”.

fluid is pumped into a wellbore that intersects the formation at high pressure, so that the fluid passes from the wellbore into the formation and fractures the formation.

160. Accordingly, *Payne* discloses “a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor, and configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation, and fractures the formation.”

c. **1[b] a variable frequency drive connected to the electric motor to control the speed of the motor,**

161. *Payne* discloses a “variable frequency drive (VFD)” that “provides ac current which turns the mechanically coupled motor and fracturing pump.” Ex. 1004, [0039]. *Payne* further explains that the “operating mechanisms for the fracturing pump unit include a variable frequency drive housing that houses a first frac motor [VFD] 410a for driving a first frac motor 411a [and] a second frac motor VFD 410b for operating a second frac motor 411b.” *Id.* [0047]. In other words, “the frac motor 411a of a fracturing pump 710a is controlled by a frac VFD 410a.” *Id.* [0053]. Moreover, the fracturing unit control system “provides a speed request signal to the VFD 410a,” allowing the VFD “to control the speed of the frac motor 411a.” *Id.* A POSITA would have understood this description to disclose “a variable frequency drive connected to the electric motor to control the speed of the motor”. A POSITA

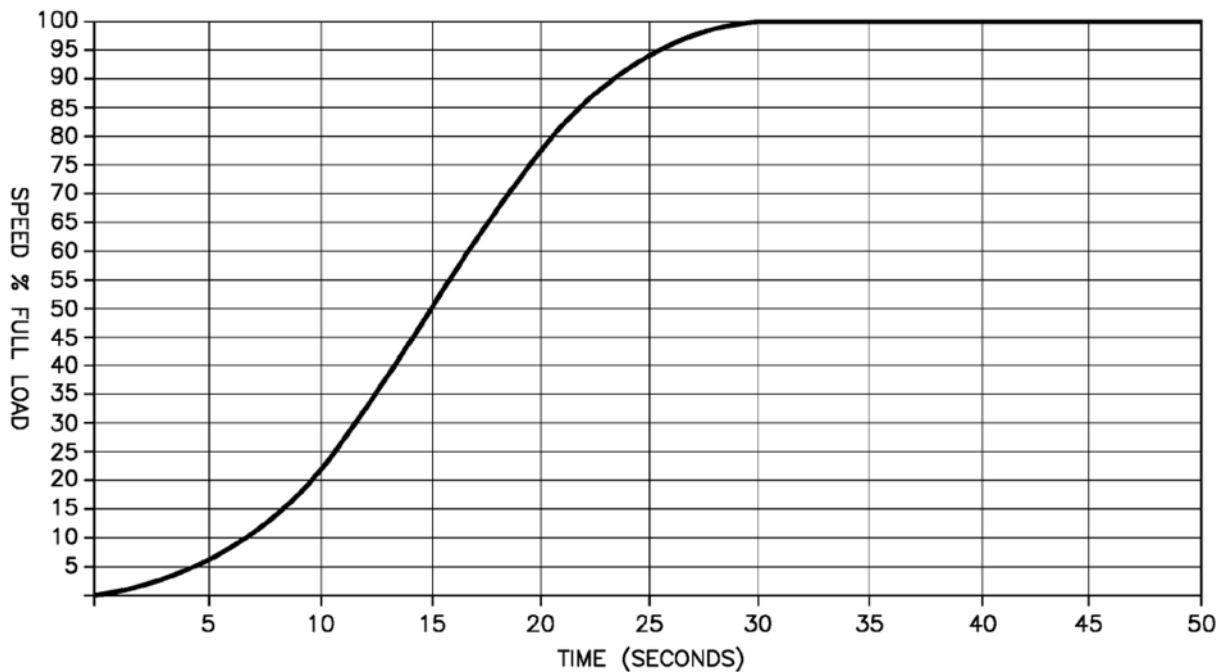
would also understand that the function of a VFD is to control the speed of the motor by controlling the electricity to the motor as described in Section IX.E.

162. *Payne* discloses the Toshiba GX7 Rig Drive as an example of a VFD. Ex. 1004, [0122] (“the selected VFD may be a Toshiba GX7 Rig Drive 1750 Hp, 600V, 1700 Amp 6-pulse Variable Frequency Drive”). Accordingly, a POSITA would also understand *Payne*’s reference to Toshiba GX7 Rig Drive as a VFD to control the speed of the motor (by controlling the electricity to the motor) based on the disclosures contained in *Toshiba Manual* regarding the GX7 VFD. I discuss *Toshiba Manual*’s disclosure of a VFD further below in Section XII.

d. **1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;**

163. *Payne* discloses that the fracturing unit control system “provides a speed request signal to the VFD 410a,” allowing the VFD “to control the speed of the frac motor 411a.” Ex. 1004, [0053]. VFDs, by their very nature, control the frequency (speed) and torque to the motor, thus regulating power delivery to the motor. See Section VIII.F A POSITA would have recognized that controlling these motor input parameters to the motor is an example of performing electric motor diagnostics to prevent damage to the motor. Further, *Payne* explicitly discloses controlling the acceleration and deceleration of the motor/pump combination by

controlling the speed/torque characteristics of the motor. “Referring specifically to Fig. 14, the VFD controls the acceleration and deceleration of the motor/pumps based on a programmed “S” curve.” Ex. 1004 [0112]. Figure 14 is duplicated below.



Ex 1004 Fig. 14

164. A POSITA would have understood that in order to control the acceleration / deceleration of the motor the VFD must control both speed and torque. Payne discloses that the VFD uses “modulated control techniques such as Constant Torque or Sensor-less Vector” in order to control the motors and pumps. This control is necessary “to ensure that the mass and inertia of the motor/pumps is properly managed to avoid damage or nuisance shutdowns of the VFD”. A POSITA would have understood that controlling speed and torque (acceleration and deceleration)

with the stated goal of avoiding damage is “performing electric motor diagnostics to prevent damage to the electric motor” and that this diagnostic function is performed during acceleration / deceleration of the motor which is more frequently than at each start.

165. *Payne* also discloses that the VFD can “provide a VFD FAULT contact to the control system to indicate if a fault condition is present.” Ex.1004, [0056]. The fault condition may relate to any number of operating parameters, including, for example, “currents and frequency, temperatures, power, percent of rated load, torque and percent of torque, output voltage and motor load, and system status.” By monitoring and comparing values such as output voltage, currents, frequency, torque, etc. the VFD would detect conditions such as a grounded or short circuited motor.

166. The VFD “raise[s] an alarm to the user whenever any of the operating parameters exceeds a corresponding threshold value”. Further, the VFD can shut down if these limits are exceeded. *Payne*’s shares load among the available VFDs with the goal of “minimizing the number of VFD faults and thermal shutdown events cause by over driving particular pieces of equipment.” *Id.* [0109]. A POSITA would understand *Payne*’s monitoring values and comparing them to “corresponding

threshold values” to be an example of “electric motor diagnostics” and the goal of this comparison is to prevent damage caused by “over driving” the motor.

167. Additionally, *Payne* discloses if a “fault condition” is present and the control system indicates “VFD FAULT,” the “VFD FAULT” can be “reset based on predefined intervals of time.” Ex. 1004, [0056]. *Payne* also discloses that VFD FAULT can be reset from the frac VFD if it occurs “more frequently than the predefined interval.” *Id.* A POSITA would, therefore, understand that the VFD performs the electric motor diagnostics—i.e., determines “if a fault condition is present”—frequently, or at least on the application of power or with each start. A POSITA would have understood that the diagnostics performed by the VFD of *Payne* are conducted on a continuous basis, in order to detect if the monitored values exceed the threshold values at any time.

168. In addition to the express disclosure of *Payne*, this limitation is obvious over *Payne* for several reasons. Because the VFD “controls the acceleration and deceleration of the motors/pumps,” a POSITA would understand that the VFD would frequently perform electric motor diagnostics to prevent damage to an electric motor in light of *Payne*’s disclosure that the VFD can indicate if a “fault condition is present”—particularly when the fault condition may relate to “output voltage and motor load.” Ex. 1004, [0056], [0109], [0112].

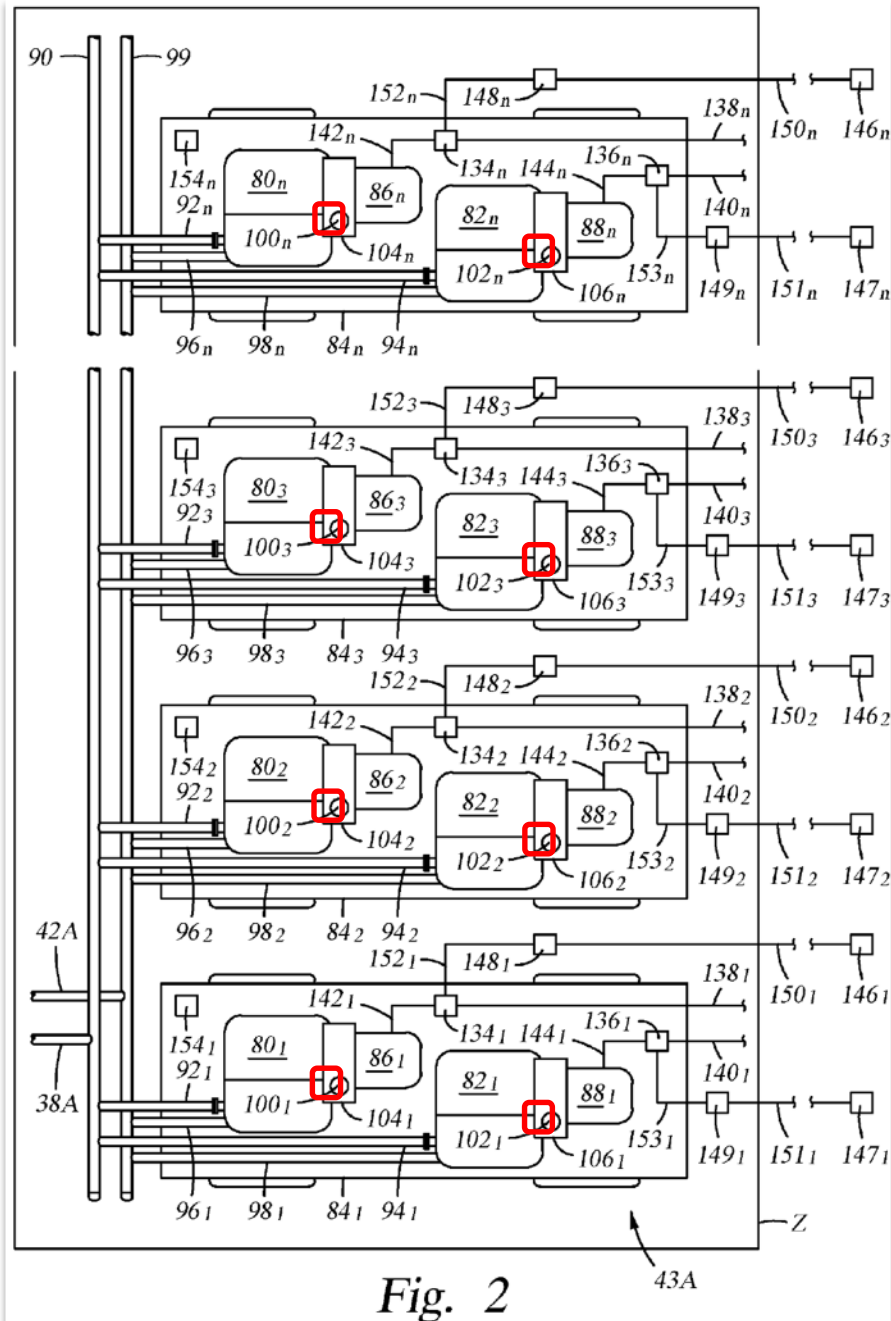
169. It also would have been obvious to use the VFD to perform motor diagnostics because a POSITA would have known that absent ensuring proper control (i.e., through motor diagnostics), the electric motors could be damaged.

170. A POSITA would have had a reasonable expectation of success in performing motor diagnostics using the VFDs of *Payne*. Using a VFD to perform the motor diagnostics would be nothing more than using known techniques to yield predictable results. For example, standards in existence more than a decade before the 871 Patent govern construction of VFDs to perform electric motor diagnostics to prevent damage to electric motors. *See* Section VI.F; Ex. 1022 (NEMA ICS-61800-4) p. 73-74 (§§ 9.5-9.6). Such well-known types of diagnostics include checking for: power source irregularities (e.g., voltage surges, over and under voltage, phase reversal, voltage unbalance), overcurrent conditions (e.g., fault currents, ground currents, and internal faults), overloads, overtemperature, motor overspeed, excessive vibration, lost lubrication, and others. Section X.L; Ex. 1022 (ICS-61800-4) p. 73-74 (§§ 9.5-9.6).

- e. **1[d] a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.**

171. *Payne* discloses this limitation. *Payne* discloses that the hydraulic fracturing pump unit “may be supplied with a multi-color light tower for each

pump.” Ex. 1004, [0058]. This light tower is a signal assembly as claimed in 1[d]. As in the ‘871 patent, *Payne* discloses light tower (signal assembly) attached to each pump/motor/VFD combination. “In an example, the hydraulic fracturing pump unit 700a may be supplied with a multi-color light tower for each pump 710a, 710b.” Ex 1004 [0058]. Compare with the ‘871 specification referring to FIG.3 “signal assemblies 100_{1-n}, 102_{1-n} are shown provided on trailers 84_{1-n} and which selectively emit visual signals that are indicative of an operational state of the fracturing system.” These signal assemblies are shown in FIG.2 as mounted on each pump/motor combination, as disclosed in *Payne*. The signal assemblies are annotated in red in the figure below. Accordingly, a POSITA would understand that both *Payne*’s light towers (signal assemblies) and ‘871’s signal assemblies each display the operational state of an individual pump/motor/VFD unit, and together display the operational state of the entire fracturing system.



Ex. 1001, Fig. 2 (annotated).

172. The beacon lights of *Payne* illuminate in different colors—which are visual signals—based on different operational states of the hydraulic fracturing

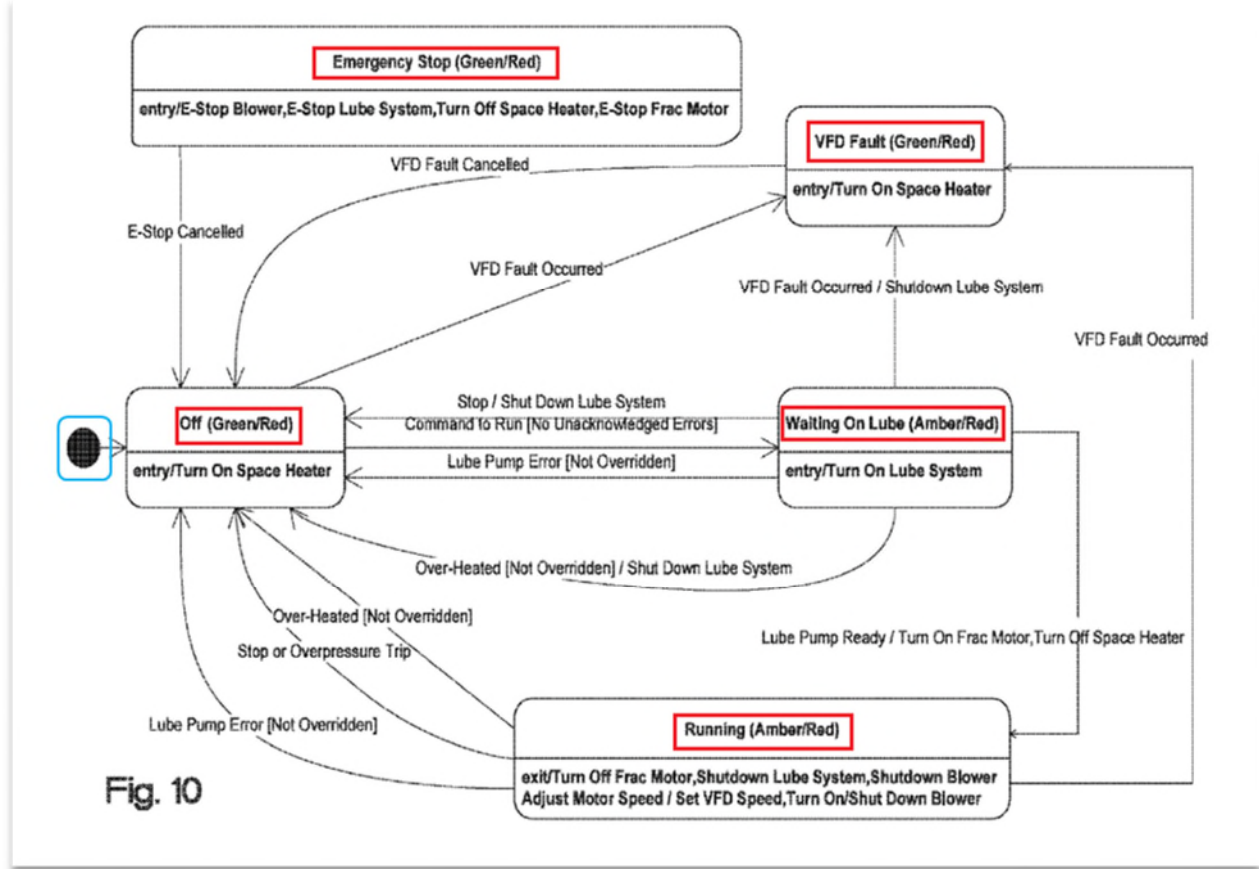
system.⁹ *Payne* discloses at least three different colors used with the multi-color light tower. “Color 1: frac motor 411a is not running and is not enabled to run; Color 2: frac motor 411a is running OR has been enabled to run; Color 3: the pump discharge pressure for the frac motor 411a is greater than a pre-defined psig setpoint.” *Id.* As another example, “[t]he beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” *Id.* [0103]. The colors disclosed by *Payne* would represent a “visual signal” being emitted by the light towers.

173. *Payne*’s Figure 10 (reproduced and annotated below) discloses that the beacon lights also may signal an operational state of the hydraulic fracturing system. Figure 10 is a state diagram (state chart) that represents “all states” of operation of a hydraulic fracturing pump unit. Ex. 1004, Fig. 10, [0102-0103]. A POSITA would have understood that Fig. 10 discloses both the state of the unit (system), along with which lights are illuminated to indicate such a state, the actions taking when the state is entered, the actions taken when the state is exited, and events that would occur to move to a different state.

⁹ I take no position on whether 1[d] requires a visual signal indicative of an operational state of the pump, the motor, and the VFD. *Payne* discloses visual signals that are indicative of an operational state of all those components, but to the extent that 1[d] is interpreted to only require a visual signal indicative of an operational state of fewer than all those components, the same analysis below would apply.

174. The colors contained in the red annotated rectangles show the illuminated portions of the light tower, as discussed above. “Green” represents electricity to some electrically powered equipment (*e.g.*, space heater, sensors, light tower); “amber” represents electricity supplied to all systems including the motor; and “red” represents the pump discharge pressure greater than a “pre-defined psig setpoint.” Ex.1004, Fig.10, [0058] A POSITA would understand, based on the disclosure of the state diagram in Fig. 10 that the system is initially off (left black circle annotated in blue) indicating there is no electricity to the system (no lights illuminated).

175. When the system is energized, electricity is supplied to some of the electrically powered devices in the system, such as the sensors and the light tower. If pressure in the pump discharge lines exceeds a “pre-defined psig setpoint”, then the red light in the system is illuminated. “The beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” Ex. 1004, [0103]; *see also id.* [0058]. This would occur, for example, if the motor/pump system is running generating pressure, or if other pumps are running providing pressure in the discharge iron even if the current motor/pump is not running, particularly if there is some pressure leakage in the valves connecting the pump discharge to a pump manifold.



176. When the system is energized, it is also placed into a waiting state, where the motor/pump has not been enabled to run. In this state, electricity is applied to auxiliaries, for example, the space heater “to help ensure that the motor windings are dry before operation. Typical practice is to have the space heaters energized for at least 24-hours before running the motor.” Ex. 1004, [0057]. Accordingly, in this state, electricity is supplied to some of the electrically powered devices in the system (e.g. space heaters) but is not supplied to others (e.g. the motor). This state is

indicated by illuminating a green light in the light tower. *See also* Ex. 1004, [0058] (“Color 1: frac motor 411a is not running and is not enabled to run”).

177. When the motor is enabled to run, electricity is supplied to all parts of the system including the motor, VFD, lube system, blower, etc. Once the lube pump has been verified to operate, the motor is started. This state, where electricity is supplied to all electrically operated pieces of equipment, is indicated by illuminating the amber light. “Color 2: frac motor 411a is running OR has been enabled to run”. Ex. 1004, [0058].

178. The table below indicates the condition of the various lights in the system and what is represented by the condition of the lights.

Light Color	Condition	State
Red	Off	Discharge Pressure less than setpoint
Red	On	Discharge Pressure greater than setpoint
Green	Off	No electricity to the system
Green	On	Electricity to some components of the system, but not all (motor/pump not running)
Amber	Off	Motor / pump not running
Amber	On	Motor / pump running or enabled to run

179. To the extent that *Payne* does not expressly disclose the light tower indicates the operational state of the hydraulic fracturing system, *Payne* also renders

1[d] obvious. Because *Payne* discloses a “multi-color light tower” that emits different colors based on different conditions of components of the hydraulic fracturing system, including the frac motor, the pump, and the VFD, a POSITA would understand that this light tower may selectively emit a visual signal that is indicative of an operational state of the hydraulic fracturing system. Ex. 1004, [0058], [0102]-[0103], Figs. 10-12.

B. DEPENDENT CLAIM 2

a. 2. The hydraulic fracturing system of claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack.

180. *Payne* discloses this limitation. As discussed in Section XI.A.e with regard to Claim 1[d], *Payne* discloses a “multi-color light tower for each pump.” This multi-color light tower is an example of a signal assembly that comprises a plurality of light assemblies arranged in a stack. Ex. 1004, [0058]. *Payne* explains that the light tower contains multiple colors, each of which indicates a different operational state of the hydraulic fracturing system. *Id.* [0058], [0103], Figs. 10-12; see Section XI.A.e. A POSITA would understand that a “light tower” comprises a plurality of light assemblies arranged in a stack (i.e. a tower of lights).

181. To the extent *Payne* does not expressly disclose Claim 2, a POSITA would find it obvious that *Payne*’s disclosure of a “multi-color light tower” would comprise a plurality of light assemblies arranged in a stack, particularly in light of

the general engineering knowledge of a POSITA and the commercial availability of light assemblies arranged in a stack designed and marketed to display the operational status of a machine or a machine system. see *supra* VIII.G

C. DEPENDENT CLAIM 3

- a. **3. The hydraulic fracturing system of claim 2, wherein each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies.**

182. *Payne* discloses this limitation. *Payne* explains that the light tower illuminates with multiple colors (*e.g.*, Color 1, Color 2, Color 3), each of which alone and in combination indicates a different operational state of the hydraulic fracturing system. Ex. 1004, [0058], [0103], Figs. 10-12; Section XI.A.e; *see also* Section VIII.G.

D. DEPENDENT CLAIM 4

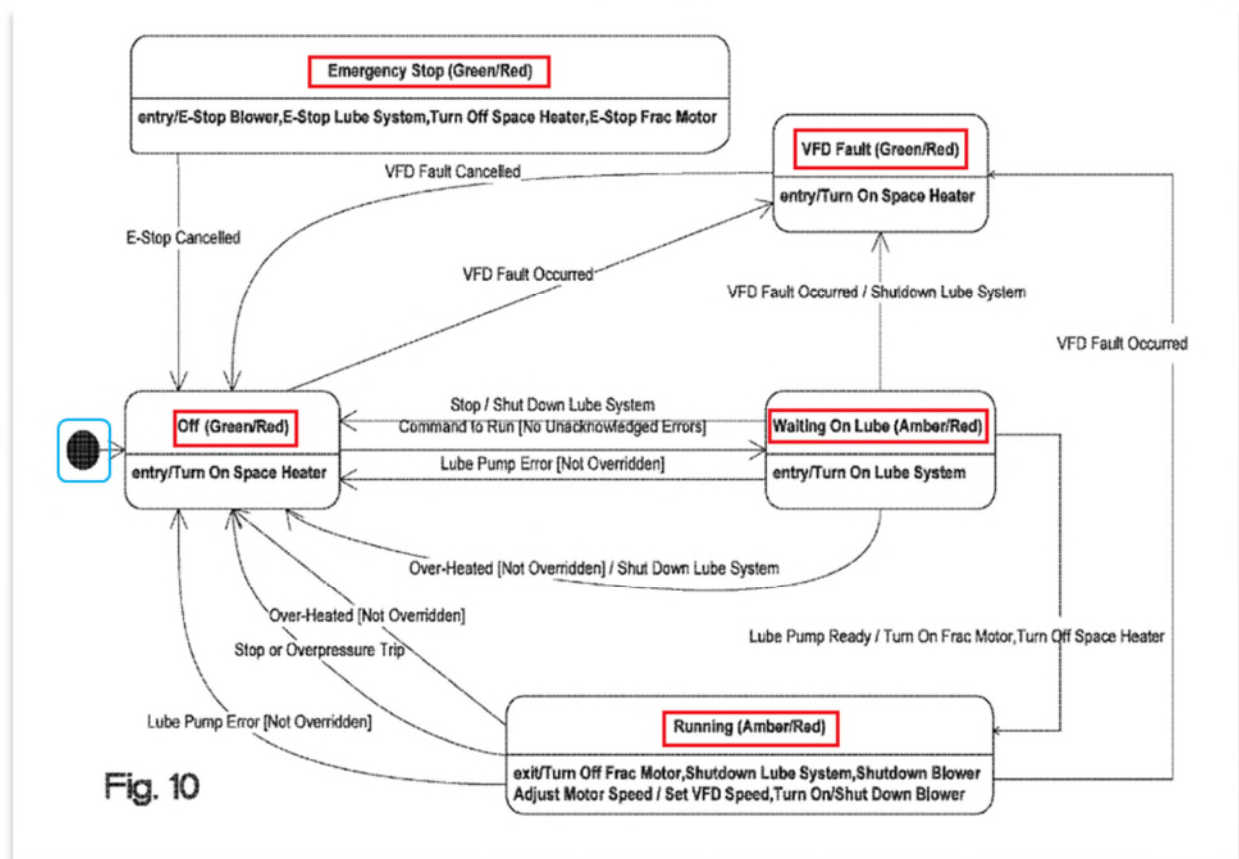
- a. **4. The hydraulic fracturing system of claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.**

183. *Payne* discloses that each of the light assemblies in the “multi-color light tower” can indicate a distinctive operational state of the system by illumination of a combination of the light assemblies. Ex. 1004, [0058]. For example, the state chart in Figure 10 of *Payne* discloses illuminating lights in different color combinations. The following table shows the lights and what the condition of the lights indicates.

Light Color	Condition	State
Red	Off	Discharge Pressure less than setpoint
Red	On	Discharge Pressure greater than setpoint
Green	Off	No electricity to the system
Green	On	Electricity to some components of the system, but not all (motor/pump not running)
Amber	Off	Motor / pump not running
Amber	On	Motor / pump running or enabled to run

184. For example, the combination of amber and red lights illuminated indicates that the motor/pump is in a running state, and the pressure in the discharge pressure is above the designated setpoint. This would indicate a condition where there was a maximum danger to personnel in the area of the pumps and discharge iron (e.g. red zone). The combination of Green illuminated and Red not illuminated would indicate a condition where electricity was only supplied to some of the electrically operated components of the unit (e.g. heaters), the motor is not enabled to run, and pressure in the discharge piping being low (i.e. below a designated setpoint). This would indicate a condition with the low danger to personnel in the

area (e.g. red zone). The combination of red, green and amber lights being in the “off” condition would indicate that no electricity was being delivered to the electrically driven components. This would indicate a condition which was safest for personnel in the area. A POSITA would understand this to disclose using combinations of lights in the assembly to indicate different operational states of components in the system. *Id.*, Fig. 10.



Ex. 1004, Fig. 10 (annotated).

185. Accordingly, *Payne* discloses “a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies” as claimed in this limitation.

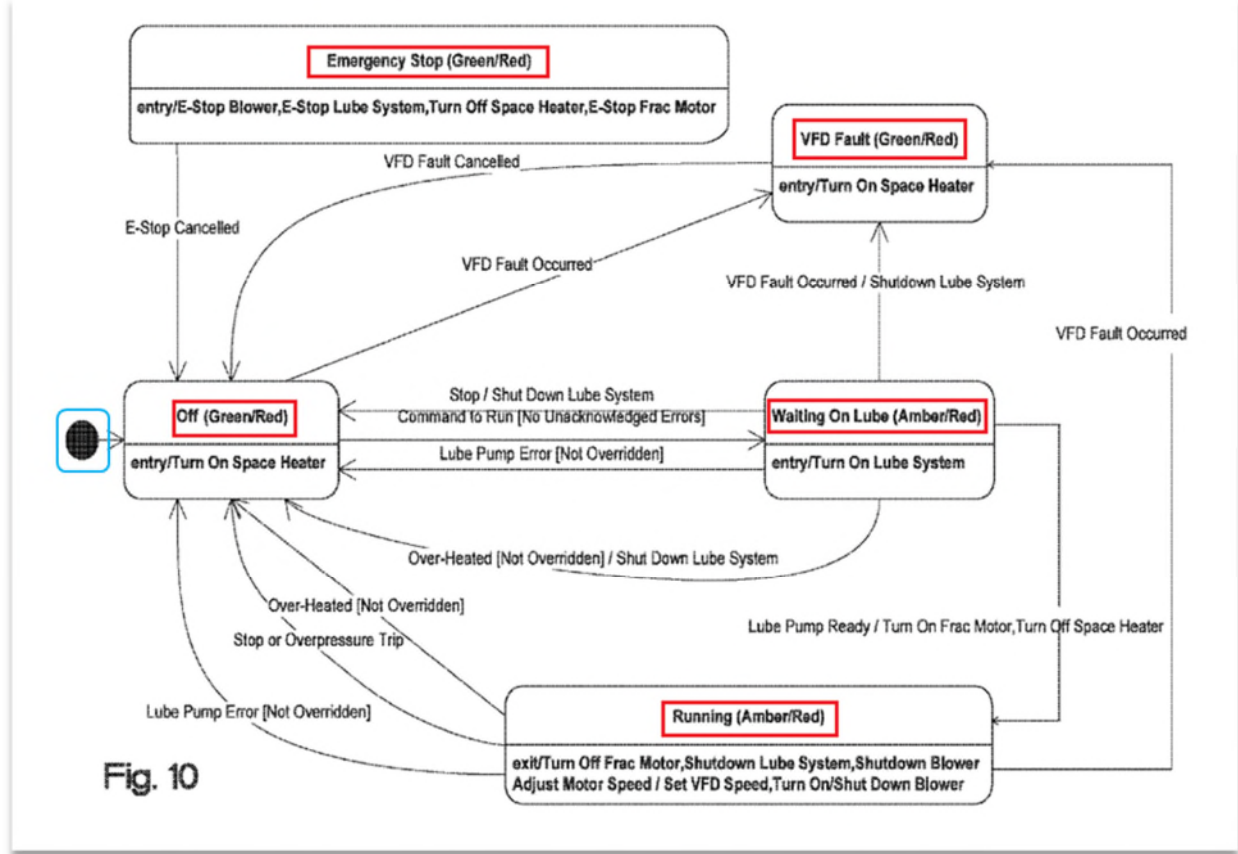
E. DEPENDENT CLAIM 5

- a. **5. The hydraulic fracturing system of claim 1, wherein the operational states of the hydraulic fracturing system comprise, [i] no electricity to the system, [ii] a supply of electricity to all electrically powered devices in the system, [iii] a supply of electricity to some of the electrically powered devices in the system, and [iv] a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.**

186. *Payne* discloses and/or renders obvious several operational states of the hydraulic fracturing system, rendering claim 5 obvious.

187. As discussed in the preceding sections dealing with claim 1[d], Claim 2, Claim 3 and Claim 4, *Payne* discloses a light tower for each pump/motor/VFD system in which the various colors of lights and combination of lights being illuminated indicates various operational states of the unit (system). This includes the operational states claimed in Claim 5.

188. For example, the operational state of (i) “no electricity to the system” is indicated by all three colors of light being in the “off” (not illuminated) condition. This is represented by the black circle to the left of Fig. 10. (annotated in blue))



Ex. 1004, Fig. 10 (annotated).

189. The operational state of (ii) “a supply of electricity to all electrically powered devices in the system” is indicated by illumination of the amber light (Color 2) as shown in Fig. 10 and described by *Payne*. “Color 2” in *Payne* may signal that “frac motor 411a is running OR has been enabled to run” which is an example of an operational state comprising (ii) “a supply of electricity to all electrically powered devices in the system” as claimed. Ex. 1004, [0058].

190. The operational state of (iii) “a supply of electricity to some of the electrically powered devices in the system” is indicated by illumination of the green

light (Color 1) as shown in Fig. 10. In this state, electricity is supplied to electrically powered devices such as sensors, the light tower, space heaters, but is not supplied to all the electrically powered devices in the system (e.g. lube pumps, blowers, motor/pump). “Color 1” in *Payne* may signal that “frac motor 411a is not running and is not enabled to run” *Id.*

191. Even in the “emergency stop” state indicated by Fig. 10 and described by *Payne* “[a]n “e-stop” may be supplied to “stop an entire fracturing pump unit” or a “master e-stop” can “shut down all deployed fracturing pump units 700a-700 (i.e. all VFDs and all motors on all trailers, trucks, or skids 20a-20h are shut down).” Ex. 1004, [0054]. Electricity is still supplied to some of the electrically powered equipment, such as the sensors and light tower. This is indicated by the “Emergency Stop (Green/Red)” state at the top of Fig. 10. The sensors still sense high pressure in the discharge piping, sense that the pump is not running, and illuminate the light tower to indicate such a state. After an emergency stop, when pressure in the discharge piping has bled down or otherwise been reduced, the red light will transition to the “off” condition.

192. Similarly for operational state (iii), *Payne* teaches that “individual motors” may be taken “off line in case the operating parameters exceed predetermined thresholds.” Ex. 1004, claim 36. Similarly, *Payne* discloses that the

VFD can be “shut[] off” when unsafe conditions are detected. *Id.* [0039]. *Payne* further discloses that an operator can intervene when “an operating parameter exceeds a corresponding threshold value” to cause the “VFD workload [to] be shared equally among the available VFDs at the wellsite, thus minimizing the number of VFD faults and thermal shut down events caused by over driving particular pieces of fracturing equipment.” *Id.* [0109] In these cases, electricity would be supplied to some of the VFDs, which are electrically powered equipment, but not to others, disclosing the operational state of (iii). For example, a number of the amber lights (associated with each pump/motor/VFD system) would be illuminated, and in other locations, the green light would be illuminated, indicating electricity supplied to some of the VFDs/motors/pumps but not others..

193. The operational state of (iv) “a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure” is indicated by illumination of the red light (Color 3). According to *Payne*, “Color 3” may indicate “the pump discharge pressure for the frac motor 411a is greater than a pre-defined psig setpoint”. *Id.* Similarly, “[t]he beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” *Id.* [0103]. This state may be because the current motor/pump unit is running, or may be because other pumps

are running supplying pressure without the current motor/pump running, as indicated in Fig. 10.

194. To the extent that claim 5 requires that the signal assembly emits visual signals indicative of each of the recited operational states and to the extent *Payne* does not expressly disclose a visual signal indicative of one or more of these operational states, a POSITA would find it obvious. Because *Payne* discloses using a multi-color light tower to illuminate lights indicative of at least certain of these operational states, a POSITA would find it obvious to use the same disclosed technique—using the light tower to illuminate lights—to indicate other operational states, including each of the operational states recited in claim 5. For example, with regard to operational state (iii), *Payne* teaches that “individual motors” may be taken “off line in case the operating parameters exceed predetermined thresholds.” It would be obvious to a POSITA to use the light tower of *Payne* (or a modified version thereof that includes more lights) to illuminate lights to indicate that individual motors have been taken offline.

F. DEPENDENT CLAIM 6

- a. **6. The hydraulic fracturing system of claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of one of the pumps, and the signal assembly.**

195. *Payne* discloses a “programmable automation controller (PAC) configured to receive commands from the system control unit” where “at least one PAC is configured to autonomously monitor operating parameters of the associated system unit.” Ex. 1004, claims 7, 11, 20. *Payne* discloses that there is a “PAC on each hydraulic fracturing unit” Ex 1004 [0039] *Payne* also describes the system control unit. “[A] system control unit for use with a system for stimulating oil or gas production from a wellbore is disclosed.” Ex 1004 [0016]. The system control unit and the PAC are in communication with each other, as shown in Fig. 6 – 8 of *Payne*. The PAC and the system control unit, either alternatively or in combination, are “a controller” as claimed in claim 6.

196. At least one PAC and the system control unit are in communication with the claimed variable frequency drive. As *Payne* explains, the “VFD process data...can be collected [and] communicated by a communications channel to the system control unit to raise an alarm to the user whenever any of the operating parameters exceeds a corresponding threshold value.” Ex. 1004, [0109]. Each of the PACs can “receive monitoring data concerning the[se] operating parameters...and

[] communicate said monitoring data to the system control unit.” *Id.*, claim 20. Additionally, the PACs communicate with the VFD by “relay[ing] the speed set point from the operator at the HMI to a variable frequency drive (VFD).” *Id.* [0039]. In order to “relay the speed set point” the PAC would necessarily be in communication with the VFD. A POSITA would also understand *Payne*’s reference to Toshiba GX7 Rig Drive as a VFD based on the disclosures contained in *Toshiba Manual* regarding the GX7 VFD. I discuss *Toshiba Manual*’s disclosure of a VFD further below in Section XII.

197. Additionally, at least one PAC and the system control unit are in communication with the claimed “pressure sensor that senses pressure in a discharge line of a one of the pumps.” *Payne* discloses that “a pressure transmitter...provides a signal for the pump discharge pressure,” which is “displayed locally [at the PAC] and remotely at the system control unit.” *Id.* [0062]. *Payne* further describes that “if the pump discharge pressure exceeds the Overpressure setpoint, the control system stops the frac motor 411a via the RUN/STOP control to the frac VFD 410a,” and “the control system should activate/indicate a shutdown.” *Id.* A POSITA would understand that the pressure transmitter must be in communication with one or both of the PAC and the system control unit in order for the control system to perform

these functions (displayed locally and remotely and compare the pressure sensed with the overpressure setpoint).

198. Finally, at least one PAC and the system control unit are in communication with the claimed signal assembly. *Payne* explains that the “multi-color light tower” can displays colors indicating a particular operational state. Ex. 1004, [0058]. For example, the “beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” *Id.* [0103]. This light indication is part of the “control operations” for the hydraulic fracturing pump units, and is driven by the communication with the pressure sensor as described above. *Id.* To the extent *Payne* does not disclose this limitation, a POSITA would find it obvious to have the controller in communication with a signal assembly based on the disclosure that the “light tower” can indicate different operational states, including power to a motor. *Id.* [0058]. It would be obvious for the control system, such as the PAC, to perform the control function of the light tower since the PAC is disclosed as being in communication with both the VFD and Pressure sensor, as well as other components of the fracturing unit “One or more PACS 702a, 702b may be used by the fracturing pumps 710a, 710b and/or the blower units and lubrication units to communicate with the system control unit 650. Accordingly, the PAC would contain information

regarding the various operational states indicated by the light tower, and it would be an obvious choice of devices to control illumination of the light tower.

G. DEPENDENT CLAIM 7

- a. **7. The hydraulic fracturing system of claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.**

199. As described in Section XI.F.a, with regard to claim 6, *Payne* discloses, or at least renders obvious communication between the pressure sensor, VFD, light tower (signal assembly) and the PAC, and that the light tower would be controlled by the PAC. For the same reasons as discussed in Section XI.F.a, the limitations of Claim 7 are disclosed or at least rendered obvious by *Payne*. Further, *Payne* expressly states the beacon light will illuminate “Color 3: the pump discharge pressure the frac motor 411a is greater than a pre-defined psig setpoint” Ex xxxx[0058] Additionally, when describing the “control state charts illustrated in FIGS. 10-12” that illustrate the function of the controller(s), the “beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” *Id.* at [0103] A POSITA would have understood that the pressure sensor is in communication with the controller, and that the controller would activate Color 3 (red) in response to the pressure sensor communicating a pressure which was above a pre-defined setpoint. To the extent that *Payne* does not expressly disclose the

controller illuminating the light tower (signal assembly), it would be obvious for the control system, such as the PAC, to perform the control function of the light tower since the PAC is disclosed as being in communication with both the VFD and Pressure sensor, as well as other components of the fracturing unit “One or more PACS 702a, 702b may be used by the fracturing pumps 710a, 710b and/or the blower units and lubrication units to communicate with the system control unit 650. Accordingly, the PAC would contain information regarding the various operational states indicated by the light tower, and it would be an obvious choice of devices to control illumination of the light tower.

H. DEPENDENT CLAIM 8

- a. **8. The hydraulic fracturing system of claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.**

200. *Payne* renders this claim obvious. *Payne* discloses that the beacon lights on the multi-color light tower illuminate certain colors, such as red, green, and amber. Ex. 1004, [0058], [0103], Fig. 10. A POSITA would understand that these colors are on the visible spectrum and are optically detectable. The light tower is a type of system that allows “an operator to focus on primary objectives, that is, pumping rates and pressures, while ensuring safe operation across multiple pumping units.” *Id.* [0055]. In other words, the beacon lights signal to operations personnel

from a safe distance that there is a “potentially hazardous zone due to fluid in piping that is pressured by at least one of the pumps,” as claimed. *Id.* [0055], [0103]. The light tower would be visually detectable “by operations personnel disposed in a zone that is potentially hazardous” because they are “for each pump” and mounting at or near the pump is an obvious choice of locations among the finite number of locations where the light tower could be mounted. The area around the pump is potentially hazardous due to pressure in the discharge line, the presence of hazardous electricity, and the ability of the motor and pump to start without warning.

201. As discussed in Section XI.D.a, the combination of Amber and Red lights illuminated indicates that there is maximum risk to personnel in the area of the fracturing unit. This combination of illuminated lights indicates that there is electricity to all equipment on the unit and there is high (above designated setpoint) pressure in the discharge piping. *Payne* explains that “the beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint.” Ex 1004 [0103] As also disclosed by *Payne*, pressure in the piping is created by “several high pressure fracturing pumps” and that pressures in the piping “can reach 100 megapascals (15,000 psi)”. Ex 1004 [0005]-[0006] A POSITA would understand that the presence of electricity at the motor, the pump and motor operating, and the presence of pressure in the piping are all potentially hazardous conditions. The

presence of electricity increases the risk of shock hazard and indicates that motors / pumps could turn on at the direction of the operator or the control system. When the motors and pumps are running (or have been commanded to run), there is pressure being placed into the piping, which increases the risk of piping rupturing, a potentially hazardous condition. Similarly, when pressure is in the piping (even without the particular pump running) there is risk of rupture. Accordingly, illumination of the red light of the light tower would indicate to operations personnel in the area around the pump (a zone) that the area is potentially hazardous due to fluid in the line that is pressurized by at least one of the pumps, as claimed by Claim 9 of the '871 patent, and a POSITA would have found it obvious for it to do so based on the teachings of *Payne*.

I. INDEPENDENT CLAIM 9

202. *Payne* discloses this claim, or at least renders it obvious. Each of the claim limitations of Claim 9 is similar to the limitations in Claim 1 or one of its dependent claim and is disclosed or rendered obvious for the same reasons.

a. 9[pre] A hydraulic fracturing system for fracturing a subterranean formation comprising:

203. This claim language is identical to that in Claim 1[pre] and is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.a.

b. 9[a] a pump having a discharge in communication with a wellbore that intersects the formation;

204. This claim language is similar to language contained in Claim 1[a], except that this claim language only requires a single pump. It also refers to the pump “having a discharge in communication with a wellbore that intersects the formation.” A POSITA would understand this limitation as the same as Claim 1[a]’s requirement that the “plurality of electric pumps” are “configured to pump fluid...into a wellbore that intersects the formation.” Claim 9[a] is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.b.

c. 9[b] an electric motor coupled to and that drives the pump;

205. This claim language is similar to language contained in Claim 1[a] (“a plurality of electric pumps fluidly connected to the formation, and powered by at least one electric motor.”). A POSITA would understand electric pumps “powered” by an electric motor to be the same requirement as an “electric motor coupled to and that drives the pump.” Claim 9[b] is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.b. Further, *Payne* expressly discloses this limitation. *Payne* discloses “The VFD provides ac current which turns the mechanically coupled motor and fracturing pump.” Ex 1004 [0039] A POSITA would recognize this as disclosure of Claim 9[b].

- d. **9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;**

206. This claim limitation is essentially identical to 1[b]-1[c] and is disclosed by *Payne* for the same reasons discussed in Section XI.A.c-XI.A.d.

- e. **9[d] a signal assembly that selectively emits different visual signals that are distinctive of an operational state of the system; and**

207. This claim limitation is essentially identical to 1[d] and is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.e.

- f. **9[e] a controller in communication with the signal assembly, and that selectively transmits a command signal to the signal assembly in response to a monitoring signal received by the controller and transmitted from a device in the system.**

208. This claim language is similar to language contained in Claims 6-7. Claim 9[e] also specifies that the controller is in “communication with the signal assembly” rather than the VFD, but Claim 7 requires that the controller “selectively activate[] the signal assembly.” A POSITA would understand that the controller may only activate the signal assembly if it is in communication with the signal assembly. Claim 9[e] further requires the monitoring signal, *i.e.*, communication signal, to be “received by the controller and transmitted from a device in the system.” Claim 7 clarifies that the signal is communicated from “one of the variable frequency drive or the pressure indicator,” which are both “a device in the system.” Claim 9[e] is

therefore disclosed by *Payne* for the same reasons as those discussed in Section XI.F-XI.G.

J. DEPENDENT CLAIM 10

- a. **The hydraulic fracturing system of claim 9, wherein the device in the system that transmits the monitoring signal to the controller comprises one of the variable frequency drive, and a pressure monitor in fluid communication with the discharge of the pump.**

209. This claim language is similar to language contained in Claim 6. It is disclosed by *Payne* for the same reasons as those discussed in Section XI.F

K. DEPENDENT CLAIM 11

- a. **11. The hydraulic fracturing system of claim 9, wherein the signal assembly comprises a stack of light assemblies.**

210. This claim language is essentially identical to Claim 2. It is disclosed by *Payne* for the same reasons as those discussed in Section XI.B.a.

L. DEPENDENT CLAIM 12

- a. **12. The hydraulic fracturing system of claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.**

211. This claim language is similar to Claim 3. Claim 12 requires that the light assemblies “each comprise an electrically powered light source.” A POSITA would understand that Claim 3’s requirement that the light assemblies “emit visual

light” to require that the light sources be “electrically powered.” Claim 12 further requires that each light assembly “emit light of a color that is different from a color of a light emitted by the other light assemblies.” A POSITA would understand this limitation to be substantively identical to Claim 3’s requirement that “each of the light assemblies selectively emit visual light of a different color from visual light emitted by other light assemblies.” Claim 12 is disclosed by *Payne* for the same reasons as those discussed in Section XI.C To the extent that *Payne* does not explicitly teach that the light sources are “electrically powered”, it would be an obvious design choice for a POSITA to power the lights by electricity, particularly since *Payne* is teaching the expanded use of electrically powered equipment (such as motors) at its fracturing site.

M. DEPENDENT CLAIM 13

a. 13[a] The hydraulic fracturing system of claim 9 further comprising a pump controller and auxiliary equipment, and

212. As I explained above in Section XI.F, *Payne* discloses that a PAC and the system control unit, either alternatively or in combination, are “a controller,” as claimed. *Payne* explains that the PAC controls the VFD, which controls the pump. Specifically, the PAC communicates with the VFD and can shut off the VFD. “The PAC relays the speed set point from the operator at the HMI to a variable frequency drive (VFD). The VFD provides ac current which turns the mechanically coupled

motor and fracturing pump. In this example, the PAC also acts [as] a safety device. If an unsafe condition is detected, for example, an over pressure event, the PAC can independently override the remote operator's command and take whatever action is appropriate, for example, shutting off the VFD." Ex. 1004, [0039]. The VFD controls the pump by "provid[ing] the ac current" for the "mechanically coupled motor and fracturing pump". *Id.*; *Payne* further explains that a PAC receives commands from the system control unit. Ex.1004, cls. 7, 11, 20. A POSITA would therefore understand that the PAC and system control unit, either alternatively or in combination, are a "pump controller," as claimed. Further, *Payne* expressly discloses a pump controller. "A system control unit for use with a system for stimulating oil or gas production from a wellbore is disclosed, which includes a hydraulic fracturing pump unit controller configured to control a hydraulic fracturing pump unit having one or more hydraulic fracturing electrical motors, the hydraulic fracturing pump unit controller including a hydraulic fracturing pump controller configured to control a hydraulic fracturing pump." Ex. 1004, [0016]. A POSITA would have understood from this disclosure that a "hydraulic fracturing pump unit controller" is disclosing a "pump controller" because it clearly describes a structure used to "control hydraulic fracturing pump" which is the clear English meaning of "pump controller."

213. *Payne* also discloses auxiliary equipment, such as the frac motor's space heater, which "ensure[s] that the motor windings are dry before operation." Ex. 1004, [0057]. Another example of auxiliary equipment includes an **"auxiliary trailer, truck or skid"** that houses the "blender/hydration transformer units" and the "blender/hydration control systems." Ex.1004, [0044]-[0045], [0048], Fig. 4. To the extent that *Payne*'s "hydraulic fracturing pump unit controller" is not read as disclosing a "pump controller", it would have been obvious to a POSITA reading *Payne* to use either the PAC, the VFD drive or the central controller to act as a "pump controller" since all three "controllers" are associated with control of the speed of the motor and the motor is mechanically coupled to the pump.

- b. **13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.**

214. As I explained above in Section XI.E regarding Claim 5, *Payne* discloses that the operational state of the system may comprise the [i] "system being isolated from electricity," (i.e. no electricity to the system) as claimed in 13[b].

215. Also, as I explained above in Section XI.E regarding Claim 5, *Payne* also discloses that the operational state may comprise [ii] "a fluid pressure of the discharge having a value at least as great as a designated value," as claimed.

Specifically, *Payne* explains that the “pump discharge pressure is displayed...at the system control unit” and “Color 3” on the light tower signals that “the pump discharge pressure for the frac motor 411a is greater than pre-defined psig setpoint.” *Id.* [0058], [0062]; *see also id.* [0103] (“the beacon light turns red whenever the pump discharge pressure is greater than a pre-defined setpoint”).

216. *Payne* teaches “a hydraulic fracturing pump unit having two or more fluid pumps, each fluid pump being driven by an alternating current (AC) motor coupled to the fluid pump, and a variable frequency drive (VFD) controlling the electrical pump motor” Ex 1004 [0014] Further, *Payne* teaches “The VFD provides ac current which turns the mechanically coupled motor and fracturing pump.” *id.* [0039] and “the frac motor 411a of a fracturing pump 710a s controlled by a frac VFD 410a. The control system provides a RUN/STOP signal to the VFD 410a to control the status of the frac motor 411a” *id.* [0053]. Accordingly, a POSITA would have recognized *Payne*’s VFD as a variable frequency drive used to control the motor and pump, i.e. a “pump drive”.

217. As I explained in Section XI.E regarding Claim 5, Illumination of the amber light (Color 2) indicates the “frac motor 411a is running OR has been enabled to run”. Accordingly, the amber light would also indicate that the control system had sent a control signal to the VFD to start the frac motor and the mechanically coupled

pump as disclosed in *Payne*. A POSITA would accordingly have understood, particularly with the disclosure of Fig.10 – Fig. 12, that an amber light would represent “the pump drive being energized”.

218. A POSITA would find it obvious given *Payne*’s disclosures that the operational state may comprise (iii) “the pump drive being energized”. A POSITA would recognize that *Payne*’s VFD is used to control the motor and pump, *i.e.*, a “pump drive.” Ex. 1004 [0014], [0039], [0053] (“[T]he frac motor 411a of a fracturing pump 710a is controlled by a frac VFD 410a. The control system provides a RUN/STOP signal to the VFD 410a to control the status of the frac motor 411a.”). *Payne* discloses that the pump drive is energized, for example, by explaining that illumination of the amber light (Color 2) indicates the “frac motor 411a is running OR has been enabled to run.” Ex.1004, [0058]. Accordingly, the amber light would also indicate that the control system had sent a control signal to the VFD to start the frac motor and the mechanically coupled pump as disclosed in *Payne*. A POSITA would understand that an amber light represents “the pump drive being energized.” Ex. 1004, Figs. 10-12. Additionally, *Payne* discloses that a “normal stop (RUN/STOP) will control each fracturing pump unit 700a independently (for example, a first fracturing pump 710a and a second

fracturing pump 710b on the same frac trailer, truck, or skid 20a will each be controlled independently).” Ex.1004, [0054]

219. Finally, as I explained in Section XI.E regarding Claim 5, *Payne* discloses that the operational state may comprise [iv] “the auxiliary equipment being energized but without a one of the motors being energized,” as claimed. *Payne* explains a typical practice is to have the space heaters (auxiliary equipment) “energized for at least 24-hours before running the motor.” Ex. 1004, [0057]. When the heater is operating in AUTO mode, “the heater is turned on when the control system is energized and the pump-motor is OFF.” *Id.* This is represented by illumination of the green light (Color 1) as described in Ex 1004 [0058] and Fig. 10. A POSITA would therefore understand *Payne* to disclose [iv] the auxiliary equipment being energized but without a one of the motors being energized. Accordingly, a POSITA would understand *Payne* to render obvious claim 13.

N. **DEPENDENT CLAIM 14**

- a. **14. The hydraulic fracturing system of claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for operations personnel, and when the system is currently unsafe for operations personnel.**

220. *Payne* renders claim 14 obvious. *Payne* discloses that the visual signals emitted by the signal assembly can selectively indicate the safety of the hydraulic fracturing system for operations personnel. For example, *Payne* explains that an

automated alarm management system operates to overlay an indicator at the system control unit to alert an “operator” if “any operating parameters exceeds its normal range.” Ex. 1004, [0055]. This system allows the “operator to focus on primary objectives, that is, pumping rates and pressures, while ensuring safe operation across multiple pumping units.” *Id.*

221. *Payne* discloses that each of the light assemblies in the “multi-color light tower” can indicate a distinctive operational state of the system by illumination of a combination of the light assemblies. Ex. 1004, [0058]. For example, the state chart in Figure 10 of *Payne* discloses illuminating lights in different color combinations. The following table shows the lights and what the condition of the lights indicates.

Light Color	Condition	State
Red	Off	Discharge Pressure less than setpoint
Red	On	Discharge Pressure greater than setpoint
Green	Off	No electricity to the system
Green	On	Electricity to some components of the system, but not all (motor/pump not running)
Amber	Off	Motor / pump not running
Amber	On	Motor / pump running or enabled to run

222. For example, the combination of amber and red lights illuminated indicates that the motor/pump is in a running state, and the pressure in the discharge pressure is above the designated setpoint. This would indicate a condition where there was a maximum danger to personnel in the area (e.g. red zone), and would correspond to a condition where “the system is currently unsafe for operations personnel” as claimed.

223. The combination of all lights being in the “off” state (not illuminated), as shown in Fig. 10 of Payne, would signal personnel in the area that the system was in a “safe” state, i.e. no electricity present and no pressure in the discharge piping.

224. Further, as described above, the combination of illumination of green light, along with the red light being illuminated, would indicate a condition where the motor/pump systems are not running, but there is still an elevated pressure trapped in the discharge piping system. A POSITA would have understood this indicates an operational state that is potentially unsafe for operations personnel (elevated pressure, but no energy being added into the system). When the pressure is bled off or otherwise reduced, the system would convert to one that is safe.

225. Further, the combination of illumination of the green or amber light, along with the red light being in the “off” (not illuminated) condition would indicate that electricity is being delivered either to all or some of the electrical components, but that pressure in the discharge piping had not yet exceeded the psig setpoint. A POSITA would have additionally understood this to be a potentially unsafe condition, as the motor is either running or could run without warning, and pressure could build quickly in the discharge piping.

226. Because *Payne* discloses that the multi-color light tower can illuminate different colors based on different operational states of the hydraulic fracturing system, Ex. 1004, [0058], [0103], a POSITA would find it obvious that the light tower also could visually indicate to an operator whether the system is safe, potentially unsafe, or currently unsafe for operations personnel—particularly in light

of *Payne*'s disclosure that an its systems "enabl[e] an operator to focus on primary objectives...while ensuring safe operation across multiple pumping units." Ex. 1004 [0058]. *Payne* also describes that "the PAC also acts as a safety device. If an unsafe condition is detected...the PAC can independently override the remote operator's command and take whatever action is appropriate, for example, shutting off the VFD[.]" *Id.* [0039].

O. INDEPENDENT CLAIM 15

227. Other than being a method claim, Claim 15 is very similar to Claim 1 and is disclosed by or rendered obvious by *Payne*.

a. 15[pre] A method of fracturing a subterranean formation comprising:

228. This claim language is similar to language contained in Claim 1[pre], except that it states a method instead of a system. The method is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.a.

b. 15[a] pressurizing fracturing fluid with a pump

229. This claim language is similar to language contained in Claim 1[a] ("a plurality of electric pumps...configured to pump fluid at high pressure into a wellbore that intersects the formation, so that the fluid passes from the wellbore into the formation and fractures the formation"). It is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.b.

c. **15[b] driving the pump with a motor that is powered by electricity**

230. This claim language is similar to language contained in Claim 1[a] (“a plurality of electric pumps...powered by at least one electric motor”). It is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.b.

d. **15[c] controlling the speed of the motor with a variable frequency drive,**

231. This claim language is essentially identical to language contained in Claim 1[b] (“a variable frequency drive connected to the electric motor to control the speed of the motor”). It is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.c.

e. **15[d] the variable frequency drive further performing electric motor diagnostics;**

232. This claim language is essentially identical to language contained in Claim 1[c] (“wherein the variable frequency drive frequently performs electric motor diagnostics...”). It is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.d.

f. **15[e] monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and**

233. *Payne* discloses monitoring an operational state of a hydraulic fracturing system. For example, *Payne* discloses “monitoring operating parameters of the individual electrical motors” of a fracturing system. Ex. 1004, claim 36. *Payne*

also discloses that a programmable automation controller (PAC) is configured to “autonomously monitor operating parameters of [its] associated system unit,” referring to the “hydraulic fracturing pump unit, hydraulic blender unit and hydration unit.” *Id.*, claims 7, 11. Although the pump unit includes “fluid pumps” driven by a motor and a VFD to control the motor, *see id.*, claim 1, *Payne* specifies that “multiple processes and subsystems on each pumping unit can be monitored autonomously,” which gives the operator information on “pumping rates and pressures.” *Id.* [0054].

234. Additionally, *Payne* discloses or renders obvious a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system, as I explained with respect to Claim 1[d] in Section XI.A.e A POSITA would understand that the signal assembly of *Payne* could not emit a visual signal that is indicative of an operational state without first “monitoring an operational state.”

235. Finally, Fig. 10 is a “fracturing pump motor control state chart”, Fig. 11 is a “lubrication system control state chart” and Fig. 12 is a “motor blower control state chart”. Referring to these diagrams, “the automatic and/or manual control operations of one or more of the hydraulic fracturing pump units 700a – 700h may be controlled accordingly” Ex 1004 [0102] – [0103]. A POSITA would understand that the control system monitors the operational state of the system, as depicted in

Fig. 10 – Fig. 12, to determine, for example, what action to take next or what light tower color to illuminate. Accordingly, *Payne* discloses “monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor” as claimed in 15[e].

g. **15[f] selectively emitting a visual signal that is indicative of the monitored operational state.**

236. This claim language is similar to language contained in Claim 1[d] (“a signal assembly that selectively emits a visual signal that is indicative of an operational state...”). It is disclosed by *Payne* for the same reasons as those discussed in Section XI.A.e.

P. **DEPENDENT CLAIM 16**

a. **16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.**

237. This claim language is similar to language contained in Claim 13[b], except it refers to a “pump controller being energized” rather than a “pump drive” being energized. It is disclosed by *Payne* for similar reasons as those discussed in Section XI.M.b. A POSITA would understand in this context a “pump drive” and a “pump controller” to be equivalent because, according to *Payne*, “[t]he VFD [*i.e.*, pump drive] provides ac current which turns the

mechanically coupled motor and fracturing pump.” Ex 1004 [0039]. Additionally, *Payne* discloses “the frac motor 411a of a fracturing pump 710a is controlled by a frac VFD. The control system provides a RUN/STOP signal to the VFD 410a to control the status of the frac motor 411a. The control system provides a speed request signal to the VFD 410a to control the speed of the frac motor 411a.” Ex. 1004, [0053]. A POSITA would understand that controlling the “frac motor 411a of a fracturing pump 70a”, the VFD (i.e. pump drive) is controlling the pump, and operating as a pump controller.

Q. DEPENDENT CLAIM 17

- a. **17. The method of claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.**

238. This claim language is similar to language contained in Claim 3 (“...each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies”). Further, as described in Section XI.E.a with regard to Claim 5, *Payne* discloses a light assembly associated with each pump/motor/VFD. Accordingly, a POSITA would have recognized that, in the condition that one motor/pump is operating and another is in the “off” condition, the color of light emitted by the associated light towers would be different (i.e. “amber”

and “green”) Accordingly, Claim is disclosed by *Payne* for the same reasons as those discussed in Section XI.C.a and Xi.E.a.

R. DEPENDENT CLAIM 18

a. 18[a] The method of claim 15, further comprising monitoring electricity to a variable frequency drive,

239. *Payne* renders this limitation obvious. *Payne* explains that the VFD “provides ac current” (electricity) “which turns the mechanically coupled motor and fracturing pump.” Ex. 1004, [0039]. *Payne* further discloses that the multi-color light tower may indicate one color when a frac motor is running or has been enabled to run and another color when a frac motor is not running and has not been enabled to run. *Id.* [0058], Fig. 10. Because the light tower of *Payne* could not do so without monitoring the status of electricity to the VFD, a POSITA would understand that *Payne* therefore also discloses monitoring electricity to a variable frequency drive.

240. To the extent *Payne* does not expressly disclose 18[a], a POSITA would have found it obvious to monitor electricity to a VFD to determine whether the VFD is running in order to signal whether the frac motor (which receives electricity from the VFD) is running. Ex. 1004, [0039], [0058].

b. 18[b] wherein the variable frequency drive controls electricity to the motor.

241. *Payne* discloses that the VFD is “controls electricity to the motor,” as I describe with respect to Claim 1[b] in Section XI.A.c. *Payne* further discloses that

the VFD “provides ac current” (electricity), “which turns the mechanically coupled motor and fracturing pump.” Ex. 1004, [0049]; *see also id.* [0047], [0053] (“[T]he frac motor 411a of a fracturing pump 710a is controlled by a frac VFD 410a.”). In other words, a POSITA would understand that the VFD also “controls electricity to the motor,” as claimed. A POSITA would also understand that the function of a VFD is to control the speed of the motor by controlling the electricity to the motor as described in Section IX.E.

242. *Payne* discloses the Toshiba GX7 Rig Drive as an example of a VFD. Ex. 1004, [0122]. “the selected VFD may be a Toshiba GX7 Rig Drive 1750 Hp, 600V, 1700 Amp 6-pulse Variable Frequency Drive”. *Id.* Accordingly, a POSITA would also understand *Payne*’s reference to Toshiba GX7 Rig Drive as a VFD to control the speed of the motor (by controlling the electricity to the motor) based on the disclosures contained in *Toshiba Manual* regarding the GX7 VFD. I discuss *Toshiba Manual*’s disclosure of a VFD further below in Section XII.

243. To the extent that the board determines *Payne* does not expressly disclose the variable frequency drive controls electricity to the motor, such a configuration would have been obvious to a POSITA long before the ‘871 patent. As described in Section IX.E, the use of VFDs to control the electricity to motors was known decades before the ‘871 patent. The use of a VFD to control electricity

to a motor would be the use of a known component (VFD) for its known function (to control electricity to a motor).

S. DEPENDENT CLAIM 19

a. 19. The method of claim 15, further comprising monitoring a fluid pressure of discharge of the pump.

244. This claim language is similar to language contained in Claims 6 and 10. It is disclosed by *Payne* for the same reasons as those discussed in Sections XI.F and XI.J.

XII. GROUND 3A: OBVIOUSNESS OVER PAYNE IN VIEW OF TOSHIBA MANUAL

245. It is my opinion that the combination of *Payne* and *Toshiba Manual* discloses and/or suggests all limitations of claims 1-19, thereby rendering these claims obvious. To the extent *Payne* alone does not anticipate or render obvious claims 1-19, this ground is presented as an alternative to Grounds 1-2. The relevant limitations disclosed by *Toshiba Manual* are presented below. All other elements of claims 1-19 are disclosed or rendered obvious by *Payne* as described above in Grounds 1-2.

A. REASONS TO COMBINE PAYNE WITH TOSHIBA MANUAL

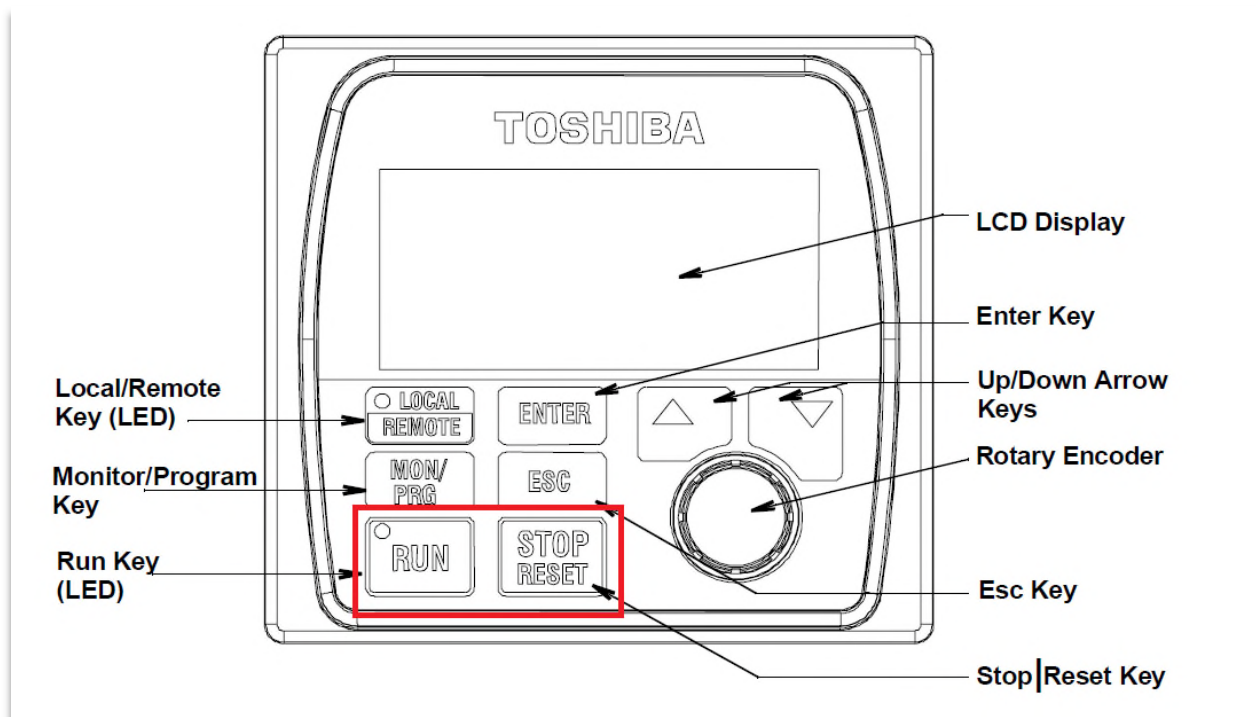
246. A POSITA would have been motivated to combine *Payne* with *Toshiba Manual*, and with a reasonable expectation of success. *Payne* discloses that its fracturing pump unit includes a VFD for driving a frac motor. Ex. 1004, [0047].

Payne lists several types of equipment that can be used as the VFD in its disclosed hydraulic fracturing system. *Payne* lists the “Toshiba GX7 Rig Drive 1750HP, 600V, 1700 AMP 6-pulse Variable Frequency Drive” as an example of the VFD for the hydraulic fracturing pump units. Ex. 1004, [0122], [0123], [0125].

247. *Toshiba Manual*, entitled “G7 Adjustable Speed Drive Operation Manual,” contains a description and details regarding the functionality, and schematics of a quintessential VFD. Ex. 1005. As described in Section X.B, *Toshiba Manual* describes the G7 family of ASDs (VFD), including the GX7. In fact the file name of *Toshiba Manual*, when obtained from the Toshiba Website was “GX7%20Operation%20Manual_3886.pdf” (emphasis added). Similar to *Payne*, *Toshiba Manual* describes how the VFD controls an electric motor. Ex.1005 at 2, 65 (“ability to allow the user direct access to the motor control functions”). In particular, *Toshiba Manual* contains information regarding the operation and setup of the G7 family of drives, including the GX7. Ex. 1005.

248. *Toshiba Manual* discloses performing electric motor diagnostics to prevent damage to the motor, including protecting against overload, overcurrent, overtorque, short circuit, and earth faults. Ex. 1005 at 19, 22, 160-163, 165. Several of the diagnostics are performed with “every run” or “every power up.” *Id.* at 162. *Toshiba Manual* lists several different motor diagnostics that are used to protect the

connected motor. *Toshiba Manual* expressly discloses that the Electronic Operator Interface (EOI) “may be used to monitor system functions, input data into the system, or perform diagnostics.” *Id.* at 43. The diagnostics include a “fault screen” that “identifies the active Fault.” *Id.* at 182-186 (Table 12, containing a list of 5 pages of faults that are diagnosed). The diagnostic functions result in an alarm or trip condition on the ASD. *Id.* at 179.



Ex. 1005, Fig. 19 (annotated).

249. A POSITA would have been motivated to use the drive from *Toshiba Manual* as the variable frequency drive in *Payne*. *Payne* specifically refers to the Toshiba GX7, described in *Toshiba Manual*, was an example of the VFD that can

be used in *Payne*'s hydraulic fracturing pump units. Ex. 1004, [0122]-[0123], [0125].

250. Likewise, a POSITA would have a reasonable expectation of success in combining *Payne* with *Toshiba Manual* because VFD technology was well-known before the '871 Patent. *Toshiba Manual* dates back to 2005 (see Ex.1006) and expressly teaches basic features that a POSITA would have already implemented in *Payne*. For example, a POSITA would have been motivated to incorporate the teachings of the *Toshiba Manual* VFD in implementing the *Payne* VFD, in light of *Payne*'s reference to Toshiba VFDs. The results of the combination would have been predictable and obvious to a POSITA.

B. INDEPENDENT CLAIM 1

a. 1[b] a variable frequency drive connected to the electric motor to control the speed of the motor,

251. *Payne* discloses 1[b] for the reasons I discussed in Section XI.A.c.

252. *Toshiba Manual* discloses an "Adjustable Speed Drive" or VFD. Ex.1005 at 2. A POSITA would have understood that a Variable Frequency Drive (VFD) is another term for an Adjustable Speed Drive (ASD). See Section IX.E. *Toshiba Manual* further explains that its VFD controls a motor that, in turn, may power a pump. See Ex. 1005 at 13 ("[t]he output terminals of the ASD...must be connected to the motor that is to be controlled"); *id.* at 71 (describing prevention of

“motor overload trips when used on fans, blowers, pumps, and other centrifugal loads which require less torque at lower frequencies”). As the term suggests, the “Adjustable Speed Drive” is used to control the speed of the motor. *Id.* at 2.

b. **1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;**

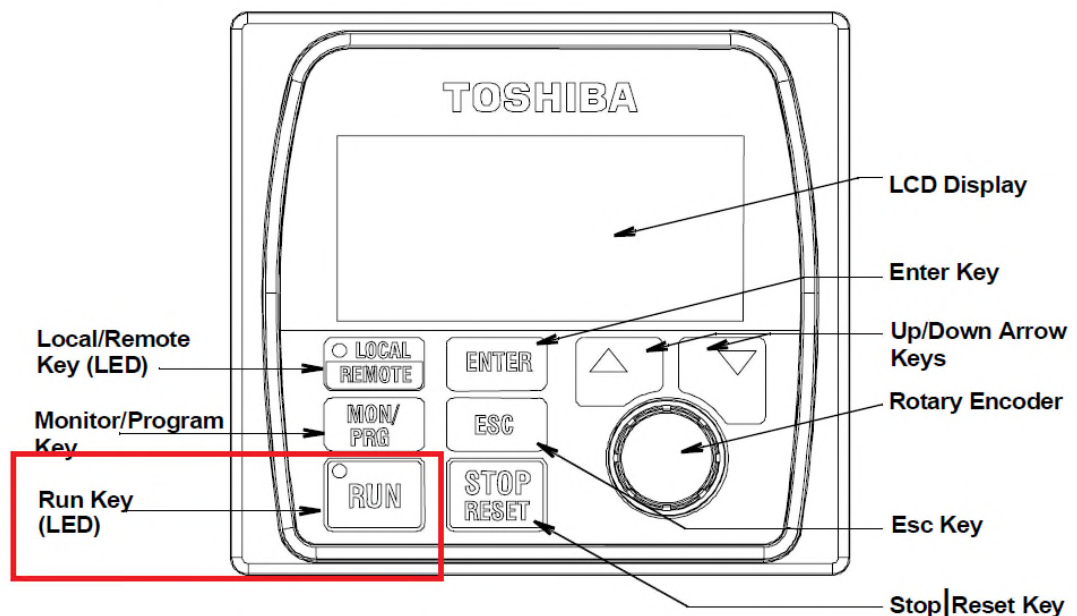
253. As I discussed above Section XII.A, it would have been obvious, and indeed *Payne discloses*, to a POSITA to use the *Toshiba Manual* VFD as the VFD in *Payne* so that the VFD controlling the motor that powers the pump would perform motor diagnostics to prevent damage to the motor. Additionally, as discussed in section XI.A.d regarding claim 1[c], *Payne* discloses VFDs performing motor diagnostic to prevent damage to the motor.

254. To the extent that *Payne* does not disclose the claimed limitation, *Toshiba Manual* discloses operating a VFD that can “perform diagnostics.” Ex. 1005 at 43. The diagnostics includes a “fault screen” that “identifies the active Fault.” *Id.* at 182-186 (Table 12, containing a list of 5 pages of faults that are diagnosed). *Toshiba Manual* further discloses a VFD that performs electric motor diagnostics to prevent damage to the electric motor, including protecting against overload, overcurrent, overtorque, short circuit, and earth faults. *Id.* I discuss each of these features above in Section X.B.b.iii.

- c. **1[d] a signal assembly that selectively emits a visual signal that is indicative of an operational state of the hydraulic fracturing system.**

255. *Toshiba Manual* discloses an “Electronic Operator Interface (EOI)” (signal assembly) that is “comprised of an LCD display, two LEDs, a rotary encoder, and eight keys.” Ex.1005, 42. The EOI displays “configuration information, performance data (e.g., motor frequency, bus voltage, torque etc.), and diagnostic information.” *Id.* Moreover, one of the EOI’s LEDs is the “Run Key,” which “illuminates green while stopped or red while running.” *Id.* at 42, Fig.19. In other words, the EOI indicates whether the motor is running. *Id.*

Figure 19. The G7 Electronic Operator Interface.



Ex.1005, Fig.19 (annotated).

The green or red display from the EOI's Run Key is a visual signal that is indicative of an operation state of the hydraulic fracturing system, i.e. whether the motor is "stopped" or "running".

C. DEPENDENT CLAIM 6

- a. **6. The hydraulic fracturing system of claim 1, further comprising a controller in communication with the variable frequency drive, a pressure indicator that senses pressure in a discharge line of one of the pumps, and the signal assembly.**

256. *Payne* discloses Claim 6 for the reasons I discussed in Section XI.F.

257. *Toshiba Manual* discloses a "communications network" that includes other ASDs and Host/Control computers (a controller) that "monitor the status of the ASD(s), transfer commands, and loads or modifies the parameter settings of the ASD." Ex. 1005 at 73. Because the Host/Control computers "monitor the status of the ASD(s)" and form a communications network with the ASDs, a POSITA would understand *Toshiba Manual* to disclose "a controller in communication with the variable frequency drive" as claimed.

D. DEPENDENT CLAIM 7

- a. **7. The hydraulic fracturing system of claim 6, wherein the controller selectively activates the signal assembly in response to a communication signal from one of the variable frequency drive or the pressure indicator.**

258. *Payne* discloses Claim 7 for the reasons I discussed in Section XI.G.

259. *Toshiba Manual* further discloses that a communication signal may come from the variable frequency drive, as I explained above with respect to Claim 6 in Section XII.C. Ex. 1005 at 65 (“The G7 ASD has the ability to allow the user direct access to the motor control functions.”). Thus, a POSITA would have found it obvious to incorporate *Toshiba Manual*’s communication signal from the VFD into *Payne*’s disclosure of a controller that selectively activates the signal assembly in response to a communication signal, at least to reduce and/or coordinate the hardware needed for the system. *Payne* explains that one reason for having an automated alarm management system, like a signal assembly, is to “ensur[e] safe operation” of the hydraulic fracturing system. Ex. 1004, [0058].

260. Allowing the controller to activate the signal assembly in response to a communication signal of the VFD furthers *Payne*’s goal of promoting safe operations. For example, *Toshiba Manual* explains that the VFD controls the motor, and *Payne* notes that the signal assembly can indicate whether the motor is or is not running, which can indicate whether the operating conditions are safe. Ex. 1005 at 13; Ex.1004, [0058], [0103].

E. INDEPENDENT CLAIM 9

261. The combination of *Payne* and *Toshiba Manual* discloses the identified elements of this claim, or at least renders them obvious. Each of the claim limitations

of Claim 9 is similar to the limitations in Claim 1 or one of its dependent claim and is disclosed or rendered obvious for the same reasons. In addition, the combination of *Payne* and *Toshiba Manual* provides additional disclosure of the claim elements identified below.

- a. **9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;**

262. This claim limitation is essentially identical Claims 1[b]-1[c] and is disclosed by the combination of *Payne* and *Toshiba Manual* for the same reasons discussed in Section XII.B.a and XII.B.b.

F. INDEPENDENT CLAIM 15

263. Other than being a method claim, Claim 15 is very similar to Claim 1 and is disclosed by the combination of *Payne* and *Toshiba Manual*.

- a. **15[c] controlling the speed of the motor with a variable frequency drive,**

264. This claim limitation is essentially identical Claims 1[b] and is disclosed by the combination of *Payne* and *Toshiba Manual* for the same reasons discussed in Section XII.B.a.

b. **15[d] the variable frequency drive further performing electric motor diagnostics;**

265. This claim limitation is essentially identical Claims 1[c] and is disclosed by the combination of *Payne* and *Toshiba Manual* for the same reasons discussed in Section XII.B.b.

c. **15[e] monitoring an operational state of a hydraulic fracturing system that comprises the pump and motor; and**

266. *Payne* discloses Claim 15[e] for the reasons I discussed in Section XI.O.f.

267. *Toshiba Manual* further discloses that a “Monitor mode” for the VFD that “allows the user to monitor motor performance variables, control settings, and configuration data during motor operation” (i.e., monitoring an operational state of a hydraulic fracturing system). Ex. 1005 at 51. Additionally, *Toshiba Manual* discloses that the Electronic Operator Interface (EOI) “may be used to monitor system functions” for the VFD, which controls the motor. *Id.* at 43. Further, *Toshiba Manual* discloses the EOI “Run Key Status LED – Illuminates green while stopped or red while running.” Ex. 1005 at 42. In order to display the “stopped” or “running” state of the motor, the operational state of the motor must necessarily be monitored by the VFD.

268. As described in Section XI.M.b with regard to Claim 13[b], the VFD controls electricity to the motor, and to the mechanically coupled fracturing pump.

By monitoring the “system functions” and “motor performance variables, control settings and configuration data” and “stopped” or “running” state of the motor, the VFD is monitoring the operational state of the motor and the mechanically coupled pump, and consequently the fracturing system.

269. Accordingly a POSITA would have understood that the combination of *Payne* and *Toshiba Manual* would disclose monitoring an operational state of a hydraulic fracturing system by monitoring “motor performance variables, control settings and configuration data” and the “stopped” or “running” state of the motor and mechanically coupled pump.

G. DEPENDENT CLAIM 18

a. 18[a] The method of claim 15, further comprising monitoring electricity to a variable frequency drive,

270. *Payne* renders obvious Claim 18[a] for the reasons I discussed in Section XI.R.a.

271. *Toshiba Manual* discloses a “Monitor Mode” for the VFD that “allows the user to monitor motor performance variables, control settings, and configuration data during motor operation.” Ex. 1005 at 51. Among the variables that may be monitored are “Input Power” and “Output Power,” (*i.e.*, “*electricity*”). *Id.* “**Input Power** – Displays the Input Power in Kilowatts (Kw).” Pg 51 A POSITA would have understood that in order to display the “Input Power in Kilowatts”, the VFD

must necessarily monitor both the voltage and current of the electricity being delivered to the VFD. see section IX.C. Accordingly, the combination of *Payne* and *Toshiba Manual* discloses and/or renders obvious “monitoring electricity to a variable frequency drive”.

XIII. GROUND 3B: OBVIOUSNESS OVER PAYNE IN VIEW OF BROUSSARD

272. It is my opinion that the combination of *Payne* and *Broussard* discloses and/or suggests all limitations of claims 1-19, thereby rendering these claims obvious. To the extent *Payne* alone does not anticipate or render obvious claims 1-19, this ground is presented as an alternative to Grounds 1-2. The relevant limitations disclosed by *Broussard* are presented below. In particular, *Broussard* discloses a variable frequency drive that is “connected to the electric motor to control the speed of the motor” and “frequently performs electric motor diagnostics...,” as claimed in the Challenged Patent.¹⁰ All other elements of claims 1-19 are disclosed or rendered obvious by *Payne* as described above in Grounds 1-2.

¹⁰ Based on the prosecution history, as I explained in Section VI.C, the purported novelty of the Challenged Patent claims is based on the diagnostic capabilities of the variable frequency drives. However, both VFDs and their diagnostic capabilities were known at the time the '871 Patent was filed, confirmed by *Broussard*, which was assigned to Patent Owner. See Ex. 1007 (*Broussard*).

A. REASONS TO COMBINE PAYNE WITH BROUSSARD

273. *Payne* discloses a hydraulic fracturing pump unit driven by an electrical fracturing motor, where a variable frequency drive controls the motor. Ex. 1004, [0014]-[0015], [0047]. Specifically, *Payne* explains that the VFD controls the speed of the motor. *Id.* [0053]. *Broussard* discloses further details about these features described by *Payne*. Ex. 1007.

274. Like *Payne*, *Broussard* relates to hydraulic fracturing systems and describes that hydraulic fracturing pumps driven by electric motors are well-known in the art. Ex. 1007, [0004] – [0007]. *Broussard* further describes that the speed of those electric motors are controlled by variable frequency drives. *Id.* [0008], [0019], [0021]

275. A POSITA would have been motivated to use the VFD disclosed by *Broussard* as the VFD in *Payne*, or to enhance the *Payne* VFD with the features taught by *Broussard*. Both *Payne* and *Broussard* disclose similar functions of a VFD (e.g., controlling the speed of electric motors) in the same field (i.e., hydraulic fracturing pumps). A POSITA, therefore, would recognize that combining *Payne* and *Broussard*, therefore, is a simple substitution of one known element for another to obtain predictable results. A POSITA would have a reasonable expectation of success in combining *Payne* with *Broussard* for the same reason.

B. INDEPENDENT CLAIM 1

a. 1[b] a variable frequency drive connected to the electric motor to control the speed of the motor,

276. *Payne* discloses 1[b] for the reasons I discussed in Section XI.A.c.

277. *Broussard* also discloses a variable frequency drive “connected to the electric motor to control the speed of the motor.” Ex. 1007, [0009], [0012], claims 8, 19.

b. 1[c] wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor;

278. *Payne* discloses 1[c] for the reasons I discussed in Section XI.A.d.

279. *Broussard* also discloses that the “variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor.” Ex. 1007, claim 15, [0011], [0021].

C. INDEPENDENT CLAIM 9

280. The combination of *Payne* and *Broussard* discloses this claim, or at least renders it obvious. Each of the claim limitations of Claim 9 is similar to the limitations in Claim 1 or one of its dependent claim and is disclosed or rendered obvious for the same reasons.

- a. **9[c] a variable frequency drive connected to the electric motor that controls a speed of the motor and performs electric motor diagnostics;**

281. This claim limitation is essentially identical to Claims 1[b]-1[c] and is disclosed by the combination of *Payne* and *Broussard* for the same reasons discussed in Section XIII.B.a and XIII.B.b.

D. INDEPENDENT CLAIM 15

282. Other than being a method claim, Claim 15 is very similar to Claim 1 and is disclosed by the combination of *Payne* and *Broussard*.

- a. **15[c] controlling the speed of the motor with a variable frequency drive,**

283. This claim limitation is essentially identical to Claims 1[b] and is disclosed by the combination of *Payne* and *Broussard* for the same reasons discussed in Section XIII.B.a.

- b. **15[d] the variable frequency drive further performing electric motor diagnostics;**

284. This claim limitation is essentially identical Claims 1[c] and is disclosed by the combination of *Payne* and *Broussard* for the same reasons discussed in Section XIII.B.b.

XIV. GROUND 4: OBVIOUSNESS OVER PAYNE IN VIEW OF FELLER

285. It is my opinion that the combination of *Payne* and *Feller* discloses and/or suggests all limitations of claims 2-4, 11-12, 17, thereby rendering these

claims obvious. To the extent *Payne* alone does not anticipate or render obvious these claims, the combination of *Payne* and *Feller* anticipates or renders obvious the claim limitations. The relevant limitations disclosed by *Feller* are presented below. In particular, *Feller* discloses a “signal assembly.” All other elements of the claims are disclosed or rendered obvious by *Payne* as described above in Grounds 1-2.

A. REASONS TO COMBINE *PAYNE* WITH *FELLER*

286. As discussed above, *Payne* discloses that its hydraulic fracturing pump unit “may be supplied with a multi-color light tower for each pump.” Ex. 1004, [0058]. According to *Payne*, the “beacon lights” on the tower may emit different colors based on different conditions of the pump, motor, or VFD. *Id.* [0058], [0103], Fig. 10.

287. Like *Payne*, *Feller* discloses “stack lights” that “may comprise a short tower of different colored lamps.” Ex. 1008, [0001]-[0003]. *Feller* also refers to the individual lights that make up the stack lights as “beacon modules.” *Id.* [0039], similar to *Payne*’s “beacon lights”. *Feller* further discloses that the stack lights are “attached to, or placed in close proximity to, operating industrial equipment to provide a visible indication of the equipment operating status.” Ex 1008, [0002].

288. A POSITA would have been motivated to substitute *Payne*’s light tower with *Feller*’s stack lights. Both *Payne* and *Feller* disclose a *signal assembly*

as claimed with similar functions, i.e., to visually signal the operational status of industrial equipment using a tower of lights. Combining *Feller* with *Payne* also furthers *Payne*'s purpose to "ensur[e] safe operation" of the hydraulic fracturing system. Ex. 1004, [0055]. *Feller* explains that its "stack lights" can be used to convey "warning information." Ex.1008, [0001]. Like *Payne*, this warning information may be related to the safety of the industrial equipment. *Id.* [0002]; *see also* Ex.1004, [0055], [0103]. I explained this further in Section XI.N regarding *Payne*'s disclosure of visual signals relating to the safety of the system (claim 14). A POSITA would, therefore, be motivated to combine *Payne* with *Feller* with a reasonable expectation of success, because the combination represents nothing more than the substituting one known element (*Payne*'s light tower) with another (*Feller*'s stack lights).

B. DEPENDENT CLAIM 2

a. 2. The hydraulic fracturing system of claim 1, wherein the signal assembly comprises a plurality of light assemblies arranged in a stack

289. *Payne* discloses Claim 2 for the reasons I discussed in Section XI.B.a.

290. *Feller* discloses "stack lights" as providing "a short tower of different colored lamps such as may be attached to, or placed in close proximity to, operating industrial equipment to provide a visible indication of the equipment operating status." Ex. 1008, [0002]. *Feller*'s Figure 1 (below) depicts the stack lights, which are "assembled of multiple interlocking beacon modules 12a, 12b, 12c." *Id.* [0039],

C. DEPENDENT CLAIM 3

- a. **3. The hydraulic fracturing system of claim 2, wherein each of the light assemblies selectively emit visual light of a color different from visual light emitted by other light assemblies.**

291. *Payne* discloses Claim 3 for the reasons I discussed in Section XI.C.a.

292. *Feller* discloses that the “[d]ifferent colors of the lights” in the stack “allow multiple types of information to be communicated at a distance in a possibly noisy environment.” Ex.1008, [0002]. Additionally, *Feller* explains that the beacon modules that make up the stack lights “may be offered in different colors (e.g. green, red, amber, blue, clear, and yellow).” *Id.* [0007]; *see also id.* [0002] (“Different colors of the lights allow multiple types of information to be communicated at a distance in a possibly noisy environment.”). The combination of *Payne* and *Feller* accordingly renders Claim 3 obvious.

D. DEPENDENT CLAIM 4

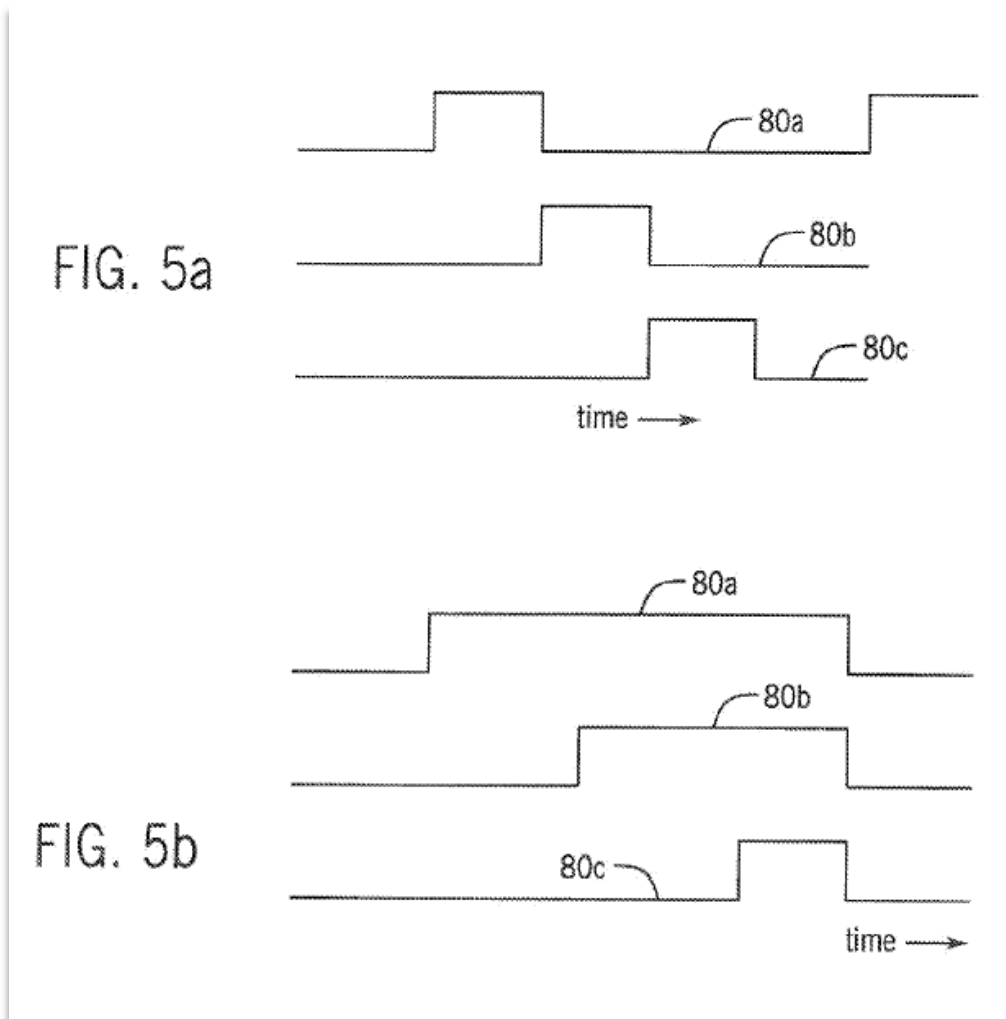
- a. **4. The hydraulic fracturing system of claim 2, wherein a distinctive operational state of the system is indicated by illumination of a combination of the light assemblies.**

293. *Payne* discloses Claim 4 for the reasons I discussed in Section XI.D.a.

294. *Feller* discloses that the stack lights may be used to “provide a visible indication of the equipment operating status.” Ex. 1008, [0002]. *Feller* further discloses that stack lights “convey operation and warning information in an industrial environment.” *Id.*, [0001]. Moreover, “[d]ifferent colors of the lights allow

multiple types of information to be communicated at a distance in a possibly noisy environment.” *Id.* [0002]. “For example, a red light may indicate a machine failure or emergency, a yellow light may indicate a warning such as over-temperature or over-pressure and green may indicate machine operation, etc.” *Id.* A POSITA, therefore, would understand that *Feller* discloses a signal assembly that can indicate a distinctive operational state of the system using the light assemblies.

295. Additionally, *Feller* discloses the illumination of a combination of the light assemblies. As *Feller* explains, the signals to the stack lights may be modulated “according to a desired pattern set by [a] user.” Ex.1008, [0062]; *see also id.* [0063] (“This modulation pattern would provide synchronized flashing of any active beacon modules 12.”). For example, Figure 5a shows that “the output signals 80a-80c of the timing state machine 86 may alternately turn high in a round-robin ‘marquee’ pattern so that when multiple beacon modules 12 are activated their illumination expresses an animation, for example, of an upwardly rising single point of illumination that passes successively through each colored beacon.” *Id.* [0065], Fig.5a. Or, as shown in Figure 5b, “a ‘stacked’ pattern may be implemented in which, for example, an upwardly rising animation is generated but with the lowermost beacon remaining on as successively higher beacons are illuminated until all are ultimately illuminated and then extinguished together and this pattern repeated.” *Id.* [0066], Fig.5b.



Ex. 1008, Figs. 5a-5b.

296. Based on *Feller*'s disclosure of stack lights to "convey operation and warning information, a POSITA would understand *Feller* to disclose that the illumination of a combination of the light assemblies can indicate a distinctive operational state. The combination of *Payne* and *Feller* accordingly renders Claim 4 obvious.

E. DEPENDENT CLAIM 11

- a. **11. The hydraulic fracturing system of claim 9, wherein the signal assembly comprises a stack of light assemblies.**

297. This claim language is similar to language contained in Claim 2. It is disclosed and rendered obvious by *Payne* and *Feller* for the same reasons as those discussed in Section XIV.B.a.

F. DEPENDENT CLAIM 12

- a. **12. The hydraulic fracturing system of claim 11, wherein the light assemblies each comprise an electrically powered light source, and that each emit light of a color that is different from a color of a light emitted by the other light assemblies.**

298. This claim language is similar to language contained in Claim 3. It is disclosed and rendered obvious by *Payne* and *Feller* for the same reasons as those discussed in Section XIV.C.a.

G. DEPENDENT CLAIM 17

- a. **17. The method of claim 15, wherein the step of selectively emitting a visual signal comprises emitting a light from one or more of a stack of light assemblies, where light from one of the stack of light assemblies is different from lights emitted from other light assemblies.**

299. This claim language is similar to language contained in Claim 3. It is disclosed and rendered obvious by *Payne* and *Feller* for the same reasons as those discussed in Section XIV.C.a.

XV. GROUND 4A AND 4B: OBVIOUSNESS OVER *PAYNE* IN VIEW OF *TOSHIBA MANUAL* AND *FELLER*; AND OBVIOUSNESS OVER *PAYNE* IN VIEW OF *BROUSSARD* AND *FELLER*

300. It is my opinion that The combination of *Payne* and *Feller* discloses and/or suggests all limitations of claims 2-4, 11-12, 17, thereby rendering these claims obvious. To the extent *Payne* and *Toshiba Manual* (Ground 3A) or *Payne* and *Broussard* (Ground 3B) do not render obvious these claims, these grounds are presented as an alternative to Grounds 3A and 3B.

A. REASONS TO COMBINE *PAYNE* WITH *TOSHIBA MANUAL* AND *FELLER*

301. A POSITA would have been motivated to combine *Feller* with *Payne* and *Toshiba Manual* for the same reasons a POSITA would have been motivated to combine *Feller* with *Payne* and *Toshiba Manual and Payne*—as I explained in Sections XIV.A and XII.A. The addition of *Toshiba Manual*, which relates to the disclosure of a VFD, would not affect a POSITA's motivation to combine *Feller* with *Payne*, because *Feller* focuses on the disclosure of a signal assembly and does not affect the use of a VFD.

B. REASONS TO COMBINE *PAYNE* WITH *BROUSSARD* AND *FELLER*

302. A POSITA would have been motivated to combine *Feller* with *Payne* and *Broussard* for the same reasons a POSITA would have been motivated to combine *Feller* with *Payne and Broussard and Payne*—as I explained in Sections XIV.A and XIII.A. The addition of *Broussard*, which relates to the disclosure of a

VFD, would not affect a POSITA's motivation to combine *Feller* with *Payne*, because *Feller* focuses on the disclosure of a signal assembly and does not affect the use of a VFD.

C. DEPENDENT CLAIMS 2, 3, 4, 11, 12, 17

303. The dependent claims are disclosed for the same reasons I explained in Section XIV (Ground 4). The addition of the references teaching VFDs and diagnostics (*Toshiba Manual* and *Broussard*) do not affect the disclosure of *Feller* and *Feller* does not affect the disclosure of the VFDs and diagnostics.

XVI. GROUND 5: OBVIOUSNESS OVER PAYNE IN VIEW OF WIEMERS

304. It is my opinion that the combination of *Payne* and *Wiemers* discloses and/or suggests all limitations of claim 5, thereby rendering the claim obvious. To the extent *Payne* alone does not anticipate or render obvious Claim 5, this ground is presented as an alternative to Grounds 1-2. Further it is my opinion that the combination of *Payne* and *Wiemers* provides additional teaching regarding monitoring the specific operational states claimed in Claim element 13[b] and Claim 16.

A. REASONS TO COMBINE PAYNE WITH WIEMERS

305. *Payne* discloses that its fracturing pump unit includes a VFD for controlling an electrical motor. Ex. 1004, [0047]. Additionally, *Payne* discloses that

those motors may be taken “off line” if certain “operating parameters exceed predetermined thresholds.” *Id.*, claim 36; *see also id.* [0055] (“bringing the affected unit offline”). *Payne* touts this practice as a “benefit” of the automated alarm management system, which allows “multiple processes and subsystems on each pumping unit [to] be monitored autonomously.” *Id.* [0055].

306. *Wiemers* describes a liquid treatment station and mobile treatment units in hydraulic-fracturing operations. Ex. 1009 [0001], [0003]-[0005]. As with *Payne*, *Wiemers* also discloses that the motors used to drive pumps in its systems are controlled by VFDs. *Id.* [0078] (“variable frequency drive (VFD) motor”), [0093], [0110], Figs. 30-32. *Wiemers* depicts in Figure 30 that each of its VFD motors can be individually taken offline in the event of a “fault.” *Id.* [0110], Fig. 30.

307. A POSITA would have been motivated to combine *Wiemers* with *Payne* with a reasonable expectation of success, because it simply involves incorporating the known practice of using a controller to control individual VFD motors to further a stated benefit of *Payne*’s automated alarm management system: allowing “multiple processes and systems on each pumping unit,” including the VFDs, to “be monitored autonomously.” Ex.1 004, [0055]. By incorporating the functionality of *Wiemers*’s controller to control and monitor the state of each VFD, the operator has more information and flexibility in “choos[ing] what action to take,”

including “bringing the affected unit” like the VFD “offline.” Ex. 1004, [0055]. The results of this combination would have been predictable and obvious to a POSITA.

B. DEPENDENT CLAIM 5

- a. **5. The hydraulic fracturing system of claim 1, wherein the operational states of the hydraulic fracturing system comprise, [i] no electricity to the system, [ii] a supply of electricity to all electrically powered devices in the system, [iii] a supply of electricity to some of the electrically powered devices in the system, and [iv] a pressure in a discharge line of the pump having a magnitude that is at least that of a designated pressure.**

308. *Payne* renders obvious Claim 5 for the reasons I discussed in Section XI.E.

309. To the extent *Payne* does not disclose that an operational state may comprise 5[iii], the combination of *Payne* and *Wiemers* renders it obvious.

310. *Wiemers* discloses that the control for its mobile liquid treatment unit includes “sensing attributes,” such as “state attributes (on/off, for example),” and includes “electronic outputs indicative thereof to controller 271.” Further, *Wiemers* discloses “Data indicative of the electronic outputs and control signals is acquired and reported and/or saved at controller 271” Ex. 1009, [0103].

311. *Wiemers* further teaches a simulator for training purposes. According to *Wiemers* “All process control can be simulated and utilized [] for training, unit development and off-site process control functions. This simulation software is an

exact duplication of the process control software programming onboard at management unit 39 and includes displays of the various treatment unit responses to operator activities or programming changes.” Ex 1009, [0107] Accordingly a POSITA would have understood that *Wiemers*’ simulator teaches what an actual controller would do in a deployed system.

312. As *Wiemers*’ Figure 30 shows, “there are status lights, start/stop buttons and speed control potentiometers for each variable frequency drive (VFD) motor in the system.” *Id.* [0110]. In particular, Figure 30 depicts status lights to “show if a VFD motor is currently energized” and “switches for each VFD motor that simulate an overheating signal or any other kind of fault.” *Id.* As described in Ground 1 with respect to Claim 5, a POSITA would have understood *Payne*’s VFD to be a “pump drive” as it controls [drives] *Payne*’s fracturing pump motors and the mechanically coupled pumps.

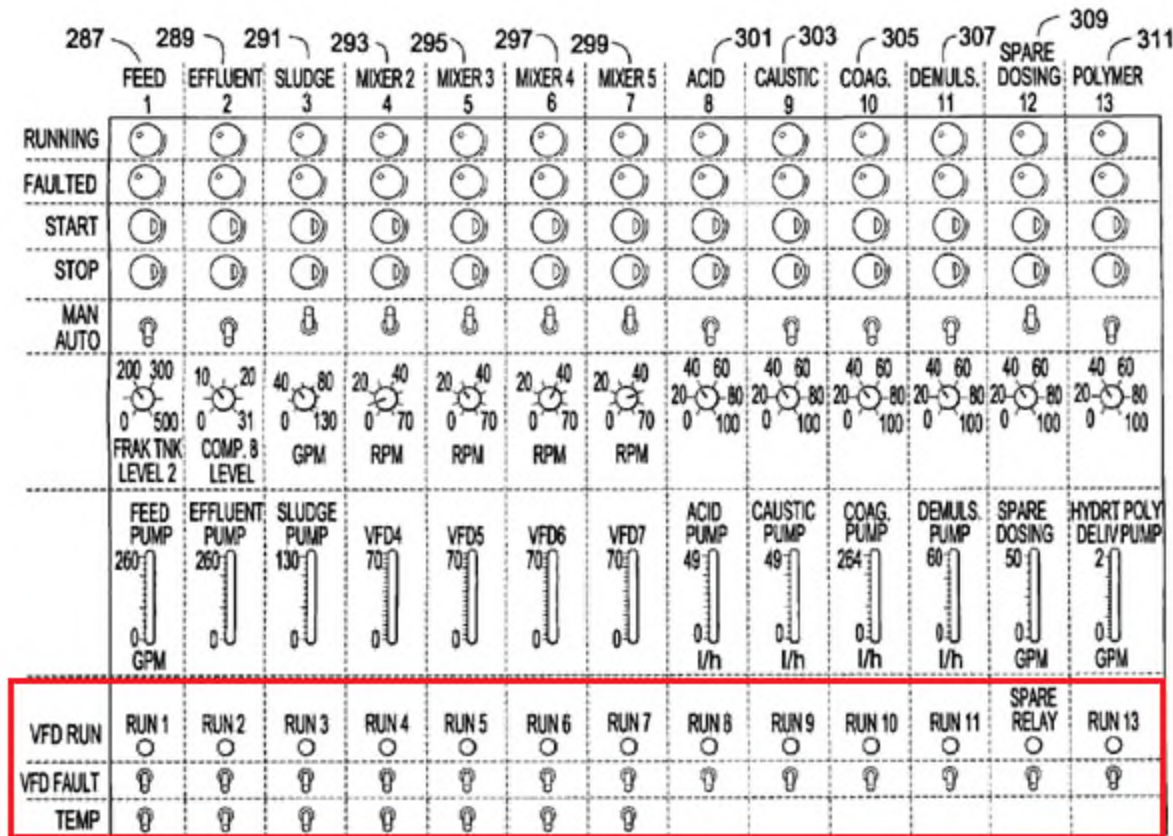


FIG.30

Ex. 1009, Fig. 30 (annotated).

313. Accordingly, a POSITA would have found it obvious to incorporate *Wiemers'* controller and indicators for each VFD motor into *Payne*, which aims to share VFD workload when an operating parameter exceeds a certain threshold value to “minimiz[e] the number of VFD faults and thermal shut down events caused by over driving particular pieces of fracturing equipment.” Ex. 1004, [0109]. By allowing an operator to take individual VFD motors offline and providing a visual signal indicative of that state, as disclosed in *Wiemers*, a POSITA would understand

that the operational state of the hydraulic fracturing system may comprise “a supply of electricity to some of the electrically powered devices in the system,” as claimed.

C. DEPENDENT CLAIM 13

- a. **13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.**

314. *Payne* renders obvious Claim 13 for the reasons I discussed in Section XI.M.b.

315. To the extent *Payne* does not disclose that an operational state may comprise 13[iii] “the pump drive being energized”, the combination of *Payne* and *Wiemers* renders it obvious for the same reasons as described in Section XVI.B.a with respect to Claim 5.

D. DEPENDENT CLAIM 16

- a. **16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.**

316. *Payne* discloses or renders obvious Claim 16 for the reasons I discussed in Section XI.P.

317. To the extent *Payne* does not disclose that an operational state may comprise the operational state of “the pump drive being energized” as claimed, the combination of *Payne* and *Wiemers* renders it obvious for the same reasons as described in Section XVI.B.a with respect to Claim 5.

XVII. GROUNDS 5A AND 5B: OBVIOUSNESS OVER *PAYNE* IN VIEW OF *TOSHIBA MANUAL* AND *WIEMERS*; AND OBVIOUSNESS OVER *PAYNE* IN VIEW OF *BROUSSARD* AND *WIEMERS*

318. It is my opinion that the combination of *Payne* and *Wiemers* discloses and/or suggests all limitations of claim 5, thereby rendering claim 5 obvious. To the extent *Payne* and *Toshiba Manual* (Ground 3A) or *Payne* and *Broussard* (Ground 3B) do not render obvious these claims, these grounds are presented as an alternative to Grounds 3A and 3B.

A. REASONS TO COMBINE *PAYNE* WITH *TOSHIBA MANUAL* AND *WIEMERS*

319. A POSITA would have been motivated to combine *Wiemers* with *Payne* and *Toshiba Manual* for the same reasons a POSITA would have been motivated to combine *Wiemers* with *Payne*— as I explained in Sections XVI.A and XII.A. The addition of *Toshiba Manual*, which relates to the disclosure of a VFD, would not affect a POSITA’s motivation to combine *Wiemers* with *Payne*, because *Wiemers*’s disclosure of a VFD is consistent with that of *Toshiba Manual*, i.e., the VFD controls the motor. Ex. 1004, [0047]; Ex. 1009, [0078], [0093], [0110].

B. REASONS TO COMBINE PAYNE WITH BROUSSARD AND WIEMERS

320. A POSITA would have been motivated to combine *Wiemers* with *Payne* and *Broussard* for the same reasons a POSITA would have been motivated to combine *Wiemers* with *Payne*— as I explained in Sections XVI.A and XIII.A. The addition of *Broussard*, which relates to the disclosure of a VFD, would not affect a POSITA's motivation to combine *Wiemers* with *Payne*, because *Wiemers*'s disclosure of a VFD is consistent with that of *Broussard*, *i.e.*, the VFD controls the motor. Ex. 1004, [0047]; Ex. 1009, [0078], [0093], [0110].

C. DEPENDENT CLAIM 5

321. Claim 5 is disclosed for the same reasons I explained in Section XVI.B (Ground 5).

XVIII. GROUND 6: OBVIOUSNESS OVER PAYNE IN VIEW OF CARLSON

322. It is my opinion that the combination of *Payne* and *Carlson* discloses and/or suggests all limitations of claims 8 and 14, thereby rendering these claims obvious. To the extent *Payne* alone does not anticipate or render obvious these claims, this ground is presented as an alternative to Grounds 1-2. The relevant limitations disclosed by *Carlson* are presented below. In particular, *Carlson* discloses the use of a signal assembly for safety purposes. All other elements of the

claims are disclosed or rendered obvious by *Payne* as described above in Grounds 1-2.

A. REASONS TO COMBINE *PAYNE* WITH *CARLSON*

323. *Payne* discloses that one objective of its systems is to “ensur[e] safe operation” of its hydraulic fracturing system. Ex. 1004, [0055]. One component of this system is to use a multi-color light tower to alert an operator using visual signals. *Id.* [0058]. *Payne* further highlights safety when it notes that the programmable automation controller (PAC) on each hydraulic fracturing unit “acts as a safety device.” *Id.* [0039]. “If an unsafe condition is detected, for example, an over pressure event, the PAC can independently override the remote operator’s command and take whatever action is appropriate, for example, shutting off the VFD[.]”). *Id.*

324. *Carlson* discloses “control pendants” that “display status conditions of the control devices and sensing devices” of *Carlson*’s blender control system, which is used in oilfield-fracturing operations. Ex. 1010, 1:15-27, 2:59-61 (“The control pendants 240 and 250 permit an operator to...display the operational status of the blender system.”). As *Carlson* explains, one goal of using the control pendants, which includes LED indicators, is to “enhance[] the safety of the operator.” *Id.* at 3:5-10, 3:55-60, 15:9-15.

325. A POSITA would have been motivated to combine *Payne* and *Carlson* with a reasonable expectation of success. Both *Carlson* and *Payne* disclose a signal assembly with similar functions, i.e., to visually signal the operational state of associated equipment. Combining the teachings of *Carlson* with *Payne* also furthers *Payne*'s purpose of its systems, which is to ensure the safe operation of the hydraulic fracturing system. Ex. 1004, [0055]. *Carlson* expressly describes the same objective for its control pendants. Ex. 1010, 3:5-10. A POSITA would, therefore, be motivated to combine *Payne* with the teachings of *Carlson* with a reasonable expectation of success, because the combination represents nothing more than using one known element (*Payne*'s light tower) for the same purpose as another similar element (*Carlson*'s control pendants) to predictably increase safety.

B. DEPENDENT CLAIM 8

- a. **8. The hydraulic fracturing system of claim 1, wherein the visual signal comprises light in the visible spectrum, and that is optically detectable by operations personnel disposed in a zone that is potentially hazardous due to fluid in piping that is pressurized by at least one of the pumps.**

326. *Payne* discloses Claim 8 for the reasons I discussed in Section XI.H.

327. *Carlson* discloses that its control pendants contain "light emitting diode (LED) drivers" and "LED indicators." Ex. 1010, 15:9-15. A POSITA would understand *Carlson* to therefore disclose a signal assembly that emits a visual signal that comprises light in the visible spectrum and is optically detectable.

328. Additionally, *Carlson* discloses that the control pendants may be moved such that they can be operated anywhere, including “on top of the blender assembly 300, beside the blender assembly 300, in any remote control location, or from two sites simultaneously.” *Id.* 3:5-10. As *Carlson* explains, “[t]his increased mobility enhances the safety of the operator.” *Id.* For instance, “the size and weight of the control pendants 240 and 250 allow a person servicing a mechanical portion of the system to move a control pendant to the location being serviced,” which “eliminates the need for a second person to operate the blender system 100 while the technician performs service.” *Id.* 3:55-60. A POSITA would understand, therefore, that *Carlson* discloses a pendant that emits a visual signal that is optically detectable by operations personnel disposed in a zone that is potentially hazardous. As I discussed in Section XI.H regarding Claim 8, *Payne* discloses the hazard may be caused by “fluid in piping that is pressured by at least one of the pumps.”

C. **DEPENDENT CLAIM 14**

- a. **14. The hydraulic fracturing system of claim 9, wherein the visual signals selectively indicate when the system is safe for operations personnel, when the system is potentially unsafe for operations personnel, and when the system is currently unsafe for operations personnel.**

329. *Payne* discloses Claim 14 for the reasons I discussed in Section XI.N.a.

330. To the extent *Payne* does not disclose claim 14, a POSITA would find it obvious in view *Carlson*. *Carlson* explains that one purpose of its control pendants

is to “enhance[] the safety of the operator.” Ex. 1010, 3:5-10, 3:55-60. *Carlson* achieves this enhanced safety in part via visual signals emitted from the control pendants’ LED indicators. *See id.* 3:5-10, 3:55-60, 15:9-15.

331. Therefore, in light of *Payne*’s disclosure of “a signal assembly that selectively emits a visual signal that is indicative of an operational state” (see my discussion of Claim 1[d] in Section XI.A.e), a POSITA would find it obvious to modify *Payne*’s signal assembly to also emit a visual signal that is indicative of an operational state related to when the system is safe for operations personnel, potentially unsafe for operations personnel, and currently unsafe for operations personnel.

XIX. GROUNDS 6A AND 6B: OBVIOUSNESS OVER *PAYNE* IN VIEW OF *TOSHIBA MANUAL* AND *CARLSON*; AND OBVIOUSNESS OVER *PAYNE* IN VIEW OF *BROUSSARD* AND *CARLSON*

332. It is my opinion that the combination of *Payne* and *Carlson* discloses and/or suggests all limitations of claims 8 and 14, thereby rendering those claims obvious. To the extent *Payne* and *Toshiba Manual* (Ground 3A) or *Payne* and *Broussard* (Ground 3B) do not render obvious these claims, these grounds are presented as an alternative to Grounds 3A and 3B.

A. REASONS TO COMBINE *PAYNE* WITH *TOSHIBA MANUAL* AND *CARLSON*

333. A POSITA would have been motivated to combine *Carlson* with *Payne* and *Toshiba Manual* for the same reasons a POSITA would have been motivated to

combine *Carlson* with *Payne*. — as I explained in Sections XVIII.A and XII.A. The addition of *Toshiba Manual*, which relates to the disclosure of a VFD, would not affect a POSITA's motivation to combine *Carlson* with *Payne*, because *Carlson*'s disclosure relates to the *signal assembly* and does not preclude the use of a VFD.

B. REASONS TO COMBINE *PAYNE* WITH *BROUSSARD* AND *CARLSON*

334. A POSITA would have been motivated to combine *Carlson* with *Payne* and *Broussard* for the same reasons a POSITA would have been motivated to combine *Carlson* with *Payne*— as I explained in Sections XVIII.A and XIII.A. The addition of *Broussard*, which relates to the disclosure of a VFD, would not affect a POSITA's motivation to combine *Wiemers* with *Payne*, because *Carlson*'s disclosure relates to the *signal assembly* and does not preclude the use of a VFD.

C. DEPENDENT CLAIMS 8 AND 14

335. The dependent claims are disclosed for the same reasons I explained in Section XVIII (Ground 6).

XX. GROUND 7: OBVIOUSNESS OVER *PAYNE* IN VIEW OF *RANDLE*

336. It is my opinion that the combination of *Payne* and *Randle* discloses and/or suggests all limitations of claims 13 and 16, thereby rendering these claims obvious. To the extent *Payne* alone does not anticipate or render obvious these claims, this ground is presented as an alternative to Grounds 1-2. The relevant limitations disclosed by *Randle* are presented below. In particular, *Randle* discloses

that the safety system for a hydraulic fracturing pump may include a controller that monitors certain conditions of the pump. All other elements of the claims are disclosed or rendered obvious by *Payne* as described above in Grounds 1-2

A. REASONS TO COMBINE *PAYNE* WITH *RANDLE*

337. *Payne* discloses a “programmable automation controller (PAC) configured to receive commands from the system control unit” where “at least one PAC is configured to autonomously monitor operating parameters of the associated system unit.” Ex. 1004, claims 7, 11, 20. *Payne* further discloses that the PAC is configured to “monitor operating parameters” related to its associated system unit, including the hydraulic fracturing pump unit. *Id.*, claims 7, 11.

338. *Randle* discloses a hydraulic fracturing pump isolation safety system that includes a controller. Ex. 1011, [0017]. As *Randle* explains, the controller may “accept[] as inputs the valve condition and the pump condition, and present[] the monitored conditions to the operator control panel for display on the operator graphical interface.” *Id.* [0032]. Among the conditions that may be monitored include “the current flow through the motor windings, fluid end pressure, temperature, sound, and/or vibration, which can also give an indication of the overall health and operation of the frac pump.” *Id.*

339. A POSITA would have been motivated to combine *Payne* and *Randle* to take advantage of *Randle*'s teaching of "presenting the monitored conditions to the operator control panel for display on the operator graphical interface". To the extent not already taught by *Payne*, a POSITA would be motivated to add additional displays of "current flow through the motor windings, fluid end pressure, temperature, sound and/or vibration" in order to take advantage of the teachings of *Randle* regarding indicating to the operator the operational health of the frac pump and motor. Both *Randle* and *Payne* disclose a controller that performs similar functions, *i.e.*, monitors certain operating parameters related to the pump. A POSITA, therefore, would be motivated to combine *Payne* with the teachings of *Randle* with a reasonable expectation of success, because the combination represents nothing more than adding the operating parameters monitored and displayed by *Randle*'s controller to the list of operating parameters monitored by *Payne*'s controller, which would generate predictable results.

B. DEPENDENT CLAIM 13

- a. 13[b] wherein the operational state of the system comprises, [i] the system being isolated from electricity, [ii] a fluid pressure of the discharge having a value at least as great as a designated value, [iii] the pump drive being energized, and [iv] the auxiliary equipment being energized but without a one of the motors being energized.

340. *Payne* discloses Claim 13[b] for the reasons I discussed in Section XI.M.b.

341. *Randle* also discloses that the operational state may comprise [iii] the pump drive being energized. *Randle* explains that each of its frac pumps “include a pump condition determining means that generates a signal that reflects the condition or operational status of the pump.” Ex. 1011, [0029]. *Randle* also discloses that certain “monitored conditions” may be presented to the operator control panel. *Id.* [0032]. One example of a monitored condition is “the current flow through the motor windings.” *Id.* [0029]. A POSITA would understand *Randle*’s disclosure of “the current flow through the motor windings” to disclose an operational state in which “the pump drive [is] energized,” as claimed.

C. **DEPENDENT CLAIM 16**

- a. **16. The method of claim 15, wherein the operational state comprises the system being isolated from electricity, a fluid pressure of discharge of the pump having a value at least as great as a designated value, a pump controller being energized, and auxiliary equipment being energized but without a one of the pump motors being energized.**

342. The combination of *Payne* and *Randle* discloses Claim 16 for the reasons I discussed in Section XX.B (claim 13).

XXI. GROUNDS 7A AND 7B: OBVIOUSNESS OVER PAYNE IN VIEW OF TOSHIBA MANUAL AND RANDLE; AND OBVIOUSNESS OVER PAYNE IN VIEW OF BROUSSARD AND RANDLE

343. It is my opinion that the combination of *Payne* and *Randle* discloses and/or suggests all limitations of claims 13 and 16, thereby rendering those claims obvious. To the extent *Payne* and *Toshiba Manual* (Ground 3A) or *Payne* and *Broussard* (Ground 3B) do not render obvious these claims, these grounds are presented as an alternative to Grounds 3A and 3B.

A. **REASONS TO COMBINE PAYNE WITH TOSHIBA MANUAL AND RANDLE**

344. A POSITA would have been motivated to combine *Randle* with *Payne* and *Toshiba Manual* for the same reasons a POSITA would have been motivated to combine *Randle* with *Payne*— as I explained in Sections XX.A and XII.A. The addition of *Toshiba Manual*, which relates to the disclosure of a VFD, would not affect a POSITA's motivation to combine *Randle* with *Payne*, because *Randle*'s

disclosure relates to the operational state of the hydraulic fracturing system that may be monitored and indicated by a signal assembly and does not preclude the use of a VFD.

B. REASONS TO COMBINE *PAYNE* WITH *BROUSSARD* AND *RANDLE*

345. A POSITA would have been motivated to combine *Randle* with *Payne* and *Broussard* for the same reasons a POSITA would have been motivated to combine *Randle* with *Payne*—as I explained in Sections XX.A and XIII.A. The addition of *Broussard*, which relates to the disclosure of a VFD, would not affect a POSITA’s motivation to combine *Randle* with *Payne*, because *Randle*’s disclosure relates to the operational state of the hydraulic fracturing system that may be monitored and indicated by a signal assembly.

C. DEPENDENT CLAIMS 13 AND 16

346. The dependent claims are disclosed for the same reasons I explained in Section XX (Ground 7).

XXII. SECONDARY CONSIDERATIONS

347. Should the Patent Owner put forth any alleged evidence of secondary considerations in this proceeding or the related Halliburton 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.

XXIII. CONCLUSION

348. 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 10, 2023.



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 - 2020
Principal

THEWAY Corp. 2004 - 2020
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 Working Group
Chair	IEEE RP1018 Working Group
Chair	IEEE RP1019 Working Group
Chair	IEEE PCIC Standards Subcommittee

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".

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

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