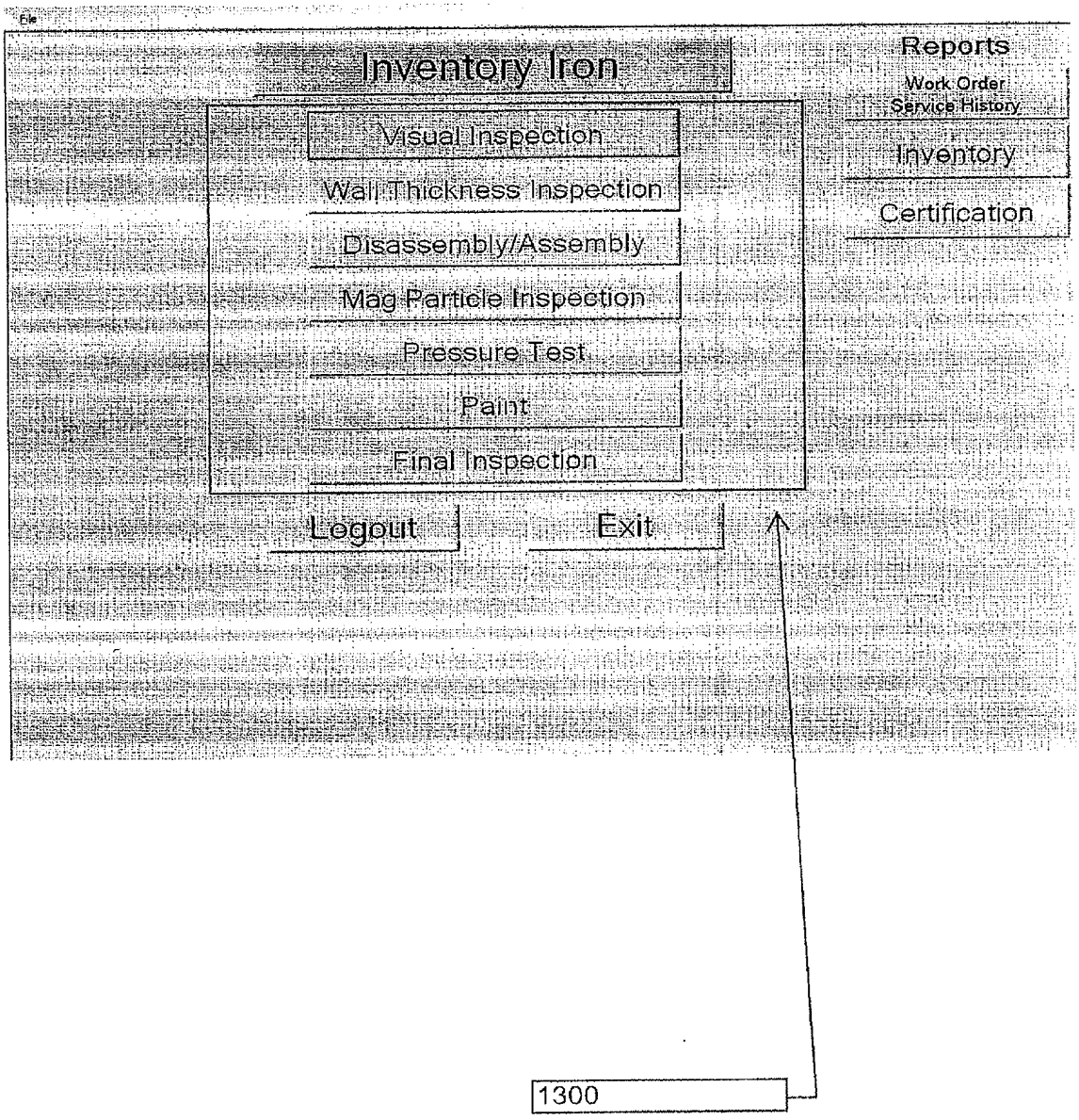

File
Inventory Iron
Visual Inspection
Wall Thickness Inspection
Disassembly/Assembly
Mag Particle Inspection
Pressure Test
Paint
Final Inspection
Logout
Exit
Reports
Work Order
Service History
Inventory
Certification
1300

FIG. 13

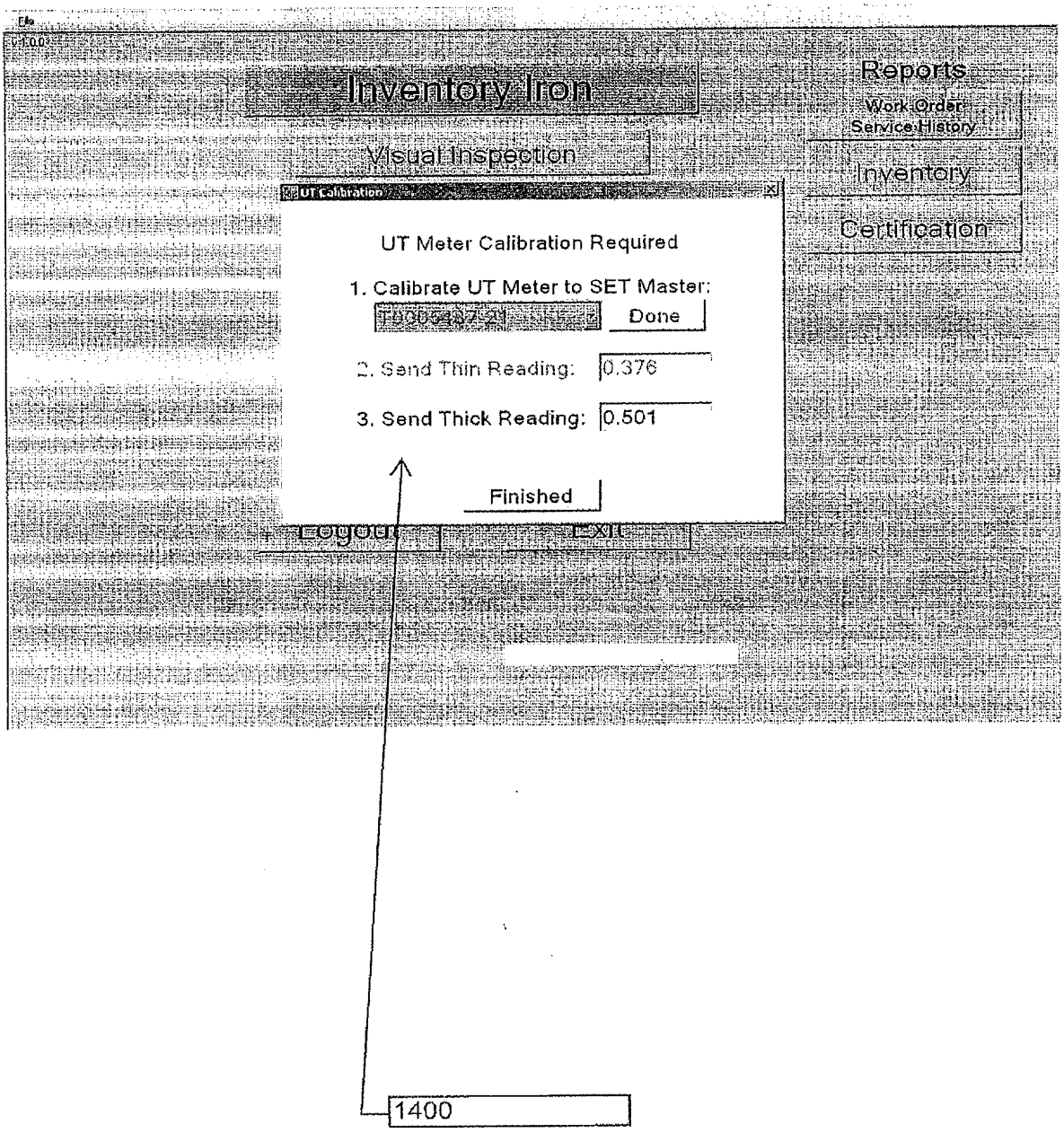

Inventory Iron
Reports
Work Order
Service History
Visual Inspection
Inventory
Certification
UT Calibration
UT Meter Calibration Required
1. Calibrate UT Meter to SET Master:
T0305437-21
Done
2. Send Thin Reading:
0.376
3. Send Thick Reading:
0.501
Finished
Logout
Exit
1400

FIG. 14

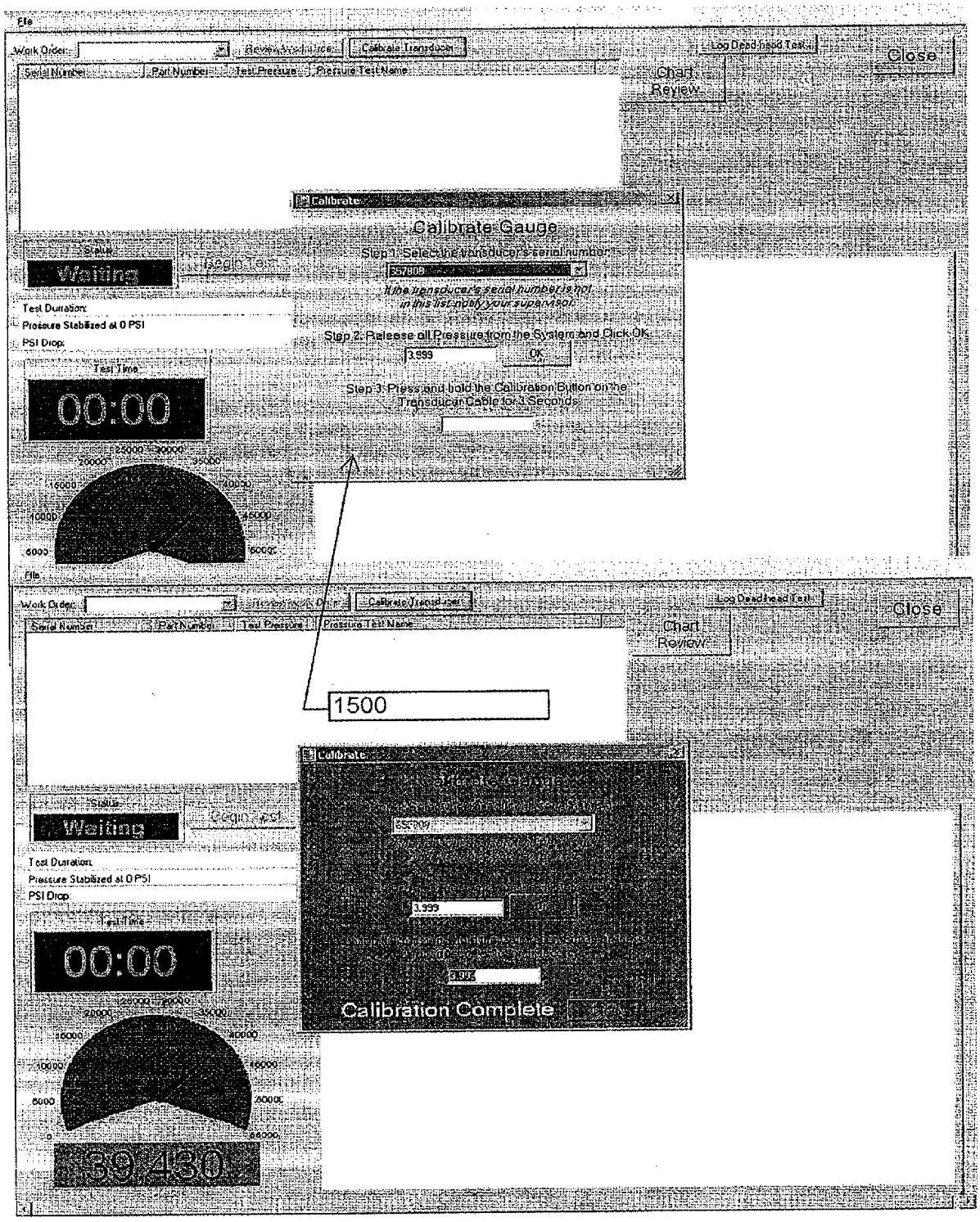

File
Work Order:
Calibrate Transducer
Log Dead Head Test
Close
Serial Number
Part Number
Test Pressure
Pressure Test Name
Chart Review
Calibrate
Calibrate Gauge
Step 1: Select the transducer's serial number
If the transducer's serial number is not in this list, notify your supervisor.
Step 2: Release all Pressure from the System and Click OK
3.999
OK
Step 3: Press and hold the Calibration Button on the Transducer Cable for 3 Seconds
Status
Waiting
Begin Test
Test Duration:
Pressure Stabilized at 0 PSI
PSI Drop:
Test Time
00:00
1500
Calibration Complete
39.430

FIG. 15

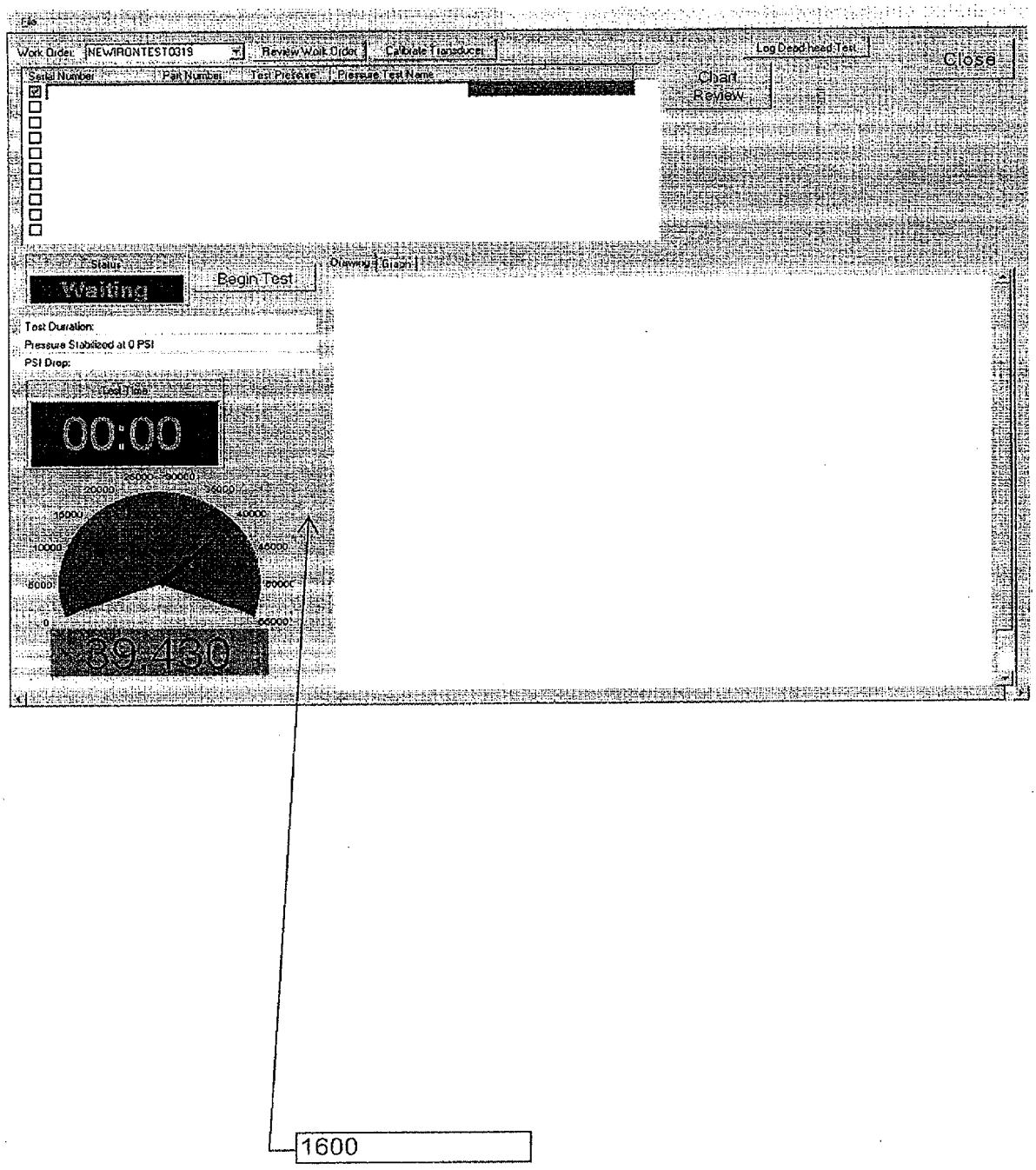

Work Order
NEWIRONTEST0319
Review Work Order
Calibrate Transducer
Log Deadhead Test
Close
Serial Number
Part Number
Test Picture
Pressure Test Name
Chart Review
Status
Waiting
Begin Test
Drawing Graph
Test Duration:
Pressure Stabilized at 0 PSI
PSI Drop:
Load Tank
00:00
89.430
1600

FIG. 16

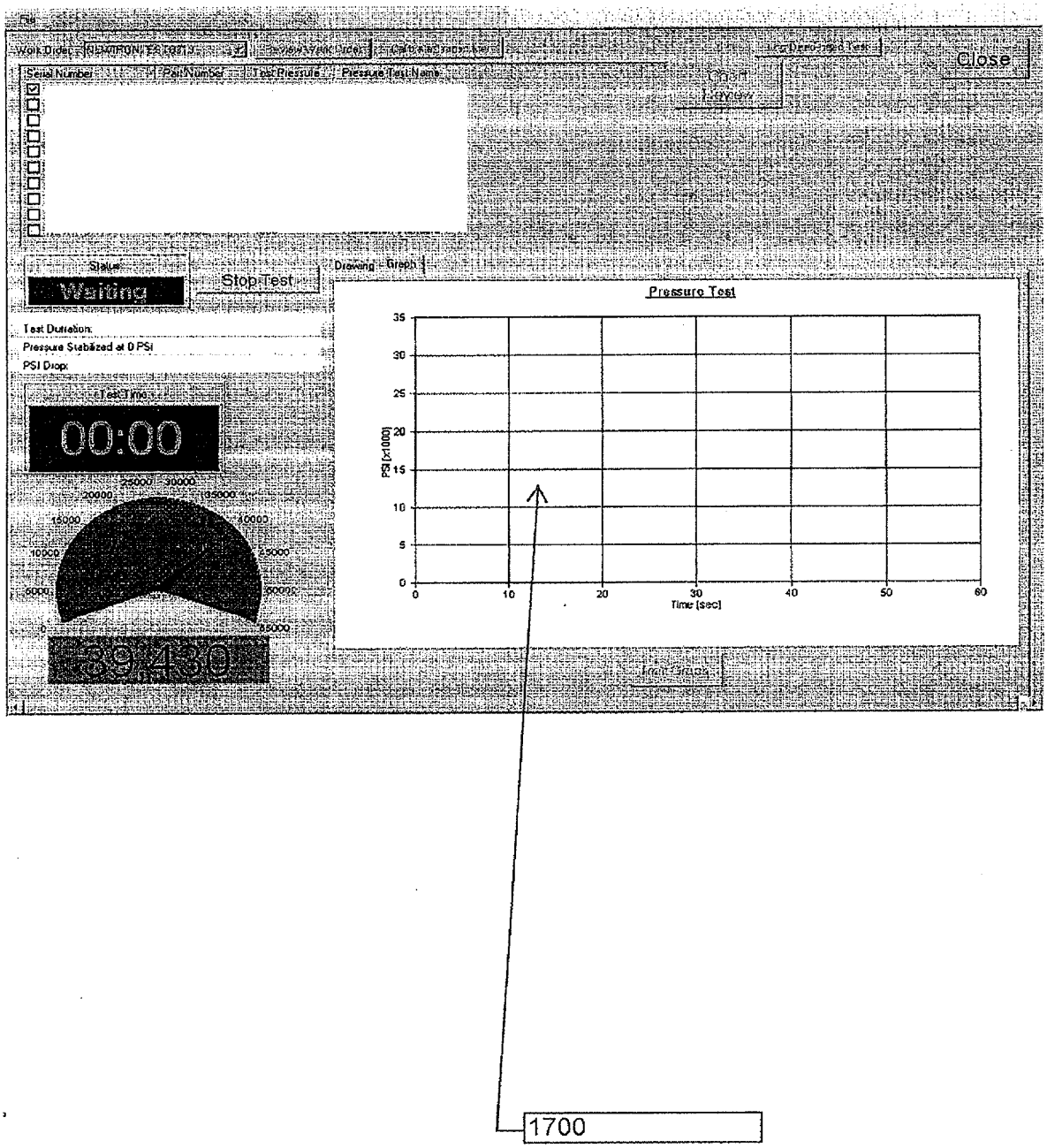

Close
Serial Number
Part Number
Test Pressure
Pressure Test Name
Status
Waiting
Stop Test
Drawing
Graph
Test Duration:
Pressure Stabilized at 0 PSI
PSI Drop:
Test Time
00:00
Pressure Test
PSI (x1000)
Time [sec]
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
1700

FIG. 17

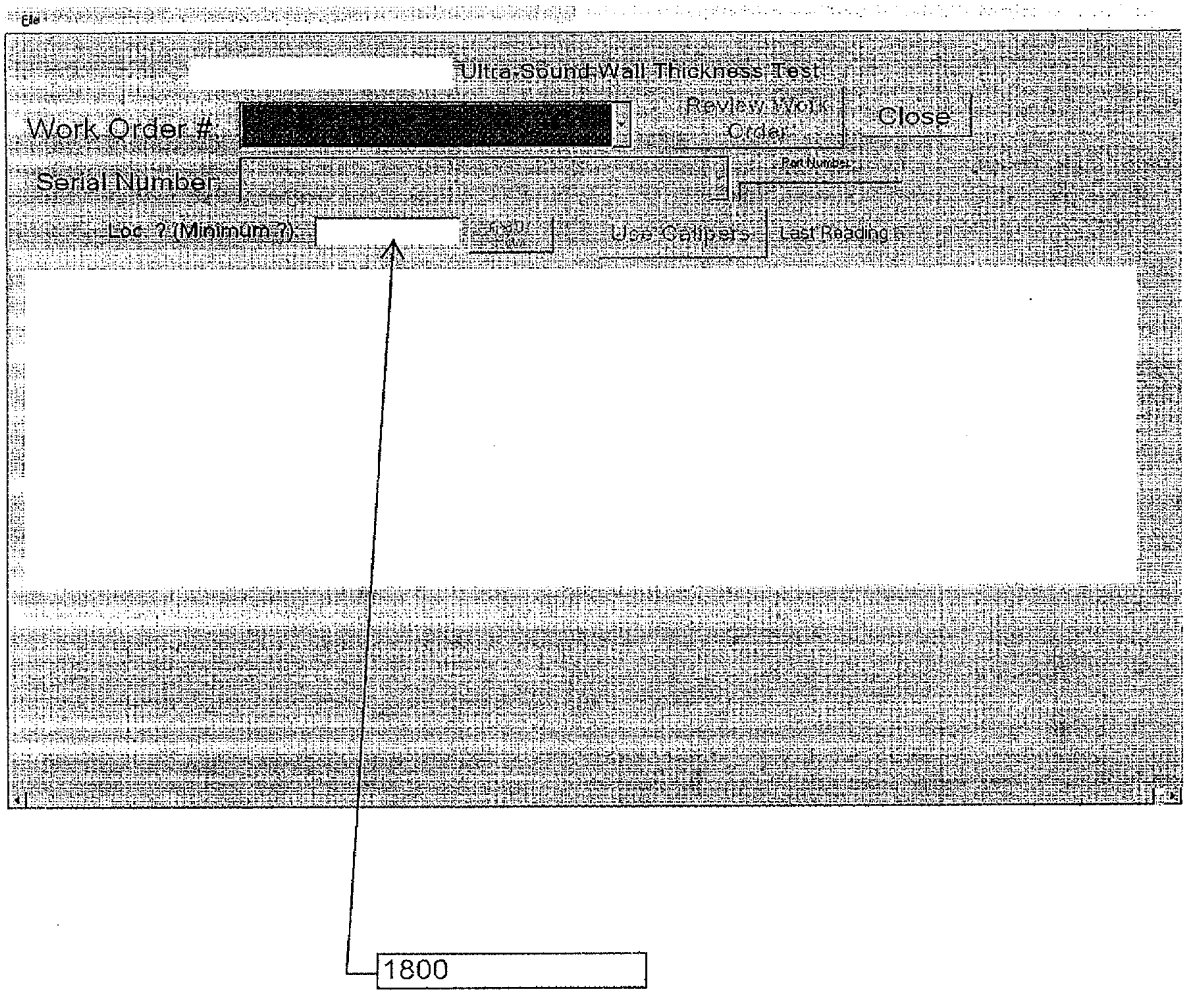

Ultra-Sound Wall Thickness Test
Review Work Order
Close
Work Order #:
Serial Number
Part Number
Loc ? (Minimum ?)
Use Calipers
Last Reading
1800

FIG. 18

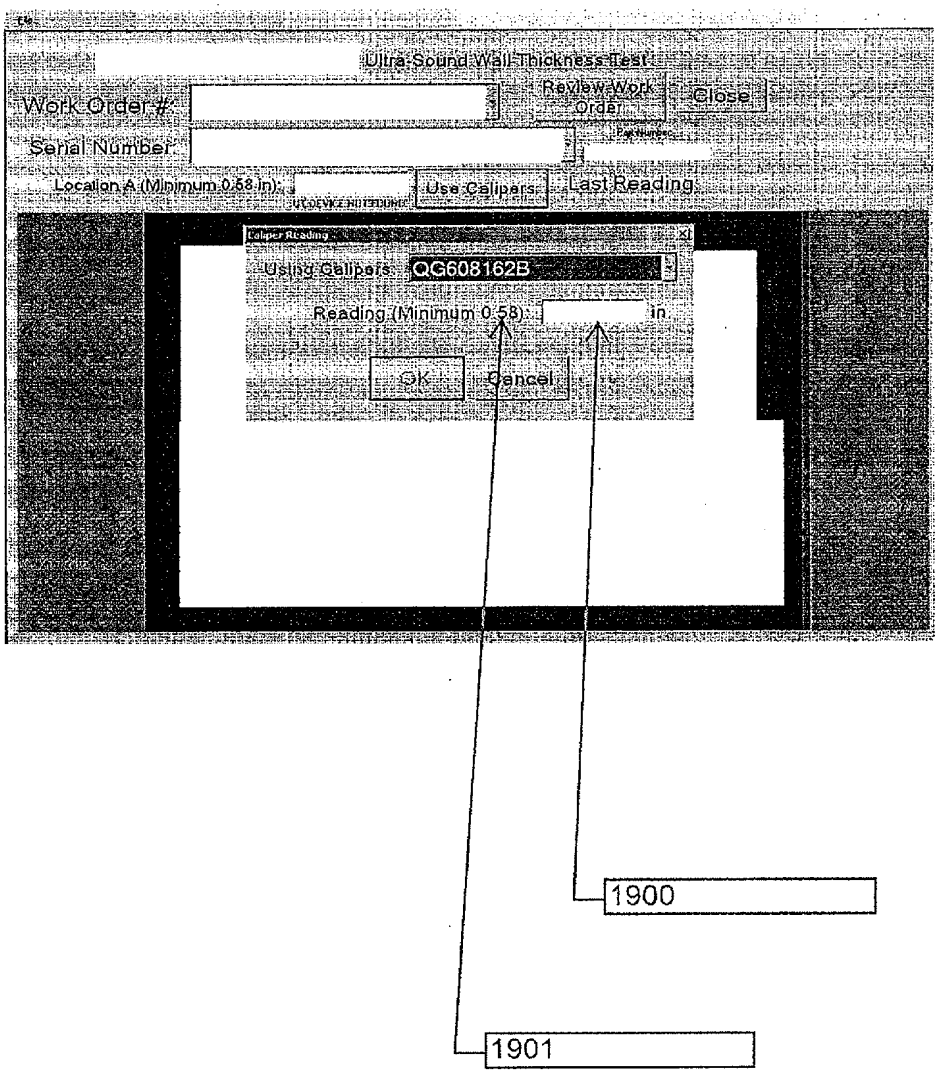

Ultra Sound Wall Thickness Test
Work Order #:
Review Work Order
Close
Serial Number:
Location A (Minimum 0.58 in):
Use Calipers
Last Reading
Using Calipers:
QG608162B
Reading (Minimum 0.58):
in
OK
Cancel
1900
1901

FIG. 19

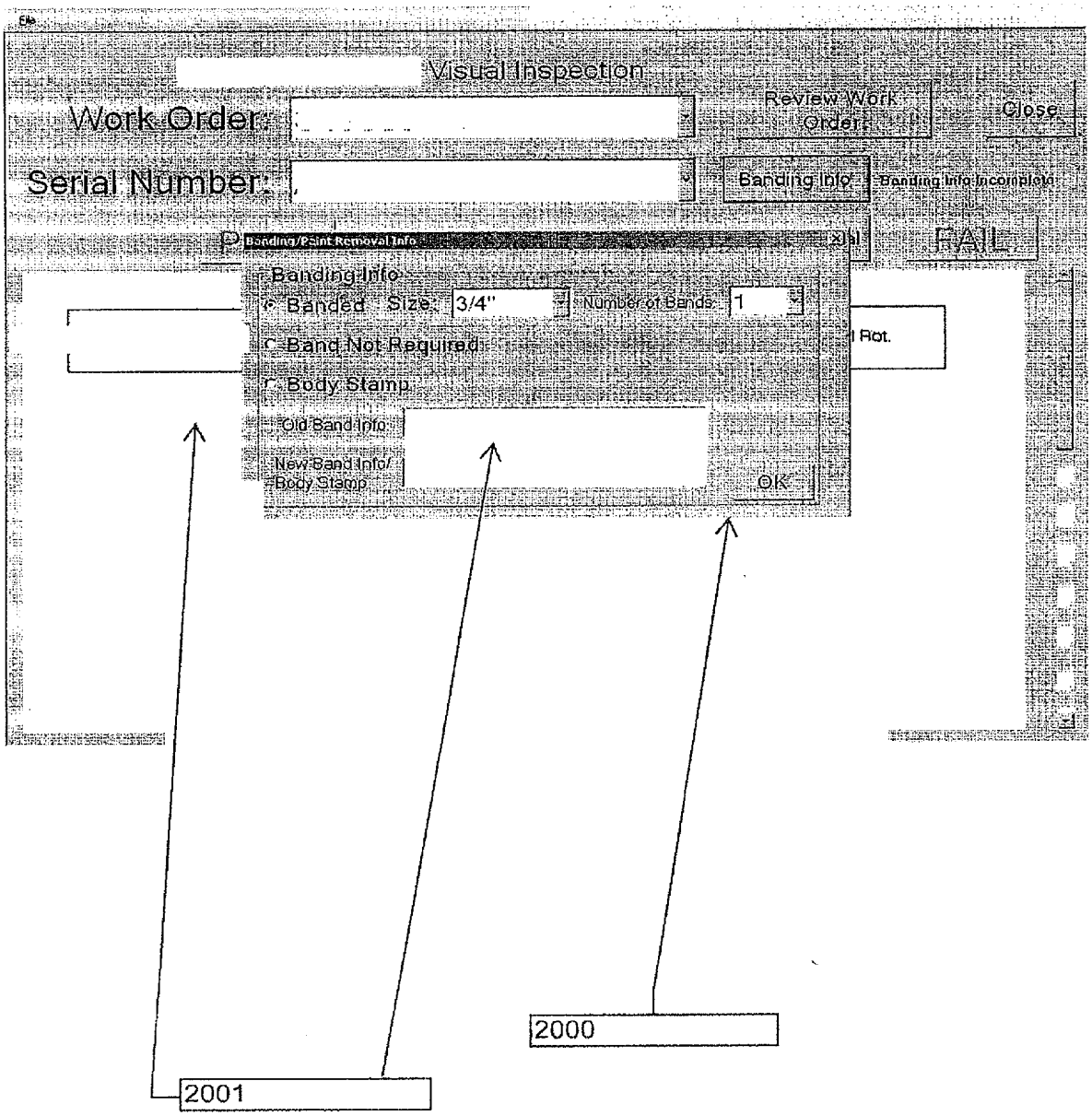

Visual Inspection
Work Order:
Serial Number:
Review Work Order
Close
Banding Info
Banding Info Incomplete
FAIL
Banding/Paint Removal Info
Banding Info
Banded Size: 3/4"
Number of Bands: 1
Band Not Required
Body Stamp
Old Band Info
New Band Info/ Body Stamp
OK
Rot.
2000
2001

FIG. 20

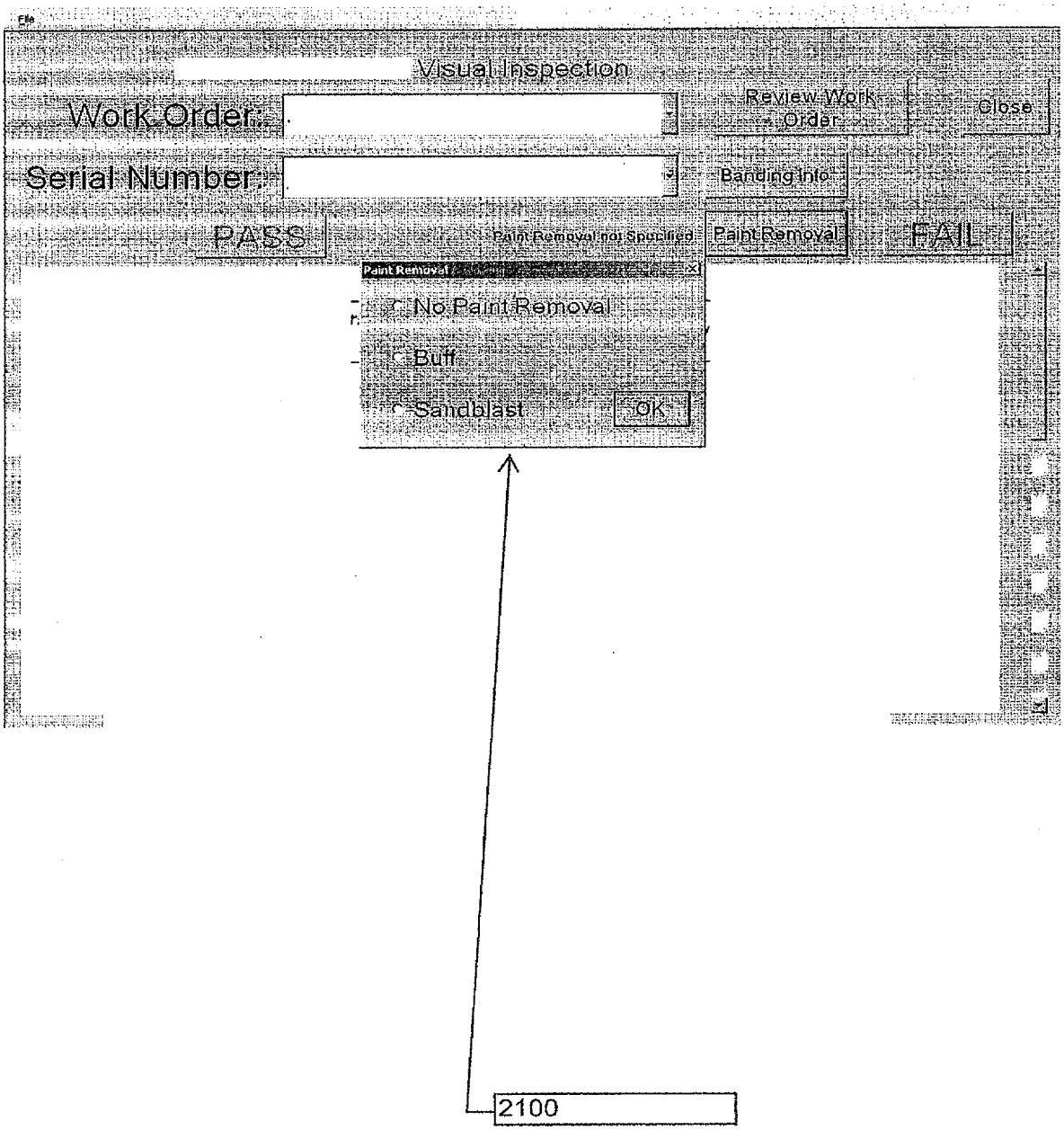

Visual Inspection
Work Order:
Review Work Order
Close
Serial Number:
Banding Info
PASS
Paint Removal not Specified
Paint Removal
FAIL
No Paint Removal
Buff
Sandblast
OK
2100

FIG. 21

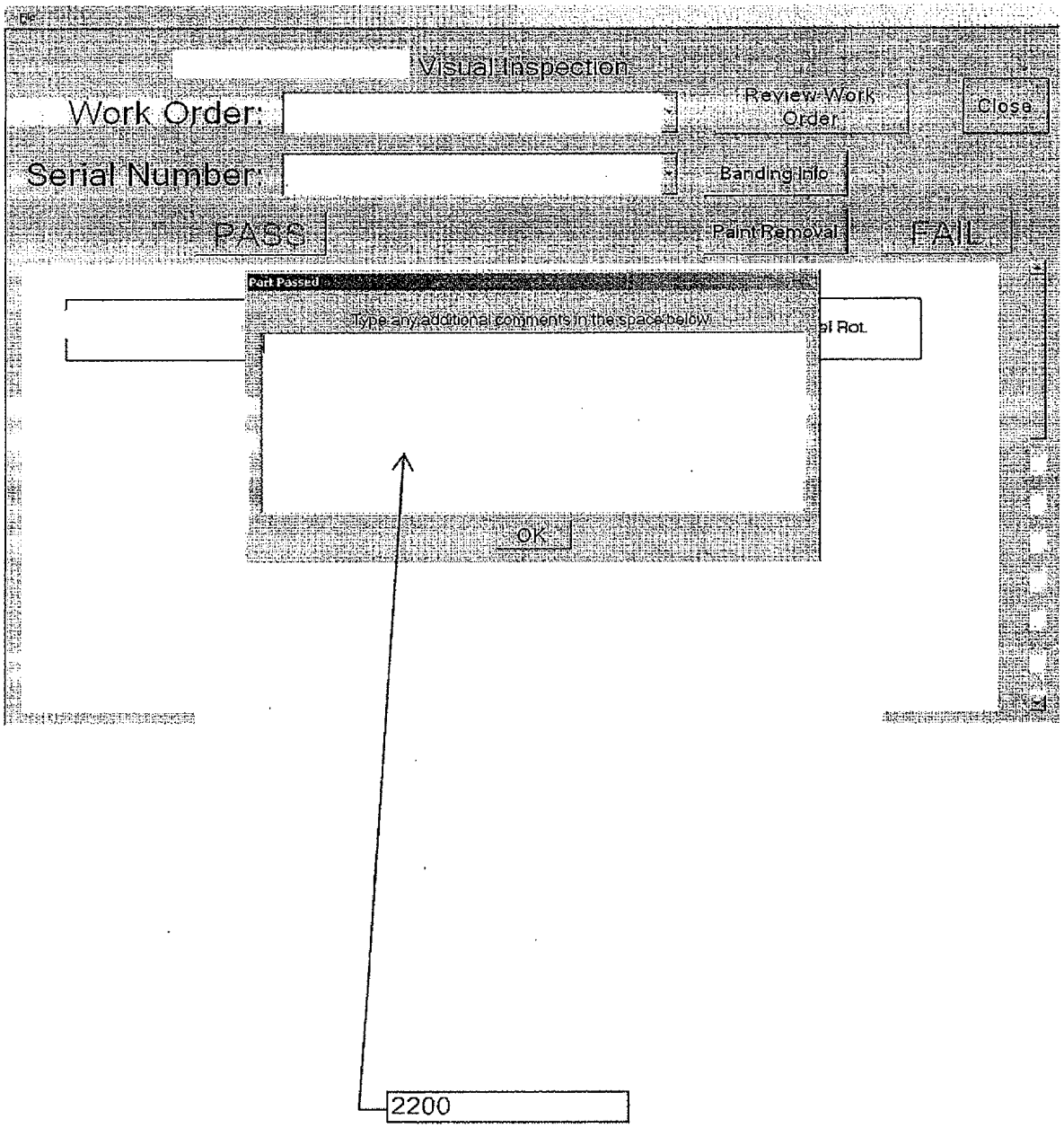

Visual Inspection
Work Order:
Review Work Order
Close
Serial Number
Banding Info
PASS
Paint Removal
FAIL
Part Passed
Type any additional comments in the space below
OK
2200

FIG. 22

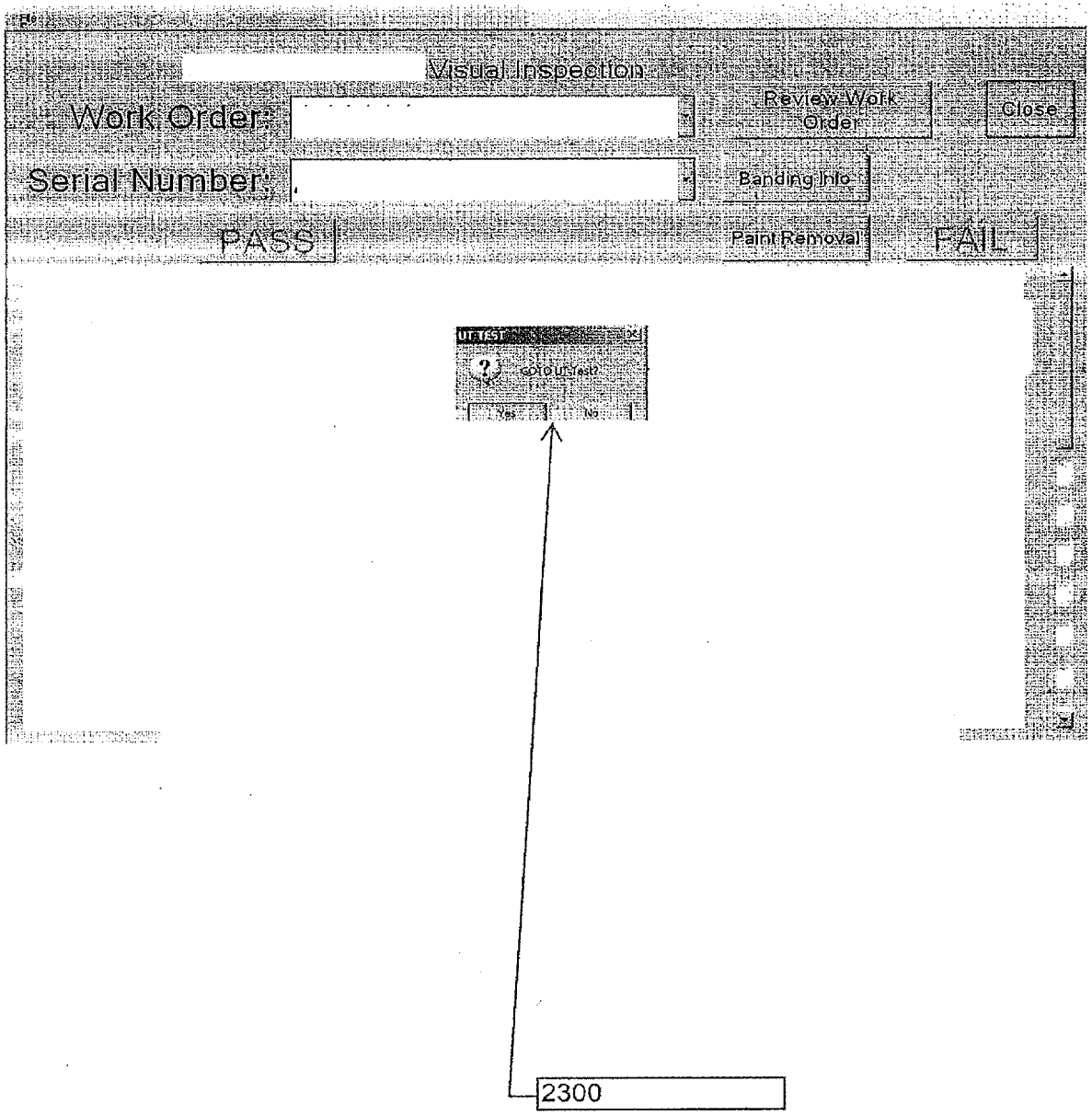

Visual Inspection
Work Order:
Review Work Order
Close
Serial Number:
Banding Info
PASS
Paint Removal
FAIL
2300

FIG. 23

Service Center Service History

Date:	02/24/2010	Customer:	
Location:		Group ID / Unit #:	
Description:	5 piece Rental	Quantity:	6
Inspection:	Rental	Start Date:	02/24/2010
		Finish Date:	
Wo / Sro #:		Approved By:	

Specifications to be followed: SERVICE COMPANY

Product Description

Cust P/N:	100011214	Cust S/N:	TEST003	Size:	1.5"
Mfr P/N:		Mfr S/N:		Style:	DART
				Connections:	UNION CONNECTIONS
Mfr:		Product Type:	CHECK VALVE	Configuration:	F X M

Svc:	
Pressure Rating:	15,000.00
Test Pressure:	15,000.00
Test Duration:	min

Inspections Performed

	Pass/Fail	Inspector	Date
Visual:			
UT Wall Thickness:			
Disembly/Asmbly:	N/A		
Magnetic Particle:	N/A		
Pressure:			
Paint:			
Final:			

Gauges Used

	Serial Number		Serial Number
Calipes:		No Go Gauge Kit:	
UT Meter:			
MPI Equip:			
Pres Gauge:		Pres Recordar:	

Wall Thickness Information

Inspection Point:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
New Wall Thickness (if reqd):	1.01	0.64	1.19	0.47											
Min Allowable Wall Thick (Spec:	0.72	0.60	1.05	0.33											
Actual Measurement:															

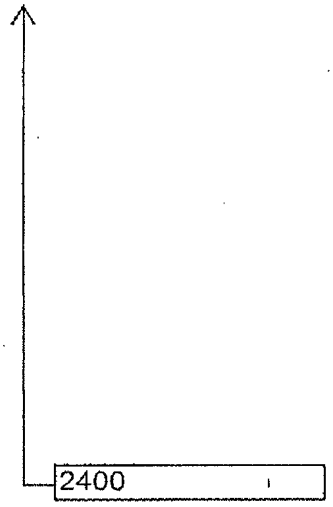


FIG. 24

Iron Inventory

Date: 02/24/2010
Location:
Description: 5 piece Rental
Inspection: Rental
WO / SRO #:

Customer:
Group ID / Unit #:
Quantity: 6
Start Date: 02/24/2010
Finish Date:
Approved By:

Specifications to be followed: SERVICE COMPANY

Serial Number	Part Number	Status	Description
		Visual Inspection (PENDING)	1.5 X 1.5-1502 DART STYLE CHECK VALVE UNION CONNECTIONS
		Visual Inspection (PENDING)	PPG ASSY/2-1502 PS 240.00
		Wall Thickness (PENDING)	SWVL ASSY/STL 10 MXF/INT/2 LR15
		Wall Thickness (PENDING)	SWVL ASSY/STL 50 MXF/INT/2 LR15
		Wall Thickness (PENDING)	SWVL ASSY/STL 50 MXF/INT/2 LR15

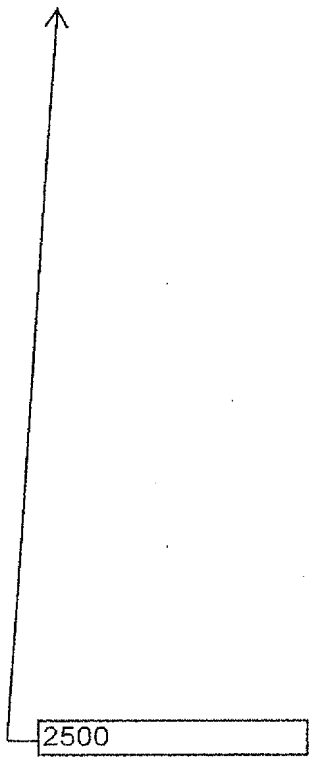
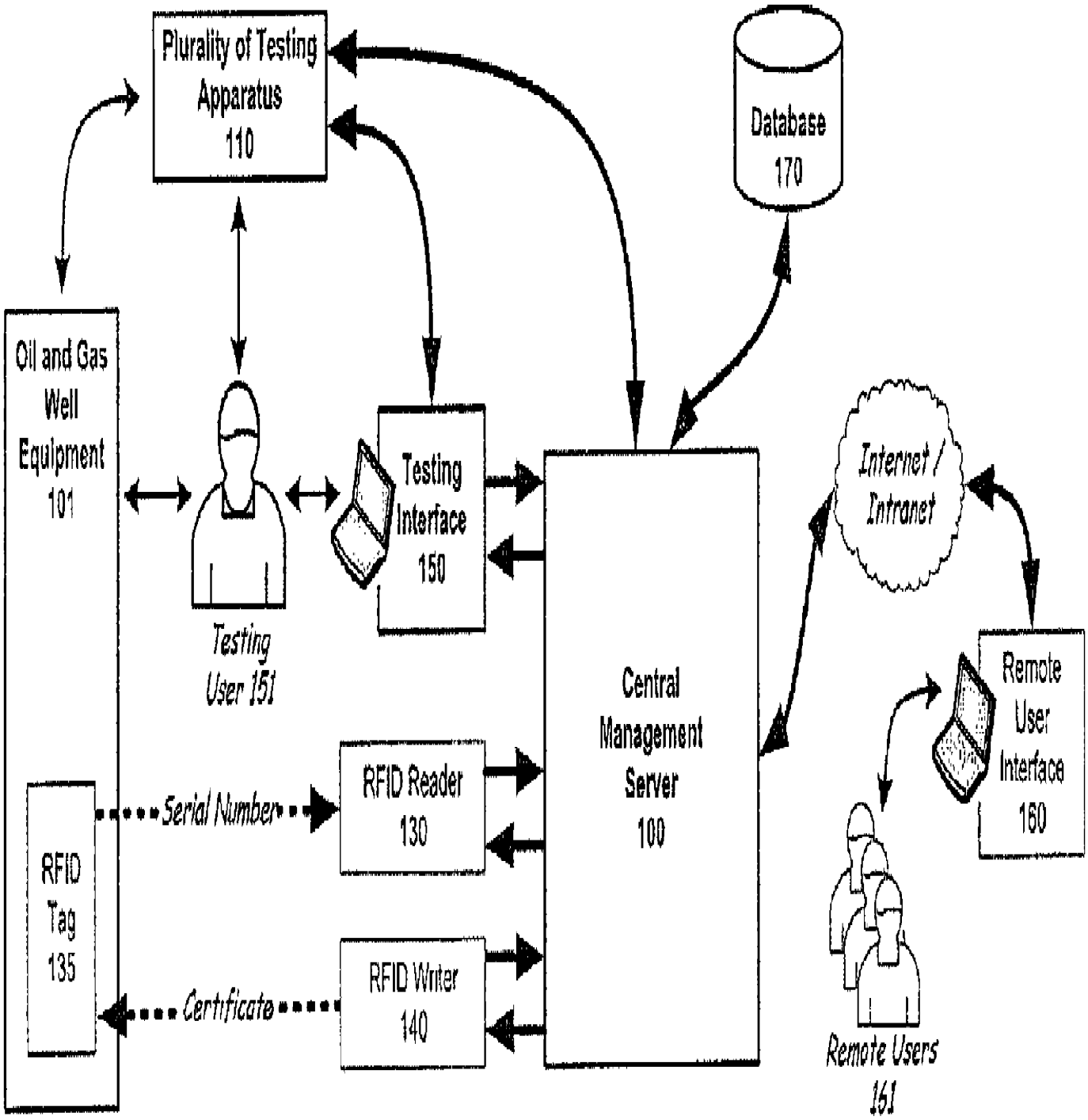


FIG. 25


Plurality of Testing Apparatus 110
Database 170
Oil and Gas Well Equipment 101
Testing User 151
Testing Interface 150
Internet / Intranet
Central Management Server 100
Remote User Interface 160
RFID Tag 135
Serial Number
RFID Reader 130
RFID Writer 140
Certificate
Remote Users 151

Electronic Patent Application Fee Transmittal

Application Number:	16170695
Filing Date:	25-Oct-2018
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Filer:	Taylor P. Evans/Stephanie McDonough
Attorney Docket Number:	047158.100032

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt

EFS ID:	38416948
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Taylor P. Evans/Stephanie McDonough
Filer Authorized By:	Taylor P. Evans
Attorney Docket Number:	047158.100032
Receipt Date:	28-JAN-2020
Filing Date:	25-OCT-2018
Time Stamp:	12:05:47
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$240
RAM confirmation Number	E20201RC06139541
Deposit Account	501349
Authorized User	Stephanie McDonough

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	100032_IDS.pdf	1036643 a30c1bf52efca83f778c376aee564cd52d09eff8	no	11
Warnings:					
Information:					
2	Other Reference-Patent/App/Search documents	100046_NOA_1-9-2020.pdf	496865 de0736297cae156177c77132fe7a4f3153298155	no	9
Warnings:					
Information:					
3	Other Reference-Patent/App/Search documents	100047_NFOA_12-23-2019.pdf	504947 e48ecf709c4a1a3c54beca9de2f5cd8a257472b9	no	15
Warnings:					
Information:					
4	Other Reference-Patent/App/Search documents	100048_NFOA_1-10-2020.pdf	426422 697dd19f949f67bf61f892dcc172c3fc0c122e87	no	12
Warnings:					
Information:					
5	Other Reference-Patent/App/Search documents	100063_NFOA_12-6-2019.pdf	339700 970ada9ad386e6440793e1bb058678705e9985d1	no	10
Warnings:					
Information:					
6	Other Reference-Patent/App/Search documents	500046_ISR_11-26-2019.pdf	608590 fb9dc546f5843b3b12fa57939cc323e9fe5c88b1	no	11
Warnings:					
Information:					

7	Other Reference-Patent/App/Search documents	500048_ISR_1-2-2020.pdf	524345 d35cf9b97e618ea680c0150c167ae602c642374d	no	10
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8	Foreign Reference	CA2406801A1.pdf	7016934 20376d882373813a07b3495cf6cb7a954b5797bd	no	101
Warnings:					
Information:					
9	Foreign Reference	CA2482943A1.pdf	777005 dbb2976ac9fa8c3d06e6225252a248b7137e2ef9	no	12
Warnings:					
Information:					
10	Foreign Reference	CA2787814A1.pdf	2377245 633856df9c7e206d9c3773a8089aeb0e232468ab	no	33
Warnings:					
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Information:					
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Warnings:					
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Information:					
12	Foreign Reference	CA2849825A1.pdf	4548042 01fa8220acd32ddbeed2ebc3c29dd806d3addd96	no	48
Warnings:					
Information:					

13	Foreign Reference	CA2919649A1.pdf	10972314 d7007d5c10a3302315126fb758a39e12b0d9593b	no	131
Warnings:					
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Warnings:					
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Information:					
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Warnings:					
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Information:					
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Warnings:					
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Warnings:					
Information:					
18	Foreign Reference	CA3000322A1.pdf	3896522 3de54d3f5d2150e39ee81997cfd6345668f53c30	no	43
Warnings:					
Information:					

19	Foreign Reference	CA3006422A1.pdf	2774965 c6790510cdf308569b86d578ee8c33770f732bc3	no	42
Warnings:					
Information:					
20	Foreign Reference	CA3018485A1.pdf	1431864 b669a867cfad80a69349757b8af3dd5580e3c968	no	23
Warnings:					
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Information:					
21	Foreign Reference	CA3050131A1.pdf	6745417 f043d57fdfbbd89327b5b5f69829436325860d11	no	68
Warnings:					
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Information:					
22	Fee Worksheet (SB06)	fee-info.pdf	30616 f3a9e9f7bf75db5a1465395f3dc2a1a01ae261f5	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	70070857		

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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United States Patent and Trademark Office
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NOTICE OF ALLOWANCE AND FEE(S) DUE

132858 7590 01/13/2020

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

EXAMINER
GAY, JENNIFER HAWKINS

ART UNIT	PAPER NUMBER
3676	

DATE MAILED: 01/13/2020

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

TITLE OF INVENTION: SMART FRACTURING SYSTEM AND METHOD

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	04/13/2020

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

LIBERTY EXHIBIT 1002, Page 912

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

132858 7590 01/13/2020

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

TITLE OF INVENTION: SMART FRACTURING SYSTEM AND METHOD

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$1000	$0.00	$0.00	$1000	04/13/2020

EXAMINER	ART UNIT	CLASS-SUBCLASS
GAY, JENNIFER HAWKINS	3676	166-250010

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

132858 7590 01/13/2020

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

EXAMINER	
GAY, JENNIFER HAWKINS	
ART UNIT	**PAPER NUMBER**
3676	

DATE MAILED: 01/13/2020

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

LIBERTY EXHIBIT 1002, Page 914

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 16/170,695	Applicant(s) Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to Applicant's Reply of 12/12/19.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-7 and 9-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information , please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/JENNIFER H GAY/
Primary Examiner, Art Unit 3676

EXAMINER'S COMMENT

1. This Allowance is in response to Applicant's Reply of December 12, 2019. Claims 8 and 21 have been cancelled.

2. Applicant's amendment to claim 14 overcomes the previously presented 35 USC 112(b) rejection thereof.

3. Claims 1-7 and 9-20 are allowed.

Reasons for Allowance

4. The following is an examiner's statement of reasons for allowance:

The claims remain allowable for the reasons set forth in the previous Office Action.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JENNIFER H GAY whose telephone number is (571)272-7029.

The examiner can normally be reached on Monday through Thursday, 6-3:30 and every other Friday 6-11.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Waseem Moorad can be reached on 571-270-3436. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JENNIFER H GAY/
Primary Examiner, Art Unit 3676

JHG
12/18/19

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	**Art Unit**
	JENNIFER H GAY	3676

CPC							
Symbol						**Type**	**Version**
E21B	/	41	/	0092		F	2013-01-01
E21B	/	43	/	26		I	2013-01-01

CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
	/		/					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	19	
/JENNIFER H GAY/ Primary Examiner, Art Unit 3676	18 December 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	13	6

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	**Art Unit**
	JENNIFER H GAY	3676

INTERNATIONAL CLASSIFICATION					
CLAIMED					
E21B41/00	/	41	/	00	
E21B43/26	/	43	/	26	

NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	**SUBCLASS**

CROSS REFERENCES(S)						
CLASS	**SUBCLASS (ONE SUBCLASS PER BLOCK)**					

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/JENNIFER H GAY/ Primary Examiner, Art Unit 3676	18 December 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	13	6

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	**Art Unit**
	JENNIFER H GAY	3676

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIMS

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	9	10	18	19										
2	2	10	11	19	20										
3	3	11	12		21										
4	4	12	13												
5	5	13	14												
6	6	14	15												
7	7	15	16												
	8	16	17												
8	9	17	18												

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	19	
/JENNIFER H GAY/ Primary Examiner, Art Unit 3676	18 December 2019	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	13	6

U.S. Patent and Trademark Office

Part of Paper No.: 20191218

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	Art Unit
	JENNIFER H GAY	3676

CPC - Searched*		
Symbol	**Date**	**Examiner**
E21B 21/062, 43/26,267, 44/00	02/07/2019	JHG
updated	09/18/2019	JHG
updated	12/18/2019	JHG

CPC Combination Sets - Searched*		
Symbol	**Date**	**Examiner**

US Classification - Searched*			
Class	**Subclass**	**Date**	**Examiner**

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	**Date**	**Examiner**
E21B 21/062, 43/26,267, 44/00 - text search only	02/07/2019	JHG
Consulted 16/160708, 15/145414, 15/291842, 13/631492	02/07/2019	JHG
EAST text search	02/07/2019	JHG
Backward/forward search	02/07/2019	JHG
EAST text search	06/03/2019	JHG
EAST text search	09/18/2019	JHG
EAST text search	12/18/2019	JHG

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	Art Unit
	JENNIFER H GAY	3676

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Interference Search	12/18/2019	JHG

LIBERTY EXHIBIT 1002, Page 928

Bibliographic Data

Application No: 16/170,695

Foreign Priority claimed: ○ Yes ◉ No

35 USC 119 (a-d) conditions met: ☐ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged: /JENNIFER H GAY/ Examiner's Signature | Initials

Title: SMART FRACTURING SYSTEM AND METHOD

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/25/2018	166	3676	047158.100032
RULE			

APPLICANTS

U.S. Well Services, LLC, Houston, TX, UNITED STATES

INVENTORS

Jared Oehring Houston, TX, UNITED STATES

Alexander James Christinzio Morgantown, WV, UNITED STATES

Brandon N. Hinderliter Houston, TX, UNITED STATES

CONTINUING DATA

This application has PRO of 62577056 10/25/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

11/15/2018

STATE OR COUNTRY

UNITED STATES

ADDRESS

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002
UNITED STATES

FILING FEE RECEIVED

$5,860

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2366	e21b21/062.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L2	27953	e21b43/26,267.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L3	10989	e21b44/00.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L4	40348	L1 or L2 or L3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L5	1046	L4 and (@PD>"20190918")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L6	1706	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and instruction$3 and (pump with (control$4 adjust$4 off))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L7	445	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and (instruction$3 same (pump with (control$4 adjus$4 off)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L8	43	e21b$.cpc. and (frac$3 fractur$3) and	US-PGPUB;	OR	ON	2019/12/18

		(processor computer controller) and (instruction$3 same (wellhead with (control$4 adjus$4 off)))	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			10:14
L9	579	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and (instruction$3 same ((valve motor engine transmission suction discharge temperature) with (control$4 adjus$4 off)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L10	76	(L6 or L7 or L8 or L9) and (@PD>"20190918")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/12/18 10:14
L12	22	("10008880" | "20030056514" | "20040167738" | "20080264625" | "20100038907" | "20100045109" | "20140060658" | "20140255214" | "20150027712" | "20160290563" | "20170159570" | "20190063309" | "20190162061" | "20190169971" | "20190178235" | "20190211661" | "20190245348" | "5172009" | "5755096" | "6484490" | "7581379" | "8616005").PN.	US-PGPUB; USPAT	OR	ON	2019/12/18 10:32

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L11	327	(frac$3 fractur$3) and (processor computer controller) and (instruction$3 same (pump with (control$4 adjus$4 off)))	USPAT	OR	ON	2019/12/18 10:29

12/18/2019 10:38:17 AM
C:\Users\jgay\Documents\EAST\Workspaces\16\1\16170695.wsp

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5172009		1992-12-15	Mohan	
	2	6484490		2002-11-26	Olsen	
	3	7581379		2009-09-01	Yoshida	
	4	8616005		2013-12-31	Cousino	
	5	10008880		2018-06-26	Vicknair	
	6	5755096		1998-05-26	Holleyman	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

LIBERTY EXHIBIT 1002, Page 927

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	1	20100045109		2010-02-25	Arnold	
	2	20030056514		2003-03-27	Lohn	
	3	20080264625		2008-10-30	Ochoa	
	4	20140060658		2014-03-06	Hains	
	5	20150027712		2015-01-29	Vicknair	
	6	20160290563		2016-10-06	Diggins	
	7	20170159570		2017-06-08	Bickert	
	8	20140255214		2014-09-11	Burnette	
	9	20190245348		2019-08-08	Hinderliter	
	10	20190211661		2019-07-11	Reckels	
	11	20190169971		2019-06-06	Oehring	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.W.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	12	20100038907		2010-02-18	Hunt	
	13	20190162061		2019-05-30	Stephenson	
	14	20190178235		2019-06-13	Coskrey	
	15	20190063309		2019-02-28	Davis	
	16	20040167738		2004-08-26	Miller	

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion mailed September 11, 2019 in related PCT Application No. PCT/US2019/037493	X

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.W.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	2	Office Action mailed August 19, 2019 in related U.S. Patent Application No. 15/356,436	☒
	3	Office Action mailed October 2, 2019 in related U.S. Patent Application No. 16/152,732	☒
	4	Office Action mailed September 11, 2019 in related U.S. Patent Application No. 16/268,030	☒
	5	Office Action mailed October 11, 2019 in related U.S. Patent Application No. 16/385,070	☒
	6	Office Action mailed September 3, 2019 in related U.S. Patent Application No. 15/994,772	☒
	7	Office Action mailed September 20, 2019 in related U.S. Patent Application No. 16/443,273	☒
	8	Canadian Office Action mailed October 1, 2019 in related Canadian Patent Application No. 2,936,997	☒

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EXAMINER SIGNATURE

Examiner Signature	/JENNIFER H GAY/	Date Considered	12/18/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Taylor P. Evans/	Date (YYYY-MM-DD)	2019-10-21
Name/Print	Taylor P. Evans	Registration Number	60506

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:		§	
		§	
Jared Oehring		§	
		§	Attorney Docket No.: 047158.100032
		§	
Serial No.:	16/170,695	§	Confirmation No.: 6906
		§	
Filed:	10/25/2018	§	Art Unit: 3676
		§	
For:	SMART FRACTURING SYSTEM AND METHOD	§	Examiner: Gay, Jennifer Hawkins

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

AMENDMENT

Dear Sir:

In response to the Non-Final Office Action mailed September 25, 2019, Applicants hereby request reconsideration of the above-referenced application for patent, and reconsideration of the rejections in view of the amendments and the following arguments. If any additional fees are necessary for continued prosecution of this Application, the commissioner is hereby authorized to charge those fees to **Hogan Lovells US LLP's Deposit Account Number 501349**.

Amendments to the Claims are reflected in the listing of claims that begin on page 2 of this paper.

Remarks/Arguments begin on page 8 of this paper.

Electronic Acknowledgement Receipt

EFS ID:	38017988
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Taylor P. Evans/Stephanie McDonough
Filer Authorized By:	Taylor P. Evans
Attorney Docket Number:	047158.100032
Receipt Date:	12-DEC-2019
Filing Date:	25-OCT-2018
Time Stamp:	19:11:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		047158-100032_Response.pdf	46154 35753cf01919221b726d1ee245ec6db07dcfaf28	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Applicant Arguments/Remarks Made in an Amendment	8	10
	Claims	2	7
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Warnings:			
Information:			
	Total Files Size (in bytes):	46154	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

REMARKS/ARGUMENTS

This amendment is in response to the Non-Final Office Action mailed September 25, 2019. Claims 1-7 and 9-20 are pending in the application. Claim 14 has been amended. No new matter has been introduced in the amendments.

In the Office Action, the Examiner indicated that claims 1-7 and 9-13 are allowed, and claims 14-20 would be allowable if rewritten to overcome the rejection under 35 U.S.C 112(b) set forth in the Office Action. Applicants thank the Examiner for the allowed claims and the indicated allowable subject matter.

The Examiner rejected claims 14-20 under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

I. Allowable Subject Matter

The Examiner indicated that claims 1-7 and 9-13 are allowed, and claims 14-20 would be allowable if rewritten to overcome the rejection under 35 U.S.C 112(b) set forth in the Office Action. Applicants thank the Examiner for the allowed claims and the indicated allowable subject matter.

II. Claims 14-20 are compliant with 35 U.S.C. 112(b).

The Examiner rejected claims 14-20 under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the

invention. Specifically, Claim 14 is rejected due to an antecedent issue in the language "the automated instructions".

Claim 14 has been amended to overcome the 35 U.S.C. 112(b) issues set forth on page 3 of the office action. Applicants submit that claims 14-20 are now in condition for allowance as indicated in the office action.

III. Dependent Claims

Finally, Applicants respectfully submit that dependent claims 2-6, 9-13, and 15-20 are patentable by virtue of their dependence from one or more of claims 1, 7, and 14, as well as for other patentable features recited therein.

CONCLUSION

The foregoing response is full, complete, and timely filed. Amendments to the claims are made without prejudice, including under the doctrine of equivalents. In addition, the comments made herein are without prejudice. Applicants respectfully request reconsideration of the instant application in light of the foregoing response and amendments. Should the Examiner have any questions, comments or suggestions in furtherance of the prosecution of the application, the Examiner is invited to contact the Applicants' representative by telephone or fax.

Respectfully submitted,

Date: December 12, 2019

/Sharon Du/
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Facsimile: (713) 632-1401
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Patent Agent for Applicants

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Previously Presented) A hydraulic fracturing system, comprising:

a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;

a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and

a control system comprising:

a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;

one or more processing devices configured to receive a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and detect that the first parameter is outside of an acceptable threshold; and generate automated control instructions at the second device based at least in part on the first parameter; and

one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device based on the control instructions.

2. (Previously Presented) The system of claim 1, wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and selected from a group including flow sensors, accelerometers, pressure transducer, and tachometers.

3. (Previously Presented) The system of claim 1, wherein the plurality of pumps or the distribution system includes at least one device selected from a group include a gate, valve, actuator, motor, suction pipe, discharge pipe, engine, transmission, and temperature regulation device, controllable via the one or more control devices.

4. (Original) The system of claim 1, further comprising:

a suction line through which fracturing fluid is supplied; and

a discharge line through which fracturing fluid is discharged, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line.

5. (Previously Presented) The system of claim 1, further comprising:

one or more blenders configured to mix together one or more materials to form the fracturing fluid, wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold, wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow conditions at the one or more blenders, the manifold, the plurality of pumps, or the distribution system.

6. (Original) The system of claim 5, wherein the one or more control device is configured to control the one or more blenders, the manifold, the plurality of pumps and the distribution system based on the flow and/or pressure conditions.

7. (Previously Presented) A hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps;

pumping the fracturing fluid into a distribution system;

injecting the fracturing fluid into a wellhead;

measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;

generating automated instructions for one or more control devices based at least in part on the one or more parameters;

automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions.

transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

generating the automated instructions at the second device based at least in part on the first parameter; and

automatically adjusting one or more functions of the second device based on the automated instructions.

8. (Canceled)

9. (Previously Presented) The method of claim 7, further comprising:

detecting that a first pump of the plurality of pumps is underperforming; and

adjusting one or more of the pumps in the plurality of pumps to compensate for the first pump.

10. (Original) The method of claim 9, further comprising:

selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters.

11. (Original) The method of claim 7, further comprising:

determining that the one or more parameters are indicative of a potential failure condition; and

determining a source of the potential failure condition.

12. (Original) The method of claim 11, further comprising:

generating an alert or notification indicative of the potential failure condition and the source.

13. (Original) The method of claim 7, further comprising:

logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and

determining a maintenance schedule based at least in part on the operation data.

14. (Currently Amended) A hydraulic fracturing method, comprising:

performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;

measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;

transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

detecting that the first parameter is outside of an acceptable threshold;

generating [[the]] automated instructions at the second device based at least in part on the first parameter; and

automatically adjusting one or more functions of the second device based on the automated instructions.

15. (Previously Presented) The method of claim 14, wherein

the distribution system receives and consolidates the fracturing fluid from the plurality of pumps for injection into a wellhead.

16. (Previously Presented) The method of claim 15, further comprising:

controlling one or more functions of the distribution system based on the automated instructions.

17. (Previously Presented) The method of claim 14, wherein the first parameter includes measurements of one or more of the plurality of pumps.

18. (Original) The method of claim 17, further comprising:

controlling one or more of the plurality of pumps individually based on the automated instructions.

19. (Original) The method of claim 18, further comprising:

detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold; and

automatically taking the first pump offline in response to the detection.

20. (Original) The method of claim 19, further comprising:

adjusting one or more of the other pumps in the plurality of pumps to compensate for taking the first pump offline.

21. (Canceled)

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/170,695	Filing Date	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 = *			x $80 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 = *			x $420 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT 12/12/19	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 19	Minus	** 20	= ——		x $0 =	
Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= ——		x $0 =	
☐ Application Size Fee (37 CFR 1.16(s))							
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
						TOTAL ADD'L FEE	

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
☐ Application Size Fee (37 CFR 1.16(s))							
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/Kreighton D. Lambert Sr./
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	5172009		1992-12-15	Mohan	
	2	6484490		2002-11-26	Olsen	
	3	7581379		2009-09-01	Yoshida	
	4	8616005		2013-12-31	Cousino	
	5	10008880		2018-06-26	Vicknair	
	6	5755096		1998-05-26	Holleyman	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
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	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	1	20100045109		2010-02-25	Arnold	
	2	20030056514		2003-03-27	Lohn	
	3	20080264625		2008-10-30	Ochoa	
	4	20140060658		2014-03-06	Hains	
	5	20150027712		2015-01-29	Vicknair	
	6	20160290563		2016-10-06	Diggins	
	7	20170159570		2017-06-08	Bickert	
	8	20140255214		2014-09-11	Burnette	
	9	20190245348		2019-08-08	Hinderliter	
	10	20190211661		2019-07-11	Reckels	
	11	20190169971		2019-06-06	Oehring	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
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	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	12	20100038907		2010-02-18	Hunt	
	13	20190162061		2019-05-30	Stephenson	
	14	20190178235		2019-06-13	Coskrey	
	15	20190063309		2019-02-28	Davis	
	16	20040167738		2004-08-26	Miller	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion mailed September 11, 2019 in related PCT Application No. PCT/US2019/037493	X

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	2	Office Action mailed August 19, 2019 in related U.S. Patent Application No. 15/356,436	☒
	3	Office Action mailed October 2, 2019 in related U.S. Patent Application No. 16/152,732	☒
	4	Office Action mailed September 11, 2019 in related U.S. Patent Application No. 16/268,030	☒
	5	Office Action mailed October 11, 2019 in related U.S. Patent Application No. 16/385,070	☒
	6	Office Action mailed September 3, 2019 in related U.S. Patent Application No. 15/994,772	☒
	7	Office Action mailed September 20, 2019 in related U.S. Patent Application No. 16/443,273	☒
	8	Canadian Office Action mailed October 1, 2019 in related Canadian Patent Application No. 2,936,997	☒

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Taylor P. Evans/	Date (YYYY-MM-DD)	2019-10-21
Name/Print	Taylor P. Evans	Registration Number	60506

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 11 SEP 2019
Applicant's or agent's file reference 047158.500042	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US2019/037493	International filing date *(day/month/year)* 17 June 2019
Applicant U.S. WELL SERVICES, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest against payment of (an) additional fee(s) under Rule 40.2,** the applicant is notified that:
   - ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   - ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

   Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within 22 months from the priority date, the applicant may request that a supplementary international search be carried out by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 047158.500042	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2019/037493	International filing date *(day/month/year)* 17 June 2019	(Earliest) Priority Date *(day/month/year)* 15 June 2018
Applicant U.S. WELL SERVICES, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 9 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the language, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the title,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

   a. the figure of the drawings to be published with the abstract is Figure No. 1

   ☐ as suggested by the applicant.

   ☒ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/037493

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.01)
CPC - E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 166/308.1; 166/244.1; 166/305.1 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/0156210 A1 (US WELL SERVICES, LLC) 07 June 2018 (07.06.2018) entire document	1-4, 9, 10, 12
---		---
Y		5-8, 13-15
Y	US 2017/0222409 A1 (US WELL SERVICES LLC) 03 August 2017 (03.08.2017) entire document	5, 7, 13, 14
Y	US 2010/0045109 A1 (ARNOLD) 25 February 2010 (25.02.2010) entire document	8, 15
A	US 5,172,009 A (MOHAN) 15 December 1992 (15.12.1992) entire document	1-15

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 2019	11 SEP 2019
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	11 SEP 2019
Applicant's or agent's file reference 047158.500042	FOR FURTHER ACTION See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2019/037493	17 June 2019	15 June 2018

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.01)
CPC - E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.08)

Applicant U.S. WELL SERVICES, INC.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	26 August 2019	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (January 2015)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/037493

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/037493

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	5-8, 11, 13-15	YES
	Claims	1-4, 9, 10, 12	NO
Inventive step (IS)	Claims	5, 11	YES
	Claims	1-4, 6-10, 12-15	NO
Industrial applicability (IA)	Claims	1-15	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-4, 9, 10, and 12 lack novelty under PCT Article 33(2) as being anticipated by U.S. Well Services, LLC (hereinafter USWell).

Regarding Claim 1, USWell discloses a system comprising: a mobile unit (power distribution system... the turbine generator 52 may be mounted on the trailer 58 [mobile unit] within a housing 60 mounted on the trailer, para 0028); at least one generator (the turbine generator 52, para 0028); and at least one switch gear (the switch gear 64 is mounted on a trailer 58 and includes the housing 60, para 0029), the at least one generator coupled to the at least one switch gear on the mobile unit (Power cables 62 from the turbines 52 can be connected to the switch gear 64 on a side, para 0029), the mobile unit configured to provide power generated by the at least one generator in electrical buses for at least one load on one or more external mobile units (direct power transmission from the switch gear units 64 to the equipment, such as the auxiliary unit 66 and the pumps 74, para 0039; The embodiment illustrated in FIG. 2 further includes an auxiliary unit 66, which in the illustrated embodiments is mounted on a trailer 58...The hydraulic fracturing pumps may be on a single common trailer, or broken up with various associated equipment on different trailers [all loads on external mobile units/trailers], para 0030; also see Fig. 4).

Regarding Claim 2, USWell discloses the system of claim 1, further comprising: at least one fracturing pump (FP) mobile unit of the one or more external mobile units, the at least one FP mobile unit physically external relative to the mobile unit (The hydraulic fracturing pumps may be on a single common trailer, or broken up with various associated equipment on different trailers [external mobile units], para 0030; also see Fig. 4); and at least one transformer provided between the at least one FP mobile unit and the at least one switch gear to condition the power supplied to the at least one FP mobile unit (the transformer 70... may be used to condition power for auxiliary equipment. For example, the transformer 70 may be a 3500 kVA transformer that converts three AC 13.8 kV electricity to three phase AC 600 V electricity. Cable connections may be arranged along the transformer 70 receive power output from the generators 52, the switch gear 64, or a combination thereof... transformer 70 may be advantageous to supply power to secondary equipment, para 0032).

Regarding Claim 3, USWell discloses the system of claim 1, further comprising: a predetermined number of FP mobile unitscomprised in the one or more external mobile units, the predetermined number of FP mobile units determined by a maximum of the power available from the at least one generator and handled by the at least one switch gear (in the illustrated embodiment includes twin fracturing pumps 74. It should be appreciated that while the illustrated embodiment includes dual pumps 74, other embodiments may include one, three, four, five, or any reasonable number of fracturing pumps 74. In the illustrated embodiment, each pump 74 is capable of consuming up to 1.2 MW of electricity. Therefore, the illustrated twin fracturing pumps 74 can draw about 2.5 MW of electricity [total available power] under full load conditions, para 0031).

Regarding Claim 4, USWell discloses the system of claim 1, further comprising: a predetermined number of generators comprising the at least one generator, the predetermined number of generators having individual power output values that is lesser than a power output of an isolated single generator occupying all available space in an independent mobile unit physically external to the mobile unit (other embodiments may have any reasonable number of generators 52 and/or switch gear units 64, as well as other equipment, based on operating conditions at the well site. , para 0044; arious auxiliary trailers may be utilized to selected equipment at the well site and various configurations may be implemented to enable different designs and configurations to be utilized based on costs, space constraints, para 0030).

Regarding Claim 9, USWell discloses a method comprising: providing a mobile unit with at least one generator and at least one switchgear (the turbine generator 52 may be mounted on the trailer 58 [mobile unit] within a housing 60 mounted on the trailer, para 0028; the switch gear 64 is mounted on a trailer 58 and includes the housing 60, para 0029), the at least one generator coupled to the at least one switch gear on the mobile unit (Power cables 62 from the turbines 52 can be connected to the switch gear 64 on a side, para 0029); generating power from the at least one generator; providing the power in electrical buses for at least one load in one or more external mobile units (direct power transmission from the switch gear units 64 to the equipment, such as the auxiliary unit 66 and the pumps 74, para 0039; The embodiment illustrated in FIG. 2 further includes an auxiliary unit 66, which in the illustrated embodiments is mounted on a trailer 58...The hydraulic fracturing pumps may be on a single common trailer, or broken up with various associated equipment on different trailers [all loads on external mobile units/trailers], para 0030; also see Fig. 4).

LIBERTY EXHIBIT 1002, Page 957

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of

Regarding Claim 10, USWell discloses the method of claim 9, further comprising: providing at least one fracturing pump (FP) mobile unit of the one or more external mobile units that is physically external relative to the mobile unit (The hydraulic fracturing pumps may be on a single common trailer, or broken up with various associated equipment on different trailers [external mobile units], para 0030; also see Fig. 4); and conditioning the power supplied to the at least one FP mobile unit using at least one transformer provided between the at least one FP mobile unit and the at least one switch gear (the transformer 70... may be used to condition power for auxiliary equipment. For example, the transformer 70 may be a 3500 kVA transformer that converts three AC 13.8 kV electricity to three phase AC 600 V electricity. Cable connections may be arranged along the transformer 70 receive power output from the generators 52, the switch gear 64, or a combination thereof... transformer 70 may be advantageous to supply power to secondary equipment, para 0032).

Regarding Claim 12, USWell discloses the method of claim 9, further comprising: providing at least one Variable Frequency Drive (VFD); and providing at least one Motor Control Center (MCC), the VFD and the MCC being on individual ones of the one or more external mobile units that is physically external relative to the mobile unit (The VFD 68 may be referred to as a VFD house and may include an independent VFD for each pump coupled to the VFD and/or VFD house 68, para 0030; a variable frequency drive connected to the motor to control the speed of the motor, claim 6; also see Fig. 5 [separate trailers for each VFD]).

Claims 6, 7, 13, and 14 lack an inventive step under PCT Article 33(3) as being obvious over U.S. Well Services, LLC (hereinafter USWell) in view of US Well Services LLC (hereinafter USWell409).

Regarding Claim 6, USWell discloses the system of claim 1, further comprising: one or more power cable interconnects configured to couple the mobile unit with a second mobile unit of the one or more external mobile units, the second mobile unit having at least one second generator and at least one second switch gear (power and communications cables 62 can extend between associated equipment, such as switch gear units 64... one or more generators can be provided in each housing 60 and/or be mounted on each skid 56 and/or trailer 58, para 0028; also see Fig. 2). USWell fails to explicitly disclose the one or more power cable interconnects to transmit power in support of redundancy or load sharing between the mobile unit and the second mobile unit.
USWell409 is in the field of hydraulic fracturing (Abstract) and teaches the one or more power cable interconnects to transmit power in support of redundancy or load sharing between the mobile unit and the second mobile unit (the power transmission network is broken into two banks with direct communication between generator sets 805-a, 805-b and switchgear "B" 825-b-1 in the first bank 807-a, and generator sets 805-c, 805-d and switchgear "B" 825-b-2 in the second bank 807-b, para 0062; Splitting the microgrid into two banks 807-a, 807-b can build redundancy into the system. If a single generator set fails during peak power demand, any other generator set on the same circuit can share the load., para 0063). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of USWell409 for the purpose of building redundancy into the system, thus if a single generator set fails during peak power demand, any other generator set on the same circuit can share the load (see USWell409, para 0063).

Regarding Claim 7, USWell discloses the system of claim 1, further comprising an optional datavan in the one or more external mobile units for control of the at least one load sharing FP mobile unit, the optional datavan offering the control of the at least one load sharing FP mobile unit instead of a second control available from within the mobile unit (Controls for operating the electric hydraulic fracturing system may be provided in the housing 60 of the electric data van 76, as well as devices for monitoring conditions and operational parameters of components of the electric hydraulic fracturing system, para 0035). USWell fails to explicitly disclose at least one load sharing FP mobile unit coupled to share the at least one load of a second FP mobile unit of the one or more external mobile units.
USWell409 teaches at least one load sharing FP mobile unit coupled to share the at least one load of a second FP mobile unit of the one or more external mobile units (the power transmission network is broken into two banks with direct communication between generator sets 805-a, 805-b and switchgear "B" 825-b-1 in the first bank 807-a, and generator sets 805-c, 805-d and switchgear "B" 825-b-2 in the second bank 807-b, para 0062; Splitting the microgrid into two banks 807-a, 807-b can build redundancy into the system. If a single generator set fails during peak power demand, any other generator set on the same circuit can share the load., para 0063). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of USWell409 for the purpose of building redundancy into the system, thus if a single generator set fails during peak power demand, any other generator set on the same circuit can share the load (see USWell409, para 0063).

Regarding Claim 13, USWell discloses the method of claim 9, further comprising: coupling the mobile unit with a second mobile unit of the one or more external mobile units using one or more power cable interconnects, the second mobile unit having at least one second generator and at least one second switch gear (power and communications cables 62 can extend between associated equipment, such as switch gear units 64... one or more generators can be provided in each housing 60 and/or be mounted on each skid 56 and/or trailer 58, para 0028; also see Fig. 2). USWell fails to explicitly disclose the one or more power cable interconnects to transmit power in support of redundancy or load sharing between the mobile unit and the second mobile unit.
USWell409 teaches the one or more power cable interconnects to transmit power in support of redundancy or load sharing between the mobile unit and the second mobile unit (the power transmission network is broken into two banks with direct communication between generator sets 805-a, 805-b and switchgear "B" 825-b-1 in the first bank 807-a, and generator sets 805-c, 805-d and switchgear "B" 825-b-2 in the second bank 807-b, para 0062; Splitting the microgrid into two banks 807-a, 807-b can build redundancy into the system. If a single generator set fails during peak power demand, any other generator set on the same circuit can share the load., para 0063). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of USWell409 for the purpose of building redundancy into the system, thus if a single generator set fails during peak power demand, any other generator set on the same circuit can share the load (see USWell409, para 0063).

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding Claim 14, USWell discloses the method of claim 12, further comprising: controlling, via an optional datavan in the one or more external mobile units, the at least one FP mobile unit, the optional datavan offering the control of the at least one FP mobile unit instead of a second control (Controls for operating the electric hydraulic fracturing system may be provided in the housing 60 of the electric data van 76, as well as devices for monitoring conditions and operational parameters of components of the electric hydraulic fracturing system, para 0035)
USWell fails to explicitly disclose coupling at least one load sharing FP mobile unit to share the at least one load of a second FP mobile unit of the one or more external mobile units. USWell409 teaches coupling at least one load sharing FP mobile unit to share the at least one load of a second FP mobile unit of the one or more external mobile units (the power transmission network is broken into two banks with direct communication between generator sets 805-a, 805-b and switchgear "B" 825-b-1 in the first bank 807-a, and generator sets 805-c, 805-d and switchgear "B" 825-b-2 in the second bank 807-b, para 0062; Splitting the microgrid into two banks 807-a, 807-b can build redundancy into the system. If a single generator set fails during peak power demand, any other generator set on the same circuit can share the load., para 0063). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of USWell409 for the purpose of building redundancy into the system, thus if a single generator set fails during peak power demand, any other generator set on the same circuit can share the load (see USWell409, para 0063).

Claims 8 and 15 lack an inventive step under PCT Article 33(3) as being obvious over U.S. Well Services, LLC (hereinafter USWell) in view of Arnold.

Regarding Claim 8, USWell fails to disclose the system of claim 1, further comprising: an isolation transformer in one of the one or more external mobile units, the isolation transformer being physically external relative to the mobile unit and being configured for filtering harmonics between the at least one generator and the at least one load in the one or more external mobile units. Arnold is in the field of an AC power distribution unit (Abstract) and teaches an isolation transformer configured for filtering harmonics between the at least one generator and the at least one load (A power input feed 62 is coupled to an optional isolating transformer 63 connected to harmonic filter... isolating transformer 63 may attenuate noise energy propagating through the point-of-use unit and reduce the harmonic current distortion at the third harmonic frequency, para 0031). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of Arnold for the purpose of reducing malfunctions of sensitive electronics (see Arnold, para 0005).

Regarding Claim 15, USWell fails to disclose the method of claim 9, further comprising: filtering harmonics between the at least one generator and the at least one load in the one or more external mobile units using an isolation transformer that is in one of the one or more external mobile units, the isolation transformer being physically external relative to the mobile unit. Arnold teaches filtering harmonics between the at least one generator and the at least one load using an isolation transforme (A power input feed 62 is coupled to an optional isolating transformer 63 connected to harmonic filter... isolating transformer 63 may attenuate noise energy propagating through the point-of-use unit and reduce the harmonic current distortion at the third harmonic frequency, para 0031). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell with the teaching of Arnold for the purpose of reducing malfunctions of sensitive electronics (see Arnold, para 0005).

Claims 5 and 11 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest:

Regarding claim 5, the prior art of record, individually or in combination, does not teach or fairly suggest the system of claim 1, further comprising: the at least one switchgear being physically arranged to replace an electronic equipment room (EER) of at least one mobile unit of the one or more external mobile units that is designed to comprise the EER.

Regarding claim 11, the prior art of record, individually or in combination, does not teach or fairly suggest the method of claim 9, further comprising: physically arranging the at least one switch gear to replace an electronic equipment room (EER) of at least one mobile unit of the one or more external mobile units that is designed to comprise the EER.

Claims 1-15 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

Search History:

Limited Classification Search

The Patent Analyst performed a limited classification search within the following US, IPC, CPC, ECLA, or F-Term classification areas:

CPC Class/Subclass(es): E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.08)

IPC (8) Class/Subclass(es): E21B 43/26; E21B 41/00; E21B 43/00; E21B 44/00 (2019.01)

U.S. Class/Subclass(es): 166/308.1; 166/244.1; 166/305.1

See Global Search Results.

Global Patent Literature Text Search

The Patent Analyst performed the following global text search, which was not limited by classification but may or may not have been limited by other criteria:

Questel Orbit: https://www.orbit.com

#	Search query	Results
1	((WELL W SERVICE+)/PA/OPA)	390
2	((HINDERLITER 2D BRANDON)/IN/OIN/INH/INV)	30
3	2 AND BUSES/TX	0
4	2 AND BUS+/TX	20
5	2 AND (REPLAC+ S ROOM)/TX	0
6	2 AND (MOBILE W UNITS)/TX	0
7	..CITB NOSOURCE SS 2 6 RANKED	0
8	(US4100822)/XPN	1
9	(WO2019152981)/XPN	1
10	..CITB NOSOURCE SS 9 1 RANKED	0
11	..SIMILARITY SS 9 RANKED 1	29861
12	(US20160105022)/XPN	1
13	2 AND (GENERATOR+ AND SWITCHGEAR)/TX	16
14	2 AND (GENERATOR+ AND (SWITCH W GEAR))/TX	14
15	13 OR 14	20
16	(REPLAC+ S ELECTRONIC S EQUIPMENT S ROOM)/TI/AB/CLMS/TX	374
17	((REPLAC+ S ELECTRONIC S EQUIPMENT S ROOM) AND SWITCHGEAR)/TI/AB/CLMS/TX	9
18	2 AND EER/TX	13

19	(E21B-043/26)/CPC	5843
20	(E21B-043/26)/IPC	10299
21	(E21B-043/00)/IPC	21446
22	(E21B-043/00)/CPC	2949
23	(E21B-044/00)/CPC	2766
24	(E21B-044/00)/IPC	6407
25	(E21B-041/00)/IPC	8347
26	(E21B-041/00)/CPC	6311
27	19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26	45741
28	27 AND (GENERATOR+ AND (SWITCH W GEAR))/TX	28
29	27 AND (GENERATOR+ AND (SWITCHGEAR))/TX	47
30	166308100/PCL	1259
31	166305100/PCL	1955
32	166244100/PCL	247
33	30 OR 31 OR 32	3254
34	33 AND (GENERATOR+ AND (SWITCHGEAR))/TX	6
35	33 AND (FRACTUR+)/TX	2350
36	33 AND (FRACTUR+ AND MOBILE)/TX	336
37	33 AND (FRACTUR+ AND TRAILER+)/TX	92

Google Patents: https://patents.google.com

#	Search query	Results
1	INTEGRATED MOBILE POWER UNIT FOR HYDRAULIC FRACTURING	100+
2	integrated generator and switchgear for fracturing	100+
3	hydraulic fracturing mobile units switchgear generators	100+
4	generator and switchgear on a transport unit	100+
5	generator and switchgear on a transport unit hydraulic fractruing	100+

Computer Accessed Text Databases Searched

The Patent Analyst searched the following computer accessed text databases:

Google Scholar: https://scholar.google.com/

#	Search query	Results
1	INTEGRATED MOBILE POWER UNIT FOR HYDRAULIC FRACTURING	100+

2	integrated generator and switchgear for fracturing	100+
3	hydraulic fracturing mobile units switchgear generators	100+
4	generator and switchgear on a transport unit	100+
5	generator and switchgear on a transport unit hydraulic fractruing	100+

Date search was completed: 26 August 2019

SV/CC

Electronic Acknowledgement Receipt

EFS ID:	37507910
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Taylor P. Evans/Stephanie McDonough
Filer Authorized By:	Taylor P. Evans
Attorney Docket Number:	047158.100032
Receipt Date:	21-OCT-2019
Filing Date:	25-OCT-2018
Time Stamp:	10:55:25
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	047158-100032_IDS.pdf	1035413 e208fc2c97bdb31f2a90d04808d3ef289d450468	no	6

Warnings:

Information:					
2	Other Reference-Patent/App/Search documents	NPL1.pdf	551837 e36f52fe4cd688e3def60e909808fe7624d0cbdd	no	11
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
3	Other Reference-Patent/App/Search documents	NPL2.pdf	929065 47c20f5c953cbc4c306d3c1ddda1fc4da7219f89	no	22
Warnings:					
Information:					
4	Other Reference-Patent/App/Search documents	NPL3.pdf	474139 46bd3842f2368cd060a4dfa5893632e0a5eb82e3	no	11
Warnings:					
Information:					
5	Other Reference-Patent/App/Search documents	NPL4.pdf	625568 8b18fa91f4706c88d3310cc571f498303725f328	no	18
Warnings:					
Information:					
6	Other Reference-Patent/App/Search documents	NPL5.pdf	242800 128faf4ea2e2bb9488664202e967397494359c4a	no	7
Warnings:					
Information:					
7	Other Reference-Patent/App/Search documents	NPL6.pdf	302630 4a11bc3747e2a87768f2a4a696e19367efe5248b	no	9
Warnings:					
Information:					
8	Other Reference-Patent/App/Search documents	NPL7.pdf	527643 d1cdf6ca56f2195651a5db5164d13d2931c0984e	no	11
Warnings:					

Information:					
9	Other Reference-Patent/App/Search documents	NPL8.pdf	207755 dae0c06a8119ed9b687e6c7363ba3834e395c7b8	no	3
Warnings:					
Information:					
			Total Files Size (in bytes):	4896850	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

132858 7590 09/25/2019

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

EXAMINER	
GAY, JENNIFER HAWKINS	

ART UNIT	PAPER NUMBER
3676	

NOTIFICATION DATE	DELIVERY MODE
09/25/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

hlusdocketing@hoganlovells.com
monica.williams@hoganlovells.com
stephanie.mcdonough@hoganlovells.com

Office Action Summary	Application No. 16/170,695	Applicant(s) Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 26 August 2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-7 and 9-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☑ Claim(s) 1-7 and 9-13 is/are allowed.

7) ☑ Claim(s) 14-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Continued Examination Under 37 CFR 1.114

2. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on August 26, 2019 has been entered.

Response to Amendment

3. This Action is in response to Applicant's Reply of August 26, 2019. Claims 8 and 21 have been cancelled.

4. Applicant's amendment to claims 1 and 9 and the cancellation of claim 21 overcomes the previously presented 35 USC 112(b) rejection thereof.

5. Applicant's amendment to claims 1, 7, and 14 overcome the previously presented 35 USC 103 rejection thereof.

Claim Rejections - 35 USC § 112

6. The following is a quotation of 35 U.S.C. 112(b):

(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

7. Claims 14-20 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 14 recites the limitation "the automated instructions" in line 1 of the "generating" step. There is insufficient antecedent basis for this limitation in the claim.

Claims 15-20 are considered indefinite due to their dependence on claim 14.

Allowable Subject Matter

8. Claims **1-7 and 9-13** are allowed.

9. Claims **14-20** would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), 2nd paragraph, set forth in this Office action.

10. The following is a statement of reasons for the indication of allowable subject matter:

Regarding claims 1, 7, and 14: The prior art of record fails to disclose or suggest transmitting a first parameter from a first device of a plurality of pumps, a distribution system, or wellhead to a second of a plurality of pumps, a distribution system, or wellhead as recited in the claimed combination and method.

Regarding claims 2-6, 9-13, and 15-20: These claims are considered allowable due to their dependence on one of the above claims.

Conclusion

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JENNIFER H GAY whose telephone number is (571)272-7029. The examiner can normally be reached on Monday through Thursday, 6-3:30 and every other Friday 6-11.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Waseem Moorad can be reached on 571-270-3436. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications

may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JENNIFER H GAY/
Primary Examiner, Art Unit 3676

JHG
9/18/19

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	Art Unit
	JENNIFER H GAY	3676

CPC - Searched*		
Symbol	Date	Examiner
E21B 21/062, 43/26,267, 44/00	02/07/2019	JHG
updated	09/18/2019	JHG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
E21B 21/062, 43/26,267, 44/00 - text search only	02/07/2019	JHG
Consulted 16/160708, 15/145414, 15/291842, 13/631492	02/07/2019	JHG
EAST text search	02/07/2019	JHG
Backward/forward search	02/07/2019	JHG
EAST text search	06/03/2019	JHG
EAST text search	09/18/2019	JHG

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

LIBERTY EXHIBIT 1002, Page 972

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	10280724		2019-05-07	Hinderliter	
	2	10254732		2019-04-09	Oehring	
	3	10232332		2019-03-19	Oehring	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20160105022		2016-04-14	Oehring	
	2	20160265457		2016-09-15	Stephenson	
	3	20140219824		2014-08-07	Burnette	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

LIBERTY EXHIBIT 1002, Page 973

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	4	20160281484		2016-09-29	Lestz	
	5	20190010793		2019-01-10	Hinderliter	
	6	20150211512		2015-07-30	Wiegman	
	7	20170234250		2017-08-17	Janik	
	8	20120049625		2012-03-01	Hopwood	
	9	20190120024		2019-04-25	Oehring	
	10	20190010793		2019-01-10	Hinderliter	
	11	20180028992		2018-02-01	Stegemoeller	
	12	20170218727		2017-08-03	Oehring	
	13	20150136043		2015-05-21	Shaaban	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2]	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2707269	CA		2010-12-09	Kidd		☒

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NON-PATENT LITERATURE DOCUMENTS [Remove]

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion mailed July 9, 2019 in corresponding PCT Application No. PCT/US2019/027584	☒
	2	Office Action mailed June 11, 2019 in corresponding US Application No. 16/210,749	☒
	3	Office Action mailed May 10, 2019 in corresponding US Application No. 16/268,030	☒
	4	Canadian Office Action mailed May 30, 2019 in corresponding CA Application No. 2,833,711	☒
	5	Canadian Office Action mailed June 20, 2019 in corresponding CA Application No. 2,964,597	☒

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EXAMINER SIGNATURE

Examiner Signature	/JENNIFER H GAY/	Date Considered	09/18/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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(Not for submission under 37 CFR 1.99)

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Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Sharon Du/	Date (YYYY-MM-DD)	2019-08-26
Name/Print	Sharon Du	Registration Number	69244

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.W.C/

Privacy Act Statement

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	15	("10232332" | "10254732" | "10280724" | "20120049625" | "20140219824" | "20150136043" | "20150211512" | "20160105022" | "20160265457" | "20160281484" | "20170218727" | "20170234250" | "20180028992" | "20190010793" | "20190120024").PN.	US-PGPUB; USPAT	OR	ON	2019/09/18 14:01
L2	2071	e21b21/062.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:24
L3	24434	e21b43/26,267.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:24
L4	9652	e21b44/00.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:24
L5	35357	L2 or L3 or L4	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:24
L6	1503	L5 and (@PD>"20190603")	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:24
L7	1645	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and instruction$3 and (pump with (control$4 adjust$4 off))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 14:25
L8	428	e21b$.cpc. and (frac$3 fractur$3) and	US-PGPUB;	OR	ON	2019/09/18

		(processor computer controller) and (instruction$3 same (pump with (control$4 adjus$4 off)))	USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			14:29
L9	39	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and (instruction$3 same (wellhead with (control$4 adjus$4 off)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 15:02
L10	543	e21b$.cpc. and (frac$3 fractur$3) and (processor computer controller) and (instruction$3 same ((valve motor engine transmission suction discharge temperature) with (control$4 adjus$4 off)))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/09/18 15:05

EAST Search History (Interference)

< This search history is empty>

9/ 18/ 2019 3:08:32 PM
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	10280724		2019-05-07	Hinderliter	
	2	10254732		2019-04-09	Oehring	
	3	10232332		2019-03-19	Oehring	

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U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20160105022		2016-04-14	Oehring	
	2	20160265457		2016-09-15	Stephenson	
	3	20140219824		2014-08-07	Burnette	

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	4	20160281484		2016-09-29	Lestz	
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FOREIGN PATENT DOCUMENTS Remove

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	1	2707269	CA		2010-12-09	Kidd		☒

If you wish to add additional Foreign Patent Document citation information please click the Add button Add

NON-PATENT LITERATURE DOCUMENTS Remove

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion mailed July 9, 2019 in corresponding PCT Application No. PCT/US2019/027584	☒
	2	Office Action mailed June 11, 2019 in corresponding US Application No. 16/210,749	☒
	3	Office Action mailed May 10, 2019 in corresponding US Application No. 16/268,030	☒
	4	Canadian Office Action mailed May 30, 2019 in corresponding CA Application No. 2,833,711	☒
	5	Canadian Office Action mailed June 20, 2019 in corresponding CA Application No. 2,964,597	☒

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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☒ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Sharon Du/	Date (YYYY-MM-DD)	2019-08-26
Name/Print	Sharon Du	Registration Number	69244

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Doc code: RCEX
Doc description: Request for Continued Examination (RCE)

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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REQUEST FOR CONTINUED EXAMINATION(RCE)TRANSMITTAL
(Submitted Only via EFS-Web)

Application Number	16170695	Filing Date	2018-10-25	Docket Number (if applicable)	047158.100032	Art Unit	3676
First Named Inventor	Jared Oehring			Examiner Name	Jennifer Hawkins Gay		

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. The Instruction Sheet for this form is located at WWW.USPTO.GOV

SUBMISSION REQUIRED UNDER 37 CFR 1.114

Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

- ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ☐ Other _____

☒ Enclosed

- ☒ Amendment/Reply
- ☒ Information Disclosure Statement (IDS)
- ☐ Affidavit(s)/ Declaration(s)
- ☐ Other _____

MISCELLANEOUS

☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of months _____ (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

☐ Other _____

FEES

☒ **The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.**
The Director is hereby authorized to charge any underpayment of fees, or credit any overpayments, to Deposit Account No 501349

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

☒ Patent Practitioner Signature

Applicant Signature

PTO/SB/30EFS (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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Signature of Registered U.S. Patent Practitioner			
Signature	/Sharon Du/	Date (YYYY-MM-DD)	2019-08-26
Name	Sharon Du	Registration Number	69244

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:		§	
		§	
Jared Oehring		§	
		§	Attorney Docket No.: 047158.100032
		§	
Serial No.:	16/170,695	§	Confirmation No.: 6906
		§	
Filed:	10/25/2018	§	Art Unit: 3676
		§	
For:	SMART FRACTURING SYSTEM AND METHOD	§	Examiner: Gay, Jennifer Hawkins

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

AMENDMENT

Dear Sir:

In response to the Final Office Action mailed June 7, 2019, Applicants hereby request reconsideration of the above-referenced application for patent, and reconsideration of the rejections in view of the amendments and the following arguments. A Request for Continued Examination is filed with this paper. If any additional fees are necessary for continued prosecution of this Application, the commissioner is hereby authorized to charge those fees to **Hogan Lovells US LLP's Deposit Account Number 501349**.

Amendments to the Claims are reflected in the listing of claims that begin on page 2 of this paper.

Remarks/Arguments begin on page 8 of this paper.

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A hydraulic fracturing system, comprising:

a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;

a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and

a control system comprising:

a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;

one or more processing devices configured to receive ~~and the one or more parameters~~ a first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead, and transmit the first parameter to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead, and detect that [[a]] the first parameter ~~of the one or more parameters~~ is outside of an acceptable threshold; and generate automated control instructions at the second device based at least in part on the first parameter ~~one or more parameters~~; and

one or more control devices configured to receive the automated control instructions and automatically adjust one or more aspects of the second device ~~the plurality of pumps or the distribution system~~ based on the control instructions.

2. (Previously Presented) The system of claim 1, wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and selected from a group including flow sensors, accelerometers, pressure transducer, and tachometers.

3. (Previously Presented) The system of claim 1, wherein the plurality of pumps or the distribution system includes at least one device selected from a group include a gate, valve, actuator, motor, suction pipe, discharge pipe, engine, transmission, and temperature regulation device, controllable via the one or more control devices.

4. (Original) The system of claim 1, further comprising:

a suction line through which fracturing fluid is supplied; and

a discharge line through which fracturing fluid is discharged, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line.

5. (Previously Presented) The system of claim 1, further comprising:

one or more blenders configured to mix together one or more materials to form the fracturing fluid, wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold, wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow conditions at the one or more blenders, the manifold, the plurality of pumps, or the distribution system.

6. (Original) The system of claim 5, wherein the one or more control device is configured to control the one or more blenders, the manifold, the plurality of pumps and the distribution system based on the flow and/or pressure conditions.

7. (Currently Amended) A hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps;

pumping the fracturing fluid into a distribution system;

injecting the fracturing fluid into a wellhead;

measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;

generating automated instructions for one or more control devices based at least in part on the one or more parameters; [[and]]

automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions.

transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

generating the automated instructions at the second device based at least in part on the first parameter; and

automatically adjusting one or more functions of the second device based on the automated instructions.

8. (Canceled)

9. (Previously Presented) The method of claim 7, further comprising:

detecting that a first pump of the plurality of pumps is underperforming; and

adjusting one or more of the pumps in the plurality of pumps to compensate for the first pump.

10. (Original) The method of claim 9, further comprising:

selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters.

11. (Original) The method of claim 7, further comprising:

determining that the one or more parameters are indicative of a potential failure condition; and

determining a source of the potential failure condition.

12. (Original) The method of claim 11, further comprising:

generating an alert or notification indicative of the potential failure condition and the source.

13. (Original) The method of claim 7, further comprising:

logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and

determining a maintenance schedule based at least in part on the operation data.

14. (Currently Amended) A hydraulic fracturing method, comprising:

performing one or more hydraulic fracturing operations at a hydraulic fracturing system, the hydraulic fracturing system comprising a plurality of pumps, a distribution system, and a wellhead;

measuring one or more operational parameters of the plurality of pumps, the distribution system, or the wellhead;

transmitting a first parameter of the one or more operational parameters from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

~~receiving a first data from a first sensing device of a pump system of a hydraulic fracturing system, the first data indicative of a condition of the pump system;~~

~~receiving second data from a second sensing device of a blender system of the hydraulic fracturing system, the blender system mixing together materials to form a fracturing fluid and delivering the fracturing fluid to the pump system, and the second data indicative of a condition of the blender system;~~

detecting that ~~at least one of the first and second data~~ the first parameter is outside of an acceptable threshold;

~~generating automated instructions for one or more control devices installed on of the pump system or the blender system based at least in part on the first and second data; and~~

~~automatically adjusting one or more functions of the pump system or the blender system based at least in part on the automated instructions~~.

generating the automated instructions at the second device based at least in part on the first parameter; and

automatically adjusting one or more functions of the second device based on the automated instructions.

15. (Currently Amended) The method of claim 14, wherein ~~the pump system comprises:~~

~~one or more pumps; and~~

[[a]] the distribution system ~~that~~ receives and consolidates the fracturing fluid from the ~~one or more~~ plurality of pumps for injection into a wellhead.

16. (Previously Presented) The method of claim 15, further comprising:

controlling one or more functions of the distribution system based on the automated instructions.

17. (Currently Amended) The method of claim 14, wherein the ~~pump system comprises a plurality of pumps, and the~~ first parameter ~~data~~ includes measurements of one or more ~~each~~ of the plurality of pumps.

18. (Original) The method of claim 17, further comprising:

controlling one or more of the plurality of pumps individually based on the automated instructions.

19. (Original) The method of claim 18, further comprising:

detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold; and

automatically taking the first pump offline in response to the detection.

20. (Original) The method of claim 19, further comprising:

adjusting one or more of the other pumps in the plurality of pumps to compensate for taking the first pump offline.

21. (Canceled)

REMARKS/ARGUMENTS

This amendment is in response to the Final Office Action mailed June 7, 2019. Claims 1-7 and 9-20 are pending in the application. Claims 1, 7, 14, 15, and 17 have been amended. Claim 21 is canceled. No new matter has been introduced in the amendments.

In the Office Action, the Examiner indicated that claim 21 would be allowable if rewritten to overcome the rejection under 35 U.S.C 112(b) set forth in the Office Action. Applicants thank the Examiner for the allowed claims and the indicated allowable subject matter.

The Examiner rejected claims 1-6, 9, 10, and 21 under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Next, the Examiner rejected claims 1-12 and 14-20 under 35 U.S.C. 103 as unpatentable over U.S. Patent Publication No. 2017/0226842 to Omont ("*Omont*") in view of U.S Patent Publication No. 2014/0379300 to Devine ("*Devine*"). The Examiner rejected claim 13 under 35 U.S.C. 103(a) as being unpatentable over Omont and Devine in view of U.S Patent Publication No. 2014/0095114 to Thomeer ("*Thom*").

I. Allowable Subject Matter

In the Office Action, the Examiner indicated that claim 21 would be allowable if rewritten to overcome the rejection under 35 U.S.C 112(b) set forth in the Office Action. Applicants thank the Examiner for the allowed claims and the indicated allowable subject matter. Accordingly, Applicant has added the allowable subject matter of claim 21 into each of independent claims 1, 7, and 14. Additionally, Applicant has also added the language "generating the automated instructions at the second device based at least in part on the first

parameter" to address the alleged 35 U.S.C 112(b) issue described on page 4 of the office action. Thus, Applicant submits that independent claims 1, 7, and 14 are also allowable as they have been amended to incorporate the allowable subject matter of claim 21.

II. Claims 1-6, 9, 10, and 21 are compliant with 35 U.S.C. 112(b).

The Examiner rejected claims 1-6, 9, 10, and 21 under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claims 1 and 9 have been amended to overcome the 35 U.S.C. 112(b) issues set forth on pages 3-4 of the office action. Claim 21 is canceled, and claims 2-6 and 10 are remedied by virtue of their dependence of amended claims 1 and 9.

III. Claims 1, 7, and 14 are patentable because they incorporate allowable subject matter of claim 21.

the Examiner rejected claims 1-12 and 14-20 under 35 U.S.C. 103 as unpatentable over U.S. Patent Publication No. 2017/0226842 to Omont ("*Omont*") in view of U.S Patent Publication No. 2014/0379300 to Devine ("*Devine*"). The Examiner rejected claim 13 under 35 U.S.C. 103(a) as being unpatentable over Omont and Devine in view of U.S Patent Publication No. 2014/0095114 to Thomeer ("*Thomeer*"). Applicant respectfully submits that Omont, Devine, and Thom do not make obvious claim 1, 7, and 14.

As mentioned above, claim 21 was indicated containing allowable subject matter. Independent claims 1, 7, and 14 have each been amendment to recite the allowable subject matter of claim 21, and are thus allowable.

For at least these reasons, claims 1, 7, and 14 are patentable over Omont, Devine, and Thom, under 35 U.S.C. 103. Accordingly, Applicant respectfully requests withdrawal of the rejection of independent claims 1, 7, and 14.

IV. Dependent Claims

Finally, Applicants respectfully submit that dependent claims 2-6, 8-13, and 15-20 are patentable by virtue of their dependence from one or more of claims 1, 7, and 14, as well as for other patentable features recited therein.

CONCLUSION

The foregoing response is full, complete, and timely filed. Amendments to the claims are made without prejudice, including under the doctrine of equivalents. In addition, the comments made herein are without prejudice. Applicants respectfully request reconsideration of the instant application in light of the foregoing response and amendments. Should the Examiner have any questions, comments or suggestions in furtherance of the prosecution of the application, the Examiner is invited to contact the Applicants' representative by telephone or fax.

Respectfully submitted,

Date: August 26, 2019

/Sharon Du/
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Patent Agent for Applicants

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 047158.500040	Date of mailing *(day/month/year)* 09 JUL 2019 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US2019/027584	International filing date *(day/month/year)* 16 April 2019
Applicant U.S. WELL SERVICES, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may **submit comments on an informal basis on the written opinion of the International Searching Authority** to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

   Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within **22 months from the priority date, the applicant may request that a supplementary international search be carried out** by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 047158.600040	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2019/027584	International filing date *(day/month/year)* 16 April 2019	(Earliest) Priority Date *(day/month/year)* 16 April 2018
Applicant U.S. WELL SERVICES, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the language, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the title,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

   a. the figure of the drawings to be published with the abstract is Figure No. 1

   ☐ as suggested by the applicant.

   ☒ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/027584

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 41/00; E21B 21/06; E21B 43/12; E21B 44/00; F04B 17/03; F04B 17/05 (2019.01)

CPC - E21B 41/0092; E21B 21/06; E21B 41/00; E21B 41/0085; E21B 43/12; E21B 44/00; F04B 17/03; F04B 17/05; F04B 17/06 (2019.05)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 166/53; 166/65.1; 166/66.4; 166/177.5; 166/250.1; 166/308.1 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2016/0105022 A1 (US WELL SERVICES LLC) 14 April 2016 (14.04.2016) entire document	1, 2, 4, 5, 9-11, 13, 14 --- 3, 6-8, 12
Y	US 2016/0265457 A1 (HALLIBURTON ENERGY SERVICES, INC.) 15 September 2016 (15.09.2016) entire document	3, 12
Y	US 2016/0369609 A1 (EVOLUTION WELL SERVICES, LLC) 22 December 2016 (22.12.2016) entire document	6, 7
Y	US 4,432,084 A (BARKER et al) 14 February 1984 (14.02.1984) entire document	8
A	US 2014/0290768 A1 (FTS INTERNATIONAL SERVICES, LLC) 02 October 2014 (02.10.2014) entire document	1-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 June 2019	09 JUL 2019

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	09 JUL 2019
Applicant's or agent's file reference 047168.500040	FOR FURTHER ACTION See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2019/027584	16 April 2019	16 April 2018

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - E21B 41/00; E21B 21/06; E21B 43/12; E21B 44/00; F04B 17/03; F04B 17/05 (2019.01)
CPC - E21B 41/0092; E21B 21/06; E21B 41/00; E21B 41/0085; E21B 43/12; E21B 44/00, F04B 17/03; F04B 17/05; F04B 17/06 (2019.05)

Applicant U.S. WELL SERVICES, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	10 June 2019	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (January 2015)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/027584

Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of a sequence listing.

a. ☐ forming part of the international application as filed:

☐ in the form of an Annex C/ST.25 text file.

☐ on paper or in the form of an image file.

b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/027584

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	3, 6-8, 12	YES
	Claims	1, 2, 4, 5, 9-11, 13, 14	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-14	NO
Industrial applicability (IA)	Claims	1-14	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1, 2, 4, 5, 9-11, 13, and 14 lack novelty under PCT Article 33(2) as being anticipated by US Well Services LLC (hereinafter US Well Services).

Regarding Claim 1, US Well Services discloses a hydraulic fracturing fleet (Figs. 1-5; Para. [0019] regarding a hydraulic fracturing operation having a plurality of pumps mounted to vehicles), characterized by: a datavan (data vans 227A, 227B, Fig. 5, data vans 227A, 227B, Para. [0045]) for engaging an interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]), the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) characterized by at least one back-up component that is either or both of diesel-powered (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered; a controller (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031]) executing a software module (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031], inherent that the programmable logic controller with touchscreen interface would have a software module) for determining a type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) of a connected component (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B) to the datavan (data vans 227A, 227B), the type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) associated with the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]); and switching components (a transfer switch could be used to switch, Para. [0052]) associated with the datavan (data vans 227A, 227B) for switching (a transfer switch could be used to switch, Para. [0052]) between the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) upon determination, by the controller (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031]), of the type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) of the connected component (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B).

Regarding Claim 2, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: multi-pump controls (the hydraulic fracturing pumps can be split evenly between the banks, Para. [0049], an A/C console that controls the VFD 15, and thus the speed of the electric motor 14 and the pump 10, other pump control and data monitoring equipment can include pump throttles, Para. [0031]) in the datavan (data vans 227A, 227B, Fig. 5) for controlling a diesel (at pumps 210A, 210B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) or an electric pump (at pumps 210A, 210B, Fig. 5, the electric system, Para. [0052]) in the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]).

LIBERTY EXHIBIT 1002, Page 1007

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2018/027584

Supplemental Box

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Regarding Claim 4, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: electric (at blenders 234A, 234B, Fig. 5, the electric system, Para. [0052]) and diesel blenders (at blenders 234A, 234B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) in the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]), the electric (at blenders 234A, 234B, Fig. 5, the electric system, Para. [0052]) and the diesel blenders (at blenders 234A, 234B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) further being associated with back-up counterpart blenders (at blenders 234A, 234B, Fig. 5, in addition, although two groups A, B are shown in FIG. 5, more than two groups can be used . . . a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052]).

Regarding Claim 5, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: a pump operator station (at data vans 227A, 227B, Fig. 5, communicating with an operator via one or more user interfaces, Para. [0024]) comprised in the datavan (data vans 227A, 227B) for enabling operator control (provide information to an operator, and to allow the operator to control different parameters of the fracturing operation, Para. [0031]) of the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) or with back-up (kept separate to create redundancy and backup capabilities in the system, Para. [0048]) counterpart components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, in addition, although two groups A, B are shown in FIG. 5, more than two groups can be used, Para. [0052]) that are either diesel powered (a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) or electric-powered (the electric system, Para. [0052]).

Regarding Claim 9, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: a redundant diesel or electric power (generators 222A, 222B, Fig. 5, two or more generators 222A, 222B grouped into two or more banks of power, which are kept separate to create redundancy and backup capabilities in the system, Para. [0048], electric power generation, Para. [0046]) to power the datavan (data vans 227A, 227B) from the hydraulic fracturing fleet (as shown in Fig. 5) or a remote station.

Regarding Claim 10, US Well Services discloses a method of operating a hydraulic fracturing fleet (Figs. 1-5; Para. [0019] regarding a hydraulic fracturing operation having a plurality of pumps mounted to vehicles), characterized by: engaging, using a datavan (data vans 227A, 227B, Fig. 5, data vans 227A, 227B, Para. [0045]), an interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]), the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) characterized by at least one back-up component that is either or both of diesel-powered (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered; determining, by a software module (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031], inherent that the programmable logic controller with touchscreen interface would have a software module) executing on a controller (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031]), a type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) of a connected component (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B) to the datavan (data vans 227A, 227B), the type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) associated with the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]); and switching, by switching components (a transfer switch could be used to switch, Para. [0052]) associated with the datavan (data vans 227A, 227B), between the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) upon determination by the controller (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031]) of the type (conventional diesel or bi-fuel powered frack system . . . the electric system, Para. [0052]) of the connected component (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B).

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
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Regarding Claim 11, US Well Services discloses the method of claim 10, further characterized by: controlling, by multi-pump controls (the hydraulic fracturing pumps can be split evenly between the banks, Para. [0049], an A/C console that controls the VFD 15, and thus the speed of the electric motor 14 and the pump 10, other pump control and data monitoring equipment can include pump throttles, Para. [0031]) in the datavan (data vans 227A, 227B, Fig. 5), a diesel (at pumps 210A, 210B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) or an electric pump (at pumps 210A, 210B, Fig. 5, the electric system, Para. [0052]) in the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]).

Regarding Claim 13, US Well Services discloses the method of claim 10, further characterized by: electric (at blenders 234A, 234B, Fig. 5, the electric system, Para. [0052]) and diesel blenders (at blenders 234A, 234B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) in the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]), the electric (at blenders 234A, 234B, Fig. 5, the electric system, Para. [0052]) and the diesel blenders (at blenders 234A, 234B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) further being associated with back-up counterpart blenders (at blenders 234A, 234B, Fig. 5, in addition, although two groups A, B are shown in FIG. 5, more than two groups can be used . . . a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052]).

Regarding Claim 14, US Well Services discloses the method of claim 10, further characterized by: enabling, from a pump operator station (at data vans 227A, 227B, Fig. 5, communicating with an operator via one or more user interfaces, Para. [0024]) comprised in the datavan (data vans 227A, 227B), operator control (provide information to an operator, and to allow the operator to control different parameters of the fracturing operation, Para. [0031]) of the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) or the back-up (kept separate to create redundancy and backup capabilities in the system, Para. [0048]) counterpart components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B) that are either diesel powered (a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) or electric-powered (the electric system, Para. [0052]).

Claims 3 and 12 lack an inventive step under PCT Article 33(3) as being obvious over US Well Services LLC (hereinafter US Well Services) in view of Halliburton Energy Services, Inc. (hereinafter Halliburton Energy Services).

Regarding Claim 3, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: the switching components (a transfer switch could be used to switch, Para. [0052]) configured to communicate with the software module (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031], inherent that the programmable logic controller with touchscreen interface would have a software module) and to receive frequency levels (other pump control and data monitoring equipment can include pump throttles, a VFD fault indicator with a reset, Para. [0031], a variable frequency drive (VFD) 15, Para. [0021]) for a variable frequency drive (as well as a VFD, Para. [0050], each electric motor 14 can be equipped with a variable frequency drive (VFD) 15, and an A/C console, that controls the speed of the electric motor 14, and hence the speed of the pump 10, Para. [0021]) of an electric pump (at pumps 210A, 210B, Fig. 5, the electric system, Para. [0052]).
US Well Services fails to explicitly disclose wherein the configured to receive includes configured to receive control gear levels for a diesel engine.
Halliburton Energy Services is in the art of diesel fuel consumption at a well site operation (Para. [0014]) and teaches wherein configured to receive includes configured to receive control gear levels (engine parameters . . . operating gear . . . into a diesel consumption model, Para. [0026]) for a diesel engine (a diesel consumption value for a dual-fuel engine configuration, Para. [0026]).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify US Well Services with the teaching of Halliburton Energy Services for the purpose of providing a diesel consumption model at a well site to adjust engine parameters and thereby ensure that operators can refine and optimize fuel consumption (Halliburton Energy Services, Para. [0015]).

Supplemental Box

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Regarding Claim 12, US Well Services discloses the method of claim 10, further characterized by: communicating with the software module (a programmable logic controller for local control, and a graphics panel, the graphics panel can include, for example, a touchscreen interface, Para. [0031], inherent that the programmable logic controller with touchscreen interface would have a software module) to receive instructions for frequency (other pump control and data monitoring equipment can include pump throttles, a VFD fault indicator with a reset, Para. [0031], a variable frequency drive (VFD) 15, Para. [0021]) and/or voltage levels for a variable frequency drive (as well as a VFD, Para. [0050], each electric motor 14 can be equipped with a variable frequency drive (VFD) 15, and an A/C console, that controls the speed of the electric motor 14, and hence the speed of the pump 10, Para. [0021]) of an electric pump (at pumps 210A, 210B, Fig. 5, the electric system, Para. [0052]); and controlling the frequency levels (other pump control and data monitoring equipment can include pump throttles, a VFD fault indicator with a reset, Para. [0031], a variable frequency drive (VFD) 15, Para. [0021]) based at least in part on requirements of the hydraulic fracturing fleet (as shown in Fig. 5).
US Well Services fails to explicitly disclose wherein to receive instructions includes to receive instructions for gear levels and engine revolutions per minute (RPM) for a diesel engine; and controlling the gear levels.
Halliburton Energy Services is in the art of diesel fuel consumption at a well site operation (Para. [0014]) and teaches wherein to receive instructions includes to receive instructions for gear levels (engine parameters . . . operating gear . . . into a diesel consumption model, Para. [0026]) and engine revolutions per minute (RPM) (engine parameters . . . engine speed . . . into a diesel consumption model, Para. [0026]) for a diesel engine (a diesel consumption value for a dual-fuel engine configuration, Para. [0025]); and controlling the gear levels (engine parameters . . . operating gear . . . into a diesel consumption model, Para. [0026], computer control to change engine parameters, Para. [0032]).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify US Well Services with the teaching of Halliburton Energy Services for the purpose of providing a diesel consumption model at a well site to adjust engine parameters and thereby ensure that operators can refine and optimize fuel consumption (Halliburton Energy Services, Para. [0015]).

Claims 6 and 7 lack an inventive step under PCT Article 33(3) as being obvious over US Well Services LLC (hereinafter US Well Services) in view of Evolution Well Services, LLC (hereinafter Evolution Well Services).

Regarding Claim 6, US Well Services discloses the hydraulic fracturing fleet of claim 1, further characterized by: a pump down station (a fracturing fluid, which is pumped down the well by the electric-powered pumps, Para. [0042]) configured to operate concurrently with the interchangeable combination (conventional diesel . . . so that conventional means could be used to power the system if the electric system becomes incapacitated, Para. [0052]) of the diesel-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, a conventional diesel or bi-fuel powered frack system could be tied into the system as a backup, Para. [0052], diesel powered . . . by a discrete diesel engine, Para. [0005]) and the electric-powered components (at pumps 210A, 210B, sand equipment 229A, 229B, blenders 234A, 234B, hydration units 232A, 232B, Fig. 5, the electric system, Para. [0052]) being in operation with a first well (the wellbore, Para. [0044]).
US Well Services fails to explicitly disclose wherein the pump down station is a pump down station configured to operate with a second well.
Evolution Well Services is in the art of a system for pumping and pressurizing fracturing fluid (Para. [0005]) and teaches wherein a pump down station is a pump down station (at fracturing pump transports 108, Fig. 1) configured to operate with a second well (Fig. 3 showing two wellheads 101; FIG. 3 is a schematic diagram an embodiment of a well site 300 that includes two wellheads 101 and two data vans 114, Para. [0054]).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify US Well Services with the teaching of Evolution Well Services for the purpose of providing fracturing at a second wellhead and thereby ensure that a well site can operate two wellheads simultaneously (Evolution Well Services, Para. [0054]).

Regarding Claim 7, US Well Services discloses the hydraulic fracturing fleet of claim 1.
US Well Services fails to explicitly disclose further characterized by: a data network coupled to the datavan for transmitting on-site data associated with the hydraulic fracturing fleet to a remote station and for transmitting remote data from the remote station to the datavan.
Evolution Well Services is in the art of a system for pumping and pressurizing fracturing fluid (Para. [0005]) and teaches further characterized by: a data network (a control network system . . . configured to operate remotely using a network topology, such as an Ethernet ring topology network, Para. [0041]) coupled to a datavan (a data van, Para. [0041]) for transmitting on-site data (a control network system that monitors and controls one or more hydraulic fracturing equipment, Para. [0041]) associated with a hydraulic fracturing fleet (the hydraulic fracturing equipment, Para. [0041]) to a remote station (a remote location, Para. [0041]) and for transmitting remote data (controls one or more hydraulic fracturing equipment remotely, Para. [0041]) from the remote station (a remote location, Para. [0041]) to the datavan (a data van, Para. [0041]).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify US Well Services with the teaching of Evolution Well Services for the purpose of providing a control network system that can monitor and control equipment remotely and thereby ensure that implementing control stations can be located away from the vicinity of the fracturing equipment (Evolution Well Services, Para. [0041]).

Supplemental Box

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Claim 8 lacks an inventive step under PCT Article 33(3) as being obvious over US Well Services LLC (hereinafter US Well Services) in view of Barker et al. (hereinafter Barker).

Regarding Claim 8, US Well Services discloses the hydraulic fracturing fleet of claim 1.
US Well Services fails to explicitly disclose further characterized by: waterproof covers provided in the datavan for safeguarding the switching components of the datavan.
Barker is in the art of microcomputer-based systems for monitoring a plurality of operations on an offshore drilling rig (Col. 1, Lns. 5-9) and teaches further characterized by: waterproof covers (electrical service is protected through a breaker box preferably located near the door 120, all switches for overhead lighting are preferably waterproof, Col. 7, Lns. 56-60) provided in a datavan (at housing 112 of skid 114, Fig. 2) for safeguarding switching components (all switches for overhead lighting are preferably waterproof, Col. 7, Lns. 56-60) of the datavan (at housing 112 of skid 114).
It would have been obvious to one of ordinary skill in the art at the time of the invention to modify US Well Services with the teaching of Barker for the purpose of having the switches of the enclosure be waterproof and thereby ensure that the equipment is maintained throughout the housing (Barker, Col. 7, Lns. 48-60).

Claims 1-14 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

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CA 2707269 A1 2010/12/09

(21) 2 707 269

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2010/06/08

(41) Mise à la disp. pub./Open to Public Insp.: 2010/12/09

(30) Priorité/Priority: 2009/06/09 (US12/481,435)

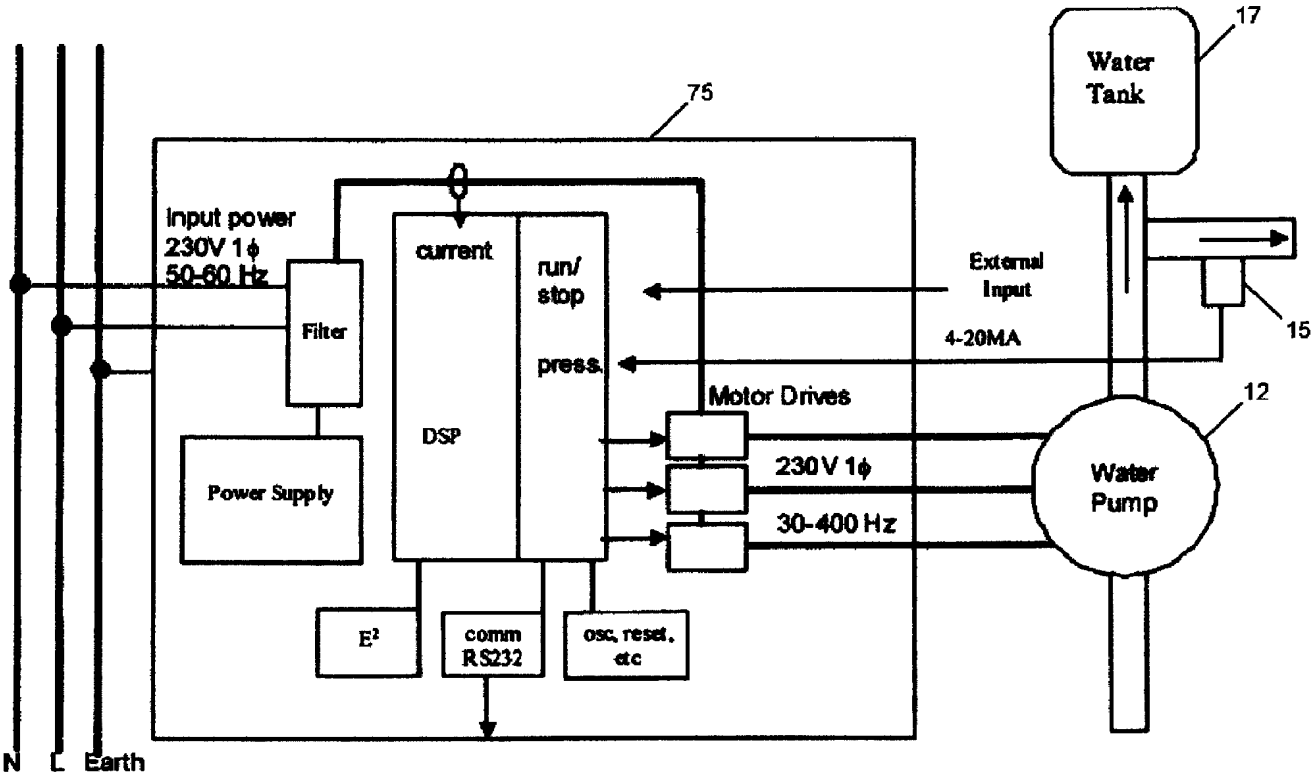
(51) Cl.Int./Int.Cl. *F04B 49/06* (2006.01), *F04B 47/06* (2006.01), *F04D 13/08* (2006.01), *F04D 15/00* (2006.01), *H02K 7/14* (2006.01)

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...

(54) Titre : METHODE DE CONTROLE D'UNE POMPE ET DE SON MOTEUR

(54) Title: METHOD OF CONTROLLING A PUMP AND MOTOR



(57) Abrégé/Abstract:
Embodiments of the invention provide a variable frequency drive system and a method of controlling a pump driven by a motor with the pump in fluid communication with a fluid system. The drive system and method can provide one or more of the following: a sleep mode, pipe break detection, a line fill mode, an automatic start mode, dry run protection, an electromagnetic interference filter compatible with a ground fault circuit interrupter, two-wire and three-wire and three-phase motor compatibility, a simple start-up process, automatic password protection, a pump out mode, digital input/output terminals, and removable input and output power terminal blocks.

(21) 2 707 269

(13) A1

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Attorney Docket No. 105196.015200

ABSTRACT

Embodiments of the invention provide a variable frequency drive system and a method of controlling a pump driven by a motor with the pump in fluid communication with a fluid system. The drive system and method can provide one or more of the following: a sleep mode, pipe break detection, a line fill mode, an automatic start mode, dry run protection, an electromagnetic interference filter compatible with a ground fault circuit interrupter, two-wire and three-wire and three-phase motor compatibility, a simple start-up process, automatic password protection, a pump out mode, digital input/output terminals, and removable input and output power terminal blocks.

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METHOD OF CONTROLLING A PUMP AND MOTOR

BACKGROUND

[0001] Submersible well pumps are connected to above-ground drive systems that control the operation of the pump. Some conventional pump controllers include only start capacitors and relays to turn the pump on and off based on system pressure. These pump controllers have limited capabilities with respect to pump control, safety, and customization. Variable frequency drives (VFDs) have also been used to control submersible well pumps but with limited capabilities regarding user-friendly control and customization. Conventional drives have also generally been designed for use with particular types of motors and often cannot be used to retrofit motors that are already installed in the well, especially two-wire, single-phase motors.

SUMMARY

[0002] Some embodiments of the invention provide a method of controlling a pump driven by a motor with the pump in fluid communication with a fluid system. The method can include determining whether the motor has reached a steady state operating frequency and causing the pump to temporarily boost a pressure in the fluid system once the motor has reached a steady state operating frequency. The method can also include determining whether the pressure in the fluid system drops after being temporarily boosted and causing the pump to enter a sleep mode if the pressure does not drop after being temporarily boosted.

[0003] In some embodiments, a method of controlling the pump can include determining whether the pump has entered the sleep mode during a predetermined time period and shutting down the pump due to a pipe break fault if the pump has not entered the sleep mode during the predetermined time period.

[0004] According to some embodiments, a method of controlling the pump can include determining a pressure in the fluid system when the pump starts and operating the motor in a line fill mode at a low frequency for a time period if the pressure in the fluid system is less than a minimum pressure set point in order to fill the fluid system. The method can also include operating the motor at a normal frequency after the minimum pressure set point is reached in order to increase the pressure to a normal pressure set point.

[0005] Some embodiments of the invention can provide a controller including a variable frequency drive circuit that controls operation of the pump and a control panel connected to the variable frequency drive circuit. The control panel can include an automatic start button and a stop button. The variable frequency drive circuit can automatically operate in a line fill mode when the pump starts when the automatic start button is engaged and the pump can be disabled when the stop button is engaged.

[0006] According to some embodiments, a method can include operating the motor at a normal operating frequency, determining an actual pressure in the fluid system, comparing the actual pressure to a pressure set point, and generating a dry run fault if the pressure set point cannot be achieved by operating the motor at the normal operating frequency.

DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a perspective view of a variable frequency drive according to one embodiment of the invention.

[0008] FIG. 2 is a perspective view of the variable frequency drive of FIG. 1 with a cover removed.

[0009] FIG. 3 is an interior view of the variable frequency drive of FIG. 1.

[0010] FIG. 4 is a front view of a control pad of the variable frequency drive of FIG. 1.

[0011] FIG. 5 is a schematic view of the variable frequency drive of FIG. 1 installed in a fluid system.

[0012] FIG. 6 is a schematic illustration of the variable frequency drive of FIG. 1.

[0013] FIG. 7 is a flow chart illustrating a pump out operation.

[0014] FIG. 8 is a flow chart illustrating an automatic line fill operation.

[0015] FIG. 9 is a flow chart illustrating a manual line fill operation.

[0016] FIG. 10 is a flow chart illustrating a stop operation.

[0017] FIG. 11 is a flow chart illustrating a proportional/integral/derivative (PID) mode control operation.

[0018] FIG. 12 is a flow chart illustrating a sleep mode operation.

[0019] FIG. 13 is a flow chart illustrating an alternate sleep mode operation.

[0020] FIG. 14 is a flow chart illustrating a digital input control operation.

[0021] FIG. 15 is a flow chart illustrating a relay output control operation.

[0022] FIG. 16 is a flow chart illustrating a main menu.

[0023] FIG. 17 is a flow chart illustrating a settings menu.

[0024] FIG. 18 is a flow chart illustrating a time parameter menu.

[0025] FIG. 19 is a flow chart illustrating a PID control parameter menu.

[0026] FIG. 20 is a flow chart illustrating a sleep parameter menu.

[0027] FIG. 21 is a flow chart illustrating a password parameter menu.

[0028] FIG. 22 is a flow chart illustrating an external set point parameter menu.

[0029] FIG. 23 is a flow chart illustrating a motor parameter menu.

[0030] FIG. 24 is a flow chart illustrating a sensor parameter menu.

[0031] FIG. 25 is a flow chart illustrating a pipe break parameter menu.

[0032] FIG. 26 is a flow chart illustrating a dry run parameter menu.

[0033] FIG. 27 is a flow chart illustrating an input/output parameter menu.

[0034] FIG. 28 is a flow chart illustrating a reset parameter menu.

[0035] FIG. 29 is a flow chart illustrating a backdoor parameter menu.

[0036] FIG. 30 is a flow chart illustrating an overheat prevention operation.

[0037] FIG. 31 is a flow chart illustrating an overcurrent prevention operation.

[0038] FIG. 32 is a flow chart illustrating a jam prevention operation.

[0039] FIG. 33 is a flow chart illustrating a pipe break prevention operation.

[0040] FIG. 34 is a flow chart illustrating a dry run detection operation.

[0041] FIG. 35 is a flow chart illustrating a dry run fault operation.

[0042] FIG. 36 is a flow chart illustrating a jam fault operation.

[0043] FIG. 37 is a flow chart illustrating an overtemperature fault operation.

[0044] FIG. 38 is a flow chart illustrating an overcurrent fault operation.

[0045] FIG. 39 is a flow chart illustrating an overvoltage fault operation.

[0046] FIG. 40 is a flow chart illustrating an internal fault operation.

[0047] FIG. 41 is a flow chart illustrating a ground fault operation.

[0048] FIG. 42 is a flow chart illustrating an open transducer fault operation.

[0049] FIG. 43 is a flow chart illustrating a shorted transducer fault operation.

[0050] FIGS. 44A-44B are flow charts illustrating a multiple faults operation.

[0051] FIG. 45 is a flow chart illustrating an undervoltage fault operation.

[0052] FIG. 46 is a flow chart illustrating a hardware fault operation.

[0053] FIG. 47 is a flow chart illustrating an external fault operation.

[0054] FIG. 48 is a flow chart illustrating a pump out button control operation.

[0055] FIG. 49 is a flow chart illustrating a pressure preset button control operation.

[0056] FIG. 50 is a flow chart illustrating a main menu button control operation.

[0057] FIG. 51 is a flow chart illustrating a fault log button control operation.

[0058] FIG. 52 is a flow chart illustrating an enter button control operation.

[0059] FIG. 53 is a flow chart illustrating a back button control operation.

[0060] FIG. 54 is a flow chart illustrating an up/down button control operation.

[0061] FIG. 55 is a flow chart illustrating a left/right button control operation.

[0062] FIG. 56 is a flow chart illustrating a password button control operation.

[0063] FIG. 57 is a flow chart illustrating a language button control operation.

[0064] FIG. 58 is a flow chart illustrating a status button control operation.

[0065] FIG. 59 is a flow chart illustrating a stop button control operation.

[0066] FIG. 60 is a flow chart illustrating an automatic start button control operation.

[0067] FIG. 61 is a flow chart illustrating a fault reset button control operation.

[0068] FIGS. 62A-62D are flow charts illustrating LED indicator control operations.

[0069] FIGS. 63A-63D are flow charts illustrating error display control operations.

DETAILED DESCRIPTION

[0070] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the

items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0071] The following discussion is presented to enable a person skilled in the art to make and use embodiments of the invention. Various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the generic principles herein can be applied to other embodiments and applications without departing from embodiments of the invention. Thus, embodiments of the invention are not intended to be limited to embodiments shown, but are to be accorded the widest scope consistent with the principles and features disclosed herein. The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the invention. Skilled artisans will recognize the examples provided herein have many useful alternatives and fall within the scope of embodiments of the invention.

[0072] FIG. 1 illustrates a variable frequency drive (VFD, hereinafter "the drive") 10 according to one embodiment of the invention. In some embodiments, the drive 10 can be used to control the operation of an AC induction motor 11 that drives a water pump 12 (as shown in FIG. 5). The drive 10 can be used in a residential, commercial, or industrial pump system to maintain a substantially constant pressure. The motor 11 and pump 12 can be a submersible type or an above-ground type. The drive 10 can monitor certain operating parameters and control the operation of the motor 11 in response to the sensed conditions.

[0073] As shown in FIGS. 1 and 2, the drive 10 can include an enclosure 13 and a control pad 14. The enclosure 13 can be a NEMA 1 indoor enclosure or a NEMA 3R outdoor enclosure. In one embodiment, the enclosure 13 can have a width of about 9.25 inches, a height of about 17.5 inches, and a depth of about 6.0 inches. The enclosure 13 can include a keyhole mount 16 for fast and easy installation onto a wall, such as a basement wall. The enclosure 13 can include

slots 18 through which air that cools the drive 10 can pass out of the enclosure 13. The control pad 14 can be positioned within the enclosure 13 for access through a rectangular aperture 20.

[0074] As shown in FIG. 2, the enclosure 13 can include a removable cover 22 with attached side panels. Removing the cover 22 allows access to a wiring area 24, which is located adjacent to a bottom panel 25 of the enclosure 13 with several conduit holes 26. As shown in FIGS. 2 and 3, the wiring area 24 is free of any electrical components or printed circuit board material that may impede any wiring. The wiring area 24 can provide access to an input power terminal block 28, input/output (I/O) spring terminals 30, and an output power terminal block 32. Each one of the conduit holes 26 can be aligned with one of the input power terminal block 28, the I/O spring terminals 30, and the output power terminal block 32. In addition, in some embodiments, the I/O spring terminals 30 can include digital output terminals 30A, digital input terminals 30B, I/O power supply terminals 30C, and analog input terminals 30D.

[0075] The wiring area 24 can include a wiring space 34 between the bottom panel 25 and the input power terminal block 28, the I/O spring terminals 30, and the output power terminal block 32. The wiring space 34 can be between about three inches and about six inches in height in order to allow enough room for an installer to access the input power terminal block 28, the I/O spring terminals 30, and the output power terminal block 32.

[0076] The input power terminal block 28, I/O spring terminals 30, and the output power terminal block 32 can be used to control the motor 11 and to provide output information in any number of configurations and applications. Various types of inputs can be provided to the drive 10 to be processed and used to control the motor 11. The analog input terminals 30D can receive analog inputs and the digital input terminals 30B can receive digital inputs. For example, any suitable type of run/enable switch can be provided as an input to the drive 10 (e.g., via the digital input terminals 30B). The run/enable switch can be part of a lawn irrigation system, a spa pump controller, a pool pump controller, a float switch, or a clock/timer. In some embodiments, the digital input terminals 30B can accept a variety of input voltages, such as voltages ranging from about 12 volts to about 240 volts, direct current (DC) or alternating current (AC).

[0077] The digital output terminals 30A can connect to digital outputs, such as relay outputs. Any suitable type of indicator device, status output, or fault alarm output can serve as a digital,

or relay, output (e.g., be connected to the digital output terminals 30A). A status output can be used to control a second pump, for example, to run the second pump when the pump 12 is running. A fault alarm output can, for example, place a call using a pre-defined phone number, signal a residential alarm system, and/or shut down the pump 12 when a fault is determined. For example, when there is a pipe break fault (as described below with reference to FIG. 33), the digital output terminals 30A can energize a relay output, causing the pre-defined phone number to be automatically dialed. The input power terminal block 28, the I/O spring terminals 30, and the output power terminal block 32 can all be coupled to a drive circuit board (not shown), for connection to a controller 75 (as shown in FIG. 6) of the drive 10. Further, the input power terminal block 28 and/or the output power terminal block 32 can be removable and replaceable without replacing the drive circuit board or the entire drive 10.

[0078] As shown in FIGS. 1-4, a control pad 14 of the drive 10 can include a backlit liquid crystal display 36 and several control buttons 38. As shown in FIG. 4, the control buttons 38 can include a pump-out button 40, a pressure preset button 42, a main menu button 44, and a fault log button 46. The control buttons 38 can also include a keypad lockout button 48 and a language button 50. The control pad 14 can include several directional buttons 52, a back button 54, and an enter button 56. The control pad 14 can further include a status button 58, a stop button 60, an automatic start button 62, and a fault reset button 64. Finally, the control pad 14 can include light emitting diode (LED) indicators 66, to indicate a status of the drive 10, such as an ON LED 68, a Warning LED 70, and a Fault LED 72.

[0079] As shown in FIGS. 2 and 3, the drive 10 can include an electromagnetic interference (EMI) filter 74. The EMI filter 74 can reduce electrical noise generated by the motor 11, especially noise that interferes with AM radio stations. The drive 10 can reduce electrical noise while simultaneously being compatible with a Ground Fault Circuit Interrupter (GFCI). An unintentional electric path between a source of current and a grounded surface is generally referred to as a "ground fault." Ground faults occur when current is leaking somewhere, and in effect, electricity is escaping to the ground.

[0080] The drive 10 can be compatible with a number of different types of motors 11, including, but not limited to, AC induction motors that are two-wire permanent split capacitor

(PSC) single-phase motors; three-wire single-phase motors; or three-phase motors. The drive 10 can be connected to a previously-installed motor 11 in order to retrofit the controls for the motor 11. If the motor is a single-phase motor, the installer can use the control pad 14 to select either two-wire or three-wire. For a three-wire motor 11, the drive 10 can automatically generate a first waveform and a second waveform with the second waveform having a phase angle of about 90 degrees offset from the first waveform. In addition, the controller 75 (as shown in FIG. 6) can automatically set a minimum and maximum frequency allowance for the motor 11 depending on the selection.

[0081] The drive 10 can be programmed to operate after a simple start-up process by a user using the control pad 14. The start-up process can be a five-step process for a single-phase motor 11 and a four-step process for a three-phase motor 11. The start-up process for a single-phase motor 11 can include (1) entering a service factor current value, (2) selecting either a two-wire motor or a three-wire motor, (3) entering a current time, (4) entering a current date, and (5) engaging the pump-out button 40 or the automatic start button 62. The start-up process for a three-phase motor 11 can include (1) entering a service factor current value, (2) entering a current time, (3) entering a current date, and (4) engaging the pump-out button 40 or the automatic start button 62.

[0082] The pump-out button 40 can be used to enter the drive 10 in a pump out mode to clean out sand and dirt from a newly-dug well. The pump-out button 40 can be engaged once the pump 12 is installed in the new well and once the drive 10 is connected to the motor 11. The pump-out mode can provide an open discharge of sand and dirt from the well, for example, onto a lawn. In one embodiment, the drive 10 can operate the pump 12 in the pump out mode at about 45 Hertz (Hz). The pump out mode operation is further described below with respect to FIG. 7, and a pump-out button control operation is further described below with respect to FIG. 48.

[0083] The controller 75 can include software executed by a digital signal processor (DSP, as shown in FIG. 6) or a microprocessor and can perform real-time control including soft-start, speed regulation, and motor protection. The drive 10 can be controlled to maintain substantially constant water pressure in a water system that may or may not utilize a tank. To achieve this, the controller 75 can implement a classical Proportional/Integral/Derivative (PID) method using

pressure error as an input. Pressure error can be calculated by subtracting an actual water pressure from the desired water pressure (i.e., a pressure set point). An updated speed control command can then be generated by multiplying the pressure error by a proportional gain, multiplying the integral of the pressure error by an integral gain, multiplying the derivative of the pressure error by a derivative gain, and summing the results. Thus, the controller 75 can increase or decrease the speed of the motor 11 to maintain a constant pressure set point. The PID mode is further described below with respect to FIG. 11.

[0084] The controller 75 can determine the actual water pressure value from an electronic pressure transducer 15 (e.g., in communication with the controller 75 via the analog input terminals 30D). In some embodiments, as shown in FIG. 5, the pressure transducer 15 can be located near a pressure tank 17 fluidly coupled to the pump 12.

[0085] If motor 11 is off (i.e., not being driven), water pressure can still be monitored, but no actions are taken until the pressure falls below a certain value (e.g., a low band pressure value). If the water pressure falls below the low band pressure, the controller 75 can restart the motor 11. In some embodiments, the low band pressure can be set, or defaulted, to 1-10 pounds per square inch (PSI) lower than the pressure set point. Once the motor 11 is restarted, normal operation with PID control (i.e., PID mode) can commence. In one embodiment, one of two conditions can trigger the controller 75 to turn the motor 11 off. A first condition can be if a sleep mode (described with respect to FIG. 12) is triggered. A second condition can be if the pressure exceeds a certain safety value (i.e., about 20 PSI above the pressure set point). Other conditions that can stop the drive 10 are various faults (described further below), the user pressing the stop button 60, and lack of a digital input for an optional run enable mode.

[0086] For normal operation, with the motor 11 being driven, the controller 75 can regulate pump speed in a continuous fashion using PID control as long as the pressure remains below the safety pressure value, such as about 20 PSI above the pressure set point. The drive 10 can stop the motor 11 whenever the actual pressure exceeds the safety pressure value. During normal operation, as long as water usage does not exceed the motor/pump capabilities, the pressure can remain constant at approximately the pressure set point. Large instantaneous changes in flow requirements can result in variations from the desired pressure band. For example, if flow is

stopped, causing the pressure to quickly increase, the motor 11 can be stopped (i.e., set to 0 Hz). This can be considered an alternate sleep mode operation and is further described below with respect to FIG. 13.

[0087] FIGS. 7-15 are flow charts describing pump control according to some embodiments of the invention. The flow chart of FIG. 7 illustrates when the controller 75 receives a signal to run the pump in the pump out mode 76 (e.g., when the pump-out button 40 is pressed). The controller 75 first determines, at step 78, if the pump is already running in pump out mode. If so, the pump is being run at a correct, fixed frequency for pump out mode (step 80). If not, the controller 75, at step 82, ramps up the input frequency of power to the motor 11 to the correct frequency, then proceeds to step 80.

[0088] FIG. 8 illustrates an automatic line fill operation 84, according to some embodiments. This operation can automatically run at drive start-up (e.g., when the drive 10 is powered up, after a power interruption, when the motor 11 is restarted, or when the automatic start button 62 is pressed). Thus, the motor may be off (i.e., at 0 Hz) at the beginning of this operation. The controller 75 first can ramp up the frequency driving the motor from 0 Hz to about 45 Hz in less than a first time period, such as about two seconds (step 86). In a second time period, such as about two minutes, or about five minutes in some embodiments, the controller 75 can start to ramp up the frequency from, for example, about 45 Hz to about 55 Hz (step 88). During the second time period, the controller 75 determines the pressure via input from the pressure transducer 15 (step 90). If the sensed pressure has reached a minimum pressure, or pressure set point (e.g., about 10 PSI), indicating the line has been filled, the fill operation is completed and the controller 75 enters PID mode (step 92). However, if the sensed pressure is less than 10 PSI at step 90, the controller 75 determines if the second time period (e.g., about two minutes or about five minutes) has passed (step 94). If the second period has not passed, the controller 75 reverts back to step 88 and continues to ramp the motor frequency. If the second time period has passed, the controller 75 will hold the frequency at about 55 Hz for about one minute (step 96). The controller 75 then determines if the sensed pressure is about 10 PSI (step 98). If the sensed pressure is about 10 PSI, indicating the line has been filled, the fill operation is completed and the controller 75 enters PID mode (step 92). However, if the sensed pressure is still less than 10 PSI at step 90, the controller 75 determines if one minute has passed (step 100). If one minute

has not passed, the controller 75 reverts back to step 96. If one minute has passed, a dry run fault is recognized and a dry run fault operation is executed (step 102) (e.g., the system is stopped).

[0089] In one alternative embodiment, step 88 can include setting the frequency to about 45 Hz for the second time period, and if the sensed pressure is less than 10 PSI after the second time period, repeating step 88 with the frequency set to about 50 Hz for another second time period. If the sensed pressure is still less than 10 PSI after the second time period while at 50 Hz, step 88 can be repeated with the frequency set to about 55 Hz for yet another second time period. If the sensed pressure is still less than 10 PSI after the second time period while at 55 Hz, the controller 75 can continue to step 96.

[0090] FIG. 9 illustrates a manual line fill operation 104, according to some embodiments. The motor 11 is run at a manually-controlled frequency (e.g., entered by a user) at step 106. The motor 11 keeps running at this frequency until the sensed pressure reaches about 10 PSI (step 108). Once the sensed pressure has reached about 10 PSI, the controller 75 enters PID mode (step 110). In some embodiments, if the controller 75 does not enter PID mode within a time period (e.g., fifteen minutes), the drive 10 is stopped.

[0091] The manual fill line operation can be considered always enabled because it can be executed at any time during the auto line fill operation. For example, by using the up and down directional buttons 52 on the control pad 14, the user can interrupt the automatic line fill operation and adjust the frequency output to the motor 11, thus changing the motor speed. Once in manual line fill mode, the user can continue to change the speed as needed at any time. The motor 10 can continue at the new set frequency until the sensed pressure reaches about 10 PSI, and then it will proceed to PID mode, as described above. The manual fill line operation can be beneficial for both vertical or horizontal pipe fill applications. In addition, both the automatic fill line operation and the manual fill line operation can prevent common motor issues seen in conventional systems, such as motor overloading and the occurrence of water hammering.

[0092] FIG. 10 illustrates a stop operation 112, according to some embodiments. The controller 75 determines if the pump is running (step 114). If the pump is not running (e.g., if the drive 10 is in sleep mode or a run enable command is not triggered), the drive 10 is stopped

(step 116). If the pump is running, the motor is allowed to coast to a stop (i.e., 0 Hz) at step 118, then proceeds to step 116.

[0093] FIG. 11 illustrates a PID mode operation 120, according to some embodiments. The controller 75 continuously determines if the pressure is at a programmed set point (step 122). If the pressure is not at the programmed set point, PID feedback control is used to ramp the frequency until the pressure reaches the set point (step 124).

[0094] FIG. 12 illustrates the controller 75, running in PID mode (at step 126), checking if the pump should enter a sleep mode. First, at step 128, the controller 75 determines if the frequency of the motor 11 is stable within about +/- 3 Hz (e.g., at a steady-state frequency). If not (step 130), a boost delay timer is reset and the controller 75 reverts to step 126. If the frequency of the motor 11 is stable, the boost delay timer is incremented at step 132. If, at step 134 the boost delay timer is not expired after being incremented, the controller 75 reverts back to step 126. However, if, at step 134 the boost delay timer has expired, the controller 75 proceeds to step 136 and the pressure is boosted (e.g., about 3 PSI above the pressure set point) for a short period of time (e.g., about 15 seconds or about 30 seconds).

[0095] Until the short period of time has passed (step 138), the controller 75 determines if the pressure stays between the pressure set point (e.g., about 10 PSI) and the boosted pressure (step 140). If, in that short period of time, the pressure falls outside (i.e., below) the range between the pressure set point and the boosted pressure, the controller 75 reverts back to step 126. If, however, the pressure stays between the pressure set point and the boosted pressure, the controller 75 then decrements the pressure over another short period of time (step 142). Until the short period of time has passed (step 144), the controller 75 determines if the pressure stays between the pressure set point (e.g., the steady-state pressure) and the boosted pressure (step 146). If, in that short period of time, the pressure falls outside the range between the pressure set point and the boosted pressure, indicating that there is flow occurring, the controller 75 reverts back to step 126. If, however, the pressure stays between the pressure set point and the boosted pressure, indicating no flow, the controller 75 then determines if the pressure is above the pressure set point (step 148). If not, the controller 75 reverts back to step 126. If the pressure is above the pressure set point, the pump enters the sleep mode causing the motor frequency to

coast down to 0 Hz (step 150) and a "sleep mode active" message to be displayed on the liquid crystal display 36 (step 152). While in sleep mode, at step 154, the controller 75 continuously determines if the pressure stays above a wakeup differential pressure (e.g., about 5 PSI below the pressure set point). If the pressure drops below the wakeup differential pressure, the controller 75 reverts back to step 126.

[0096] In some embodiments, the controller 75 will only proceed from step 126 to step 128 if the pressure has been stable for at least a minimum time period (e.g., one or two minutes). Also, when the controller 75 cycles from step 128 to step 130 and back to step 126, the controller 75 can wait a time period (e.g., one or two minutes) before again proceeding to step 128. In some embodiments, the controller 75 can determine if the motor speed is stable at step 128. In addition, the controller 75 can perform some steps of FIGS. 11 and 12 simultaneously.

[0097] By using the sleep mode operation, a separate device does not need to be purchased for the drive 10 (e.g., a flow meter). Further, the sleep mode operation can self-adjust for changes in pump performance or changes in the pumping system. For example, well pump systems often have changes in the depth of the water in the well both due to drawdown as well as due to time of year or drought conditions. The sleep mode operation can be executed independent of such changes. In addition, the sleep mode operation does not require speed conditions specific to the pump being used.

[0098] FIG. 13 illustrates the controller 75, running in PID mode, checking if the pump should enter an alternate sleep mode 156. First, at step 158, the controller 75 determines if pressure is at a preset value above the pressure set point (e.g., 20 PSI above the pressure set point). If not (step 160), a timer is reset and the controller 75 reverts to step 156. If the pressure is 20 PSI above the pressure set point, the timer is incremented at step 162. If, at step 164 the timer is less than a value, such as 0.5 seconds, the controller 75 reverts back to step 156. However, if, at step 164 the timer has exceeded 0.5 seconds, the controller 75 proceeds to step 166 and the timer is reset. The controller 75 then sets the motor frequency to 0 Hz (step 168) and displays a "sleep mode active" message 170 on the liquid crystal display 36. The controller 75 then again increments the timer (step 172) until the time reaches another value, such as 1 minute (step 174), and then proceeds to step 176. At step 176, the controller 75 keeps the motor

frequency at 0 Hz and displays a "sleep mode active" message 178 on the liquid crystal display 36 as long as the pressure is above a wakeup differential pressure (step 180). If the pressure drops below the wakeup differential pressure (e.g., water is being used), the controller 75 reverts back to step 156.

[0099] FIG. 14 illustrates an example of controller operation using the digital input. The controller 75 first recognizes a digital input (step 182). If an external input parameter is unused (step 184), the controller 75 takes no action whether the input is high or low (steps 186 and 188, respectively). If the external input parameter is set to a run enabled mode (step 190) and the input is high (e.g., indicating allowing the drive 10 to be run), the controller 75 determines if the drive 10 is running (step 192). If the drive 10 is running, the controller 75 can take no action (step 196) and continue in its current mode of operation. If the drive 10 is not running, the controller 75 can start an auto line fill operation (step 194), as described with reference to FIG. 8 (e.g., similar to actions taken if the auto start button 62 is pressed). If the external input parameter is set to a run enabled mode (step 190) and the input is low (e.g., indicating to stop the drive 10), the controller 75 can check if the drive 10 is stopped (step 198). If the drive 10 is not stopped, the controller 75 can execute a stop operation (step 200), as described with reference to FIG. 10. If the drive 10 is stopped, the controller 75 can take no action (step 202). If the external input parameter is set to an external fault mode (step 204) and the input is high (e.g., indicating an external fault), the controller 75 can perform an external fault operation (step 206), as described with reference to FIG. 47. If the external input parameter is set to an external fault mode (step 204) and the input is low (e.g., indicating there is no external fault), the controller 75 can clear any external fault indications (step 208). If the external input parameter is set to an external set point mode (step 210) and the input is high, the controller 75 sets the PID set point to "external" (step 212), for example, so that the digital input controls the pressure set point for PID pressure control. If the external input parameter is set to an external set point mode (step 210) and the input is low, the controller 75 sets the PID set point to "normal" (step 214), for example, so that the digital input has no control over the pressure set point for PID pressure control.

[00100] FIG. 15 illustrates controller operation of a relay output. When the drive 10 is powered (step 216), the controller 75 determines if a relay output parameter is unused (step 218). If so, the controller 75 turns the relay off (step 220). If not, the controller 75 determines if the

relay output parameter is set to a run mode (step 222). If the relay output parameter is set to a run mode (at step 222), the controller 75 determines if the drive 10 is running (step 224). The controller 75 will then turn the relay off if the drive 10 is not running (step 226) or turn the relay on if the drive 10 is running (step 228). If the relay output parameter is not set to a run mode (at step 222), the controller 75 determines if the relay output parameter is set to a fault mode (step 230). If so, the controller 75 determines, at step 232, if the drive 10 is tripped (e.g., a fault has occurred and the drive 10 has been stopped). The controller 75 will then turn the relay off if the drive 10 has not been tripped (step 234) or turn the relay on if the drive 10 has been tripped (step 236). For example, if an alarm is the relay output, the alarm can be activated if the drive 10 has been tripped to indicate the fault condition to the user.

[00101] FIGS. 16-29 are flow charts describing menu operations according to some embodiments of the invention. FIG. 16 illustrates a main menu 238 of the controller 75. The main menu 238 can include the following parameters: settings menu 240, motor 242, sensor 244, pipe break 246, dry run 248, I/O (input/output) 250, and reset to defaults 252. The user can view the main menu 238 on the liquid crystal display 36 using the main menu button 44 on the control pad 14. The user can then toggle up and down through the parameters of the main menu 238 using the directional buttons 52. The user can select a parameter using the enter button 56.

[00102] From the main menu 238, the user can select the settings menu 240. The user can toggle up and down through the settings menu 240 to view the following parameters, as shown in FIG. 17: time 254, PID control 256, sleep 258, password 260, and external set point 262.

[00103] FIG. 18 illustrates the user's options after selecting the time parameter 254 from the settings menu 240. The user can toggle up and down between setting a current hour 264 or a date 266. If the user selects the hour parameter 264, the user can enter a current time 268, and a time value for the controller 75 will be changed according to the user's input 270. If the user selects the date parameter 266, the user can enter a current date 272 and a date value for the controller 75 will be changed according to the user's input 270.

[00104] FIG. 19 illustrates the user's options after selecting the PID control parameter 256 from the settings menu 240. The following parameters can be chosen after selecting PID control 256: proportional gain 274, integral time 276, derivative time 278, derivative limit 280, and

restore to defaults 282. The user can select any of the parameters 274-282 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270.

[00105] FIG. 20 illustrates the user's options after selecting the sleep parameter 258 from the settings menu 240. The following parameters can be chosen after selecting sleep 258: boost differential 284, boost delay 286, wakeup differential 288, and restore to defaults 290. The user can select any of the parameters 284-290 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270. The parameters can be set to modify or adjust the sleep mode operation described with reference to FIG. 12.

[00106] FIG. 21 illustrates the user's options after selecting the password parameter 260 from the settings menu 240. The following parameters can be chosen after selecting password 260: password timeout 292 and password 294. The user can select any of the parameters 292-294 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270. The password timeout parameter 292 can include a timeout period value. If the control pad 14 is not accessed within the set timeout period, the controller 75 175 can automatically lock the control pad 14 (i.e., enter a password protection mode). To unlock the keys, or leave the password protection mode, the user must enter the password that is set under the password parameter 294. This is further described below with reference to FIG. 56.

[00107] FIG. 22 illustrates the user's options after selecting the external set point parameter 262 from the settings menu 240. The user can select the external set point parameter 296 to modify one or more preferences associated with the parameter 296, and appropriate values for the controller 75 will be changed 270.

[00108] FIG. 23 illustrates the user's options after selecting the motor parameter 242 from the main menu 238. The following parameters can be chosen after selecting motor 242: service factor amps 298, connection type 300, minimum frequency 302, maximum frequency 304, and restore to defaults 306. The connection type parameter 300 may only be available if the drive 10 is being used to run a single-phase motor. If the drive 10 is being used to run a three-phase motor, the connection type parameter 300 may not be provided. The user can select any of the

parameters 298-306 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270.

[00109] FIG. 24 illustrates the user's options after selecting the sensor parameter 244 from the main menu 238. The following parameters can be chosen after selecting sensor 244: minimum pressure 308, maximum pressure 310, and restore to defaults 312. The user can select any of the parameters 308-312 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270.

[00110] FIG. 25 illustrates the user's options after selecting the pipe break parameter 246 from the main menu 238. The following parameters can be chosen after selecting pipe break 246: enable pipe break detection 314 and number of days without sleep 316. The user can select either of the parameters 314-316 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270. In some embodiments, the number of days without sleep parameter 316 can include values in the range of about four hours to about fourteen days. The enable pipe break detection parameter 314 can allow the user to enable or disable pipe break detection.

[00111] FIG. 26 illustrates the user's options after selecting the dry run parameter 248 from the main menu 238. The following parameters can be chosen after selecting dry run 248: auto reset delay 318, number of resets 320, and reset window 322. The user can select either of the parameters 318-320 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270. The user can select the reset window parameter 322 to view a value 324 indicating a reset window of the controller 75. The reset window value can be based from the values chosen for the auto reset delay 318 and the number of resets 320. Thus, the reset window parameter 322 can be a view-only (i.e., non-adjustable) parameter.

[00112] FIG. 27 illustrates the user's options after selecting the I/O parameter 250 from the main menu 238. The following parameters can be chosen after selecting I/O 250: external input 326 and relay output 328. The user can select either of the parameters 326-328 to modify one or more preferences associated with the parameters, and appropriate values for the controller 75 will be changed 270.

[00113] FIG. 28 illustrates the user's options after selecting the reset to defaults parameter 252 from the main menu 238. The user can select the parameter 330 to change all values to factory default values 270.

[00114] FIG. 29 illustrates a backdoor parameter 332, according to some embodiments. With the backdoor parameter 332, the user can choose a parameter 334 not normally accessible through other menus. The user can select the parameter 334 to modify one or more preferences associated with the parameter, and appropriate values for the controller 75 will be changed 270. The parameter 334 that the user selects can be from a list of parameters 336. The list of parameters 336 can include one or more of the parameters disclosed above as well as other parameters.

[00115] FIGS. 30-47 are flow charts describing drive warnings and faults according to some embodiments of the invention. FIG. 30 illustrates an overheat prevention operation of the controller 75. When the drive 10 is running (step 338), the controller 75 first determines, at step 340, if a power module temperature is greater than a first temperature (e.g., 115 degrees Celsius). If so, an overheat fault operation is executed (step 342). If not, the controller 75 then determines, at step 344, if the power module temperature is greater than a second temperature (e.g., about 113 degrees Celsius). If so, the controller 75, at step 346, decreases the speed of the motor by a first value (e.g., about 12 Hz per minute) and continues to step 348. If not, the controller 75 then determines, at step 350, if the power module temperature is greater than a third temperature (e.g., about 110 degrees Celsius). If so, the controller 75, at step 352, decreases the speed of the motor by a second value (e.g., about 6 Hz per minute) and continues to step 348. If not, the controller 75 then determines, at step 354, if the power module temperature is greater than a fourth temperature (e.g., about 105 degrees Celsius). If so, the controller 75, at step 356, decreases the speed of the motor by a third value (e.g., about 3 Hz per minute) and continues to step 348. If not, the controller 75 proceeds to step 348. At step 348, the controller 75 determines if the speed has been reduced (i.e., if the controller 75 performed steps 346, 352, or 356). If so, the controller 75, at step 358, determines if the power module temperature is less than a fifth value (e.g., about 95 degrees Celsius). If the power module temperature is less than the fifth value, then the controller 75 increases the speed of the motor by a fourth value (e.g., about 1.5 Hz per minute) until the motor's original speed is reached (step 360) and a warning message "TPM: Speed

Reduced" is displayed (step 362). If the power module temperature is greater than the fifth value, the controller 75 proceeds straight to step 362. From step 362, the controller 75 reverts back to step 338, and repeats the above process. If, at step 348, the controller 75 determines that the speed has not been reduced (i.e., the controller 75 did not performed steps 346, 352, or 356), then the "TPM: Speed Reduced" warning message is cleared (step 364), the controller 75 reverts back to step 338, and the above operation is repeated. In some embodiments, the power module being monitored can be the drive 10 itself or various components of the drive 10 (e.g., a heat sink of the controller 75, the motor 11, or the pump 12).

[00116] FIG. 31 illustrates an overcurrent prevention operation of the controller 75. When the drive 10 is running (step 366), the controller 75 determines, at step 368, if the drive current is being limited (e.g., because it is above the reference service factor amps parameter 298 in FIG. 23). If so, a warning message "TPM: Service Amps" is displayed (step 370) and the Warning LED 70 is illuminated (step 372). The controller 75 then reverts back to step 366 where the operation is repeated. If the drive current is not being limited, the "TPM: Service Amps" warning message and the Warning LED 70 are cleared (step 374).

[00117] FIG. 32 illustrates a jam prevention operation of the controller 75. When the motor is triggered to start (step 376), the controller 75 determines, at step 378, if a startup sequence is completed. If so, a timer and a counter are reset (step 380), any warning messages are cleared (step 382), and the motor is operating (step 384). If the startup sequence is not completed at step 378, then the controller 75 proceeds to step 386 to check if current limitation is active. If not, the timer and the counter can be reset (step 388), and the controller 75 can proceed back to step 376. If the controller 75 detects that current limitation is active at step 386, then the timer is incremented (step 390). If the timer has not reached five seconds, at step 392, the controller 75 reverts back to step 376. However, if the timer has reached five seconds, at step 392, the controller 75 proceeds to step 396. The controller 75 sets a jam warning (step 396) and increments the counter (step 398). If the counter is greater than five, at step 400, the controller 75 executes a jam fault operation (step 402). If the counter is not greater than five, the controller 75 determines if it is controlling a two-wire motor (step 404). If yes, the controller 75 pulses the motor about three times (step 406), then proceeds back to step 376. If the motor is not a two-

wire (e.g., if the motor is a three-wire motor), the controller 75 executes a series of three forward-reverse cycles (step 408), then proceeds back to step 376.

[00118] FIG. 33 illustrates a line or pipe break fault operation of the controller 75. During PID control (step 410), the controller 75 determines if a pipe break parameter (e.g., pipe break detection parameter 314 from FIG. 25) is enabled (step 412). The controller 75 continues back to step 410 until the parameter is enabled. If the controller 75 determines that the parameter is enabled at step 412, a timer is incremented (step 414), and the controller 75 determines if the pump is in sleep mode (step 416). If the pump is in sleep mode, the timer is reset (step 418) and the controller 75 reverts back to step 410. If the pump is not in sleep mode, the controller 75, at step 420, determines if the timer has been incremented above a certain number of days (e.g., as set by the number of days without sleep parameter 316). If the timer has not exceeded the set number of days, then the controller 75 proceeds back to step 410. If the timer has exceeded the set number of days, the motor is coasted to a stop and a "possible pipe break" fault message is displayed (step 422), causing the drive 10 to be stopped (step 424).

[00119] FIG. 34 illustrates a dry run detection operation of the controller 75. During PID control (step 426), the controller 75 determines, at step 428, if the frequency output to the motor is greater than a frequency preset value (e.g., about 30 Hz). If so, a timer is reset (step 430) and the controller 75 reverts back to step 426. If the frequency is under the frequency preset value, the controller 75 then determines, at step 432, if the pressure is greater than a pressure preset value (e.g., about 10 PSI). If so, the timer is reset (step 430) and the controller 75 reverts back to step 426. If the pressure is under 10 PSI, the timer is incremented (step 434) and the controller 75 determines if the timer has reached 15 seconds (step 436). If not, the controller 75 reverts back to step 426. However, if the timer has reached 15 seconds, the controller 75 determines that a dry run has occurred and executes a dry run fault operation (step 438). The preset value in step 428 can be checked to ensure the motor 11 is operating at a normal operating frequency (e.g., above 30 Hz).

[00120] FIG. 35 illustrates a dry run fault operation of the controller 75. The controller 75 can proceed to step 440 if step 438 of FIG. 34 was reached. From step 440, the controller 75 can check if a reset counter value is less than a set value (e.g., the value set under the number of

resets parameter 320 of FIG. 26) at step 442. If the reset counter is not less than the set value, the controller 75 can update a fault log (step 444), coast the motor to a stop and display a "Dry Run" fault message (step 446), so that the drive 10 is stopped (step 448). If, at step 442, the reset counter is less than the set value, the reset counter is incremented (step 450) and the fault log is updated (step 452). The controller 75 can then coast the motor to a stop and display a "Dry Run - Auto Restart Pending" fault message (step 454), then start a fault timer (step 456), and continuously check if the user has pressed the fault reset button 64 (step 458) or if a timer has exceeded a time value (step 460). The time value can be the auto reset delay parameter 318 (shown in FIG. 26) set by the user. If the user presses the fault reset button 64, the controller 75 will proceed from step 458 to step 462 and clear the fault message displayed, then stop the drive 10 (step 448). If the timer exceeds the time value, the controller 75 will proceed from step 460 to step 464 and clear the fault message displayed, then restart the drive 10 in PID mode (step 466).

[00121] FIG. 36 illustrates a jam fault operation of the controller 75. When a jam has been detected (step 468), the fault log is updated (step 470). After step 470, the motor is coasted to a stop and a "Foreign Object Jam" fault message is displayed (step 472), then the drive 10 is stopped (step 474).

[00122] FIG. 37 illustrates an overtemperature fault operation of the controller 75. When the drive 10 is powered (step 476), the controller 75 determines if the power module temperature is too high (step 478), for example, using the overheat prevention operation in FIG. 30. If the power module temperature is not too high, the fault is cleared (step 480) and the controller 75 reverts back to step 476. If the power module temperature is too high, the fault log is updated (step 482), the motor is coasted to a stop and a "Drive Temp - Auto Restart Pending" fault message is displayed (step 484), and a fault timer is incremented (step 486). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 488) until the timer has been incremented past a value (step 490). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 488 or step 490, respectively, to step 492 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 486. If the fault condition is not present, the controller 75 clears the fault (step 480) and reverts back to step 476.

[00123] The motor 11 and pump 12 combination can satisfy typical performance requirements as specified by the pump manufacturer while maintaining current under service factor amps as specified for the motor 11. Performance can match that of a typical capacitor start/capacitor run control box for each motor HP offering. If the motor 11 performs outside of such specifications, the controller 75 can generate a fault and stop the motor 11. For example, FIG. 38 illustrates an overcurrent fault operation of the controller 75. When the drive 10 is powered (step 494), the controller 75 determines if there is a high current spike (step 496), for example, using the overcurrent prevention operation of FIG. 31. If there is no high current spike, the fault is cleared (step 498) and the controller 75 reverts back to step 494. If there a high current spike, the fault log is updated (step 500), the motor is coasted to a stop and a "Motor High Amps - Auto Restart Pending" fault message is displayed (step 502), and a fault timer is incremented (step 504). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 506) until the timer has been incremented past a value (step 508). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 506 or step 508, respectively, to step 510 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 504. If the fault condition is not present, the controller 75 clears the fault (step 498) and reverts back to step 494.

[00124] FIG. 39 illustrates an overvoltage fault operation of the controller 75. When the drive 10 is powered (step 512), the controller 75 determines if a maximum bus voltage has been exceeded (step 514). If the bus voltage has not exceeded the maximum value, the fault is cleared (step 516) and the controller 75 reverts back to step 512. If the bus voltage has exceeded the maximum value, the fault log is updated (step 518), the motor is coasted to a stop and an "Over Voltage - Auto Restart Pending" fault message is displayed (step 520), and a fault timer is incremented (step 522). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 524) until the timer has been incremented past a value (step 526). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 524 or step 526, respectively, to step 528 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 522. If the fault condition is not present, the controller 75 clears the fault (step 516) and reverts back to step 512.

[00125] FIG. 40 illustrates an internal fault operation of the controller 75. When the drive 10 is powered (step 530), the controller 75 determines if any internal voltages are out of range (step 532). If the internal voltages are not out of range, the fault is cleared (step 534) and the controller 75 reverts back to step 530. If the internal voltages are out of range, the fault log is updated (step 536), the motor is coasted to a stop and an "Internal Fault - Auto Restart Pending" fault message is displayed (step 538), and a fault timer is incremented (step 540). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 542) until the timer has been incremented past a value (step 544). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 542 or step 544, respectively, to step 546 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 540. If the fault condition is not present, the controller 75 clears the fault (step 534) and reverts back to step 530.

[00126] FIG. 41 illustrates a ground fault operation of the controller 75. When the drive 10 is powered (step 548), the controller 75 continuously determines if there is current flow between an earth, or ground, lead and any motor lead (step 550). If so, the fault log is updated (step 552), the motor is coasted to a stop and a "Ground Fault" fault message is displayed (step 554), and the drive 10 is stopped (step 556).

[00127] FIG. 42 illustrates an open transducer fault operation of the controller 75. While in PID mode (step 558), the controller 75 determines if a current measured at the transducer input is less than a value, such as 2 milliamps (step 560). If the current is not less than the value, the controller 75 reverts back to step 558. If the current is less than the value, the fault log is updated (step 562), the motor is coasted to a stop and an "Open Transducer - Auto Restart Pending" fault message is displayed (step 564), and a fault timer is incremented (step 566). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 568) until the timer has been incremented past a value (step 570). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 568 or step 570, respectively, to step 572 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 566. If the fault condition is not present, the controller 75 reverts back to step 558.

[00128] FIG. 43 illustrates a shorted transducer fault operation of the controller 75. While in PID mode (step 574), the controller 75 determines if a current measured at the transducer input is greater than a value, such as 25 milliamps (step 576). If the current is not greater than the value, the controller 75 reverts back to step 574. If the current is greater than the value, the fault log is updated (step 578), the motor is coasted to a stop and a "Shorted Transducer - Auto Restart Pending" fault message is displayed (step 580), and a fault timer is incremented (step 582). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 586) until the timer has been incremented past a value (step 588). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 586 or step 588, respectively, to step 590 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 582. If the fault condition is not present, the controller 75 reverts back to step 574.

[00129] FIGS. 44A-44B illustrate a multiple faults operation of the controller 75. Referring to FIG. 44A, when the drive 10 is powered (step 592), the controller 75 continuously determines if a fault has occurred (step 594). If a fault has a occurred, a counter is incremented (step 596) and the controller 75 determines if the counter has reached a value, such as ten (step 598). If the counter has reached the value, the motor is coasted to a stop and a "Multiple Faults" fault message is displayed (step 600), and the drive 10 is stopped (step 602). The steps of FIG. 44B serve to provide a time frame for which the counter can reach the value. When the drive 10 is powered (step 592), the controller 75 continuously determines if the counter (i.e., the counter in step 596 of FIG. 44A) has been incremented (step 604). If so, a timer is incremented (step 606). The controller 75 continues to increment the timer as long as the counter is above zero until the timer reaches a value, such as thirty minutes (step 608). Once the timer has reached the value, the counter is decremented and the timer is reset (step 610).

[00130] FIG. 45 illustrates an undervoltage fault operation of the controller 75. When the drive 10 is powered (step 612), the controller 75 determines if the bus voltage is below a minimum value (step 614). If the bus voltage is not below the minimum value, the fault is cleared (step 616) and the controller 75 reverts back to step 612. If the bus voltage is below the minimum value, the fault log is updated (step 618), the motor is coasted to a stop and an "Under Voltage - Auto Restart Pending" fault message is displayed (step 620), the fault log is saved in

memory, such as the device's electrically erasable programmable read-only memory, or EEPROM (step 622) and a fault timer is incremented (step 624). The controller 75 then continuously determines if the user has pressed the fault reset button 64 (step 626) until the timer has been incremented past a value (step 628). If the user has pressed the fault reset button 64 or if the timer has incremented past the value, the controller 75 proceeds from step 626 or step 628, respectively, to step 630 to check if the fault condition is still present. If the fault condition is still present, the controller 75 reverts back to step 624. If the fault condition is not present, the controller 75 clears the fault (step 616) and reverts back to step 612.

[00131] FIG. 46 illustrates a hardware fault operation of the controller 75. When the controller 75 recognizes a hardware error (step 632), the fault log is updated (step 634). After step 634, the motor is coasted to a stop and a "Hardware Error" fault message is displayed (step 636), then the drive 10 is stopped (step 638).

[00132] FIG. 47 illustrates an external fault operation of the controller 75. When the drive 10 is powered (step 640), the controller 75 continuously determines if an external fault parameter is present, for example, from a relay input at the input power terminal block 28 or the digital input/output (I/O) spring terminals 30 (step 642). If so, the controller 75 determines if a digital input is high (step 644). If the digital input is not high, the controller 75 determines if the external fault is active (step 646). If the external fault is not active, the controller 75 reverts back to step 640. If the external fault is active, the controller 75 clears an "external fault" fault message (if it is being displayed) at step 648 and the device's previous state and operation are restored (step 650). If, at step 644, the digital input is high, the fault log is updated (step 652) and the device's current state and operation are saved (step 654). Following step 654, the motor is coasted to a stop and a "External Fault" fault message is displayed (step 656), then the drive 10 is stopped (step 658).

[00133] FIGS. 48-63 are flow charts describing control operations for the control pad 14 according to some embodiments of the invention. FIG. 48 illustrates a pump-out button control operation, according to some embodiments. When the pump-out button 40 is pressed (step 660), the controller 75 first determines if the control pad 14 is locked, or in the password protection mode (step 662). If so, the controller 75 executes a keys locked error operation (step 664). If

not, a valve screen 666 is displayed (step 668) asking the user if a valve is open. Once the user chooses if the valve is open or not and presses enter, a valve parameter value is changed (step 670). The controller 75 then determines, at step 672, if the valve parameter value is yes (i.e., if the valve is open). If the valve parameter is not yes (i.e., if the user selected that the valve was not open), a stopped screen is displayed (step 674), indicating that the pump 12 is stopped. If the valve parameter is yes, the controller 75 sets LED indicators 66 on or off accordingly (step 676), displays a status screen 678 (step 680), and runs the pump out operation to drive the motor 11 in the pump out mode (step 682). The status screen 678 can include information about the pump 12, such as motor frequency, pressure, and motor current during the pump out mode.

[00134] FIG. 49 illustrates a pressure preset button control operation, according to some embodiments. When the pressure preset button 42 is pressed (step 684), the controller 75 first determines if the control pad 14 is locked (step 686). If so, the controller 75 executes a keys locked error operation (step 688). If the control pad 14 is not locked, the controller 75 sets the LED indicators 66 on or off accordingly (step 690) and a preset pressure parameter is displayed (step 692). The user can adjust the displayed pressure parameter using the keypad and hit enter to change the value of the preset pressure parameter, changing the pressure set point for the controller 75 (step 694).

[00135] FIG. 50 illustrates a main menu button control operation, according to some embodiments. When the main menu button 44 is pressed (step 696), the controller 75 first determines if the control pad 14 is locked (step 698). If so, the controller 75 executes a keys locked error operation (step 700). If the control pad 14 is not locked, the controller 75 sets the LED indicators 66 on or off accordingly (step 702) and the main menu, as described with respect to FIG. 16, is displayed (step 704).

[00136] FIG. 51 illustrates a fault log button control operation, according to some embodiments. When the fault log button 46 is pressed (step 706), the controller 75 sets the LED indicators 66 on or off accordingly (step 708) and the fault log is displayed, detailing fault history information to the user (step 710).

[00137] FIG. 52 illustrates an enter button control operation, according to some embodiments. When the enter button 56 is pressed (step 712), the controller 75 first determines if the fault log

is active (e.g., being displayed) at step 714 or if the stopped status screen is being displayed (step 716). If either step 714 or step 716 is true, the controller 75 executes an invalid key error operation (step 718). If neither the fault log or stopped status screen are being displayed, the controller 75 determines if the control pad 14 is locked (step 720). If so, the controller 75 executes a keys locked error operation (step 722). If the control pad 14 is not locked, the controller 75 determines if the display currently selecting a menu option or a parameter (step 724). If the display is currently selecting a menu option, the controller 75 will enter the selected menu (step 726). If the display is currently selecting a parameter option, the controller 75 determines if the parameter is highlighted (step 728). If the parameter is highlighted, the controller 75 saves the value of the selected parameter and cancels the highlighting of the parameter (step 730). If, at step 728, the parameter is not highlighted, the controller 75 determines if the parameter can be changed with the motor is running and the drive 10 is stopped (step 732). If not, a running error operation is executed (step 734). If the parameter may be changed, then the selected parameter is highlighted (step 736).

[00138] FIG. 53 illustrates a back button control operation, according to some embodiments. When the back button 54 is pressed (step 738), the controller 75 determines if a status screen is being displayed (step 740). If so, an invalid key error operation is executed (step 742). If a status screen is not being displayed, the controller 75 determines if a line in the display is highlighted (step 744). If so, the new value on the highlighted line is cancelled and the highlighting is cancelled as well (step 746). If, at step 744, there is no highlighted line, the parent, or previous, menu is displayed (step 748).

[00139] FIG. 54 illustrates an up/down button control operation, according to some embodiments. When either the up or down directional button 52 is pressed (step 750), the controller 75 determines if a line in the display is highlighted (step 752). If so, the controller 75 then determines if the auto line fill operation is being executed (step 754). If so, the controller 75 proceeds to the manual line fill operation (step 756), as described with reference to FIG. 9, then scrolls to another value in the display (step 758). If the controller 75 determines that the auto line fill operation is not being executed at step 754, the controller 75 proceeds to step 758 and scrolls to another value in the display. If, at step 752, the controller 75 determines that no line is highlighted, the controller 75 then determines if a menu in the display can be scrolled (step 760).

If so, the menu is scrolled (step 762). If not, an invalid key error operation is executed (step 764).

[00140] FIG. 55 illustrates a left/right button control operation, according to some embodiments. When either the left or right directional button 52 is pressed (step 766), the controller 75 determines if a line in the display is highlighted (step 768). If not, an invalid key error operation is executed (step 770). If, at step 768, the controller 75 determines that the line is highlighted, the controller 75 then determines if a curser in the display can be moved (step 772). If so, the curser is moved (step 774). If not, an invalid key error operation is executed (step 776).

[00141] FIG. 56 illustrates a password button control operation, according to some embodiments. When the password button 48 is pressed (step 778), the controller 75 first determines if the control pad 14 is locked (step 780). If not, a status screen is displayed (step 782). If the control pad 14 is locked, the controller 75 sets the LED indicators 66 on or off accordingly (step 784) and executes a keys locked error operation (step 786). If a user then enters a password (step 788), the controller 75 determines if the password is correct (step 790). If the password is correct, any lockable keys are unlocked (step 792) and the status screen is displayed (step 794). If the password is incorrect, an invalid password error operation is executed (step 796), then the status screen is displayed (step 794). In some embodiments, the lockable keys can include the directional buttons 52, the language button 50, the pump-out button 40, the pressure preset button 42, and/or the main menu button 44.

[00142] FIG. 57 illustrates a language button control operation, according to some embodiments. When the language button 50 is pressed (step 796), the controller 75 first determines if the control pad 14 is locked (step 798). If so, the controller 75 executes a keys locked error operation (step 800). If the control pad 14 is not locked, the controller 75 sets the LED indicators 66 on or off accordingly (step 802) and a language parameter is displayed (step 804). The user can change the displayed language using the keypad and hit enter to update the language parameter (step 806).

[00143] FIG. 58 illustrates a status button control operation, according to some embodiments. When the status button 58 is pressed (step 808), the controller 75 sets the LED indicators 66 on or off accordingly (step 810) and determines if a current status screen is being displayed (step

812). If not, the current status screen 814 or 816 is displayed (step 818). If the controller 75, at step 812, determines that the current status screen is being displayed, the currents status screen is cleared and a power status screen 820 or 822 is displayed (step 824).

[00144] FIG. 59 illustrates a stop button control operation, according to some embodiments. When the stop button 60 is pressed (step 826), the controller 75 sets the LED indicators 66 on or off accordingly (step 828) and a stopped status screen 830 is displayed (step 832). The controller 75 then stops the drive 10 (step 834), as described with reference to FIG. 10.

[00145] FIG. 60 illustrates an automatic start button control operation, according to some embodiments. When the automatic start button 62 is pressed (step 836), the controller 75 sets the LED indicators 66 on or off accordingly (step 838) and a status screen 840 is displayed (step 842). The controller 75 then runs the automatic line fill operation (step 844), as described with reference to FIG. 8.

[00146] FIG. 61 illustrates a fault reset button control operation, according to some embodiments. When the fault reset button 64 is pressed (step 846), the controller 75 determines if there is an active fault (step 848). If not, the controller 75 executes an invalid key error operation (step 850). If there is an active fault, the controller 75 determines if the fault condition is still present (step 852). If so, the controller 75 stops the drive 10 (step 854), as described with reference to FIG. 10. If not, the controller 75 first clears the fault (step 856), then stops the drive 10 (step 854).

[00147] FIGS. 62A-62D illustrate LED indicator control operations, according to some embodiments. As shown in FIG. 62A, if a fault is active and a restart is pending (step 856), the Fault LED 72 blinks (step 858), and a "Restart Pending" message is displayed (step 860). As shown in FIG. 62B, if a fault is active and the drive 10 is stopped (step 862), the Fault LED 72 blinks (step 864), and a "Drive Stopped" message is displayed (step 866). As shown in FIG. 62C, if a TPM is active and the drive 10 is still running (step 868), the Warning LED 70 is lit (step 870), and a message is displayed describing the warning (step 872). As shown in FIG. 62D, when the drive 10 is powered up (step 874), the ON LED 68 is lit (step 876).

[00148] FIGS. 63A-63D illustrate error display control operations, according to some embodiments. As shown in FIG. 63A, for the invalid key error operation (step 878), a "Key Error! Invalid Key!" error screen can be displayed (step 880). The controller 75 can display the error screen for a time period, such as 0.9 seconds (step 882), then return the display to the previous screen (step 884). As shown in FIG. 63B, for the keys locked error operation (step 886), an "Error! Press Password Key" error screen can be displayed (step 888). The controller 75 can display the error screen for a time period, such as 0.9 seconds (step 890), then return the display to the previous screen (step 892). As shown in FIG. 63C, for the invalid password error operation (step 894), an "Error! Invalid Password!" error screen can be displayed (step 896). The controller 75 can display the error screen for a time period, such as 0.9 seconds (step 898), then return the display to the previous screen (step 900). As shown in FIG. 63D, for the running error operation (step 902), an "Error! Stop before editing" error screen can be displayed (step 904). The controller 75 can display the error screen for a time period, such as 0.9 seconds (step 906), then return the display to the previous screen (step 908).

[00149] It will be appreciated by those skilled in the art that while the invention has been described above in connection with particular embodiments and examples, the invention is not necessarily so limited, and that numerous other embodiments, examples, uses, modifications and departures from the embodiments, examples and uses are intended to be encompassed by the claims attached hereto. The entire disclosure of each patent and publication cited herein is incorporated by reference, as if each such patent or publication were individually incorporated by reference herein. Various features and advantages of the invention are set forth in the following claims.

CLAIMS

1. A method of controlling a pump driven by a motor, the pump in fluid communication with a fluid system, the method comprising:

determining whether the motor has reached a steady state operating frequency;

causing the pump to temporarily boost a pressure in the fluid system once the motor has reached a steady state operating frequency;

determining whether the pressure in the fluid system drops after being temporarily boosted; and

causing the pump to enter a sleep mode if the pressure does not drop after being temporarily boosted.

2. The method of claim 1 and further comprising causing the pump to continue normal operation if the pressure does drop after being temporarily boosted.

3. The method of claim 2 and further comprising periodically determining whether the motor has reached a steady state operating frequency again.

4. The method of claim 3 and further comprising determining whether the motor has reached a steady state operating frequency about every two minutes.

5. The method of claim 1 wherein determining whether the motor has reached a steady state operating frequency includes determining whether the speed of the motor is steady.

6. The method of claim 1 wherein entering the sleep mode is independent of well depth.

7. The method of claim 1 and further comprising boosting the pressure by about three pounds per square inch.

8. The method of claim 7 and further comprising determining whether the pressure drops below a pressure set point.

9. The method of claim 1 and further comprising disabling the sleep mode when the pressure drops to below a pressure set point minus about five pounds per square inch.

10. The method of claim 1 and further comprising determining whether the motor has reached a steady state operating frequency by determining whether a frequency of the motor has stayed constant for at least about one minute.

11. The method of claim 1 and further comprising determining whether the pressure in the fluid system drops within about 15 seconds after being temporarily boosted.

12. A method of controlling a pump driven by a motor, the pump in fluid communication with a fluid system, the method comprising:

causing the pump to enter a sleep mode if a pressure in the fluid system does not drop after being temporarily boosted;

determining whether the pump has entered the sleep mode during a predetermined time period; and

shutting down the pump due to a pipe break fault if the pump has not entered the sleep mode during the predetermined time period.

13. The method of claim 12 wherein the predetermined time period is at least about four hours.

14. The method of claim 12 wherein the predetermined time period is up to about fourteen days.

15. The method of claim 12 and further comprising determining whether the motor has reached a steady state operating frequency.

16. The method of claim 15 and further comprising causing the pump to temporarily boost the pressure in the fluid system once the motor has reached a steady state operating frequency.

17. The method of claim 12 and further comprising indicating on a display that there has been a pipe break fault.

18. The method of claim 12 and further comprising automatically causing a relay output to be energized when there is a pipe break fault.

19. The method of claim 12 and further comprising modifying the predetermined time period.

20. The method of claim 12 and further comprising temporarily disabling the pipe break fault.

21. A method of controlling a pump driven by a motor, the pump in fluid communication with a fluid system, the method comprising:

determining a pressure in the fluid system when the pump starts;

operating the motor in a line fill mode at a low frequency for a time period if the pressure in the fluid system is less than a minimum pressure set point in order to fill the fluid system; and

operating the motor at a normal frequency after the minimum pressure set point is reached in order to increase the pressure to a normal pressure set point.

22. The method of claim 21 and further comprising operating the motor at a low frequency until the pressure reaches a pressure set point of about 10 pounds per square inch.

23. The method of claim 21 and further comprising operating the motor at a low frequency for a time period of about five minutes.

24. The method of claim 21 and further comprising operating the motor at a low frequency of about 45 Hertz.

25. The method of claim 24 and further comprising operating the motor at about 45 Hertz for about one minute to about five minutes, then operating the motor at about 45 Hertz to about 50 Hertz for about three minutes to about five minutes, and then operating the motor at about 55 Hertz for about one minute, if the pressure has not reached the minimum pressure set point.

26. The method of claim 25 and further comprising operating the motor at about 55 Hertz for about five minutes if the pressure has not reached the minimum pressure set point.

27. The method of claim 21 and further comprising automatically operating the motor in the line fill mode unless a manual interrupt feature is enabled.

28. The method of claim 27 and further comprising enabling the manual interrupt feature by manually changing a speed of the motor.

29. The method of claim 21 and further comprising operating the motor in the line fill mode in order to help prevent water hammering.

30. The method of claim 21 and further comprising operating the motor in the line fill mode after the motor has been manually stopped and then started again.

31. The method of claim 21 and further comprising operating the motor at the normal frequency after the line fill mode and increasing the pressure up to a normal pressure set point of about 60 pounds per square inch.

32. A controller for a pump driven by a motor, the pump in fluid communication with a fluid system, the controller comprising:

a variable frequency drive circuit that controls operation of the pump; and

a control panel connected to the variable frequency drive circuit,

the control panel including an automatic start button and a stop button,

the variable frequency drive circuit automatically operating in a line fill mode when the pump starts when the automatic start button is engaged,

the variable frequency drive circuit disabling the pump when the stop button is engaged.

33. The controller of claim 32 wherein the variable frequency drive circuit operates in the line fill mode by determining a pressure in the fluid system when the pump starts.

34. The controller of claim 33 wherein the variable frequency drive circuit operates the motor at a low frequency for a time period if the pressure in the fluid system is less than a minimum pressure set point in order to fill the fluid system.

35. The controller of claim 34 wherein the variable frequency drive circuit operates the motor at a normal frequency after the timer period has expired in order to maintain a normal pressure set point.

36. The controller of claim 32 wherein the variable frequency drive circuit automatically starts and operates in the line fill mode after a power interruption if the automatic start button is engaged.

37. A method of controlling a pump driven by a motor, the pump in fluid communication with a fluid system, the method comprising:

operating the motor at a normal operating frequency;

determining an actual pressure in the fluid system;

comparing the actual pressure to a pressure set point; and

generating a dry run fault if the pressure set point cannot be achieved by operating the motor at the normal operating frequency.

38. The method of claim 37 and further comprising operating the motor at a normal operating frequency above about 30 Hertz.

39. The method of claim 37 and further comprising comparing the actual pressure to a pressure set point of about 10 pounds per square inch.

40. The method of claim 37 and further comprising determining an actual pressure adjacent to a pressure tank fluidly coupled to the pump.

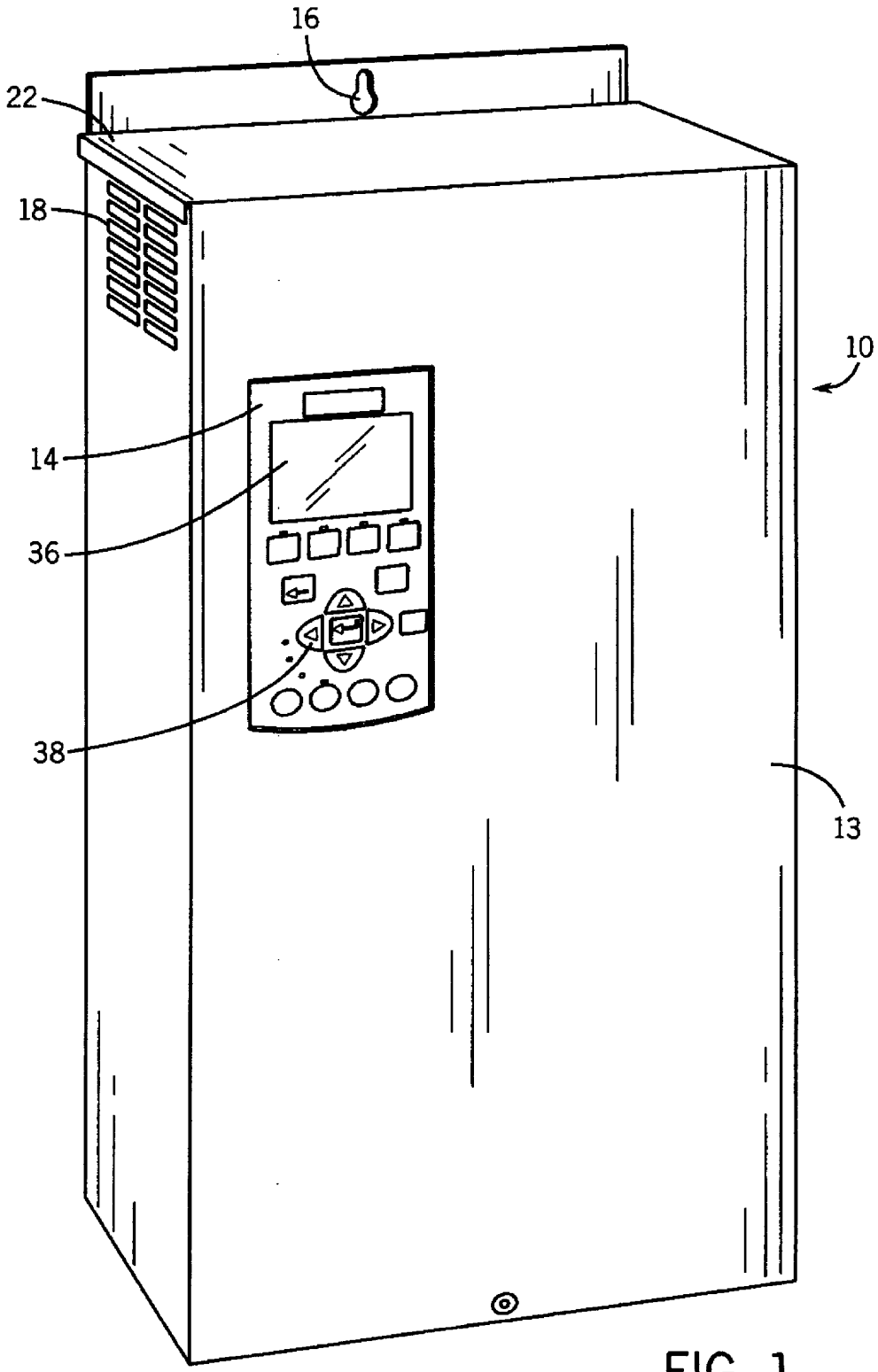


FIG. 1

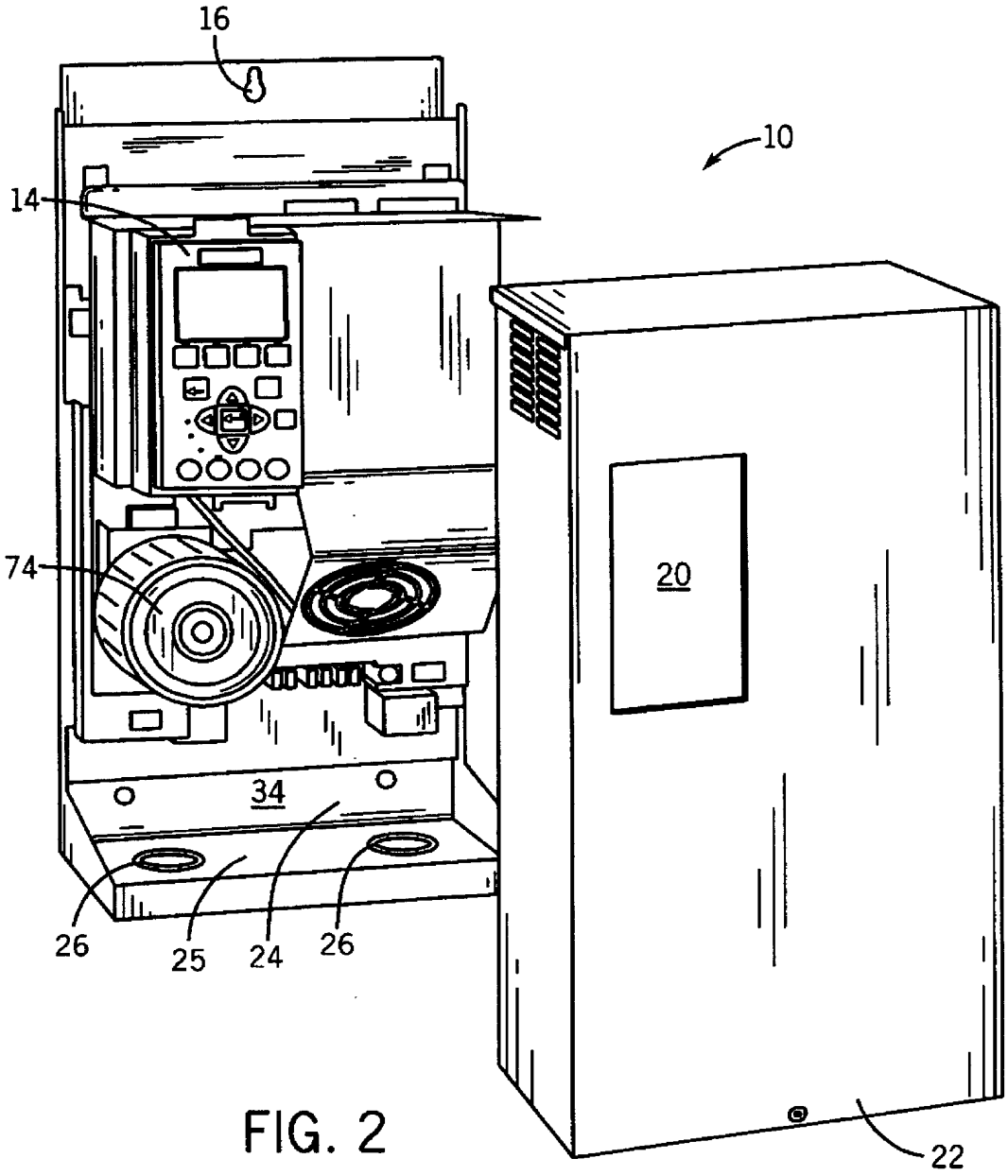


FIG. 2

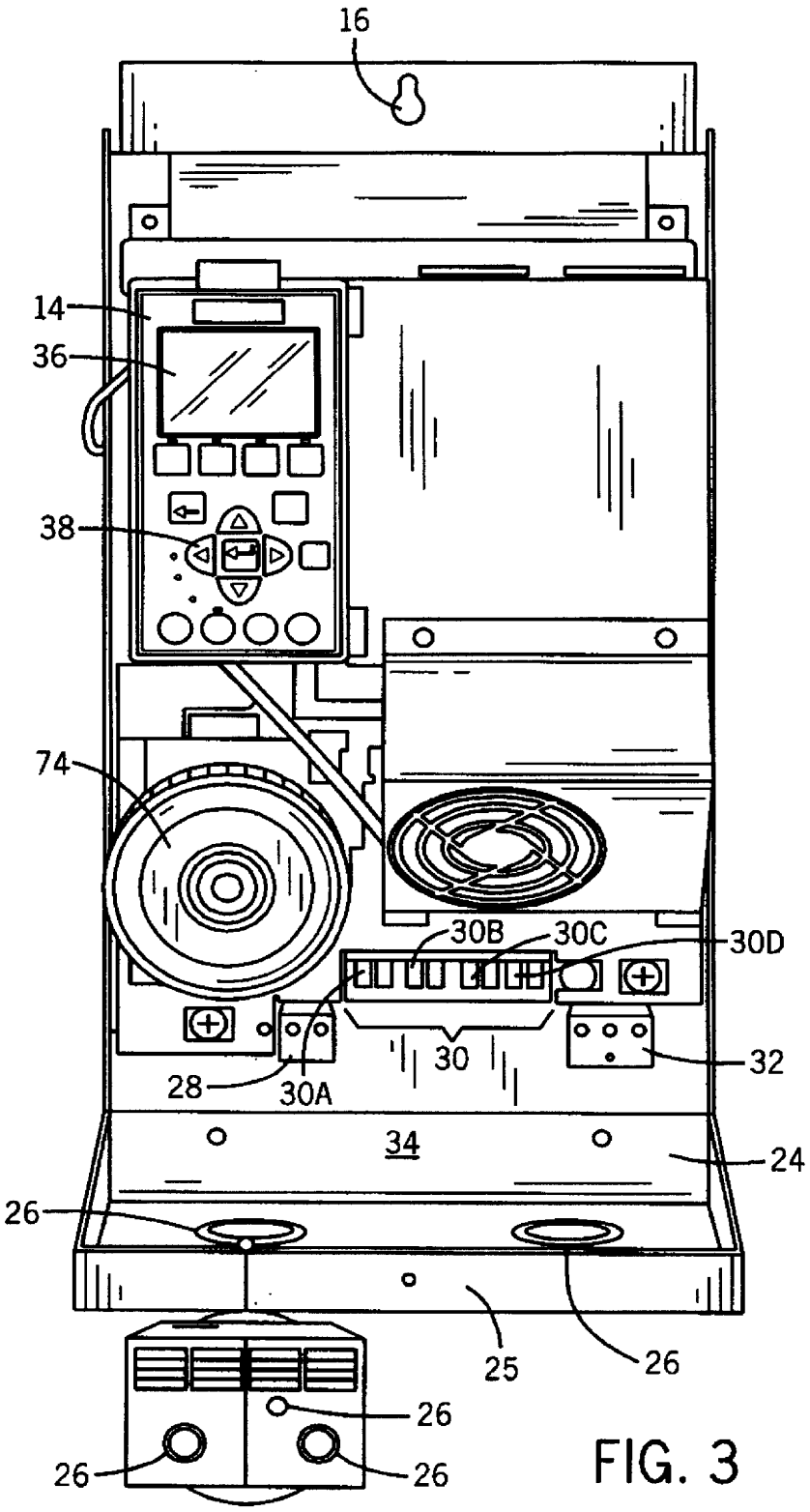


FIG. 3

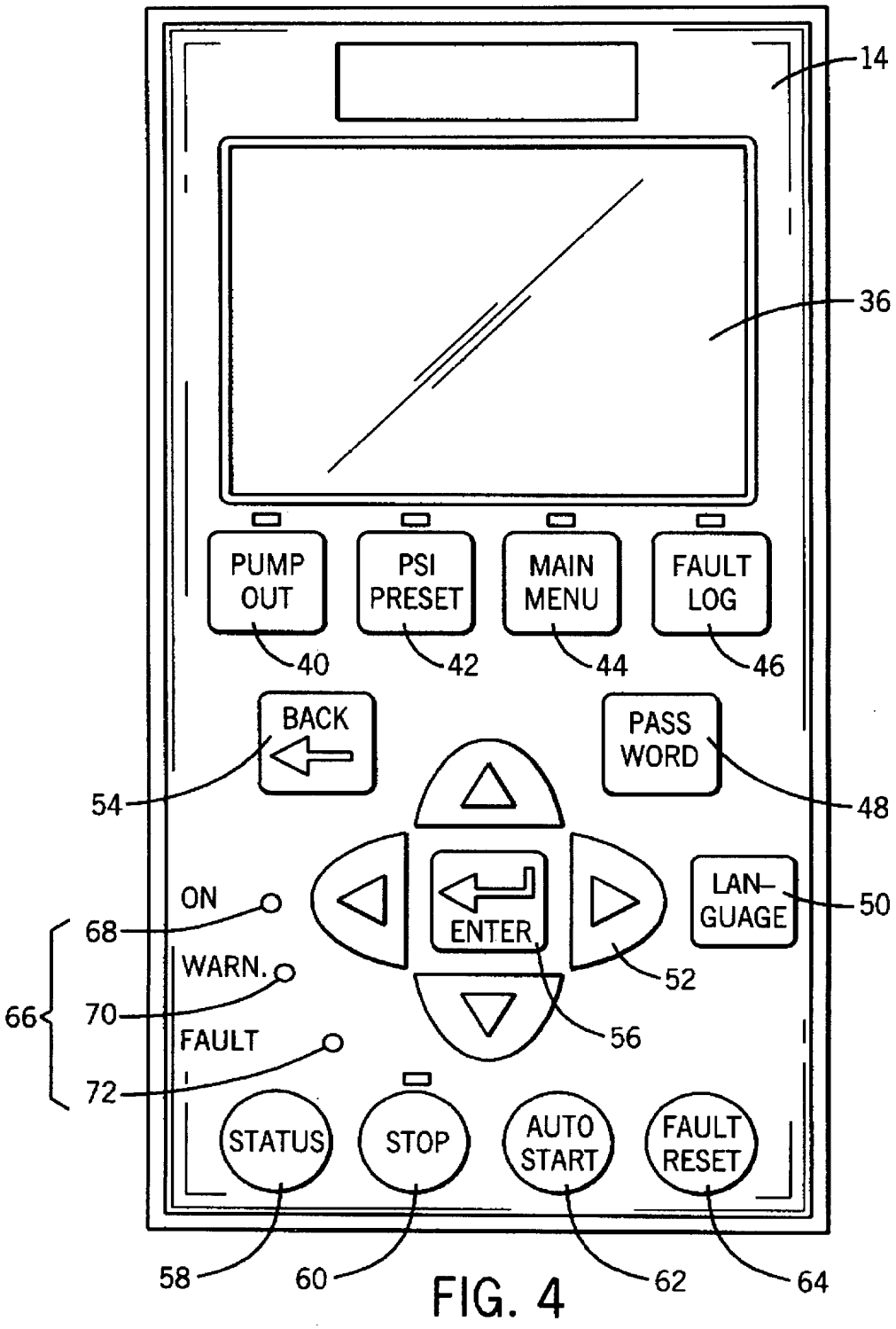

14
36
PUMP OUT
PSI PRESET
MAIN MENU
FAULT LOG
40
42
44
46
BACK
PASS WORD
54
48
ON
68
WARN.
70
FAULT
72
66
ENTER
LAN-GUAGE
50
52
56
STATUS
STOP
AUTO START
FAULT RESET
58
60
62
64

FIG. 4

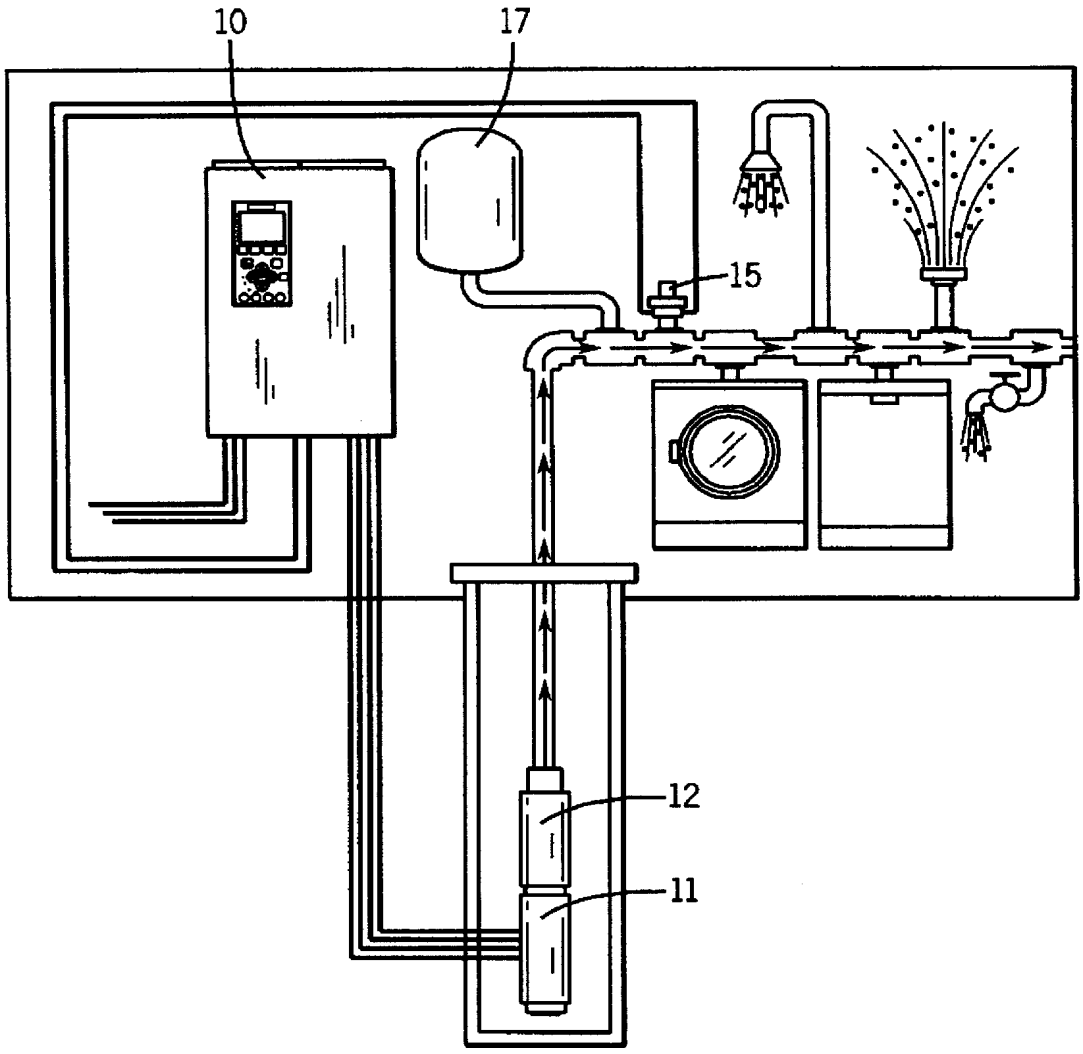


FIG. 5

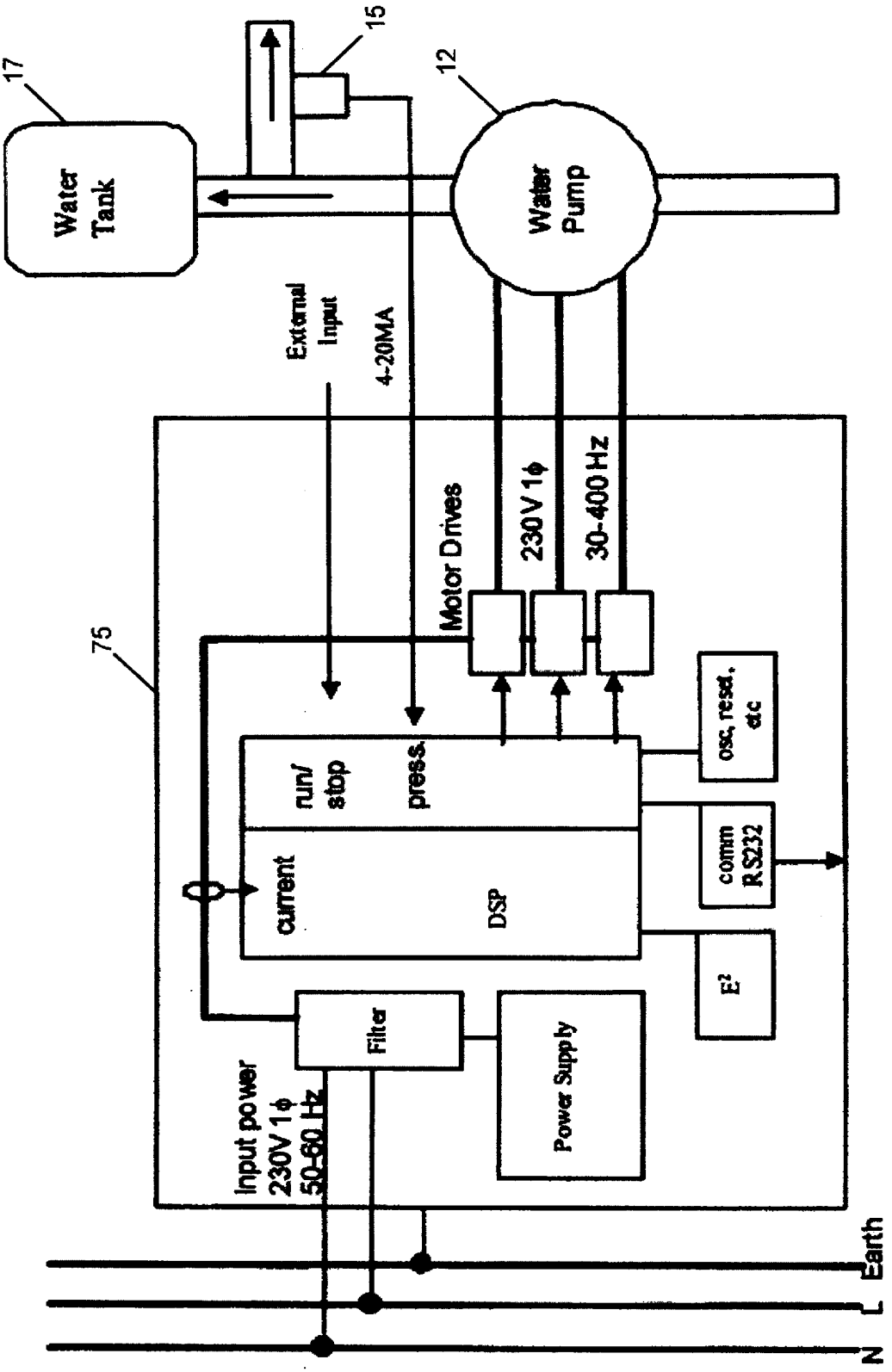

17
15
12
Water Tank
Water Pump
External Input
4-20MA
Motor Drives
230V 1ϕ
30-400 Hz
75
run/ stop
press.
current
DSP
osc, reset, etc
comm RS232
E²
Filter
Power Supply
Input power 230V 1ϕ 50-60 Hz
Earth
L
N

FIGURE 6

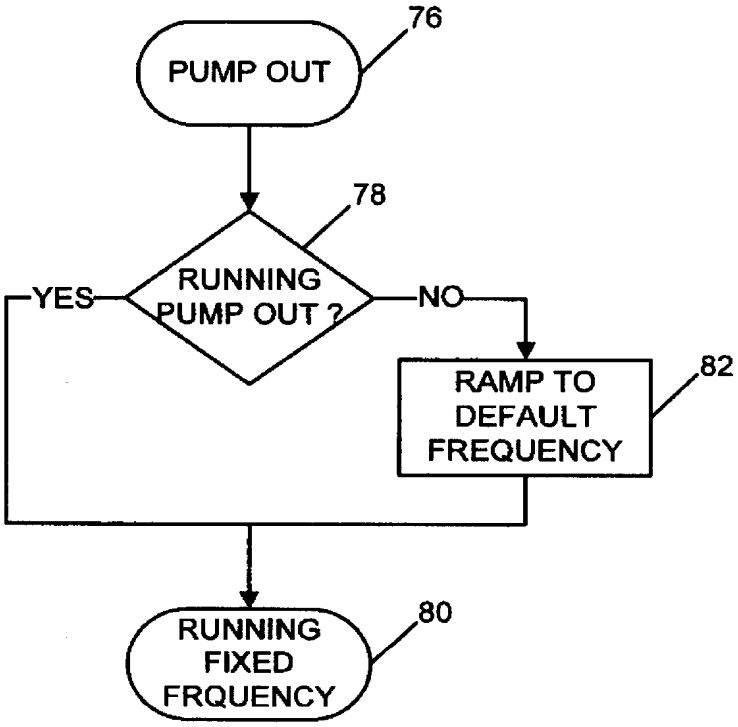

76
PUMP OUT
78
RUNNING
PUMP OUT ?
YES
NO
82
RAMP TO
DEFAULT
FREQUENCY
80
RUNNING
FIXED
FRQUENCY

FIGURE 7

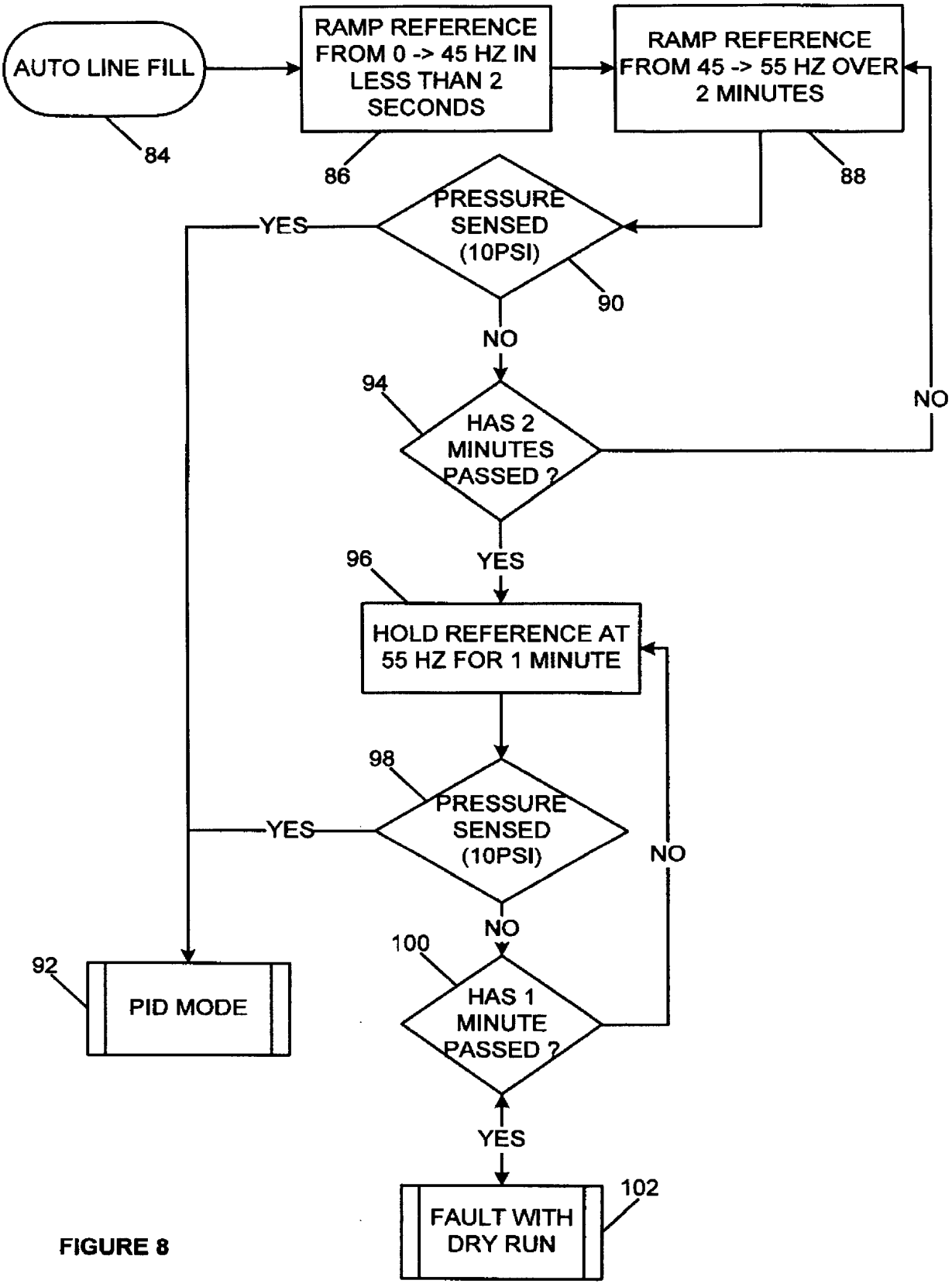

AUTO LINE FILL
84
RAMP REFERENCE FROM 0 -> 45 HZ IN LESS THAN 2 SECONDS
86
RAMP REFERENCE FROM 45 -> 55 HZ OVER 2 MINUTES
88
PRESSURE SENSED (10PSI)
90
YES
NO
94
HAS 2 MINUTES PASSED ?
NO
YES
96
HOLD REFERENCE AT 55 HZ FOR 1 MINUTE
98
PRESSURE SENSED (10PSI)
YES
NO
NO
100
HAS 1 MINUTE PASSED ?
YES
92
PID MODE
102
FAULT WITH DRY RUN

FIGURE 8

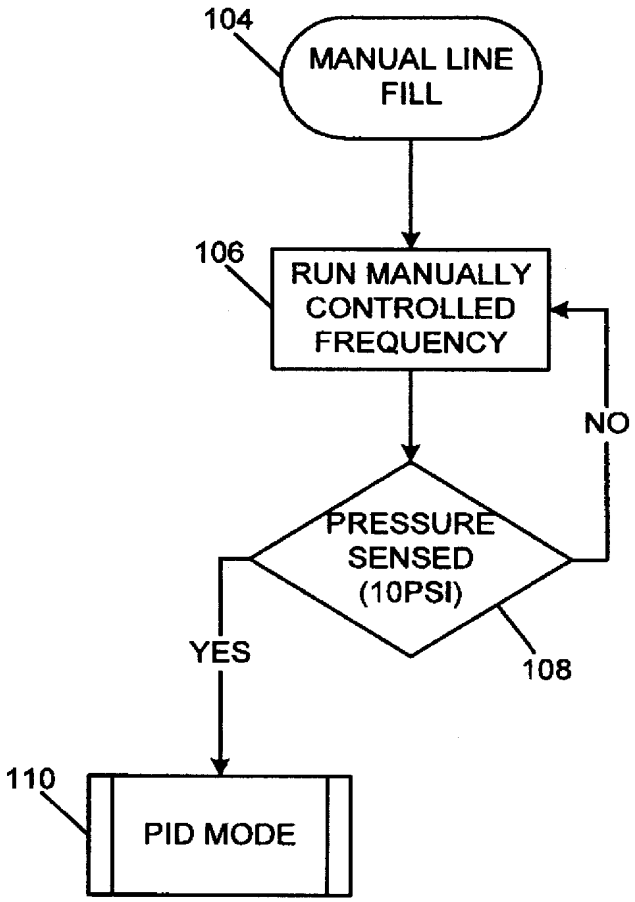

104
MANUAL LINE FILL
106
RUN MANUALLY CONTROLLED FREQUENCY
NO
PRESSURE SENSED (10PSI)
108
YES
110
PID MODE

FIGURE 9

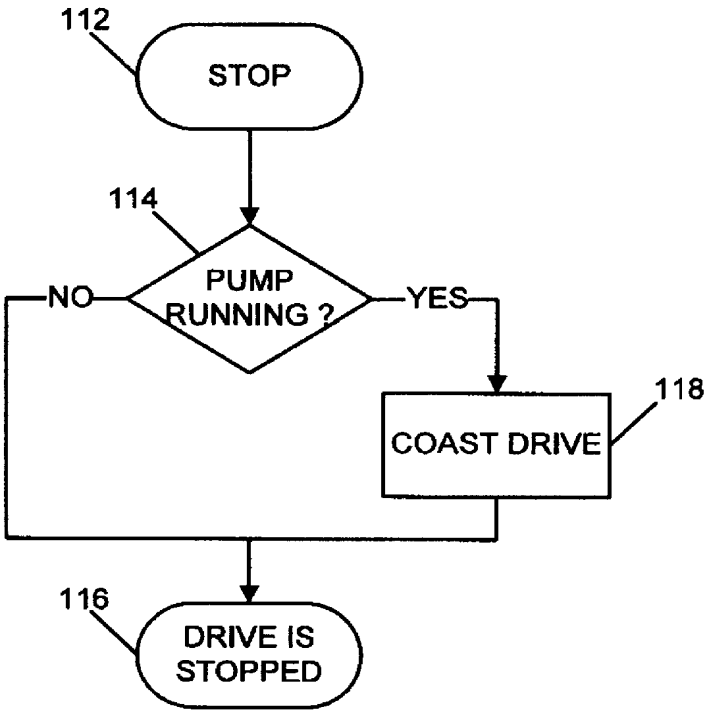

112
STOP
114
PUMP RUNNING ?
NO
YES
118
COAST DRIVE
116
DRIVE IS STOPPED

FIGURE 10

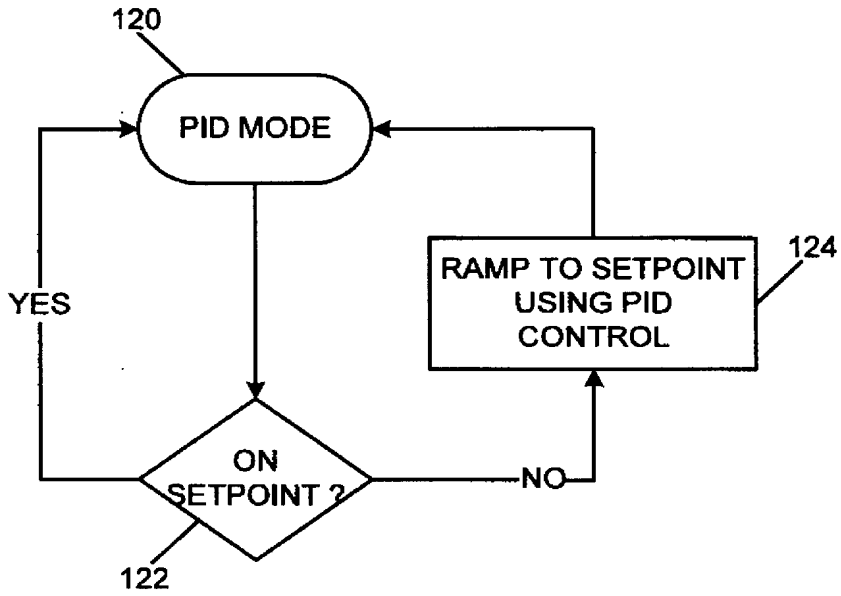

120
PID MODE
RAMP TO SETPOINT USING PID CONTROL
124
YES
ON SETPOINT ?
NO
122

FIGURE 11

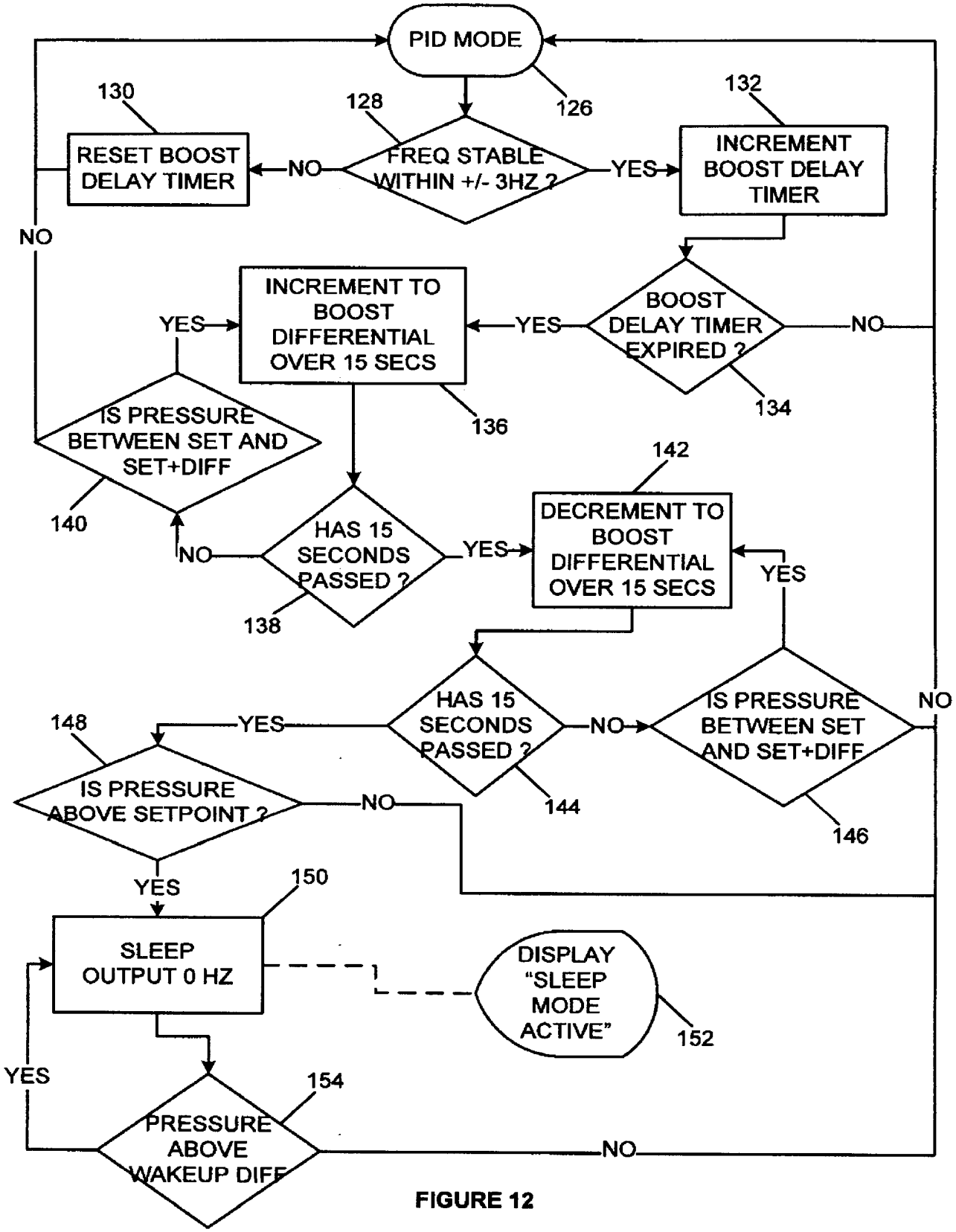

PID MODE
126
128
FREQ STABLE WITHIN +/- 3HZ ?
NO
YES
130
RESET BOOST DELAY TIMER
132
INCREMENT BOOST DELAY TIMER
NO
BOOST DELAY TIMER EXPIRED ?
134
NO
YES
INCREMENT TO BOOST DIFFERENTIAL OVER 15 SECS
136
YES
IS PRESSURE BETWEEN SET AND SET+DIFF
140
NO
HAS 15 SECONDS PASSED ?
138
YES
142
DECREMENT TO BOOST DIFFERENTIAL OVER 15 SECS
YES
HAS 15 SECONDS PASSED ?
144
NO
IS PRESSURE BETWEEN SET AND SET+DIFF
146
NO
148
YES
IS PRESSURE ABOVE SETPOINT ?
NO
YES
150
SLEEP OUTPUT 0 HZ
DISPLAY "SLEEP MODE ACTIVE"
152
YES
154
PRESSURE ABOVE WAKEUP DIFF
NO

FIGURE 12

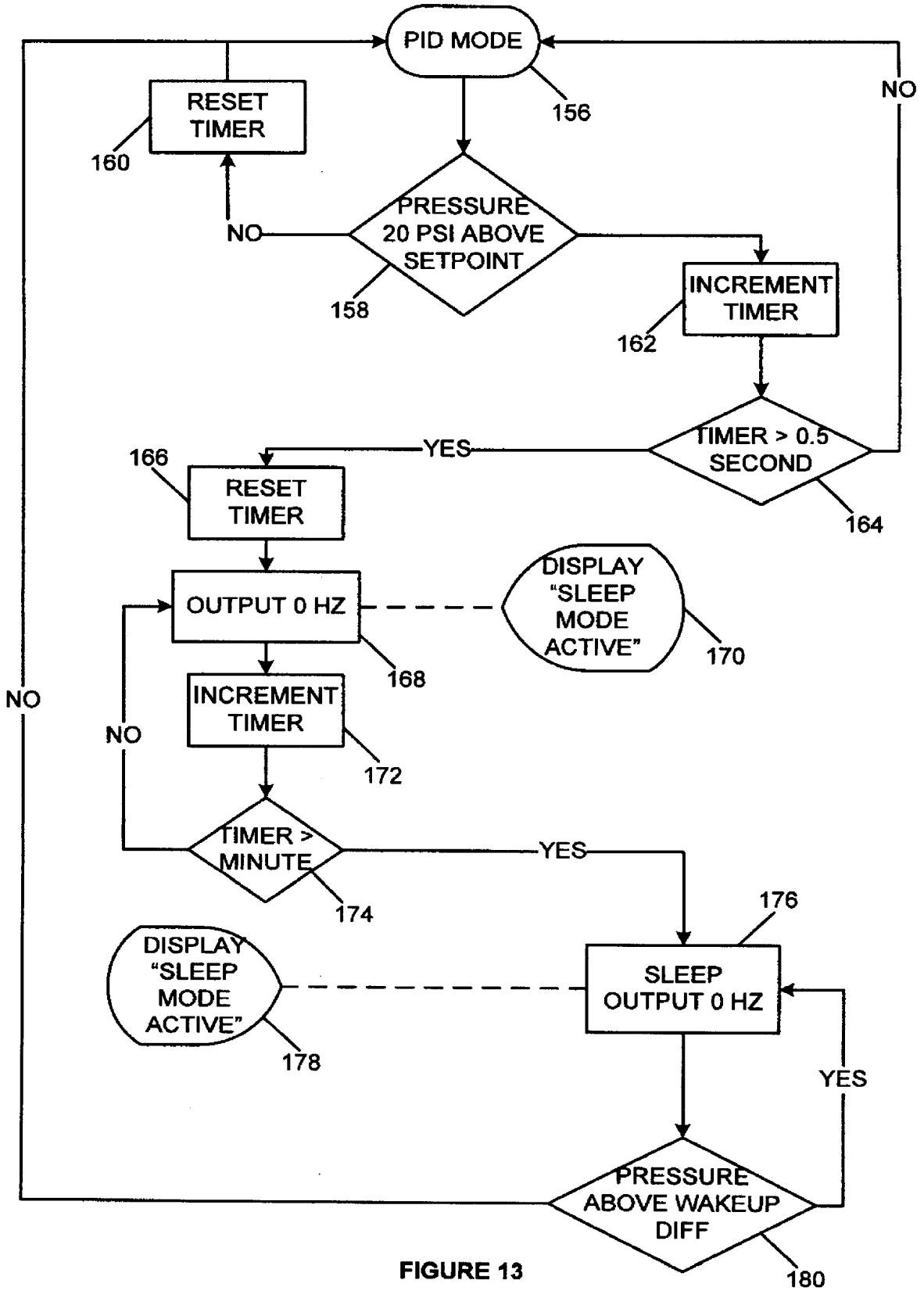

PID MODE
156
NO
RESET TIMER
160
PRESSURE 20 PSI ABOVE SETPOINT
158
NO
INCREMENT TIMER
162
TIMER > 0.5 SECOND
164
YES
166
RESET TIMER
OUTPUT 0 HZ
168
DISPLAY "SLEEP MODE ACTIVE"
170
INCREMENT TIMER
172
NO
NO
TIMER > MINUTE
174
YES
176
DISPLAY "SLEEP MODE ACTIVE"
178
SLEEP OUTPUT 0 HZ
YES
PRESSURE ABOVE WAKEUP DIFF
180

FIGURE 13

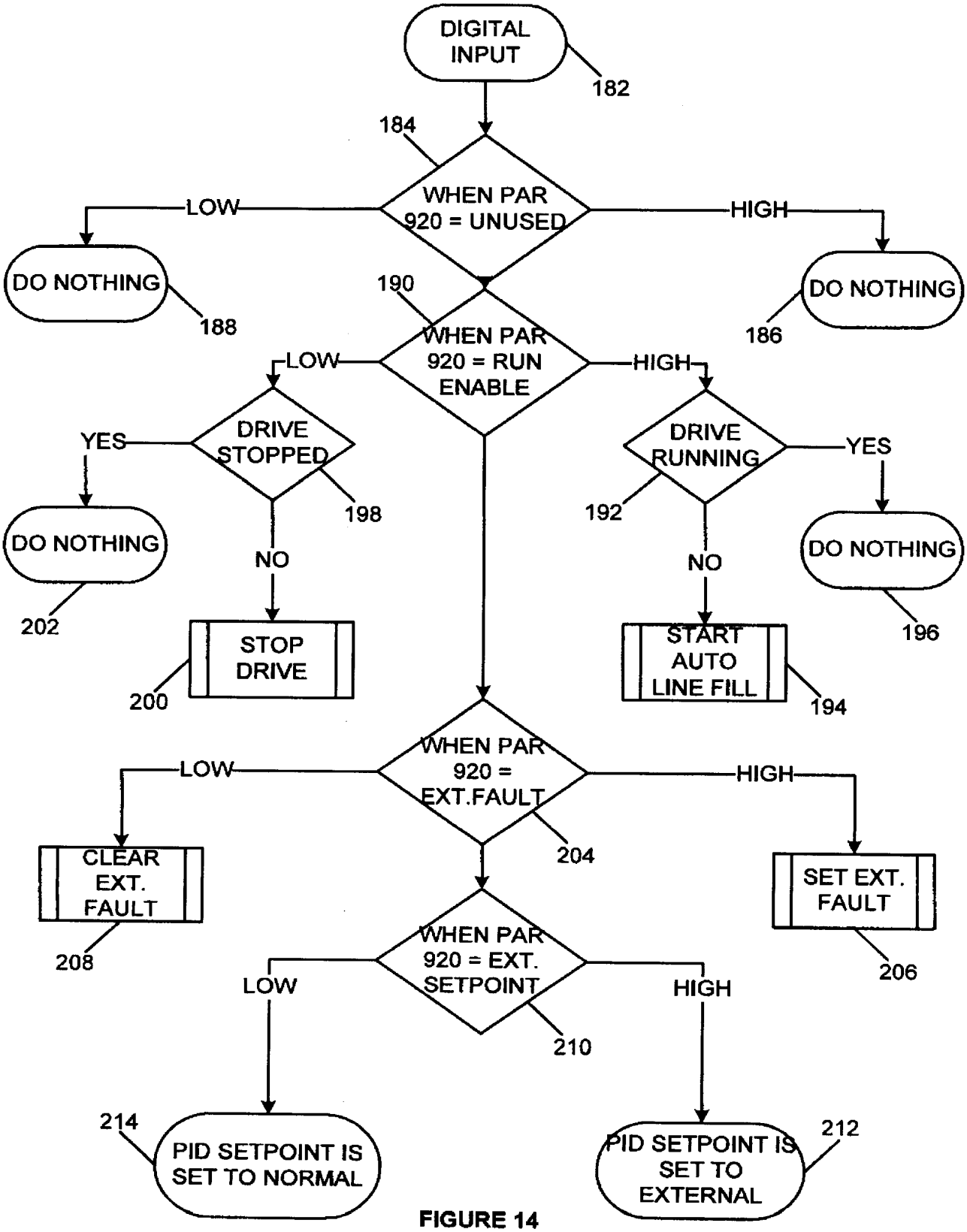

DIGITAL INPUT
182
184
WHEN PAR 920 = UNUSED
LOW
HIGH
DO NOTHING
188
DO NOTHING
186
190
WHEN PAR 920 = RUN ENABLE
LOW
HIGH
DRIVE STOPPED
198
YES
NO
DO NOTHING
202
STOP DRIVE
200
DRIVE RUNNING
192
YES
NO
DO NOTHING
196
START AUTO LINE FILL
194
WHEN PAR 920 = EXT.FAULT
204
LOW
HIGH
CLEAR EXT. FAULT
208
SET EXT. FAULT
206
WHEN PAR 920 = EXT. SETPOINT
210
LOW
HIGH
214
PID SETPOINT IS SET TO NORMAL
212
PID SETPOINT IS SET TO EXTERNAL

FIGURE 14

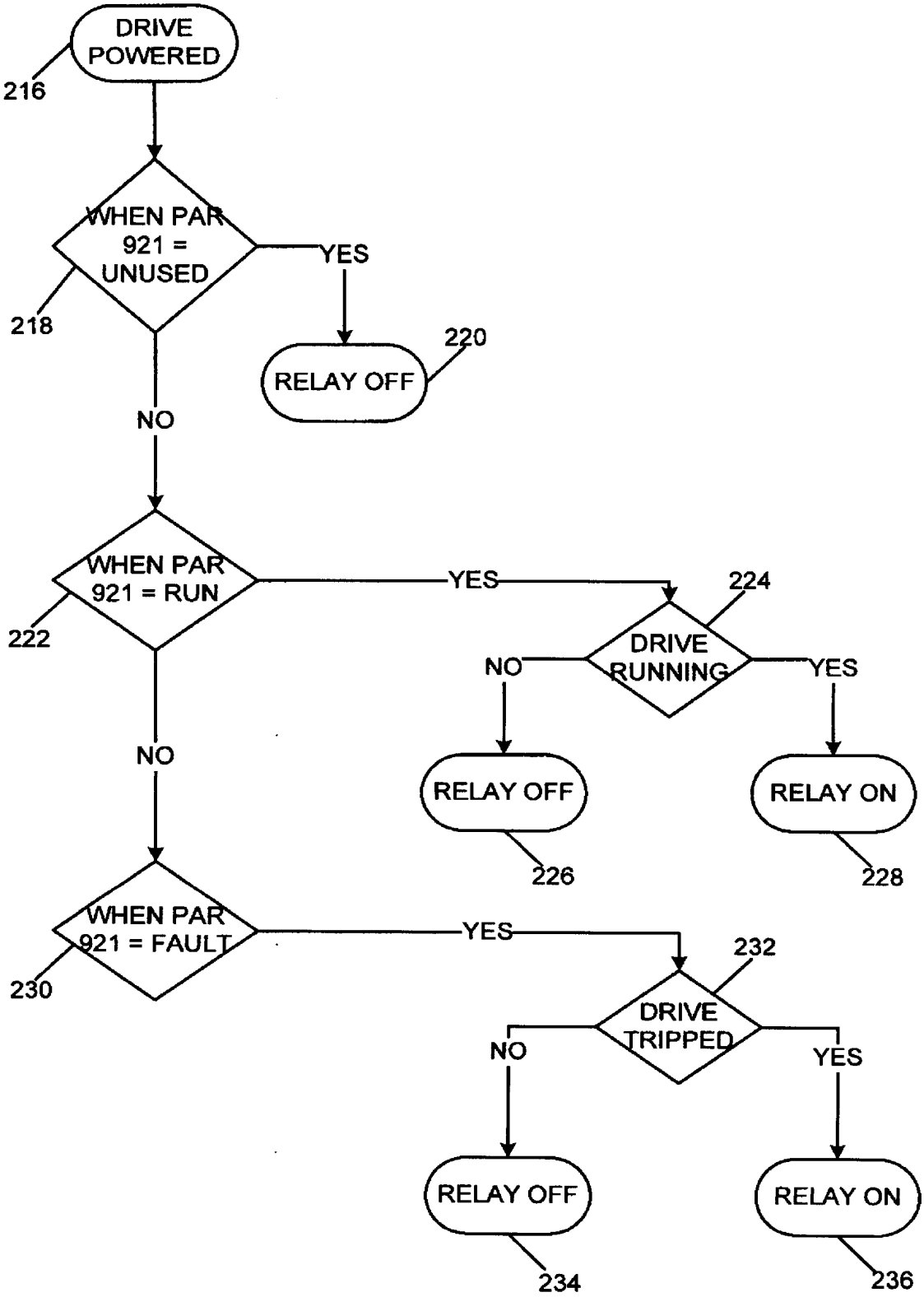

DRIVE POWERED
216
WHEN PAR 921 = UNUSED
218
YES
220
RELAY OFF
NO
WHEN PAR 921 = RUN
222
YES
224
DRIVE RUNNING
NO
YES
RELAY OFF
226
RELAY ON
228
NO
WHEN PAR 921 = FAULT
230
YES
232
DRIVE TRIPPED
NO
YES
RELAY OFF
234
RELAY ON
236

FIGURE 15

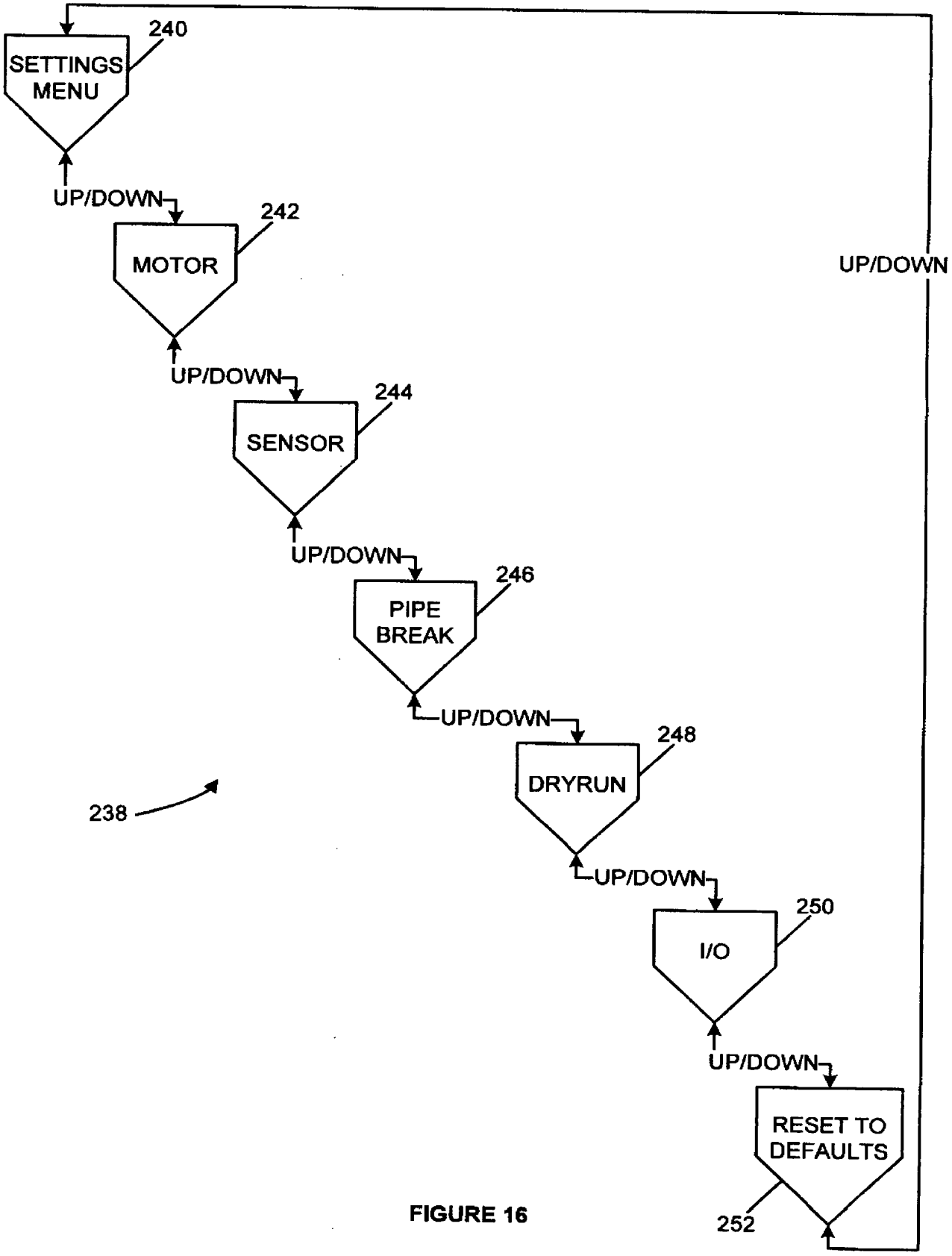

SETTINGS MENU
240
UP/DOWN
MOTOR
242
UP/DOWN
SENSOR
244
UP/DOWN
PIPE BREAK
246
UP/DOWN
DRYRUN
248
UP/DOWN
I/O
250
UP/DOWN
RESET TO DEFAULTS
252
UP/DOWN
238

FIGURE 16

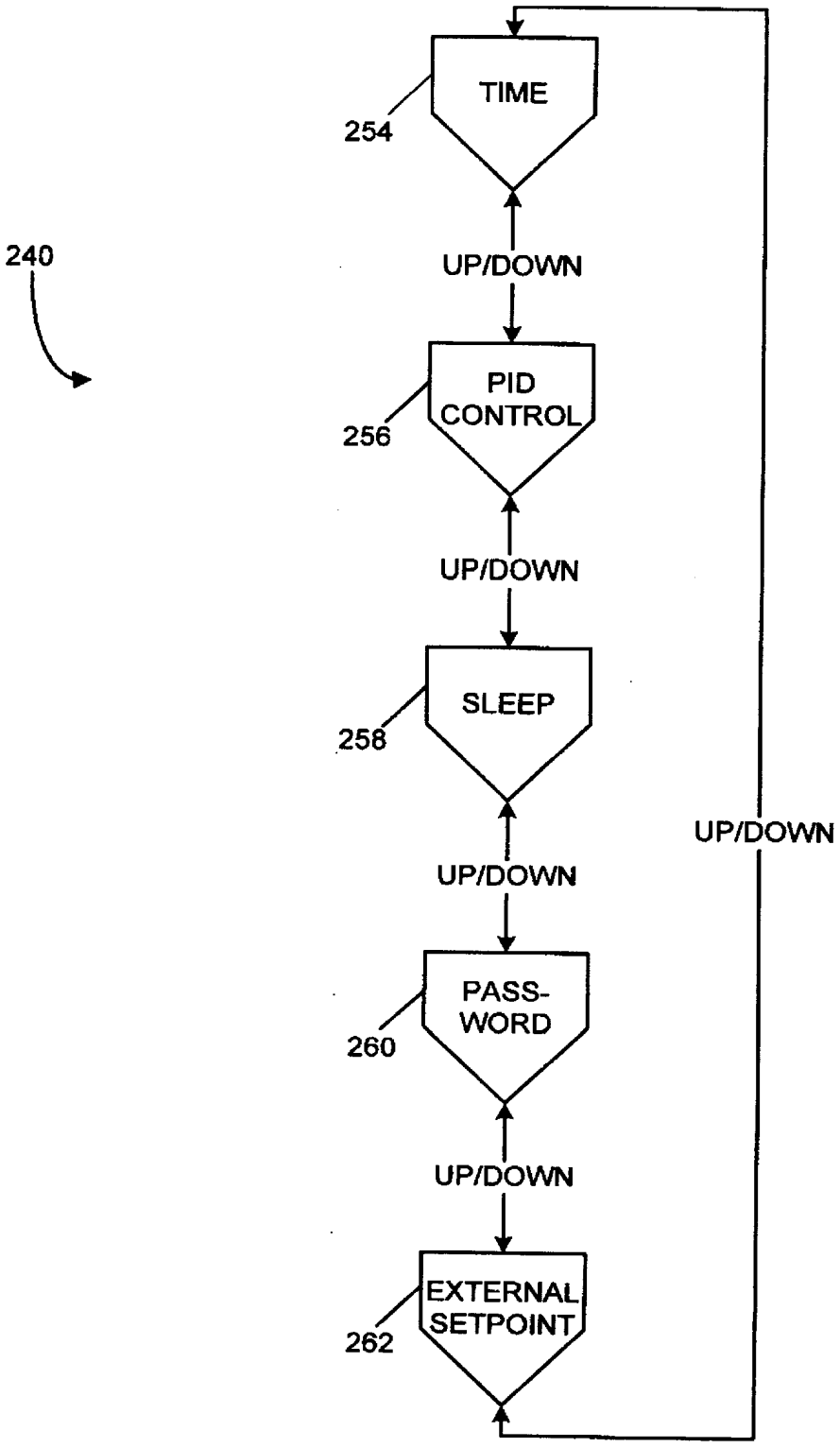

240
TIME
254
UP/DOWN
PID CONTROL
256
UP/DOWN
SLEEP
258
UP/DOWN
PASS-WORD
260
UP/DOWN
EXTERNAL SETPOINT
262
UP/DOWN

FIGURE 17

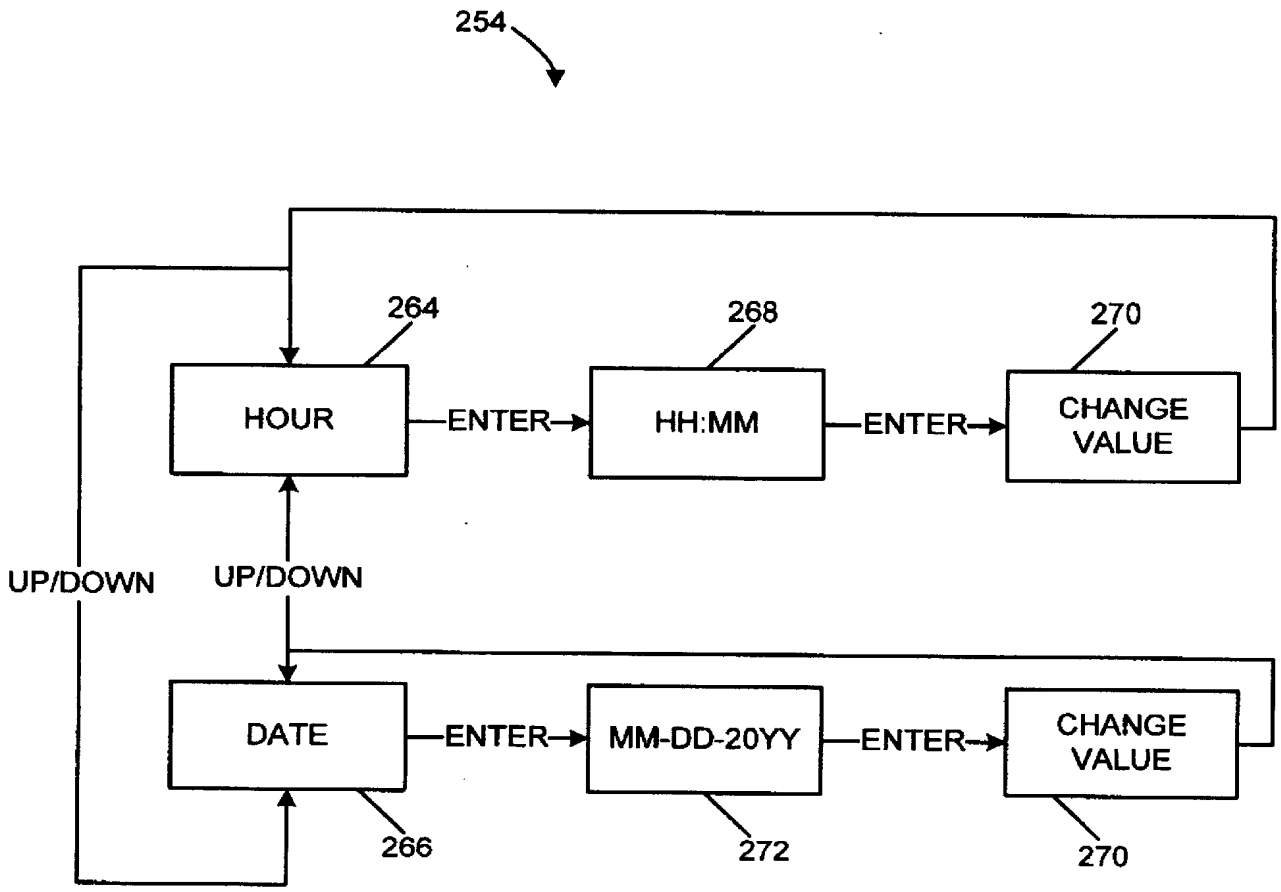

254
264
268
270
HOUR
ENTER
HH:MM
ENTER
CHANGE VALUE
UP/DOWN
UP/DOWN
DATE
ENTER
MM-DD-20YY
ENTER
CHANGE VALUE
266
272
270

FIGURE 18

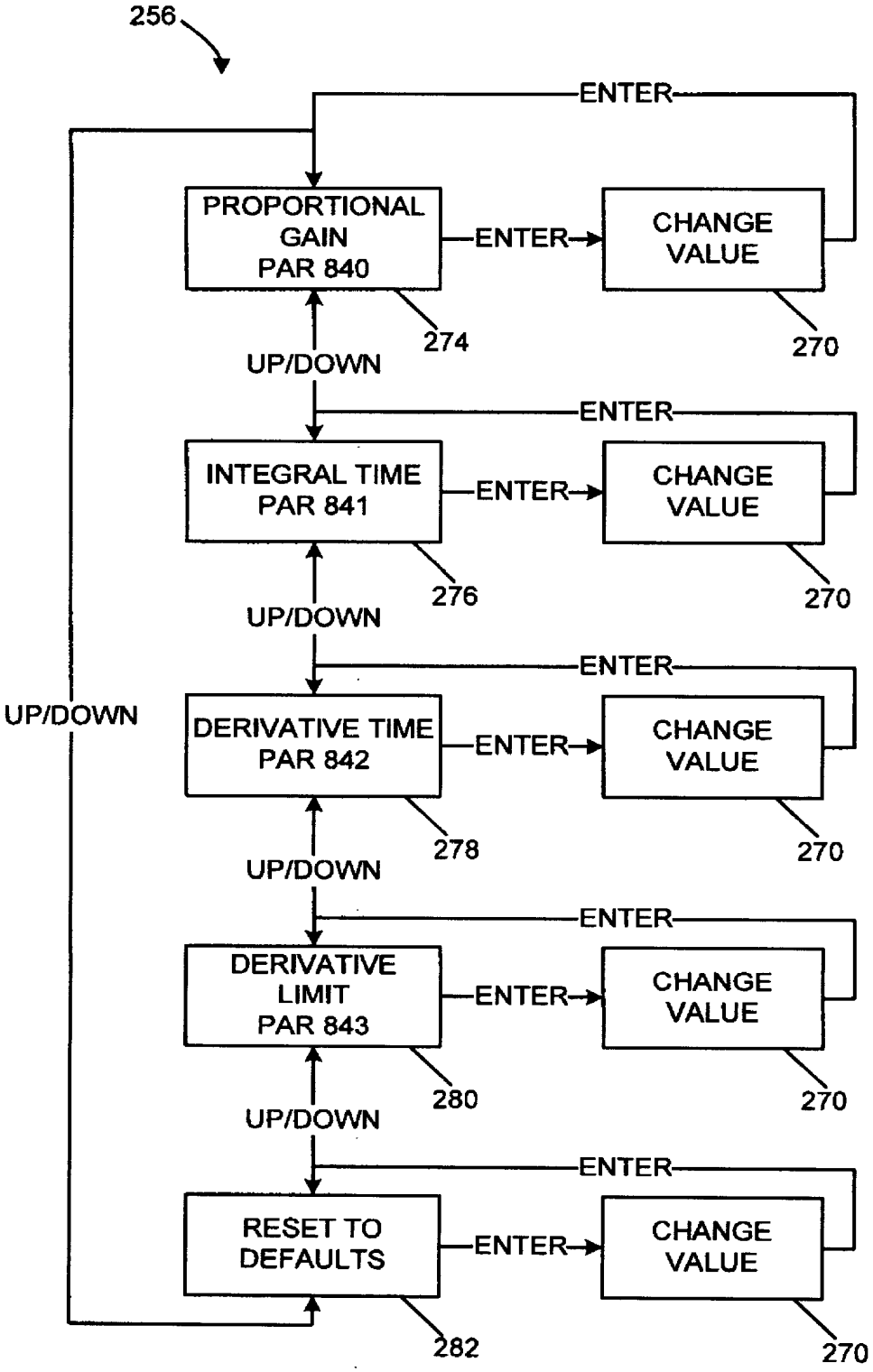

256
ENTER
PROPORTIONAL GAIN PAR 840
ENTER
CHANGE VALUE
274
270
UP/DOWN
ENTER
INTEGRAL TIME PAR 841
ENTER
CHANGE VALUE
276
270
UP/DOWN
ENTER
UP/DOWN
DERIVATIVE TIME PAR 842
ENTER
CHANGE VALUE
278
270
UP/DOWN
ENTER
DERIVATIVE LIMIT PAR 843
ENTER
CHANGE VALUE
280
270
UP/DOWN
ENTER
RESET TO DEFAULTS
ENTER
CHANGE VALUE
282
270

FIGURE 19

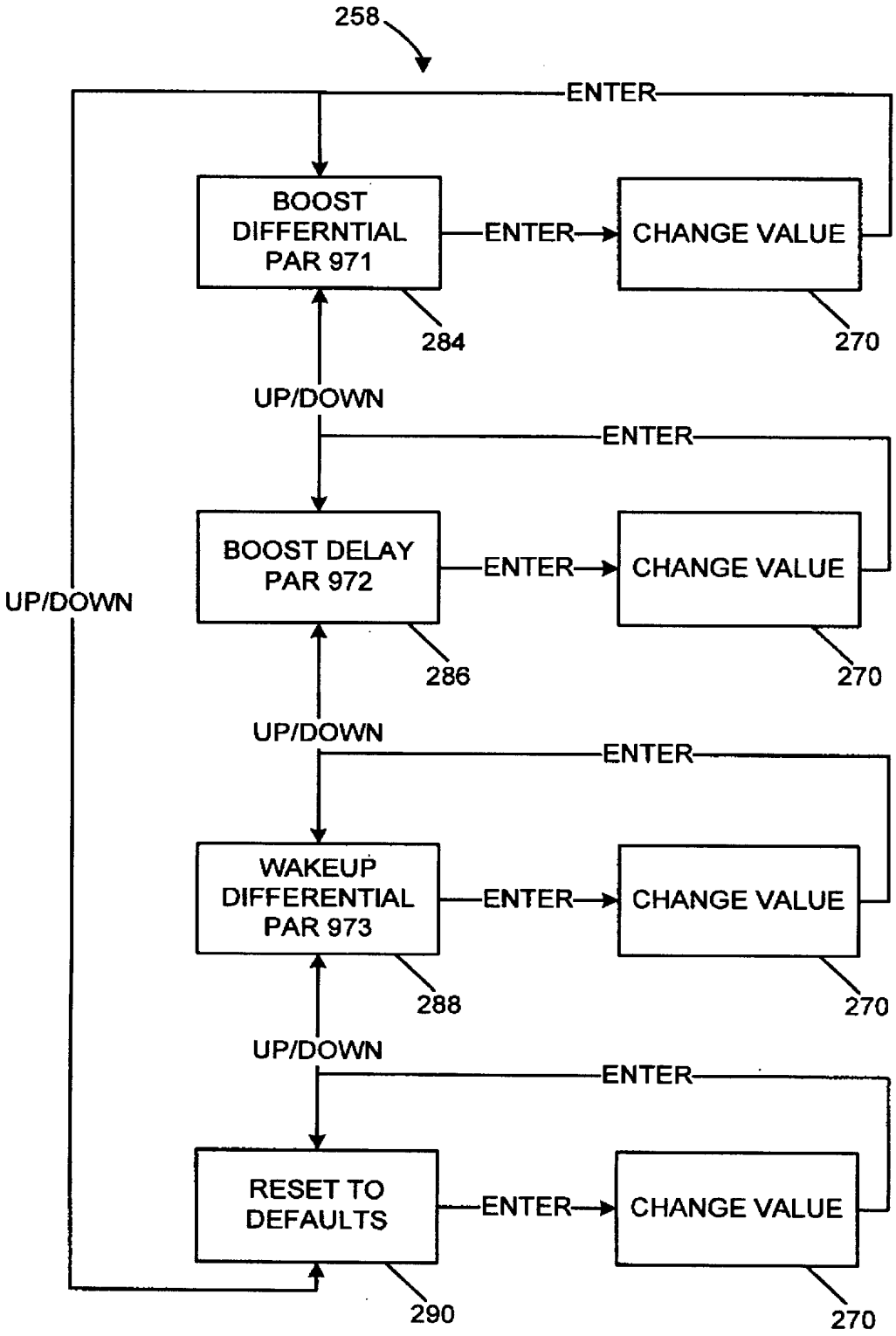

258
ENTER
BOOST DIFFERNTIAL PAR 971
ENTER
CHANGE VALUE
284
270
UP/DOWN
ENTER
BOOST DELAY PAR 972
ENTER
CHANGE VALUE
UP/DOWN
286
270
UP/DOWN
ENTER
WAKEUP DIFFERENTIAL PAR 973
ENTER
CHANGE VALUE
288
270
UP/DOWN
ENTER
RESET TO DEFAULTS
ENTER
CHANGE VALUE
290
270

FIGURE 20

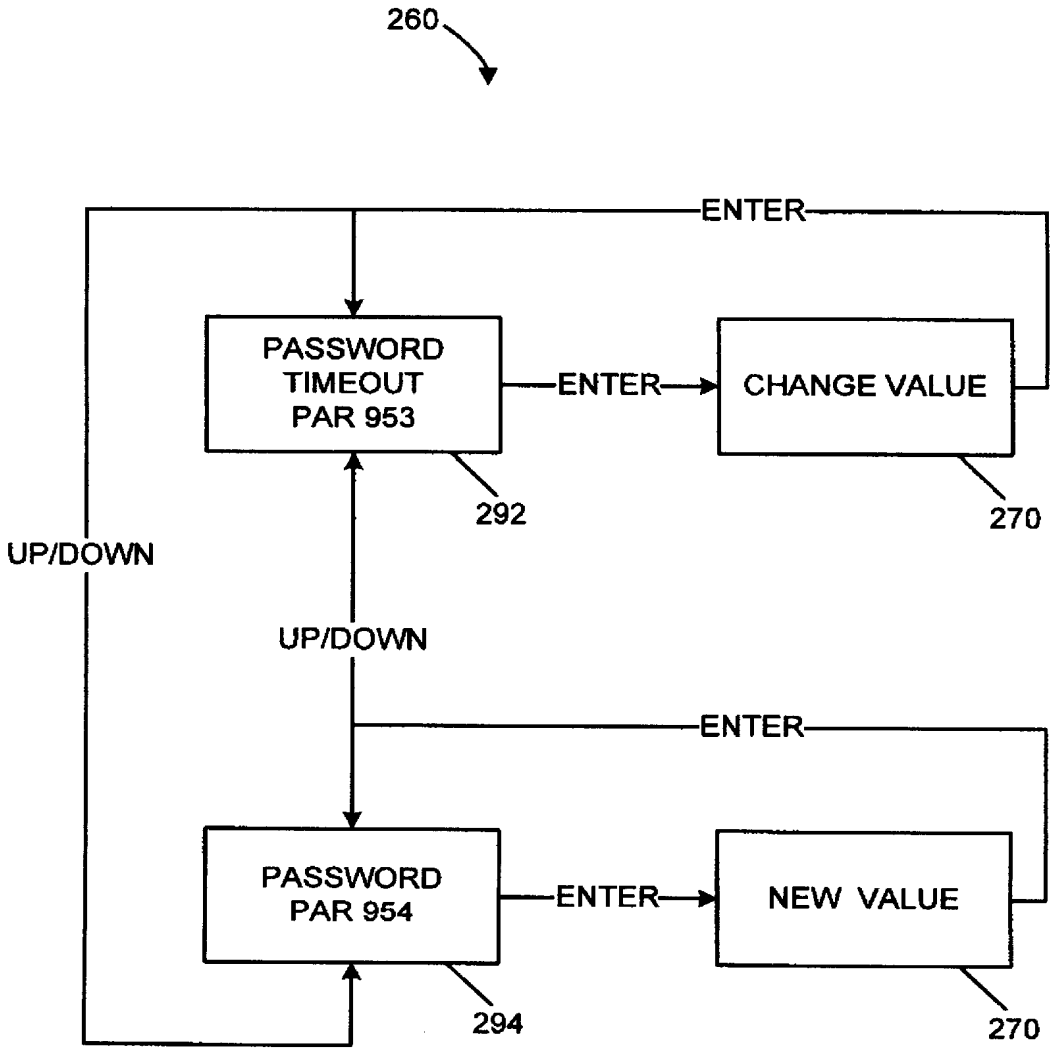

260
ENTER
PASSWORD
TIMEOUT
PAR 953
ENTER
CHANGE VALUE
292
270
UP/DOWN
UP/DOWN
ENTER
PASSWORD
PAR 954
ENTER
NEW VALUE
294
270

FIGURE 21

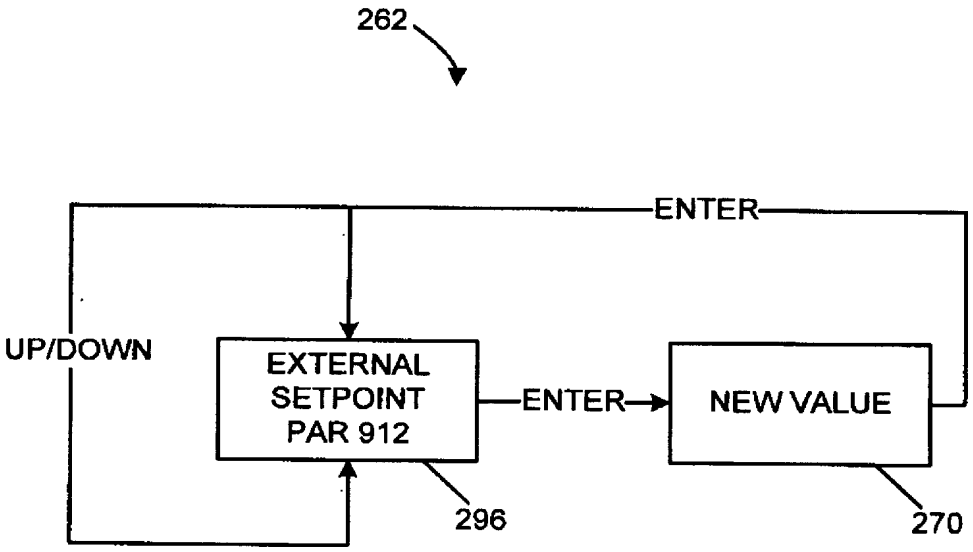

262
ENTER
UP/DOWN
EXTERNAL SETPOINT PAR 912
ENTER
NEW VALUE
296
270

FIGURE 22

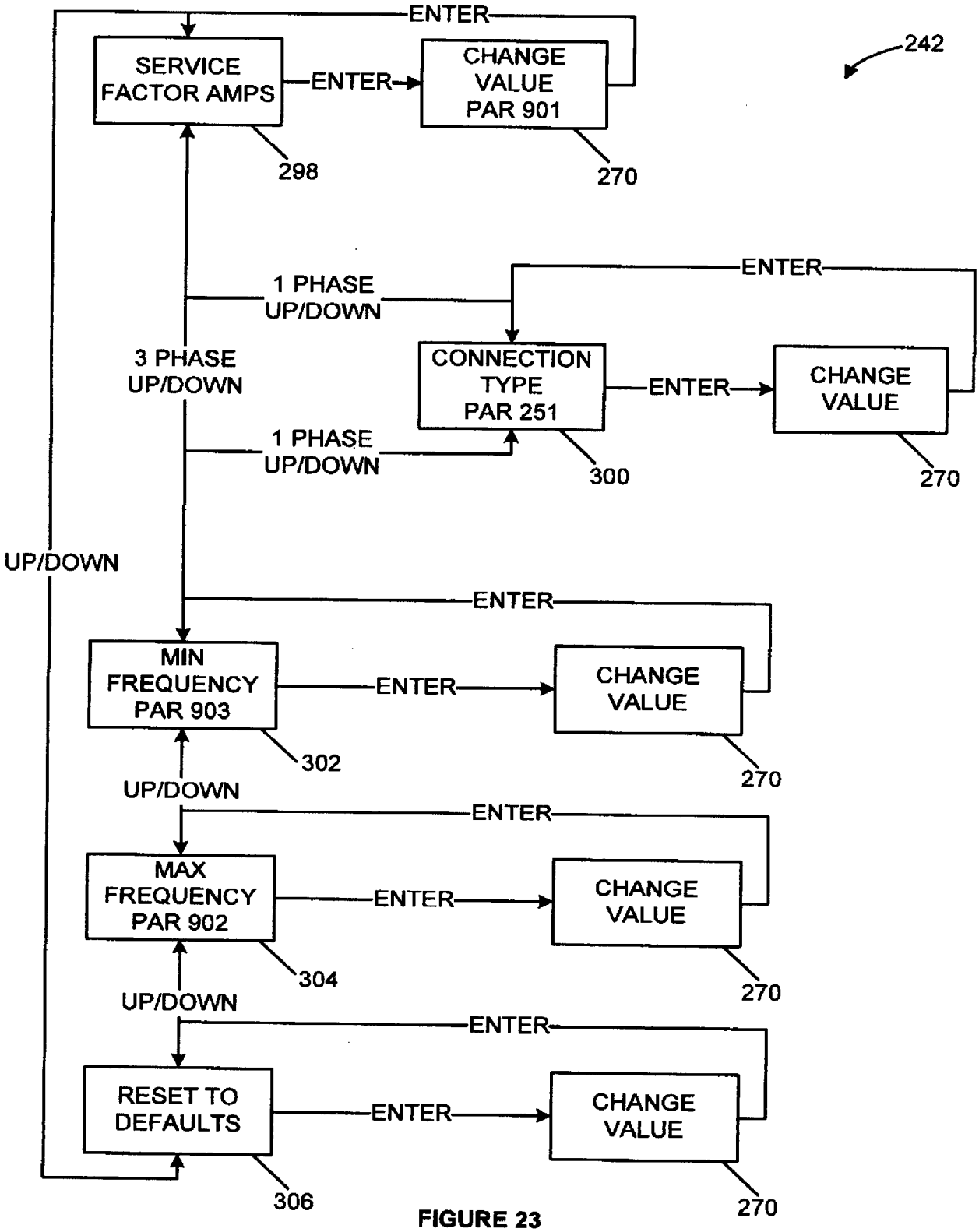

ENTER
SERVICE FACTOR AMPS
ENTER
CHANGE VALUE PAR 901
242
298
270
1 PHASE UP/DOWN
ENTER
3 PHASE UP/DOWN
CONNECTION TYPE PAR 251
ENTER
CHANGE VALUE
1 PHASE UP/DOWN
300
270
UP/DOWN
ENTER
MIN FREQUENCY PAR 903
ENTER
CHANGE VALUE
302
270
UP/DOWN
ENTER
MAX FREQUENCY PAR 902
ENTER
CHANGE VALUE
304
270
UP/DOWN
ENTER
RESET TO DEFAULTS
ENTER
CHANGE VALUE
306
270

FIGURE 23

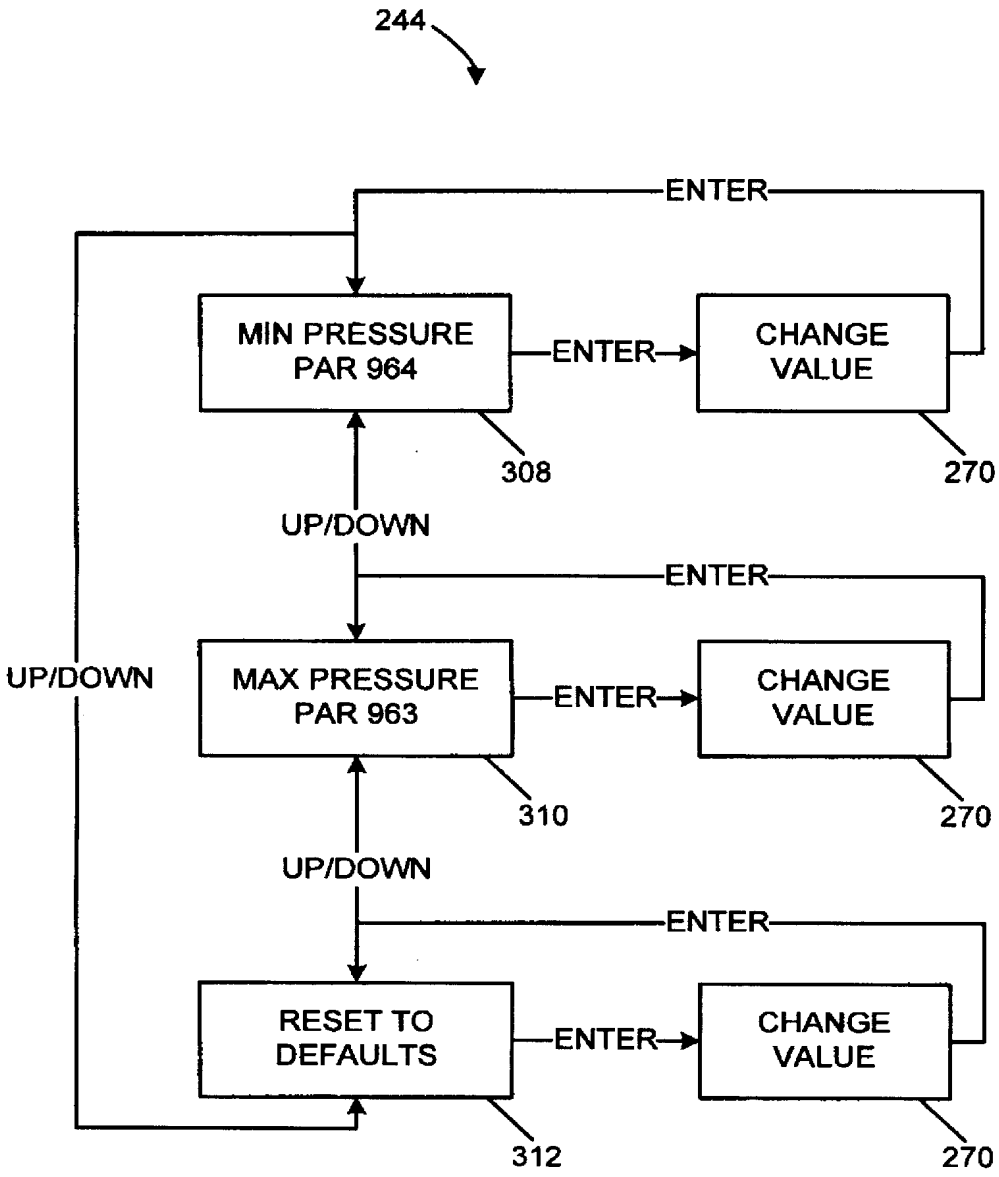

244
ENTER
MIN PRESSURE
PAR 964
ENTER
CHANGE
VALUE
308
270
UP/DOWN
ENTER
UP/DOWN
MAX PRESSURE
PAR 963
ENTER
CHANGE
VALUE
310
270
UP/DOWN
ENTER
RESET TO
DEFAULTS
ENTER
CHANGE
VALUE
312
270

FIGURE 24

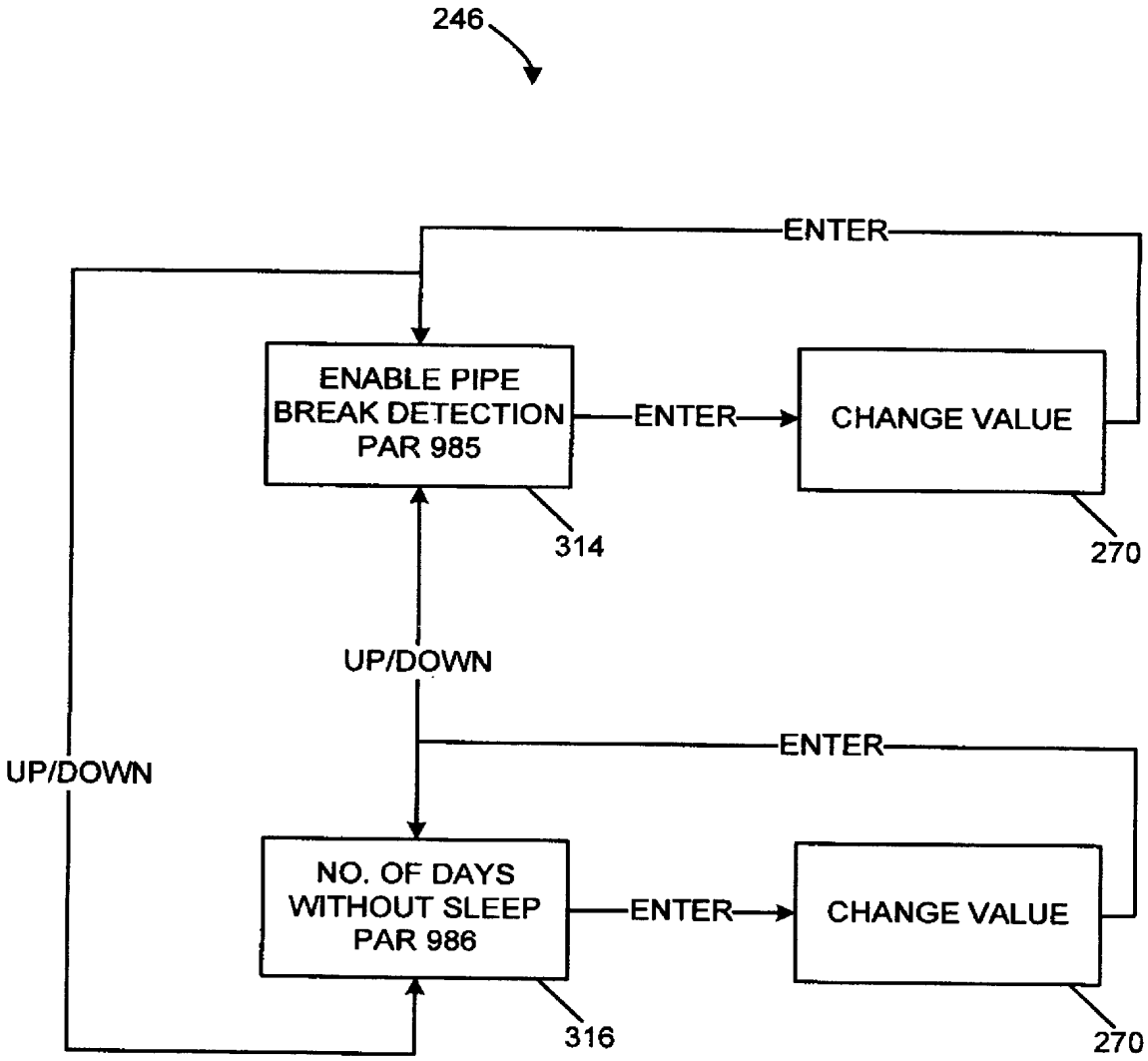

246
ENTER
ENABLE PIPE BREAK DETECTION PAR 985
ENTER
CHANGE VALUE
314
270
UP/DOWN
ENTER
UP/DOWN
NO. OF DAYS WITHOUT SLEEP PAR 986
ENTER
CHANGE VALUE
316
270

FIGURE 25

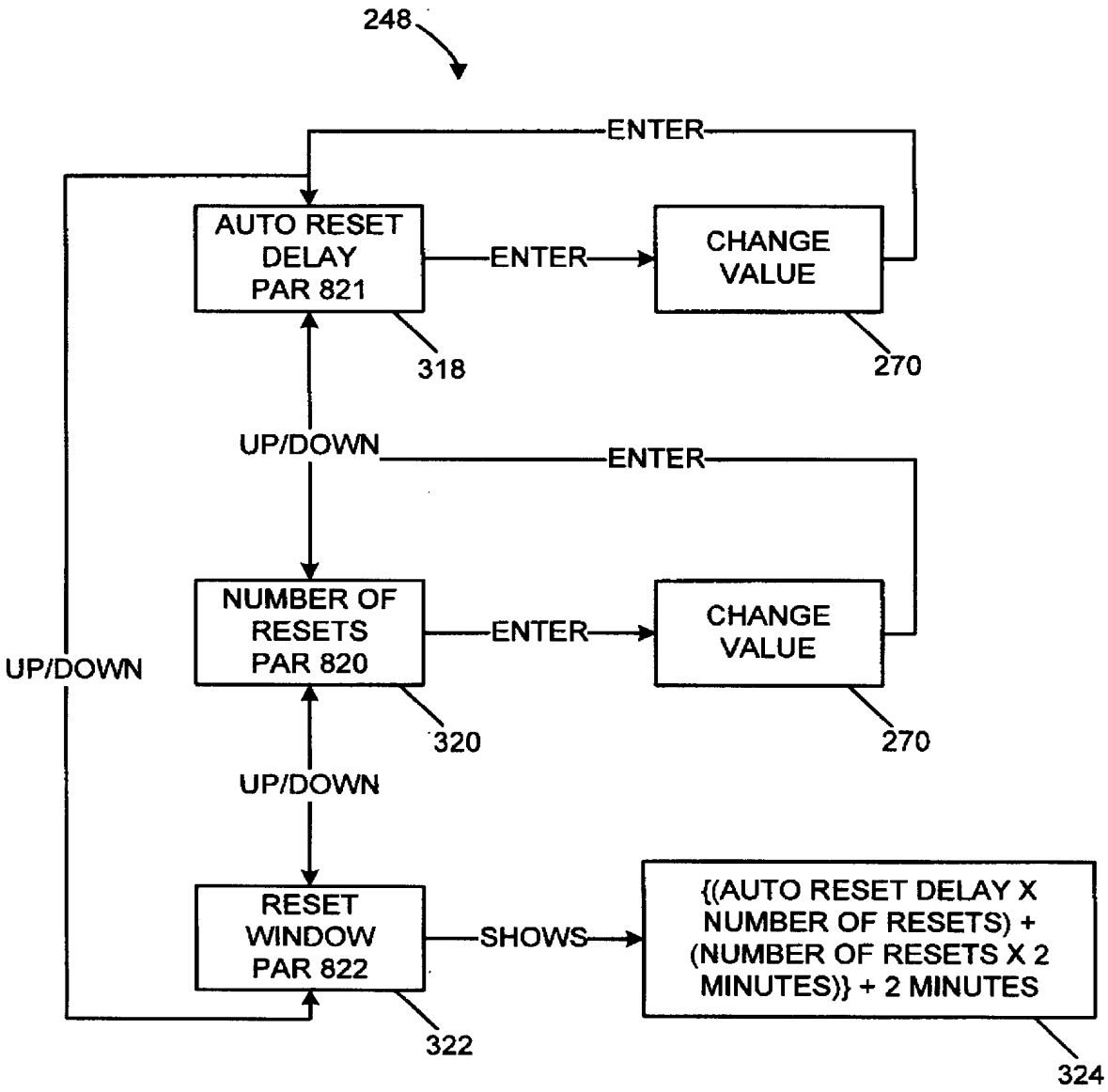

248
ENTER
AUTO RESET DELAY PAR 821
ENTER
CHANGE VALUE
318
270
UP/DOWN
ENTER
NUMBER OF RESETS PAR 820
ENTER
CHANGE VALUE
UP/DOWN
320
270
UP/DOWN
RESET WINDOW PAR 822
SHOWS
{(AUTO RESET DELAY X NUMBER OF RESETS) + (NUMBER OF RESETS X 2 MINUTES)} + 2 MINUTES
322
324

FIGURE 26

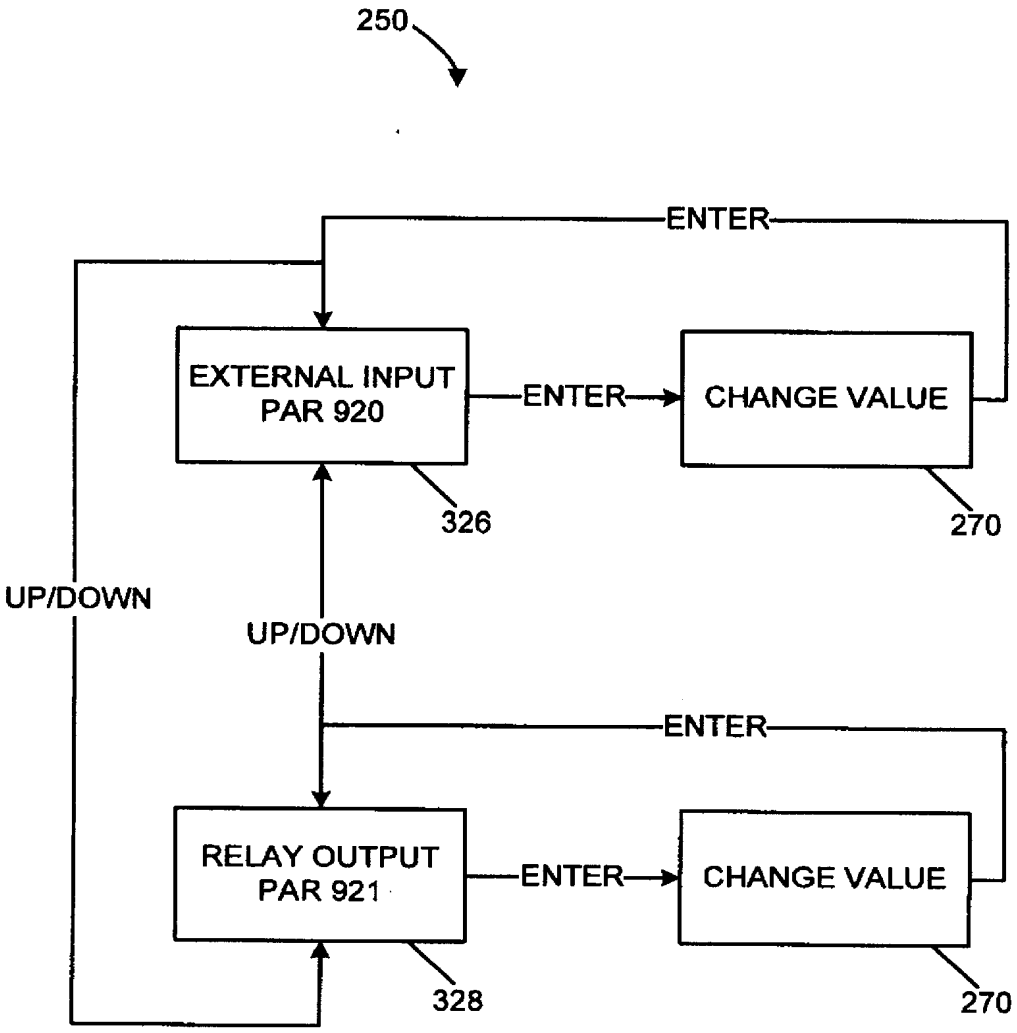

250
ENTER
EXTERNAL INPUT
PAR 920
ENTER
CHANGE VALUE
326
270
UP/DOWN
UP/DOWN
ENTER
RELAY OUTPUT
PAR 921
ENTER
CHANGE VALUE
328
270

FIGURE 27

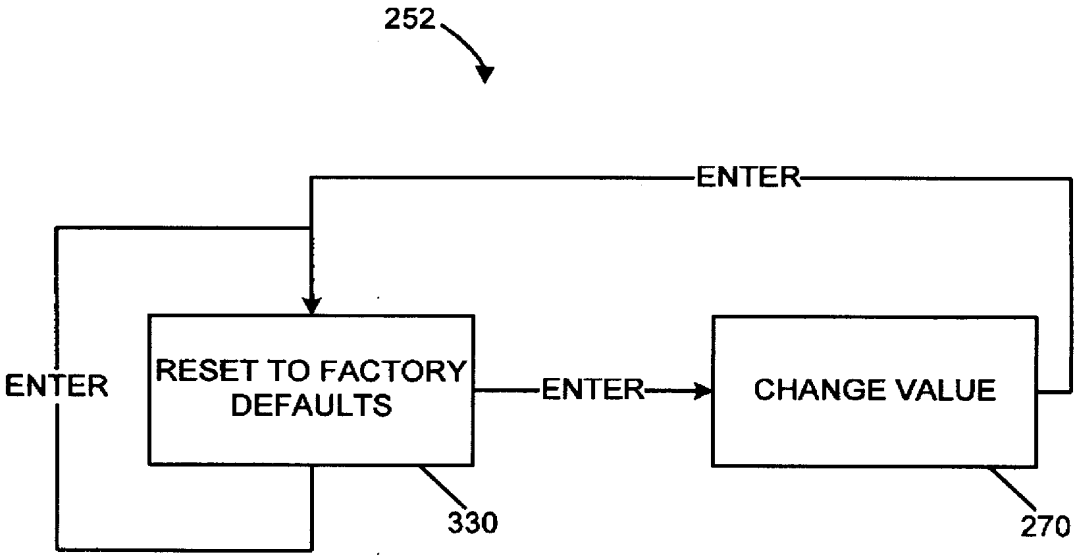

252
ENTER
ENTER
RESET TO FACTORY DEFAULTS
ENTER
CHANGE VALUE
330
270

FIGURE 28

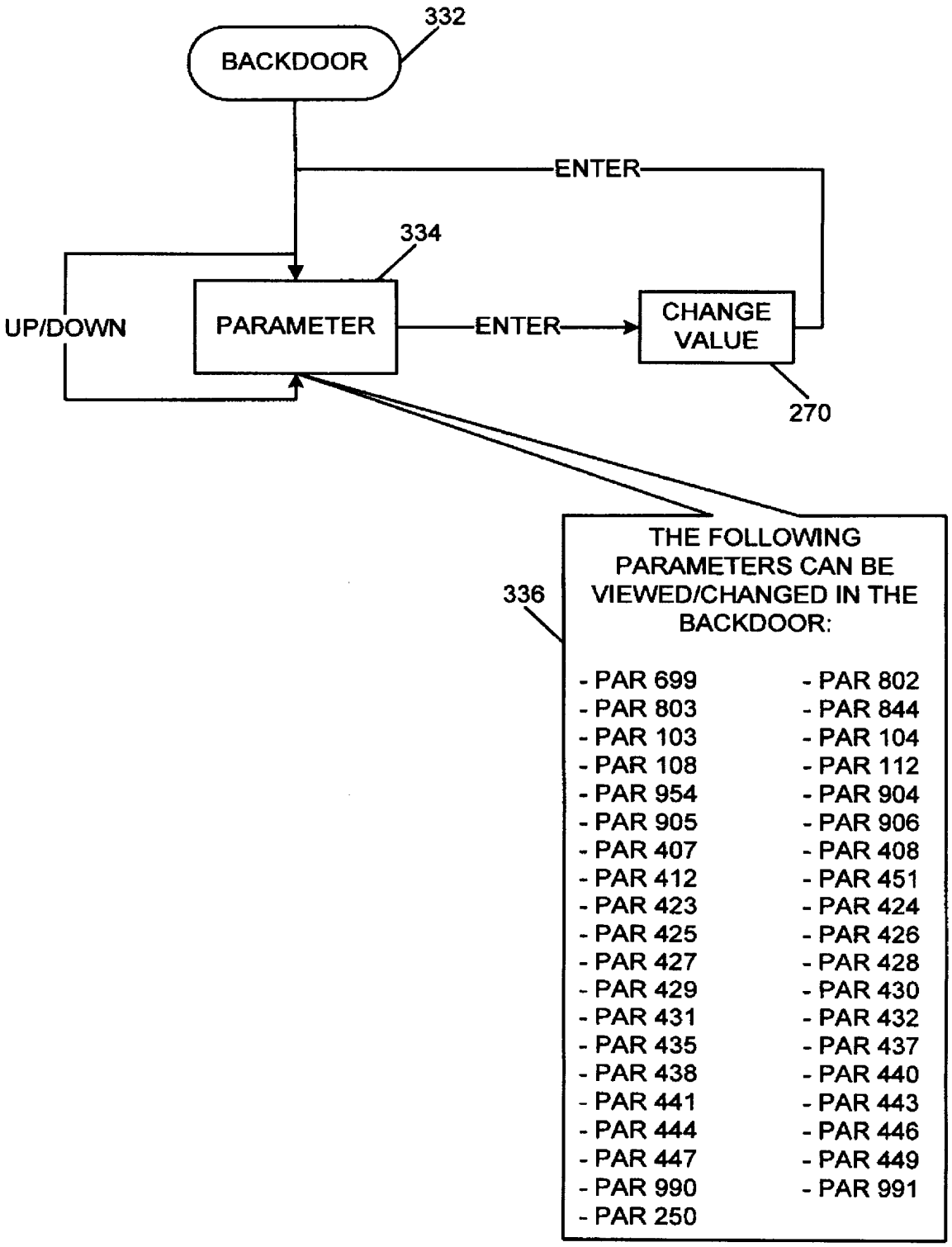

332
BACKDOOR
ENTER
334
UP/DOWN
PARAMETER
ENTER
CHANGE VALUE
270
336
THE FOLLOWING PARAMETERS CAN BE VIEWED/CHANGED IN THE BACKDOOR:
- PAR 699
- PAR 802
- PAR 803
- PAR 844
- PAR 103
- PAR 104
- PAR 108
- PAR 112
- PAR 954
- PAR 904
- PAR 905
- PAR 906
- PAR 407
- PAR 408
- PAR 412
- PAR 451
- PAR 423
- PAR 424
- PAR 425
- PAR 426
- PAR 427
- PAR 428
- PAR 429
- PAR 430
- PAR 431
- PAR 432
- PAR 435
- PAR 437
- PAR 438
- PAR 440
- PAR 441
- PAR 443
- PAR 444
- PAR 446
- PAR 447
- PAR 449
- PAR 990
- PAR 991
- PAR 250

FIGURE 29

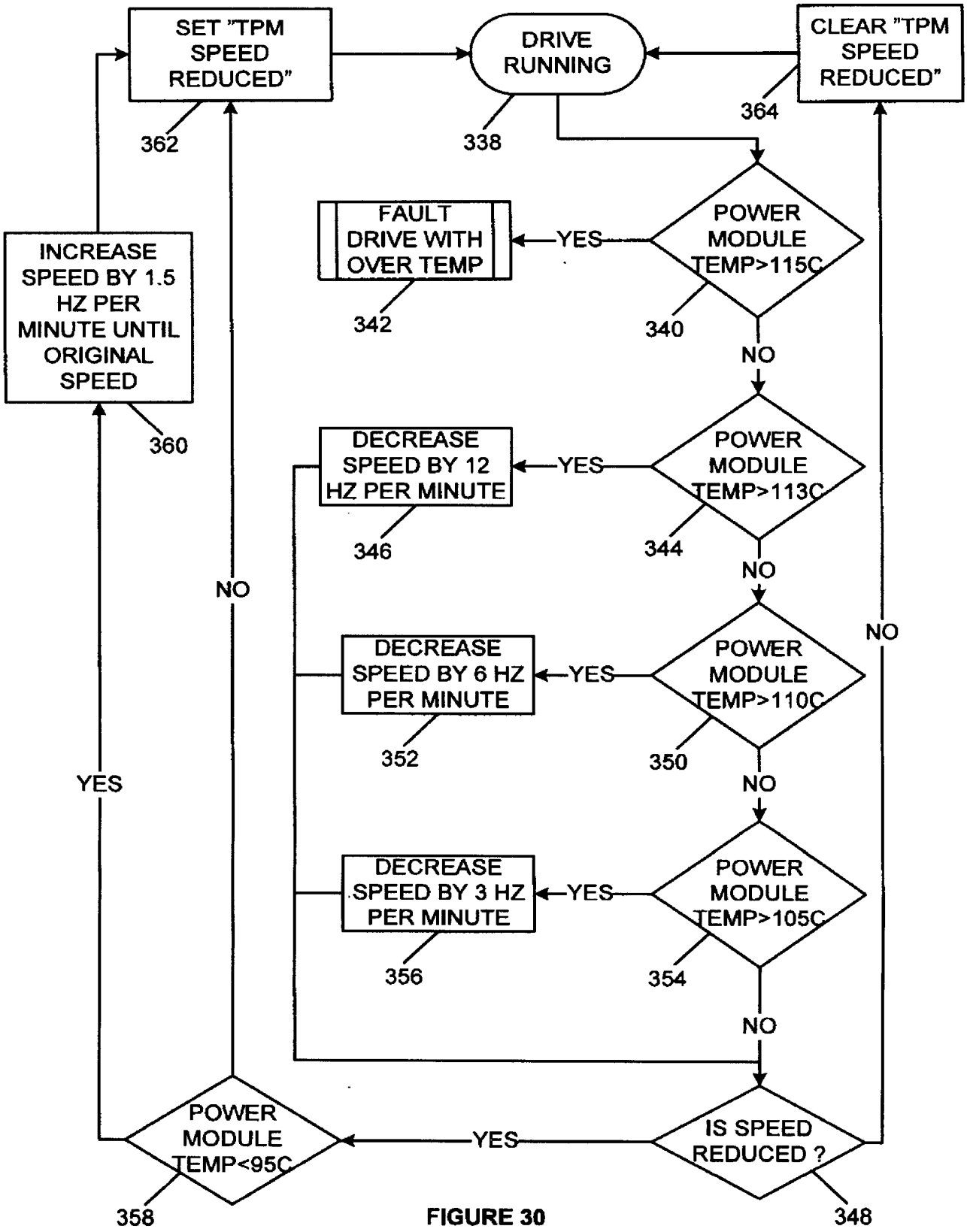

SET "TPM SPEED REDUCED"
DRIVE RUNNING
CLEAR "TPM SPEED REDUCED"
362
338
364
FAULT DRIVE WITH OVER TEMP
YES
POWER MODULE TEMP>115C
342
340
NO
INCREASE SPEED BY 1.5 HZ PER MINUTE UNTIL ORIGINAL SPEED
360
DECREASE SPEED BY 12 HZ PER MINUTE
YES
POWER MODULE TEMP>113C
346
344
NO
NO
DECREASE SPEED BY 6 HZ PER MINUTE
YES
POWER MODULE TEMP>110C
NO
352
350
YES
NO
DECREASE SPEED BY 3 HZ PER MINUTE
YES
POWER MODULE TEMP>105C
356
354
NO
POWER MODULE TEMP<95C
YES
IS SPEED REDUCED ?
358
348

FIGURE 30

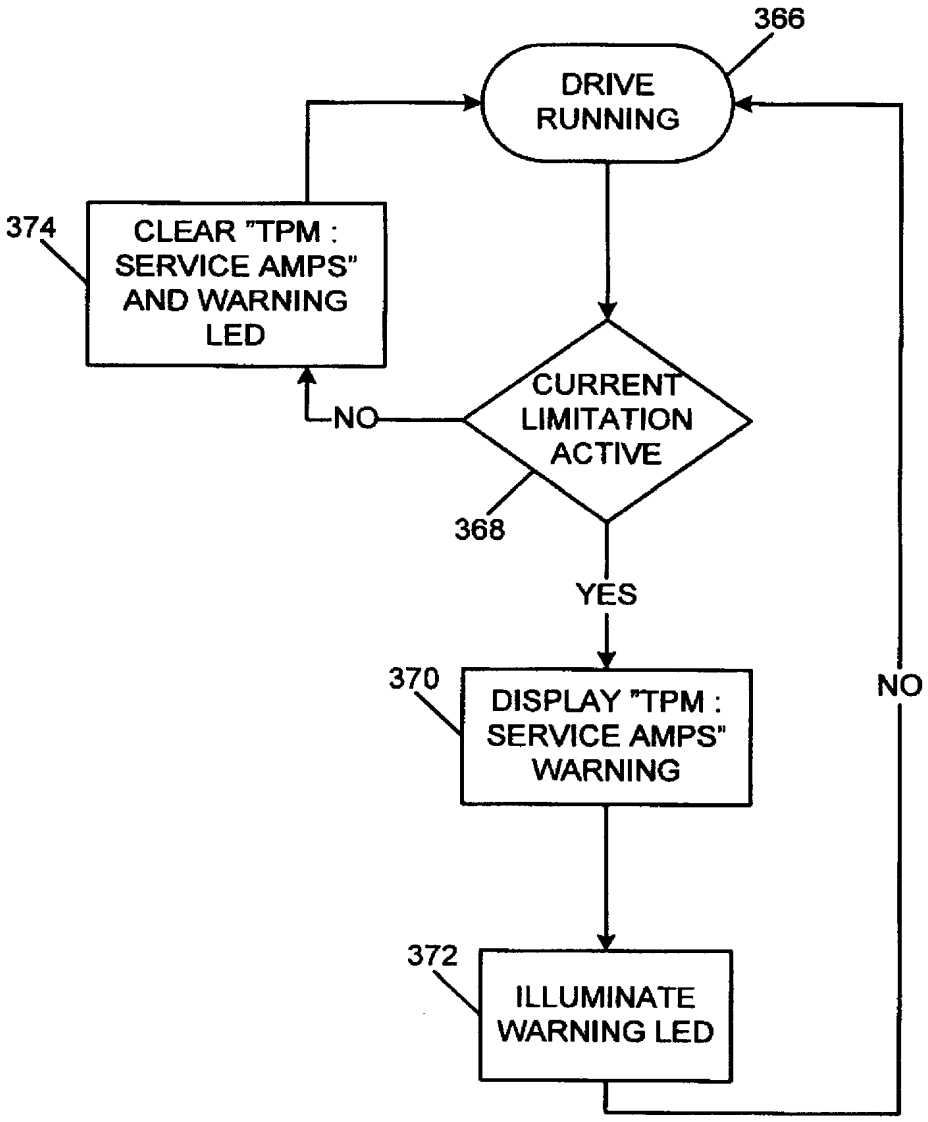

366
DRIVE RUNNING
374
CLEAR "TPM : SERVICE AMPS" AND WARNING LED
NO
CURRENT LIMITATION ACTIVE
368
YES
370
DISPLAY "TPM : SERVICE AMPS" WARNING
372
ILLUMINATE WARNING LED
NO

FIGURE 31

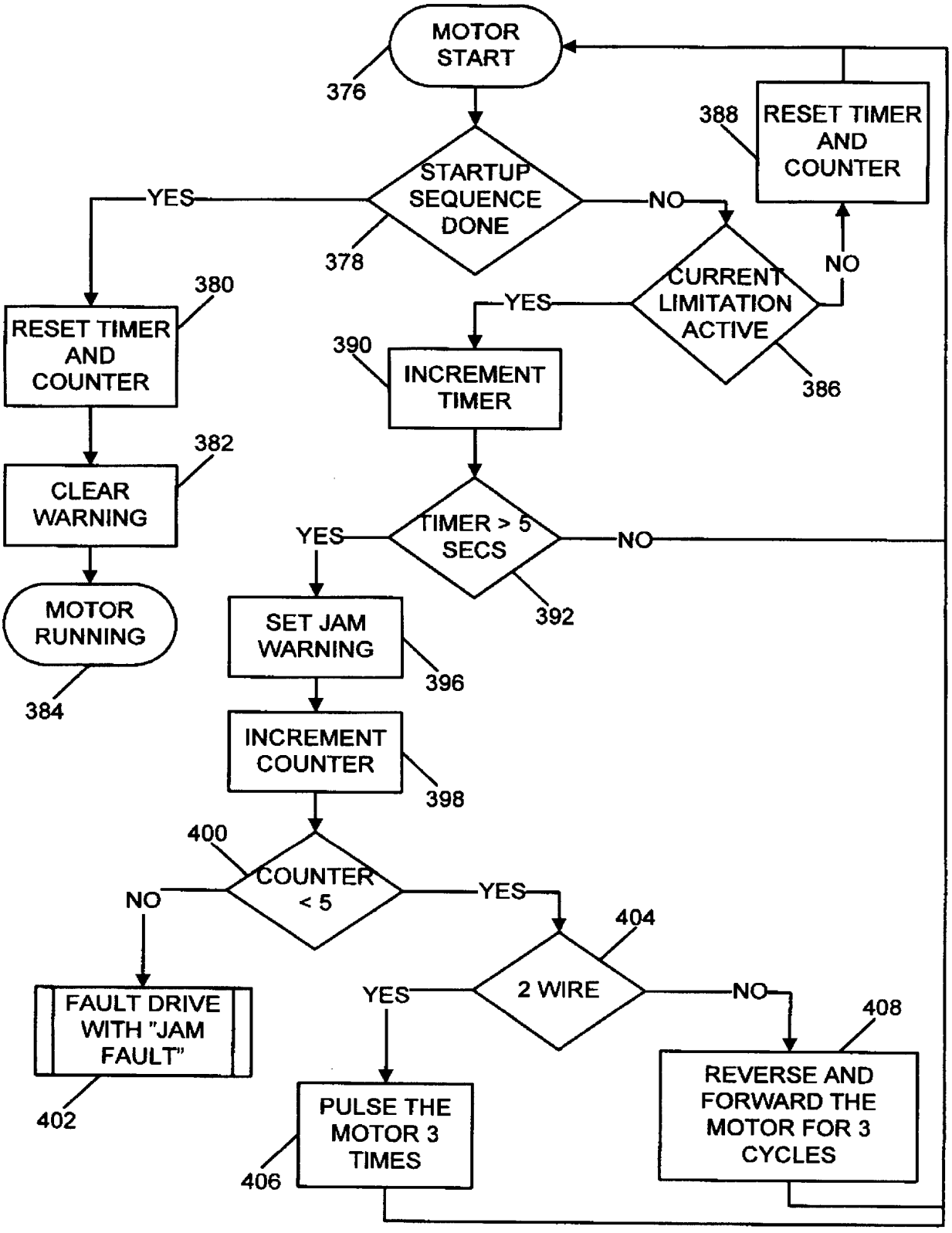

MOTOR START
376
STARTUP SEQUENCE DONE
378
YES
NO
RESET TIMER AND COUNTER
380
CLEAR WARNING
382
MOTOR RUNNING
384
388
RESET TIMER AND COUNTER
CURRENT LIMITATION ACTIVE
386
NO
YES
390
INCREMENT TIMER
TIMER > 5 SECS
392
YES
NO
SET JAM WARNING
396
INCREMENT COUNTER
398
400
COUNTER < 5
NO
YES
FAULT DRIVE WITH "JAM FAULT"
402
404
2 WIRE
YES
NO
PULSE THE MOTOR 3 TIMES
406
408
REVERSE AND FORWARD THE MOTOR FOR 3 CYCLES

FIGURE 32

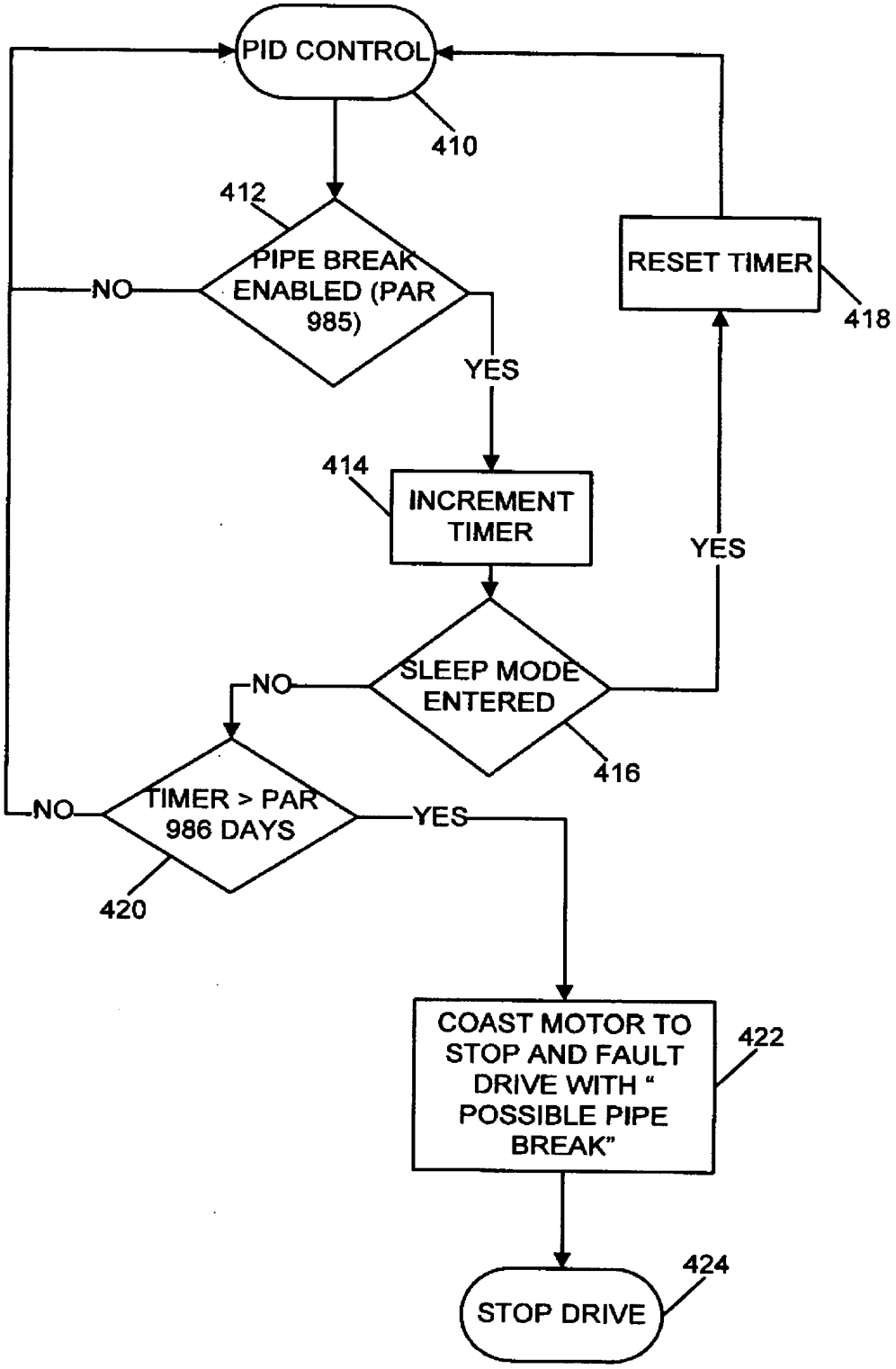

PID CONTROL
410
412
PIPE BREAK ENABLED (PAR 985)
NO
YES
414
INCREMENT TIMER
SLEEP MODE ENTERED
NO
YES
416
TIMER > PAR 986 DAYS
NO
YES
420
RESET TIMER
418
COAST MOTOR TO STOP AND FAULT DRIVE WITH " POSSIBLE PIPE BREAK"
422
STOP DRIVE
424

FIGURE 33

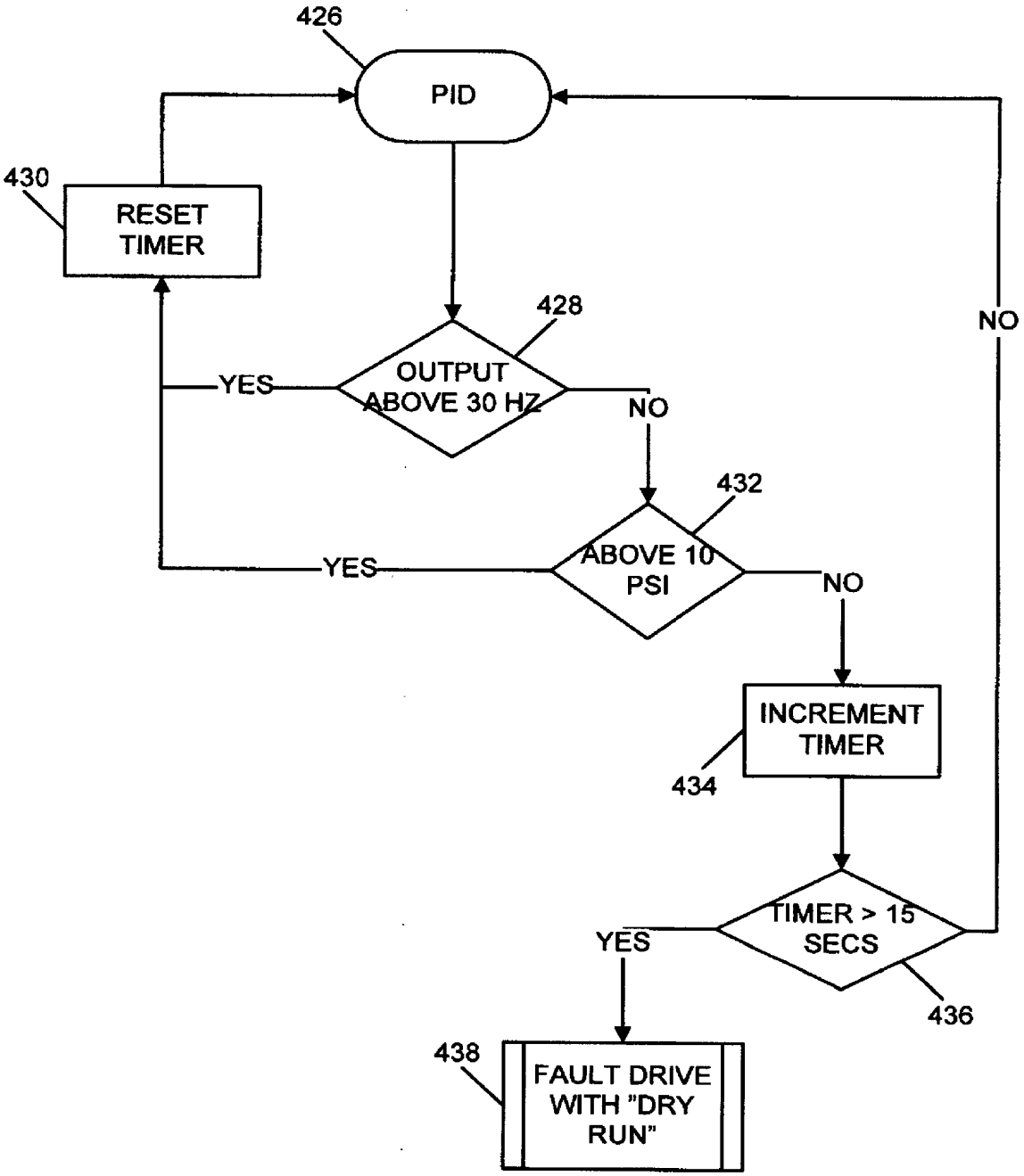

426
PID
430
RESET TIMER
428
OUTPUT ABOVE 30 HZ
YES
NO
NO
432
ABOVE 10 PSI
YES
NO
INCREMENT TIMER
434
TIMER > 15 SECS
YES
436
438
FAULT DRIVE WITH "DRY RUN"

FIGURE 34

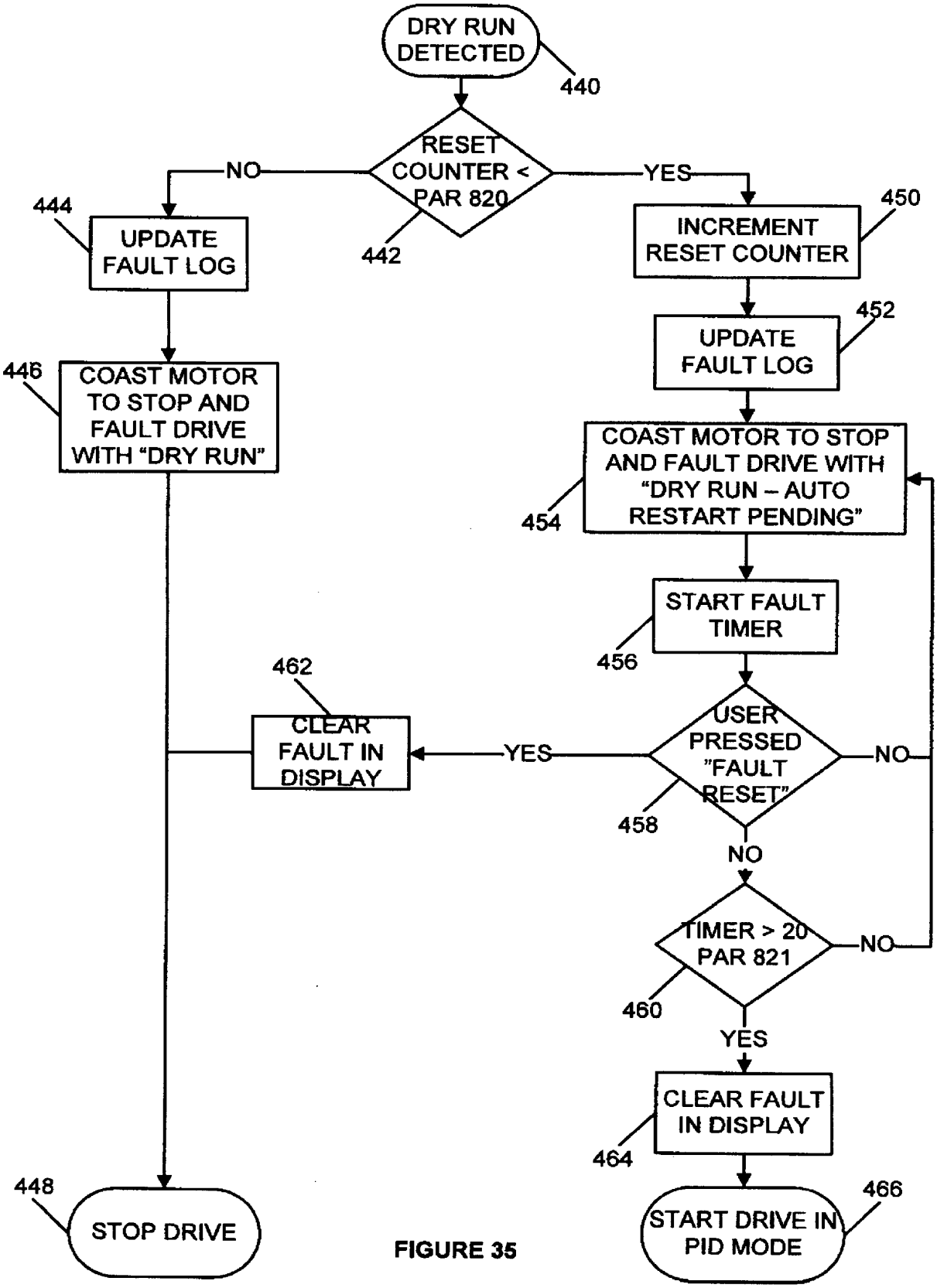

DRY RUN DETECTED
440
RESET COUNTER < PAR 820
442
NO
YES
444
UPDATE FAULT LOG
446
COAST MOTOR TO STOP AND FAULT DRIVE WITH "DRY RUN"
450
INCREMENT RESET COUNTER
452
UPDATE FAULT LOG
454
COAST MOTOR TO STOP AND FAULT DRIVE WITH "DRY RUN – AUTO RESTART PENDING"
456
START FAULT TIMER
458
USER PRESSED "FAULT RESET"
YES
NO
462
CLEAR FAULT IN DISPLAY
NO
460
TIMER > 20 PAR 821
NO
YES
464
CLEAR FAULT IN DISPLAY
466
START DRIVE IN PID MODE
448
STOP DRIVE

FIGURE 35

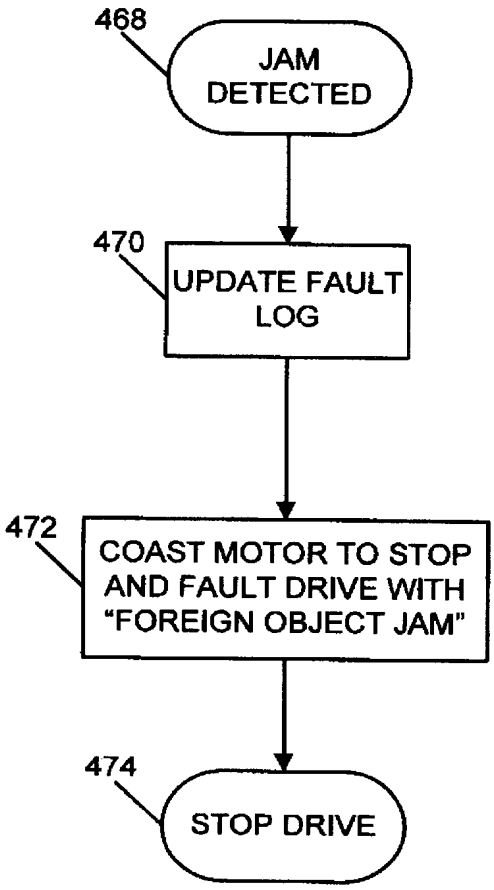

468
JAM DETECTED
470
UPDATE FAULT LOG
472
COAST MOTOR TO STOP AND FAULT DRIVE WITH "FOREIGN OBJECT JAM"
474
STOP DRIVE

FIGURE 36

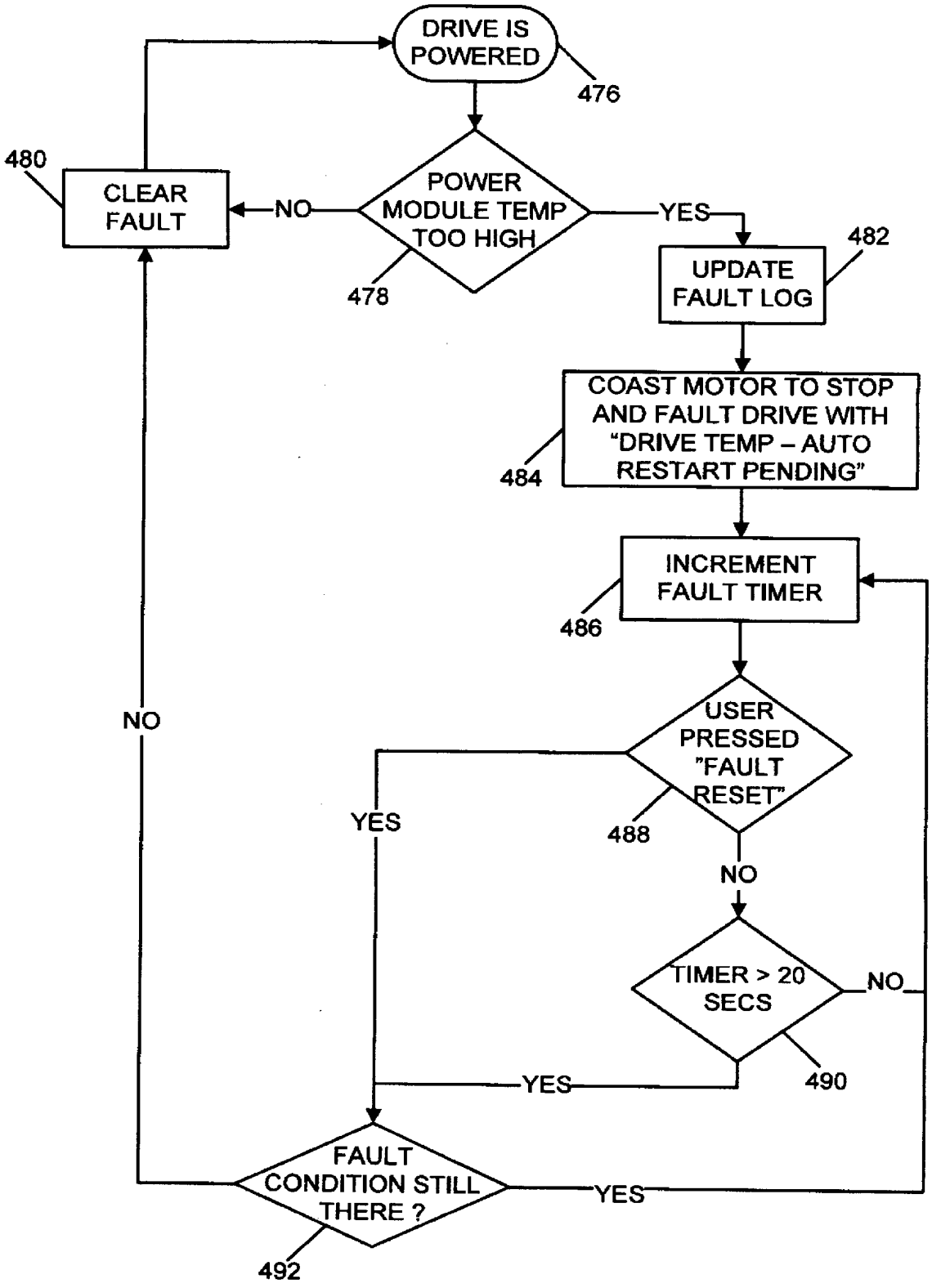

DRIVE IS POWERED
476
POWER MODULE TEMP TOO HIGH
478
NO
CLEAR FAULT
480
YES
UPDATE FAULT LOG
482
COAST MOTOR TO STOP AND FAULT DRIVE WITH "DRIVE TEMP – AUTO RESTART PENDING"
484
INCREMENT FAULT TIMER
486
USER PRESSED "FAULT RESET"
488
YES
NO
TIMER > 20 SECS
490
NO
YES
FAULT CONDITION STILL THERE ?
492
YES
NO

FIGURE 37

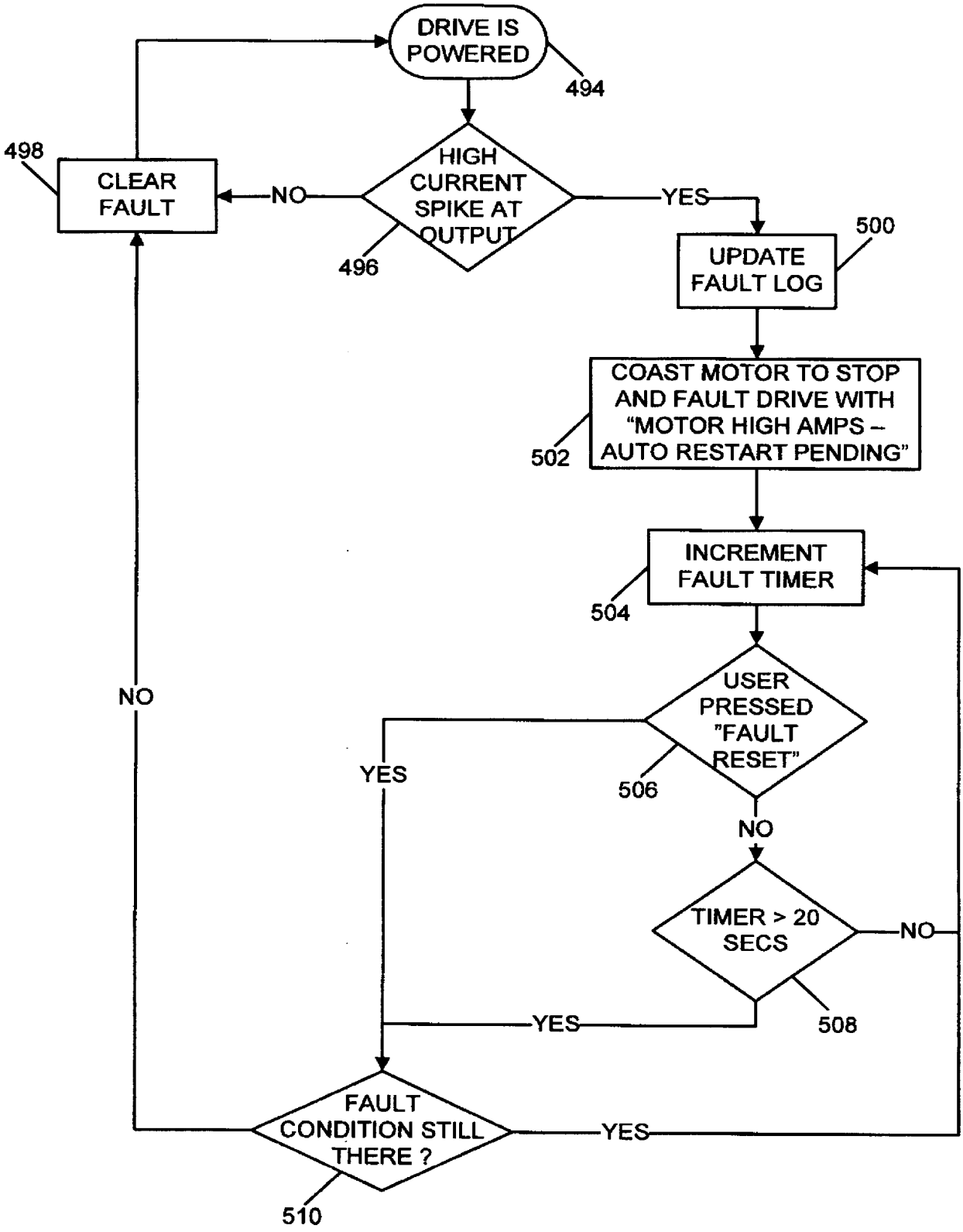

DRIVE IS POWERED
494
HIGH CURRENT SPIKE AT OUTPUT
496
NO
CLEAR FAULT
498
YES
UPDATE FAULT LOG
500
COAST MOTOR TO STOP AND FAULT DRIVE WITH "MOTOR HIGH AMPS – AUTO RESTART PENDING"
502
INCREMENT FAULT TIMER
504
USER PRESSED "FAULT RESET"
506
YES
NO
TIMER > 20 SECS
508
NO
YES
FAULT CONDITION STILL THERE ?
510
YES
NO

FIGURE 38

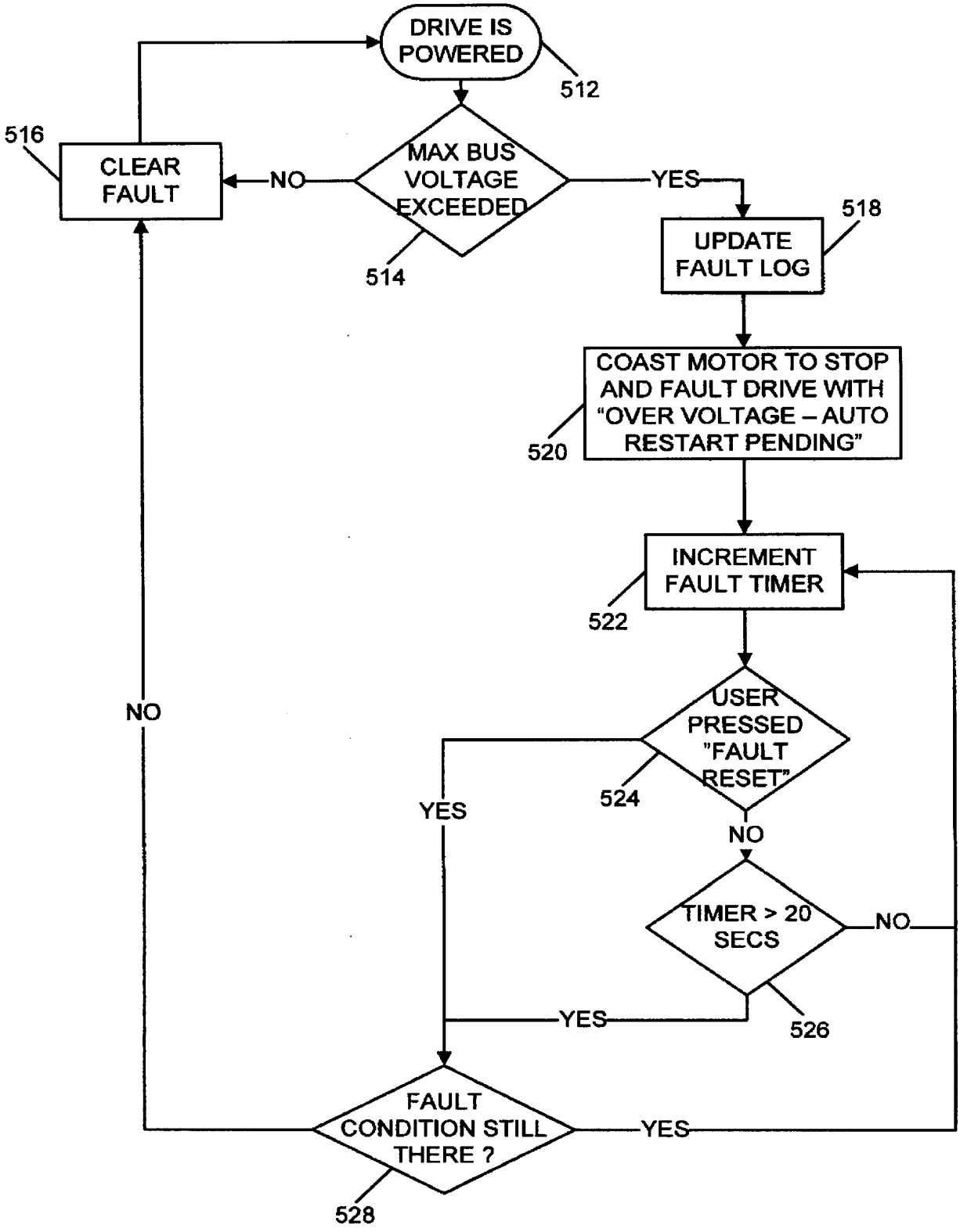

DRIVE IS POWERED
512
MAX BUS VOLTAGE EXCEEDED
514
NO
CLEAR FAULT
516
YES
UPDATE FAULT LOG
518
COAST MOTOR TO STOP AND FAULT DRIVE WITH "OVER VOLTAGE – AUTO RESTART PENDING"
520
INCREMENT FAULT TIMER
522
USER PRESSED "FAULT RESET"
524
YES
NO
TIMER > 20 SECS
NO
YES
526
FAULT CONDITION STILL THERE ?
YES
NO
528

FIGURE 39

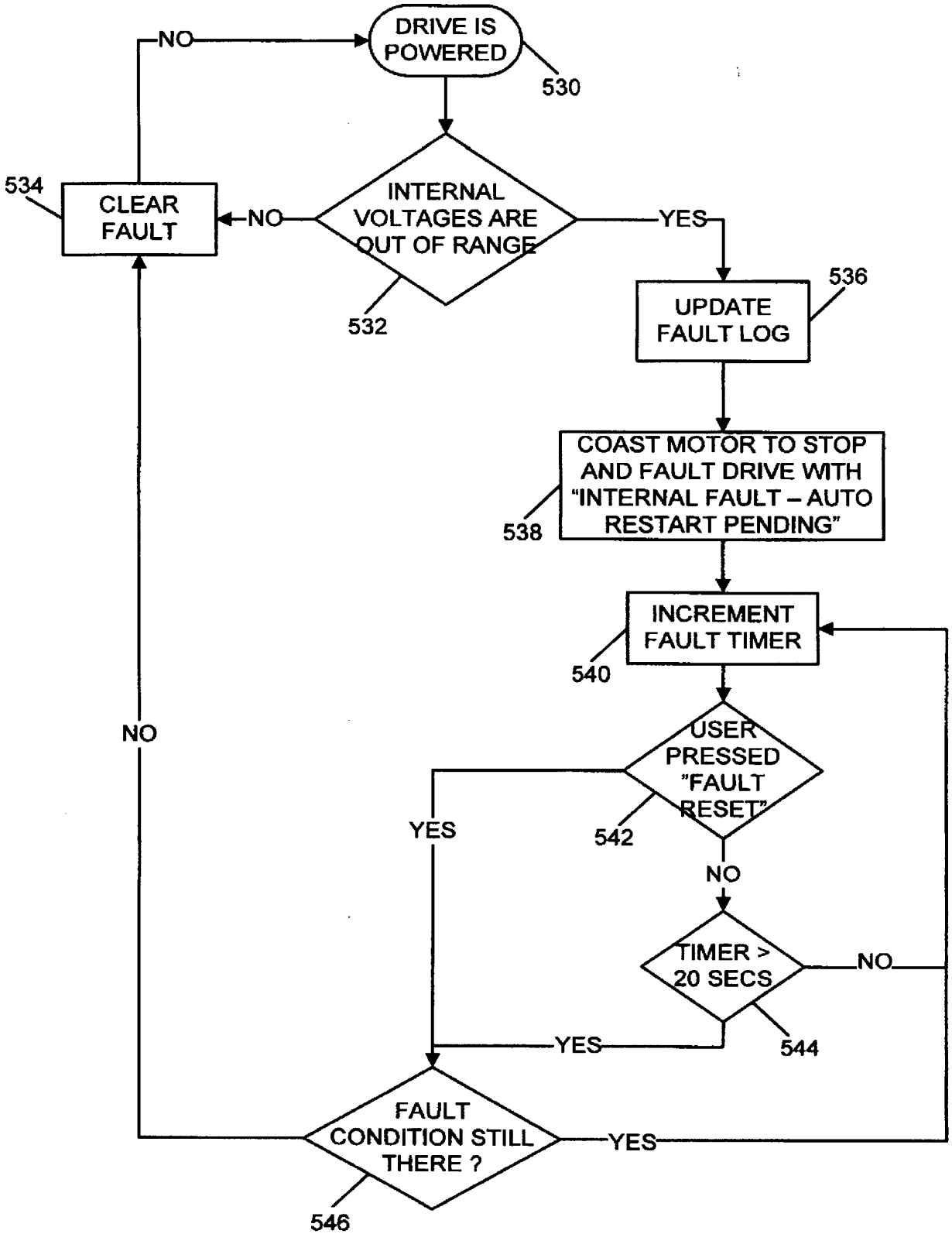

DRIVE IS POWERED
530
NO
INTERNAL VOLTAGES ARE OUT OF RANGE
532
NO
CLEAR FAULT
534
YES
UPDATE FAULT LOG
536
COAST MOTOR TO STOP AND FAULT DRIVE WITH "INTERNAL FAULT – AUTO RESTART PENDING"
538
INCREMENT FAULT TIMER
540
USER PRESSED "FAULT RESET"
542
YES
NO
TIMER > 20 SECS
544
NO
YES
FAULT CONDITION STILL THERE ?
546
YES
NO

FIGURE 40

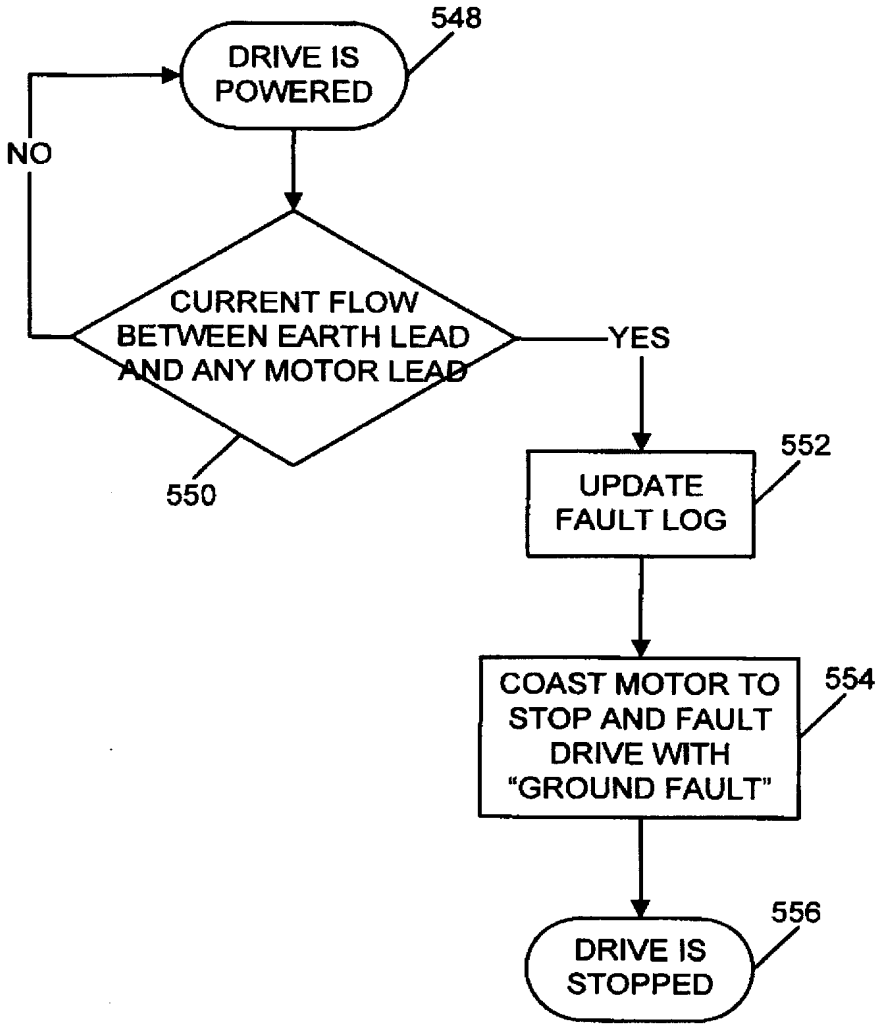

548
DRIVE IS POWERED
NO
CURRENT FLOW BETWEEN EARTH LEAD AND ANY MOTOR LEAD
YES
550
552
UPDATE FAULT LOG
554
COAST MOTOR TO STOP AND FAULT DRIVE WITH "GROUND FAULT"
556
DRIVE IS STOPPED

FIGURE 41

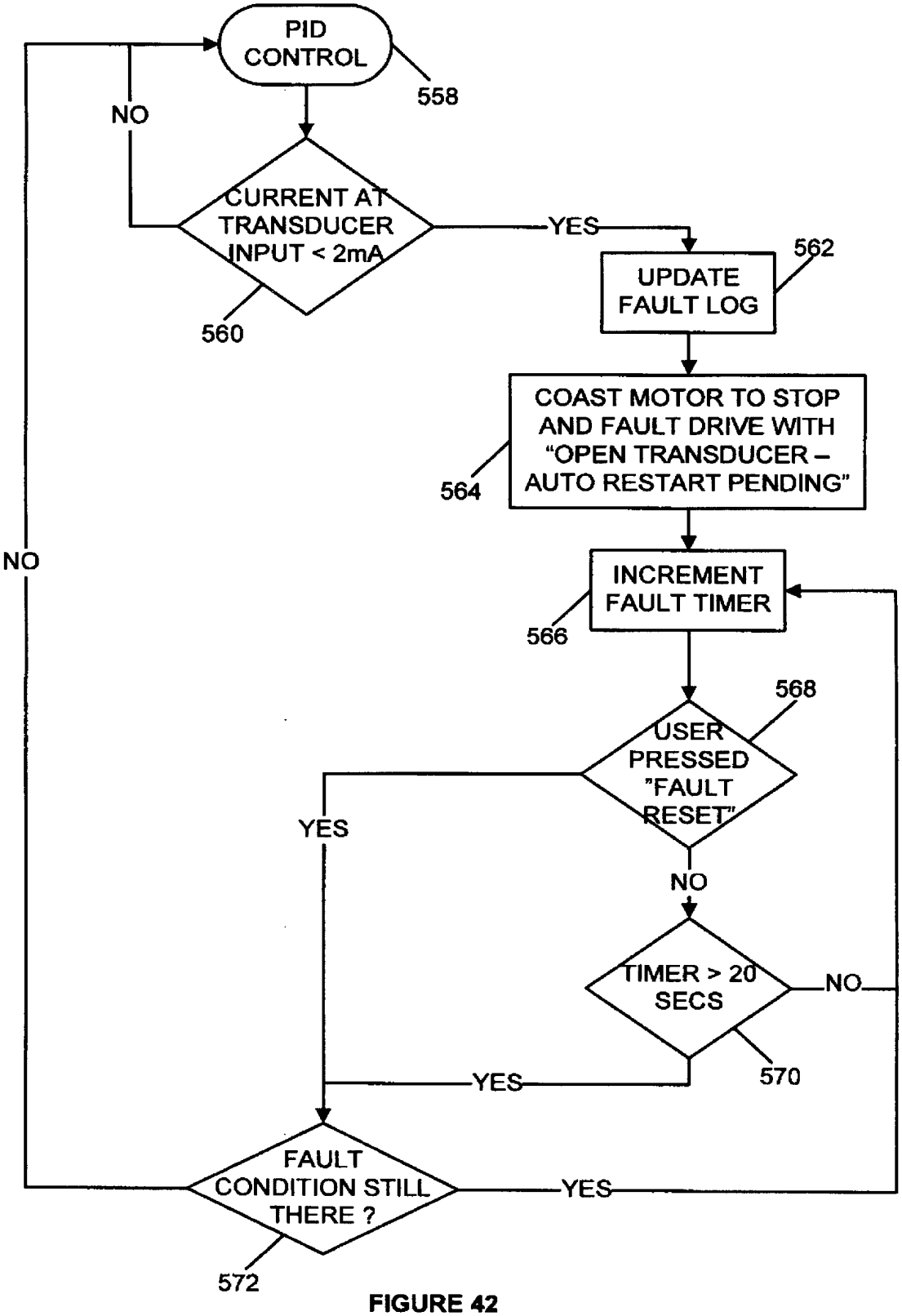

PID CONTROL
558
NO
CURRENT AT TRANSDUCER INPUT < 2mA
YES
560
562
UPDATE FAULT LOG
COAST MOTOR TO STOP AND FAULT DRIVE WITH "OPEN TRANSDUCER – AUTO RESTART PENDING"
564
NO
INCREMENT FAULT TIMER
566
568
USER PRESSED "FAULT RESET"
YES
NO
TIMER > 20 SECS
NO
570
YES
FAULT CONDITION STILL THERE ?
YES
572

FIGURE 42

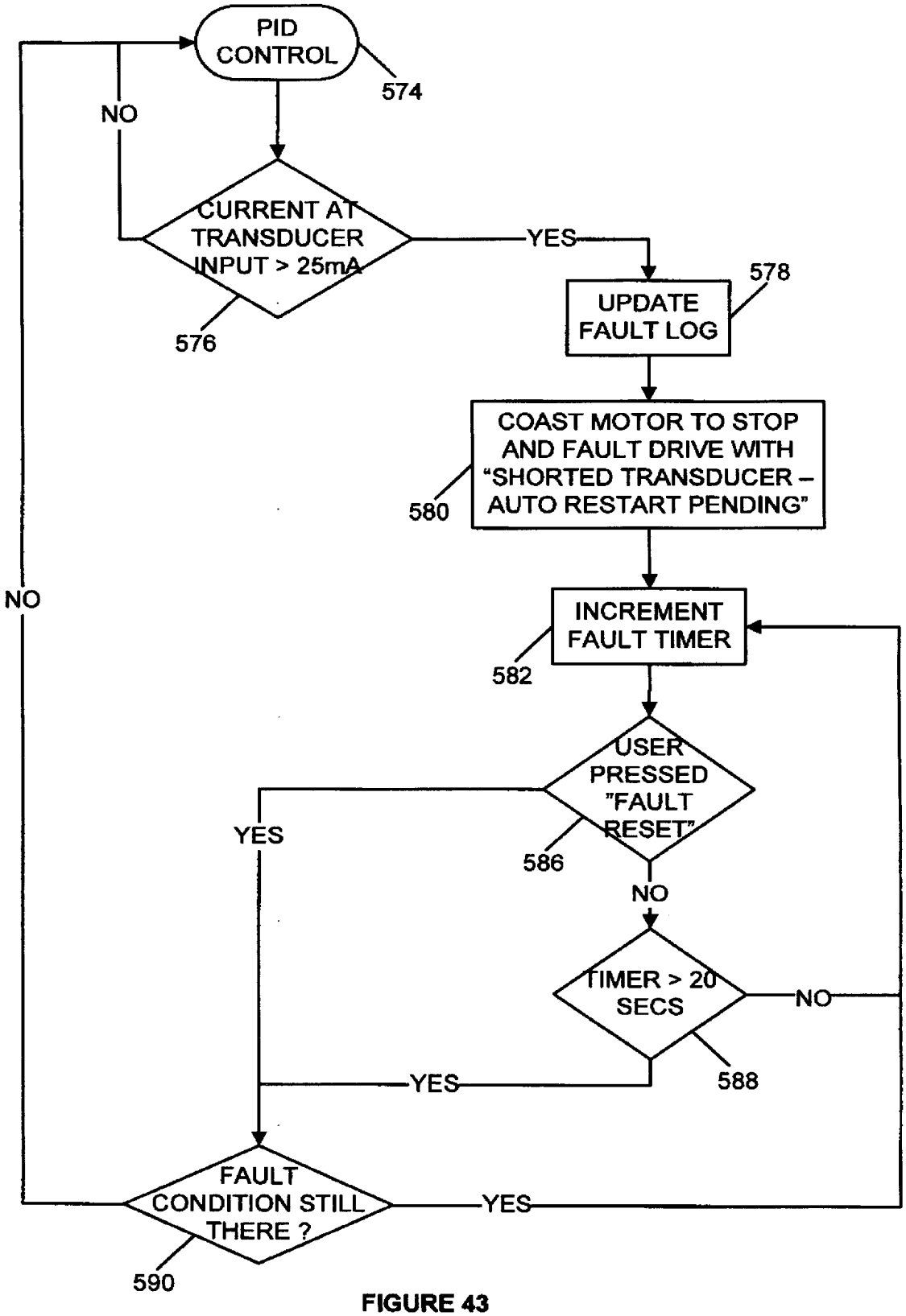

PID CONTROL
574
NO
CURRENT AT TRANSDUCER INPUT > 25mA
YES
576
578
UPDATE FAULT LOG
COAST MOTOR TO STOP AND FAULT DRIVE WITH "SHORTED TRANSDUCER – AUTO RESTART PENDING"
580
NO
INCREMENT FAULT TIMER
582
USER PRESSED "FAULT RESET"
YES
586
NO
TIMER > 20 SECS
NO
588
YES
FAULT CONDITION STILL THERE ?
YES
590

FIGURE 43

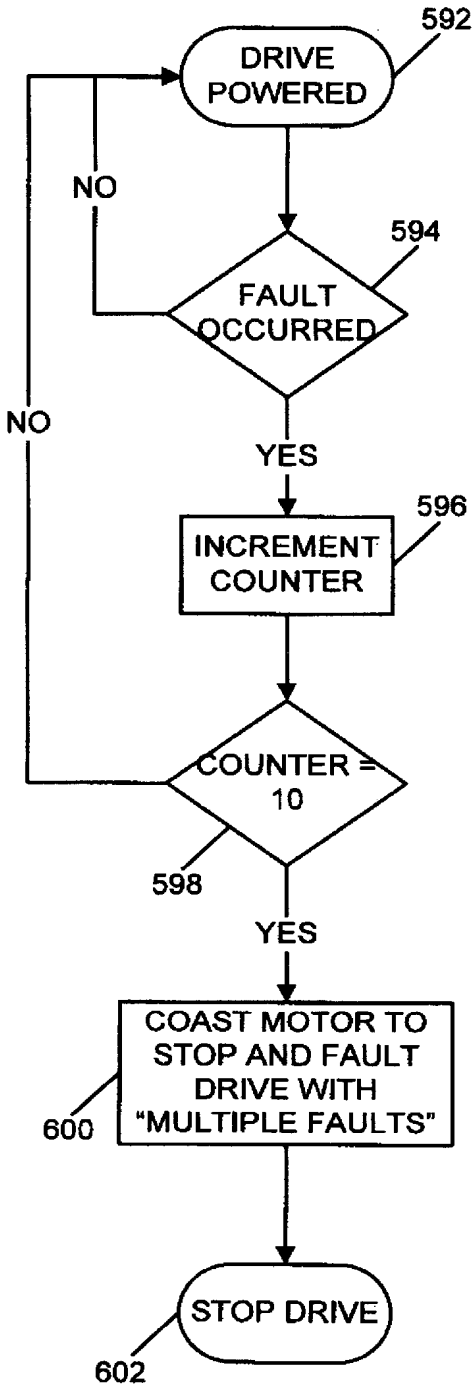


FIGURE 44A

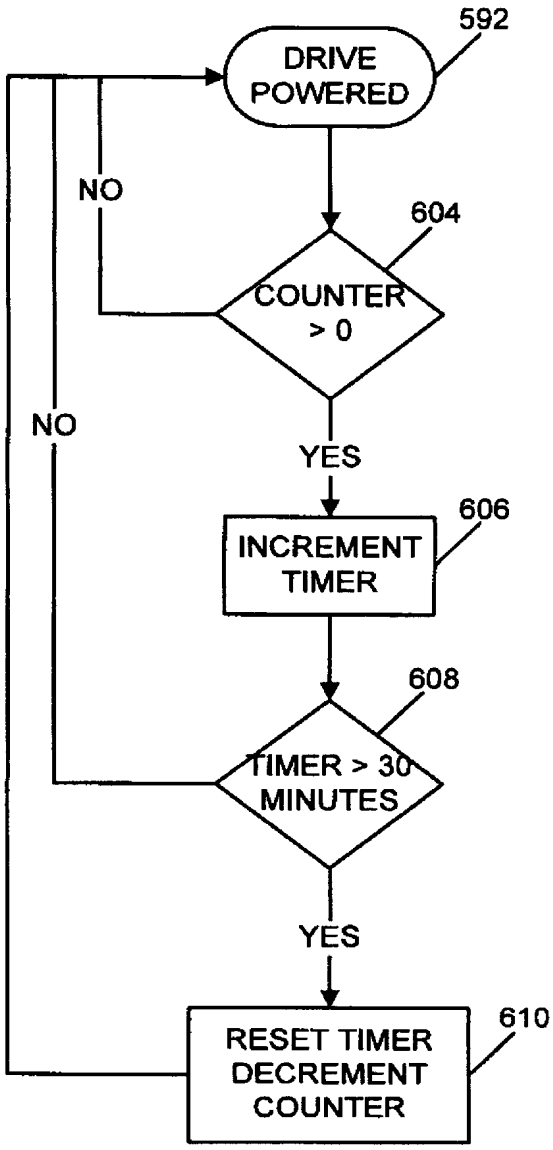


FIGURE 44B

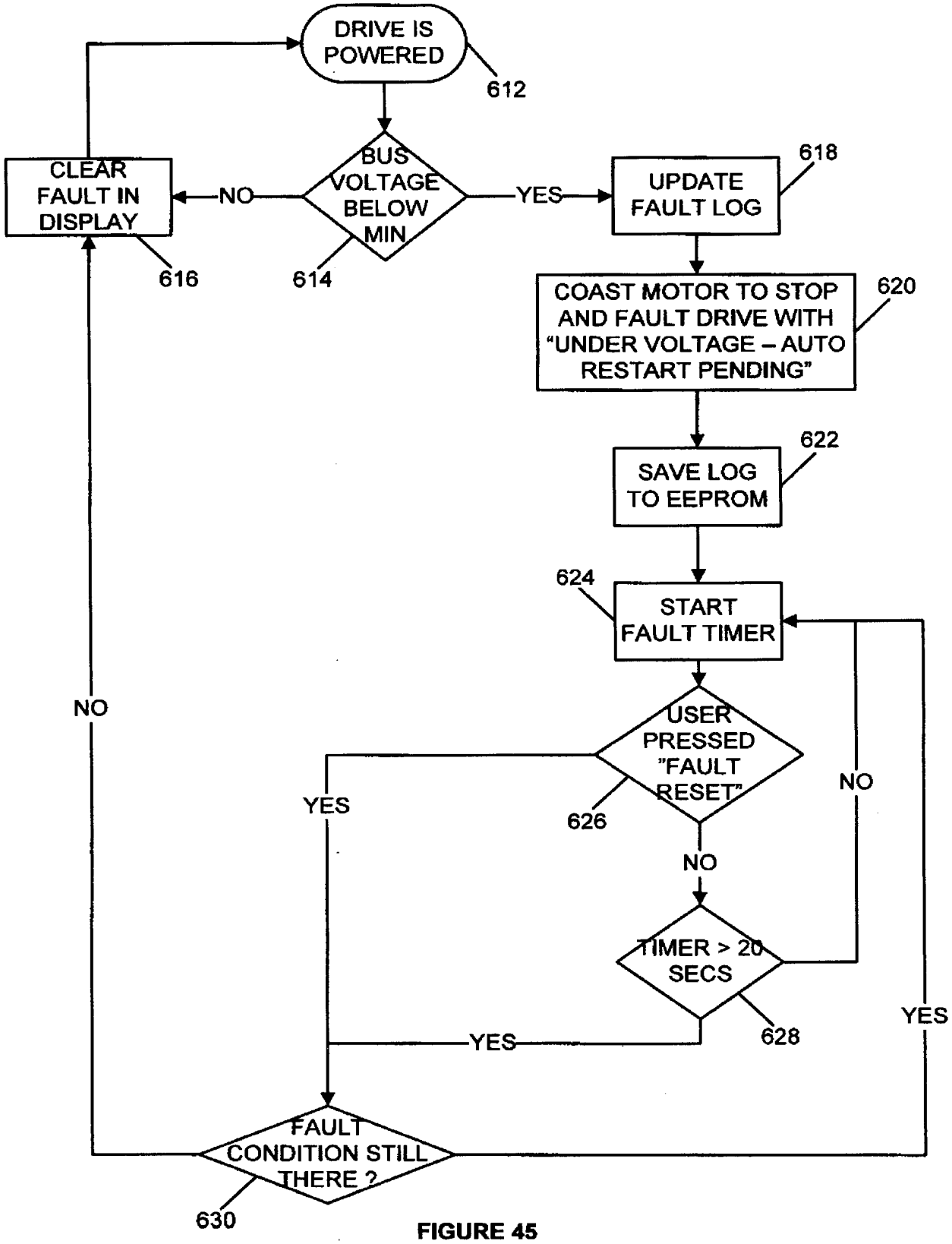

DRIVE IS POWERED
612
BUS VOLTAGE BELOW MIN
614
NO
YES
CLEAR FAULT IN DISPLAY
616
UPDATE FAULT LOG
618
COAST MOTOR TO STOP AND FAULT DRIVE WITH "UNDER VOLTAGE – AUTO RESTART PENDING"
620
SAVE LOG TO EEPROM
622
START FAULT TIMER
624
USER PRESSED "FAULT RESET"
626
YES
NO
NO
TIMER > 20 SECS
628
YES
YES
FAULT CONDITION STILL THERE ?
630
NO

FIGURE 45

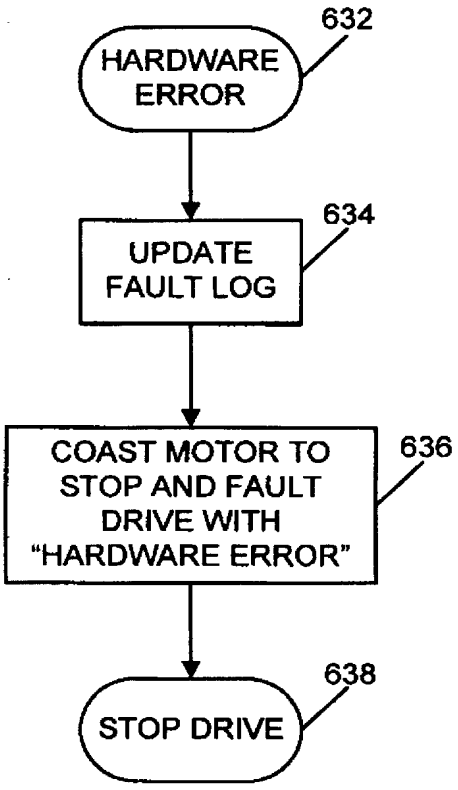

632
HARDWARE ERROR
634
UPDATE FAULT LOG
636
COAST MOTOR TO STOP AND FAULT DRIVE WITH "HARDWARE ERROR"
638
STOP DRIVE

FIGURE 46

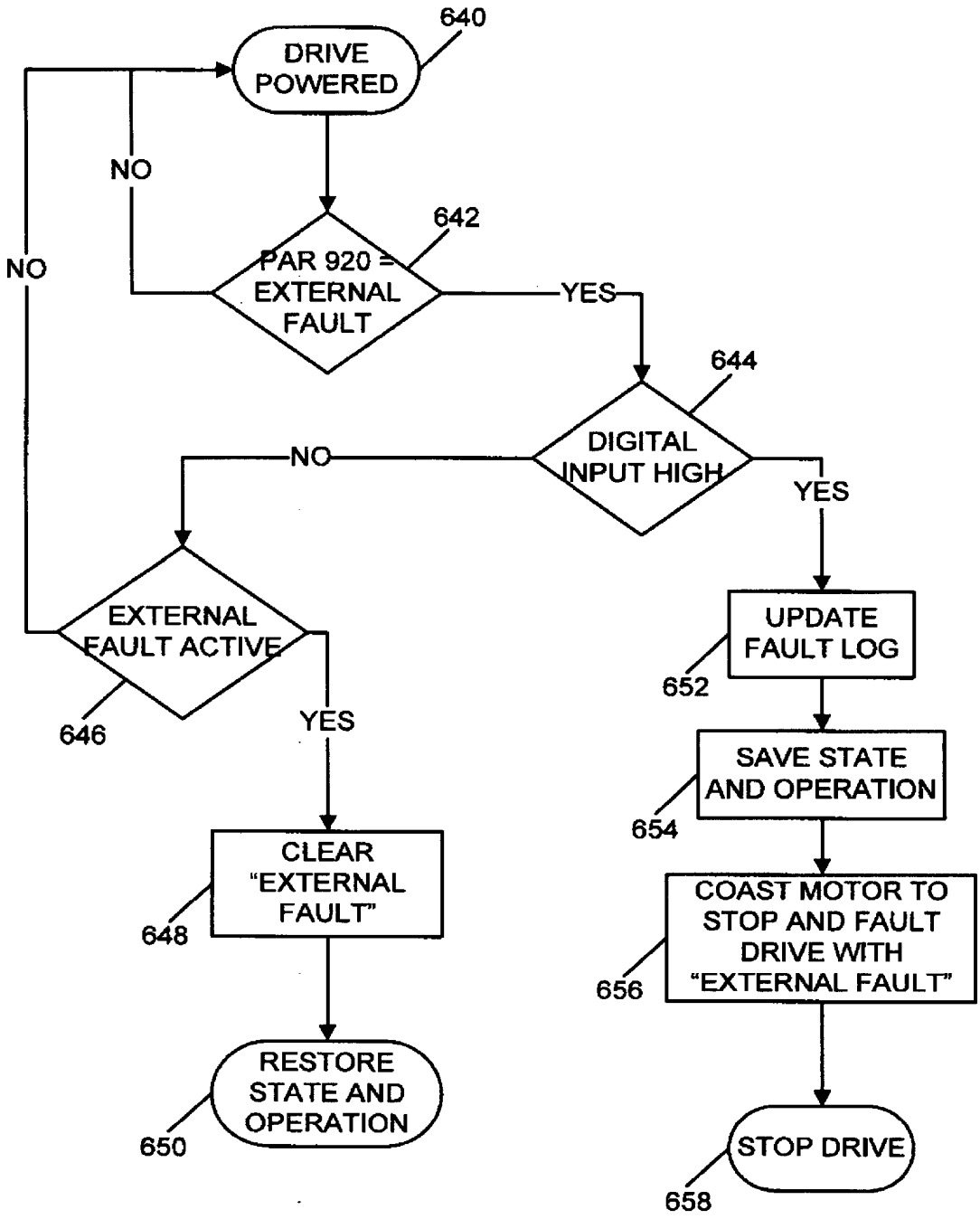

640
DRIVE POWERED
NO
642
PAR 920 = EXTERNAL FAULT
NO
YES
644
DIGITAL INPUT HIGH
NO
YES
EXTERNAL FAULT ACTIVE
646
YES
UPDATE FAULT LOG
652
SAVE STATE AND OPERATION
654
CLEAR "EXTERNAL FAULT"
648
COAST MOTOR TO STOP AND FAULT DRIVE WITH "EXTERNAL FAULT"
656
RESTORE STATE AND OPERATION
650
STOP DRIVE
658

FIGURE 47

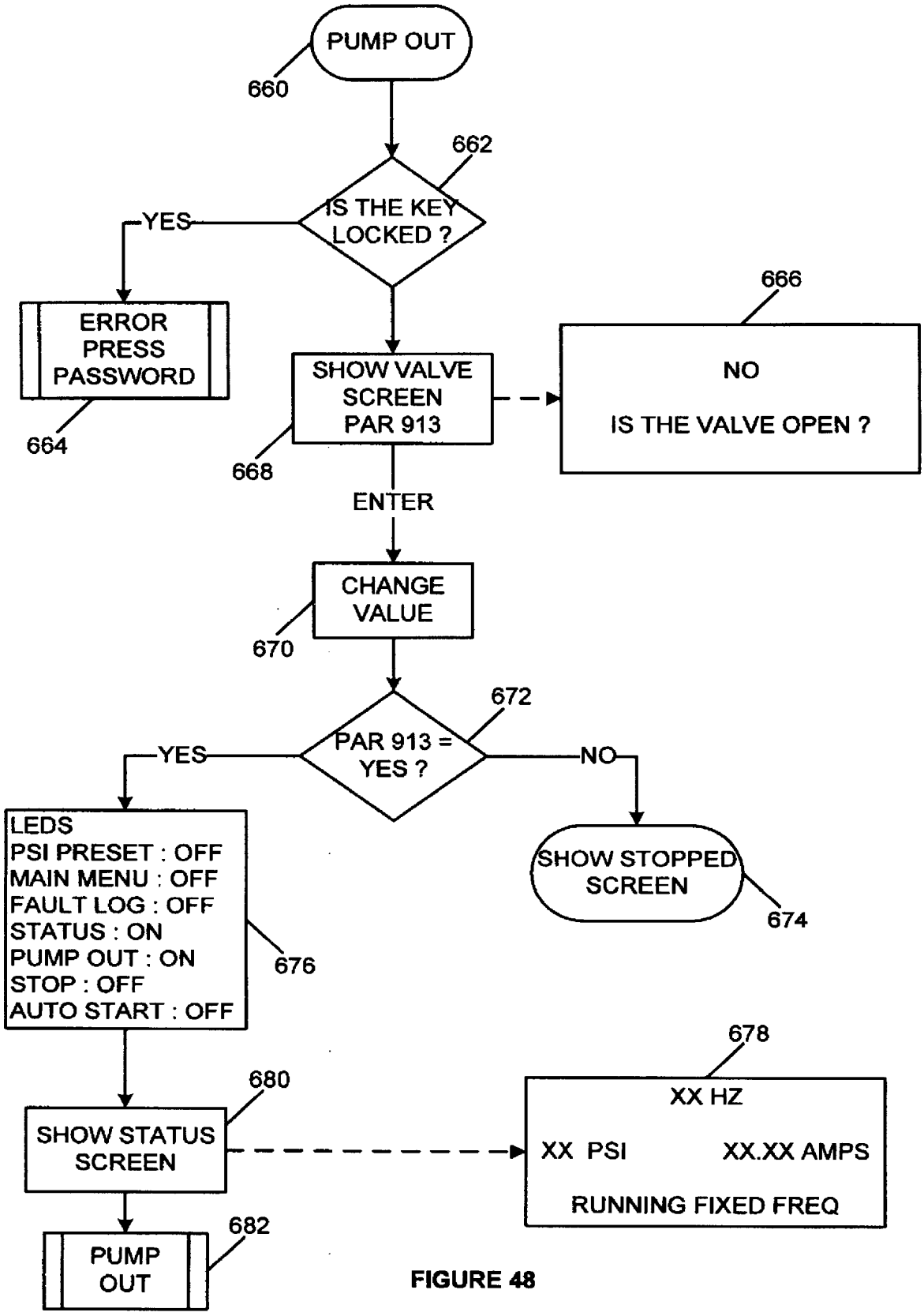

PUMP OUT
660
662
IS THE KEY LOCKED ?
YES
ERROR PRESS PASSWORD
664
SHOW VALVE SCREEN PAR 913
668
666
NO
IS THE VALVE OPEN ?
ENTER
CHANGE VALUE
670
672
PAR 913 = YES ?
YES
NO
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : ON
PUMP OUT : ON
STOP : OFF
AUTO START : OFF
676
SHOW STOPPED SCREEN
674
678
XX HZ
XX PSI
XX.XX AMPS
RUNNING FIXED FREQ
680
SHOW STATUS SCREEN
682
PUMP OUT

FIGURE 48

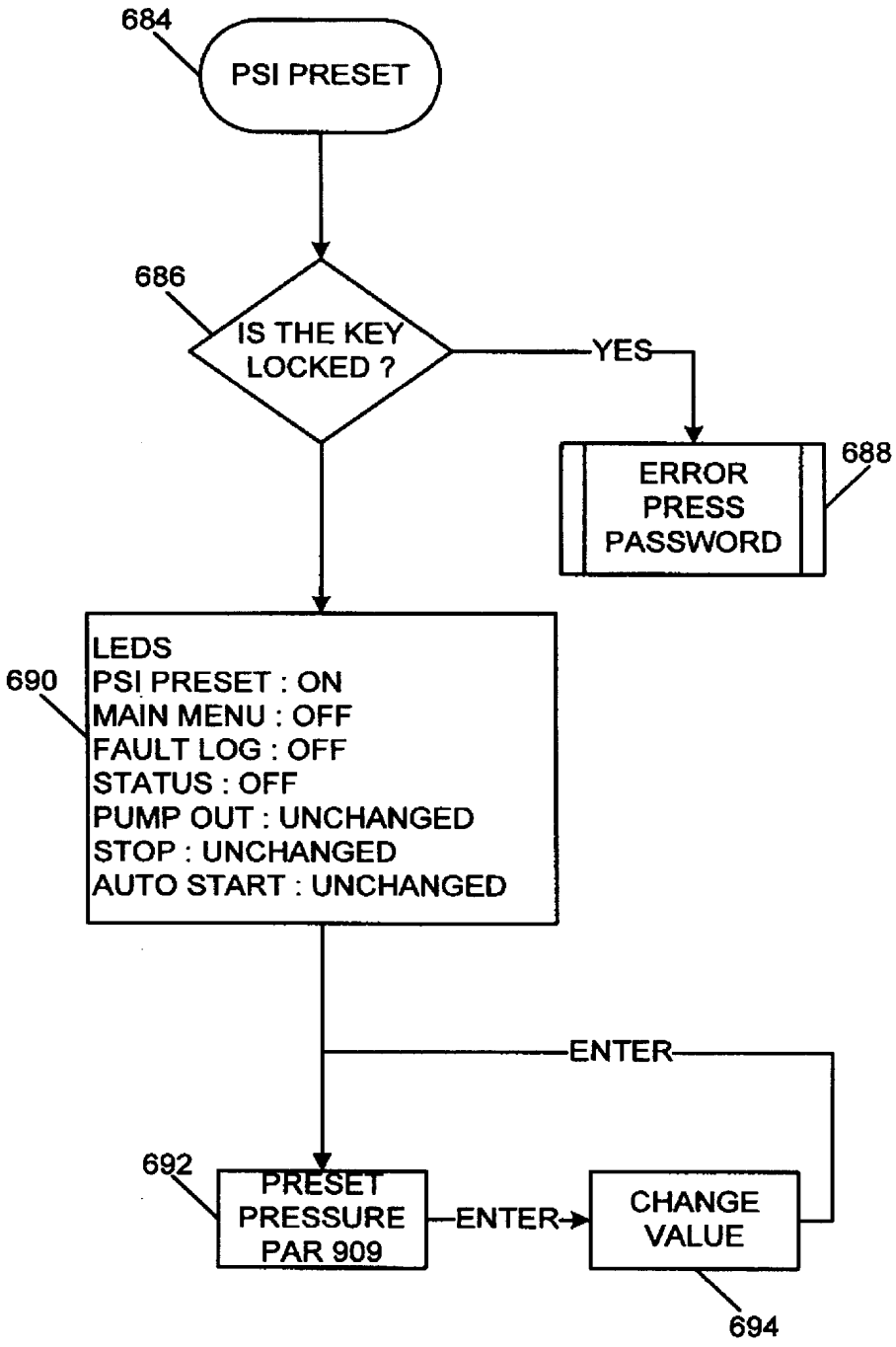

684
PSI PRESET
686
IS THE KEY LOCKED ?
YES
688
ERROR
PRESS
PASSWORD
690
LEDS
PSI PRESET : ON
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : OFF
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
ENTER
692
PRESET
PRESSURE
PAR 909
ENTER
CHANGE
VALUE
694

FIGURE 49

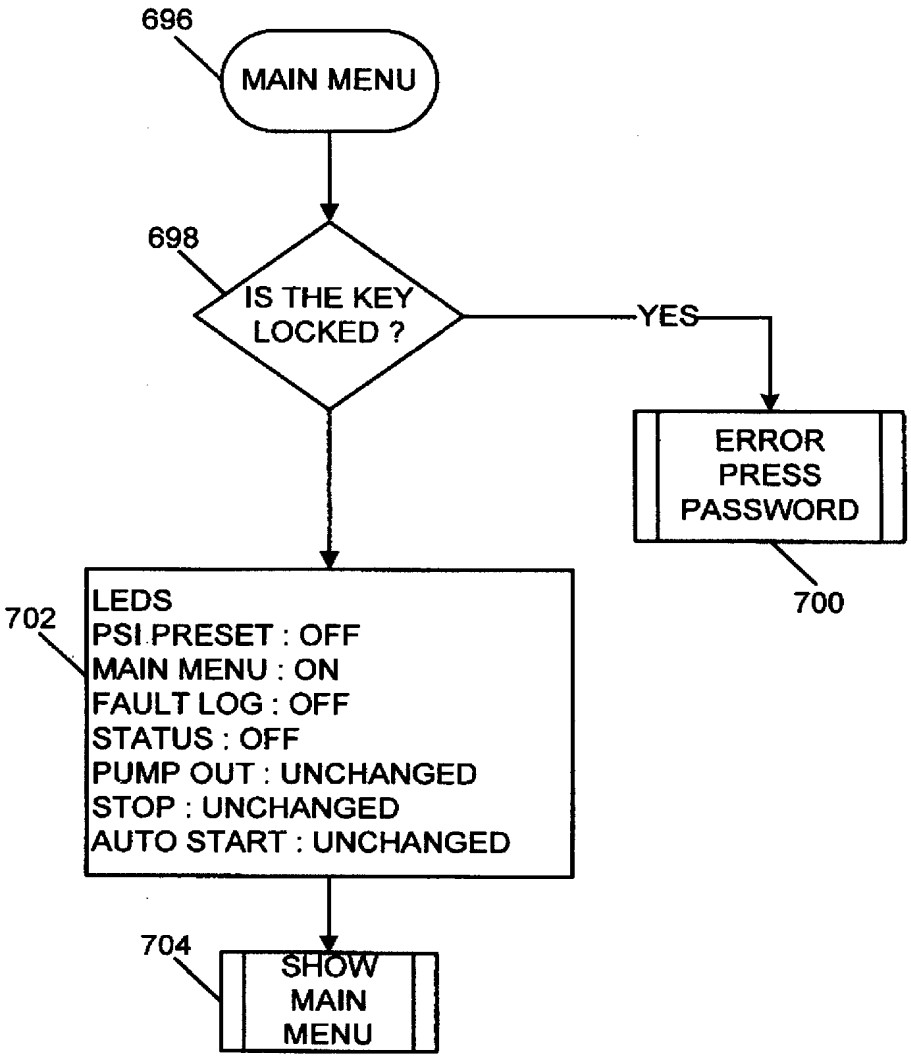

696
MAIN MENU
698
IS THE KEY LOCKED ?
YES
ERROR PRESS PASSWORD
700
702
LEDS
PSI PRESET : OFF
MAIN MENU : ON
FAULT LOG : OFF
STATUS : OFF
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
704
SHOW MAIN MENU

FIGURE 50

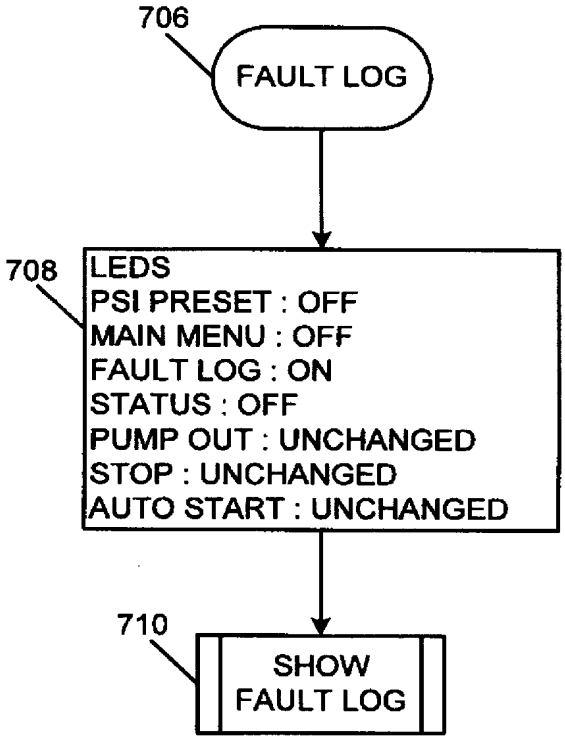

706
FAULT LOG
708
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : ON
STATUS : OFF
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
710
SHOW
FAULT LOG

FIGURE 51

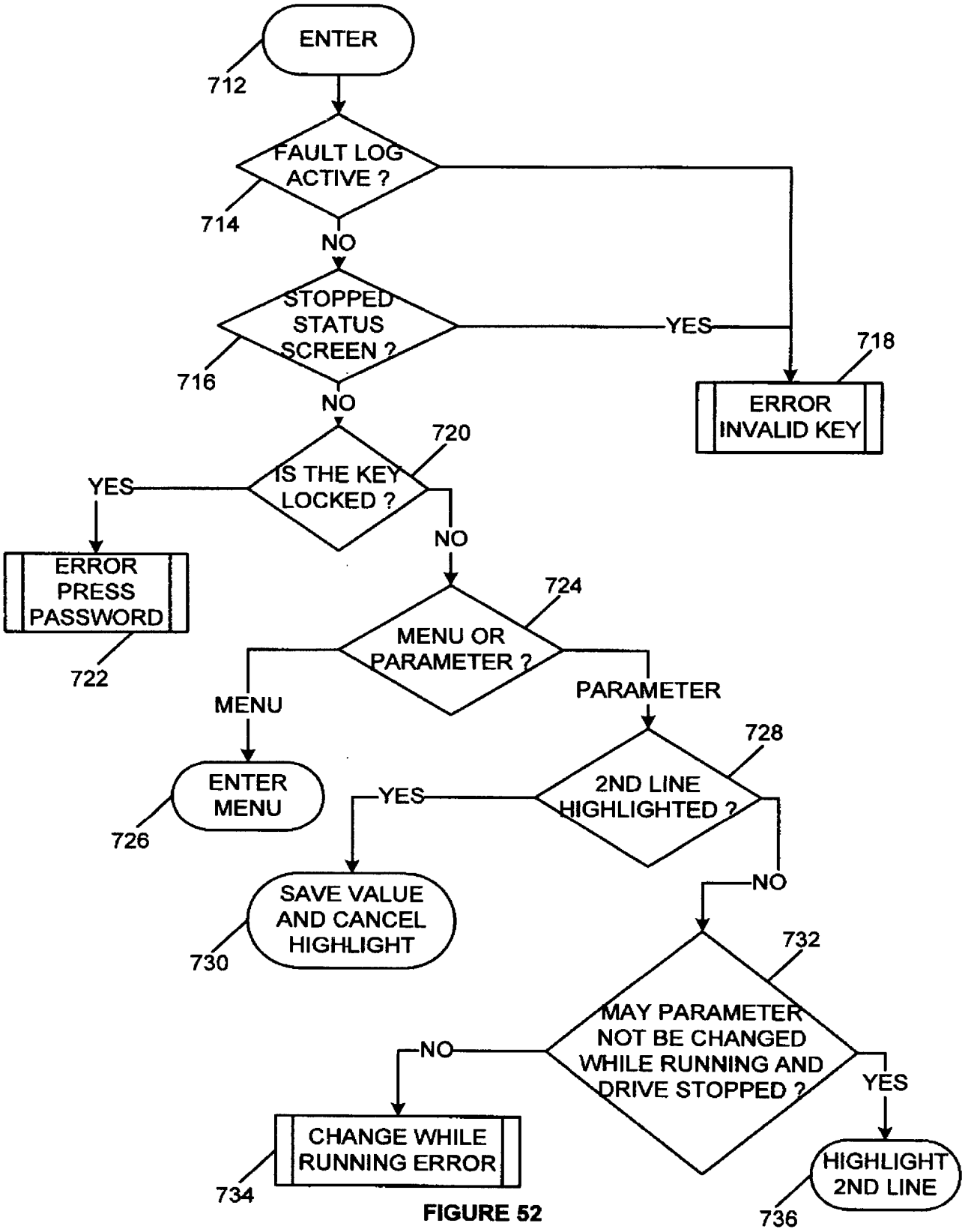

ENTER
712
FAULT LOG ACTIVE ?
714
NO
STOPPED STATUS SCREEN ?
716
YES
718
ERROR INVALID KEY
NO
720
IS THE KEY LOCKED ?
YES
ERROR PRESS PASSWORD
722
NO
724
MENU OR PARAMETER ?
MENU
ENTER MENU
726
PARAMETER
728
2ND LINE HIGHLIGHTED ?
YES
SAVE VALUE AND CANCEL HIGHLIGHT
730
NO
732
MAY PARAMETER NOT BE CHANGED WHILE RUNNING AND DRIVE STOPPED ?
NO
CHANGE WHILE RUNNING ERROR
734
YES
HIGHLIGHT 2ND LINE
736

FIGURE 52

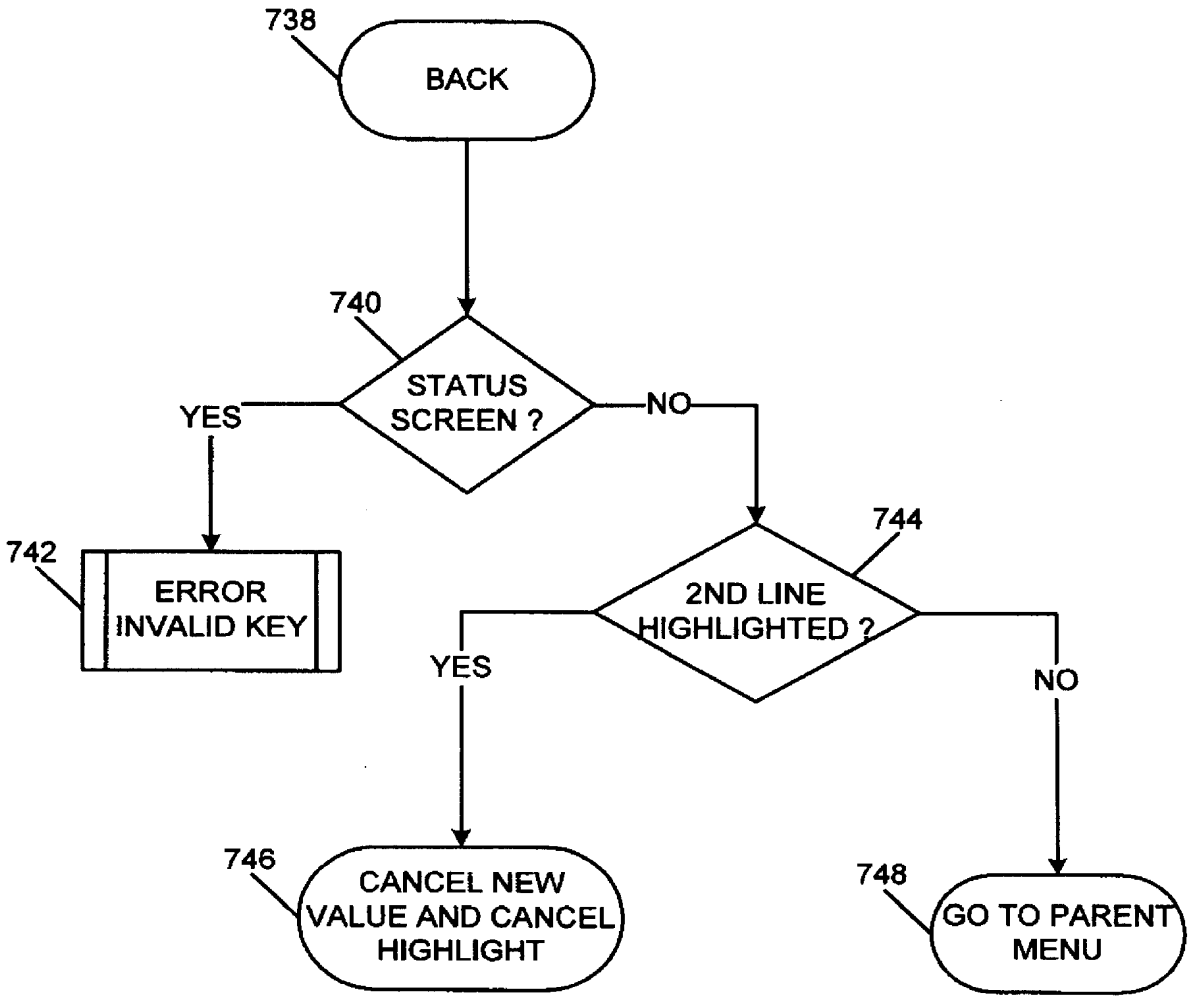

738
BACK
740
STATUS SCREEN ?
YES
NO
742
ERROR INVALID KEY
744
2ND LINE HIGHLIGHTED ?
YES
NO
746
CANCEL NEW VALUE AND CANCEL HIGHLIGHT
748
GO TO PARENT MENU

FIGURE 53

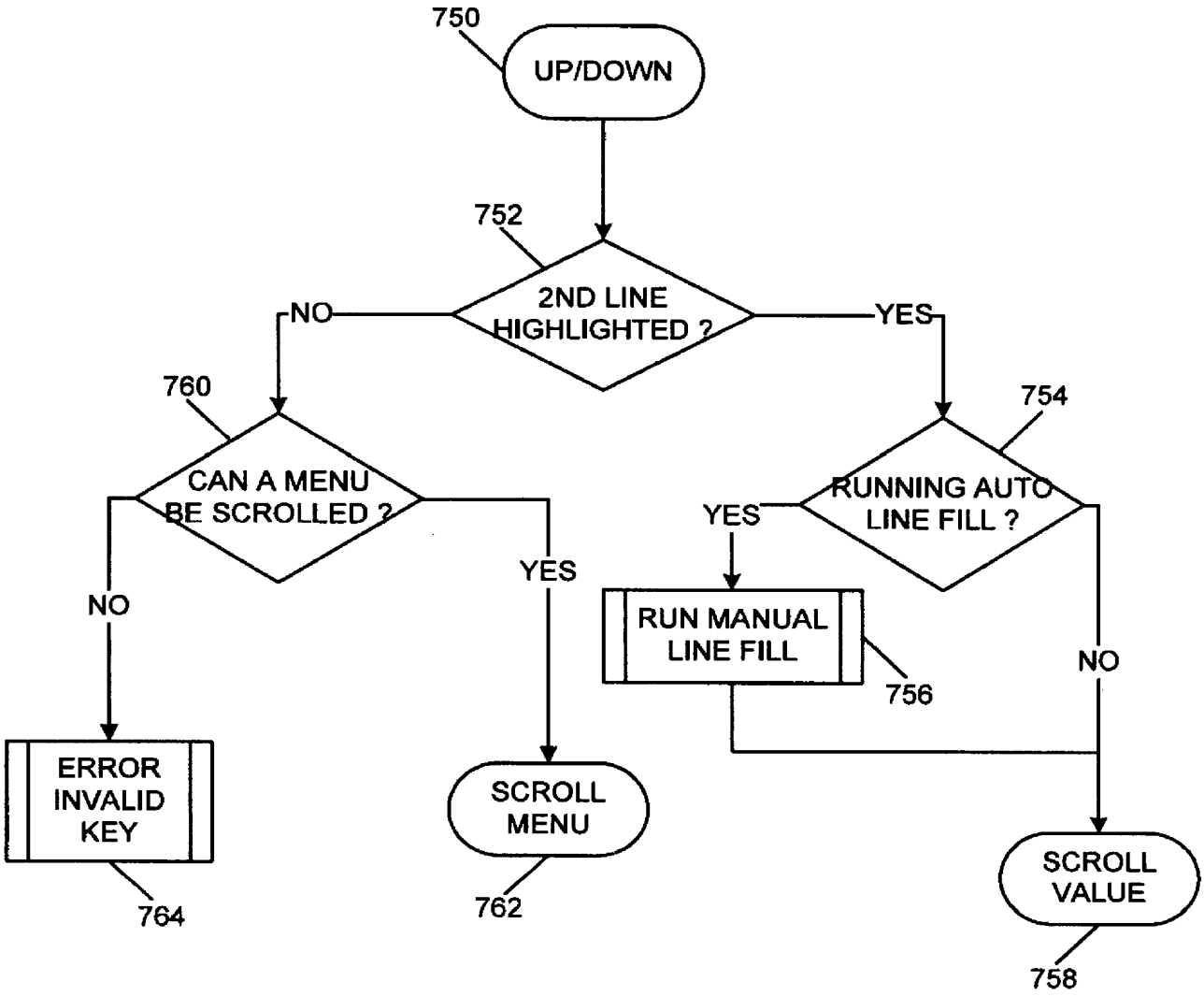

750
UP/DOWN
752
2ND LINE HIGHLIGHTED ?
NO
YES
760
CAN A MENU BE SCROLLED ?
754
RUNNING AUTO LINE FILL ?
YES
NO
YES
NO
RUN MANUAL LINE FILL
756
ERROR INVALID KEY
764
SCROLL MENU
762
SCROLL VALUE
758

FIGURE 54

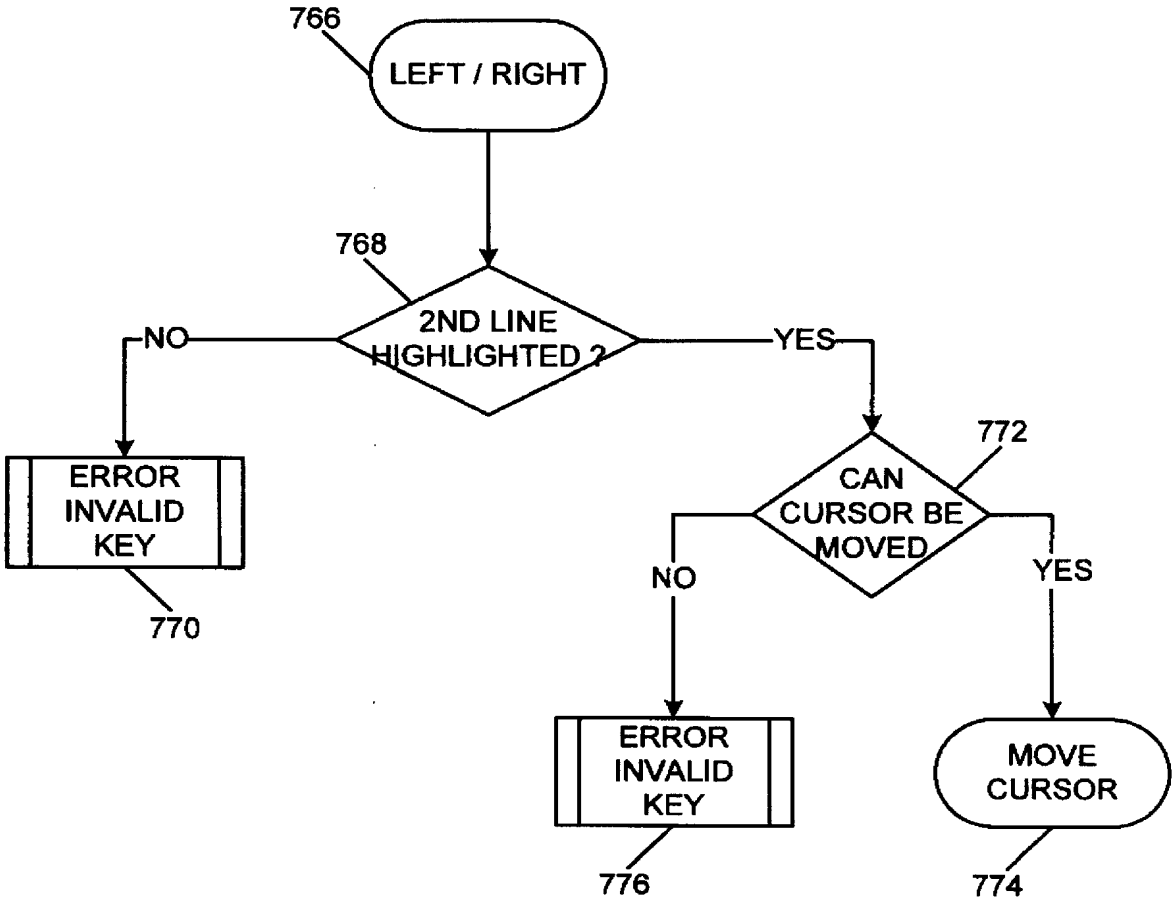

766
LEFT / RIGHT
768
2ND LINE HIGHLIGHTED ?
NO
YES
ERROR INVALID KEY
770
772
CAN CURSOR BE MOVED
NO
YES
ERROR INVALID KEY
776
MOVE CURSOR
774

FIGURE 55

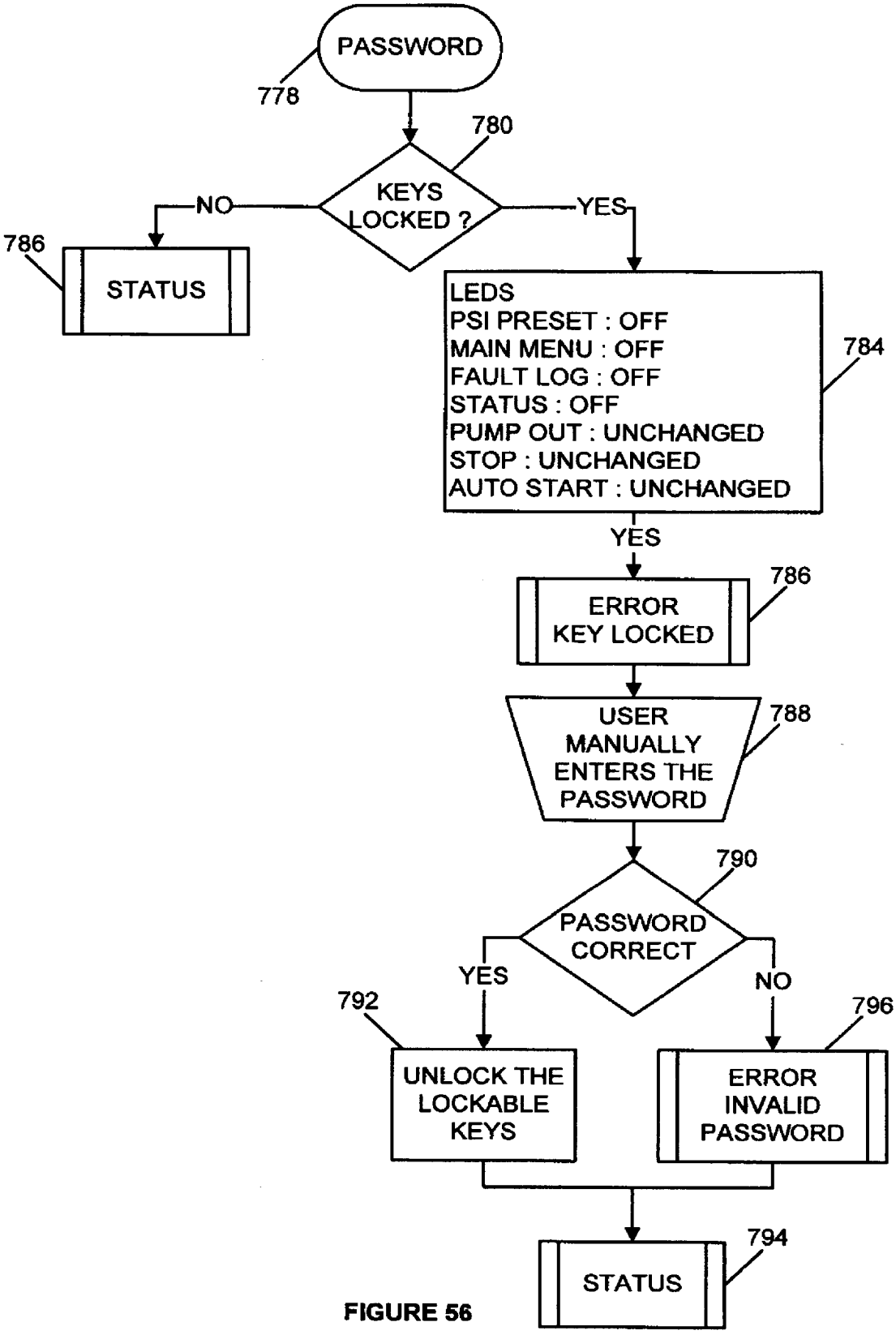

PASSWORD
778
780
KEYS LOCKED ?
NO
YES
786
STATUS
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : OFF
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
784
YES
786
ERROR KEY LOCKED
USER MANUALLY ENTERS THE PASSWORD
788
790
PASSWORD CORRECT
YES
NO
792
796
UNLOCK THE LOCKABLE KEYS
ERROR INVALID PASSWORD
794
STATUS

FIGURE 56

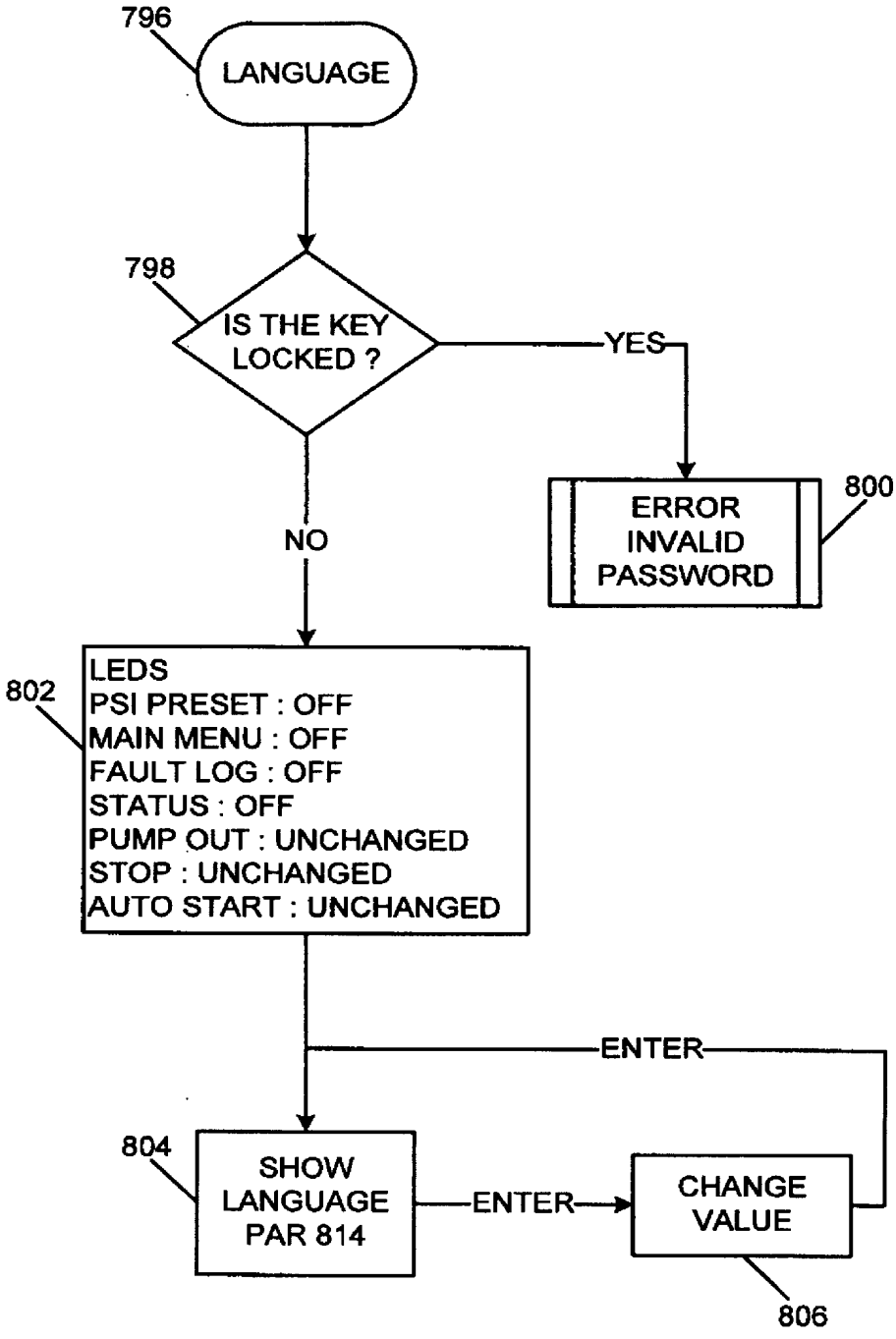

796
LANGUAGE
798
IS THE KEY LOCKED ?
YES
NO
800
ERROR
INVALID
PASSWORD
802
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : OFF
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
ENTER
804
SHOW
LANGUAGE
PAR 814
ENTER
CHANGE
VALUE
806

FIGURE 57

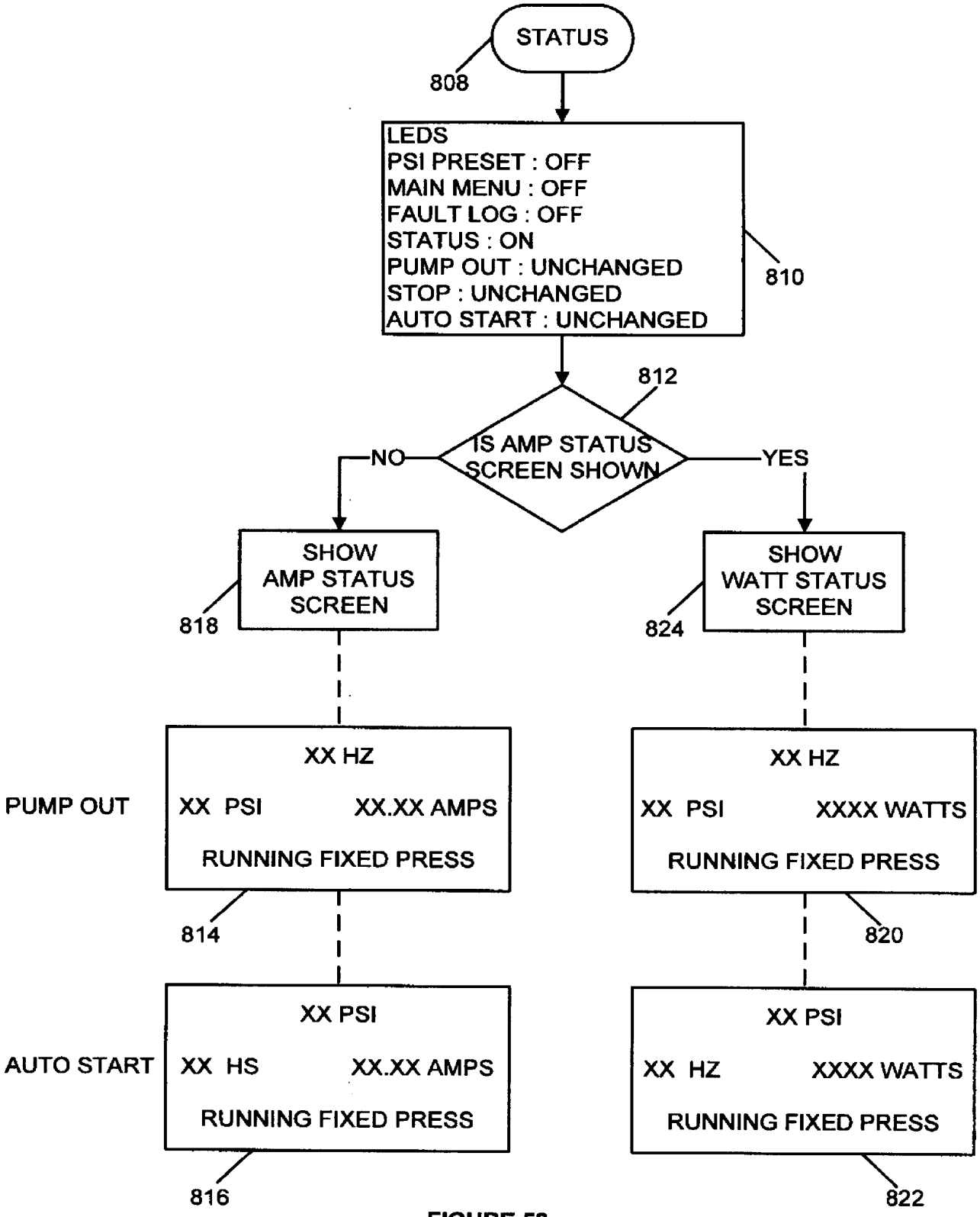

STATUS
808
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : ON
PUMP OUT : UNCHANGED
STOP : UNCHANGED
AUTO START : UNCHANGED
810
812
IS AMP STATUS SCREEN SHOWN
NO
YES
SHOW AMP STATUS SCREEN
818
SHOW WATT STATUS SCREEN
824
XX HZ
PUMP OUT
XX PSI
XX.XX AMPS
RUNNING FIXED PRESS
814
XX HZ
XX PSI
XXXX WATTS
RUNNING FIXED PRESS
820
XX PSI
AUTO START
XX HS
XX.XX AMPS
RUNNING FIXED PRESS
816
XX PSI
XX HZ
XXXX WATTS
RUNNING FIXED PRESS
822

FIGURE 58

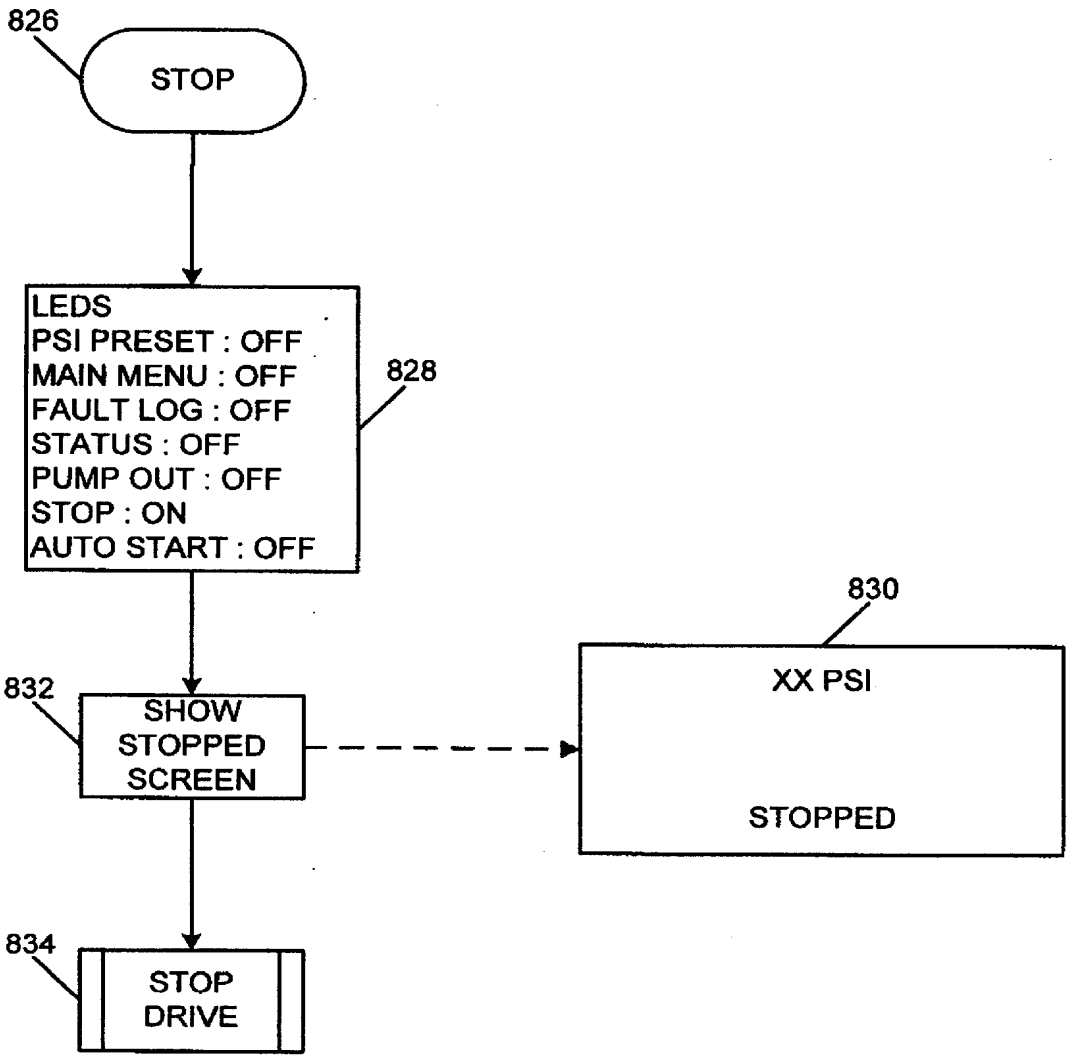

826
STOP
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : OFF
PUMP OUT : OFF
STOP : ON
AUTO START : OFF
828
830
XX PSI
STOPPED
832
SHOW
STOPPED
SCREEN
834
STOP
DRIVE

FIGURE 59

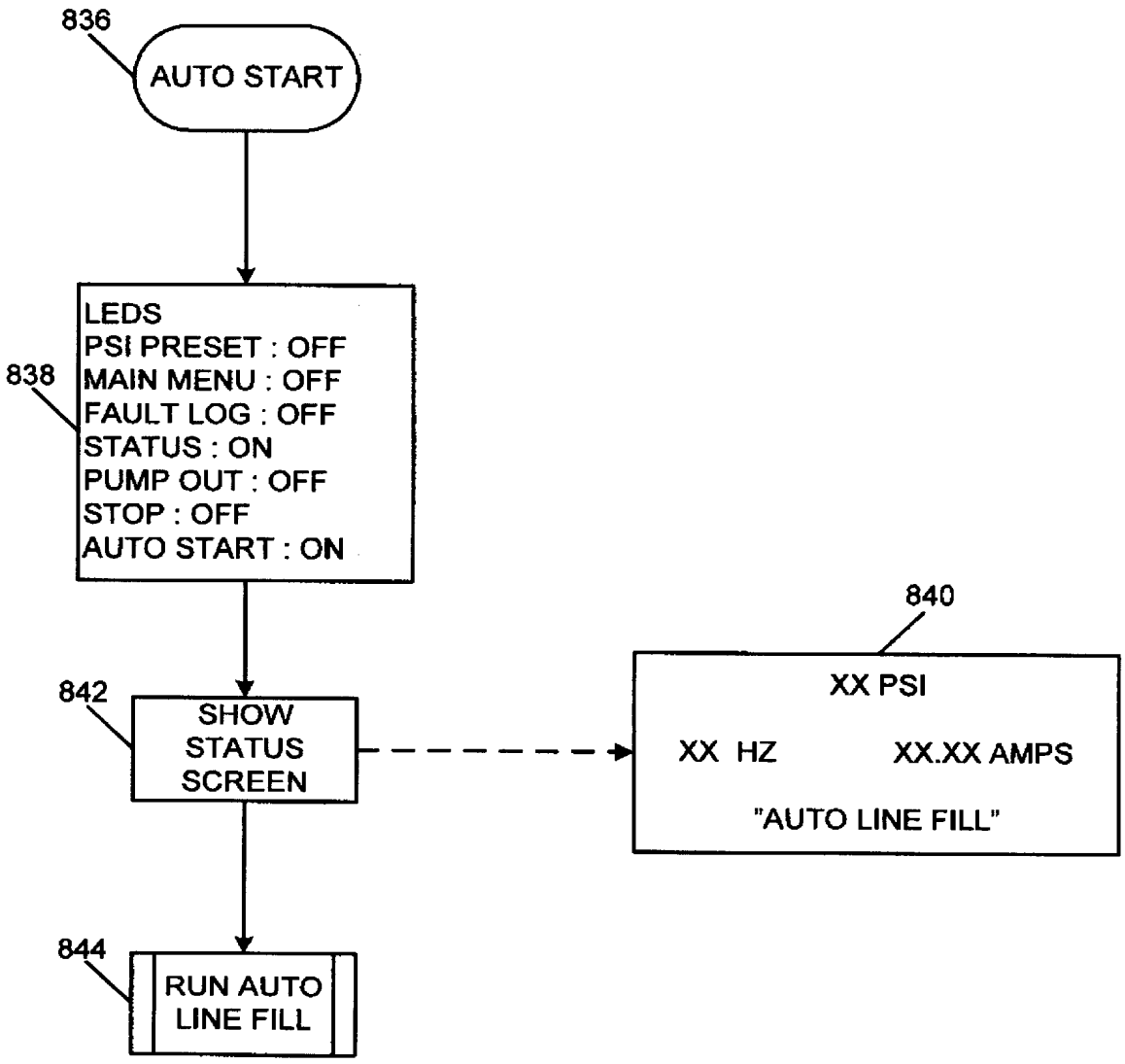

836
AUTO START
LEDS
PSI PRESET : OFF
MAIN MENU : OFF
FAULT LOG : OFF
STATUS : ON
PUMP OUT : OFF
STOP : OFF
AUTO START : ON
838
840
842
SHOW
STATUS
SCREEN
XX PSI
XX HZ
XX.XX AMPS
"AUTO LINE FILL"
844
RUN AUTO
LINE FILL

FIGURE 60

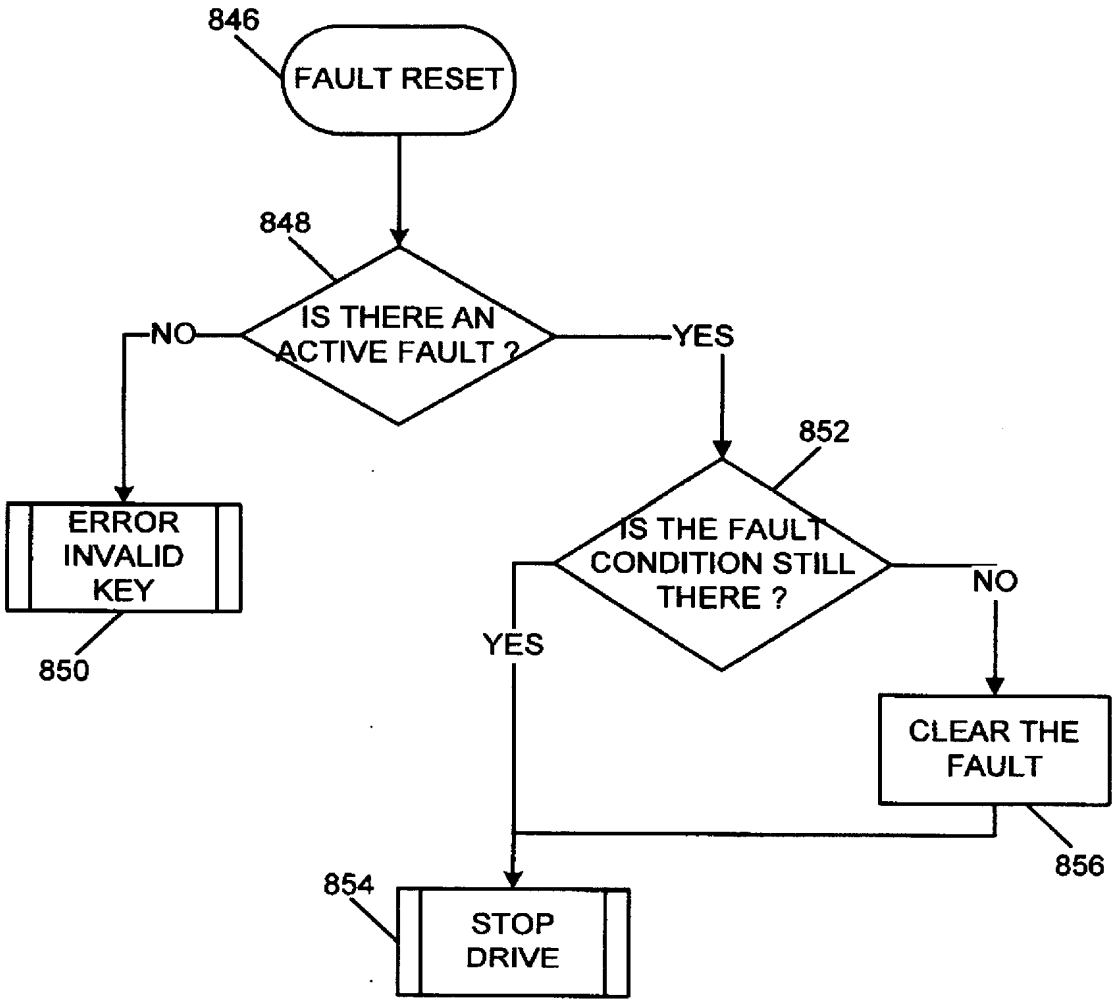

846
FAULT RESET
848
IS THERE AN ACTIVE FAULT ?
NO
YES
ERROR INVALID KEY
850
852
IS THE FAULT CONDITION STILL THERE ?
NO
YES
CLEAR THE FAULT
856
854
STOP DRIVE

FIGURE 61

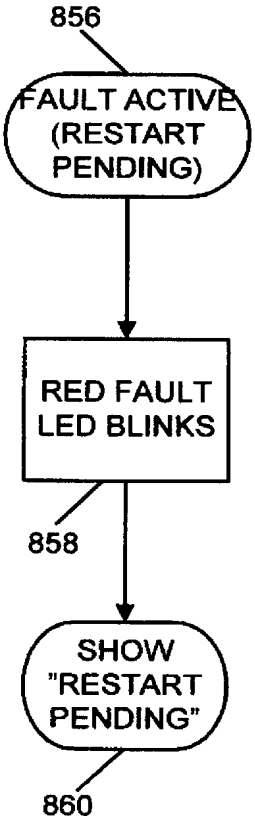


FIGURE 62A

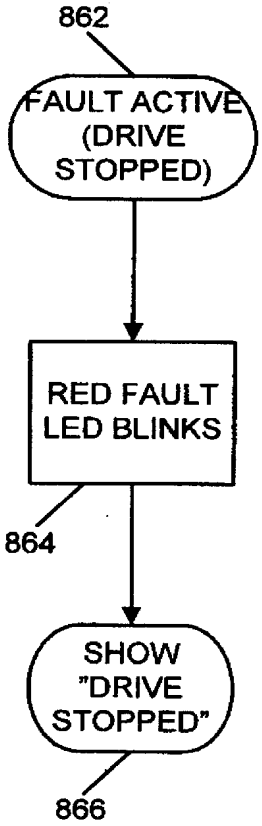


FIGURE 62B

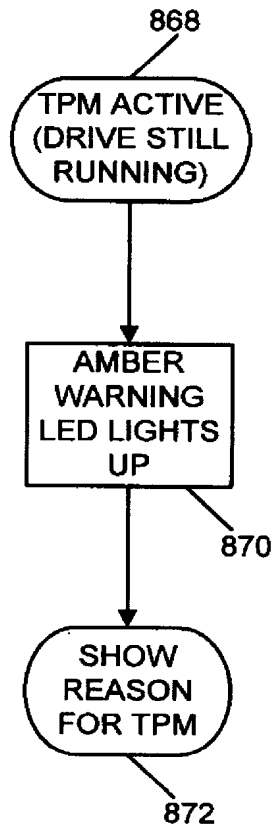


FIGURE 62C

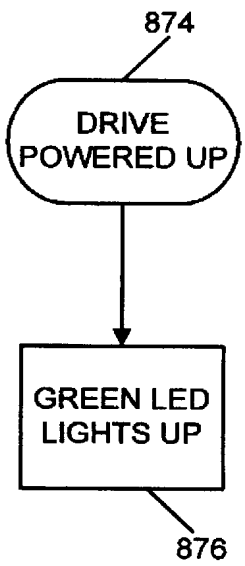


FIGURE 62D

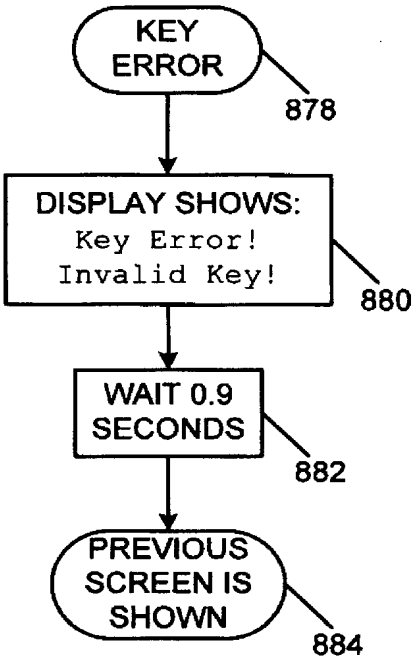


FIGURE 63A

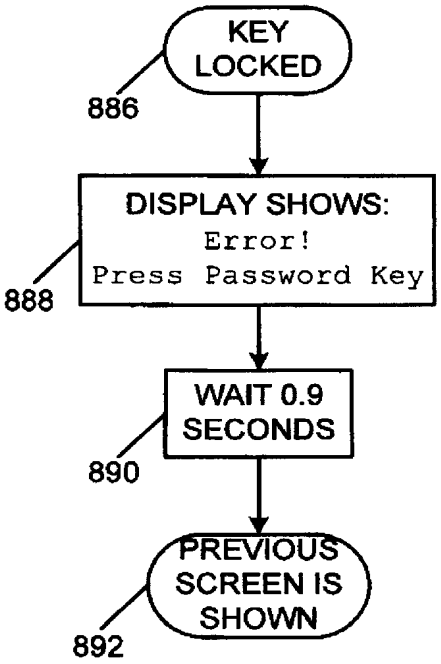


FIGURE 63B

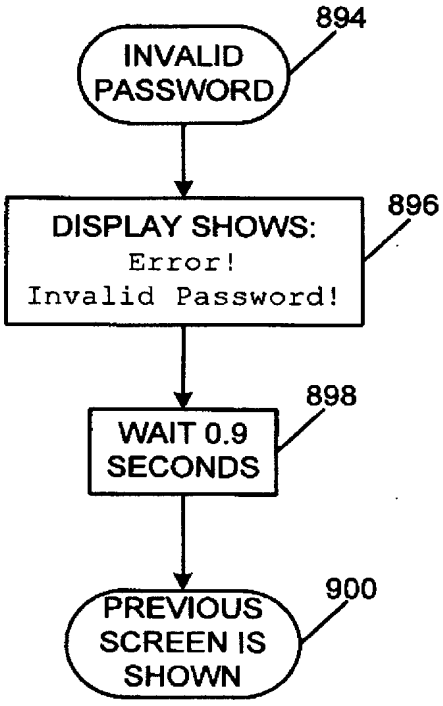


FIGURE 63C

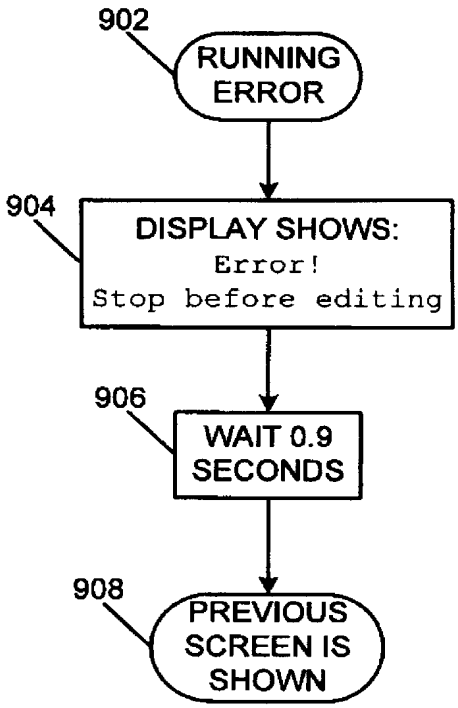
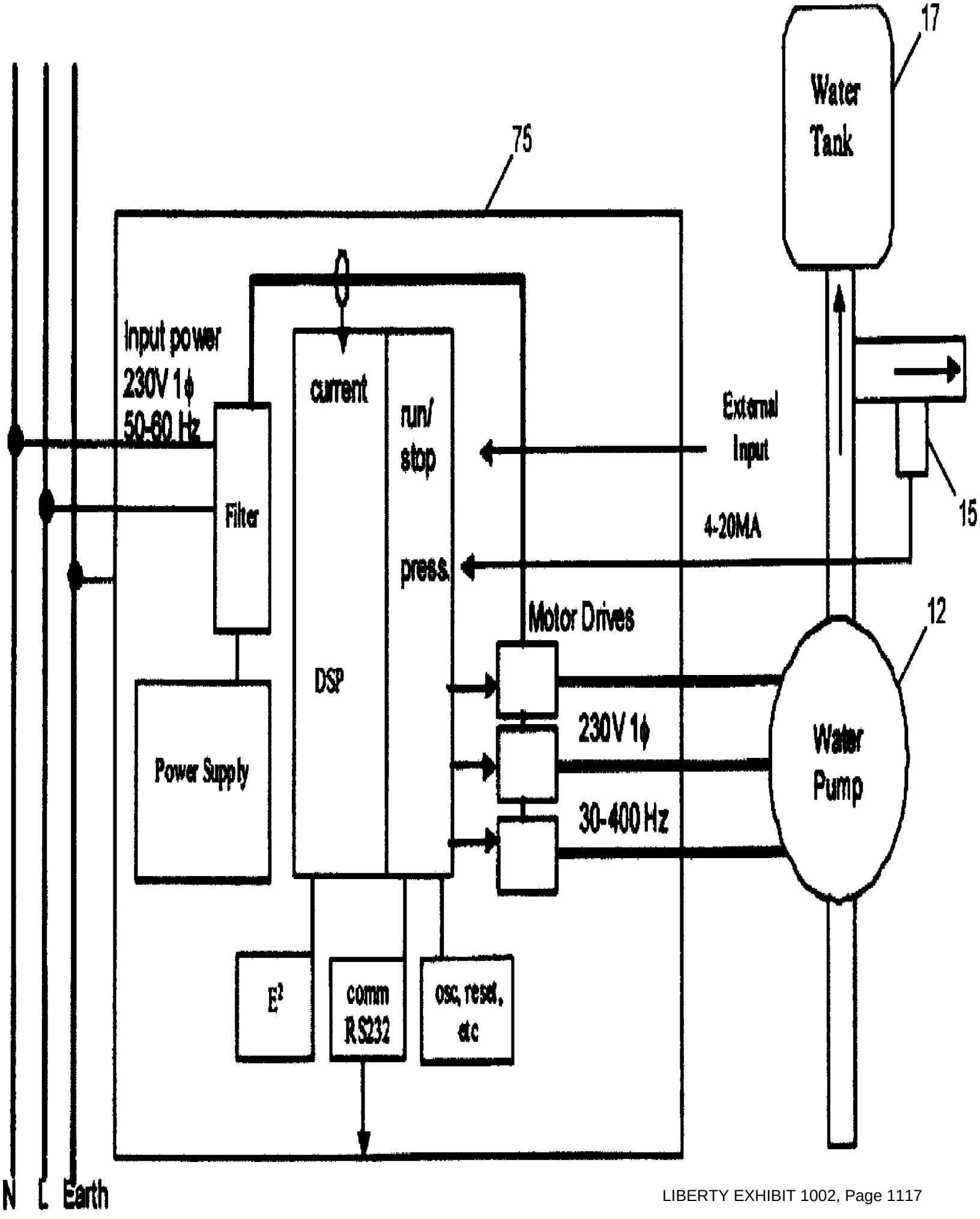


FIGURE 63D


17
Water Tank
75
Input power
230V 1ϕ
50-60 Hz
current
run/ stop
press.
External Input
4-20MA
15
Filter
Motor Drives
12
DSP
230V 1ϕ
Water Pump
Power Supply
30-400 Hz
E²
comm RS232
osc, reset, etc
N
L
Earth

Electronic Patent Application Fee Transmittal

Application Number:	16170695
Filing Date:	25-Oct-2018
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Filer:	Sharon Du/Stephanie McDonough
Attorney Docket Number:	047158.100032

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
RCE- 1ST REQUEST	1801	1	1300	1300
		Total in USD ($)		**1300**

Electronic Acknowledgement Receipt

EFS ID:	36979202
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Sharon Du/Stephanie McDonough
Filer Authorized By:	Sharon Du
Attorney Docket Number:	047158.100032
Receipt Date:	26-AUG-2019
Filing Date:	25-OCT-2018
Time Stamp:	17:44:19
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$1300
RAM confirmation Number	E20198PH44508414
Deposit Account	501349
Authorized User	Stephanie McDonough

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

37 CFR 1.16 (National application filing, search, and examination fees)

37 CFR 1.17 (Patent application and reexamination processing fees)

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	047158-100032_IDS.pdf	1035171 6d0a009a0b8167f5e00e3d403b2c71378d90a68c	no	6
Warnings:					
Information:					
2	Request for Continued Examination (RCE)	047158-100032_RCE.pdf	1349895 c3bbfc8bc7dd7e9d41aaa9268963d566a06b379d	no	3
Warnings:					
Information:					
3		047158-100032_Response.pdf	57366 70e0cd137d5591f26de8ef6f17bbccae295e7e95	yes	12

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment Submitted/Entered with Filing of CPA/RCE	1	1
Claims	2	8
Applicant Arguments/Remarks Made in an Amendment	9	12

Warnings:					
Information:					
4	Other Reference-Patent/App/Search documents	500040_ISR.pdf	578182 966b85f87c03a86b8fac975469bf19159f62cd49	no	10
Warnings:					

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Information:

5	Other Reference-Patent/App/Search documents	16210749_OA.pdf	345039 1d1aa5b51ec9f9ebb313e2156cbf6e2c56fed807	no	10
Warnings:					
Information:					
6	Other Reference-Patent/App/Search documents	16268030_OA.pdf	534865 8291f2a91518e612a1611fb951691aa5204cce11	no	16
Warnings:					
Information:					
7	Foreign Reference	CA2707269A1.pdf	2897967 f7ee72a1a6aa3c4c9649dbde6d1c8668ec9e94d2	no	106
Warnings:					
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Information:					
8	Other Reference-Patent/App/Search documents	P52016CA00_OA_as-filed.pdf	285103 518c95719a4f720bd90ca152af1aa8a15b48ba2d	no	5
Warnings:					
Information:					
9	Other Reference-Patent/App/Search documents	P53041CA00_OA_as-filed.pdf	277907 6611c7d232b3de98e376b2ddc9f91b176ce8140b	no	4
Warnings:					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	30301 f33812e46abb6bb1006612e576c5a650291a0d9c	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7391796		

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 16/170,695	Filing Date 10/25/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	08/26/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/MARGARET R BYARS/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

132858 7590 06/07/2019

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

EXAMINER	
GAY, JENNIFER HAWKINS	

ART UNIT	PAPER NUMBER
3676	

NOTIFICATION DATE	DELIVERY MODE
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The time period for reply, if any, is set in the attached communication.

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stephanie.mcdonough@hoganlovells.com

Office Action Summary	Application No. 16/170,695	Applicant(s) Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 13 May 2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☑ This action is **FINAL.** 2b) ☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-7 and 9-21 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-7 and 9-20 is/are rejected.

8) ☑ Claim(s) 20 is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 10/25/18 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Response to Amendment

2. This Action is in response to Applicant's reply of May 13, 2019. Claim 8 has been cancelled and claim 21 has been added.

3. Applicant's amendment to claims 2, 3, and 16 and the cancellation of claim 8 overcome the previously presented 35 USC 112(b) rejection. It is noted that the 35 USC 112(b) rejection of claim 5 has been withdrawn as having been given in error.

4. Applicant's amendment to claims 1, 7, and 14 overcomes the previously presented 35 USC 102(a)(2) rejection thereof however claims 1, 7, and 14 now stand rejected under 35 USC 103.

Response to Arguments

5. Applicant's arguments have been fully considered but they are not persuasive.

Applicant has argued that "Devine only teaches taking a pump out of service, and does not teach *adjusting one or more functions* based on the automated

instructions." and thus fails to teach ""automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions".

The act of turning one or more pumps off in response to the automated instructions is considered an adjustment of one or more functions; the function being if the pump is on or off. The claims are not specific as to what is considered a "function". It is further noted that element 172 in Figure 3 shows a list of "actions" that can take place in response to a threshold of a parameter being exceeded. These "actions" would also be considered, at least in part, a function.

Claim Rejections - 35 USC § 112

6. The following is a quotation of 35 U.S.C. 112(b):

(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

7. Claims 1-6, 9, 10, and 21 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Regarding claim 1: The phrase "receive and the one or more parameters" in line 9 of claim 1 as amended is considered generally confusing. It is suggested that Applicant intended to delete "and" as well. Correction is required.

Regarding claims 2-6: These claims are rejected due to their dependence on claim 1.

Regarding claim 9: Claim 9 depends from claim 8 which has been cancelled. Correction is required.

Regarding claim 10: Claim 10 is rejected due to its dependence on claim 9.

Regarding claim 21: Claim 21 is rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being incomplete for omitting essential structural cooperative relationships of elements, such omission amounting to a gap between the necessary structural connections. See MPEP § 2172.01. The omitted structural cooperative relationships are: Claim 21 requires transmitting data from a first device to a second and generating instructions at the second device however the claim fails to provide any correlation between the transmitted data and the instructions.

Claim Rejections - 35 USC § 103

8. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

9. This application currently names joint inventors. In considering patentability of the claims the examiner presumes that the subject matter of the various claims was commonly owned as of the effective filing date of the claimed invention(s) absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and effective filing dates of each claim that was not commonly owned as of the effective filing date of the later invention in order for the examiner to consider the applicability of 35 U.S.C. 102(b)(2)(C) for any potential 35 U.S.C. 102(a)(2) prior art against the later invention.

10. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

11. Claims 1-12 and 14-20 is/are rejected under 35 U.S.C. 103 as being unpatentable over Omont et al. (US 2017/0226842, Omont) in view of Devine et al. (US 2014/0379300, Devine).

Regarding claim 1: Omont discloses a hydraulic fracturing system **100 – [0017]**, comprising:

a plurality of pumps **150** positioned at a wellsite **102** and configured to pressurize a fracturing fluid **[0023]**;

a distribution system **142** fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection **[0023]** into a wellhead **for well 104**; and

a control system **170/300** comprising:

a plurality of sensing devices **214, 222** configured to measure one or more parameters of the plurality of pumps **[0037], [0052], [0054], [0093]** and the distribution system **[0059]**;

one or more processing devices **306 – [0038], [0043]** configured to receive the one or more parameters and detect that a first parameter of the one or more parameters is outside of an acceptable threshold **[0094], [0119], [0121], [0122]-[0129]** and generate control instructions based at least in part on the one or more parameter **[0038], [0043]**s; and

one or more control devices **226, 228** configured to receive the control instructions and control one or more aspects of the plurality of pumps **[0043]** or the distribution system based on the control instructions **[0059]**.

Omont fails to disclose that the method further discloses automatically adjusting one or more aspects of the plurality of pumps.

Devine discloses a method and system for determining pump efficiency **Abstract** where the method and system can be used in the oil sector **[0002]**. The method involves:

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0015], [0051]**, wherein the first parameter is associated

with a first pump of the plurality of pumps **plurality of pumps – [0116], [0146]**; and

automatically adjusting or turning off the first pump **[0020]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified the method of Omont to include automatically adjusting or turning off the first pump in order to have been able to proactively replace the faulty pump before catastrophic events occur **[0031]**.

Regarding claim 2: Wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and include at least one of flow sensors **[0054] of Omont**, accelerometers, pressure transducer **[0054], [0057] of Omont**, or tachometers **"operating speed" – [0052] of Omont**.

Regarding claim 3: Wherein the plurality of pumps or the distribution system includes at least one of a gate **[0049] of Omont**, valve **244 – Fig 3, [0050] of Omont**, actuator **248, 256, 266 – Fig 3 of Omont**, motor, suction pipe, discharge pipe, engine **252 – [0051] of Omont**, transmission, or temperature regulation device, controllable via the one or more control devices.

Regarding claim 4: The system further comprising:

a suction line **146 of Omont** through which fracturing fluid is supplied **[0023] of Omont**; and

a discharge line **148 of Omont** through which fracturing fluid is discharged **[0023] of Omont**, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line **0054] of Omont**.

Regarding claim 5: The system further comprising one or more blenders **108, 128 of Omont** configured to mix together one or more materials **110, 112 of Omont** to form the fracturing fluid, wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold **distribution system include multiple components including a manifold – [0023] of Omont**, wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow **260 – [0054] of Omont** and/or pressure conditions **[0054], [0057] of Omont** at the one or more blenders **[0037] of Omont**, the manifold **[0059] of Omont**, the plurality of pumps **[0037], [0052], [0054] of Omont**, or the distribution system **[0059] of Omont**.

Regarding claim 6: Wherein the one or more control device is configured to control the one or more blenders **[0057] of Omont**, the manifold **[0059] of Omont**, the plurality of pumps **[0037], [0052], [0054] of Omont** and the distribution system **[0059] of Omont** based on the flow **260 – [0054] of Omont** and/or pressure conditions **[0054], [0057] of Omont**.

Regarding claim 7: Omont discloses a hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps **150 - [0017]**;

pumping the fracturing fluid into a distribution system **142 - [0018]**;

injecting the fracturing fluid into a wellhead **for well 104 – [0023]**;

measuring one or more parameters of the plurality of pumps **[0037], [0052], [0054]**, the distribution system **[0059]**, or the wellhead via a plurality of sensing devices **214, 222 – [0059]** instrumented thereon;

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0094], [0119], [0121], [0122]-[0129]**;

generating automated instructions **"automated" – [0096]** for one or more control devices **226, 228 – [0043]** based at least in part on the one or more parameters; and

controlling one or more functions of the plurality of pumps **[0043]**, the distribution system **[0059]**, or the wellhead based at least in part on the automated instructions.

Omont fails to disclose that the method further discloses automatically adjusting one or more aspects of the plurality of pumps.

Devine discloses a method and system for determining pump efficiency **Abstract** where the method and system can be used in the oil sector **[0002]**. The method involves:

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0015], [0051]**, wherein the first parameter is associated

with a first pump of the plurality of pumps **plurality of pumps – [0116], [0146]**;

and

automatically adjusting or turning off the first pump **[0020]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified the method of Omont to include automatically adjusting or turning off the first pump in order to have been able to proactively replace the faulty pump before catastrophic events occur **[0031]**.

Regarding claims 9 and 20: The method Omont, as modified, further comprising adjusting one or more of the other pumps in the plurality of pumps to compensate for the first pump **[0151] of Devine**.

Regarding claim 10: Omont, as modified, discloses all of the limitations of the above claim(s) except for the method further comprising selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters. However the system and method of Omont is designed to monitor the operation and efficiency of a plurality of pumps and as such it would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, that the system would have chosen to turn on or adjust another pump that was operating efficiently. This would have achieved the predictable result of ensuring that the pump that was turned on or adjusted would operate as long as possible before failure.

Regarding claim 11: The method further comprising:

determining that the one or more parameters are indicative of a potential failure condition **[0067], [0084], [0099] of Omont**; and

determining a source of the potential failure condition **[0099], [0101] of Omont**.

Regarding claim 12: The method further comprising generating an alert or notification indicative of the potential failure condition and the source **[0090], [0094], [0099] of Omont**.

Regarding claim 14: Omont discloses a hydraulic fracturing method, comprising:

receiving a first data from a first sensing device **222 - [0037], [0052], [0054]** of a pump system **150** of a hydraulic fracturing system **100**, the first data indicative of a condition of the pump system **[0037], [0052], [0054]**;

receiving second data from a second sensing device **222 – [0037]** of a blender system **108, 128** of the hydraulic fracturing system, the blender system mixing together materials **110, 112** to form a fracturing fluid and delivering the fracturing fluid to the pump system **[0018], [0023]**, and the second data indicative of a condition of the blender system **[0037]**;

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0094], [0119], [0121], [0122]-[0129]**;

generating automated instructions **"automated" – [0096]** for one or more control devices **226, 228 – [0043]** of the pump system or the blender system based at least in part on the first and second data; and

controlling one or more functions of the pump system or the blender system based at least in part on the automated instructions **[0043], [0059]**.

Omont fails to disclose that the method further discloses automatically adjusting one or more aspects of the plurality of pumps.

Devine discloses a method and system for determining pump efficiency **Abstract** where the method and system can be used in the oil sector **[0002]**. The method involves:

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0015], [0051]**, wherein the first parameter is associated with a first pump of the plurality of pumps **plurality of pumps – [0116], [0146]**; and

automatically adjusting or turning off the first pump **[0020]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified the method of Omont to include automatically adjusting or turning off the first pump in order to have been able to proactively replace the faulty pump before catastrophic events occur **[0031]**.

Regarding claim 15: Wherein the pump system comprises:

one or more pumps **150 of Omont**; and

a distribution system **142 of Omont** that receives and consolidates the fracturing fluid from the one or more pumps for injection **[0023] of Omont** into a wellhead **for well 104 of Omont**.

Regarding claim 16: The method further comprising controlling one or more functions of the distribution system based on the automated instructions **[0059] of Omont**.

Regarding claim 17: Wherein the pump system comprises a plurality of pumps **150- Fig 1 of Omont**, and the first data includes measurements of each of the plurality of pumps **[0037], [0052], [0054], [0057] of Omont**.

Regarding claim 18: The method further comprising controlling one or more of the plurality of pumps individually based on the automated instructions **[0043], [0059] of Omont**.

Regarding claim 19: The method further comprising detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold and automatically taking the first pump offline in response to the detection **[0015], [0020] [0051] of Devine**.

12. Claim 13 is/are rejected under 35 U.S.C. 103 as being unpatentable over Omont in view of Devine as applied to claim 7 above, and further in view of Thomeer et al. (US 2014/0095114, Thom).

Omont discloses that the system and method includes a logging tool **560 – [0115]** that logs such parameters as operating time **[0120], [0121]** and relays this information to a maintenance terminal unit **[0118], [0131]**.

Omont discloses all of the limitations of the above claim(s) except for that the tool logs such things as number of strokes and that a maintenance schedule was determined based at least in part on the operation data.

Thom discloses a system and method for tracking the operation of equipment used in an oil field **Abstract**. The method includes the steps of:

a logging tool **606 – [0081]** that logs such parameters as flow rate of the pump or number of barrels per minute passing through the pump, i.e. number of strokes **[0076]** performed by a pump of a plurality pumps **101**; and

determining a maintenance schedule based at least in part on the operation data **[0047], [0049]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified Omont so that the logging tool logged such things as number of strokes and that a maintenance schedule

was determined based at least in part on the operation data as taught by Thom in order to have avoid needing to stop the fracturing operation due to failing pumps **[0007]**.

Allowable Subject Matter

13. Claim **21** would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), 2nd paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

14. The following is a statement of reasons for the indication of allowable subject matter:

The prior art of record fails to disclose or suggest transmitting a first parameter from a first device of a plurality of pumps, a distribution system, or wellhead to a second of a plurality of pumps, a distribution system, or wellhead as recited in the claimed method.

Conclusion

15. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period

will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

16. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JENNIFER H GAY whose telephone number is (571)272-7029. The examiner can normally be reached on Monday through Thursday, 6-3:30 and every other Friday 6-11.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Waseem Moorad can be reached on 571-270-3436. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would

like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JENNIFER H GAY/
Primary Examiner, Art Unit 3676

JHG
6/3/19

Notice of References Cited	Application/Control No. 16/170,695	Applicant(s)/Patent Under Reexamination Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20190120024-A1	04-2019	Oehring; Jared	E21B41/0092	1/1
*	B	US-20190112910-A1	04-2019	Oehring; Jared	E21B43/26	1/1
*	C	US-20180320483-A1	11-2018	Zhang; Yanchai	E21B41/0092	1/1
*	D	US-20180038216-A1	02-2018	ZHANG; Yanchai	E21B43/26	1/1
*	E	US-20170096885-A1	04-2017	Oehring; Jared	E21B43/26	1/1
*	F	US-20160102537-A1	04-2016	Lopez; Miguel Angel	E21B43/26	700/282
*	G	US-20140290768-A1	10-2014	Randle; Coy	E21B43/26	137/565.16
*	H	US-20140277772-A1	09-2014	Lopez; Miguel	F04D13/12	700/282
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	Art Unit
	JENNIFER H GAY	3676

CPC - Searched*		
Symbol	Date	Examiner
E21B 21/062, 43/26,267, 44/00	02/07/2019	JHG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
E21B 21/062, 43/26,267, 44/00 - text search only	02/07/2019	JHG
Consulted 16/160708, 15/145414, 15/291842, 13/631492	02/07/2019	JHG
EAST text search	02/07/2019	JHG
Backward/forward search	02/07/2019	JHG
EAST text search	06/03/2019	JHG

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

LIBERTY EXHIBIT 1002, Page 1144

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4100822		1978-07-18	Rosman	
	2	8851860		2014-10-07	Mail	
	3	6208098		2001-03-27	Kume	
	4	5189388		1993-02-23	Mosley	

If you wish to add additional U.S. Patent citation information please click the Add button. Add

U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20190003329		2019-01-03	Morris	
	2	20150097504		2015-04-09	Lamascus	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	16170695
	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	3	20090045782		2009-02-19	Datta	
	4	20070131410		2007-06-14	Hill	
	5	20160341281		2016-11-24	Onesubsea IP UK Limited	
	6	20170051732		2017-02-23	Baker Hughes Incorporated	
	7	20070277982		2007-12-06	Shampine	
	8	20050274508		2005-12-15	Folk	

If you wish to add additional U.S. Published Application citation information please click the Add button. Add

FOREIGN PATENT DOCUMENTS Remove

Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	2833711	CA		2014-05-16	Broussard et al.		☒
	2	2955706	CA		2012-10-07	Coli et al.		☒

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NON-PATENT LITERATURE DOCUMENTS Remove

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

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Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Office Action mailed January 30, 2019 in related Canadian Patent Application No. 2,936,997	☒
	2	International Search Report and Written Opinion mailed February 15, 2019 in related PCT Application No. PCT/US18/63977	☒
	3	Non-Final Office Action mailed February 25, 2019 in related U.S. Patent Application No. 16/210,749	☒
	4	International Search Report and Written Opinion mailed March 5, 2019 in related PCT Application No. PCT/US18/63970	☒
	5	Non-Final Office Action mailed March 6, 2019 in related U.S. Patent Application No. 15/183,387	☒
	6	Office Action mailed March 1, 2019 in related Canadian Patent Application No. 2,943,275	☒

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EXAMINER SIGNATURE

Examiner Signature	/JENNIFER H GAY/	Date Considered	06/03/2019

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.H.G/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☒ See attached certification statement.

The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Taylor P. Evans/	Date (YYYY-MM-DD)	2019-03-15
Name/Print	Taylor P. Evans	Registration Number	60506

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (02-18)
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U.S.PATENTS Remove

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	9206684		2015-12-08	Parra	
	2	9175554		2015-11-03	Watson	
	3	9458687		2016-10-04	Hallundbaek	

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U.S.PATENT APPLICATION PUBLICATIONS Remove

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20170241221		2017-08-24	Seshadri	
	2	20150330172		2015-11-19	Allmaras	
	3	20110166046		2011-07-07	Weaver	

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	4	20060260331		2006-11-23	Andreychuk	
	5	20100101785		2010-04-29	Khvoshchev	
	6	20100200224		2010-08-12	Nguete	
	7	20090090504		2009-04-09	Weightman	
	8	20080264640		2008-10-30	Eslinger	
	9	20080236818		2008-10-02	Dykstra	

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	1	2964593	CA		2017-10-15	Oehring		☒
	2	202023547	CN		2011-11-02	Univ China Mining		☒
	3	102602322	CN		2012-07-25	Xi An Bangpu Ind Automation Co Ltd.		☒

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	5	2007340913	AU		2008-07-10	Schlumberger Technology B.V.		☒

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	International Search Report and Written Opinion mailed April 10, 2019 in corresponding PCT Application No. PCT/US2019/016635	☒
	2	Notice of Allowance mailed April 23, 2019 in corresponding U.S. Patent Application No. 15/635,028	☒
	3	Schlumberger, "Jet Manual 23, Fracturing Pump Units, SPF/SPS-343, Version 1.0," January 31, 2007, 68 pages	☒
	4	Stewart & Stevenson, "Stimulation Systems," 2007, 20 pages	☒
	5	Luis Gamboa, "Variable Frequency Drives in Oil and Gas Pumping Systems," December 17, 2011, 5 pages	☒
	6	"Griswold Model 811 Pumps: Installation, Operation and Maintenance Manual, ANSI Process Pump," 2010, 60 pages	☒

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Examiner Signature	/JENNIFER H GAY/	Date Considered	06/03/2019

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Signature	/Taylor P. Evans/	Date (YYYY-MM-DD)	2019-05-29
Name/Print	Taylor P. Evans	Registration Number	60506

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L3	0	(14/376326).APP.	USPAT; USOCR	OR	ON	2019/06/03 12:47
L4	2267	e21b21/062.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:07
L5	26119	e21b43/26,267.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:07
L6	10329	e21b44/00.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:07
L7	37824	L4 or L5 or L6	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:07
L8	3	7 and (transmit$4 with (parameter data) with pump with blender)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:08
L9	19	7 and ((transmit$4 with (parameter data)) same pump same (blender wellhead))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/06/03 13:11
L10	12	("20050274508" | "20070131410" | "20070277982" | "20090045782" | "20150097504" | "20160341281" | "20170051732" | "20190003329" | "4100822" | "5189388" | "6208098" | "8851860").PN.	US-PGPUB; USPAT	OR	ON	2019/06/03 13:14
L11	12	("20060260331" | "20080236818" | "20080264640" | "20090090504" | "20100101785" | "20100200224" | "20110166046" | "20150330172" | "20170241221" | "9175554" | "9206684" | "9458687").PN.	US-PGPUB; USPAT	OR	ON	2019/06/03 13:17

EAST Search History (Interference)

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U.S.PATENTS Remove

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	3	9458687		2016-10-04	Hallundbaek	

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	6	20100200224		2010-08-12	Nguete	
	7	20090090504		2009-04-09	Weightman	
	8	20080264640		2008-10-30	Eslinger	
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	2	Notice of Allowance mailed April 23, 2019 in corresponding U.S. Patent Application No. 15/635,028	☒
	3	Schlumberger, "Jet Manual 23, Fracturing Pump Units, SPF/SPS-343, Version 1.0," January 31, 2007, 68 pages	☒
	4	Stewart & Stevenson, "Stimulation Systems," 2007, 20 pages	☒
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A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Taylor P. Evans/	Date (YYYY-MM-DD)	2019-05-29
Name/Print	Taylor P. Evans	Registration Number	60506

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(11) Application No. AU 2007340913 A1

(19) AUSTRALIAN PATENT OFFICE

(54) Title
Pump integrity monitoring

(51)[6] International Patent Classification(s)
F04B 51/00 (2006.01) 0BHEP F04D
F04D 15/00 (2006.01) 15/00
F04B 51/00 20060101ALI2008071
20060101AFI2008071 0BHEP
PCT/IB2007/054995

(21) Application No: 2007340913 (22) Application Date: 2007.12.10

(87) WIPO No: WO08/081368

(30) Priority Data

(31) Number	(32) Date	(33) Country
11/617,338	2006.12.28	US

(43) Publication Date : 2008.07.10

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 July 2008 (10.07.2008)

PCT

(10) International Publication Number
WO 2008/081368 A1

(51) International Patent Classification:
F04B 51/00 (2006.01) *F04D 15/00* (2006.01)

(21) International Application Number:
PCT/IB2007/054995

(22) International Filing Date:
10 December 2007 (10.12.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/617,338 28 December 2006 (28.12.2006) US

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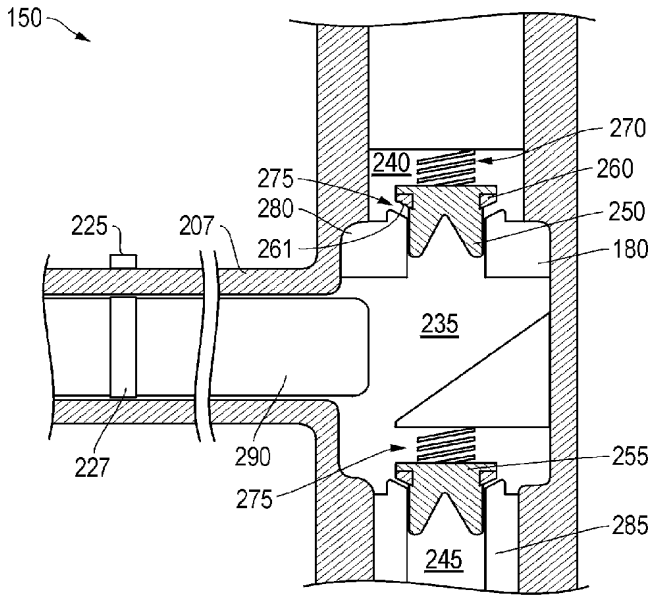
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[Continued on next page]

(54) Title: PUMP INTEGRITY MONITORING



(57) Abstract: A method of monitoring integrity of a pump. The method may include recording timing information of the pump during operation while simultaneously sampling acoustic data with a high speed equidistant acquisition mechanism or at a rate based on the speed of the pump in operation. The acquisition of acoustic data is followed by evaluation thereof. Such techniques may improve resolution of acquired data while substantially increasing processor capacity for evaluation. A pump integrity monitor for carrying out such techniques is also described.

WO 2008/081368 A1

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

PUMP INTEGRITY MONITORING

BACKGROUND

[0001] Embodiments described relate to the monitoring of pumps in use. In particular, embodiments of oilfield pumps and techniques for their monitoring with a pump integrity monitor are described.

BACKGROUND OF THE RELATED ART

[0002] Large oilfield operations generally involve any of a variety of positive displacement or centrifugal pumps. Such pumps may be employed in applications for accessing underground hydrocarbon reservoirs. For example, positive displacement pumps are often employed in large scale high pressure applications directed at a borehole leading to a hydrocarbon reservoir. Such applications may include cementing, coiled tubing, water jet cutting, or hydraulic fracturing of underground rock.

[0003] A positive displacement pump such as those described above may be a fairly massive piece of equipment with associated engine, transmission, crankshaft and other parts, operating at between about 200 Hp and about 4,000 Hp. A large plunger is driven by the crankshaft toward and away from a chamber in the pump to dramatically effect a high or low pressure thereat. This makes it a good choice for high pressure applications. Indeed, where fluid pressure exceeding a few thousand pounds per square inch (PSI) is to be generated, a positive displacement pump is generally employed. Hydraulic fracturing of underground rock, for example, often takes place at pressures of 10,000 to 20,000 PSI or more to direct an abrasive containing fluid through a borehole such as that noted above to release oil and gas from rock pores for extraction.

[0004] Whether a positive displacement pump as described above, a centrifugal pump, or some other form of pump for large scale or ongoing operations, regular pump

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monitoring and maintenance may be sought to help ensure uptime and increase efficiency of operations. That is, like any other form of industrial equipment a pump is susceptible to natural wear that could affect uptime or efficiency. This may be of considerable significance in the case of pumps for large scale oilfield operations as they may be employed at a production site on a near round the clock basis. For example, in the case of hydraulic fracturing applications, a positive displacement pump may be employed at a production site and intended to operate for six to twelve hours per day for more than a week.

[0005] Wear on pump components during operation may present in a variety of forms. For example, internal valve seals of a pump may be prone to failure, especially where abrasive fluids are directed through the pump during an application. Issues with other pump components may develop during operation such as plunger wear, loosening engine mounts, deteriorating crankshaft bearings, and transmission breakdown in such forms as a slipping clutch or broken gear teeth. Thus, as indicated above, regular pump monitoring and maintenance of pump health may be an important part of ongoing pump operations.

[0006] Issues with wearing pump components such as those indicated above may be accompanied by certain vibrations particular to the type of wear taking place. Therefore, it is not uncommon to monitor the health of a pump during operation by taking into account such acoustic or vibration information. For example, a positive displacement pump may be evaluated during operation by employing an acoustic sensor coupled to the pump. The acoustic sensor may be a conventional sonic transmitter used to detect high-frequency vibrations particular to a leak or incomplete seal within the chamber of the positive displacement pump, such a leak being a common precursor to pump failure. By employing an acoustic sensor in this manner,

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the costly and somewhat unreliable alternative of regularly timed interruption of pump operation for manual seal inspection and replacement may be avoided. Similar acoustic monitoring of the health of the pump may be employed for the detection of other types of potential pump component wearing as well.

[0007] The above described technique of monitoring the health of the pump via detection of acoustic information during pump operation faces several practical challenges in implementation. For example, pump operations often employ several pumps and associated equipment simultaneously at a production site. In fact, in a multi-pump operation several pumps may be in fluid communication with one another through a common manifold. Therefore, even the detection of a given unhealthy pump condition may not be indicative of the particular pump having the unhealthy condition.

[0008] In order to distinguish the source of unhealthy acoustic data in a multi-pump operation as described above each pump of the multi-pump operation may be operated at a distinct RPM. That is, each pump of a multi-pump operation may operate at its own unique RPM with its own acoustically detectable timing. In this manner, occurrences of unhealthy acoustic data may be correlated to a particular pump operating at a given RPM. However, as a practical matter, operating a host of different pumps at a variety of RPM's for an operation may be near impossible to implement as indicated below.

[0009] The vast majority of oilfield pumps are only able to operate at a limited number of speeds making the above manner of operation potentially very difficult to achieve depending on the particular level of total output called for in a given operation. In fact, even if achievable, the operating of pumps at a variety of RPM's for an operation leads to uneven stress on the pumps with significantly greater loads applied to certain pumps. As a result, there is a greater likelihood of pump failure during the

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operation. Furthermore, regardless of the RPM assigned to a particular pump of a multi-pump operation, natural inconsistencies in behavior of pump components may require data collection over a period of operating time before any reliable acoustic analysis may take place. This delays diagnosis of unhealthy conditions and increases computational complexity of such monitoring, thus requiring significant processing capacity to carry out. Thus, addressing pump health over the long haul remains primarily addressed through regular manual intervention or acoustic monitoring techniques of limited diagnostic effectiveness.

SUMMARY

[0010] An embodiment of monitoring a pump assembly is disclosed wherein the pump assembly is operated and timing information relative thereto is recorded. Sampling of acoustic data then occurs with a high speed acquisition mechanism followed by an evaluation of the acoustic data in light of the timing information. Sampling of acoustic data may also take place based on a speed of the operating pump assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Fig. 1 is a side partially sectional view of a pump assembly employing an embodiment of a pump integrity monitor.

[0012] Fig. 2 is a cross-sectional view of a portion of the pump assembly of Fig. 1.

[0013] Fig. 3 is a perspective partially sectional view of an embodiment of employing the pump assembly of Fig. 1 in a multi-pump operation.

[0014] Fig. 4 is a chart depicting data obtained by employing an embodiment of the pump integrity monitor and pump assembly of Fig. 1.

[0015] Fig. 5A is a graph depicting data obtained from employing an embodiment of the pump integrity monitor and pump assembly of Fig. 1.

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[0016] Fig. 5B is a graph depicting data obtained from employing another embodiment of the pump integrity monitor and the pump assembly of Fig. 1.

[0017] Fig. 6 is a flow-chart summarizing an embodiment of employing the pump integrity monitor and pump assembly of Fig. 1.

DETAILED DESCRIPTION

[0018] Embodiments are described with reference to certain positive displacement pump assemblies for fracturing operations. However, other types of pumps may be employed for a variety of operations. Regardless, embodiments described herein include a pump assembly 100 that incorporates a pump integrity monitor 101 having particular capabilities. For example, the pump integrity monitor 101 may employ particularly located sensors in conjunction with a high speed data acquisition board that takes up acoustic data from the pump assembly 100 a rate algorithmically adjusted to minimize the effect of noise from neighboring equipment, including noise from equipment and pumps that are in fluid coupling with the pump assembly 100. Furthermore, the pump integrity monitor 101 may acquire data at a lower non-uniform sampling rate based on operating speed of equipment of the pump assembly 100, thereby drastically increasing processing capacity. In a particular example, the pump integrity monitor 101 may acquire acoustic data based on the speed of a pump 150 and thus, plot data in line with positioning characteristics of the pump 150 with less computational complexity.

[0019] Referring specifically now to Fig. 1, an embodiment of a pump assembly 100 is shown equipped with a pump integrity monitor 101. In the embodiment shown, the pump assembly 100 includes a pump 150. The pump 150 shown is a positive displacement pump that may be of a triplex configuration and for use in a fracturing

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operation. However, other types of pumps, including centrifugal pumps, may be employed for a variety of applications according to embodiments described herein.

[0020] The above-described pump assembly 100 includes a variety of equipment with a multitude of parts susceptible to natural wearing and deterioration during operation. In the embodiment shown, this equipment includes a pump 150 with a fluid housing 157 in which a fluid is pressurized for distribution to a fluid pipe 165 and ultimately to a common fluid line 175 as described further herein. The pressurization of the fluid within the fluid housing 157 is created by plungers as directed by a rotating crankshaft 155 of the pump 150. With the fracturing pump 150 of the embodiment shown, pressurization of up to about 20,000 PSI may be achieved in this manner. Alternatively, other degrees of pressurization may be achieved for other applications. For example, where the pump 150 is to be employed in a cementing application, up to about 5,000 PSI may be generated as indicated. Additionally, embodiments of the pump 150 may be employed for coiled tubing or water jet cutting applications.

[0021] The crankshaft 155 is driven by a driveline mechanism 180, itself, driven by an engine 125 as directed through a transmission 140. The engine 125 may be a 200 Hp to 5,000 Hp prime mover. In the embodiment shown, all of this equipment is accommodated at the same platform 130 for placement and use at a production site, such as the well fracturing site 300 shown in Fig. 3. The platform 130 may be a skid for dropping in tact at the production site, part of a conventional trailer, or other form of delivery mechanism.

[0022] With added reference to Fig. 2, all of the above described equipment and components thereof, are subject to natural wear during operation as indicated. Therefore, the pump integrity monitor 101 is provided at the platform 130. In the embodiment shown, the pump integrity monitor 101 may include several circuit boards

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within a control box for sampling and analyzing a host of acoustic and other information. The pump integrity monitor 101 may also include a variety of sensors 120, 110, 179, 225 for obtaining such information during operation of the pump assembly 100 (see also Fig. 2). In particular, as shown in Fig. 1, the information may relate to harmonics of the pump assembly 100 in operation as detected by an acoustic sensor 110 or a pressure transducer 179. Additionally, as detailed further below, operational timing information such as the position of a driveline or crankshaft may be detected by a proximity switch 120 or an index sensor 225, respectively.

[0023] Similar to the embodiment described above, an index sensor may be coupled to a flywheel housing to obtain engine timing information. The engine timing sensor may be employ a magnetic pickup that senses position of a location on a rotating part coupled to the engine 125 such as its flywheel. In this sense, the information is obtained similar to information obtained by the index sensor 225 as described further below. This information may be analyzed by the pump integrity monitor 101 in conjunction with acoustic data obtained from an acoustic sensor coupled to the engine 125 or transmission 140 for establishing a condition thereof as described below. In an embodiment where the pump 150 is electrically driven, the sensors described here may be modified and located to acquire data regarding electrical current input.

[0024] Continuing with reference to Fig. 1, a circuit board of the pump integrity monitor 101 may be provided in the form of a high speed acquisition board which may include no microcontroller or processing capacity. Rather, the high speed acquisition board may be dedicated to sampling acoustic, vibration, or pressure sensor data at a rate of between about 100 to about 600,000 samples per second or more. The high speed acquisition board may be dedicated to obtaining data from the acoustic sensor 110 and/or the pressure transducer 179 as indicated above. These sensors 110, 179 may be

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specifically positioned to acquire acoustic vibration data from the pump assembly 100 during its operation. In an embodiment where the pump 150 is hydraulic in nature, such sensors 110, 179 may be positioned and equipped to acquire hydraulic pressure data in place of acoustic data as described herein. Regardless, the acquired data may be analyzed by the pump integrity monitor 101 in order to provide a recognizable pattern of pump health or integrity information so as to alert an operator of an unhealthy condition of the pump assembly 100 should one arise. Furthermore, it is not required that the pump flow rate remain constant in order to employ techniques described further below.

[0025] Continuing with reference to Figs. 1 and 2, an example of an acoustically detectable unhealthy condition in the pump assembly 100 is described in detail. That is, while a host of harmonic or vibration data is provided by an operating pump assembly 100, certain data may be indicative of a variety of unhealthy conditions. Acoustic profiles of common unhealthy conditions may be pre-loaded on a processor of the pump integrity monitor 101 to allow analysis. With respect to the embodiments described herein, these unhealthy conditions may include plunger wear, loosening engine mounts, piston issues, deteriorating crankshaft bearings, and transmission breakdown in such forms as a slipping clutch or broken gear teeth to name a few. Another such example includes the unhealthy condition of a failing pump valve seal 260 as shown in Fig. 2. This type of failure may be prone to occur in circumstances where abrasive fluids are directed through a pump 150 such as during a fracturing application.

[0026] With particular reference to Fig. 2, the pump 150 includes a plunger 290 for reciprocating within a plunger housing 207 toward and away from a chamber 235. In this manner, the plunger 290 effects high and low pressures on the chamber 235. For

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example, as the plunger 290 is thrust toward the chamber 235, the pressure within the chamber 235 is increased. At some point, the pressure increase will be enough to effect an opening of a discharge valve 250 to allow the release of fluid and pressure within the chamber 235. The amount of pressure required to open the discharge valve 250 as described may be determined by a discharge mechanism 270 such as valve spring which keeps the discharge valve 250 in a closed position until the requisite pressure is achieved in the chamber 235. In an embodiment where the pump 150 is to be employed in a fracturing operation pressures may be achieved in the manner described pressures of up to about 20,000 PSI may be achieved in the manner described here.

[0027] The plunger 290 may also effect a low pressure on the chamber 235. That is, as the plunger 290 retreats away from its advanced discharge position near the chamber 235, the pressure therein will decrease. As the pressure within the chamber 235 decreases, the discharge valve 250 will close returning the chamber 235 to a sealed state. As the plunger 290 continues to move away from the chamber 235 the pressure therein will continue to drop, and eventually a low or negative pressure will be achieved within the chamber 235. Similar to the action of the discharge valve 250 described above, the pressure decrease will eventually be enough to effect an opening of an intake valve 255. The opening of the intake valve 255 allows the uptake of fluid into the chamber 235 from a fluid channel 245 adjacent thereto. The amount of pressure required to open the intake valve 255 as described may be determined by an intake mechanism 275 such as spring which keeps the intake valve 255 in a closed position until the requisite low pressure is achieved in the chamber 235.

[0028] As described above, and with added reference to Fig. 1, a reciprocating or cycling motion of the plunger 290 toward and away from the chamber 235 within the pump 150 controls pressure therein. The valves 250, 255 respond accordingly in order

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to dispense fluid from the chamber 235 through a dispensing channel 240 and ultimately to a fluid pipe 165 at high pressure. That fluid is then replaced with fluid from within a fluid channel 245. All of the movements of the various parts of the pump 150 as described may resonate to a degree throughout the pump 150 including to its non-moving portions, such as at the fluid housing 157 within which the chamber 235 is located. Thus, as indicated above, an acoustic sensor 110 may be secured thereto for sensing such resonating vibrations.

[0029] As noted, certain vibrations detected by the acoustic sensor 110 of Fig. 1 may be indicative of an unhealthy valve seal 260 of the pump 150. For example, upon closer inspection of Fig. 2 it is apparent that the discharge valve 250 includes a conformable valve seal 260 for sealing off of the chamber 235. The conformable nature of such a valve seal 260 is conducive to the pumping of abrasive containing fluids through the pump 150 as is often called for in the case of fracturing operations. For example, the abrasive fluid may include a proppant such as sand, ceramic material or bauxite mixed therein. The conformable nature of the valve seal 260 allows it to conform about any proppant present at the interface 275 of the discharge valve 250 and seat 280. Unfortunately, the conformable nature of the valve seal 260 also leaves it susceptible to the unhealthy circumstance of degradation by such abrasive fluids.

[0030] A conformable valve insert 260 of urethane or other conventional polymers employed in a conventional fracturing operation as described above may degrade completely in about one to six weeks of substantially continuous use. As this degradation begins to occur a completed seal fails to form between the valve 250 and the valve seat 280. Thus, as noted above, an acoustic vibration indicative of an unhealthy condition of the operating pump 150 may then persist that is attributable to a growing leak between the chamber 235 and the dispensing channel 240.

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[0031] Continuing now with reference to Figs. 1-3, the above described unhealthy condition of a failing pump valve seal 260 may be acoustically detectable by the acoustic sensor 110 as indicated. However, as shown in Fig. 3, the pump 150 may be part of but one pump assembly 100 of a multi-pump assembly 300 at a production site 375. Therefore, embodiments described herein include techniques for discerning acoustic data emanating from other assemblies 302, 303, 304, 305, 306 and equipment from the acoustic data of the pump assembly 100 such as that indicative of the unhealthy condition of the valve seal 260 as indicated.

[0032] As shown in Fig. 3, and indicated above, multiple pump assemblies 302, 303, 304, 305, 306 are provided at the production site 375 in addition to the pump assembly 100 of Fig. 1. Each of the assemblies 302, 303, 304, 305, 306, and 100 may be no more than 10-12 feet from one another, with each operating at 1,500 Hp to 5,000 Hp to propel an abrasive fluid 310 into a well 325. The abrasive fluid 310 may be directed into the well 325 and directed to fracturable rock 315 or other earth material as is the nature of a convention fracturing operation.

[0033] Apart from the acoustics emanating from the pump assembly 100 of Fig. 1, a considerable amount of noise is generated in the above described fracturing operation of Fig. 3. In fact, in continuing with reference to Fig 3, added equipment such as a blender 307 may be provided on site adding noise to the operation. Furthermore, each assembly 302, 303, 304, 305, 306, and 100 may generate up to about 20,000 PSI for directing the abrasive fluid 310 through a common manifold 375 and to a well head 350 coupled to the well 325. That is, all of the assemblies 100, 302, 303, 304, 305, 306 may be in fluid communication with one another. As a result of such communication, the ability of acoustics emanating from a single pump assembly to resonate at an adjacent pump assembly is enhanced. Thus, referring back to Fig. 1, the ability of the

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pump integrity monitor 101 to decipher the source of acoustics for establishing the condition of its associated pump assembly 100 in particular, may be of significant benefit.

[0034] Continuing with reference to Figs. 1-3, in spite of the above described fluid communication among pump assemblies 100, 302, 303, 304, 305, 306 during conventional operations such as fracturing, the pump integrity monitor 101 is configured for use in a manner that allows deciphering and favoring the acquisition of acoustic information relative to its own particular pump assembly 100. This may be achieved by the pump integrity monitor 101 employing both the above noted high speed acquisition board in combination with one or both of two sensors 110, 179 positioned to enhance the sensing of acoustic information from the pump assembly 100 of Fig. 1 in particular. That is, as indicated, the high speed acquisition board may be dedicated to sampling sensor data at a rate of between about 100 to about 300,000 samples per second or more. Thus, as detailed further below, the acquisition of acoustic data from the pump assembly 100 of Fig. 1 may be enhanced by use of the sensors 110, 179 positioned as indicated above whereas the resolution of this acoustic data may be enhanced by use of such a high speed acquisition board.

[0035] Continuing with reference to Figs. 1-3, the pump integrity monitor 101 may be directly wired to one or both of two sensors 110, 179 positioned to enhance the sensing of acoustic information from the pump assembly 100 of Fig. 1 in particular. For example, the first sensor, the above described acoustic sensor 110, is positioned directly on the fluid housing 157 of the pump 150. The second sensor, the above noted pressure transducer 179, may be positioned within the common fluid line 175 to the manifold 375. While positioned in a common fluid area, the pressure transducer 179 is located to the pump side of choke 177 that briefly cuts down the inner diameter of the

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line 175 (e.g. about in half). This contributes to the attenuation of acoustics emanating from outside of the pump assembly 100 of Fig. 1. Thus, the sensing of acoustic information from the pump assembly 100 of Fig. 1 by the pressure transducer 179 is still enhanced. In fact, the location of the choke 177 also aids in dampening of acoustics from the pump assembly 100 of Fig. 1 to other assemblies 302, 303, 304, 305, 306 such as those of Fig. 3.

[0036] In addition to the enhanced acquisition of acoustic data from the pump assembly 100 of interest, the enhanced resolution of data as indicated renders noise from other sources of little significance. A speed sensor such as a proximity switch 120 may be provided to the pump integrity monitor 101 and coupled to a rotating driveline mechanism 180 for monitoring speed of the operating assembly 100, thus, allowing the processor to confirm outside noise as out of sync from the assembly 100. Therefore, with added reference to Fig. 3, such a high rate of acoustic sampling by the pump integrity monitor 101, the need to operate separate assemblies 100, 302, 303, 304, 305, 306 of a multi-pump operation at significantly different and/or constant speeds is substantially obviated. Rather, distinction between noise emanating from outside sources, out of time from the associated assembly, may readily be deciphered by a processor of the pump integrity monitor 101 with such a vast amount of acoustic data at its disposal.

[0037] As described above, the pump integrity monitor 101 may be employed to diagnose an unhealthy condition such as a leaking pump valve seal 260 in spite of surrounding noise at a production site 375. Furthermore, all other assemblies 302, 303, 304, 305, 306 of a multi-pump operation such as that shown in Fig. 3 may be equipped with individual pump integrity monitors for diagnosis of unhealthy conditions of the associated pump assembly 302, 303, 304, 305, 306. Again, such unhealthy conditions

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may include leaking pump seals, plunger wear, valve spring wear, loosening engine mounts, pump mounts, piston issues, deteriorating crankshaft bearings, crossheads, pony rods, transmission breakdowns such as clutch slippage or broken gear teeth and any other conditions presenting acoustic abnormalities.

[0038] While the above described techniques of employing the pump integrity monitor 101 provide detection of the health of a given assembly 100 regardless of surrounding noise, acoustic data indicative of equipment health or integrity may also be employed in a manner drastically reducing the amount of processor capacity required for establishing equipment health. That is, rather than sampling the above noted acoustic data at a constant rate (i.e. equidistant sampling) and performing an FFT to plot the information, acoustic data may be sampled at a rate based on the speed of the operating equipment (i.e. non-uniform or angular sampling). In this manner the need for a discrete FFT conversion may be eliminated or transferred to the angular domain, also referred to herein as the "order" space. The pump integrity monitor 101 may be provided with the capability to detect and analyze much higher frequencies. For example, frequencies substantially beyond 25KHz, more preferably beyond 100KHz may be analyzed by a processor of the pump integrity monitor 101. As a result, leaks or other acoustically detectable problems encountered by the pump assembly 100 may be detected much earlier on, when presenting at such higher frequencies. In fact, in an alternate embodiment, a very limited Fourier analysis may be performed over a small frequency range in order to increase spectral resolution. Nevertheless, the signal detection may be obtained earlier on at higher frequencies.

[0039] For example, with reference to Figs. 1-3 above, the pump integrity monitor 101 may sample acoustic data at a rate of between about 50 and 5,000 samples per revolution of the crankshaft 155. Thus, positioning information relative to cycling of

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the pump 150 may automatically be provided without any need to perform FFT conversions. In order to regulate the sampling of acoustic data in this manner, a sensor may be provided to monitor or track the timing of a moving part of the pump 150 and thus, its speed. For example, as shown in Fig. 2, an index sensor 225 is provided adjacent a plunger 290 that is driven by the noted crankshaft 155 of Fig. 1. The plunger is equipped with a collar 227 detectable by the index sensor 225 such that timing information may be transmitted to the pump integrity monitor 101. In this manner, the processor of the pump integrity monitor 101 need only keep time of the operating pump 150 in acquiring and plotting acoustically obtained data relative thereto.

[0040] Referring now to Fig. 4, with added reference to Figs. 1-3, acoustic data acquired by the pump integrity monitor 101 via techniques described above is plotted on a chart. The chart shown plots acoustic data that has been obtained from a pump assembly 100 having a pump 150 with a leaking valve seal 260 as shown in Fig. 2. In the embodiment shown, between about 500 and about 5,000 samples of acoustic data have been obtained for a given revolution of the crankshaft 155 of the pump 150. Thus, given timing information from the index sensor 225 acoustic data has been plotted without the requirement of FFT conversions, thereby saving substantial processor capacity of the pump integrity monitor 101.

[0041] Continuing with reference to Fig. 4, timing information from the index sensor 225 allows for the plotting of an acoustic profile of the angular position of the cycling pump 150 based on three plunger reciprocation areas 1, 2, 3. That is, in the embodiments described herein, the pump 150 is of a positive displacement triplex configuration. Thus, three separate plungers, such as the plunger 190 of Fig. 2, reciprocate in any given cycle of the pump 150. A variety of acoustic data 400, 401, 402, 403, 475 may be plotted in accordance therewith.

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[0042] The chart of Fig. 4 reveals that certain acoustic data is persistent throughout an entire cycling of the pump 150. This persistent acoustic data 475 may be the expected acoustics of the operating pump 150 and other equipment of the assembly 100. Due to the improved resolution and enhanced detection provided by the pump integrity monitor 101 as detailed above, the probability of an overwhelming amount of persistent acoustic data 475 emanating from another assembly (i.e. 302, 303, 304, 305, 306 of Fig. 3), is minimized. Regardless, such data fails to be indicative of an unhealthy condition of the pump 150 associated with the pump integrity monitor 101 being employed.

[0043] The chart of Fig. 4 is depicted in a logarithmic scale as alluded to above, with a maximum frequency detectable at half the sampling frequency (i.e. Fs/2). With respect to particular plunger reciprocation areas 1, 2, 3 of the chart, each includes strike data 401, 402, 403, revealing two valve strikes per plunger reciprocation, resonating at between about 1/64 and about 3/8 of the sampling frequency (Fs). This would be expected as described in detail above with respect to Fig. 2 where valves 250, 255 strike valve seats 280, 285 as described above. Again, this particular acoustic data fails to be indicative of any unhealthy condition of the pump assembly 100.

[0044] Unfortunately, upon close examination of the first plunger reciprocation area 1 an unhealthy condition of the pump assembly 100 is revealed. That is, recalling the leaking valve seal 260 of Fig. 2, unhealthy acoustic data indicative of this leak presents in the form of leak data 400 in the first plunger reciprocation area 1. The leak data 400 presents immediately after the striking of a valve (i.e. 250) as shown by the strike data 401. As described with reference to Fig. 2, it is at this time that a completed seal fails to form between the valve 250 and the valve seat 280. Thus, an acoustic vibration, depicted here as leak data 400, resonates as fluid leaks between the chamber

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235 and the dispensing channel 240. An unhealthy condition of the pump assembly 100 is thereby detected and displayed.

[0045] In Fig. 4 detailed above, leak data 400 is depicted in a chart that reflects the angular position of a cycling pump 150 such as that of Fig. 1. The depiction of acoustic leak data 400 in this manner provides some insight into the condition of pump parts driven by a rotating mechanism such as the crankshaft 155. However, with reference to Fig. 1, a variety of other equipment such as an engine 125, transmission 140 or driveline mechanism 180 may also be subject to wear and breakdown. Similarly, the health of such equipment may be detected and monitored according to techniques described above. That is, the above-described techniques may be employed for analyzing both pump and engine data. For example, acoustic data corresponding to a gear ratio employed by the transmission 140 may be indicative of a problem prior to the driveline mechanism 180. Similarly, as described below, unexpected acoustic data corresponding to the rpm of the engine 125 may be indicative of engine side issues such as with engine mounts or piston reciprocation. Additionally, it may be of benefit to examine the acoustics of such equipment in terms other than angular positioning. For example, the amplitude or power (or power spectral density), as shown in Fig. 5A, may provide insight into the condition of operating equipment in other frequency ranges as detailed further below.

[0046] Referring now to Fig. 5A, with added reference to Fig. 1, a graph is shown depicting an acoustic profile of acoustic data acquired from a pump assembly 100 having a four stroke 12 cylinder engine 125 that is running at about 2,400 rpm's. This may be the same pump assembly 100 as that depicting the acoustic data of Fig. 4. However, by way of comparison, the acoustic data of Fig. 4 presents at frequencies higher than the chart of Fig. 5A extends. However, an extension of Fig. 5A in terms of

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frequency would reveal the acoustic pump related data depicted in Fig. 4. Another distinction from Fig. 4 is that in Fig. 5A, rather than depicting the acoustic frequency data against angular positioning, the graph of Fig. 5A depicts acoustic data against power as described further below.

[0047] With added reference to Fig. 1, Fig. 5A depicts acoustic data relative to an engine 125 operating at about 2,400 rpm as indicated. Such an engine 125 would generate a frequency of about 40 Hz by definition. Thus, an examination of the chart of Fig. 5A at about 40 Hz reveals acoustic engine rpm data 560. In fact, the greatest amount of power revealed for the frequency range depicted in Fig. 5A is revealed in the form of the acoustic engine rpm data 560. Other acoustic data is revealed such as camshaft data 551 at about 20 Hz and piston data 580 at about 240 Hz. Again, given a conventional 12 cylinder engine 125 running at about 2,400 rpm, the location of camshaft data 551 at half that of the engine rpm data 560 and the location of the piston data 580 is to be expected. However, abnormalities in such data may be telling. For example, an abnormality in the camshaft data 551 may be indicative of misfiring whereas an abnormality in rpm data 560 may be indicative of engine imbalance, misalignment, abnormal torque reaction, or a weak foundation of the engine 125.

[0048] While the location of the acoustic data 551, 560, 580 reflects the expected operating acoustics of a 12 cylinder engine 125 operating at 2,400 rpm, additional acoustic information is presented in the graph of Fig. 5A. Namely, engine rpm data 560 presents with a peak 565 that breaks into a smooth portion 562 and a smaller rough portion 567 by comparison. Similarly, the piston data 580 includes a smooth portion 582 and a rough portion 587. Thus, it is apparent that a problem has arisen in the firing or operating of at least one of the pistons of the engine. That is, rather than acoustic leak data 400 apparent in Fig. 4, rough portions 567, 587 of data present in Fig. 5A

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revealing an unhealthy condition in the pump assembly 100 outside of the pump 150. Fortunately, however, with particular reference to the z-axis of the chart of Fig. 5A, it does not appear that the problem is increasing over the period of time shown. Therefore, an operator may have time to intervene before failure of the operating pump assembly 100 due to the problem shown.

[0049] In addition to the acoustic data depicted in Fig. 5A 551, 560, 580, additional data relative to the condition of the engine 125 may be obtained. For example, in such an engine 125 as described above, cylinder combustion peaks at about 60 Hz, 100 Hz, 140 Hz, and 180 Hz might be expected along with peaks representing harmonics of crankshaft speed at about 80 Hz, 120 Hz, 160 Hz, and 200 Hz. Such acoustic data may again be analyzed to determine a condition of the engine 125. For example, a peak representing crankshaft harmonics at about 80 Hz that is significantly higher than other crankshaft harmonic peaks may be indicative of a problem such as vibration damper failure relative to a position of the rotating crankshaft.

[0050] Referring now to Fig. 5B, again with added reference to Fig. 1, a graph is shown similar to that of 5A, but with reference now to pump acoustics (i.e. as opposed to engine acoustics). For the embodiment shown and described below, the pump 150 is a positive displacement pump 150 of a triplex configuration. The pump 150 includes a crankshaft 155 rotating at a frequency of about 4 Hz where an initial peak is depicted. In a circumstance of an unhealthy pump condition correlating to the timing of the crankshaft rotation, the peak depicted at about 4 Hz may rise or present otherwise abnormally. Such pump failures may include a valve leak, broken valve spring, loose plunger, loose pump mount, or crank bearing failure.

[0051] Given that the pump 150 employs three plungers 290 as indicated above, each reciprocating with every rotation of the crankshaft 155, the peak at about 12 Hz is

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to be expected. Furthermore, a peak is noted at about 24 Hz which reflects a reduction ration of about six that is provided by gearing between the transmission 140 and the crankshaft 155. For the embodiment shown, a high peak at about 24 Hz would be indicative of problems such as with the transmission 140, driveline 180, or related parts. Similarly, where a bull gear of the described gearing is equipped with say 108 teeth, a harmonic peak at about 432 Hz would be expected as shown. Abnormalities in this peak would be indicative of degradation or other problems with gearing teeth for the depicted embodiment.

[0052] Referring now to Fig. 6, an embodiment of employing a pump integrity monitor is summarized in the form of a flow chart. The monitor is employed as a part of a pump assembly that is in operation as indicated at 620. As noted above, the pump assembly may be operated in conjunction with a host of other equipment, including other pump assemblies in fluid communication therewith. Nevertheless, as indicated, the pump integrity monitor may be employed to decipher the health or integrity that is particular to the pump assembly.

[0053] Deciphering the health of the pump assembly may be achieved in part by employing the pump integrity monitor to record timing information of the pump assembly as indicated at 635 (e.g. perhaps with a proximity switch). With timing information in mind, a vast amount of acoustic data may be sampled with a high speed acquisition mechanism, perhaps at between about 100,000 and 300,000 samples per second as indicated at 650. With properly located sensors to obtain such samples, a fairly high resolution of the acoustics of the operating assembly may be obtained for evaluation as indicated at 680. Additionally, the acoustic data may be sampled based on the speed of the pump as noted at 660 such that an FFT conversion of such data may

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be entirely avoided saving significant processing capacity of the pump integrity monitor.

[0054] Embodiments described herein include a method of monitoring pump integrity with a pump integrity monitor in a manner that distinguishes outside noise from acoustics related to the pump. In fact, even where surrounding noise emanates from other pumps fluidly coupled to the pump of interest, the pump integrity monitor is operated so as to distinguish outside noise without requiring that other pumps be operated at substantially different speeds or constant rates of speed. Thus, there is no need to place undue loads on certain pumps of a multi-pump operation in order to acoustically monitor the operating health of each pump. Furthermore, the pump integrity monitor is operated in such a manner so as to dramatically increase processing capacity by elimination of FFT conversion requirements and to shorten time for diagnosis of the health of the pump. Thus, the practical effectiveness of acoustic diagnostics of an operating pump assembly may be significantly improved.

[0055] Although exemplary embodiments describe particular techniques for monitoring pump assemblies such as positive displacement pumps for fracturing applications, additional embodiments are possible. For example, several pump integrity monitors may be coupled to a central host or one another over a network for analysis of operational conditions at a variety of pumps or even multiple operation sites. Additionally, analysis techniques described above may be further and more particularly tailored based on program configuration. In one example, spectrum averaging bound to timing positions (i.e. stacking) may be employed to reduce noise and improve resolution irrespective of steady or repeatable conditions. Cepstral analysis may also be employed for multiple harmonics originating from a variety of mechanical parts. Joint time-frequency analysis may even be employed to handle time-

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varying frequency content through patter recognition in two dimensional time-frequency space wherein a Bayesian-based pattern classification technique is employed with an embedded database of vibration signatures.

[0056] In addition to that above, methods may be employed tailored to the pump integrity monitor electronics employed. In this regard, interleaved virtual sub-devices may be integrated into a single firmware frame, re-programmable virtual devices may be employed with functionality based on a particular frequency range of interest while still within a single frame, and portable device implementation may be employed.

[0057] Further additional features may be provided for employing the pump integrity monitor described herein such as pre-programming of the pump integrity monitor with a variety of vibration signatures to enhance pattern recognition for the types of problems likely to be acoustically detected during pump operation. In fact, to enhance such recognition, applications may be run that tend to avoid natural operating frequencies that may overlap with frequencies otherwise reflective of an unhealthy pump condition. Furthermore, many other changes, modifications, and substitutions may be made without departing from the scope of the described embodiments.

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CLAIMS

We Claim:

1. A method of monitoring integrity of a pump assembly, the method comprising:

operating the pump assembly;

recording timing information relative to said operating;

sampling acoustic data with a high speed acquisition mechanism of the pump assembly; and

evaluating the acoustic data in light of the timing information.

2. The method of claim 1 wherein said sampling occurs at a rate of more than about 100,000 samples of the acoustic data per second.

3. The method of claim 2 wherein the high speed acquisition mechanism is a high speed acquisition board of a pump integrity monitor for said recording, said sampling and said evaluating.

4. The method of claim 1 wherein said evaluating further comprises distinguishing acoustic data that represents a healthy pump assembly condition from acoustic data that represents an unhealthy pump assembly condition.

5. The method of claim 4 wherein the unhealthy condition is a condition of one of pump mounts, a plunger, crankshaft bearings, a transmission, a pump valve seal, valve spring, crossheads, pony rods, and piston operation of the pump assembly.

6. The method of claim 4 wherein said distinguishing is achieved with reference to a vibration signature pre-programmed into a processor of the pump integrity monitor.

7. The method of claim 1 wherein said recording further comprises monitoring a position of a moving part of the pump assembly.

8. The method of claim 7 wherein said monitoring is achieved with a speed sensor coupled to a driveline mechanism of the pump assembly.

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9. The method of claim 1 wherein said operating of the pump assembly is at a given speed, said sampling occurring at a rate based on the given speed.

10. A method of monitoring integrity of a pump assembly, the method comprising:

operating the pump assembly;

monitoring a speed of said operating;

sampling acoustic data from the pump assembly at a rate based on the speed; and

evaluating the acoustic data for distinguishing acoustic data that represents a healthy pump assembly condition from acoustic data that represents an unhealthy pump assembly condition.

11. The method of claim 10 wherein the unhealthy condition is a condition of one of pump mounts, a plunger, crankshaft bearings, a transmission, a pump valve seal, valve spring, crossheads, ponyrods, and piston operation of the pump assembly.

12. The method of claim 10 wherein said pump assembly includes a crankshaft for rotation during said operating, said sampling occurring at a rate of between about 50 and about 5,000 samples of the acoustic data per rotation.

13. The method of claim 10 wherein said monitoring further comprises tracking a position of a moving part of the pump assembly.

14. The method of claim 13 wherein the pump assembly is a positive displacement pump assembly and the moving part is a plunger, said monitoring achieved with an index sensor coupled to a plunger housing of the pump assembly, the plunger housing to accommodate the plunger, the plunger having a collar detectable by the index sensor.

15. The method of claim 10 wherein said evaluating occurs without performing a discrete Fourier Transform conversion.

16. The method of claim 10 wherein said evaluating further comprises analyzing acoustic data in frequencies between about 100 Hz and about 600 KHz.

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17. The method of claim 10 wherein said evaluating occurs as the speed varies.

18. The method of claim 10 wherein the distinguishing is achieved with reference to a vibration signature loaded into a processor of a pump integrity monitor for said monitoring, said sampling and said evaluating.

19. The method of claim 10 wherein the distinguishing of data that represents a healthy pump assembly condition includes recognizing noise based on the speed.

20. The method of claim 10 wherein said sampling occurs at a rate of more than about 100,000 samples of the acoustic data per second.

21. The method of claim 10 wherein said sampling takes place at one of a constant sampling rate and a variable sampling rate.

22. A pump integrity monitor comprising:

a processor;

a speed sensor coupled to said processor for monitoring a speed of an operating pump assembly; and

a data sensor coupled to said processor for sampling harmonic data from the pump assembly at a rate based upon the speed.

23. The pump integrity monitor of claim 22 wherein said speed sensor is one of an index sensor and a proximity switch for tracking a position of a moving part of the pump assembly.

24. A pump assembly comprising:

a pump;

a pump integrity monitor having a speed sensor coupled to said pump for monitoring a speed thereof during operation thereof; and

an acoustic sensor coupled to said pump integrity monitor for sampling acoustic data at a rate based upon the speed.

25. A multi-pump assembly comprising:

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a first pump assembly having a first pump integrity monitor with a speed sensor coupled to a pump of said first pump assembly for monitoring a speed thereof and an acoustic sensor for sampling acoustic data at a rate based on the speed;

a second pump assembly having a second pump integrity monitor with a speed sensor coupled to a pump of said second pump assembly for monitoring a speed thereof and an acoustic sensor for sampling acoustic data at a rate based on the speed; and

a common manifold in fluid communication with said first pump assembly and said second pump assembly.

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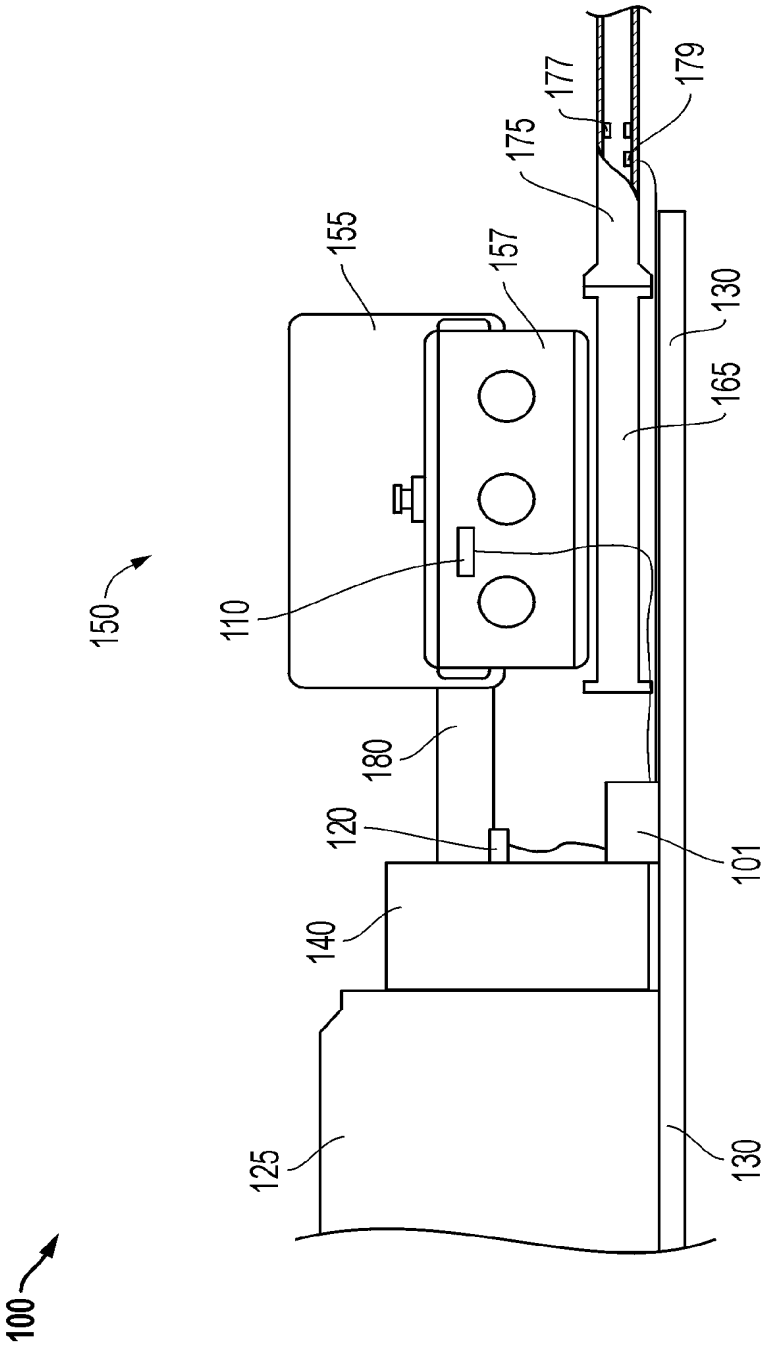


FIG. 1

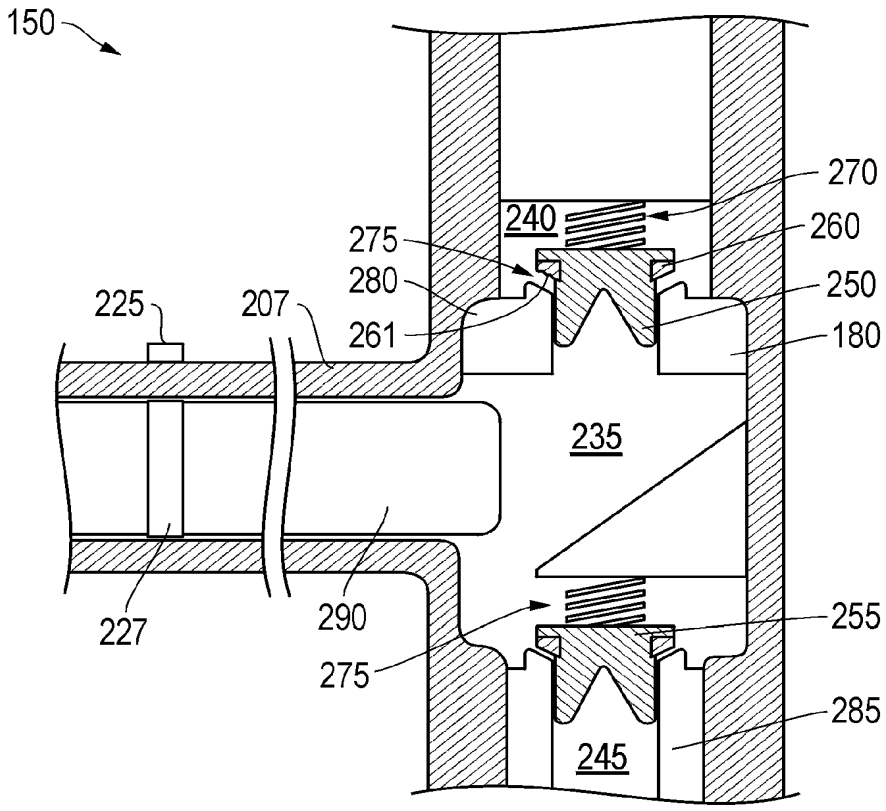

150
270
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275
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250
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207
261
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227
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285
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FIG. 2

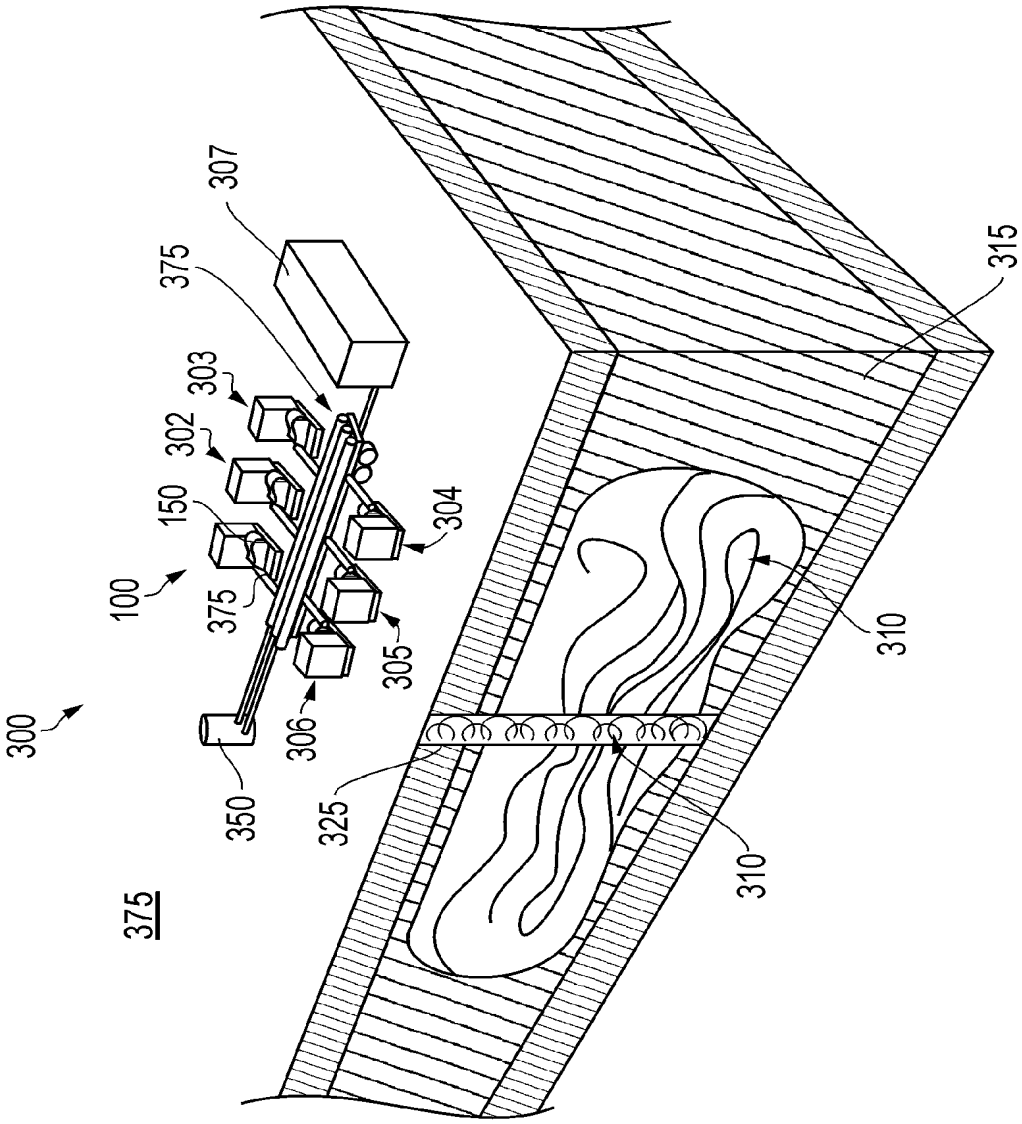

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302
303
304
305
306
307
315
310
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325
350
375
375
375

FIG. 3

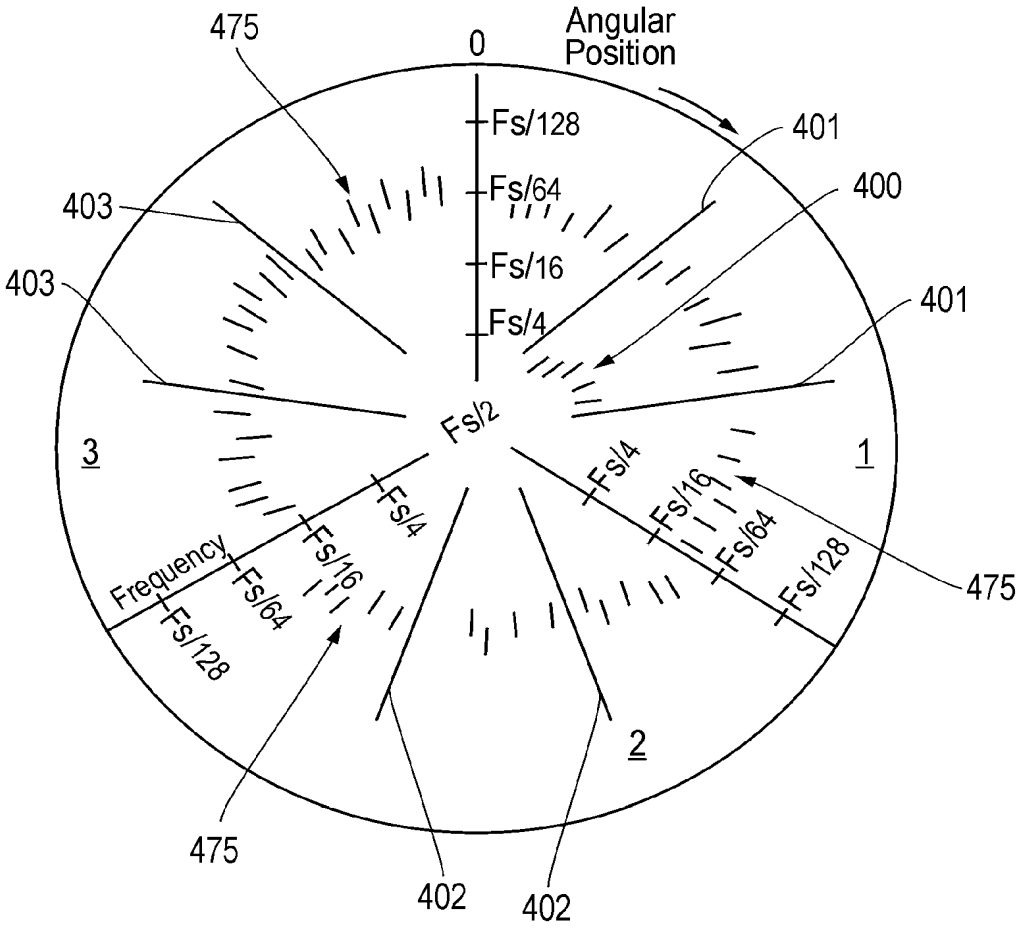

475
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Angular
Position
401
400
403
403
401
Fs/128
Fs/64
Fs/16
Fs/4
Fs/2
3
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475
402
402

FIG. 4

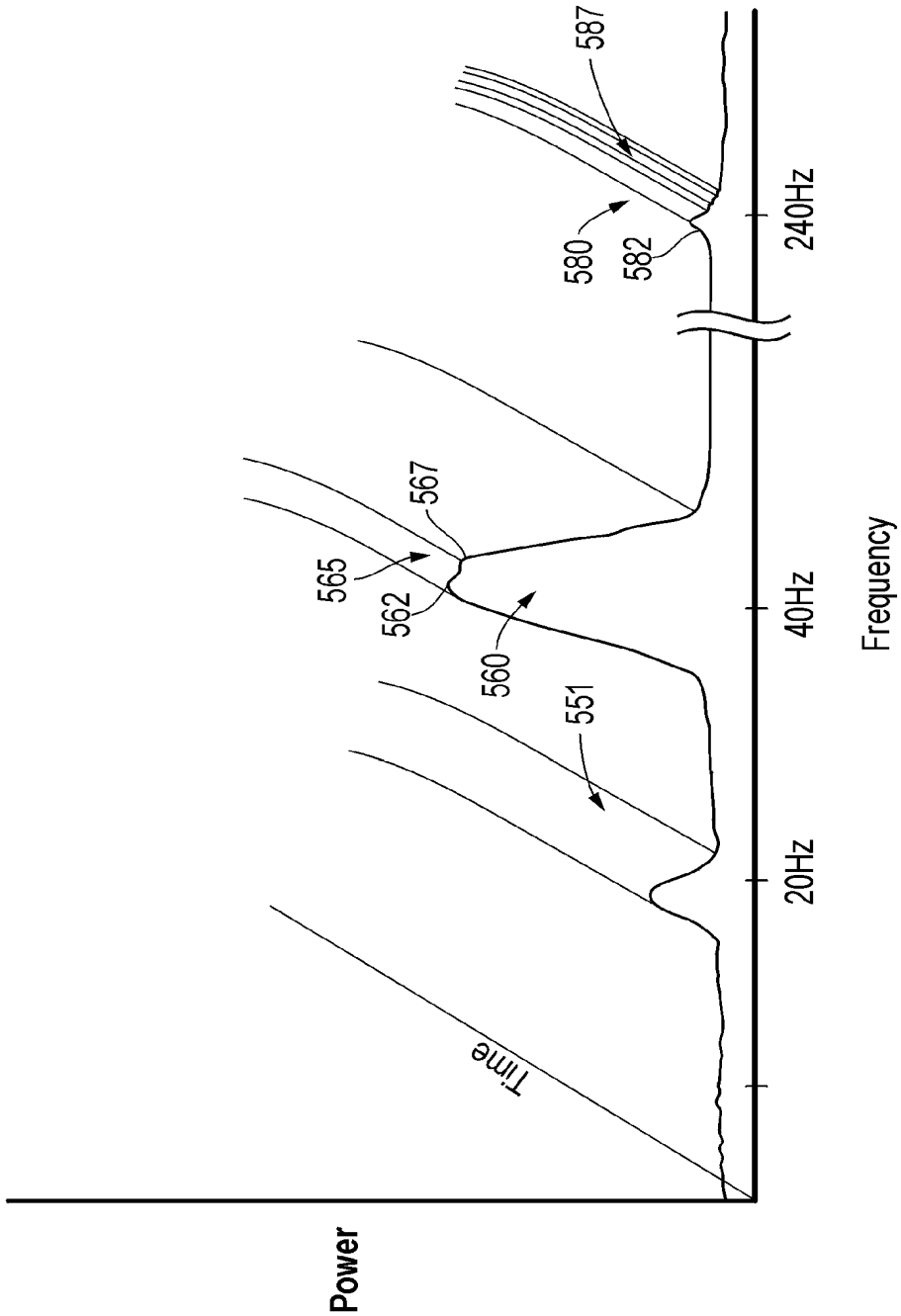

Power
Time
Frequency
20Hz
40Hz
240Hz
551
560
562
565
567
580
582
587

FIG. 5A

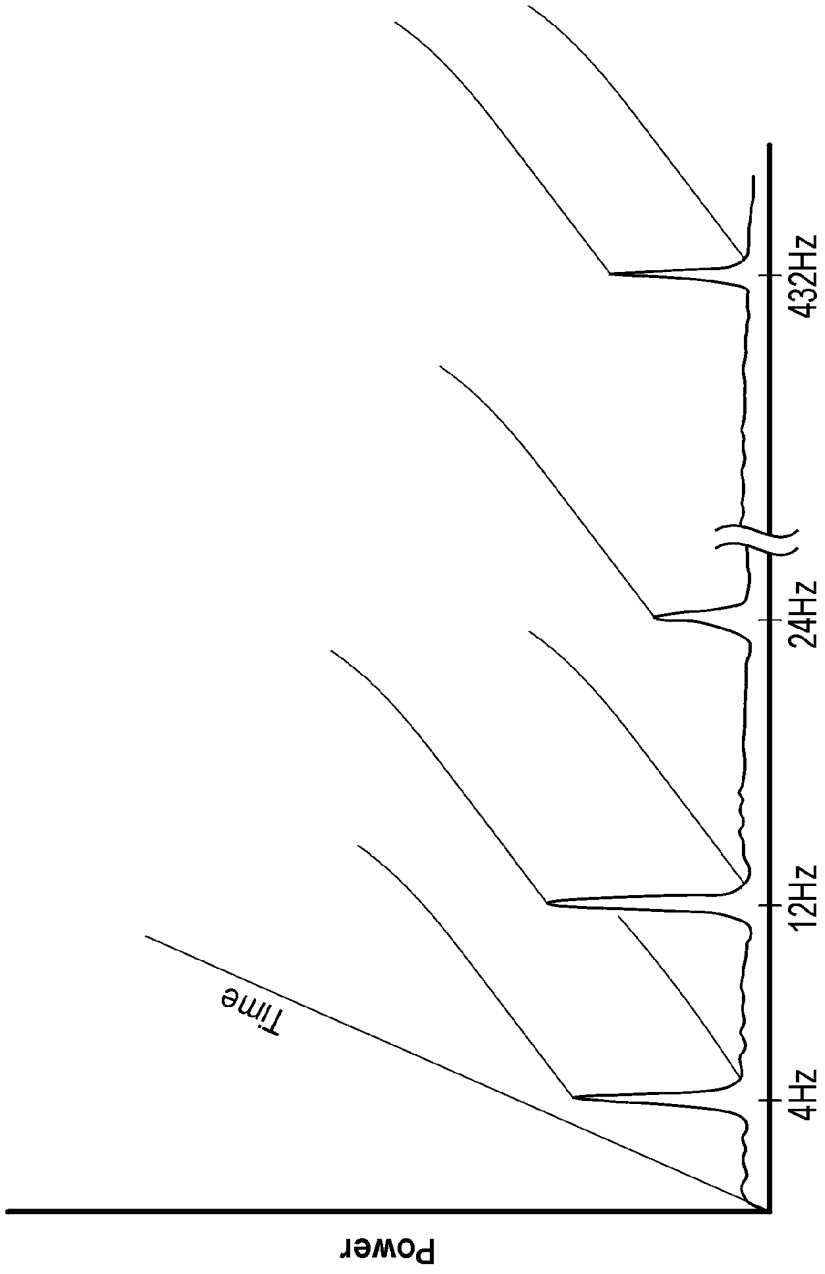


FIG. 5B

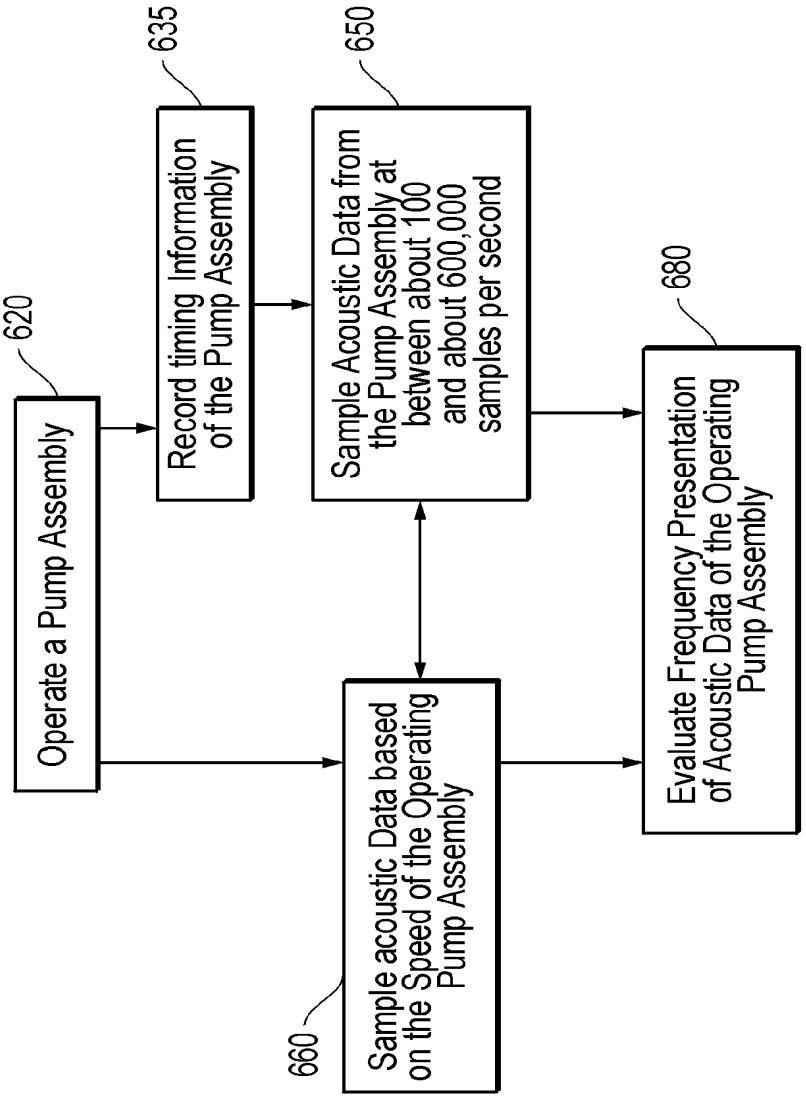

620
Operate a Pump Assembly
635
Record timing Information of the Pump Assembly
650
Sample Acoustic Data from the Pump Assembly at between about 100 and about 600,000 samples per second
660
Sample acoustic Data based on the Speed of the Operating Pump Assembly
680
Evaluate Frequency Presentation of Acoustic Data of the Operating Pump Assembly

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2007/054995

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B51/00 F04D15/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B F04D G01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	US 2004/230384 A1 (HAYNES HOWARD D [US] ET AL) 18 November 2004 (2004-11-18) the whole document	1-25
A	US 5 825 657 A (HERNANDEZ WALTER C [US]) 20 October 1998 (1998-10-20) the whole document	1-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 May 2008	20/05/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Ingelbrecht, Peter

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2007/054995

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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CA 2964593 A1 2017/10/15

(21) 2 964 593

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2017/04/18

(41) Mise à la disp. pub./Open to Public Insp.: 2017/10/15

(30) Priorités/Priorities: 2016/04/15 (US62/323,168); 2016/05/03 (US15/145,491); 2016/08/12 (US15/235,788)

(51) Cl.Int./Int.Cl. *E21B 43/26* (2006.01), *E21B 41/00* (2006.01)

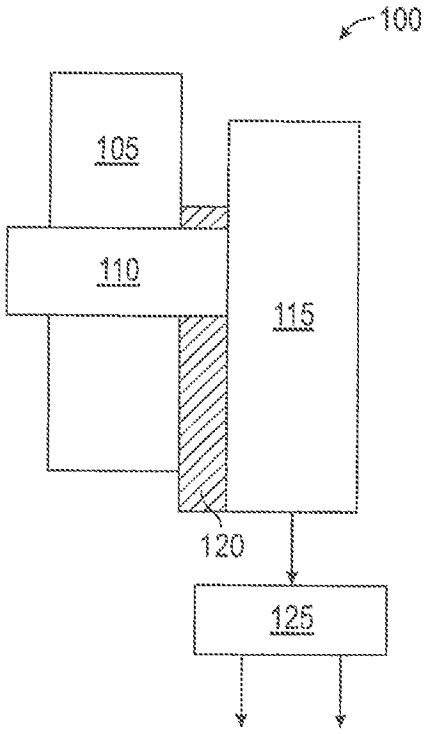
(71) Demandeur/Applicant:
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(74) Agent: BERESKIN & PARR LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : PARTAGE DE CHARGE D'EQUIPEMENT DE COMMUTATION DESTINE A UN EQUIPEMENT DE CHAMP PETROLIER

(54) Title: SWITCHGEAR LOAD SHARING FOR OIL FIELD EQUIPMENT



(57) Abrégé/Abstract:
A hydraulic fracturing system for fracturing a subterranean formation is disclosed. In an embodiment, the system may include a plurality of electric pumps fluidly connected to a well associated with the subterranean formation and powered by at least one

CA 2964593 A1 2017/10/15
(21) 2 964 593
(13) A1

(57) Abrégé(suite)/Abstract(continued):
electric motor, and configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation; at least one generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps; and at least one switchgear electrically coupled to the at least one generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one generator.

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ABSTRACT

A hydraulic fracturing system for fracturing a subterranean formation is disclosed. In an embodiment, the system may include a plurality of electric pumps fluidly connected to a well associated with the subterranean formation and powered by at least one electric motor, and configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation; at least one generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps; and at least one switchgear electrically coupled to the at least one generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one generator.

SWITCHGEAR LOAD SHARING FOR OIL FIELD EQUIPMENT

BACKGROUND

[0001] 1. Technical Field

[0002] This disclosure relates generally to hydraulic fracturing and more particularly to systems and methods for spare turbine power generation, which is sometimes referred to as reserve power.

[0003] 2. Background

[0004] With advancements in technology over the past few decades, the ability to reach unconventional sources of hydrocarbons has tremendously increased. Horizontal drilling and hydraulic fracturing are two such ways that new developments in technology have led to hydrocarbon production from previously unreachable shale formations. Hydraulic fracturing (fracturing) operations typically require powering numerous components in order to recover oil and gas resources from the ground. For example, hydraulic fracturing usually includes pumps that inject fracturing fluid down the wellbore, blenders that mix proppant into the fluid, cranes, wireline units, and many other components that all must perform different functions to carry out fracturing operations.

[0005] Usually in fracturing systems the fracturing equipment runs on diesel-generated mechanical power or by other internal combustion engines. Such engines may be very powerful, but have certain disadvantages. Diesel is more expensive, is less environmentally friendly, less safe, and heavier to transport than natural gas. For example, heavy diesel engines may require the use of a large amount of heavy equipment, including trailers and trucks, to transport the engines to and from a wellsite. In addition, such engines are not clean, generating large amounts of exhaust and pollutants that may cause environmental hazards, and are extremely loud, among

other problems. Onsite refueling, especially during operations, presents increased risks of fuel leaks, fires, and other accidents. The large amounts of diesel fuel needed to power traditional fracturing operations requires constant transportation and delivery by diesel tankers onto the well site, resulting in significant carbon dioxide emissions.

[0006] Some systems have tried to eliminate partial reliance on diesel by creating bi-fuel systems. These systems blend natural gas and diesel, but have not been very successful. It is thus desirable that a natural gas powered fracturing system be used in order to improve safety, save costs, and provide benefits to the environment over diesel powered systems. Turbine use is well known as a power source, but is not typically employed for powering fracturing operations.

[0007] Though less expensive to operate, safer, and more environmentally friendly, turbine generators come with their own limitations and difficulties as well. As is well known, turbines generally operate more efficiently at higher loads. Many power plants or industrial plants steadily operate turbines at 98% to 99% of their maximum potential to achieve the greatest efficiency and maintain this level of use without significant difficulty. This is due in part to these plants having a steady power demand that either does not fluctuate (i.e., constant power demand), or having sufficient warning if a load will change (e.g., when shutting down or starting up a factory process).

[0008] In hydraulic fracturing, by contrast, the electrical load constantly changes and can be unpredictable. This unpredictability is due to the process of pumping fluid down a wellbore, which can cause wellhead pressure to spike several thousand PSI without warning, or can cause pressure to drop several PSI unexpectedly (sometimes called a "break," as in the formation broke open somewhere). In order to maintain a consistent pump rate, the pump motors are required to

"throttle" up or "throttle" down (applying more or less torque from a variable frequency drive), drawing either more or less electrical power from the turbines with little to no notice in many situations.

[0009] Concurrently with pressure variations, fluid rate variations can also occur. At any moment, the contracting customer may ask for an extra 5 barrels per minute (bpm) of pump rate or may request an instantly decreased pump rate with little to no warning. These power demand changes can vary from second to second – unlike industrial power demands, which may vary from hour to hour or day to day, allowing for planning and coordination.

[0010] Hydraulic horsepower (HHP) can be calculated with the following relationship:

$$HHP = \frac{(\text{Wellhead Pressure}) \times (\text{Pump Rate})}{40.8}$$

HHP also directly correlates with the power demand from the turbines, where:

$$HHP \approx \text{Electrical Power Demand}$$

Therefore, if both variables (rate and pressure) are constantly changing, maintaining a steady power demand can be difficult. Due to this, it is impossible to design the equipment and hold the turbine output at 98% - 99% of full potential because a minute increase in power demand may shut the turbines down and may result in failure of the fracturing job. To prevent such turbine shutdown from happening, fracturing equipment is designed to only require approximately 70% of the maximum output of the turbine generators during normal and expected operating conditions. This allows the fleet to be able to operate against changing fracturing conditions, including increased fluid rate and increased wellhead pressure.

[0011] There are also other small loads which contribute to changing power demand. These include turning on or off small electrical motors for hydraulic pumps, chemical pumps, cooling fans, valve actuators, small fluid pumps, etc., or power for metering instrumentation,

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communication equipment, and other small electronics. Even lighting or heating can contribute to the fluctuating power load.

[0012] Therefore it may be desirable to devise a means by which turbine power generation can be managed at an output usable by fracturing equipment.

SUMMARY

[0013] The present disclosure is directed to a method and system for providing electrical load sharing between switchgear trailers acting as power hubs to combine the output of multiple electrical generators.

[0014] In accordance with an aspect of the disclosed subject matter, the method and system of the present disclosure provide a hydraulic fracturing system for fracturing a subterranean formation. In an embodiment, the system can include a plurality of electric pumps fluidly connected to the formation and configured to pump fluid into a wellbore at high pressure so that the fluid passes from the wellbore into the formation and fractures the formation; at least one generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps; and at least one switchgear electrically coupled to the at least one generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one generator.

[0015] In an embodiment, the system including the plurality of electric pumps, the at least one generator, and the at least one switchgear can be a single electrical microgrid.

[0016] In an embodiment, the system making up the single electrical microgrid can be split into two or more electrical banks. In an embodiment, each of the two or more electrical banks can include at least one generator and at least one switchgear. In an embodiment, when one or more

of the two or more electrical banks is shut down, each of the other active electrical banks can be configured to distribute the electrical load between the plurality of electric pumps and the at least one generator associated with each active electrical bank.

[0017] In an embodiment, the system can further include at least two switchgear units electrically coupled to the at least one generator, and a tie breaker electrically coupled between each of the at least two switchgear units.

[0018] In an embodiment, the tie breaker can be configured to evenly distribute the electrical load between the plurality of electric pumps and the at least one generator when the tie breaker is in a closed position; and isolate one or more of the plurality of electric pumps, the at least one generator, and the at least two switchgear units when the tie breaker is in an open position.

[0019] In an embodiment, when the tie breaker is in the closed position, at least one generator is shut down and at least one other generator is active, the electrical load can be evenly distributed among the at least one other active generators.

[0020] In an embodiment, the tie breaker can include a long distance transmission line.

[0021] In an embodiment, the at least one switchgear can be configured to distribute power among any of one or more transformers, auxiliaries, or other switchgear units, or a combination thereof.

[0022] In an embodiment, the one or more auxiliaries can include any of a blender, electric wireline equipment, a water transfer pump, an electric crane, a data van, a work trailer, living quarters, an emergency shower, sand equipment, a turbine inlet chiller, a compressor station, a pumping station, a second fracturing site, a drill rig, or a nitrogen plant, or a combination thereof.

[0023] In an embodiment, the at least one generator can be one of a turbine generator or a diesel generator, or a combination thereof.

[0024] In an embodiment, the at least one turbine generator can be powered by natural gas.

[0025] In an embodiment, wherein each component of the system can be modular and movable to different locations on mobile platforms.

[0026] In an embodiment, the system can further include a power connection panel associated with the plurality of electric pumps. In an embodiment, the power connection panel can include a plurality of power connections for each of the plurality of electric pumps, and a system ground connection configured to act as a ground between the plurality of electric pumps and a transformer. In an embodiment, the transformer can be configured to provide power to the plurality of electric pumps.

[0027] In an embodiment, the system can further include a variable frequency drive connected to the at least one electric motor to control the speed of the at least one electric motor. In an embodiment, the variable frequency drive can frequently perform electric motor diagnostics to prevent damage to the at least one electric motor.

[0028] In accordance with another aspect of the disclosed subject matter, the method and system of the present disclosure provide a hydraulic fracturing system for fracturing a subterranean formation. In an embodiment, the system can include a plurality of electric pumps fluidly connected to the formation and configured to pump fluid into a wellbore at high pressure so that the fluid passes from the wellbore into the formation and fractures the formation; at least one turbine generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps; at least two switchgear units electrically coupled to the at least one turbine generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one turbine generator; a tie breaker electrically coupled between each of the at least two switchgear units and configured to evenly

distribute the electrical load between the plurality of electric pumps and the at least one turbine generator when the tie breaker is in a closed position; and a variable frequency drive connected to the at least one electric motor to control the speed of the at least one electric motor, wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the at least one electric motor.

[0029] Other aspects and features of the present disclosure will become apparent to those of ordinary skill in the art after reading the detailed description herein and the accompanying figures.

BRIEF DESCRIPTION OF DRAWINGS

[0030] Some of the features and benefits of the present disclosure having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0031] FIG. 1 is a schematic example of a turbine generator in communication with an electronic equipment room, which connects to a switchgear according to an embodiment of the disclosure.

[0032] FIG. 2 is a perspective view of an example of a turbine generator and electronic equipment room according to an embodiment of the disclosure.

[0033] FIGS. 3A and 3B are perspective views of a switchgear trailer according to an embodiment of the disclosure.

[0034] FIG. 4 is a perspective view of cables connecting to a hydraulic fracturing pump trailer according to an embodiment of the disclosure.

[0035] FIGS. 5-15 are block diagrams of portions of a microgrid having a plurality of turbine generator sets and switchgear units according to various embodiments.

[0036] While the disclosure will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the disclosure to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the disclosure as defined by the appended claims.

DETAILED DESCRIPTION

[0037] The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. Like numbers refer to like elements throughout. In an embodiment, usage of the term "about" includes +/- 5% of the cited magnitude. In an embodiment, usage of the term "substantially" includes +/- 5% of the cited magnitude.

[0038] It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation.

[0039] Described herein is an example of a method and system for providing electrical load sharing between switchgear trailers acting as power hubs to combine the output of multiple electrical generators. Adding a tie breaker between two switchgear trailers can eliminate the need

for a third switchgear trailer, while still retaining the ability to evenly distribute power between all of the equipment, and to concurrently evenly distribute the electrical load between a plurality of turbine generator sets.

[0040] A feature of the switchgear configurations described herein is the capability to selectively choose between either load sharing, to provide efficiency and flexibility; or having isolated banks of equipment, to provide protection and redundancy. In an embodiment, the switchgear optionally includes a tie breaker. The tie breaker can synchronize three-phase power of a similar voltage and frequency from different sources to act as a common bus, and can evenly distribute the electrical load between a plurality of electric pumps and turbine generators when the tie breaker is in a closed position. The tie breaker will isolate one or more of the plurality of electric pumps, the turbine generator, and the switchgear units when the tie breaker is in an open position. The use of a tie breaker can provide an advantage over previous load sharing systems because use of a tie breaker provides more options for the equipment operators and allows the fleet to be more versatile as to which mode of operation – protection and redundancy, or efficiency and flexibility – is more desirable at any given moment.

[0041] Another favorable aspect of load sharing is the ability to shutdown turbines when peak power output is not required. If the power load is distributed evenly between all of the generator sets in the fleet, then it can be possible to shut down unnecessary power generation as long as the remaining generator sets can compensate for the loss and pick up the extra load placed on them. This flexibility for partial shutdown can allow the remaining turbines to operate at a higher efficiency, which can reduce wear on the fleet by not running every turbine continuously, and increase efficiency while reducing emissions by allowing fewer turbines to run in a lower emissions mode. The lower emissions mode is called SoloNox, and can be performed due to load

sharing using a switchgear, because the turbines can only operate in this mode while operating above a 50% load. In some embodiments, directly powering fracturing pumps can involve using all turbines regardless of the required power load.

[0042] In an embodiment, a variable frequency drive (VFD) – and in some cases, an A/C console used to keep the VFD from overheating – can be utilized to control the speed of an electric motor associated with a pump powered by the turbine(s).

[0043] In some examples, certain tasks can be accomplished with fewer turbines. Instead of having redundancy or spare power generation available to isolated power banks, the reserve power generation capability can be consolidated across the entire fleet. Requiring fewer turbine generators means the equipment can now fit on smaller well sites which reduces the need to clear more land and disrupt the surrounding environment to create a larger pad, and reduces the costs associated with such clearing and construction.

[0044] The systems described herein are not limited to use in processes involving hydraulic fracturing. For example, the system includes electric fracturing equipment and power generation equipment. The power generation equipment can be used to supply any oilfield equipment including compressor stations, pumping stations, nitrogen plants, CO_2 plants, drilling rigs, work-over rigs, barracks, coiled tubing units, refineries, or other systems or applications that do not have access to a utility provided power grid or that have a dynamic power load or low power factor.

[0045] **FIG. 1** is a block diagram showing the basic components of a hydraulic fracturing well site power generation system 100 for providing electrical load sharing according to an embodiment. A turbine generator 105 can include a natural gas turbine engine coupled to a three-phase, 60 hertz (Hz) electric generator to produce power as the turbine engine rotates. In an

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alternative, the generator can generate electricity at 50 Hz, or at any other power level useful for hydraulic fracturing fleets. In the illustrated embodiment, the turbine generator 105 is shown being electrically connected to an electronic equipment room (EER) 115, which can house wiring, breakers, controls, monitoring systems, fire suppression support, and a battery bank for secondary power when the turbine is not operating and there is no other power source. In some examples, the battery bank can power lighting, fire suppression, emergency turbine lube pumps, and onboard electronics. The combination of a turbine generator 105 and an EER 115 can be referred to as a generator set. A switchgear trailer 125 can provide power distribution, high voltage breakers, and "lock-out, tag-out" (a safety procedure used to ensure that dangerous machines are properly shut off and not able to be started up again prior to the completion of maintenance or servicing work) capabilities.

[0046] Transformers can optionally be included with the equipment of FIG. 1. As illustrated in the embodiment shown in FIG. 1, an air intake filter house 110 can be positioned on top of or adjacent to the turbine generator 105, and a catwalk 120 can connect turbine generator 105 and EER 115 for ease of access. The system 100 as a whole can define an example of an electrical microgrid.

[0047] **FIG. 2** shows a perspective view of an example system 200 having a single generator set with a turbine generator 205 and an overhanging filter house 210 according to an embodiment. A power cable 206 can connect the turbine generator 205 to an EER 215 with plugs 204-a, 204-b. In some embodiments, plugs 204-a, 204-b are enclosed and concealed while energized. Between turbine 205 and EER 215 is an elevated catwalk 220 with stairs leading to the EER 215 for employee access, in the illustrated embodiment. Turbine 205 can also include maintenance

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hatches for purposes of employee access. A plug 202 can provide a power cable between the EER 215 and a switchgear trailer (not shown).

[0048] An example 300-a of a switchgear trailer 325 is shown in an end perspective view in FIG. 3A. Electrical connections 302 for turbines and an auxiliary trailer are shown in recesses formed on a lateral surface of the trailer 325. A side opposite the lateral side of the trailer 325, as shown in the example 300-b according to an embodiment illustrated in FIG. 3B, can include electrical connections 302 for transformers.

[0049] FIG. 3B illustrates in side perspective view a side of the switchgear trailer 325 opposite from that of shown in FIG. 3A. In the illustrated example, switchgear trailer 325 can be an example of a switchgear "B" trailer. Four connections 302 are visible, which are for the 13.8 kV cable that spans between the switchgear and the transformers. Each connection 302 is a cable that contains all three electrical phases, a ground, and a ground check; which is different from the cabling configuration of FIG. 4, which relies on the use of multiple conductors per phase, as discussed below.

[0050] The switchgear trailer 325 can house large breakers and fault protection equipment required for safe operations and for "lock-out, tag-out" of power going to selected equipment. The switchgear is optionally rated for 15 kV (13.8 kV), and can be designed or reconfigured for different voltages, such as 138 kV, 4,160 V, or 600 V, or any other voltage suitable for fracturing fleet operations. The switchgear can include ground fault detection, color coordinated cable receptacles, interlock system, and other safety features.

[0051] Illustrated in a side perspective view in FIG. 4 is an example 400 of multiple single-conductor cables connecting to a fracturing pump trailer 425, according to an embodiment. In the illustrated example, a 600 V power connection panel 401 contains power connections for two

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fracturing pumps. Each electrical phase is split into two separate cables. An upper row of plugs 402-a can be used to power one fracturing pump, while a lower row of plugs 402-b can be used to power a second fracturing pump on the same fracturing pump trailer 425.

[0052] In the illustrated example, the upper row of plugs 402-a includes six single-phase cable connections, and the lower row of plugs 402-b includes six single-phase cable connections, allowing for two cables per phase. The plugs can be color-coded based on the electrical phase. The power connection panel 401 can also include a control power cable 404 and a system ground cable 406. The system ground cable 406 can act as a ground between the fracturing pump trailer 425 and a 13.8 kV to 600 V transformer (not shown) providing power to the fracturing pump trailer 425. Additional cables can span between the 13.8 kV to 600 V transformer and the fracturing pump trailer 425.

[0053] **FIG. 5** is a block diagram illustrating one example 500 of a plurality of generator sets 505-a, 505-b, 505-c for use with a system for fracturing a subterranean formation. Each generator set 505-a, 505-b, 505-c can include a turbine engine with sufficient mechanical power to rotate an electric generator with sufficient electrical power to provide electricity to a small, closed circuit, electrical grid. This grid can be considered part of the microgrid.

[0054] For the sake of discussion herein, certain types of switchgear units have nomenclature based on their application; for example a switchgear "A" can distribute power to other switchgear units, a switchgear "B" can transmit power to transformers and auxiliaries, and a switchgear "C" can transmit power to transformers. However, a switchgear trailer is not limited to the previously stated configurations. It is possible to power more than four transformers from a switchgear "B" or switchgear "C"; and a switchgear "B" can supply more than one auxiliary trailer if needed. Similarly, a switchgear "A" is not limited to connections for only three or four

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generator sets and only two switchgear trailers. The denotation of A, B, C, A+, B+ and C+ switchgear units does not reflect industry standards, but is a naming convention for use herein.

[0055] In the illustrated embodiment, switchgear "A" 525-a is an electrical hub combining the power output of three 5.7 MW natural gas turbine generators from generator sets 505-a, 505-b, 505-c. Further in this example, switchgear "A" 525-a can supply electrical power to two other switchgear units. Switchgear "B" 525-b can receive power from switchgear "A" 525-a and distribute the power to an auxiliary unit and multiple transformers, as shown. Switchgear "C" 525-c can also receive power from switchgear "A" 525-a and distribute the power to one or more transformers, but in the illustrated embodiment does not distribute power to an auxiliary unit.

[0056] In this example, the illustrated lines leading between the generator sets 505-a, 505-b, 505-c, switchgear units 525-a, 525-b, 525-c, and auxiliary units and transformers can be 13,800 volt, three-phase, 60 Hz, power lines. This example allows load distribution between all three turbines in generator sets 505-a, 505-b, 505-c through switchgear "A" 525-a. Optionally, the power demand placed on each generator set 505-a, 505-b, 505-c can be equal, and each generator set 505-a, 505-b, 505-c can run at an equal output.

[0057] **FIG. 6** is a block diagram showing an embodiment 600 illustrating a plurality of generator sets 605-a, 605-b, 605-c for use with a system for fracturing a subterranean formation. Similarly to the example 500 illustrated in FIG. 5, switchgear "A" 625-a is an electrical hub combining the power output of three 5.7 MW natural gas turbine generators from generator sets 605-a, 605-b, 605-c, where switchgear "A" 625-a can supply electrical power to two other switchgear "B" units 625-b-1, 625-b-2. While described as being a 5.7 MW generator, other generator configurations capable of operating at other power outputs are also envisioned. For example, in an embodiment, a 6.5 MW turbine generator can be used.

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[0058] In contrast to the example provided in FIG. 5, in this example switchgear "C" 525-c is replaced with a second switchgear "B" 625-b-2. Both switchgear "B" units 625-b-1, 625-b-2 couple to and provide power for a secondary auxiliary, which can include any one or more of a secondary blender, electric wireline, water transfer, crane, a second data van, turbine inlet chillers, and the like.

[0059] **FIG. 7** is a block diagram of another example 700 of a switchgear layout for use with a fracturing system, according to an embodiment. In this example, switchgear "A" 625-a of FIG. 6 is substituted with switchgear "A+" 725-a, allowing for connections and breakers for a fourth generator set 705-d. This configuration allows for powering more equipment for a wider range of applications. Switchgear "A+" 725-a can supply electrical power to two other switchgear "B" units 725-b-1, 725-b-2. In an alternate embodiment, one or more of switchgear "B" units 725-b-1, 725-b-2 can be replaced with a switchgear "B+" unit. This embodiment provides advantages with regard to cost, as existing switchgear trailers can be upgraded or modified accordingly without the need for purchasing new trailers.

[0060] **FIG. 8** is a block diagram illustrating an alternate example 800 of a plurality of generator sets for use with a system for fracturing a subterranean formation, according to an embodiment. In the illustrated example, the power transmission network is broken into two banks with direct communication between generator sets 805-a, 805-b and switchgear "B" 825-b-1 in the first bank 807-a, and generator sets 805-c, 805-d and switchgear "B" 825-b-2 in the second bank 807-b. Generator sets 805-a, 805-b can be load sharing through one switchgear "B" 825-b-1, and generator sets 805-c, 805-d can be load sharing through another switchgear "B" 825-b-2. Direct communication between generator sets 805-a, 805-b, 805-c, 805-d and switchgear "B" 825-b-1, 825-b-2 can require fewer switchgear trailers, which can save space, decrease equipment costs,

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and decrease the amount of cables being run, while allowing addition of a fourth generator set 805-d.

[0061] Splitting the microgrid into two banks 807-a, 807-b can build redundancy into the system. If a single generator set fails during peak power demand, any other generator set on the same circuit can share the load. If the load is too high, the other turbines will shut down, causing a complete blackout; in hydraulic fracturing, this can result in a "screen out." During a "screen out," the fluid in the wellbore is full of sand when the pumps stop, causing the sand to drop out of suspension in the fluid and plug off the well, which is expensive and time consuming to clean out. With two separate electrical banks, a failure in one bank (due to a ground fault, mechanical breakdown, software issue, fuel problem, cable issue, breaker failure, etc.) will not cause a failure in the other bank. The load on the opposite pair of turbines will remain the same, resulting in only a blackout for half of the equipment; operators can flush the well bore with half of the equipment in most situations. Two switchgear units "B" can be used to allow either bank to provide power to a blender, which allows the hydraulic fracturing equipment that is connected to either power bank to be self-sufficient and capable of flushing the well bore in event of a generator failure.

[0062] In the example of FIG. 8, if all four turbines 805-a, 805-b, 805-c, 805-d were operating at 50% while configured in pairs on two separate power banks 807-a, 807-b, shutting one turbine down in a given load bank will result in the other turbine in that pair having to pick up the entire power demand for the bank (circuit). This will result in 100% load on a single turbine, and could likely shut down the operating turbine, causing a blackout for half of the equipment. In the summer months when temperatures are elevated, turbine engines cannot reach their maximum potential as power output is derated due to the hot ambient air being less dense. Thus all four

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turbines may be required to operate despite their load percentage being as low as 35% in certain cases.

[0063] Another alternate example 900 of a plurality of generator sets for use with a system for fracturing a subterranean formation is schematically illustrated in **FIG. 9**. Similarly to the example 800 illustrated in FIG. 8, generator sets 905-a, 905-b and switchgear "B+" 925-b-1 can make up a first bank 907-a, and generator sets 905-c, 905-d and switchgear "B+" 925-b-2 can make up a second bank 907-b. Differently from example 800, however, in the illustrated example 900, the switchgear units 925-b-1, 925-b-2 are able to load share with one another.

[0064] Example cables are shown spanning between the two "B+" switchgear units 925-b-1, 925-b-2, which optionally are 13.8 kV cables for a tie breaker 909. Tie breaker 909 can allow for complete load sharing between all four turbines in generator sets 905-a, 905-b, 905-c, 905-d without the need for a switchgear "A," as illustrated in FIG. 5. A bus tie breaker 909 between switchgear "B+" 925-b-1 and switchgear "B+" 925-b-2 can be used when combining the power output from difference sources, such as in the case of using multiple generator sets 905-a, 905-b, 905-c, 905-d.

[0065] In one example of operation of the system of FIG. 9, all four turbines 905-a, 905-b, 905-c, 905-d can continue to operate even at loads below 50%, which can increase fuel consumption and wear on the turbines. For example, if four load sharing turbines were operating at a 50% load, one turbine could be shut down, allowing the other turbines to distribute the power demand, resulting in three turbines running at approximately 67% load. Turbines typically operate more efficiently at higher loads and the turbine generators enter the lean dry fuel ratio mode at above 50% load, allowing them to operate at higher efficiency with lower emissions than normal.

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[0066] In one example procedure for starting the turbine generators, all breakers (not shown) in each switchgear and EER can be set to an open position such that no electricity passes across the breakers, and generator set 905-b can be started from a black start generator (not shown). Once generator set 905-b is running and operating steadily, generator set 905-b can be connected to the bus on switchgear "B+" 925-b-1 by closing the breakers in each switchgear and EER.

[0067] In the described embodiment, generator set 905-a can be started through the power supplied from switchgear "B+" 925-b-1, which can in turn be powered by generator set 905-b. This configuration is commonly known as back-feeding, a process that ensures that the generators are in sync with each other. Operating out of sync, operating with three electrical phases not having identical phase angles, or operating when any two phases are reversed, can each cause catastrophic damage to the system.

[0068] Phase synchronization can be controlled by the EER, and may not allow current to flow onto a common power bus between two electrical sources (by keeping breakers open in the EER) until synchronization is complete. A tie breaker can also be used to synchronize the electrical phases so that two separate generator sources can be put on a bus together to provide power to equipment. In some cases, the electrical sources can be the two isolated switchgear units 925-b-1, 925-b-2.

[0069] A tie breaker can be installed in each switchgear "B+" 925-b-1, 925-b-2 to allow generator sets 905-a, 905-b, 905-c, 905-d to be synchronized and placed on a single bus together. Thus the two switchgear units "B+" 925-b-1, 925-b-2 can act as a single switchgear to provide load sharing, power transmission, and breaker protection to all four generator sets 905-a, 905-b, 905-c, 905-d. If load sharing is desired, the tie breaker can be used to close the joining breaker 909 between the switchgear "B+" 925-b-1, 925-b-2 trailers, which can allow for electrical

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current to flow in either direction to balance the load. If having two separate electrical banks 907-a, 907-b is desired, the joining breaker 909 can be kept open, separating the switchgear units "B+" 925-b-1, 925-b-2 from each other electrically.

[0070] This switchgear model example 900 can provide an option to have modular generator sets 905-a, 905-b, 905-c, 905-d. If only two or three generator sets are required, for example due to ambient temperatures or customer requirements, one or more generator sets can be shut down (or not rigged in). In the described configuration, even with one or more generator sets shut down, the system can nevertheless balance the load properly to supply power to the equipment, and to run the remaining turbines at a higher load and efficiency. During startup, the turbine generators can be started by back-feeding from the common bus 909 of the switchgear units "B+" 925-b-1, 925-b-2, as long as one turbine generator is started from the black start generator (not shown).

[0071] **FIG. 10** is a block diagram illustrating an example 1000 of a portion of a power flow diagram of a microgrid for use with a wellbore fracturing system, which includes electrical connections for 480 V, 600 V, and 13.8 kV, according to an embodiment. Shown are gas compressors 1030-a, 1030-b, which can be powered by electricity in some examples, but can optionally be powered by combusting fuel, such as natural gas, diesel, and the like, in other examples. Fuel gas filtration and heating units 1035-a, 1035-b, 1035-c, 1035-d are also depicted.

[0072] A black start generator 1003 is shown in electrical communication with generator sets 1005-b, 1005-c, and can be used to start the turbine generators. In an alternative embodiment, black start generator 1003 can be connected to each generator set 1005-a, 1005-b, 1005-c, 1005-d, or to a single turbine. The black start generator 1003 can initially provide power to equipment operating at 480 V, which can then be handed off to a small 480 V transformer (not shown)

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located on each generator set 1005-a, 1005-b, 1005-c, 1005-d, once the generator sets 1005-a, 1005-b, 1005-c, 1005-d are operational.

[0073] Also shown are 480 V, three-phase, 60 Hz power lines between the compressors 1030-a, 1030-b, generator sets 1005-a, 1005-b, 1005-c, 1005-d, and fuel gas filtration and heating units 1035-a, 1035-b, 1035-c, 1035-d. The power lines can depict the normal flow path of electrical current between the components of the microgrid. A chiller unit 1040 is shown, which can be an option for boosting the output of the turbine generators of generator sets 1005-a, 1005-b, 1005-c, 1005-d to negate the need for a fourth turbine. However, a fourth turbine may be required in some embodiments, or can be used in lieu of an air inlet chiller unit in some embodiments.

[0074] Also depicted in the illustrated embodiment is power transmission equipment, which can include switchgear "B+" units 1025-b-1, 1025-b-2, and 13.8 kV, three-phase, 60 Hz power cables. The switchgear "B+" units 1025-b-1, 1025-b-2 can provide power to the 3,500 kVA, 13.8 kV to 600 V step-down transformers 1045-a, 1045-b, 1045-c, 1045-d, 1045-e, 1045-f, 1045-g, 1045-h and auxiliary units 1050-a, 1050-b. The auxiliary units 1050-a, 1050-b can contain a large 13.8 kV to 600 V transformer, and can perform motor control, switching, and further distribution of power to auxiliary equipment and smaller loads. Power cables operating at 600 V, three-phase, 60 Hz are depicted according to a normal current flow path.

[0075] The mini-substations 1055-a, 1055-b shown can also be part of the distribution network, receiving power supplied by an auxiliary trailer, and having 120 V and 240 V, single-phase, 60 Hz plugs for power plant lights, heaters, or data vans. Mini-substations 1055-a, 1055-b can also contain 600 V, three-phase, 60 Hz connections as an extra hub to provide power to any extra equipment. Extra equipment can include, for example, water transfer pumps, wireline equipment,

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electric cranes, work trailers, living quarters, emergency showers, sand equipment, or future additions to the fleet.

[0076] The orientations and positions of the equipment in example 900 are for graphical purposes only to illustrate the flow of electricity and interconnections. On a well site, the equipment may be placed in any order or configuration geographically, as long as the electrical schematic does not change.

[0077] The example methods of using two "B+" switchgear units to provide power transmission and load sharing advantageously allows for load sharing, while still having the advantage of fewer cables and less equipment. The method of using two "B+" switchgear units enables operation of two separate grids for redundancy or a single load sharing grid for efficiency.

[0078] Illustrated in **FIG. 11** is a block diagram showing an example 1100 of switchgear load sharing for multiple generator sets 1105-a, 1105-b, 1105-c, 1105-d, 1105-e, 1105-f, according to an embodiment. Here a switchgear "C+" 1125-c is depicted having tie breakers 1109-a, 1109-b for load sharing without provisions for an auxiliary trailer. In some examples, the switchgear "C+" 1125-c trailer and switchgear "B+" 1125-b-1, 1125-b-2 trailers can be interchanged with each other, as some applications may not require auxiliary trailers or their corresponding equipment. Additionally, although three or four turbines are illustrated in many of the examples provided herein, this is not a limitation and alternate configurations having more or fewer turbines are envisioned to provide power for multiple fleets or well sites, including non-hydraulic fracturing applications.

[0079] Similarly to FIGS. 8 and 9, the power transmission network can be broken into multiple banks with direct communication between generator sets 1105-a, 1105-b and switchgear "B+" 1125-b-1 in the first bank 1107-a; generator sets 1105-c, 1105-d and switchgear "C+" 1125-c in

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the second bank 1107-b; and generator sets 1105-e, 1105-f and switchgear "B+" 1125-b-2 in the third bank 1107-c. Generator sets 1105-a, 1105-b can be load sharing through switchgear "B+" 1125-b-1, generator sets 1105-c, 1105-d can be load sharing through switchgear "C+" 1125-c, and generator sets 1105-e, 1105-f can be load sharing through another switchgear ""B+" 1125-b-2. Additionally, as in FIG. 9, the switchgear units "B+" 1125-b-1, 1125-b-2 and switchgear "C+" 1125-c are able to load share with one another via tie breakers 1109-a, 1109-b.

[0080] **FIG. 12** is a block diagram depicting an example 1200 of a switchgear load sharing option for providing power to equipment which is on a different site than the power generation equipment, according to an embodiment. Although illustrated in example 1200 in one configuration, many other switchgear configurations can provide power to equipment located remotely from the power generation equipment.

[0081] As shown, a series of four generator sets 1205-a, 1205-b, 1205-c, 1205-d can provide power to switchgear "A" 1225-a-1 at a first location. Power received at switchgear "A" 1225-a-1 can be communicated to switchgear "A" 1225-a-2 at a second location. In the illustrated embodiment, load sharing is handled by switchgear units "A" 1225-a-1, 1225-a-2, such that a tie breaker between two switchgear "B" units 1225-b-1, 1225-b-2 may not be necessary. In one example, the long distance transmission line can be several miles long and can be in the form of overhead or buried power lines. Any distance up to approximately 30 miles is feasible; at further distances, step-up transformers may be used to prevent transmission losses from becoming prohibitive. This approximation can depend on the power generated, the power required, and the power conductors used.

[0082] Switchgear "A" 1225-a-2 can supply electrical power to two other switchgear units. Switchgear "B" 1225-b-1 can receive power from switchgear "A" 1225-a-2 and distribute the

power to an auxiliary unit and one or more transformers as shown. Switchgear "B" 1225-b-2 can also receive power from switchgear "A" 1225-a-2 and can distribute the power to an auxiliary unit and one or more transformers.

[0083] **FIG. 13** is a block diagram illustrating an example 1300 of a system that, like the system of FIG. 12, is capable of powering and load sharing from multiple sites and processes, according to an embodiment. Generator sets 1305-a, 1305-b, 1305-c and switchgear "A+" 1325-a-1 can make up a first bank 1307-a, and generator sets 1305-d, 1305-e, 1305-f and switchgear "A+" 1325-a-2 can make up a second bank 1307-b. In the illustrated example 1300, switchgear units "A+" 1325-a-1, 1325-a-2 are able to load share with one another. The switchgear units in this configuration can provide load sharing through their internal electrical bus as well as through external power connections with tie breakers as previously described. Example cables are shown spanning between the two switchgear units "A+" 1325-a-1, 1325-a-2, which optionally are 13.8 kV cables for a tie breaker 1309. Tie breaker 1309 can allow for complete load sharing between all six turbines in generator sets 1305-a, 1305-b, 1305-c, 1305-d, 1305-e, 1305-f.

[0084] Each switchgear "C" 1325-c-1, 1325-c-2 can be used to power sites like drilling rigs, compressor stations, nitrogen plants, "man camps," pumping stations, a second fracturing site (e.g., for pump-down operations, injections tests, low rate jobs, or to power third party equipment), etc. The switchgear units "B" 1325-b-1, 1325-b-2 combined can power a single hydraulic fracturing fleet. As previously described, the lines from switchgear units "A+" 1325-a-1, 1325-a-2 to switchgear units "C" 1325-c-1, 1325-c-2 and switchgear units "B" 1325-b-1, 1325-b-2 can be representative of power transmission lines and can be as long as 30 miles in this configuration. The lines from switchgear units "C" 1325-c-1, 1325-c-2 and switchgear units "B" 1325-b-1, 1325-b-2 can be representative of diesel locomotive cables ("DLO") which, when laid

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out on the ground between the equipment, may span about one mile in distance. In other embodiments the distances can be about 25 feet to about 200 feet. Buried or suspended cables can also be used if desired or required.

[0085] **FIG. 14** illustrates an example 1400 of a configuration for load sharing with a utility grid, according to an embodiment. In the illustrated example, the power transmission network is broken into two banks with direct communication between generator sets 1405-a, 1405-b and switchgear "B+" 1425-b in the first bank 1407-a, and generator sets 1405-c, 1405-d and switchgear "C+" 1425-c in the second bank 1407-b. In alternate embodiments, generator sets 1405-c, 1405-d can optionally be excluded.

[0086] In an example of operation, the transformer 1445 can convert the grid voltage to the power generation voltage, and tie breakers 1409-a, 1409-b can enable the switchgear units "B+" 1425-b and "C+" 1425-c to load share between the generator sets 1405-a, 1405-b, 1405-c, 1405-d and the utility grid. For example, if the utility grid is transmitting power at 69 kV, the transformer 1445 can step down the 69kV voltage to 13.8 kV for use by the microgrid. In this configuration, power can be either provided to the grid or supplemented from the utility grid during times of peak power demand.

[0087] Depicted in **FIG. 15** is another example 1500 for load sharing with a utility grid, according to an embodiment. Multiple transformers 1545-a, 1545-b are shown to depict the replacement of generator sets (e.g., generator sets 1405-c, 1405-d as illustrated in the embodiment shown in FIG. 14) with grid power. In the illustrated embodiment, multiple cables can be used to share the power load to allow for smaller cable sizes and transformers. In this embodiment, switchgear "A+" 1525-a can be used for load sharing, and tie breakers 1509-a, 1509-b can be located at each connection point with utility grid on switchgear "A+" 1525-a.

Switchgear "A+" 1525-a can also supply electrical power to two other switchgear "B" units 1525-b-1, 1525-b-2.

[0088] In some embodiments, a small, diesel-fueled piston engine generator (not shown) can be used in lieu of an extra turbine generator for providing electrical power to transmission and distribution systems, which can add an extra megawatt of power if peak demand cannot be met with the existing turbine generators. An inability to meet peak demand could be due to hot weather, turbine de-rate, long transmission distance, or extra power demand from a user. These systems of switchgear load sharing by using either tie breakers or a hierarchy of switchgear units supplying power to each other can be used with any method of power generation. Power generation can be provided from turbine generators, piston engine generators, rotary engine generators, solar power cells, wind turbine power, utility grid power, or any other method of electricity generation. Switchgear trailers can be positioned on mobile trailers in some embodiments, or can be body-load or skid mounted units in other embodiments.

[0089] Examples of microgrid designs use 13.8 kV for transmission stepped down to 600 V for equipment, and in some cases 480 V for distribution to equipment. It is possible to use different voltages and to design or refit the switchgear trailers accordingly. The principles of power load sharing, transmission, and distribution can remain the same regardless of the generated voltage. Voltage levels such as 138 kV, 69 kV, 50 kV, 12 kV, 4,160 V, 1,380 V, 600 V, or 480 V can be used for transmission or power distribution. These voltages are based on a small sample of the many common methods used in the national power grids; technically, any voltage can be specified and used.

[0090] The type of power conductor used can be dependent on the current equipment requirements, customer requirements, and method of power transmission and distribution. In one

embodiment, power transmission between generator sets and switchgear units employs a single large cable per connection, each cable containing conductors for all three power phases, ground, and ground check. Power distribution between transformers and fracturing equipment can include diesel locomotive (DLO) cable, which can lie on the ground between the equipment. Two cables can be used for each power phase, totaling six power cables (three-phase power, with two cables per phase). This practice allows cables to be smaller, lighter, and easier to manage. Also an equipment ground spanning between the transformers and equipment can be used, which in one example can bring the power cable requirement to seven single conductor DLO cables per fracturing pump. However, many possible cable configurations exist. In some embodiments a single cable per phase can be used, or three or more cables per phase can also be used. The method of using multiple single-conductor cables can also be used for 13.8 kV transmission between switchgear units.

[0091] It is also possible to use multi-conductor cables for 600 V power distribution; these cables can be similar to those used for 13.8 kV transmission, and can contain all three phases and a ground inside the cable. A single multi-conductor cable can be used in some embodiments, or several multi-conductor cables can be used to split the power load so that the cable can be lighter and smaller in other embodiments. These multi-conductor cables can have an internal ground and ground check in some embodiments, or the grounds can be external in other embodiments. These power cables can simply lie on the ground in between the equipment. The cables can also be suspended like power transmission lines, in which case non-insulated cables could be used. Alternatively the cables can also be buried underground to be out of sight and to avoid trip hazards.

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[0092] The present disclosure described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the disclosure has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present disclosure disclosed herein and the scope of the appended claims.

CLAIMS

What is claimed is:

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

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

at least one generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps; and

at least one switchgear electrically coupled to the at least one generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one generator.

2. The system of claim 1, wherein the system comprising the plurality of electric pumps, the at least one generator, and the at least one switchgear comprises a single electrical microgrid.

3. The system of claim 2, wherein the system comprising the single electrical microgrid is split into two or more electrical banks, each of the two or more electrical banks comprising:

at least one generator, and

at least one switchgear,

wherein when one or more of the two or more electrical banks is shut down, each of the other active electrical banks is configured to distribute the electrical load between the plurality of electric pumps and the at least one generator associated with each active electrical bank.

4. The system of claim 1, further comprising:

at least two switchgear units electrically coupled to the at least one generator; and

a tie breaker electrically coupled between each of the at least two switchgear units.

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5. The system of claim 4, wherein the tie breaker is configured to:

evenly distribute the electrical load between the plurality of electric pumps and the at least one generator when the tie breaker is in a closed position; and

isolate one or more of the plurality of electric pumps, the at least one generator, and the at least two switchgear units when the tie breaker is in an open position.

6. The system of claim 5, wherein:

the tie breaker is in the closed position, and

at least one generator is shut down and at least one other generator is active,

wherein the electrical load is evenly distributed among the at least one other active generators.

7. The system of claim 4, wherein the tie breaker comprises a long distance transmission line.

8. The system of claim 1, wherein the at least one switchgear is configured to distribute power among any of one or more transformers, auxiliaries, or other switchgear units, or a combination thereof.

9. The system of claim 8, wherein the one or more auxiliaries comprise any of a blender, electric wireline equipment, a water transfer pump, an electric crane, a data van, a work trailer, living quarters, an emergency shower, sand equipment, a turbine inlet chiller, a compressor station, a pumping station, a second fracturing site, a drill rig, or a nitrogen plant, or a combination thereof.

10. The system of claim 1, wherein the at least one generator comprises one of a turbine generator or a diesel generator, or a combination thereof.

11. The system of claim 10, wherein the at least one turbine generator is powered by natural gas.

12. The system of claim 1, wherein each component of the system is modular and movable to different locations on mobile platforms.

13. The system of claim 1, further comprising:

a power connection panel associated with the plurality of electric pumps, wherein the power connection panel comprises:

a plurality of power connections for each of the plurality of electric pumps; and

a system ground connection configured to act as a ground between the plurality of electric pumps and a transformer, wherein the transformer is configured to provide power to the plurality of electric pumps.

14. The system of claim 1, further comprising:

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

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

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

at least one turbine generator electrically coupled to the plurality of electric pumps so as to generate electricity for use by the plurality of electric pumps;

at least two switchgear units electrically coupled to the at least one turbine generator and configured to distribute an electrical load between the plurality of electric pumps and the at least one turbine generator;

a tie breaker electrically coupled between each of the at least two switchgear units and configured to evenly distribute the electrical load between the plurality of electric pumps and the at least one turbine generator when the tie breaker is in a closed position; and

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

16. The system of claim 15, wherein the system comprising the plurality of electric pumps, the at least one turbine generator, the at least two switchgear units, the tie breaker, and the variable frequency drive comprises a single electrical microgrid.

17. The system of claim 16, wherein the system comprising the single electrical microgrid is split into two or more electrical banks, each of the two or more electrical banks comprising:

at least one turbine generator, and

at least one switchgear,

wherein when one or more of the two or more electrical banks is shut down, each of the other active electrical banks is configured to distribute the electrical load between the plurality of electric pumps and the at least one turbine generator associated with each active electrical bank.

18. The system of claim 15, wherein the tie breaker is further configured to:

isolate one or more of the plurality of electric pumps, the at least one turbine generator, and the at least two switchgear units when the tie breaker is in an open position.

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19. The system of claim 18, wherein:

the tie breaker is in the closed position, and

at least one turbine generator is shut down and at least one other turbine generator is active,

wherein the electrical load is evenly distributed among the at least one other active turbine generators.

20. The system of claim 15, wherein the at least two switchgear units are configured to distribute power among any of one or more transformers, auxiliaries, or other switchgear units, or a combination thereof.

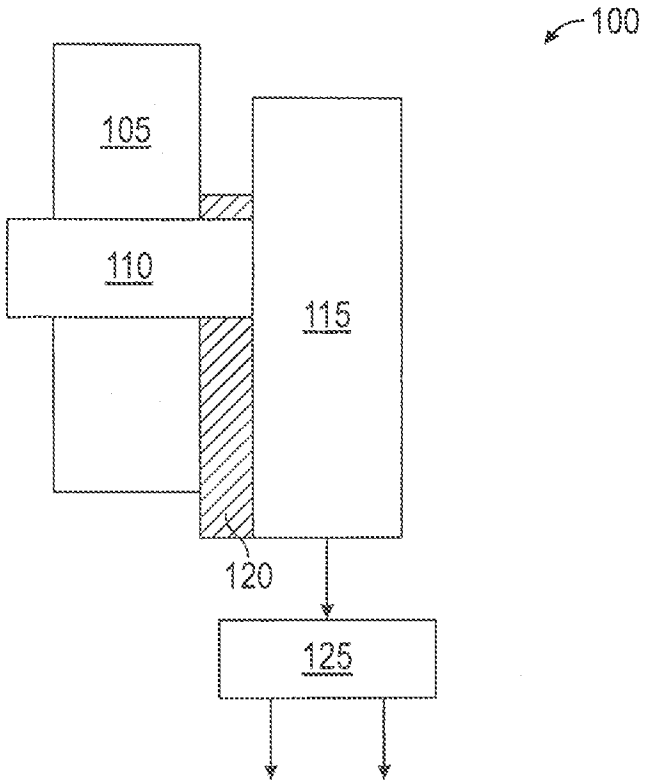


FIG. 1

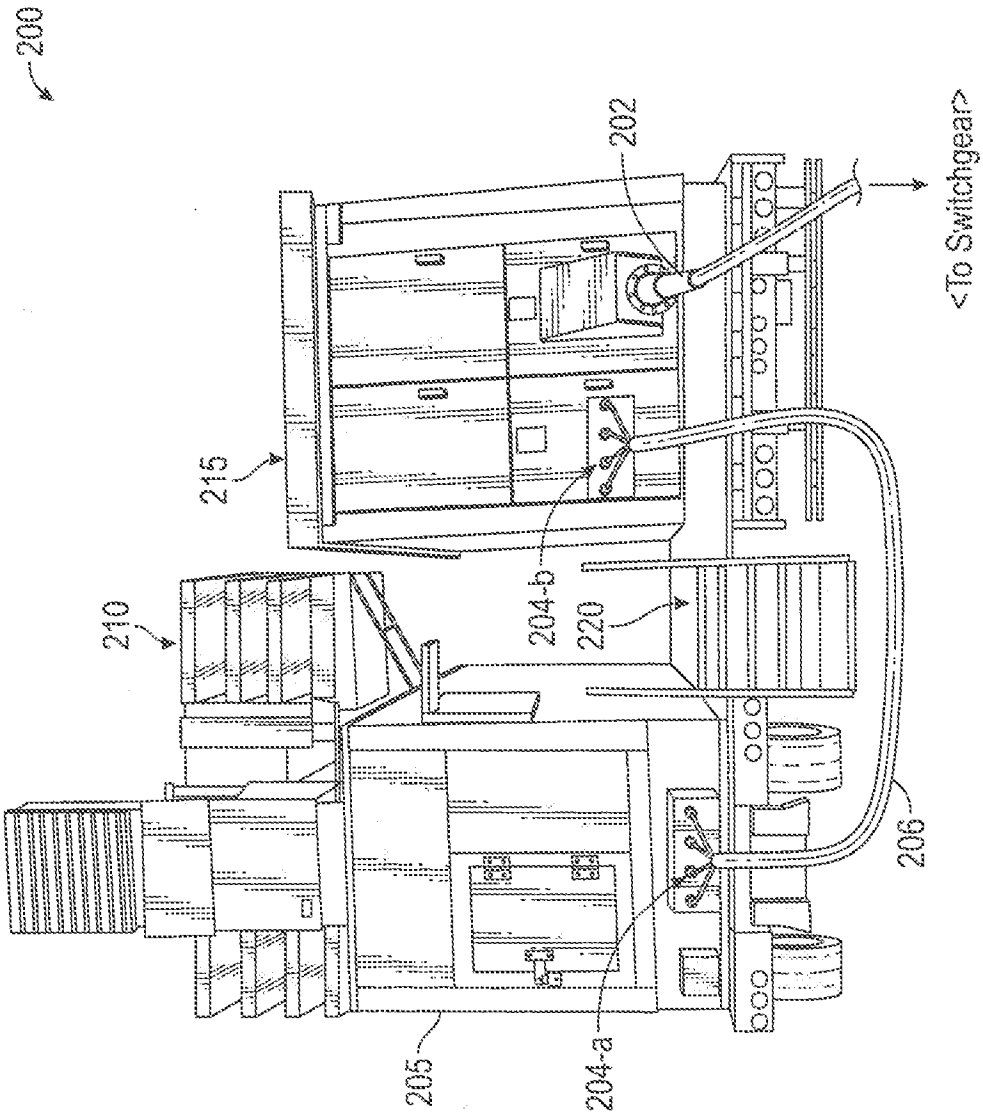


FIG. 2

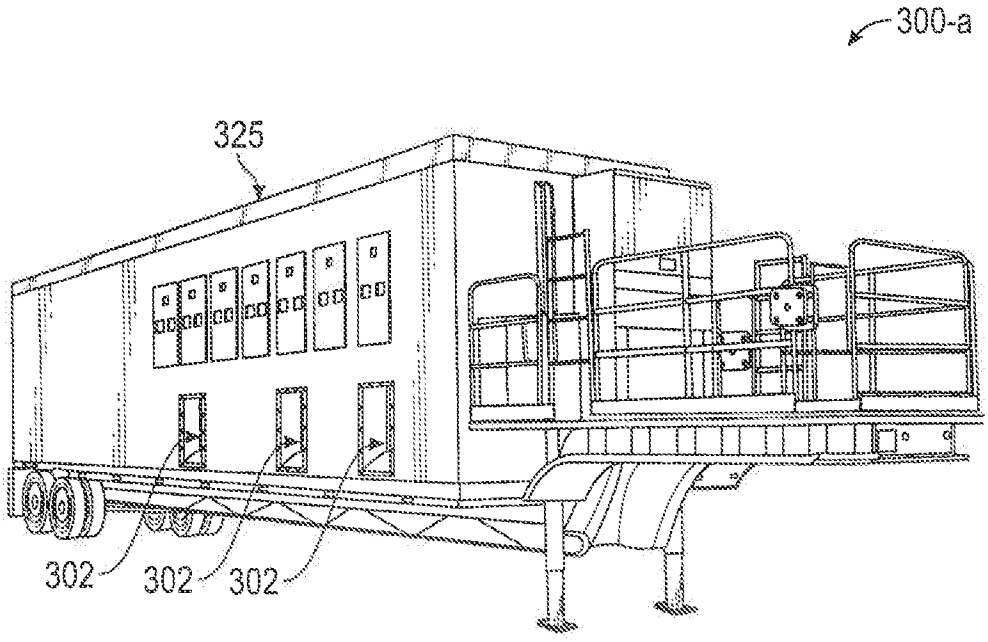


FIG. 3A

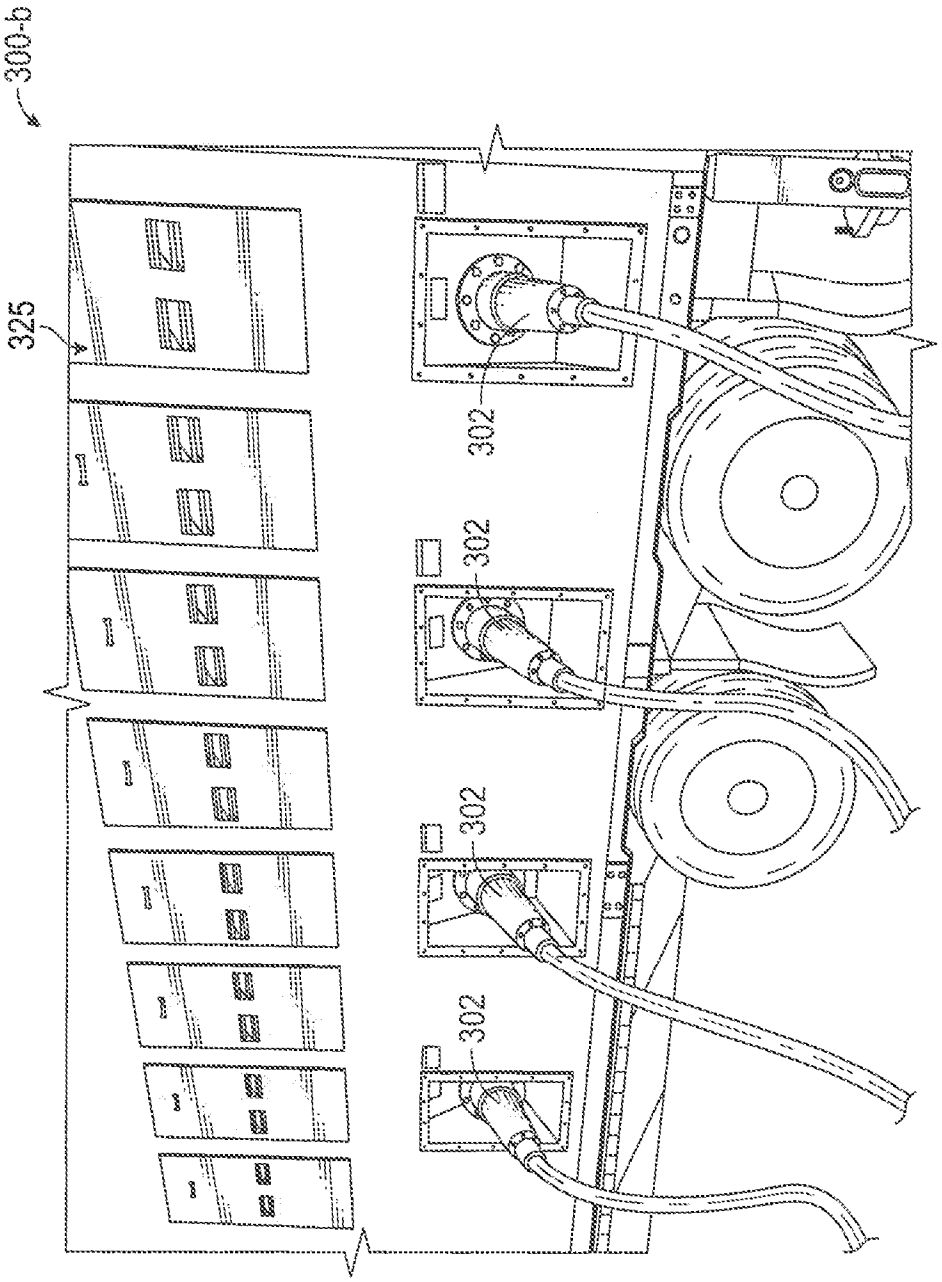


FIG. 3B

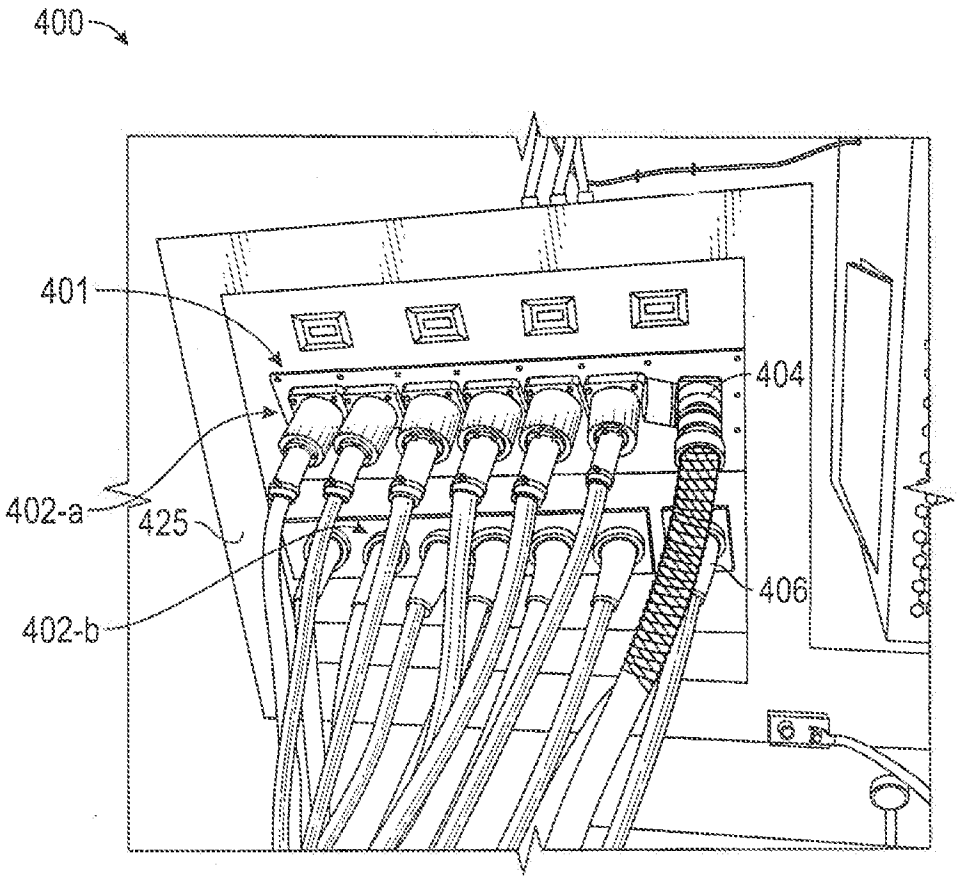


FIG. 4

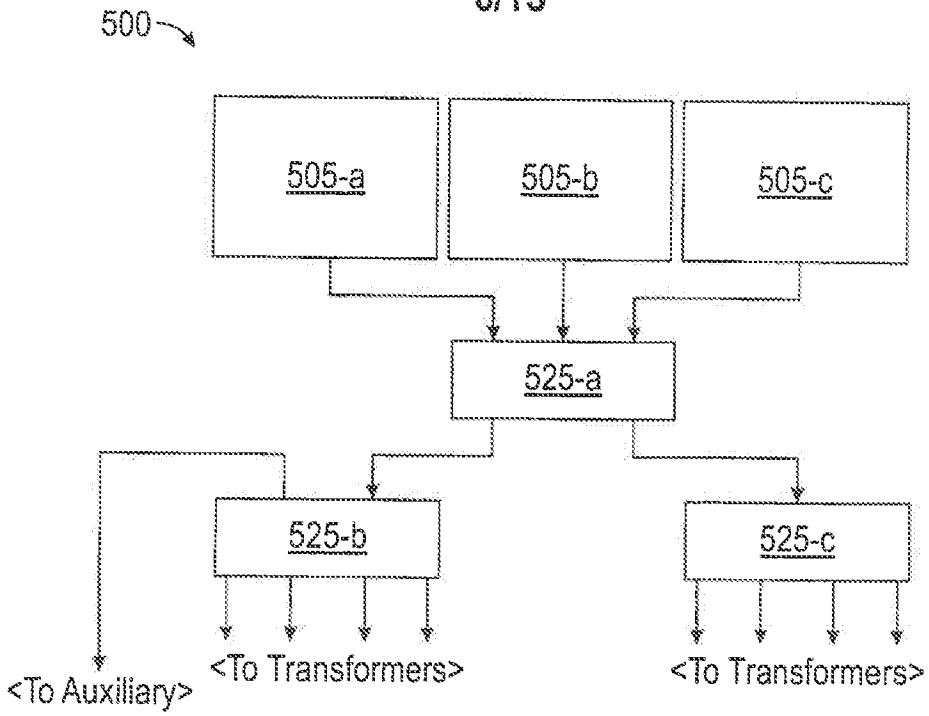

500
505-a
505-b
505-c
525-a
525-b
525-c
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<To Transformers>
<To Transformers>

FIG. 5

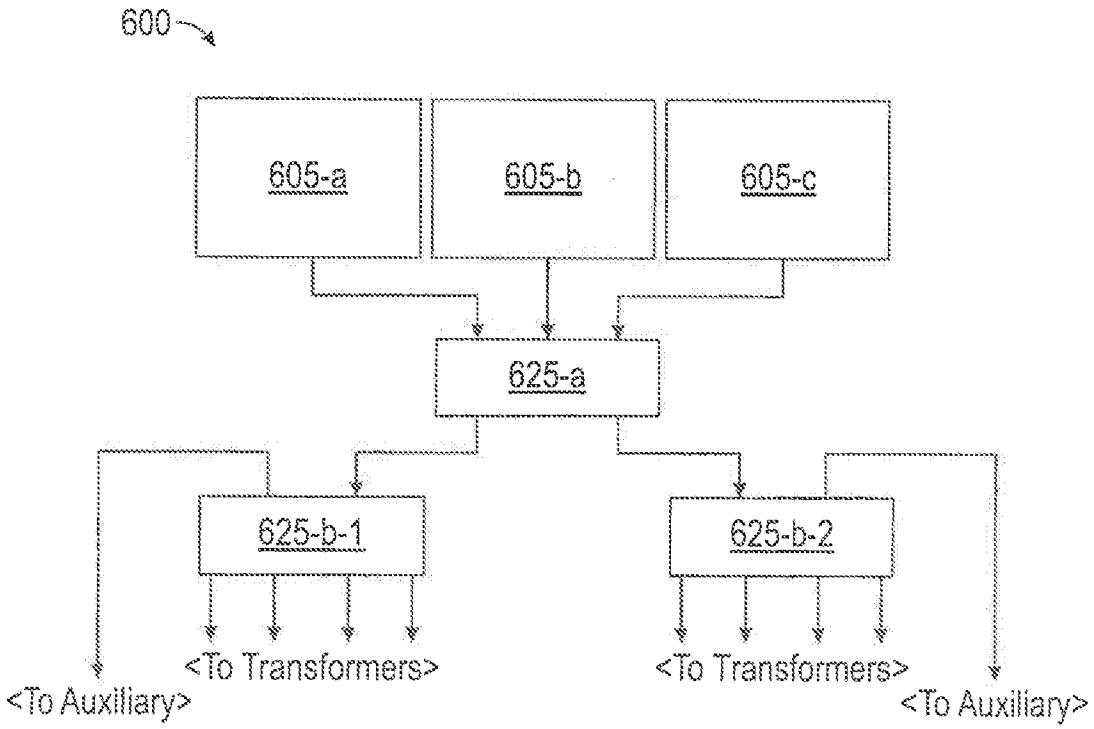

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605-a
605-b
605-c
625-a
625-b-1
625-b-2
<To Auxiliary>
<To Transformers>
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<To Auxiliary>

FIG. 6

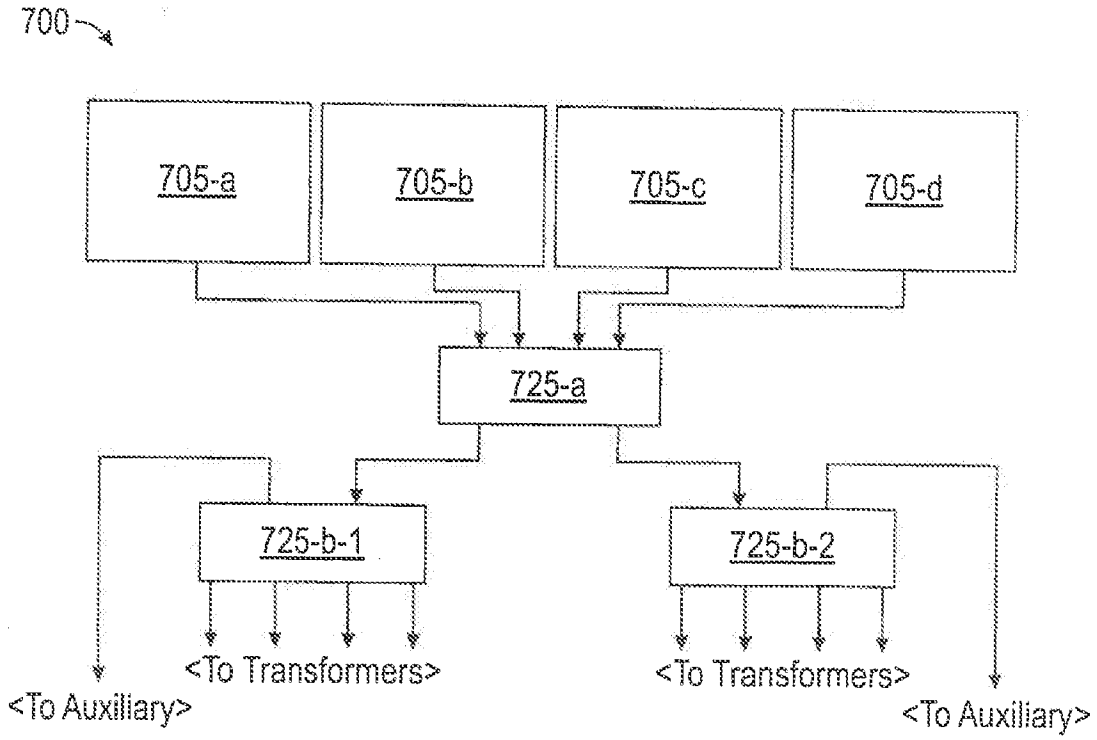

700
705-a
705-b
705-c
705-d
725-a
725-b-1
725-b-2
<To Transformers>
<To Transformers>
<To Auxiliary>
<To Auxiliary>

FIG. 7

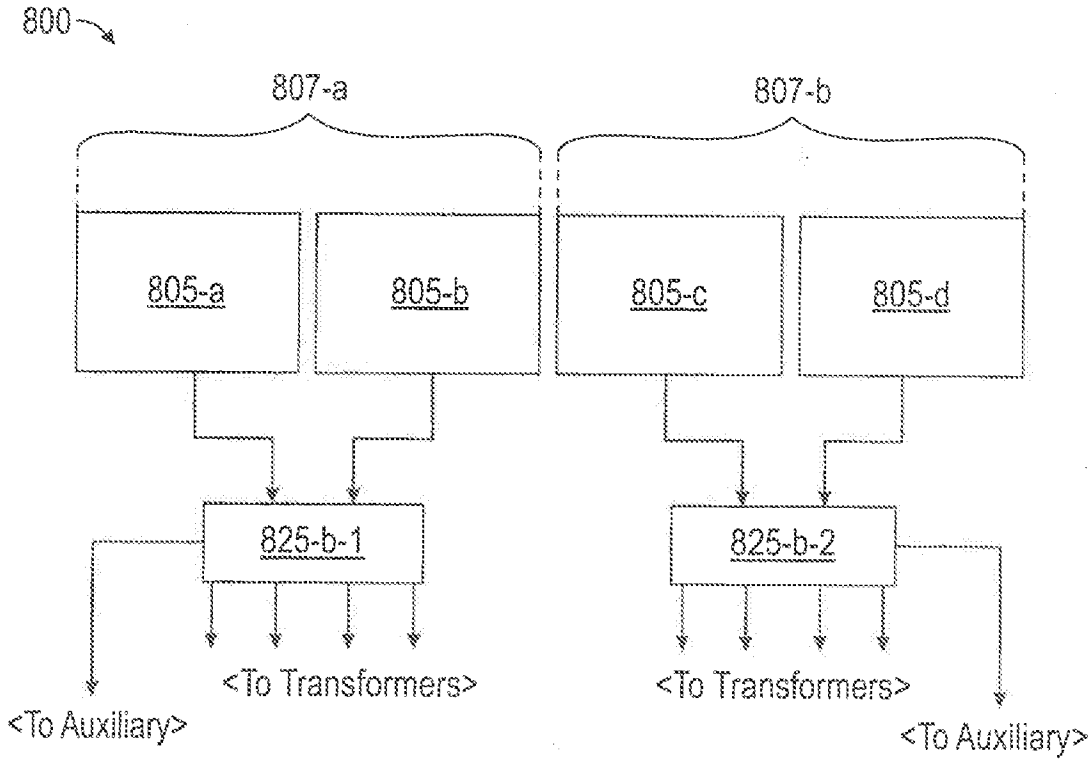

800
807-a
807-b
805-a
805-b
805-c
805-d
825-b-1
825-b-2
<To Transformers>
<To Transformers>
<To Auxiliary>
<To Auxiliary>

FIG. 8

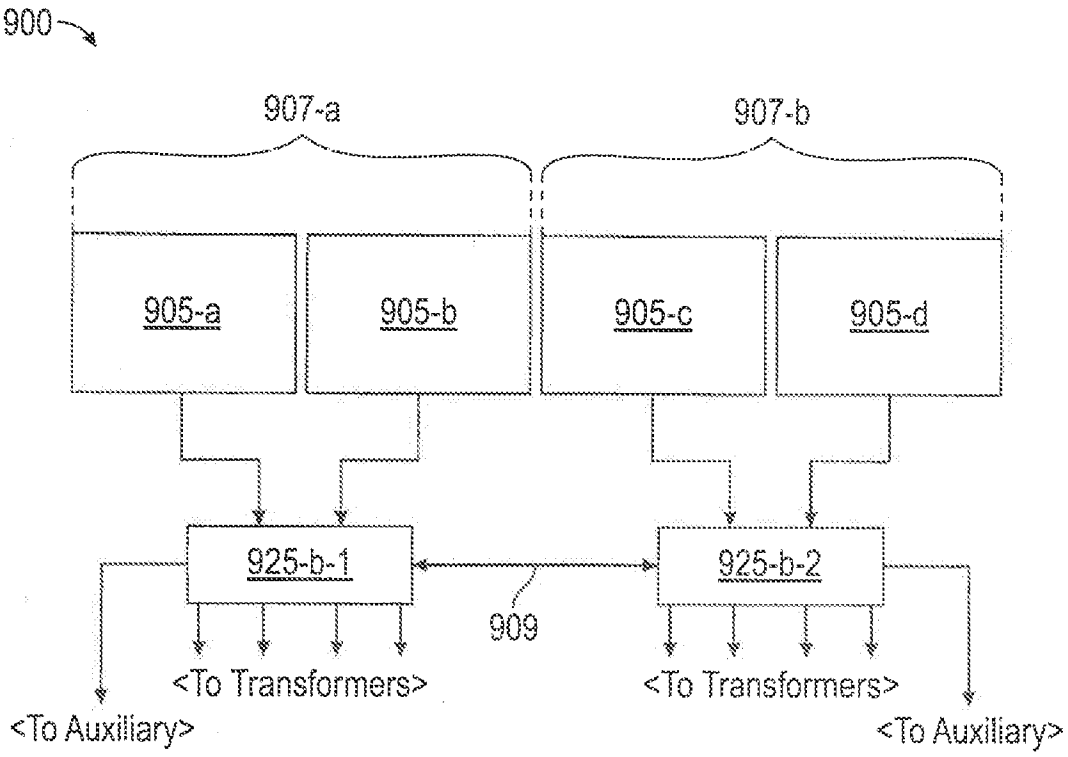

900
907-a
907-b
905-a
905-b
905-c
905-d
925-b-1
925-b-2
909
<To Transformers>
<To Transformers>
<To Auxiliary>
<To Auxiliary>

FIG. 9

1000
1030-a
1030-b
1035-a
1035-b
1035-c
1035-d
1005-a
1005-b
1005-c
1005-d
1003
1025-b-1
1025-b-2
1040
1045-a
1045-b
1045-c
1045-d
1045-e
1045-f
1045-g
1045-h
1050-a
1050-b
1055-a
1055-b
480V
13.8kV
600V
600V 600V
600V 240V 120V
120V 240V 600V
< To Auxiliary Equipment>
<To Small Equipment>
<To 600V Equipment Requiring up to 3500KVA>

FIG. 10

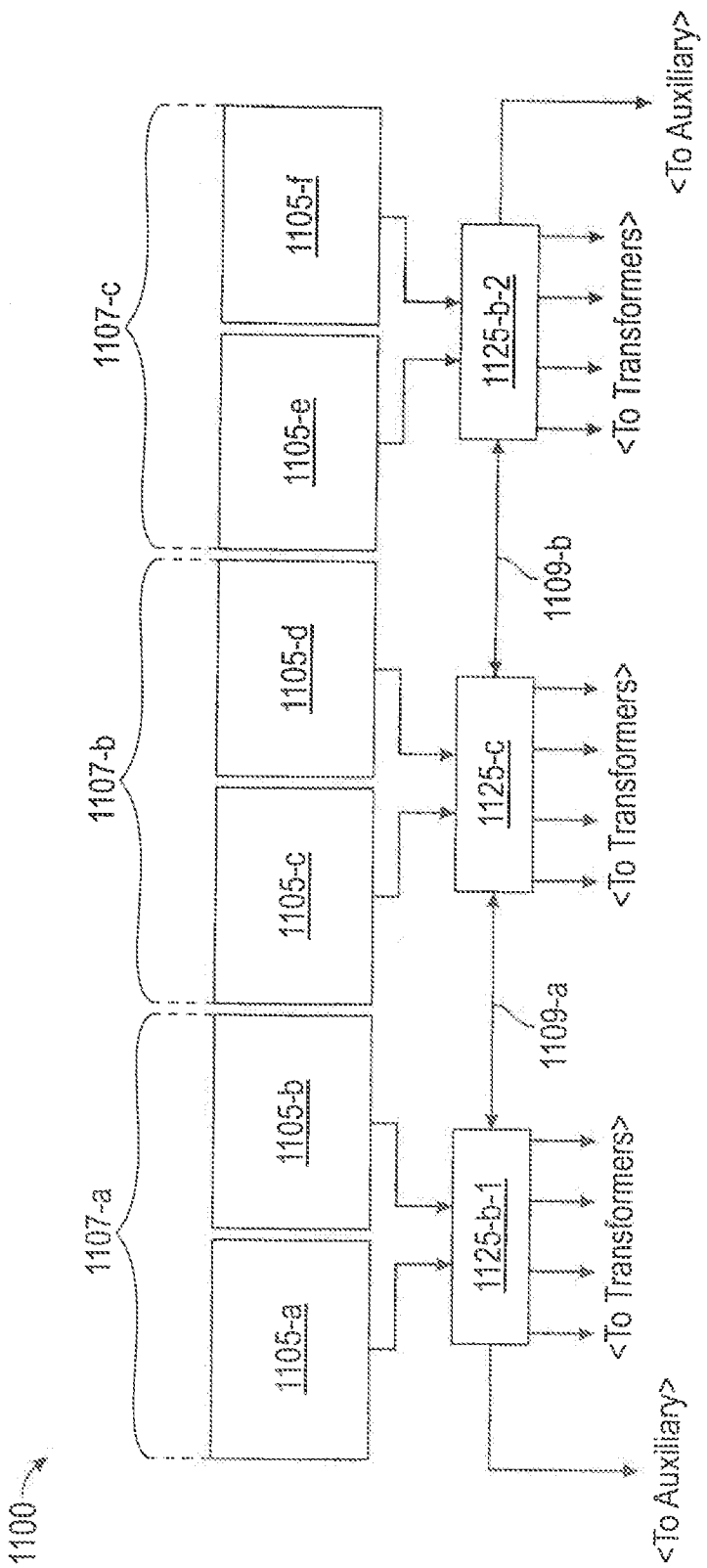

1100
1107-a
1107-b
1107-c
1105-a
1105-b
1105-c
1105-d
1105-e
1105-f
1125-b-1
1125-c
1125-b-2
1109-a
1109-b
<To Auxiliary>
<To Transformers>
<To Transformers>
<To Transformers>
<To Auxiliary>

FIG. 11

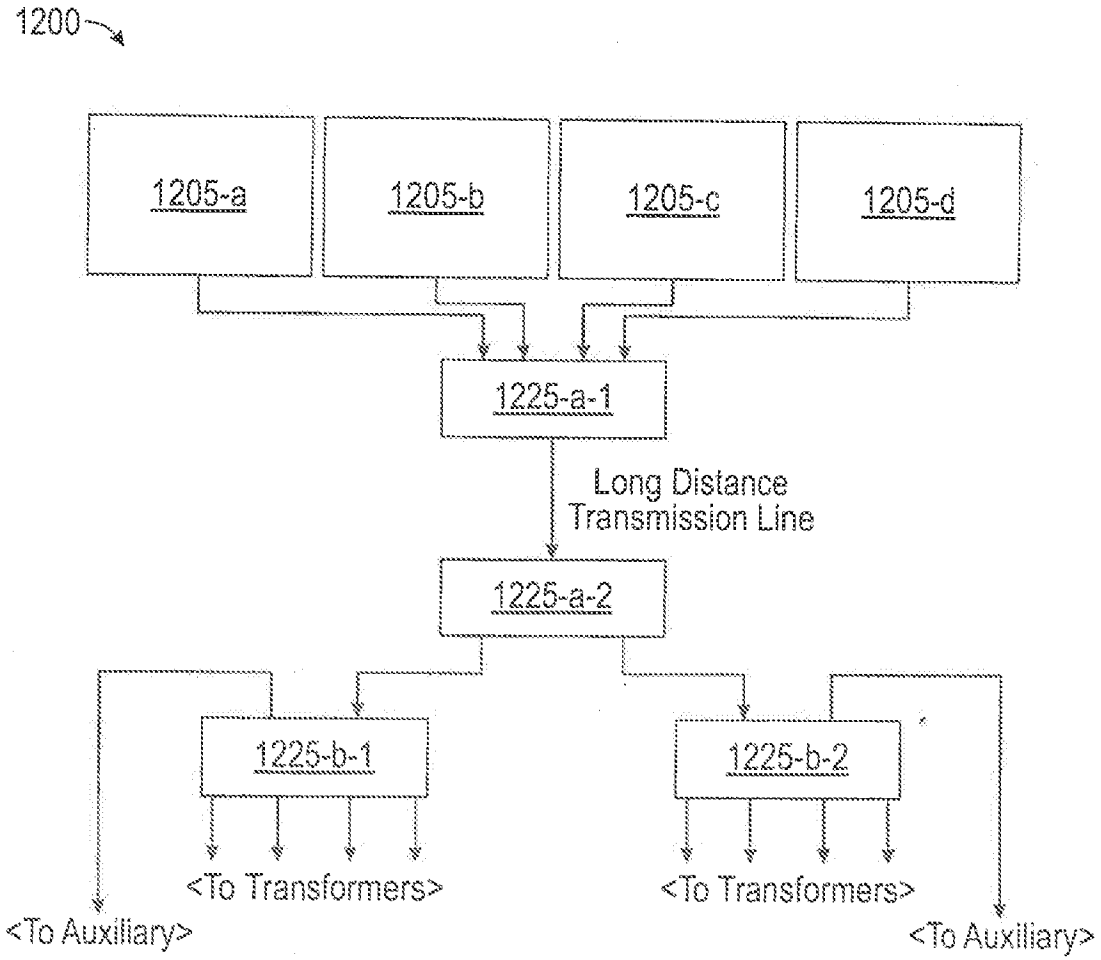

1200
1205-a
1205-b
1205-c
1205-d
1225-a-1
Long Distance
Transmission Line
1225-a-2
1225-b-1
1225-b-2
<To Transformers>
<To Transformers>
<To Auxiliary>
<To Auxiliary>

FIG. 12

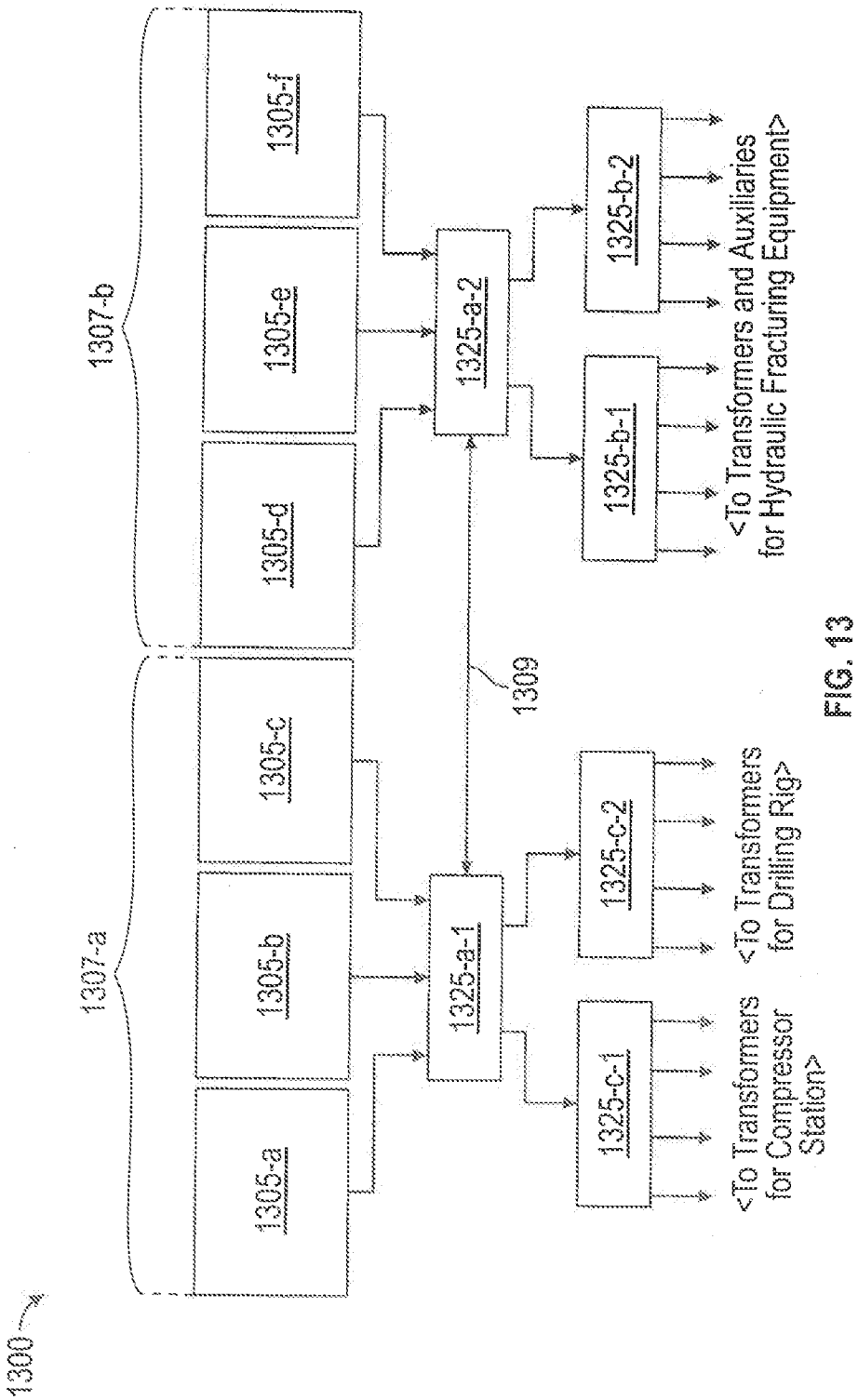

1300
1307-a
1307-b
1305-a
1305-b
1305-c
1305-d
1305-e
1305-f
1325-a-1
1325-a-2
1309
1325-b-1
1325-b-2
1325-c-1
1325-c-2
<To Transformers and Auxiliaries for Hydraulic Fracturing Equipment>
<To Transformers for Drilling Rig>
<To Transformers for Compressor Station>

FIG. 13

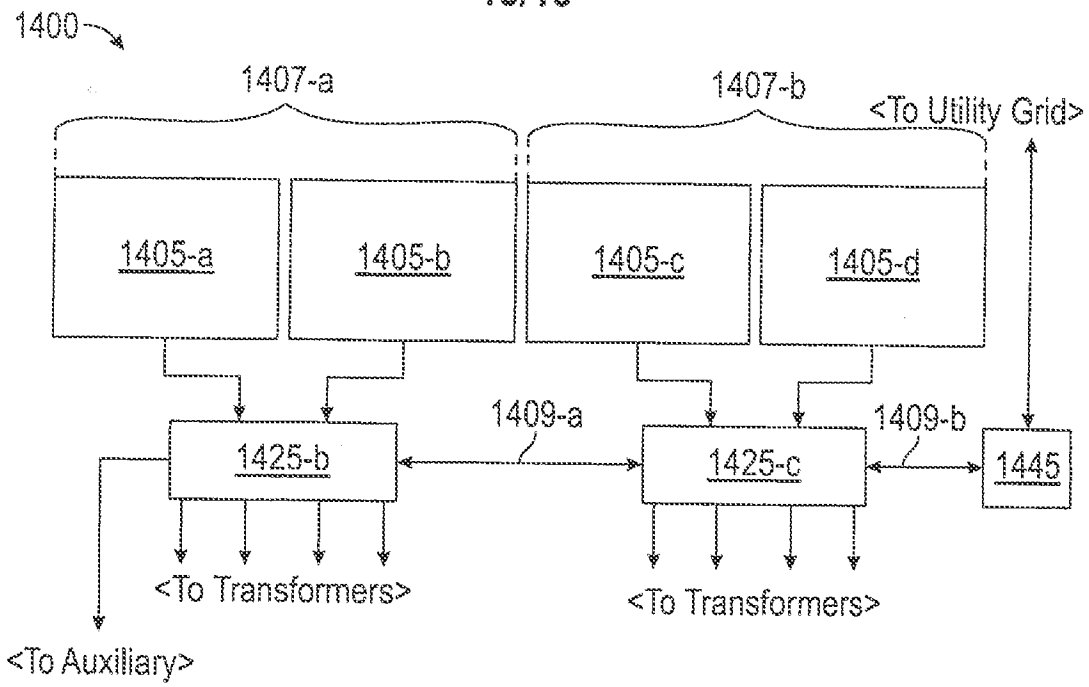

1400
1407-a
1407-b
<To Utility Grid>
1405-a
1405-b
1405-c
1405-d
1409-a
1409-b
1425-b
1425-c
1445
<To Transformers>
<To Transformers>
<To Auxiliary>

FIG. 14

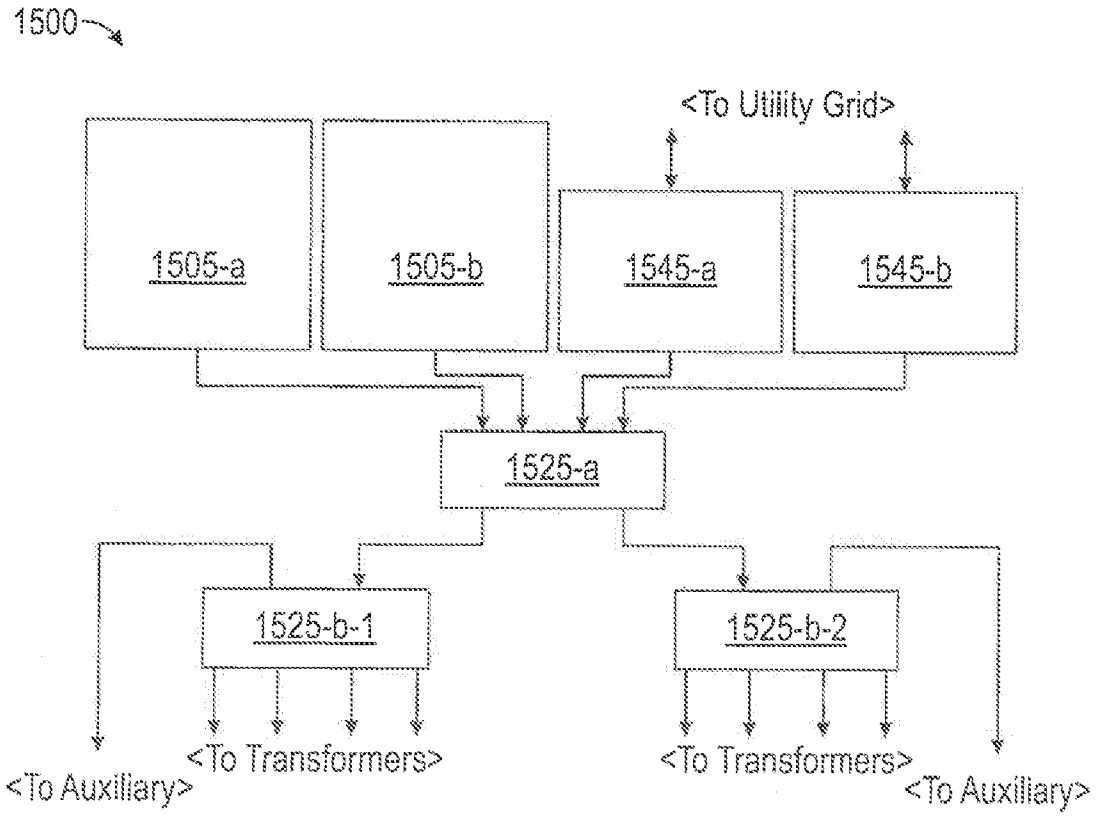
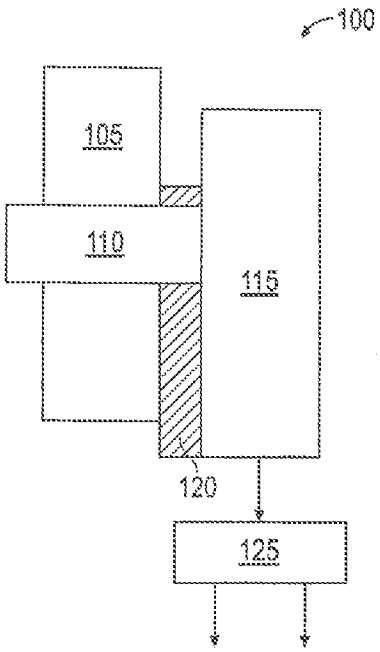

1500
<To Utility Grid>
1505-a
1505-b
1545-a
1545-b
1525-a
1525-b-1
1525-b-2
<To Auxiliary>
<To Transformers>
<To Transformers>
<To Auxiliary>

FIG. 15


100
105
110
115
120
125

CN102602322A

Electrically-driven fracturing pump truck

Publication Number: CN102602322A

Application Number: CN2012100725967A

Priority Date: March 19, 2012

Filing Date: March 19, 2012

Publication Date: July 25, 2012

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Assignees: N/A

Legal Status: N/A

Abstract

The invention discloses an electrically-driven fracturing pump truck, which comprises a truck chassis with a cab. A lubricating and cooling system, a fracturing pump, a suction manifold, an exhaust manifold, an electrically-driven system and a control system, the suction manifold and the exhaust manifold are connected with the fracturing pump, the electrically-driven system comprises a motor and a motor-driven device, the motor is used for driving the fracturing pump to run, the control system comprises a main power control system and an auxiliary power control system, the main power control system is used for controlling the motor-driven device, the auxiliary power control system is used for controlling the lubricating and cooling system, and the motor-driven device, the main power control system and the auxiliary power control system are powered by an external power source. The electrically-driven fracturing pump truck is simple in structure, reasonable in design, convenient in matching, low in manufacture cost, high in work efficiency and reliability, convenient in energy supply, fine in emission reducing effect, easy in maintenance, capable of overcoming defects and shortcomings of high fuel consumption, difficulty in matching of an engine and a torque converter and the like of a fracturing pump truck in the prior art, and convenient in popularization and use.

Claims

1. An electrically driven pump fracturing, truck chassis comprising (I) with a cab (1-1), attached to the truck chassis lubrication cooling system (8) and fracturing pumps (5) (I), , and an intake manifold (6-1) and a discharge manifold (6-2) is connected to the fracturing pump (5), characterized in that: said truck chassis (I), also equipped with an electric drive system and control system , the electric drive system includes an electric motor (4) and the motor drive means (3) to (5) driving of fracturing pump, the control system comprises an active force control system for controlling the motor driving means (3) (14) and means for controlling the lubrication cooling system (3) auxiliary power control system (15), said motor drive means (3), the active power control system (14) and the auxiliary power control system (15) are powered by an external power source.

2. 2. The electric drive fracturing pump as claimed in claim I in claim 1, characterized in that: said motor (4) for one of the electric motor (4) by a first coupler (9-1) and the fracturing pump (5) is connected.

3. 3. The electric drive as claimed in claim I said fracturing pump, wherein: the electric motor (4) and each of the two first motors (4-1) and the second motor (4-2), said motor drive means (3) and the second of the two motors are a first motor drive means (3-1) and a second motor (4-2) connected to a first electric motor (4-1) connected drive means (3-2), the electric drive system further comprises a gearbox (10), said first motor (4-1) connected to the second coupler (9-2) and the transmission (10), the second motor (4-2) is connected via a third coupler (9-3) and the transmission (10), said gearbox (10) by a fourth joint (9-4) with the fracturing the pump (5) is connected.

4. 4. The electric drive as claimed in claim fracturing pump 2 or 3, wherein: said external power source comprises a wellsite grid (16), a main transformer (11) connected to the wellsite grid (16) and with the main transformer auxiliary transformer (11) connected to (7), said auxiliary transformer (7) mounted on the truck chassis (the I), said motor drive means (3) connected to said main transformer (11) , the active power control system (14) and the auxiliary power control system (15) are connected to the auxiliary transformer (7).

5. 5. The electric drive as claimed in claim fracturing pump 2 or 3, wherein: said external power source comprises an auxiliary transformer (7) generator (12) and the generator (12) is connected, the said auxiliary transformer (7) mounted on the truck chassis (the I), said motor drive means (3) and the generator (12) connected to the main power control system (14) and the auxiliary power control system (15) are connected with the auxiliary transformer (7) is connected.

6. 6. The electric drive as claimed in claim fracturing pump 5, characterized in that: said number generator (12) is one or more, said plurality of generators (12) parallel to each other.

7. 7. The electric drive as claimed in claim fracturing pump 2 or 3, wherein: said active power control system (14) includes a controller (14-1) and a controller (14-1) in contact interactive device (14-2), said motor drive means (3) in contact with said controller (14-1).

8. 8. The electric drive as claimed in claim 7 of the fracturing pump, wherein: said active power control system (14) mounted in the main cabinet control (13-1), the auxiliary power control system (15) mounted in the auxiliary control cabinet (13-2), said motor drive means (3), the main control cabinet (13-1) and the auxiliary control cabinet (13-2) are set in the (2) electric control room, the said electric control room (2) mounted on the truck chassis (I).

9. 9. The electric drive as claimed in claim fracturing pump 2 or 3, wherein: the electric motor (4) is an AC motor or DC motor, said motor drive means (3) for the electric motor (4) supporting the AC motor drive means or dc motor drive apparatus.

10. 10. The electrical drive according to claim 9, fracturing pump, wherein: said drive means to drive the AC motor, said DC motor driving device is a thyristor.

Description

Description

Translated from Chinese

BACKGROUND electrically driven pump fracturing

[0001] The present invention belongs to the technical field of oil exploration, oil-Open relates to a mechanical working device, particularly to an electrically driven pump fracturing.

Background technique

[0002] Fracturing is an important technique in producing oil and gas fields by the reservoir, it needs a high pressure fluid formation fracture pressure to open first, and then further frac sand filled fractures, enhanced formation permeability, improved oil and gas production.

In fracturing, the fracturing equipment performance is good or bad decision to implement fracturing technology to improve.

Well fracturing fracturing equipment is essential technical support.

The total amount of oil and gas fracturing operations, China's annual rate of 10% ~ 20% growth, with the development of deep and difficult wells, fracturing scale increases.

The country has a fracturing fracturing equipment can not meet the growing demand.

[0003] is a high-tech power units fracturing oil equipment, European and American countries, especially the United States more than 80 years of development, production and application of history in this area.

For a long period, China's acquisition of advanced ways of fracturing equipment is imported.

Fracturing fracturing equipment, especially high-power equipment became a "strangle hold" our equipment in the field of oil and gas production.

[0004] Fracturing is a pump pumping equipment mounted on a self-propelled truck chassis, used to perform high pressure, special operations equipment fracturing stimulation job large displacement.

The apparatus consists of two parts, a chassis and upload devices.

The main chassis to move the vehicle provides transport functions, in addition to providing power to upload part (carts) auxiliary systems; upload part fracturing pump working portion is mainly from the power system, transmission system, fracturing pump and manifold system components.

Power generated by the power system, the power transmitted to the end of the fracturing pump via a transmission system, fracturing pump drive operates.

[0005] prior art, whether it is imported or domestic vehicles, which are used in fracturing pump "Diesel - hydraulic torque converter - transmission shaft - fracturing pump" power transmission program.

This arrangement is a scheme based on the power of the engine as a prime mover.

The main problems are: 1, when the fracturing pump truck stand-alone power of 1500kw above, the engine rapidly rising costs, difficulty selection; 2, due to the large size of high-power diesel engine and gearbox weight is not conducive to the design scheme of car and the development of more powerful pump, a diesel engine driving scheme become the bottleneck of the development of new fracturing pump; 3 narrow, component selection and the like supporting the torque converter range, high price; critical elements (engine, torque converter, change twisting, etc.) are to be imported, not only cause costly machine, but also hindered the development of proprietary equipment; 4, fracturing truck grouped in the field of high-power operation, fuel consumption, high cost of oil supply, pushing l overall operating costs; 5, diesel engine

output power when running non-economic range, fuel consumption, adaptability to different operating conditions of the poor.

6, high-power diesel engine noise, high emission and poor working conditions of workers.

SUMMARY

[0006] The present invention solves the technical problem that the prior art in view of the above deficiencies, to provide an electrically driven pump fracturing, its structure is simple, reasonable and novel design, facilitate matching, low cost, high level of automation, working high efficiency, easy supply of energy, good energy saving effect, easy maintenance, high reliability, easy to promote the use of.

[0007] To solve the above technical problem, the technical solution adopted by the invention is: an electrically driven pump fracturing, including a truck chassis with a cab, a cooling system is attached to the lubrication pump and fracturing of the truck chassis, and a suction manifold and a discharge manifold connected to the fracturing pump, wherein: said truck chassis is also equipped with an electric drive system and a control system, the electric

3 and a motor drive system includes a motor drive means for driving the fracturing operation of the pump, the control system comprising a control system for actively controlling the force motor driving means and a control system for controlling a power assist for lubrication and cooling system, the electric motor driving means active force control system and auxiliary power systems are controlled by an external power supply.

[0008] The electrically driven pump fracturing, characterized in that: the motor is a one, the first electric motor through a coupling connected to the fracturing pump.

[0009] The electrically driven pump fracturing, characterized in that: said motor is a two, respectively, and first and second motors, said motor drive means is two and respectively connected to the first electric motor first motor drive means and the second motor drive means connected to the second electric motor, the electric drive system further comprises a gearbox, the first motor is connected through a second clutch and transmission, by the second electric motor coupling a third connector to the gearbox, said gearbox and via a fourth coupling fracturing pump.

[0010] The electrically driven pump fracturing, wherein: said external power source comprises an auxiliary power transformer wellsite, a main transformer connected to the wellsite and the grid is connected with the main transformer, the secondary of the transformer is mounted the truck chassis, said motor drive means connected to the main transformer, the active power control system and auxiliary power to the control systems are connected to an auxiliary transformer.

[0011] The electrically driven pump fracturing, wherein: said external power source comprises a generator and an auxiliary transformer connected to the generator set, the auxiliary transformer is mounted on the truck chassis, the motor drive means connected to the generator set, the active power control system and auxiliary power to the control systems are connected to an auxiliary transformer.

[0012] The electrically driven pump fracturing, characterized in that: said number generator is one or more, the plurality of generators connected in parallel with each other.

[0013] The electrically driven pump fracturing, characterized in that: said active power control system includes a controller and a human interface device in contact with the controller, the motor driving device in contact with the controller.

[0014] The electrically driven pump fracturing, characterized in that: said active power control system installed in the main cabinet control, the control system is installed in the auxiliary power assist control cabinet, said motor drive means, the main control auxiliary control cabinets and cabinets are disposed electrical control room, the electric control room mounted on the truck chassis.

[0015] The electrically driven pump fracturing, characterized in that: said motor is a DC motor or an AC motor, the motor driving apparatus is the motor driving apparatus supporting AC motor or DC motor driving device.

[0016] The electrically driven pump fracturing, characterized in that: said AC motor drive to the drive means, the drive means is a DC motor SCR.

[0017] The present invention and the prior art has the following advantages:

[0018] I, the present invention has a simple structure, reasonable and novel design.

[0019] 2. Supporting facilitate: the present invention and corresponding drive motors, both at home and abroad thyristor mature product, to facilitate selection of matching.

[0020] 3, low cost: the present invention in an electric motor as prime mover fracturing pump, can pump fracturing driving power of the motor to choose the number of medium-power low cost motor, when the motor driving apparatus drives a motor , the overall cost is lower than the engine program.

[0021] 4, a high level of automation, improves the work efficiency: in the motor drive means, the motor can maintain optimum energy efficiency at different power output, the working lowest energy consumption, good energy saving effect, and can achieve a variety of ways to match the output torque, speed, automation and easy to improve the efficiency of the fracturing operation.

[0022] 5, to facilitate the supply of energy: electric drive mode using the present invention, power supply can directly use the well site, eliminating the need for oil transport.

[0023] 6. Easy maintenance: The present invention employs a motor driven pump fracturing operation, as compared with high-power diesel engines, the maintenance of the electrical driving scheme is simple, less control targets, greatly reducing the routine maintenance work and costs.

[0024] 7, high reliability: the reliability of the system is much higher than diesel motors, AC motors can achieve 20 years of maintenance-free motor drive device either using inverter or thyristor, can maintain long-term continuous operation in the case of a plurality of diesel powered generator sets, multiple units in parallel higher reliability than the reliability of a single high-power diesel engines, wherein one unit fail, the reduced power can continue to run without affecting the fracturing operations .

[0025] 8, the present invention is the use of effective, easy to promote use.

[0026] In summary, the invention has simple structure, novel design reasonable, convenient facilities, low cost, high level of automation, high efficiency, convenient energy supply, good energy saving effect, easy maintenance, high reliability, It solves the prior art fracturing pump truck drivetrain prevailing fuel consumption, engine and torque converter difficulty supporting large low power consumption unit is running, poor working conditions and lack of defects, easy to promote the use of.

[0027] The following drawings and embodiments, detailed description of the further aspect of the present invention.

BRIEF DESCRIPTION schematic structural diagram of Embodiment I [0028] I of the present invention FIG.

[0029] FIG 2 structural diagram of embodiment 2 of the present invention.

[0030] FIG. 3 is a plan view of FIG.

[0031] FIG. 4 is a schematic of the power supply connection relationship Example I embodiment of the present invention.

[0032] FIG 5 Example 2 Relationship between the power supply connection schematic embodiment of the present invention.

[0033] REFERENCE NUMERALS: [0034] I- truck chassis; 1-1- cab; 2- electric control room; [0035] 3- motor driving means; a first motor driving means 3-1-; [0036] 3-2- second motor drive means; 4- motor; [0037] 4-1- first motor; 4-2- second motor; 5- fracturing pump; [0038] 6-1- intake manifold ; 6-2- discharge manifold; 7- auxiliary transformer; [0039] 8- lubrication cooling system; 9-1- a first coupling; 9_2_ a second coupling; [0040] The second coupling 9_3_ ; a fourth coupling 9_4_; 10- gearbox; [0041] 11- main transformer; 12- generators; 12-1- a first generator; [0042] 12-1- second generators; 13 -1- main control cabinet; 13-2- auxiliary control cabinet; [0043] 14_ Wang power control system; 14-1- controller; 14-2- interactive apparatus; [0044] 15 auxiliary power control system ; 16- well site grid.

DETAILED DESCRIPTION [0045] Example I [0046] As shown in FIG I, the present invention includes a truck chassis cab 1-1 1, mounted on the truck chassis with a I Run

The cooling system 8 and the sliding fracturing pump 5, and an intake manifold connected to the fracturing pump 5 6-1 and 6-2 exhaust manifold, on the truck chassis I are also equipped with an electric drive system and a control system, the the electric drive system comprises a fracturing pump for driving the motors 4 and 5 the operation of the motor driving device 3, the control system 14 for controlling the lubricating power and the auxiliary cooling system 8 of the main power device 3 comprises a control system for controlling a motor drive the control system 15, the motor driving device 3, the active power control system 14 and control system 15 are auxiliary power by an external power supply.

[0047] In this embodiment, the electric motor 4 is one, the electric motor 4 is connected to the fracturing pump 5 via a first coupling 9-1.

When the fracturing pump 5 require less input power (e.g., less than 900kw), you can use a single high-power electric motor 4 is directly driven fracturing pump 5.

[0048] In this embodiment, the external power supply 16 comprises a wellsite, a main transformer connected to the wellsite grid 11 and the auxiliary transformer 16 and the transformer 11 is connected to the main 7, 7 mounted on the said auxiliary transformer on a truck chassis I, 3 of the main transformer 11 is connected to the motor drive means, said active power control system, power control system 14 and the auxiliary 15 are connected to the auxiliary transformer 7; this embodiment is the vehicle power supply and cost the lowest operating costs of the program.

Specifically, as shown, the primary side coil 4 of the main transformer 11 is connected in series through a cable, and the cable and the vacuum circuit breaker vacuum interrupter Zl and Z2 wellsite grid 16, the vacuum circuit breaker and the well Zl field connection between the power cable 16 TAl current transformers, surge arresters and a charging indicator LI Fl, Al is connected to the meter current transformer TAl, between the vacuum circuit breakers and vacuum circuit breakers Zl and Z2 of cable is

connected between the lightning arrester and connected with a fuse FU F2 and TV voltage transformer in series, the voltage V voltmeter connected transformer on a TV, the main vacuum circuit breaker Z2 transformer primary side coil 11 the current transformer is connected on the cable TA2, arrester F3, K and grounding switch electric lights L2, is connected to said current transformer has TA2 ammeter A2; primary side coil of the auxiliary transformer 7 through the circuit breaker and the circuit breaker QFl QF2 with the main transformer secondary coil 11 is connected.

[0049] In this embodiment, the active power control system 14 includes a controller 14-1 and the controller 14-1 in contact with the human interface device 14-2, the drive motor 3 and the controller means 14-1 phase.

In particular, the active control system 14 further includes a force into the circuit breaker, the voltage detection circuit, a current detection circuit, etc., are conventional in the prior art circuit; said motor drive means into the power supply terminal 3 via the line circuit QF3 QFl breaker device and the main transformer 11 is connected to the secondary coil; the power controller 14-1 and the terminal 14-2 are human interface devices connected to the secondary side coil of the auxiliary transformer 7; the auxiliary power control system of the auxiliary power line side of the secondary side coil 15 of the transformer 7 is connected.

Parameters provided by the interactive apparatus 14-2 comprises a motor drive means 3 is stopped to start, start lubricating cooling system 8 is stopped, the motor 4 is stopped to start, speed and fracturing pressure of the pump motor 4 is 5, the computer interaction 14-2 shows the parameters of the device comprising: a motor driving device 3 of the operating state (including start-stop state and the rotation speed), the pump output pressure fracturing and displacement output 5, 5 fracturing pump oil pressure and temperature, as well as the circuit current and voltage, the above parameters are displayed and transmitted to the controller 14-1 obtained by conventional detection means for detecting the prior art, then the controller 14-1 controls interactive display device 14-2.

The auxiliary power system 15 control the main control loop for the lubrication and cooling system 8, including circuit breakers, contactors, thermal relays control relays and other components, are used in a conventional prior art circuit.

[0050] In this embodiment, the active power control system 14 installed in the main control cabinet 13-1, the auxiliary power control system 15 is mounted in the auxiliary control cabinet 13-2, the motor driving device 3, the main auxiliary control cabinet and control cabinet 13-1 13-2 are arranged in the electric control room 2, the electric control room 2 is mounted on the truck chassis I.

In particular, the electric control room walls 2 can be welded together by a steel plate, in order to make electrical insulation function having a control room 2, to ensure proper operating at a suitable temperature in the electric control room 2, through the electrically control room wall 2 is provided two-layer structure and be implemented within the electric control room filled with a refractory wall 2; in addition, may also be mounted on the movable door in the wall of electric control room 2, the electrical control room 2 the seat 2-1 is provided, personnel access and easy operation of the electronic control device installed in the control room.

[0051] In this embodiment, the electric motor 4 is a DC motor or an AC motor, said motor drive means 3 and 4 supporting the AC motor or DC motor driving apparatus a motor driving apparatus.

In particular, the AC motor drive to the drive means, the drive means is a DC motor thyristor, i.e., when the AC motor 4 is an electric motor drive device 3 using frequency converter, when the motor 4 using the DC

motor, the motor drive device 3 is realized using silicon, two drive scheme has a significant energy saving and emission reduction.

[0052] Example 2

[0053] As shown in FIGS. 2 and 3, the present embodiment and the embodiment I except that: the two motors 4, respectively, and the first motor and the second motor 4-1 4-2, the electric motor two drive means 3 and the second motor are connected to a first motor driving the first motor means 4-1 and 3-1 and 4-2 connected to the second motor drive apparatus 32, the electric drive system, 10 further includes a first electric motor through a gearbox connected to a second 4-1 and 9-2 clutch transmission 10, the second motor 4-2 through 9-3 and the third transmission clutch 10 connected to a gearbox 10 connected to the fracturing pump 5 via a fourth coupling 9-4.

The external power supply includes an auxiliary transformer 12 and a generator 12 connected to the generator set 7, the auxiliary transformer 7 is mounted on the truck chassis I, the generator 3 is connected with the motor driving device 12, the said control system 14 main power and auxiliary power to the control system 15 are auxiliary transformer 7 is connected.

In particular, the generator 12 of the number of groups is one or more, 12 parallel to each other of the plurality of generators.

The remaining structures are the same as in Example I.

[0054] In particular, the generator 12 is a diesel or gas turbine generator sets.

In this embodiment, the two generators 12 and 12-1 respectively, the first and second generators 12 generators.

5, the first and second generators generators 12-1 12-2 parallel with each other, the primary coil of the auxiliary transformer 7 through the circuit breaker and the circuit breaker QF8 QF4 first generator 12-1 an output terminal connected to an output terminal and is connected by a circuit breaker and a circuit breaker QF8 QF5 second generator 12-2, a first motor drive device 3-1 through the power supply terminal and a breaker breaker QF6 feed line and the first power QF4 unit 12-1 connected to an output terminal through the output terminal and connected into the circuit breaker and the circuit breaker QF5 QF6 second generator 12-2, a second power supply terminal via the motor drive apparatus 32 into the circuit breaker and QF7 and a first circuit breaker QF4 generator output terminal 12-1 is connected via the output terminal and connected into the circuit breaker and the circuit breaker QF5 QF7 second generators 12-2; 14-1 and the interactive controller supply terminal apparatus 14-2 are connected to the secondary side coil of the auxiliary transformer 7; the auxiliary power control system power supply line side and the secondary side coil of the transformer 7 is connected to the secondary 15.

When [0055] When Li fracturing and 5 require a large input power of a single motor is insufficient to drive a fracturing Li 4 5, 4 by two electric motors commonly driven through a gearbox 10 5 fracturing pump.

When the driving more powerful fracturing pump 5, a plurality of motors may also be employed by 4 in series or in parallel to the transfer case driven fracturing pump 5.

Power generator 12 are connected in parallel [0056] The use of multiple lower power, more advantages compared with a single power supply generator 12, cost, and reliability.

Using a generator to power grid can be arbitrarily selected number generator 12 according to power requirements, help save fuel.

[0057] In the present invention, the active power control system 14 is responsible for controlling the entire electrically driven pump fracturing job, interactive device 14-2 through the input control parameters, but also electrically through interactive display device 14-2 driving the real-time status fracturing pump, and improve the control precision degree of information throughout the fracturing pump.

Adjusting the output 14-1 via the motor driving device 3 in the main power control system controller 14 may be implemented stepless speed motor 4, 5 meet the operational needs of the fracturing pump can be driven at different pressures fracturing pump output 5 and high pressure liquid flow, easy to implement more and more complex control functions.

[0058] In the present invention, the electric drive system, and the lubrication and cooling system 8 may also have a control system powered by a battery.

The main control cabinet 13-1 through 13-3 and the auxiliary control cabinet is bolted to the electrical control room 2 the floor or wall to accommodate long-distance transport.

2 electric control room with sound insulation, waterproofing, insulation and other functions, operator time for the control operation.

[0059] In summary, the present invention is directed to the existing truck powertrain fracturing present fuel consumption, the engine and the torque converter matching difficulties, high fuel consumption and low-power operation unit, defects and poor working conditions, proposed 4 electric motor as the prime mover of fracturing truck program, simple structure, novel and reasonable design, convenient facilities, low cost, high level of automation, high efficiency, energy supply, convenient, easy maintenance, high reliability, the use of effective easy to promote the use.

[0060] The above are only preferred embodiments of the present invention, not any limitation of the present invention, any simple modification according to any of the technical spirit of the present invention made of the foregoing embodiments, changes and equivalents structural changes, fall within the scope of the technical solution of the present invention.

(19)中华人民共和国国家知识产权局

(12)发明专利申请

(10)申请公布号 CN 102602322 A
(43)申请公布日 2012.07.25

(21)申请号 201210072596.7

(22)申请日 2012.03.19

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(51)Int.Cl.
B60P 3/14(2006.01)

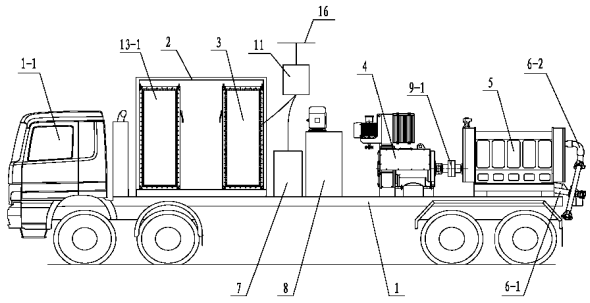
权利要求书 1 页 说明书 6 页 附图 5 页

(54)发明名称

电驱动压裂泵车

(57)摘要

本发明公开了一种电驱动压裂泵车，包括带驾驶室的卡车底盘，卡车底盘上安装有润滑冷却系统和压裂泵，以及与压裂泵连接的吸入管汇和排出管汇，卡车底盘上还安装有电驱动系统和控制系统，电驱动系统包括用于驱动压裂泵运转的电动机和电动机驱动装置，控制系统包括用于控制电动机驱动装置的主动力控制系统以及用于控制润滑冷却系统的辅助动力控制系统，电动机驱动装置、主动力控制系统和辅助动力控制系统均通过外部电源供电。本发明结构简单，设计合理，配套方便，造价低，工作效率高、可靠性高，能源供应方便，节能减排效果好，易于维护，解决了现有技术中压裂泵车存在的燃油消耗大、发动机和变矩器配套困难等缺陷和不足，便于推广使用。



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1. 一种电驱动压裂泵车，包括带驾驶室（1-1）的卡车底盘（1），所述卡车底盘（1）上安装有润滑冷却系统（8）和压裂泵（5），以及与压裂泵（5）连接的吸入管汇（6-1）和排出管汇（6-2），其特征在于：所述卡车底盘（1）上还安装有电驱动系统和控制系统，所述电驱动系统包括用于驱动压裂泵（5）运转的电动机（4）和电动机驱动装置（3），所述控制系统包括用于控制电动机驱动装置（3）的主动力控制系统（14）以及用于控制润滑冷却系统（8）的辅助动力控制系统（15），所述电动机驱动装置（3）、主动力控制系统（14）和辅助动力控制系统（15）均通过外部电源供电。

2. 按照权利要求 1 所述的电驱动压裂泵车，其特征在于：所述电动机（4）为一台，所述电动机（4）通过第一联轴器（9-1）与所述压裂泵（5）连接。

3. 按照权利要求 1 所述的电驱动压裂泵车，其特征在于：所述电动机（4）为两台且分别为第一电动机（4-1）和第二电动机（4-2），所述电动机驱动装置（3）为两台且分别为与第一电动机（4-1）连接的第一电动机驱动装置（3-1）和与第二电动机（4-2）连接的第二电动机驱动装置（3-2），所述电驱动系统还包括变速箱（10），所述第一电动机（4-1）通过第二联轴器（9-2）与变速箱（10）连接，所述第二电动机（4-2）通过第三联轴器（9-3）与变速箱（10）连接，所述变速箱（10）通过第四联轴器（9-4）与压裂泵（5）连接。

4. 按照权利要求 2 或 3 所述的电驱动压裂泵车，其特征在于：所述外部电源包括井场电网（16）、与井场电网（16）连接的主变压器（11）和与所述主变压器（11）连接的辅助变压器（7），所述辅助变压器（7）安装在所述卡车底盘（1）上，所述电动机驱动装置（3）与所述主变压器（11）连接，所述主动力控制系统（14）和辅助动力控制系统（15）均与所述辅助变压器（7）连接。

5. 按照权利要求 2 或 3 所述的电驱动压裂泵车，其特征在于：所述外部电源包括发电机组（12）和与所述发电机组（12）连接的辅助变压器（7），所述辅助变压器（7）安装在所述卡车底盘（1）上，所述电动机驱动装置（3）与所述发电机组（12）连接，所述主动力控制系统（14）和辅助动力控制系统（15）均与所述辅助变压器（7）连接。

6. 按照权利要求 5 所述的电驱动压裂泵车，其特征在于：所述发电机组（12）的数量为一台或多台，多台所述发电机组（12）相互并联。

7. 按照权利要求 2 或 3 所述的电驱动压裂泵车，其特征在于：所述主动力控制系统（14）包括控制器（14-1）和与控制器（14-1）相接的人机交互设备（14-2），所述电动机驱动装置（3）与所述控制器（14-1）相接。

8. 按照权利要求 7 所述的电驱动压裂泵车，其特征在于：所述主动力控制系统（14）安装在主控制柜（13-1）内，所述辅助动力控制系统（15）安装在辅助控制柜（13-2）内，所述电动机驱动装置（3）、主控制柜（13-1）和辅助控制柜（13-2）均设置在电控房（2）内，所述电控房（2）安装在所述卡车底盘（1）上。

9. 按照权利要求 2 或 3 所述的电驱动压裂泵车，其特征在于：所述电动机（4）为交流电动机或直流电动机，所述电动机驱动装置（3）为与电动机（4）配套的交流电动机驱动装置或直流电动机驱动装置。

10. 按照权利要求 9 所述的电驱动压裂泵车，其特征在于：所述交流电动机驱动装置为变频器，所述直流电动机驱动装置为可控硅。

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电驱动压裂泵车

技术领域

[0001] 本发明属于石油开采技术领域，涉及一种石油开采用机械作业设备，尤其是涉及一种电驱动压裂泵车。

背景技术

[0002] 压裂是油气田增储上产的重要技术手段，需要借助高压流体先将地层裂缝压开，再往裂缝中充填压裂砂，增强地层渗透率，提高油气产量。在压裂施工中，压裂设备性能好坏决定压裂技术提高的实现。精良的压裂装备是压裂施工必备的技术支撑。我国油气田压裂施工作业总量每年以 10％～ 20％的速度增长，随着深井和难井的开发，压裂施工规模逐渐增大。国内拥有的压裂设备远不能满足压裂施工增长需求。

[0003] 大功率压裂机组是高技术含量石油装备，欧美国家，特别是美国在这一领域已有 80 年的研发生产和应用历史。在相当长的一个时期，我国获取先进压裂装备的途径就是进口。压裂装备特别是大功率压裂装备一度成为我国油气生产领域的“卡脖子”设备。

[0004] 压裂泵车是将泵送设备安装在自走式卡车底盘上，用来执行高压力、大排量的油井压裂增产作业的特种作业装备。该装置由底盘和上装设备两部分组成。底盘主要为整车提供移运功能，此外还为上装部分（车台）的辅助系统提供动力；上装部分是压裂泵车的工作部分，主要由动力系统、传动系统、压裂泵和管汇系统等组成。由动力系统产生的动力，通过传动系统传递到压裂泵动力端，驱动压裂泵进行工作。

[0005] 现有技术中，无论是进口产品，还是国产车辆，其压裂泵车均采用“柴油机－液力变矩器－传动轴－压裂泵”的动力传动方案。这种布置方式是基于发动机为原动机的动力方案。存在的主要问题是：1、当压裂泵车的单机功率达到 1500kW 以上的时候，发动机成本迅速上升，选型困难；2、由于大功率柴油机和变速箱尺寸重量大，不利于车载方案的设计和更大功率泵车的开发，柴油机驱动方案成为制约新型压裂泵车开发的瓶颈；3、配套的变矩器等元件选型范围窄，价格高；重要元件（发动机、变矩器、变扭器等）均需要进口，不仅造成整机成本高昂，还阻碍了具有自主知识产权装备的开发；4、大功率压裂泵车编组在野外运行时，燃油消耗大，油料补给成本高，推升整体作业成本；5、柴油机输出功率在非经济运行区间时，燃油消耗大，对不同作业条件的适应性差。6、大功率柴油机噪音大、排放高，工人作业条件差。

发明内容

[0006] 本发明所要解决的技术问题在于针对上述现有技术中的不足，提供一种电驱动压裂泵车，其结构简单，设计新颖合理，配套方便，造价低，自动控制水平高，工作效率高，能源供应方便，节能减排效果好，易于维护，工作可靠性高，便于推广使用。

[0007] 为解决上述技术问题，本发明采用的技术方案是：一种电驱动压裂泵车，包括带驾驶室的卡车底盘，所述卡车底盘上安装有润滑冷却系统和压裂泵，以及与压裂泵连接的吸入管汇和排出管汇，其特征在于：所述卡车底盘上还安装有电驱动系统和控制系统，所述电

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驱动系统包括用于驱动压裂泵运转的电动机和电动机驱动装置，所述控制系统包括用于控制电动机驱动装置的主动力控制系统以及用于控制润滑冷却系统的辅助动力控制系统，所述电动机驱动装置、主动力控制系统和辅助动力控制系统均通过外部电源供电。

[0008] 上述的电驱动压裂泵车，其特征在于：所述电动机为一台，所述电动机通过第一联轴器与所述压裂泵连接。

[0009] 上述的电驱动压裂泵车，其特征在于：所述电动机为两台且分别为第一电动机和第二电动机，所述电动机驱动装置为两台且分别为与第一电动机连接的第一电动机驱动装置和与第二电动机连接的第二电动机驱动装置，所述电驱动系统还包括变速箱，所述第一电动机通过第二联轴器与变速箱连接，所述第二电动机通过第三联轴器与变速箱连接，所述变速箱通过第四联轴器与压裂泵连接。

[0010] 上述的电驱动压裂泵车，其特征在于：所述外部电源包括井场电网、与井场电网连接的主变压器和与所述主变压器连接的辅助变压器，所述辅助变压器安装在所述卡车底盘上，所述电动机驱动装置与所述主变压器连接，所述主动力控制系统和辅助动力控制系统均与所述辅助变压器连接。

[0011] 上述的电驱动压裂泵车，其特征在于：所述外部电源包括发电机组和与所述发电机组连接的辅助变压器，所述辅助变压器安装在所述卡车底盘上，所述电动机驱动装置与所述发电机组连接，所述主动力控制系统和辅助动力控制系统均与所述辅助变压器连接。

[0012] 上述的电驱动压裂泵车，其特征在于：所述发电机组的数量为一台或多台，多台所述发电机组相互并联。

[0013] 上述的电驱动压裂泵车，其特征在于：所述主动力控制系统包括控制器和与控制器相接的人机交互设备，所述电动机驱动装置与所述控制器相接。

[0014] 上述的电驱动压裂泵车，其特征在于：所述主动力控制系统安装在主控制柜内，所述辅助动力控制系统安装在辅助控制柜内，所述电动机驱动装置、主控制柜和辅助控制柜均设置在电控房内，所述电控房安装在所述卡车底盘上。

[0015] 上述的电驱动压裂泵车，其特征在于：所述电动机为交流电动机或直流电动机，所述电动机驱动装置为与电动机配套的交流电动机驱动装置或直流电动机驱动装置。

[0016] 上述的电驱动压裂泵车，其特征在于：所述交流电动机驱动装置为变频器，所述直流电动机驱动装置为可控硅。

[0017] 本发明与现有技术相比具有以下优点：

[0018] 1、本发明的结构简单，设计新颖合理。

[0019] 2、配套方便：本发明中电动机和相应的变频器、可控硅在国内外均有成熟的产品，选型配套方便。

[0020] 3、造价低：本发明以电动机作为原动机驱动压裂泵，可以根据所驱动的压裂泵的功率，选择电动机的数量，中等功率的电动机造价低，用电动机驱动装置驱动电动机时，整体造价比发动机方案低。

[0021] 4、自动控制水平高，提高了工作效率：在电动机驱动装置驱动下，电动机可在不同功率输出下保持最佳的能源利用率，使作业能源消耗达到最低，节能减排效果好，同时可以实现扭矩、转速的各种匹配输出方式，易于提高压裂作业的自动化水平和效率。

[0022] 5、能源供应方便：本发明采用电力驱动方式，可以直接利用井场电网供电，省去了

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油料运输。

[0023] 6、易于维护：本发明采用电动机驱动压裂泵运转，与大功率柴油机相比，该电驱动方案的维护非常简单，控制指标少，大大减少了日常维护工作量和成本。

[0024] 7、工作可靠性高：电动机系统的可靠性远高于柴油机系统，交流电动机可以实现20年免维护，电动机驱动装置无论是采用变频器还是可控硅，均可保持长期不间断运行，在采用多台柴油机发电机机组供电的情况下，多台机组并联的可靠性高于单台大功率柴油机的可靠性，其中一台机组出现问题，系统可以降功率继续运行，不影响压裂作业。

[0025] 8、本发明的使用效果好，便于推广使用。

[0026] 综上所述，本发明结构简单，设计新颖合理，配套方便，造价低，自动控制水平高，工作效率高，能源供应方便，节能减排效果好，易于维护，工作可靠性高，解决了现有技术中压裂泵车动力传动系统存在的燃油消耗大、发动机和变矩器配套困难、机组低功率运行时油耗大、作业条件差等缺陷和不足，便于推广使用。

[0027] 下面通过附图和实施例，对本发明的技术方案做进一步的详细描述。

附图说明

[0028] 图1为本发明实施例1的结构示意图。

[0029] 图2为本发明实施例2的结构示意图。

[0030] 图3为图2的俯视图。

[0031] 图4为本发明实施例1的供电连接关系示意图。

[0032] 图5为本发明实施例2的供电连接关系示意图。

[0033] 附图标记说明：

[0034] 1-卡车底盘；1-1-驾驶室；2-电控房；

[0035] 3-电动机驱动装置；3-1-第一电动机驱动装置；

[0036] 3-2-第二电动机驱动装置；4-电动机；

[0037] 4-1-第一电动机；4-2-第二电动机；5-压裂泵；

[0038] 6-1-吸入管汇；6-2-排出管汇；7-辅助变压器；

[0039] 8-润滑冷却系统；9-1-第一联轴器；9-2-第二联轴器；

[0040] 9-3-第三联轴器；9-4-第四联轴器；10-变速箱；

[0041] 11-主变压器；12-发电机组；12-1-第一发电机组；

[0042] 12-1-第二发电机组；13-1-主控制柜；13-2-辅助控制柜；

[0043] 14-主动力控制系统；14-1-控制器；14-2-人机交互设备；

[0044] 15-辅助动力控制系统；16-井场电网。

具体实施方式

[0045] 实施例1

[0046] 如图1所示，本发明包括带驾驶室1-1的卡车底盘1，所述卡车底盘1上安装有润滑冷却系统8和压裂泵5，以及与压裂泵5连接的吸入管汇6-1和排出管汇6-2，所述卡车底盘1上还安装有电驱动系统和控制系统，所述电驱动系统包括用于驱动压裂泵5运转的电动机4和电动机驱动装置3，所述控制系统包括用于控制电动机驱动装置3的主动力控制

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系统 14 以及用于控制润滑冷却系统 8 的辅助动力控制系统 15，所述电动机驱动装置 3、主动力控制系统 14 和辅助动力控制系统 15 均通过外部电源供电。

[0047] 本实施例中，所述电动机 4 为一台，所述电动机 4 通过第一联轴器 9-1 与所述压裂泵 5 连接。当压裂泵 5 输入功率需要较小时（例如小于 900kw），就可以用单台大功率电动机 4 直接驱动压裂泵 5。

[0048] 本实施例中，所述外部电源包括井场电网 16、与井场电网 16 连接的主变压器 11 和与所述主变压器 11 连接的辅助变压器 7，所述辅助变压器 7 安装在所述卡车底盘 1 上，所述电动机驱动装置 3 与所述主变压器 11 连接，所述主动力控制系统 14 和辅助动力控制系统 15 均与所述辅助变压器 7 连接；这种供电方案是整车造价和运行成本最低的方案。具体地，如图 4 所示，所述主变压器 11 的一次侧线圈通过电缆以及串联在电缆上的真空断路器 Z1 和真空断路器 Z2 与井场电网 16 连接，所述真空断路器 Z1 与井场电网 16 之间的电缆上连接有电流互感器 TA1、避雷器 F1 和带电指示灯 L1，所述电流互感器 TA1 上连接有电流表 A1，所述真空断路器 Z1 和与真空断路器 Z2 之间的电缆上连接有避雷器 F2 且连接有相串联的熔断器 FU 和电压互感器 TV，所述电压互感器 TV 上连接有电压表 V，所述真空断路器 Z2 与主变压器 11 的一次侧线圈之间的电缆上连接有电流互感器 TA2、避雷器 F3、接地开关 K 和带电指示灯 L2，所述电流互感器 TA2 上连接有电流表 A2；所述辅助变压器 7 的一次侧线圈通过断路器 QF1 和断路器 QF2 与主变压器 11 的二次侧线圈连接。

[0049] 本实施例中，所述主动力控制系统 14 包括控制器 14-1 和与控制器 14-1 相接的人机交互设备 14-2，所述电动机驱动装置 3 与所述控制器 14-1 相接。具体地，所述主动力控制系统 14 还包括进线断路器、电压检测电路、电流检测电路等，均采用现有技术中的常规电路连接；所述电动机驱动装置 3 的电源端通过进线断路器 QF3 和断路器 QF1 与主变压器 11 的二次侧线圈连接；所述控制器 14-1 和人机交互设备 14-2 的电源端均与辅助变压器 7 的二次侧线圈连接；所述辅助动力控制系统 15 的电源进线端与辅助变压器 7 的二次侧线圈连接。通过人机交互设备 14-2 设置的参数包括电动机驱动装置 3 的启动停止、润滑冷却系统 8 的启动停止、电动机 4 的启动停止、电动机 4 的转速和压裂泵 5 的压力，通过人机交互设备 14-2 显示的参数包括：电动机驱动装置 3 的运行状态（包括启停状态和转速）、压裂泵 5 的输出压力和输出排量、压裂泵 5 润滑油压力和温度、以及电路中的电流和电压，以上显示的参数均通过现有技术中的常规检测手段检测得到并传输给控制器 14-1，控制器 14-1 再控制人机交互设备 14-2 进行显示。所述辅助动力控制系统 15 主要为润滑冷却系统 8 的控制回路，包括有断路器、接触器、热继电器以及控制继电器等元器件，均采用现有技术中的常规电路连接。

[0050] 本实施例中，所述主动力控制系统 14 安装在主控制柜 13-1 内，所述辅助动力控制系统 15 安装在辅助控制柜 13-2 内，所述电动机驱动装置 3、主控制柜 13-1 和辅助控制柜 13-2 均设置在电控房 2 内，所述电控房 2 安装在所述卡车底盘 1 上。具体地，所述电控房 2 的墙体可以通过钢板焊接而成，为了使得电控房 2 具有保温功能，以便确保电控房 2 内的设备能在合适的温度下工作，可以通过将电控房 2 的墙体设置为双层结构并在电控房 2 的墙体内填充耐火材料来实现；另外，还可以在电控房 2 的墙体上安装活动门，在电控房 2 内设置座椅 2-1，方便操作人员进出及对安装在电控房内的设备进行控制。

[0051] 本实施例中，所述电动机 4 为交流电动机或直流电动机，所述电动机驱动装置 3 为

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与电动机 4 配套的交流电动机驱动装置或直流电动机驱动装置。具体地，所述交流电动机驱动装置为变频器，所述直流电动机驱动装置为可控硅，即当电动机 4 采用交流电动机时，电动机驱动装置 3 采用变频器实现，当电动机 4 采用直流电动机时，电动机驱动装置 3 采用可控硅实现，两种驱动方案均有显著的节能、减排效果。

[0052] 实施例 2

[0053] 如图 2 和图 3 所示，本实施例与实施例 1 不同的是：所述电动机 4 为两台且分别为第一电动机 4-1 和第二电动机 4-2，所述电动机驱动装置 3 为两台且分别为与第一电动机 4-1 连接的第一电动机驱动装置 3-1 和与第二电动机 4-2 连接的第二电动机驱动装置 3-2，所述电驱动系统还包括变速箱 10，所述第一电动机 4-1 通过第二联轴器 9-2 与变速箱 10 连接，所述第二电动机 4-2 通过第三联轴器 9-3 与变速箱 10 连接，所述变速箱 10 通过第四联轴器 9-4 与压裂泵 5 连接。所述外部电源包括发电机组 12 和与所述发电机组 12 连接的辅助变压器 7，所述辅助变压器 7 安装在所述卡车底盘 1 上，所述电动机驱动装置 3 与所述发电机组 12 连接，所述主动力控制系统 14 和辅助动力控制系统 15 均与所述辅助变压器 7 连接。具体地，所述发电机组 12 的数量为一台或多台，多台所述发电机组 12 相互并联。其余结构均与实施例 1 相同。

[0054] 具体地，所述发电机组 12 为柴油发电机组或燃气发电机组。本实施例中，所述发电机组 12 为两台且分别为第一发电机组 12-1 和第二发电机组 12。如图 5 所示，第一发电机组 12-1 和第二发电机组 12-2 相互并联，所述辅助变压器 7 的一次侧线圈通过断路器 QF4 和断路器 QF8 与第一发电机组 12-1 的输出端连接且通过断路器 QF5 和断路器 QF8 与第二发电机组 12-2 的输出端连接，第一电动机驱动装置 3-1 的电源端通过进线断路器 QF6 和断路器 QF4 与第一发电机组 12-1 的输出端连接且通过进线断路器 QF6 和断路器 QF5 与第二发电机组 12-2 的输出端连接，第二电动机驱动装置 3-2 的电源端通过进线断路器 QF7 和断路器 QF4 与第一发电机组 12-1 的输出端连接且通过进线断路器 QF7 和断路器 QF5 与第二发电机组 12-2 的输出端连接；所述控制器 14-1 和人机交互设备 14-2 的电源端均与辅助变压器 7 的二次侧线圈连接；所述辅助动力控制系统 15 的电源进线端与辅助变压器 7 的二次侧线圈连接。

[0055] 当压裂泵 5 输入功率需要较大且单台电动机 4 不足以驱动压裂泵 5 时，由两台电动机 4 通过变速箱 10 共同驱动压裂泵 5。当驱动更大功率的压裂泵 5 时，还可以采用多台电动机 4 串联或者通过分动箱并联的方式驱动压裂泵 5。

[0056] 使用多台较小功率的发电机组 12 相互并联供电，与单台大功率发电机组 12 供电相比，造价和运行可靠性上更有优势。采用发电机组供电可以根据功率需求任意选择并网发电机组 12 的数量，有助于节省燃油。

[0057] 本发明中，主动力控制系统 14 负责对整个电驱动压裂泵车工作的控制，能够通过人机交互设备 14-2 输入控制参数，还能通过人机交互设备 14-2 显示电驱动压裂泵车的实时状态，提高了整个压裂泵车的控制精度和信息化程度。通过主动力控制系统 14 中的控制器 14-1 调节电动机驱动装置 3 的输出，可以实现电动机 4 的无级连续调速，满足压裂泵 5 的工作需要，能够驱动压裂泵 5 输出不同压力和流量的高压液体，易于实现更多、更复杂的控制功能。

[0058] 另外，本发明中，所述电驱动系统、润滑冷却系统 8 和控制系统还可以均通过电池

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供电。主控制柜 13-1 和辅助控制柜 13-3 通过螺栓固定在电控房 2 内地面或者墙壁上，以适应长途运输。电控房 2 具有隔音、防水、保温等功能，适合操作人员长时间控制作业。

[0059] 综上所述，本发明针对现有压裂泵车动力传动系统存在的燃油消耗大、发动机和变矩器配套困难、机组低功率运行时油耗大、作业条件差等缺点，提出了以电动机 4 作为原动机的压裂泵车方案，结构简单，设计新颖合理，配套方便，造价低，自动控制水平高，工作效率高，能源供应方便，易于维护，工作可靠性高，使用效果好，便于推广使用。

[0060] 以上所述，仅是本发明的较佳实施例，并非对本发明作任何限制，凡是根据本发明技术实质对以上实施例所作的任何简单修改、变更以及等效结构变化，均仍属于本发明技术方案的保护范围内。

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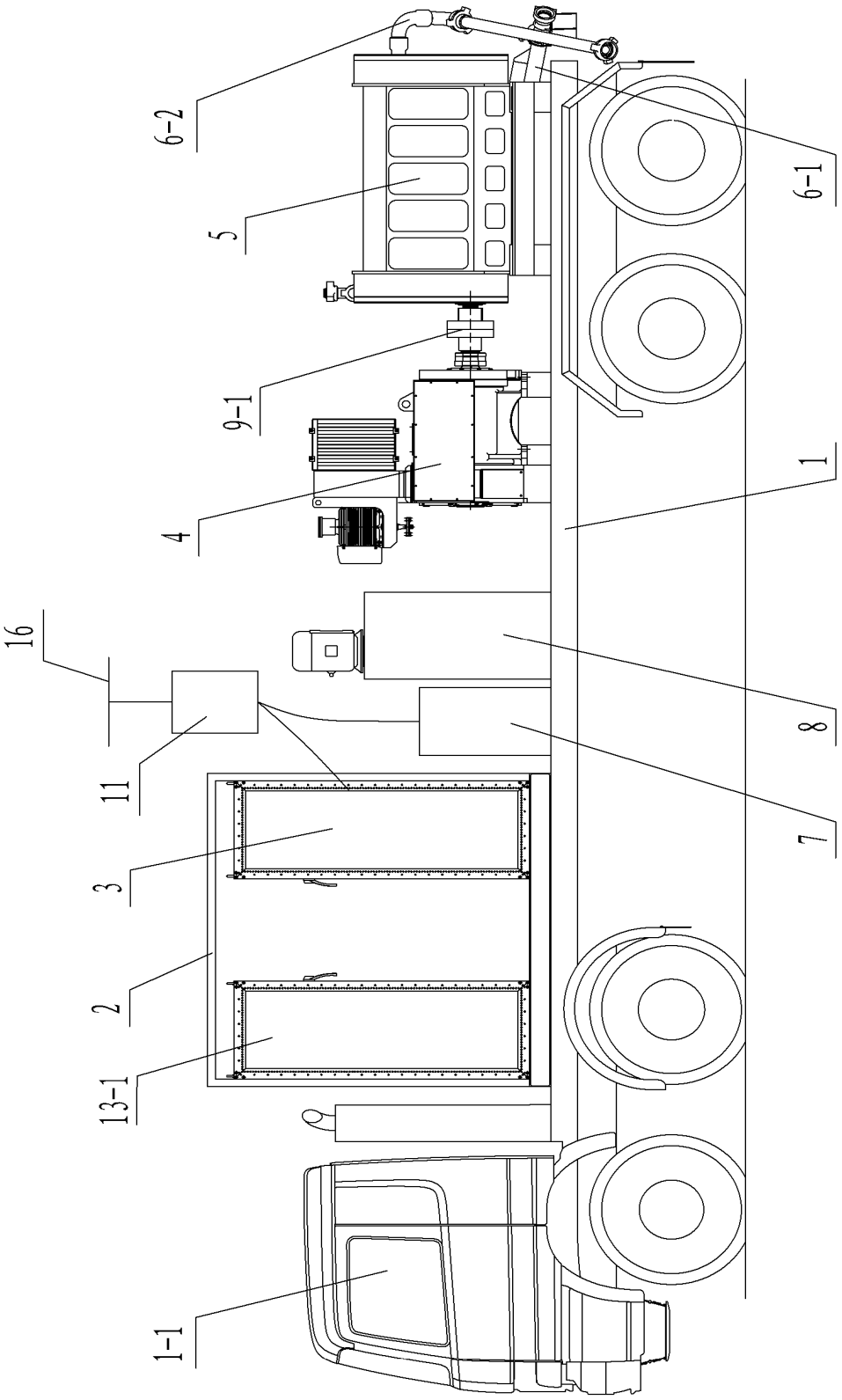


图 1

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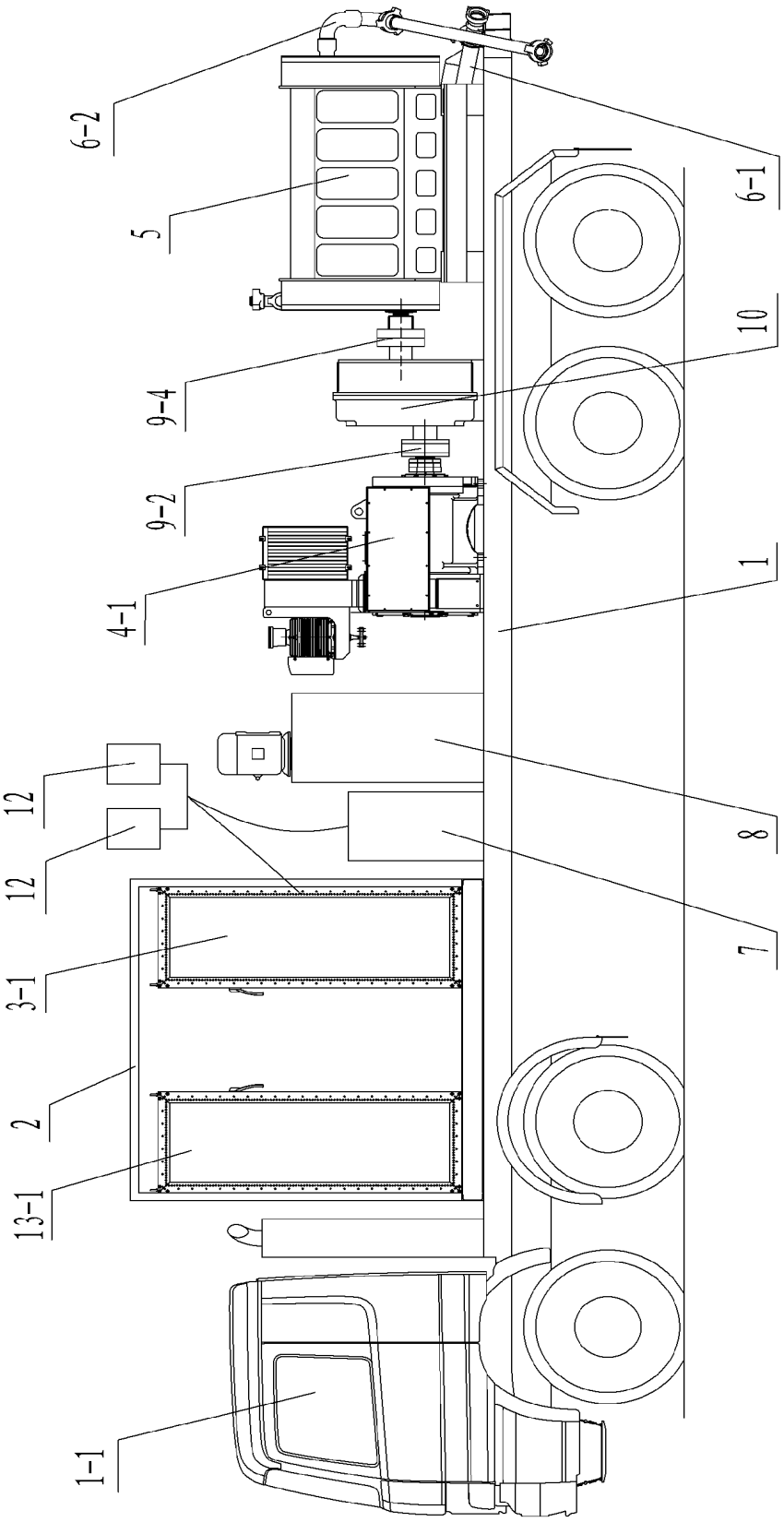


图 2

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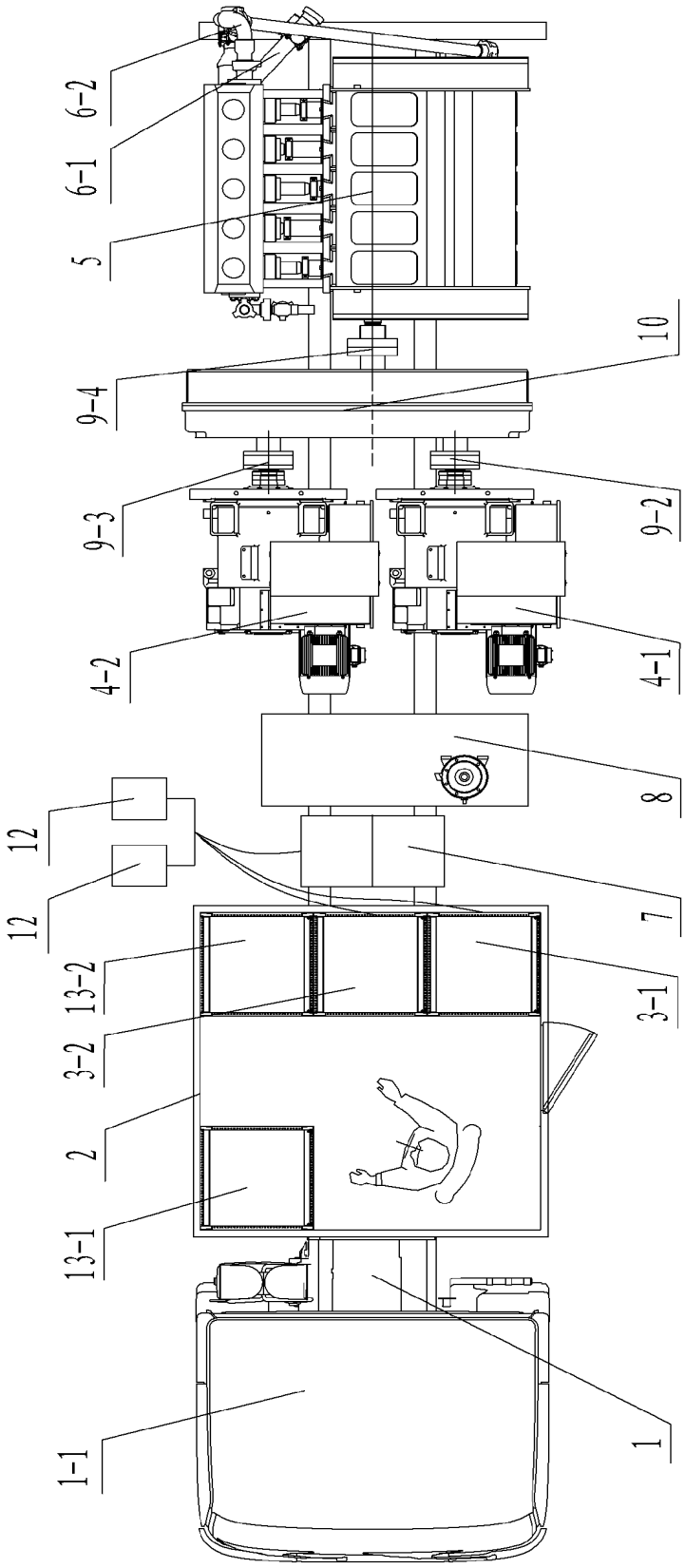


图 3

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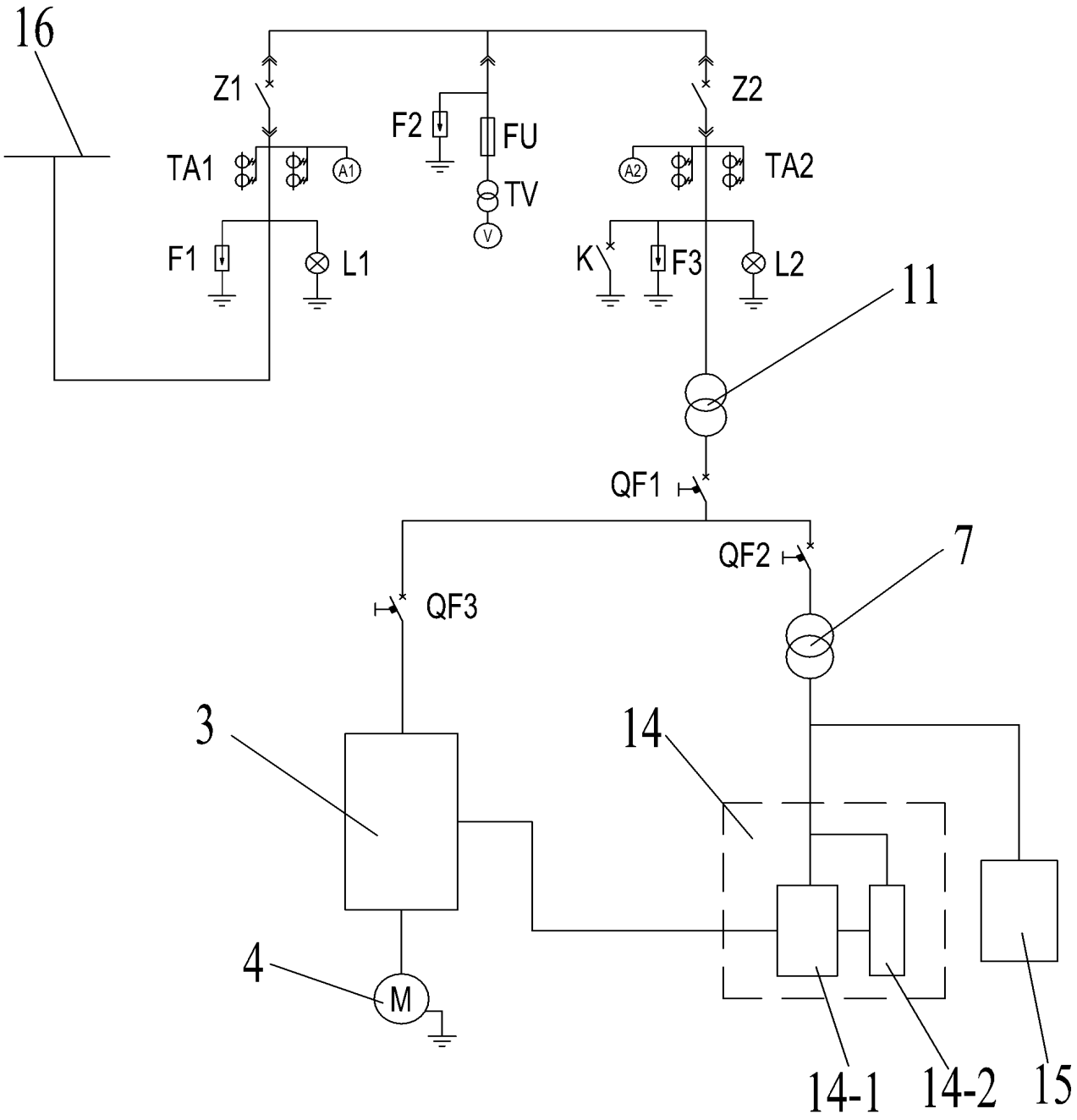


图 4

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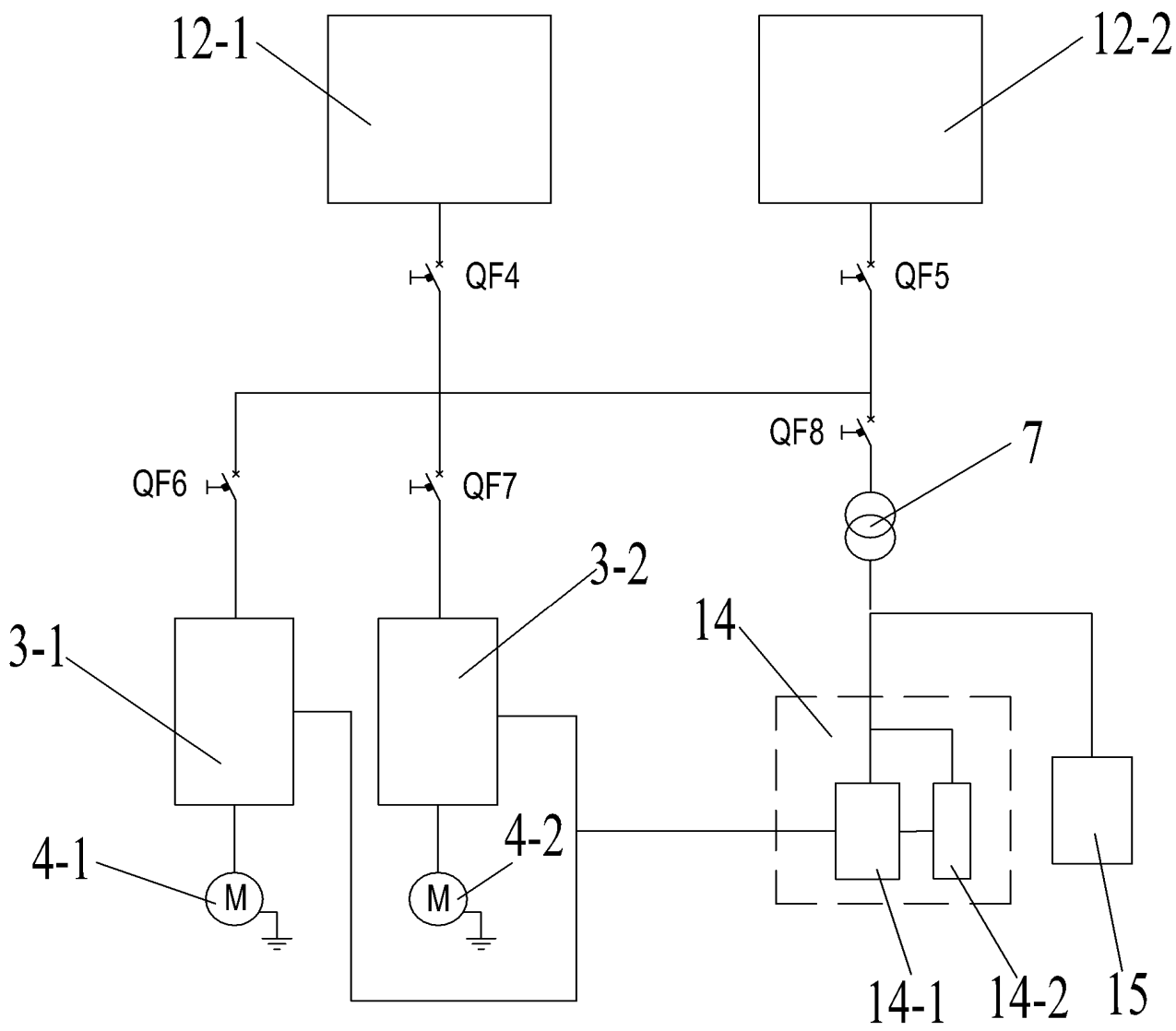


图 5

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CN201687513U

Underground borehole hydraulic fracturing system

Publication Number: CN201687513U

Application Number: CN2010202092857U

Priority Date: May 31, 2010

Filing Date: May 31, 2010

Publication Date: December 29, 2010

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Assignees: N/A

Legal Status: N/A

Abstract

The utility model discloses an underground borehole hydraulic fracturing system which comprises a borehole sealing device, a high pressure injection pump, a power device and an electrical cabinet; the electrical cabinet is electrically connected with the power device, the power device is in transmission connection with the high pressure injection pump, the high pressure injection pump is connected with the borehole sealing device by a high pressure hose, and the electrical cabinet is connected with a ground monitoring control device by a control conducting wire. The underground borehole hydraulic fracturing system has small volume, easy operation, high safety, can realize the underground borehole hydraulic fracturing process through ground operation, achieves the purposes of gas control and coal seam gas exploitation, remarkably improves the underground single bore drainage ability, has good market prospect and is easy for popularization and application.

Claims

1. Hydraulic fracturing a downhole drilling system, characterized in that: sealing means, high-pressure injection pump, the power unit and control cabinet, cabinet and power means electrically connected to the power means connected to drive the high-pressure injection pump, by a high pressure injection pump comprising high-pressure hose and sealing means connected to the monitoring control cabinet is connected to ground via a control line means.

2. The downhole drilling according to claim 1 hydraulic fracturing system characterized in that: said system is provided over a data line connected by two probes, probe and ground monitoring and control device.

3. The downhole of claim 12 or claim hydraulic fracturing drilling system, wherein: said sealing means comprises a sealing device, and the anchor hole of the connecting pipe, and sealing the rear end connecting bore tube connected to the tip, the bore high pressure hose connection pipe connected to the rear end, the anchor hole provided in the rear of the connection pipe.

4. The downhole drilling the hydraulic fracturing system of claim 3, characterized in that: said power means comprises a motor proof, explosion-proof motor is connected via a transmission to drive the high-pressure injection pump.

Description

Description

Translated from Chinese

Hydraulic fracturing downhole drilling system

FIELD

[0001] The present invention belongs to a technical field Mine Gas Control development, in particular, it relates to a downhole drilling system of hydraulic fracturing.

Background technique

[0002] hydraulic fracturing downhole drilling coal seam gas as an important process of governance and development of coalbed methane, coal can increase the amount of gas drainage hole and concentration, improve high gas pumping efficiency, thereby inhibiting the occurrence of accidents and speed up gas the development of coalbed methane industry.

However, due to downhole fracturing process conditions and limitations, it is necessary to device miniaturization, simplification, and easy operation, high safety.

But currently there is no downhole drilling for hydraulic fracturing equipment.

Although CBM fracturing equipment has been very mature, but limited to its large size, it can not go down to use.

SUMMARY

[0003] The present invention to solve the shortcomings of the prior art, there is provided a downhole specifically for use in the hydraulic fracturing system of the mine drilling.

[0004] In order to solve the above problems, the present invention adopts the following technical solutions: hydraulic fracturing a downhole drilling system, comprising plugging means, high-pressure injection pump, the power unit and control cabinet, power means electrically connected to the cabinet, power means connected to drive the high-pressure injection pump, high-pressure injection pump via a high pressure hose connected to the sealing means, the monitoring control cabinet is connected to ground via a control line means.

The [0005] above the system is provided with two probes, probe and ground monitoring and control device is connected via a data line.

The [0006] plugging means comprises a sealing device, and the anchor hole of the connecting pipe, and sealing the rear end hole of the connecting pipe connected to a front end, a rear end hole of the connecting pipe connected to the high-pressure hose, is provided in the anchor a rear bore of the connection pipe.

[0007] The flameproof power means comprises a motor, explosion-proof motor is connected via a transmission to drive the high-pressure injection pump.

[0008] With the above technical solution, sealing has a high expansion ratio, high compressive strength, good sealing performance, adaptability, etc; hole connecting pipe of any length in meters, it is possible to adapt the underground small operating space, conditions complex features, and resistant to high pressure (40MPa or more), while the joint portion of the tube connecting hole requirements butt firmly, tightly; anchor is simple, high compressive strength, high friction with the hole wall, ingenious characteristics, so that the hole can be plugged tube and connector bore is not moved by the high pressure water; high-pressure hose with a high compressive strength, butt firmly, tightly sealed, may be determined according to the characteristics required length; high-pressure injection pump having simple, small, large displacement (Im3Aiin), high pressure (40MPa or more), the boosting speed is fast, able to adapt to conditions downhole, high moisture resistance, explosion-proof security characteristics; high voltage transmission can be controlled by using different shift and the pressure of the pump displacement, small, safe explosion-proof; the motor can provide enough power a high pressure pump, explosion; downhole control cabinet

The whole process of hydraulic fracturing hole, having a pump, the pump stops, the high pressure pump is heated so that the operator can be away from the high pressure region; a probe to monitor the location of fracturing the fracturing case, a probe to monitor downhole drilling apparatus hydraulic fracturing ; ground monitoring and control means, connected to the probe and a downhole electrical control cabinet through a dedicated data line, and the construction returns downhole fracturing scene data, so that safe, accurate and real-time record.

[0009] The present invention is small, easy to operate, safe, it can be operated on the ground by hydraulic fracturing downhole drilling technology, to solve the soft, low permeability, high gas control sudden coal and coalbed methane development problems of implementation, significantly improve the underground hole extraction capacity, with good market prospects and easy application.

BRIEF DESCRIPTION

[0010] FIG. 1 is a structural diagram of the present invention novel.

Detailed ways

[0011] As shown, the present invention is a downhole hydraulic fracturing drilling system 1, comprising sealing means, high-pressure injection pump 1, power cabinet 2, and means, connected to the cabinet 2 electric power plant, the power means high-pressure injection pump connected to a drive, a high-pressure injection pump 13 is connected to the high pressure hose through the plugging means, cabinet 2 is connected to ground monitoring and control device 4 via a control line 5.

Power means comprises a motor 6 proof, explosion-proof motor 6 is connected to the high-pressure injection pump via a transmission gear 7.

Plugging means 11 is inserted into the pre-seam construction which bore 12, the sealing means comprises a sealing device 8, the connection pipe 9 and the anchor hole 10, sealing the bore 8 is connected to the rear end of the tip of the connecting pipe 9 the drilling depth settings 9, a plurality of connecting tube bore root and sequentially end to end, a rear end hole 9 connected to the high-pressure pipe connecting hose 3, the anchor hole 10 provided in the rear portion of the connection pipe 9, the anchor 10 external blocking bore 12.

The system is provided above the probe 13 and the probe 14, the probe 13 and the probe 14 and the ground monitoring apparatus 5 is connected via a control data line 15 and data line 16, respectively, the case of fracturing the fracturing location monitoring probe 13, the probe 14 to monitor downhole drilling hydraulic fracturing equipment.

Cabinet 2, the control device 5 as monitoring ground prior art, will not be repeated.

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 201687513 U
(45)授权公告日 2010.12.29

(21)申请号 201020209285.7

(22)申请日 2010.05.31

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(51)Int.Cl.
E21F 7/00(2006.01)
E21B 43/26(2006.01)

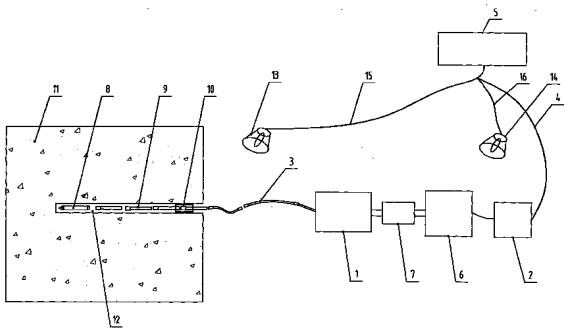
权利要求书 1 页 说明书 2 页 附图 1 页

(54)实用新型名称

井下钻孔水力压裂系统

(57)摘要

本实用新型公开了一种井下钻孔水力压裂系统，包括封孔装置、高压注水泵、动力装置和电控柜，电控柜与动力装置电连接，动力装置与高压注水泵传动连接，高压注水泵通过高压软管与封孔装置连接，电控柜通过控制导线与地面监测控制装置连接。本实用新型体积小、易操作、安全性高，可以通过在地面操作实现井下钻孔水力压裂工艺，达到瓦斯治理和煤层气开发的目的，显著提高井下单孔抽采能力，具有良好的市场前景，易于推广应用。



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1. 井下钻孔水力压裂系统，其特征在于：包括封孔装置、高压注水泵、动力装置和电控柜，电控柜与动力装置电连接，动力装置与高压注水泵传动连接，高压注水泵通过高压软管与封孔装置连接，电控柜通过控制导线与地面监测控制装置连接。

2. 根据权利要求 1 所述的井下钻孔水力压裂系统，其特征在于：所述系统上方设有两个探头，探头与地面监测控制装置通过数据线连接。

3. 根据权利要求 1 或 2 所述的井下钻孔水力压裂系统，其特征在于：所述封孔装置包括封孔器、孔内连接管和锚固器，封孔器后端与孔内连接管前端连接，孔内连接管后端与高压软管连接，锚固器设在孔内连接管后部。

4. 根据权利要求 3 所述的井下钻孔水力压裂系统，其特征在于：所述动力装置包括隔爆电机，隔爆电机通过变速器与高压注水泵传动连接。

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井下钻孔水力压裂系统

技术领域

[0001] 本实用新型属于一种矿井瓦斯治理开发技术领域，尤其涉及一种井下钻孔水力压裂系统。

背景技术

[0002] 井下钻孔水力压裂作为煤层瓦斯治理及煤层气开发的一项重要工艺，可以增加煤的单孔瓦斯抽采量及浓度，提高瓦斯抽采效率，从而抑制瓦斯事故的发生和加快煤层气产业的发展。但由于井下条件及压裂工艺限制，所以需要设备小型化、简单化、易操作、安全性高。但目前尚没有针对井下钻孔水力压裂的设备。地面煤层气压裂设备尽管已经很成熟，但限于其庞大的体积，也无法下井使用。

实用新型内容

[0003] 本实用新型为了解决现有技术中的不足之处，提供一种专门适用于矿井内使用的井下钻孔水力压裂系统。

[0004] 为解决上述技术问题，本实用新型采用如下技术方案：井下钻孔水力压裂系统，包括封孔装置、高压注水泵、动力装置和电控柜，电控柜与动力装置电连接，动力装置与高压注水泵传动连接，高压注水泵通过高压软管与封孔装置连接，电控柜通过控制导线与地面监测控制装置连接。

[0005] 所述系统上方设有两个探头，探头与地面监测控制装置通过数据线连接。

[0006] 所述封孔装置包括封孔器、孔内连接管和锚固器，封孔器后端与孔内连接管前端连接，孔内连接管后端与高压软管连接，锚固器设在孔内连接管后部。

[0007] 所述动力装置包括隔爆电机，隔爆电机通过变速器与高压注水泵传动连接。

[0008] 采用上述技术方案，封孔器具有膨胀率高、抗压强度大、密封性能好、适应性强等优点；孔内连接管以米为单位的任意长度，能够适应井下操作空间小、条件复杂的特点，并且能够抗高压力（40MPa 以上），同时孔内连接管的接头部分要求对接牢固、紧密；锚固器具有操作简单、抗压能力高、与孔壁摩擦力大、制作精巧的特点，能够使孔内封孔器及连接管在高压水的作用下不在孔内移动；高压软管具有抗压能力高、对接牢固、密封严实、可根据需要确定长度的特点；高压注水泵具有操作简单、体积小、排量大（$1m^3/min$）、压力高（40MPa 以上）、升压速度快、能够适应井下复杂条件、抗潮湿能力强、安全防爆的特点；变速器能够通过使用不同档位控制高压泵的排量及压力，体积小，安全防爆；电机能够提供高压泵足够的动力，防爆；电控柜控制井下钻孔水力压裂的整个过程，具有开泵、停泵、为高压泵加热、使操作者能够远离高压区；一个探头监控压裂地点的压裂情况，一个探头监控井下钻孔水力压裂的设备；地面监测控制装置，通过专用的数据线连接井下探头及电控柜，返回井下压裂场景及施工数据，做到安全操作，准确实时记录。

[0009] 本实用新型体积小、易操作、安全性高，可以通过在地面操作实现井下钻孔水力压裂工艺，达到解决松软、低透、高突煤体的瓦斯治理及煤层气开发问题，显著提高井下单孔

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抽采能力，具有良好的市场前景，易于推广应用。

附图说明

[0010] 图 1 是本实用新型的结构示意图。

具体实施方式

[0011] 如图 1 所示，本实用新型的井下钻孔水力压裂系统，包括封孔装置、高压注水泵 1、动力装置和电控柜 2，电控柜 2 与动力装置电连接，动力装置与高压注水泵 1 传动连接，高压注水泵 1 通过高压软管 3 与封孔装置连接，电控柜 2 通过控制导线 4 与地面监测控制装置 5 连接。动力装置包括隔爆电机 6，隔爆电机 6 通过变速器 7 与高压注水泵 1 传动连接。封孔装置插设到煤层 11 当中预先施工的钻孔 12 中，封孔装置包括封孔器 8、孔内连接管 9 和锚固器 10，封孔器 8 后端与孔内连接管 9 前端连接，根据钻孔深度，孔内连接管 9 设置若干根并依次首尾相连，孔内连接管 9 后端与高压软管 3 连接，锚固器 10 设在孔内连接管 9 后部，锚固器 10 的外部封堵钻孔 12。系统上方设有探头 13 和探头 14，探头 13 和探头 14 与地面监测控制装置 5 分别通过数据线 15 和数据线 16 连接，探头 13 监控压裂地点的压裂情况，探头 14 监控井下钻孔水力压裂的设备。电控柜 2、地面监测控制装置 5 为现有技术，不再赘述。

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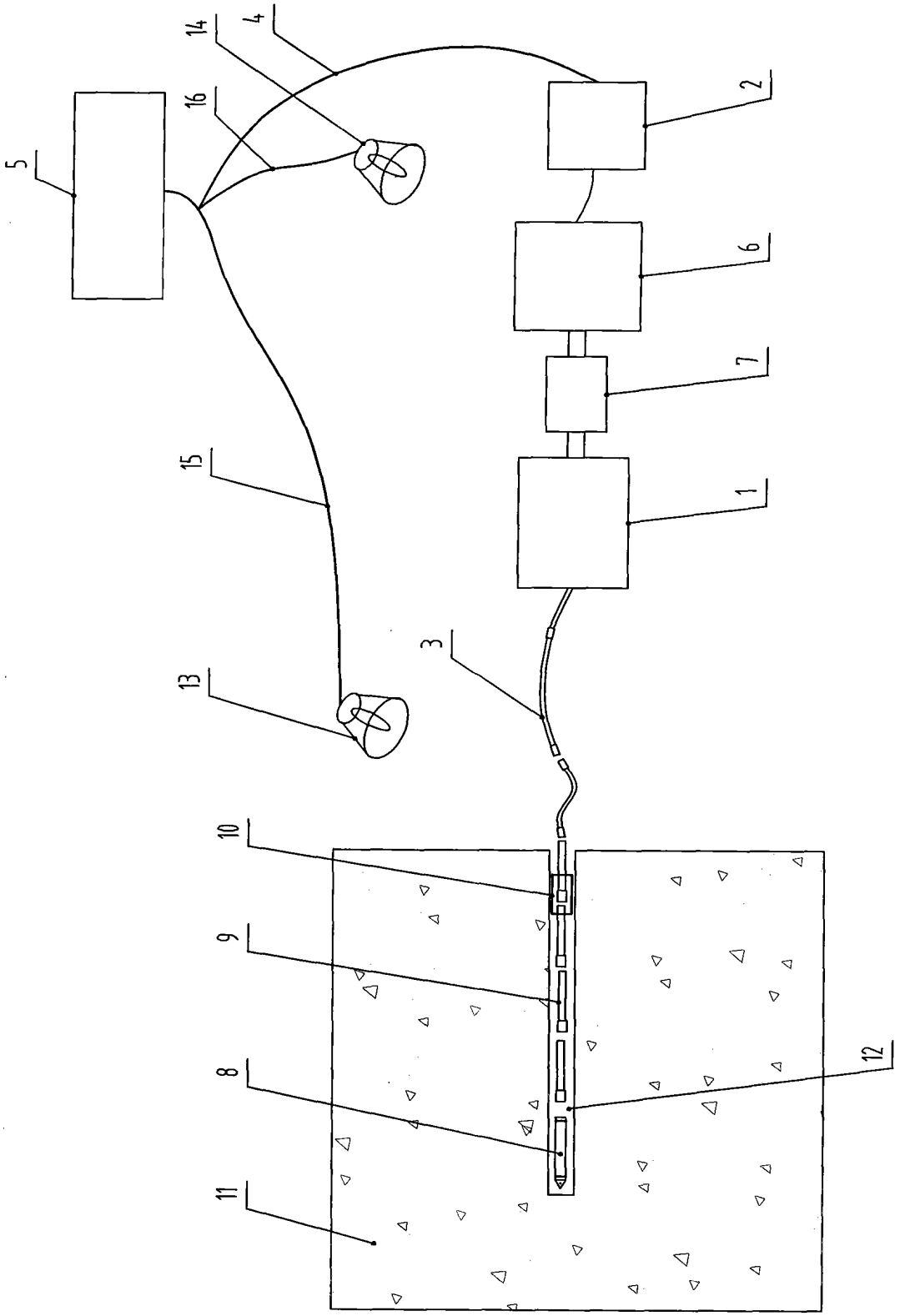


图 1

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CN202023547U

Coal mine underground pulsed hydraulic fracturing equipment

Publication Number: CN202023547U

Application Number: CN2011201339382U

Priority Date: April 29, 2011

Filing Date: April 29, 2011

Publication Date: November 02, 2011

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Assignees: N/A

Legal Status: N/A

Abstract

The utility model discloses coal mine underground pulsed hydraulic fracturing equipment which is suitable for underground hydraulic fracturing operation in a coal bed with high methane content and low gas permeability. The coal mine underground pulsed hydraulic fracturing equipment comprises frequency conversion equipment, a pulsed injection pump, an automatic control water tank and a fracturing pipe. The frequency conversion equipment is connected with the pulsed injection pump through a transmission shaft, the automatic control water tank is connected with the pulsed injection pump through a water inlet pipe of the pulsed injection pump, and the pulsed injection pump is connected with the fracturing pipe in a drill hole through a pulsed water outlet pipe of the pulsed injection pump. The frequency conversion equipment comprises a mining flameproof filter reactor, a mining flameproof and intrinsically safe alternating current frequency converter and a mining flameproof variable frequency motor. The pulsed water frequency of the pulsed injection pump is changed through adjusting the frequency parameter of the mining flameproof and intrinsically safe alternating current frequency converter, and the coal bed is fractured by a pulsed hydraulic effect generated through the periodic variation of high-pressure pulsed water in a coal body drill hole, therefore, a coal bed pressure release and permeability improvement effect is achieved. In addition, controllable and adjustable pulsed hydraulic fracturing pulsed water frequency can be achieved.

Claims

1. An underground mine pulsation of hydraulic fracturing apparatus comprising: a main device flameproof filter reactor (1), mine explosion-proof and intrinsically safe AC inverter (2), mine explosion frequency the motor (5), pulsating injection pump (7), automatic control of the water tank (9), inserted into the borehole fracturing sealed tube (11) inside (13) configured; flameproof filter reactor (1) aND mINERAL is connected between the (2) reactor cable (3) explosion-proof and intrinsically safe AC drive; mine explosion-proof and intrinsically safe AC inverter (2) and the mine explosion-proof connection between the inverter motor (5) with a drive cable (4); mine explosion inverter motor (5) to the pulsating injection pump (7) via a drive shaft (6) is connected; pulsating injection pump (7) is inserted into the water inlet is connected to the automatic control tank (9) pulsations injection pump inlet (8); pulsating injection pump (7) is provided at the outlet is connected to the fracturing pulsation tube (11) of the injection inlet of the pump outlet (10).

2. The coal mine pulsating hydraulic fracturing apparatus according to claim 1, characterized in that: said pulsating injection pump outlet pipe (10) is provided with a flow control valve.

Description

Description

Translated from Chinese

Pulsating hydraulic fracturing underground coal mine equipment

FIELD

[0001] The present invention relates to coal mine pulsating hydraulic fracturing equipment, especially for coal mine gas control area.

Background technique

[0002] Hydraulic fracturing is one of the key technologies of the current coal mine gas control area.

By region of hydraulic fracturing coal seam permeability can be increased to improve gas pumping rate, gas pressure release seam, changing the nature of the coal body, thereby reducing the purpose of coal and gas outburst, to the coal and gas extraction.

For high gas permeability is low, a single seam, hydraulic fracturing equipment currently used common problems are: difficulties in coal water, injection water is small, insufficient fractured, stress concentration area, is not obvious seam permeability, resulting in the drill and the amount of drainage holes low concentrations drainage, drainage drilling faster decay rate, it is difficult to achieve the desired effect.

SUMMARY

[0003] The object of the present invention to overcome the deficiencies of the prior art, there is provided a coal water convenient, water volume, to facilitate hydraulic fracturing underground mine pulsating gas drainage device.

[0004] aspect of the present invention to solve the technical problem is: equipment consists of flameproof filter reactors, mine explosion-proof and intrinsically safe AC drive, injection pump mine explosion-proof motor frequency, pulsating automatic control tanks, tubes inserted into the borehole a fracturing seal segment; flameproof filter reactor and have essentially flameproof reactor cable connection between the safety AC drive; flameproof AC drive and intrinsically safe mine explosion frequency between the drive motor is connected to a cable; mine explosion-proof injection pump inverter motor shaft is connected via the pulsating; pulsation at the inlet of the injection pump is connected to the automatic control is inserted in the tank pulsating injection pump inlet; pulsating injection pump provided at the outlet pulsations and fracturing injection inlet connected to the pump outlet; a pulsating injection flow rate control valve provided on the pump outlet.

[0005] Advantageous Effects: As a result of the above technical solution, mine explosion-proof and intrinsically safe explosion-proof AC drive connection with the filter reactor ore achieved grid suppressing waveform distortion function; by adjusting Flameproof and intrinsically safe AC inverter control mine explosion frequency motor speed; mine explosion-proof injection pump connected to the motor pulsation

frequency, the pulsation frequency Remineralization water injection pump explosion frequency changes with motor speed, and ultimately the pulsation of hydraulic fracturing water pulse frequency controlled, adjustable.

Apparatus by hydraulic fracturing, hydraulic fracturing injection frequency adjustment, achieve water ripple pulse frequency controlled hydraulic fracturing, adjustable to achieve target seam integral pressure relief antireflection effect.

Easy to operate, easy coal injection, injection amount, to facilitate gas drainage, strong controllability characteristics.

BRIEF DESCRIPTION

[0006] Figure 1 is a schematic view of the structure of the new hydraulic fracturing underground utility equipment pulsation coal.

[0007] FIG: 1 a flameproof filter reactor, 2 - Flameproof and intrinsically safe AC drive 3 - reactor cable, a drive cable 4, 5 - mine explosion frequency motor , 6- shaft, 7-- pulsating injection pump, 8 - pulsating injection pump inlet, automatic control of a water tank 9, a pulsating injection pump outlet pipe 10, 11 a pipe fracture, a bore 12, a bore seal 13 segment.

Detailed ways

[0008] DRAWINGS Embodiments of the present invention described below a further binding:

[0009] The present invention pulsating hydraulic fracturing coal mine equipment consists flameproof filter reactor 1, flameproof and intrinsically safe AC converter 2, the motor 5 mine explosion frequency pulsating injection pump 7 , automatic control of the water tank 9, the sealing bore inserted in the tube 11 fracturing constituting 13; reactance between the cable connector 2 flameproof filter reactor 1 flameproof and intrinsically safe AC inverter 3 ; mine explosion-proof and intrinsically safe 2 and the AC drive mine explosion frequency between the drive motor 5 is connected to the cable 4; mineral water injection pump 7 is connected via the drive shaft 6 with explosion-proof motor 5 and the ripple frequency; pulsating injection pump water inlet 7 is connected to the automatic control tank 9 is inserted into the inlet 8 pulsating injection pump; pulsating injection pump 7 is provided at the outlet pipe connected to the pulsating fracturing injection pump outlet pipe 11 an inlet 10, an injection pump pulsation with the flow control valve 10 on the pipe.

In operation, drilling coal seam fracturing orifice 12 is inserted into the tube 11, the seal required to complete the seal segment 13 in accordance with the high-pressure bore drilled, fracturing the tube so that the bore 12 in the body 11, the tube 11 fracturing exposed borehole orifice 15cnT30Cm.

Mine explosion frequency motor 5 through the shaft 6 is connected to the pulsating injection pump 7, the tank 9 via automatically controlled pulsating injection pump inlet 7 pump 8 is connected to the pulsating injection, injection pump outlet 10 is connected to the pulsation tube 11 fracturing the borehole.

In turn starts mine explosion-proof and intrinsically safe AC inverter 2, inverter motor 5 mine explosion implementation of coal seam water injection to fracture.

The preset parameters, adjusting the output frequency Flameproof and intrinsically safe AC inverter 2, changing the pulsation frequency of water injection pump 7, can achieve a controllable pulse frequency pulsating injection pump, is adjustable.

(19)中华人民共和国国家知识产权局

(12)实用新型专利

(10)授权公告号 CN 202023547 U
(45)授权公告日 2011.11.02

(21)申请号 201120133938.2

(22)申请日 2011.04.29

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(51)Int.Cl.
E21B 43/26(2006.01)

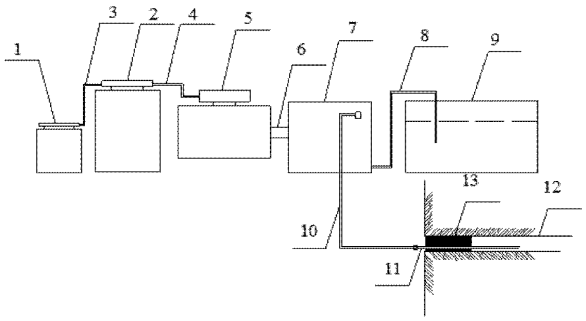
权利要求书 1 页 说明书 2 页 附图 1 页

(54)实用新型名称

煤矿井下脉动水力压裂设备

(57)摘要

一种煤矿井下脉动水力压裂设备，适用于高瓦斯低透气性煤层井下水力压裂作业。它由变频设备、脉动注水泵、自动控制水箱、压裂管组成。变频设备通过传动轴连接脉动注水泵，自动控制水箱通过脉动注水泵进水管连接脉动注水泵，脉动注水泵通过脉动注水泵脉动出水管连接钻孔内压裂管。变频设备由矿用隔爆型滤波电抗器、矿用隔爆兼本质安全型交流变频器、矿用防爆变频电机组成。通过调节矿用隔爆兼本质安全型交流变频器频率参数来改变脉动注水泵脉冲水频率，利用高压脉冲水在煤体钻孔内部的周期性变化所产生的脉冲水力效应压裂煤层，达到煤层卸压增透效果。可实现脉动水力压裂脉冲水频率可控、可调。



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1. 一种煤矿井下脉动水力压裂设备，其特征在于：设备主要由矿用隔爆型滤波电抗器（1）、矿用隔爆兼本质安全型交流变频器（2）、矿用防爆变频电机（5）、脉动注水泵（7）、自动控制水箱（9）、插入钻孔密封段（13）内的压裂管（11）构成；矿用隔爆型滤波电抗器（1）与矿用隔爆兼本质安全型交流变频器（2）之间连接有电抗器电缆（3）；矿用隔爆兼本质安全型交流变频器（2）与矿用防爆变频电机（5）之间连接有变频器电缆（4）；矿用防爆变频电机（5）与脉动注水泵（7）经传动轴（6）相连接；脉动注水泵（7）的进水口处连接有插入自动控制水箱（9）中的脉动注水泵进水管（8）；脉动注水泵（7）的出水口处设有与压裂管（11）入口相连的脉动注水泵出水管（10）。

2. 根据权利要求 1 所述的煤矿井下脉动水力压裂设备，其特征在于：所述的脉动注水泵出水管（10）上设有流量控制阀。

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煤矿井下脉动水力压裂设备

技术领域

[0001] 本实用新型涉及煤矿井下脉动水力压裂设备，尤其适用于煤矿井下区域的瓦斯治理。

背景技术

[0002] 水力压裂是当前煤矿井下区域瓦斯治理主要技术之一。通过对区域煤体实施水力压裂可以增大煤层透气性，提高瓦斯抽采率，释放煤层瓦斯压力，改变煤体性质，从而降低煤与瓦斯突出危险性，达到煤与瓦斯共采的目的。对于高瓦斯、低透气性、单一煤层，目前使用的水力压裂设备常见问题有：煤体注水困难、注水量小、裂隙发育不充分、产生应力集中区、煤层透气性提高不明显，导致钻孔抽采量及抽采浓度低，钻孔抽采衰减速度快，难以达到理想效果。

发明内容

[0003] 本实用新型的目的是克服已有技术中的不足之处，提供一种煤体注水方便、注水量大、便于瓦斯抽采的煤矿井下脉动水力压裂设备。

[0004] 本实用新型解决其技术问题所采用的技术方案是：设备主要由矿用隔爆型滤波电抗器、矿用隔爆兼本质安全型交流变频器、矿用防爆变频电机、脉动注水泵、自动控制水箱、插入钻孔密封段内的压裂管构成；矿用隔爆型滤波电抗器与矿用隔爆兼本质安全型交流变频器之间连接有电抗器电缆；矿用隔爆兼本质安全型交流变频器与矿用防爆变频电机之间连接有变频器电缆；矿用防爆变频电机与脉动注水泵经传动轴相连接；脉动注水泵的进水口处连接有插入自动控制水箱中的脉动注水泵进水管；脉动注水泵的出水口处设有与压裂管入口相连的脉动注水泵出水管；所述的脉动注水泵出水管上设有流量控制阀。

[0005] 有益效果：由于采用了上述技术方案，矿用隔爆型滤波电抗器与矿用隔爆兼本质安全型交流变频器连接，实现了抑制电网波形畸变的功能；通过调节矿用隔爆兼本质安全型交流变频器控制矿用防爆变频电机转速；矿用防爆变频电机连接脉动注水泵，矿用防爆变频电机转速的变化影响脉动注水泵的注水频率，最终实现脉动水力压裂脉冲水频率可控、可调。通过水力压裂设备，调节水力压裂注水频率，实现脉动水力压裂脉冲水频率可控、可调，达到目标煤层整体卸压增透效果。具有操作方便、煤体注水方便、注水量大、便于瓦斯抽采、可控制性强的特点。

附图说明

[0006] 图 1 为本实用新型的煤矿井下脉动水力压裂设备结构示意图。

[0007] 图中：1 —矿用隔爆型滤波电抗器，2 —矿用隔爆兼本质安全型交流变频器，3 —电抗器电缆，4 —变频器电缆，5 —矿用防爆变频电机，6 —传动轴，7 —脉动注水泵，8 —脉动注水泵进水管，9 —自动控制水箱，10 —脉动注水泵出水管，11 —压裂管，12 —钻孔，13 —钻孔密封段。

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具体实施方式

[0008] 下面结合附图对本实用新型的一个实施例作进一步的描述：

[0009] 本实用新型的煤矿井下脉动水力压裂设备主要由矿用隔爆型滤波电抗器 1、矿用隔爆兼本质安全型交流变频器 2、矿用防爆变频电机 5、脉动注水泵 7、自动控制水箱 9、插入钻孔密封段 13 内的压裂管 11 构成；矿用隔爆型滤波电抗器 1 与矿用隔爆兼本质安全型交流变频器 2 之间连接有电抗器电缆 3；矿用隔爆兼本质安全型交流变频器 2 与矿用防爆变频电机 5 之间连接有变频器电缆 4；矿用防爆变频电机 5 与脉动注水泵 7 经传动轴 6 相连接；脉动注水泵 7 的进水口处连接有插入自动控制水箱 9 中的脉动注水泵进水管 8；脉动注水泵 7 的出水口处设有与压裂管 11 入口相连的脉动注水泵出水管 10，脉动注水泵出水管 10 上装有流量控制阀。工作时，在煤层钻孔 12 的孔口处插入压裂管 11，按照高压钻孔密封要求完成钻孔密封段 13，使压裂管 11 主体在钻孔 12 内，压裂管 11 外露钻孔孔口 15cm~30cm。矿用防爆变频电机 5 通过传动轴 6 连接脉动注水泵 7，自动控制水箱 9 通过脉动注水泵进水管 8 连接脉动注水泵 7，脉动注水泵出水管 10 连接钻孔内压裂管 11。依次启动矿用隔爆兼本质安全型交流变频器 2、矿用防爆变频电机 5 实施煤层注水至煤层压裂。根据预先设定的参数，可调节矿用隔爆兼本质安全型交流变频器 2 的输出频率，改变脉动注水泵 7 的注水频率，即可实现脉动注水泵脉冲频率可控、可调。

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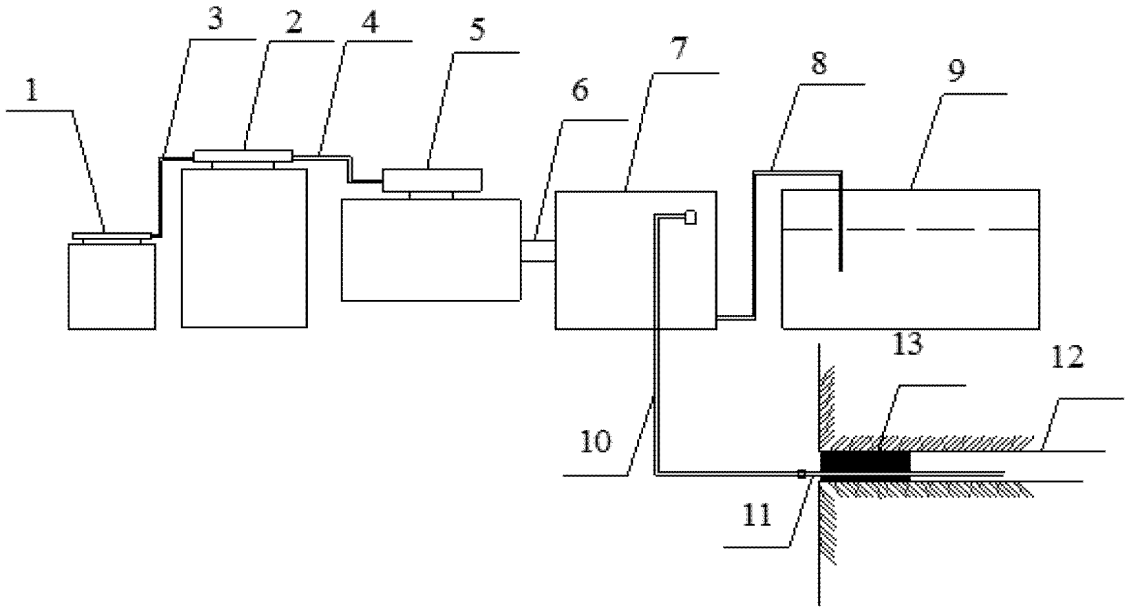


图 1

LIBERTY EXHIBIT 1002, Page 1289

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 047158.500037	Date of mailing *(day/month/year)* 10 APR 2019 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US2019/016635	International filing date *(day/month/year)* 05 February 2019
Applicant U.S. WELL SERVICES, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:**
   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

   Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 28 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within 22 months from the priority date, the applicant may request that a supplementary international search be carried out by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 047158.500037	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2019/016835	International filing date *(day/month/year)* 05 February 2019	(Earliest) Priority Date *(day/month/year)* 05 February 2018
Applicant U.S. WELL SERVICES, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 9 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the language, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, see Box No. I.

2. ☐ Certain claims were found unsearchable (see Box No. II).

3. ☐ Unity of invention is lacking (see Box No. III).

4. With regard to the title,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the abstract,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the drawings,

   a. the figure of the drawings to be published with the abstract is Figure No. 1

   ☐ as suggested by the applicant.

   ☒ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/016635

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.01)
CPC - H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.02)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 700/295; 166/305.1; 166/308.1; 700/293 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2016/0105022 A1 (US WELL SERVICES LLC) 14 April 2016 (14.04.2016) entire document	1-4, 15, 19, 20 --- 5, 7-12, 14, 16, 18
Y	US 2010/0019574 A1 (BALDASSARRE et al) 28 January 2010 (28.01.2010) entire document	5
Y	CA 2 964 593 A1 (US WELL SERVICES LLC) 15 October 2017 (15.10.2017) entire document	7-12, 14, 16, 18
A	US 2016/0369609 A1 (EVOLUTION WELL SERVICES, LLC) 22 December 2016 (22.12.2016) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 March 2019	10 APR 2019
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)* 10 APR 2019

Applicant's or agent's file reference
047158.500037

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2019/016635	05 February 2019	05 February 2018

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.01)
CPC - H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.02)

Applicant U.S. WELL SERVICES, INC.

1. This opinion contains indications relating to the following items.

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	25 March 2019	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (January 2015)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/016635

Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

a. ☐ forming part of the international application as filed:

☐ in the form of an Annex C/ST.25 text file.

☐ on paper or in the form of an image file.

b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/016635

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	5-14, 16-18	YES
	Claims	1-4, 15, 19, 20	NO
Inventive step (IS)	Claims	6, 13, 17	YES
	Claims	1-5, 7-12, 14-16, 18-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-4, 15, 19, and 20 lack novelty under PCT Article 33(2) as being anticipated by US Well Services LLC (hereinafter USWell022).

Regarding Claim 1, USWell022 discloses a system for completing a well (a hydraulic fracturing operation can be carried out according to the following process... The fracturing fluid can be pumped into the wellbore at a high enough pressure that the fracturing fluid cracks the formation, para 0042), the system comprising: a generator (generators 222A, 222B, para 0045; also see Fig. 5); a plurality of electric load components, each electric load component powered by the generator (at least one first generator in electrical communication with a first switchgear for providing power to primary components of a hydraulic fracturing operation;, claim 1; Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B [load components], para 0045; also see Fig. 5); and a load shedding control panel that monitors the generator and, if the generator loses functionality, is capable of deactivating one or more of the plurality of electric load components to reduce the electric load (The turbine generators 122 can be connected to the electric motors 114 [of the pumps/loads] via power distribution panels, para 0036; The load shed system of the embodiment of FIG. 5 can monitor when power draw will overload the system (i.e., when demand is higher than supply), and it will send a signal to open a breaker 233A, 233B to cut certain pumps 210A, 210B, thereby reducing power before the entire bank is overloaded para 0047; if one of the turbines loses power,... [in prior art] the ability to shed load, such as by shutting down power to non-critical parts of the system, is limited. The power draw from all of the units overloads the turbines, para 0006; if the at least one first generator loses the ability to generate electricity, the at least one second generator can continue to generate electricity, para 0007).

Regarding Claim 2, USWell022 discloses the system of claim 1, further comprising: a switch gear positioned between the generator and the plurality of electric load components to distribute power between the generator and the plurality of electric load components (The power from the generators 222A of group A goes to switchgear 235A. From switchgear 235A, the power goes to the transformers 223A, and to the auxiliary trailer 225A, which can have a transformer, as well as a VFD and softstarts for the blender and hydration units. Power can then go to one or more of the following: the primary blender 234A, the primary hydration unit 232A, the primary data van 227A, and/or the primary sand equipment 229A. Power from the transformers 223A also goes to pumps 210A.. para 0050; also see Fig. 5).

Regarding Claim 3, USWell022 discloses the system of claim 1, wherein the generator is a natural gas turbine generator, a natural gas generator, or a diesel generator (the electric generators 22 can be powered by natural gas.. para 0027).

Regarding Claim 4, USWell022 discloses the system of claim 1, wherein the electric load components are selected from the group consisting of electric hydraulic fracturing pumps, a blender, sand equipment, a hydration unit, and a data van (Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B, as well as separate and distinct auxiliary trailers 225A, 225B, each including its own ancillary equipment, such as, for example, data vans 227A, 227B, sand equipment 229A, 229B, blenders 234A, 234B, and hydration units 232A, 232B, para 0045; also see Fig. 5).

Regarding Claim 15, USWell022 discloses a method of completing a well (a hydraulic fracturing operation can be carried out according to the following process... The fracturing fluid can be pumped into the wellbore at a high enough pressure that the fracturing fluid cracks the formation, para 0042), the method comprising the steps of: a) powering a plurality of hydraulic fracturing equipment components with a generator (at least one first generator in electrical communication with a first switchgear for providing power to primary components of a hydraulic fracturing operation;, claim 1; Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B [load components], para 0045; also see Fig. 5); b) monitoring the generator to determine when the generator loses functionality; c) when the generator loses functionality, selectively deactivating one or more of the plurality of hydraulic fracturing equipment components to decrease the load (The turbine generators 122 can be connected to the electric motors 114 [of the pumps/loads] via power distribution panels, para 0036; The load shed system of the embodiment of FIG. 5 can monitor when power draw will overload the system (i.e., when demand is higher than supply), and it will send a signal to open a breaker 233A, 233B to cut certain pumps 210A, 210B, thereby reducing power before the entire bank is overloaded para 0047; if one of the turbines loses power,... [in prior art] the ability to shed load, such as by shutting down power to non-critical parts of the system, is limited. The power draw from all of the units overloads the turbines, para 0006; if the at least one first generator loses the ability to generate electricity, the at least one second generator can continue to generate electricity, para 0007).

Regarding Claim 19, USWell022 discloses the method of claim 15, further comprising: distributing power between the generator and the plurality of hydraulic fracturing equipment components with a switchgear (at least one first generator in electrical communication with a first switchgear for providing power to primary components of a hydraulic fracturing operation;, claim 1; Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B [load components], para 0045; also see Fig. 5)

LIBERTY EXHIBIT 1002, Page 1295

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding Claim 20, USWell022 discloses the method of claim 15, wherein step c) is carried out by a load shedding control panel that monitors the generator to determine when the generator loses functionality (The turbine generators 122 can be connected to the electric motors 114 [of the pumps/loads] via power distribution panels, para 0036; The load shed system of the embodiment of FIG. 5 can monitor when power draw will overload the system (i.e., when demand is higher than supply), and it will send a signal to open a breaker 233A, 233B to cut certain pumps 210A, 210B, thereby reducing power before the entire bank is overloaded para 0047; if the at least one first generator loses the ability to generate electricity, the at least one second generator can continue to generate electricity, para 0007).

Claim 5 lacks an inventive step under PCT Article 33(3) as being obvious over US Well Services LLC (hereinafter USWell022) in view of Baldassarre et al. (hereinafter Baldassarre).

Regarding Claim 5, USWell022 fails to disclose the system of claim 4, wherein the load shedding panel prioritizes the order in which the plurality of electric load components will be deactivated. Baldassarre is in the field of energy management systems (para 0002) and teaches wherein the load shedding panel prioritizes the order in which the plurality of electric load components will be deactivated (loads are shed in the predetermined sequence established by a user and/or as defined by a user in real-time via a user interactive device until the total current is less than the predetermined peak total or until the system has detected a stable current situation, para 0058; the control system can store this information and statistically translate it to determine the priority of each sensed load, and subsequently create a priority list to be implemented by an auxiliary power source in the instance when the utility power source fails, para 0076). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of Baldassarre for the purpose of shedding lower priority loads based on predetermined priority or real-time decisions made by the user so as to ensure that the vital loads remain connected and active while the auxiliary or generator power source remains below a threshold value (see Baldassarre, para 0130).

Claims 7-12, 14, 16, and 18 lack an inventive step under PCT Article 33(3) as being obvious over US Well Services LLC (hereinafter USWell022) in view of US Well Services LLC (hereinafter USWell593).

Regarding Claim 7, USWell022 fails to disclose the system of claim 1, wherein the generator is in selective electrical communication with a power grid.
USWell593 is in the field of hydraulic fracturing (para 0002) and teaches wherein the generator is in selective electrical communication with a power grid (FIG. 14 illustrates an example 1400 of a configuration for load sharing with a utility grid, according to an embodiment, para 0085; enable the switchgear units -B+- 1425-b and "C+- 1425-c to load share between the generator sets 1405-a, 1405-b, 1405-c, 1405- d and the utility grid. For example, if the utility grid is transmitting power at 69 kV, the transformer 1445 can step down the 69kV voltage to 13.8 kV for use by the microgrid. In this configuration, power can be either provided to the grid or supplemented from the utility grid during times of peak power demand, para 0086). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of allowing for power transfer to and from the grid as needed (see USWell593, para 0086).

Regarding Claim 8, USWell022 discloses a system for completing a well (a hydraulic fracturing operation can be carried out according to the following process... The fracturing fluid can be pumped into the wellbore at a high enough pressure that the fracturing fluid cracks the formation, para 0042), the system comprising: a generator (generators 222A, 222B, para 0045; also see Fig. 5); a plurality of hydraulic fracturing equipment components, each of the plurality of hydraulic fracturing equipment components powered by the generator (at least one first generator in electrical communication with a first switchgear for providing power to primary components of a hydraulic fracturing operation;, claim 1; Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B, as well as separate and distinct auxiliary trailers 225A, 225B, each including its own ancillary equipment, such as, for example, data vans 227A, 227B, sand equipment 229A, 229B, blenders 234A, 234B, and hydration units 232A, 232B [hydraulic fracturing components], para 0045; also see Fig. 5); an electric equipment, the electric equipment powered by the generator; and a load shedding control panel that monitors the generator and, if the generator loses functionality, is capable of deactivating one or more of the plurality of hydraulic fracturing equipment components or the electric equipment to reduce the electric load (The turbine generators 122 can be connected to the electric motors 114 [of the pumps/loads] via power distribution panels, para 0036; The load shed system of the embodiment of FIG. 5 can monitor when power draw will overload the system (i.e., when demand is higher than supply), and it will send a signal to open a breaker 233A, 233B to cut certain pumps 210A, 210B, thereby reducing power before the entire bank is overloaded para 0047; if one of the turbines loses power,... [in prior art] the ability to shed load, such as by shutting down power to non-critical parts of the system, is limited. The power draw from all of the units overloads the turbines, para 0006; if the at least one first generator loses the ability to generate electricity, the at least one second generator can continue to generate electricity, para 0007).
USWell022 does not disclose wherein the electric equipment is an electric drilling rig. USWell593 discloses wherein the electric equipment is an electric drilling rig (The power generation equipment can be used to supply any oilfield equipment including... drilling rigs, para 0044). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of providing power for oilfield equipment that doe not have access to a utility provided power grid or that has a dynamic power load or low power factor(see USWell593, para 008644).

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2019/016635

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding Claim 9, modified USWell022 discloses the system of claim 8, further comprising: a switch gear positioned between the generator and the plurality of hydraulic fracturing equipment components, and between the generator and the electric equipment, to distribute power between the generator and the plurality of hydraulic fracturing equipment components, and between the generator and the electric equipment (at least one first generator in electrical communication with a first switchgear for providing power to primary components of a hydraulic fracturing operation;, claim 1; Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B [load components], para 0045; also see Fig. 5). USWell022 does not disclose wherein the electric equipment is an electric drilling rig. USWell593 discloses wherein the electric equipment is an electric drilling rig (The power generation equipment can be used to supply any oilfield equipment including... drilling rigs, para 0044). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of providing power for oilfield equipment that doe not have access to a utility provided power grid or that has a dynamic power load or low power factor(see USWell593, para 008644).

Regarding Claim 10, modified USWell022 discloses the system of claim 8, wherein the generator is a natural gas turbine generator, a natural gas generator, or a diesel generator (the electric generators 22 can be powered by natural gas., para 0027).

Regarding Claim 11, modified USWell022 discloses the system of claim 8, wherein the hydraulic fracturing equipment components are selected from the group consisting of electric hydraulic fracturing pumps, a blender, sand equipment, a hydration unit, and a data van (Each group A, B of generators 222A, 222B is connected in turn to separate and distinct groups of transformers 223A, 223B and pumps 210A, 210B, as well as separate and distinct auxiliary trailers 225A, 225B, each including its own ancillary equipment, such as, for example, data vans 227A, 227B, sand equipment 229A, 229B, blenders 234A, 234B, and hydration units 232A, 232B, para 0045; also see Fig. 5).

Regarding Claim 12, modified USWell022 fails to disclose the system of claim 11, wherein the load shedding panel prioritizes the order in which the plurality of hydraulic fracturing equipment components and the electric drilling rig will be deactivated. USWell593 teaches wherein the load shedding panel prioritizes the order in which the plurality of hydraulic fracturing equipment components and electric equipment will be deactivated (loads are shed in the predetermined sequence established by a user and/or as defined by a user in real-time via a user interactive device until the total current is less than the predetermined peak total or until the system has detected a stable current situation, para 0058; the control system can store this information and statistically translate it to determine the priority of each sensed load, and subsequently create a priority list to be implemented by an auxiliary power source in the instance when the utility power source fails, para 0076). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of Baldassarre for the purpose of shedding lower priority loads based on predetermined priority or real-time decisions made by the user so as to ensure that the vital loads remain connected and active while the auxiliary or generator power source remains below a threshold value (see Baldassarre, para 0130).

Regarding Claim 14, modified USWell022 fails to disclose the system of claim 8, wherein the generator is in selective electrical communication with a power grid. USWell593 teaches wherein the generator is in selective electrical communication with a power grid (FIG. 14 illustrates an example 1400 of a configuration for load sharing with a utility grid, according to an embodiment, para 0085; enable the switchgear units -B+- 1425-b and "C+- 1425-c to load share between the generator sets 1405-a, 1405-b, 1405-c, 1405-d and the utility grid. For example, if the utility grid is transmitting power at 69 kV, the transformer 1445 can step down the 69kV voltage to 13.8 kV for use by the microgrid. In this configuration, power can be either provided to the grid or supplemented from the utility grid during times of peak power demand, para 0086). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of allowing for power transfer to and from the grid as needed (see USWell593, para 0086).

Regarding Claim 16, USWell022 fails to explicitly disclose the method of claim 15, further comprising: powering an electric drilling rig with the generator. USWell593 discloses wherein the electric equipment is an electric drilling rig (The power generation equipment can be used to supply any oilfield equipment including... drilling rigs, para 0044). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of providing power for oilfield equipment that doe not have access to a utility provided power grid or that has a dynamic power load or low power factor(see USWell593, para 008644).

Regarding Claim 18, USWell022 fails to discloses the method of claim 15, further comprising: distributing power from the generator to a power grid. USWell593 teaches distributing power from the generator to a power grid (FIG. 14 illustrates an example 1400 of a configuration for load sharing with a utility grid, according to an embodiment, para 0085; enable the switchgear units -B+- 1425-b and "C +- 1425-c to load share between the generator sets 1405-a, 1405-b, 1405-c, 1405- d and the utility grid. For example, if the utility grid is transmitting power at 69 kV, the transformer 1445 can step down the 69kV voltage to 13.8 kV for use by the microgrid. In this configuration, power can be either provided to the grid or supplemented from the utility grid during times of peak power demand, para 0086). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify USWell022 with the teaching of USWell593 for the purpose of allowing for extra power generated to be fed to the grid (see USWell593, paras 0086 and 0088).

Claims 6, 13, and 17 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest:

Regarding claim 6, the prior art of record, individually or in combination, does not teach or fairly suggest the system of claim 5, wherein the load shedding panel is programmed to deactivate the blender after other electric load components are deactivated.

Regarding claim 13, the prior art of record, individually or in combination, does not teach or fairly suggest the system of claim 12, wherein the load shedding panel is programmed to deactivate the blender after other hydraulic fracturing equipment components are deactivated.

LIBERTY EXHIBIT 1002, Page 1297

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding claim 17, the prior art of record, individually or in combination, does not teach or fairly suggest the method of claim 15, wherein the plurality of hydraulic fracturing equipment includes at least one blender, the method further comprising: prioritizing the deactivation of the plurality of hydraulic fracturing equipment components so that the at least one blender is deactivated only after other hydraulic fracturing equipment is deactivated.

Claims 1-20 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

Search History:

Limited Classification Search

The Patent Analyst performed a limited classification search within the following US, IPC, CPC, ECLA, or F-Term classification areas:

CPC Class/Subclass(es): H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.02)

IPC (8) Class/Subclass(es): H02J 3/14; E21B 43/26; F04D 13/06; H02J 3/12 (2019.01)

U.S. Class/Subclass(es): 700/295; 166/305.1; 166/308.1; 700/293

See Global Search Results.

Global Patent Literature Text Search

The Patent Analyst performed the following global text search, which was not limited by classification but may or may not have been limited by other criteria:

Questel Orbit: https://www.orbit.com

#	Search query	Results
1	((BRANDON 2D HINDERLITER)/IN/OIN/INH/INV)	24
2	((JARED 2D OEHRING)/IN/OIN/INH/INV)	34
3	((WELL W SERVICES)/PA/OPA)	214
4	(1 OR 2) AND 3	35
5	1 OR 2 OR 3	214
6	5 AND (LOAD W SHED+)/TX	5
7	5 AND (LOAD W SHED+)/TX AND RIG/TX	2
8	(HYDRAULIC AND FRACTUR+ AND (LOAD W SHED+) AND (DRILLING W RIG))/TX	7
9	5 AND ((LOAD W SHED+) AND (CONTROL W PANEL))/TX	1
10	5 AND (PRIORITIZ+)/TX	0
11	(HYDRAULIC AND FRACTUR+ AND BLENDER AND (LOAD W SHED+))/TX	6
12	(CA2964593)/XPN	1
13	(LOAD W SHED+)/TI/AB	1126
14	(700295)/PCL	1333
15	(700293)/PCL	390
16	(166308100)/PCL	1261
17	(166305100)/PCL	1957
18	14 OR 15 OR 16 OR 17	4711

19	18 AND (HYDRAULIC AND FRACTURING)/TX	1567
20	18 AND (HYDRAULIC AND FRACTURING AND SHED+)/TX	10
21	(E21B-043/26)/CPC	5467
22	(E21B-043/26)/IPC	9814
23	(F04D-013/06)/IPC	12913
24	(F04D-013/06)/CPC	5242
25	(H02J-003/14)/CPC	4245
26	(H02J-003/14)/IPC	5368
27	(H02J-003/12)/IPC	3841
28	(H02J-003/12)/CPC	1026
29	21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28	34106
30	29 AND (LOAD W SHED+)/TX	963
31	29 AND (HYDRAULIC AND FRACTUR+ AND (LOAD W SHED+))/TX	7
32	29 AND (HYDRAULIC AND DRILL+ AND (LOAD W SHED+))/TX	4

Google Patents: https://patents.google.com

#	Search query	Results
1	hydraulic fracturing generator control	100+
2	hydraulic fracturing generator control load shedding	100+
3	MICROGRID ELECTRICAL LOAD MANAGEMENT for hydraulic fracturing	100+
4	hydraulic fracturing generator load shedding prioritize	100+
5	drilling generator load shedding prioritize	100+
6	generator load control prioritize	100+
7	generator load control prioritize blender drilling	100+
8	hydraulic fracturing blender turned off last	100+
9	generator powered earth equipment blender turned off last	100+

Computer Accessed Text Databases Searched

The Patent Analyst searched the following computer accessed text databases:

Google Scholar: https://scholar.google.com/

#	Search query	Results
1	hydraulic fracturing generator control	100+
2	hydraulic fracturing generator control load shedding	100+

3	MICROGRID ELECTRICAL LOAD MANAGEMENT for hydraulic fracturing	100+
4	drilling generator load shedding prioritize	100+
5	generator load control prioritize	100+
6	generator load control prioritize blender drilling	100+
7	hydraulic fracturing blender turned off last	100+
8	generator powered earth equipment blender turned off last	100+

Date search was completed: 25 March 2019

SV/CC

Electronic Acknowledgement Receipt

EFS ID:	36142836
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Taylor P. Evans/Stephanie McDonough
Filer Authorized By:	Taylor P. Evans
Attorney Docket Number:	047158.100032
Receipt Date:	29-MAY-2019
Filing Date:	25-OCT-2018
Time Stamp:	14:18:36
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	047158-100032_IDS.pdf	1035536 e5c29ee43396cf12a271324e99de71bafaf56f6e	no	6

Warnings:

Information:					
2	Foreign Reference	AU2007340913A1.pdf	1351624 101a4d4491bcfb8cb322f11c91a32fec4999bd3b	no	38
Warnings:					
Information:					
3	Foreign Reference	CA2964593.pdf	1476224 d94262210b3f8d029de0bcd0ce2e257484eefd25	no	49
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
4	Foreign Reference	CN102602322A.pdf	756641 2f962b7091d51561cff0d155ce4b83c3d20c1453	no	22
Warnings:					
Information:					
5	Foreign Reference	CN201687513U.pdf	226387 bd1aa982c8e9e1b3d3f9b75a38ad666796b36e4e	no	9
Warnings:					
Information:					
6	Foreign Reference	CN202023547U.pdf	242077 ae7f12a5e0111626416ac63d9496c328546482dc	no	8
Warnings:					
Information:					
7	Non Patent Literature	NPL_1.pdf	569979 fa07922bb2ee2d542cee7270b6bc9a01575ef50a	no	12
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					

8	Non Patent Literature	NPL_2.pdf	445182 339ddab7193a4c87d8a87d76d732f7c3f8ad7fbd	no	9
Warnings:					
Information:					
9	Non Patent Literature	NPL_3.pdf	2634600 5cb5a23f980f25c78b9c04c432b8659abd56aebb	no	68
Warnings:					
Information:					
10	Non Patent Literature	NPL_4.pdf	4418430 7c3949d82a563157c64e7cad804a19f9b22fa4bf	no	20
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
11	Non Patent Literature	NPL_5.pdf	152937 ee9d31e30faee015704fe45bc3fff0913f8c8df8	no	5
Warnings:					
Information:					
12	Non Patent Literature	NPL_6.pdf	4115633 58fd5f51e7bdea0ba14aeba1f86b04988b9a9817	no	60
Warnings:					
Information:					
13	Non Patent Literature	NPL_7.pdf	356270 d5002fc782514d02cc3f46821f8c466c4963f67a	no	5
Warnings:					
Information:					
		Total Files Size (in bytes):	17781520		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:		§	
		§	
Jared Oehring		§	
		§	Attorney Docket No.: 047158.100032
		§	
Serial No.:	16/170,695	§	Confirmation No.: 6906
		§	
Filed:	10/25/2018	§	Art Unit: 3676
		§	
For:	SMART FRACTURING SYSTEM AND METHOD	§	Examiner: Gay, Jennifer Hawkins

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

AMENDMENT

Dear Sir:

In response to the Non-Final Office Action mailed February 12, 2019, Applicants hereby request reconsideration of the above-referenced application for patent, and reconsideration of the rejections in view of the amendments and the following arguments. If any additional fees are necessary for continued prosecution of this Application, the commissioner is hereby authorized to charge those fees to **Hogan Lovells US LLP's Deposit Account Number 501349**.

Amendments to the Claims are reflected in the listing of claims that begin on page 2 of this paper.

Remarks/Arguments begin on page 8 of this paper.

Electronic Acknowledgement Receipt

EFS ID:	36000382
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Sharon Du/Stephanie McDonough
Filer Authorized By:	Sharon Du
Attorney Docket Number:	047158.100032
Receipt Date:	13-MAY-2019
Filing Date:	25-OCT-2018
Time Stamp:	20:48:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		047158-100032_Response.pdf	52740 d006f451327a45800756374a040c27608a6b4d33	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Applicant Arguments/Remarks Made in an Amendment	8	10
	Claims	2	7
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Warnings:			
Information:			
	Total Files Size (in bytes):	52740	

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National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

REMARKS/ARGUMENTS

This amendment is in response to the Non-Final Office Action mailed February 12, 2019. Claims 1-20 are pending in the application. Claims 1, 2, 3, 5, 7, 9, 14, and 16 have been amended. Claim 8 is canceled. Claim 21 is added. No new matter has been introduced in the amendments.

The Examiner rejected claims 2, 3, 5, 6, 8, and 16 under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Next, the Examiner rejected claims 1-7, 11, 12, and 14-18 under 35 U.S.C. 102(a) as anticipated by U.S. Patent Publication No. 2017/0226842 to Omont. ("*Omont*"). The Examiner rejected claims 8-10, 19, and 20 under 35 U.S.C. 103(a) as being unpatentable over Omont in view of U.S Patent Publication No. 2014/0379300 to Devine ("*Devine*"). The Examiner rejected claim 13 under 35 U.S.C. 103(a) as being unpatentable over Omont in view of U.S Patent Publication No. 2014/0095114 to Thomeer ("*Thom*").

I. Claims 2, 3, 5, 6, 8, and 16 are compliant with 35 U.S.C. 112(b).

Without acquiescence, Applicants submit that the above claim amendments overcome the rejections of 2, 3, 5, 6, and 16 under 35 U.S.C. 112(b). Claim 8 is canceled, rendering the rejection of claim 8 moot.

II. Claims 1, 7, and 14 are patentable because Omont fails to teach sensors or controller installed on pumps.

Applicant respectfully submits that Omont does not disclose all elements of the pending claims. Claims 1, 7, and 14 are not anticipated by Omont at least in part because Omont fails to teach "automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions", as recited in claim 7 and generally set forth in claims 1 and 14, as amended. The Office Action admits that "Omont fails to disclose that the method further discloses automatically adjusting or turning off the first pump". The Office Action cites Devine as teaching such. However, Devine only teaches taking a pump out of service, and does not teach *adjusting one or more functions* based on the automated instructions. Thus, Omont and Devine, taken alone or in combination, fail to teach "automatically adjusting one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions", as recited in claim 7 and similarly set forth in claims 1 and 14 as amended. For at least these reasons, claims 1, 7, and 14 are patentable over Omont and Devine, taken alone under 35 U.S.C. 102 or in combination under 35 U.S.C. 103. Accordingly, Applicant respectfully requests withdrawal of the rejection of independent claims 1, 7, and 14.

III. Dependent Claims

Finally, Applicants respectfully submit that dependent claims 2-6, 8-13, and 15-20 are patentable by virtue of their dependence from one or more of claims 1, 7, and 14, as well as for other patentable features recited therein.

CONCLUSION

The foregoing response is full, complete, and timely filed. Amendments to the claims are made without prejudice, including under the doctrine of equivalents. In addition, the comments made herein are without prejudice. Applicants respectfully request reconsideration of the instant application in light of the foregoing response and amendments. Should the Examiner have any questions, comments or suggestions in furtherance of the prosecution of the application, the Examiner is invited to contact the Applicants' representative by telephone or fax.

Respectfully submitted,

Date: May 13, 2019

/Sharon Du/
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Patent Agent for Applicants

Amendments to the Claims

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently Amended) A hydraulic fracturing system, comprising:

a plurality of pumps positioned at a wellsite and configured to pressurize a fracturing fluid;

a distribution system fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection into a wellhead; and

a control system comprising:

a plurality of sensing devices configured to measure one or more parameters of the plurality of pumps and the distribution system;

one or more processing devices configured to receive and ~~analyze~~ the one or more parameters ~~measured by the plurality of sensing devices~~ and detect that a first parameter of the one or more parameters is outside of an acceptable threshold; and generate control instructions based at least in part on the one or more parameters; and

one or more control devices configured to receive the control instructions and ~~control~~ automatically adjust one or more aspects of the plurality of pumps or the distribution system based on the control instructions.

2. (Currently Amended) The system of claim 1, wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and selected from a group including ~~at least one of~~ flow sensors, accelerometers, pressure transducer, [[or]] and tachometers.

3. (Currently Amended) The system of claim 1, wherein the plurality of pumps or the distribution system includes at least one device selected from a group include [[of]] a gate, valve, actuator, motor, suction pipe, discharge pipe, engine, transmission, [[or]] and temperature regulation device, controllable via the one or more control devices.

4. (Original) The system of claim 1, further comprising:

a suction line through which fracturing fluid is supplied; and

a discharge line through which fracturing fluid is discharged, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line.

5. (Currently Amended) The system of claim 1, further comprising:

one or more blenders configured to mix together one or more materials to form the fracturing fluid, wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold, wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow ~~and/or pressure~~ conditions at the one or more blenders, the manifold, the plurality of pumps, or the distribution system.

6. (Original) The system of claim 5, wherein the one or more control device is configured to control the one or more blenders, the manifold, the plurality of pumps and the distribution system based on the flow and/or pressure conditions.

7. (Currently Amended) A hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps;

pumping the fracturing fluid into a distribution system;

injecting the fracturing fluid into a wellhead;

measuring one or more parameters of the plurality of pumps, the distribution system, or the wellhead via a plurality of sensing devices instrumented thereon;

detecting that a first parameter of the one or more parameters is outside of an acceptable threshold;

generating automated instructions for one or more control devices based at least in part on the one or more parameters; and

automatically adjusting ~~controlling~~ one or more functions of the plurality of pumps, the distribution system, or the wellhead based at least in part on the automated instructions.

8. (Canceled)

9. (Currently Amended) The method of claim 8, further comprising:

detecting that a first pump of the plurality of pumps is underperforming; and

adjusting one or more of the ~~other~~ pumps in the plurality of pumps to compensate for the first pump.

10. (Original) The method of claim 9, further comprising:

selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters.

11. (Original) The method of claim 7, further comprising:

determining that the one or more parameters are indicative of a potential failure condition; and

determining a source of the potential failure condition.

12. (Original) The method of claim 11, further comprising:

generating an alert or notification indicative of the potential failure condition and the source.

13. (Original) The method of claim 7, further comprising:

logging operation data including a number of strokes and pumping hours performed by a pump of the plurality of pumps; and

determining a maintenance schedule based at least in part on the operation data.

14. (Currently Amended) A hydraulic fracturing method, comprising:

receiving a first data from a first sensing device of a pump system of a hydraulic fracturing system, the first data indicative of a condition of the pump system;

receiving second data from a second sensing device of a blender system of the hydraulic fracturing system, the blender system mixing together materials to form a fracturing fluid and delivering the fracturing fluid to the pump system, and the second data indicative of a condition of the blender system;

detecting that at least one of the first and second data is outside of an acceptable threshold;

generating automated instructions for one or more control devices installed on of the pump system or the blender system based at least in part on the first and second data; and

~~controlling~~ automatically adjusting one or more functions of the pump system or the blender system based at least in part on the automated instructions.

15. (Original) The method of claim 14, wherein the pump system comprises:

one or more pumps; and

a distribution system that receives and consolidates the fracturing fluid from the one or more pumps for injection into a wellhead.

16. (Currently Amended) The method of claim [[17]] 15, further comprising:

controlling one or more functions of the distribution system based on the automated instructions.

17. (Original) The method of claim 14, wherein the pump system comprises a plurality of pumps, and the first data includes measurements of each of the plurality of pumps.

18. (Original) The method of claim 17, further comprising:

controlling one or more of the plurality of pumps individually based on the automated instructions.

19. (Original) The method of claim 18, further comprising:

detecting that a measurement associated with a first pump of the plurality of pumps is outside of an acceptable threshold; and

automatically taking the first pump offline in response to the detection.

20. (Original) The method of claim 19, further comprising:

adjusting one or more of the other pumps in the plurality of pumps to compensate for taking the first pump offline.

21. (New) The method of claim 7, further comprising:

transmitting the first parameter from a first device of the plurality of pumps, the distribution system, or the wellhead to a second device of the plurality of the plurality of pumps, the distribution system, or the wellhead;

generating the automated instructions at the second device; and

automatically adjusting one or more functions of the second devices based on the automated instructions.

PTO/SB/06 (09-11)
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APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
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APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	05/13/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
16/170,695	10/25/2018	Jared Oehring	047158.100032

CONFIRMATION NO. 6906

132858
Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

PUBLICATION NOTICE

OC000000107680646

Title:SMART FRACTURING SYSTEM AND METHOD

Publication No.US-2019-0120024-A1
Publication Date:04/25/2019

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Application Number	16170695
Filing Date	2018-10-25
First Named Inventor	Jared Oehring
Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

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	2	8851860		2014-10-07	Mail	
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	Examiner Name	Jennifer Hawkins Gay
	Attorney Docket Number	047158.100032

	3	20090045782		2009-02-19	Datta		
	4	20070131410		2007-06-14	Hill		
	5	20160341281		2016-11-24	Onesubsea IP UK Limited		
	6	20170051732		2017-02-23	Baker Hughes Incorporated		
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Art Unit	3676
Examiner Name	Jennifer Hawkins Gay
Attorney Docket Number	047158.100032

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	1	Office Action mailed January 30, 2019 in related Canadian Patent Application No. 2,936,997	☒
	2	International Search Report and Written Opinion mailed February 15, 2019 in related PCT Application No. PCT/US18/63977	☒
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	Filing Date	2018-10-25
	First Named Inventor	Jared Oehring
	Art Unit	3676
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Name/Print	Taylor P. Evans	Registration Number	60506

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CA 2833711 A1 2014/05/16

(21) 2 833 711

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2013/11/15

(41) Mise à la disp. pub./Open to Public Insp.: 2014/05/16

(30) Priorité/Priority: 2012/11/16 (US13/679,689)

(51) Cl.Int./Int.Cl. *E21B 43/26* (2006.01),
E21B 43/12 (2006.01)

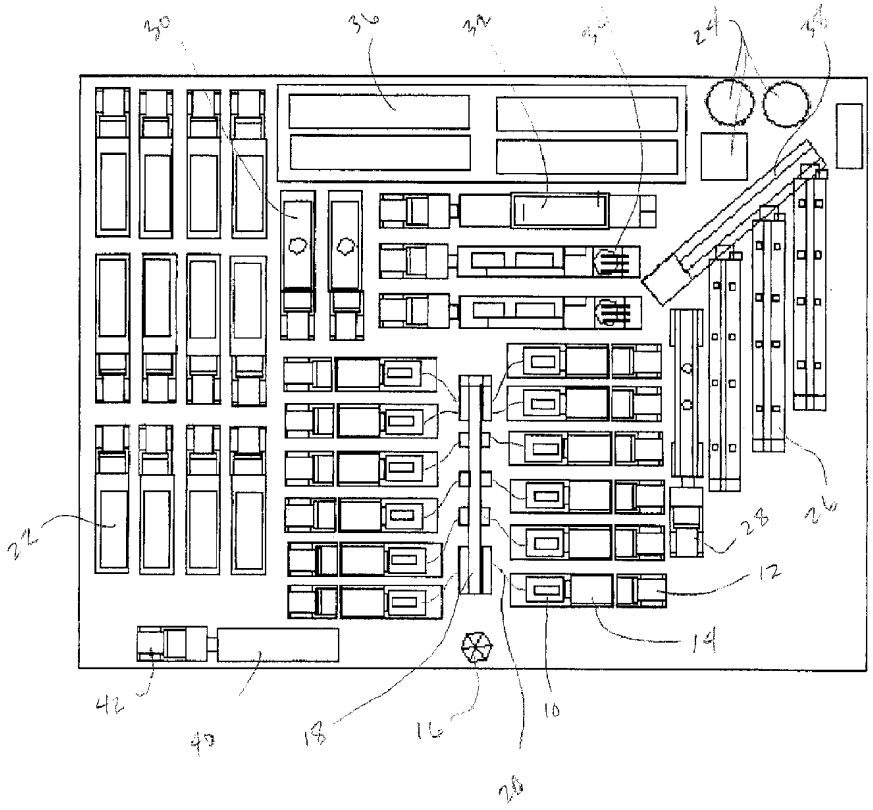
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(54) Titre : SYSTEME POUR POMPAGE DE FLUIDE DE FRACTIONNEMENT HYDRAULIQUE AU MOYEN DE POMPES ELECTRIQUES

(54) Title: SYSTEM FOR PUMPING HYDRAULIC FRACTURING FLUID USING ELECTRIC PUMPS



(57) Abrégé/Abstract:
A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a plurality of

(21) 2 833 711

(13) A1

(57) Abrégé(suite)/Abstract(continued):
electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the, and fractures the formation. The system can also include a plurality of natural gas powered generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps.

ABSTRACT

A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a plurality of electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the, and fractures the formation. The system can also include a plurality of natural gas powered generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps.

SYSTEM FOR PUMPING HYDRAULIC FRACTURING FLUID USING ELECTRIC PUMPS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This technology relates to hydraulic fracturing in oil and gas wells. In particular, this technology relates to pumping fracturing fluid into an oil or gas well using pumps powered by electric motors.

2. Brief Description of Related Art

[0002] Hydraulic fracturing has been used for decades to stimulate production from conventional oil and gas wells. The practice consists of pumping fluid into a wellbore at high pressure. Inside the wellbore, the fluid is forced into the formation being produced. When the fluid enters the formation, it fractures, or creates fissures, in the formation. Water, as well as other fluids, and some solid proppants, are then pumped into the fissures to stimulate the release of oil and gas from the formation.

[0003] Fracturing rock in a formation requires that the fracture fluid be pumped into the wellbore at very high pressure. This pumping is typically performed by large diesel-powered pumps. Such pumps are able to pump fracturing fluid into a wellbore at a high enough pressure to crack the formation, but they also have drawbacks. For example, the diesel pumps are very heavy, and thus must be moved on heavy duty trailers, making transport of the pumps between oilfield sites expensive and inefficient. In addition, the diesel engines required to drive the pumps require a relatively high level of expensive maintenance. Furthermore, the cost of diesel fuel is much higher than in the past, meaning that the cost of running the pumps has increased.

[0004] What is needed therefore, is a pump system for hydraulic fracturing fluid that overcomes the problems associated with diesel pumps.

SUMMARY OF THE INVENTION

[0005] Disclosed herein is a system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a plurality of electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation. The system also includes a plurality of generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps. At least some of the plurality of generators can be powered by natural gas. In addition, at least some of the plurality of generators can be turbine generators.

[0006] In one embodiment, the system further includes an A/C console and a variable frequency drive that controls the speed of the pumps. Furthermore, the electric pumps, as well as the electric generators, can be mounted on vehicles, and can be ported from one well to another. The vehicles can be trucks and can have at least five axles.

[0007] Further disclosed herein is a system for fracturing a rock formation in an oil or gas well by pumping hydraulic fracturing fluid into the well that includes a pump, an electric motor, a variable frequency drive, and a natural gas powered electric generator. The pump is configured for pumping the hydraulic fracturing fluid into the well, and then from the well into the formation, and is capable of pumping the hydraulic fracturing fluid at high pressure to crack the formation. The electric motor can have a high-strength steel or steel alloy shaft attached to the pump and configured to drive the pump. The variable frequency drive can be connected to the electric motor to control the speed of the motor. In addition, the natural gas powered generator,

which can be a turbine generator, can be connected to the electric motor and provide electric power to the electric motor.

[0008] In one embodiment, the pump can be a triplex or a quinteplex pump, optionally rated at about 2250 hydraulic horsepower or more. In addition, the pump can also have 4.5 inch diameter plungers with an eight inch stroke. In another embodiment, the electric motor can have a maximum continuous power output of about 1500 brake horsepower, 1750 brake horsepower, or more, and a maximum continuous torque of about 8750 lb-ft or more. Furthermore, the electric motor can have a high temperature rating of about 1100 degrees C or more, and a shaft composed of 4340 alloy steel.

[0009] In another embodiment, variable frequency drive can frequently perform electric motor diagnostics to prevent damage to the electric motor if it becomes grounded or shorted. In addition, the variable frequency drive can include power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat.

[0010] Also disclosed herein is a system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation. The system includes a trailer for attachment to a truck. Two or more electric pumps can be attached to the trailer and are fluidly connected to the well, the electric pumps configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation. One or more electric motors are attached to the electric pumps to drive the pumps. The electric motors can also be attached to the trailer. A natural gas powered generator is provided for connection to the electric motor to provide electric power to the electric motor. The

system of claim can further include a variable frequency drive attached to the trailer and connected to the electric motor to control the speed of the motor. In addition, the system can include a skid to which at least one of the electric pumps, the one or more electric motors, and the variable frequency drives are attached.

[0011] Also disclosed herein is a process for stimulating an oil or gas well by hydraulically fracturing a formation in the well. The process includes the steps of pumping fracturing fluid into the well with an electrically powered pump at a high pressure so that the fracturing fluid enters and cracks the formation, the fracturing fluid having at least a liquid component and a solid proppant, and inserting the solid proppant into the cracks to maintain the cracks open, thereby allowing passage of oil and gas through the cracks. The process can further include powering the electrically powered pump with a natural gas generator, such as, for example, a turbine generator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present technology will be better understood on reading the following detailed description of nonlimiting embodiments thereof, and on examining the accompanying drawing, in which:

[0013] Fig. 1 is a schematic plan view of equipment used in a hydraulic fracturing operation, according to an embodiment of the present technology; and

[0014] Fig. 2 is a schematic plan view of equipment used in a hydraulic fracturing operation, according to an alternate embodiment of the present technology.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The foregoing aspects, features, and advantages of the present technology will be further appreciated when considered with reference to the following description of preferred embodiments and accompanying drawing, wherein like reference numerals represent like elements. In describing the preferred embodiments of the technology illustrated in the appended drawing, specific terminology will be used for the sake of clarity. However, the technology is not intended to be limited to the specific terms used, and it is to be understood that each specific term includes equivalents that operate in a similar manner to accomplish a similar purpose.

[0016] Fig. 1 shows a plan view of equipment used in a hydraulic fracturing operation. Specifically, there is shown a plurality of pumps 10 mounted to pump vehicles 12. The pump vehicles 12 can be trucks having at least five axles. In the embodiment shown, the pumps 10 are powered by electric motors 14, which can also be mounted to the pump vehicles 12. The pumps 10 are fluidly connected to the wellhead 16 via the missile 18. As shown, the pump vehicles 12 can be positioned near enough to the missile 18 to connect fracturing fluid lines 20 between the pumps 10 and the missile 18. The missile 18 is then connected to the wellhead 16 and configured to deliver fracturing fluid provided by the pumps 10 to the wellhead 16.

[0017] In some embodiments, each electric motor 14 can be capable of delivering about 1500 brake horsepower (BHP), 1750 BHP, or more, and each pump 10 can optionally be rated for about 2250 hydraulic horsepower (HHP) or more. In addition, the components of the system, including the pumps 10 and the electric motors 14, can be capable of operating during prolonged pumping operations, and in temperature in a range of about 0 degrees C or less to about 55 degrees C or more. In addition, each electric motor 14 can be equipped with a variable

frequency drive (VFD), and an A/C console, that controls the speed of the electric motor 14, and hence the speed of the pump 10.

[0018] The electric motors 14 of the present technology can be designed to withstand an oilfield environment. Specifically, some pumps 10 can have a maximum continuous power output of about 1500 BHP, 1750 BHP, or more, and a maximum continuous torque of about 8750 lb-ft or more. Furthermore, electric motors 14 of the present technology can include class H insulation and high temperature ratings, such as about 1100 degrees C or more. In some embodiments, the electric motor 14 can include a single shaft extension and hub for high tension radial loads, and a high strength 4340 alloy steel shaft, although other suitable materials can also be used.

[0019] The VFD can be designed to maximize the flexibility, robustness, serviceability, and reliability required by oilfield applications, such as hydraulic fracturing. For example, as far as hardware is concerned, the VFD can include packaging receiving a high rating by the National Electrical Manufacturers Association (such as nema 1 packaging), and power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat. 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.

[0020] In some embodiments, the pump 10 can optionally be a 2250 HHP triplex or quinteplex pump. The pump 10 can optionally be equipped with 4.5 inch diameter plungers that have an

eight (8) inch stroke, although other size plungers can be used, depending on the preference of the operator. The pump 10 can further include additional features to increase its capacity, durability, and robustness, including, for example, a 6.353 to 1 gear reduction, autuofrettaged steel or steel alloy fluid end, wing guided slush type valves, and rubber spring loaded packing.

[0021] In addition to the above, certain embodiments of the present technology can include a skid (not shown) for supporting some or all of the above-described equipment. For example, the skid can support the electric motor 14 and the pump 10. In addition, the skid can support the VFD. Structurally, the skid can be constructed of heavy-duty longitudinal beams and cross-members made of an appropriate material, such as, for example, steel. The skid can further include heavy-duty lifting lugs, or eyes, that can optionally be of sufficient strength to allow the skid to be lifted at a single lift point.

[0022] Referring back to Fig. 1, also included in the equipment is a plurality of electric generators 22 that are connected to, and provide power to, the electric motors 14 on the pump vehicles 12. To accomplish this, the electric generators 22 can be connected to the electric motors 14 by power lines (not shown). The electric generators 22 can be connected to the electric motors 14 via power distribution panels (not shown). In certain embodiments, the electric generators 22 can be powered by natural gas. For example, the generators can be powered by liquefied natural gas. The liquefied natural gas can be converted into a gaseous form in a vaporizer prior to use in the generators. The use of natural gas to power the electric generators 22 can be advantageous because, where the well is a natural gas well, above ground natural gas vessels 24 can already be placed on site to collect natural gas produced from the well. Thus, a portion of this natural gas can be used to power the electric generators 22, thereby reducing or eliminating the need to import fuel from offsite. If desired by an operator, the

electric generators 22 can optionally be natural gas turbine generators, such as those shown in Fig. 2.

[0023] Fig. 1 also shows equipment for transporting and combining the components of the hydraulic fracturing fluid used in the system of the present technology. In many wells, the fracturing fluid contains a mixture of water, sand or other proppant, acid, and other chemicals. Examples of fracturing fluid components include acid, anti-bacterial agents, clay stabilizers, corrosion inhibitors, friction reducers, gelling agents, iron control agents, pH adjusting agents, scale inhibitors, and surfactants. Historically, diesel has at times been used as a substitute for water in cold environments, or where a formation to be fractured is water sensitive, such as, for example, clay. The use of diesel, however, has been phased out over time because of price, and the development of newer, better technologies.

[0024] In Fig. 1, there are specifically shown sand transporting vehicles 26, an acid transporting vehicle 28, vehicles for transporting other chemicals 30, and a vehicle carrying a hydration unit 32, such as, for example, a water pump. Also shown are fracturing fluid blenders 34, which can be configured to mix and blend the components of the hydraulic fracturing fluid, and to supply the hydraulic fracturing fluid to the pumps 10. In the case of liquid components, such as water, acids, and at least some chemicals, the components can be supplied to the blenders 34 via fluid lines (not shown) from the respective component vehicles, or from the hydration unit 32. In the case of solid components, such as sand, the component can be delivered to the blender 34 by a conveyor belt 38. The water can be supplied to the hydraulic unit 32 from, for example, water tanks 36 onsite. Alternately, the water can be provided by water trucks. Furthermore, water can be provided directly from the water tanks 36 or water trucks to the blender 34, without first passing through the hydration unit 32.

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[0025] Pump control and data monitoring equipment 40 can be mounted on a control vehicle 42, and connected to the pumps 10, electric motors 14, blenders 34, and other downhole sensors and tools (not shown) to provide information to an operator, and to allow the operator to control different parameters of the fracturing operation. For example, the pump control and data monitoring equipment 40 can include an A/C console that controls the VFD, and thus the speed of the electric motor 14 and the pump 10. Other pump control and data monitoring equipment can include pump throttles, a pump VFD fault indicator with a reset, a general fault indicator with a reset, a main estop, a programmable logic controller for local control, and a graphics panel. The graphics panel can include, for example, a touchscreen interface.

[0026] Referring now to Fig. 2, there is shown an alternate embodiment of the present technology. Specifically, there is shown a plurality of pumps 110 which, in this embodiment, are mounted to pump trailers 112. As shown, the pumps 110 can optionally be loaded two to a trailer 112, thereby minimizing the number of trailers needed to place the requisite number of pumps at a site. The ability to load two pumps 110 on one trailer 112 is possible because of the relatively light weight of the electric pumps 110 compared to other known pumps, such as diesel pumps. In the embodiment shown, the pumps 110 are powered by electric motors 114, which can also be mounted to the pump trailers 112. Furthermore, each electric motor 114 can be equipped with a VFD, and an A/C console, that controls the speed of the motor 114, and hence the speed of the pumps 110.

[0027] In addition to the above, the embodiment of Fig. 2 can include a skid (not shown) for supporting some or all of the above-described equipment. For example, the skid can support the electric motors 114 and the pumps 110. In addition, the skid can support the VFD. Structurally, the skid can be constructed of heavy-duty longitudinal beams and cross-members made of an

appropriate material, such as, for example, steel. The skid can further include heavy-duty lifting lugs, or eyes, that can optionally be of sufficient strength to allow the skid to be lifted at a single lift point.

[0028] The pumps 110 are fluidly connected to a wellhead 116 via a missile 118. As shown, the pump trailers 112 can be positioned near enough to the missile 118 to connect fracturing fluid lines 120 between the pumps 110 and the missile 118. The missile 118 is then connected to the wellhead 116 and configured to deliver fracturing fluid provided by the pumps 110 to the wellhead 116.

[0029] Still referring to Fig. 2, this embodiment also includes a plurality of turbine generators 122 that are connected to, and provide power to, the electric motors 114 on the pump trailers 112. To accomplish this, the turbine generators 122 can be connected to the electric motors 114 by power lines (not shown). The turbine generators 122 can be connected to the electric motors 114 via power distribution panels (not shown). In certain embodiments, the turbine generators 122 can be powered by natural gas, similar to the electric generators 22 discussed above in reference to the embodiment of Fig. 1. Also included are control units 144 for the turbine generators 122.

[0030] The embodiment of Fig. 2 can include other equipment similar to that discussed above. For example, Fig. 2 shows sand transporting vehicles 126, acid transporting vehicles 128, other chemical transporting vehicles 130, hydration units 132, blenders 134, water tanks 136, conveyor belts 138, and pump control and data monitoring equipment 140 mounted on a control vehicle 142. The function and specifications of each of these is similar to corresponding elements shown in Fig. 1.

[0031] Use of pumps 10, 110 powered by electric motors 14, 114 and natural gas powered electric generators 22 (or turbine generators 122) to pump fracturing fluid into a well is advantageous over known systems for many different reasons. For example, the equipment (e.g. pumps, electric motors, and generators) is lighter than the diesel pumps commonly used in the industry. The lighter weight of the equipment allows loading of the equipment directly onto a truck body. In fact, where the equipment is attached to a skid, as described above, the skid itself can be lifted on the truck body, along with all the equipment attached to the skid, in one simple action. Alternatively, and as shown in Fig. 2, trailers 112 can be used to transport the pumps 110 and electric motors 114, with two or more pumps 110 carried on a single trailer 112. Thus, the same number of pumps 110 can be transported on fewer trailers 112. Known diesel pumps, in contrast, cannot be transported directly on a truck body or two on a trailer, but must be transported individually on trailers because of the great weight of the pumps.

[0032] The ability to transfer the equipment of the present technology directly on a truck body or two to a trailer increases efficiency and lowers cost. In addition, by eliminating or reducing the number of trailers to carry the equipment, the equipment can be delivered to sites having a restricted amount of space, and can be carried to and away from worksites with less damage to the surrounding environment. Another reason that the electric pump system of the present technology is advantageous is that it runs on natural gas. Thus, the fuel is lower cost, the components of the system require less maintenance, and emissions are lower, so that potentially negative impacts on the environment are reduced.

[0033] In practice, a hydraulic fracturing operation can be carried out according to the following process. First, the water, sand, and other components are blended to form a fracturing fluid, which is pumped down the well by the electric-powered pumps. Typically, the well is designed

so that the fracturing fluid can exit the wellbore at a desired location and pass into the surrounding formation. For example, in some embodiments the wellbore can have perforations that allow the fluid to pass from the wellbore into the formation. In other embodiments, the wellbore can include an openable sleeve, or the well can be open hole. The fracturing fluid can be pumped into the wellbore at a high enough pressure that the fracturing fluid cracks the formation, and enters into the cracks. Once inside the cracks, the sand, or other proppants in the mixture, wedges in the cracks, and holds the cracks open.

[0034] Using the pump control and data monitoring equipment 40, the operator can monitor, gauge, and manipulate parameters of the operation, such as pressures, and volumes of fluids and proppants entering and exiting the well. For example, the operator can increase or decrease the ratio of sand to water as the fracturing process progresses and circumstances change.

[0035] This process of injecting fracturing fluid into the wellbore can be carried out continuously, or repeated multiple times in stages, until the fracturing of the formation is optimized. Optionally, the wellbore can be temporarily plugged between each stage to maintain pressure, and increase fracturing in the formation. Generally, the proppant is inserted into the cracks formed in the formation by the fracturing, and left in place in the formation to prop open the cracks and allow oil or gas to flow into the wellbore.

[0036] While the technology has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the technology. Furthermore, it is to be understood that the above disclosed embodiments are merely illustrative of the principles and applications of the present technology. Accordingly, numerous modifications can be made to the illustrative

embodiments and other arrangements can be devised without departing from the spirit and scope of the present technology as defined by the appended claims.

What is claimed is:

1. A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

a plurality of electric pumps fluidly connected to the well, and configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation; and

a plurality of generators electrically connected to the plurality of electric pumps to provide electrical power to the pumps.

2. The system of claim 1, wherein at least some of the plurality of generators are powered by natural gas.

3. The system of claim 1, wherein at least some of the plurality of generators are turbine generators.

4. The system of claim 1, further comprising:

an A/C console and a variable frequency drive that controls the speed of the pumps.

5. The system of claim 1, wherein the electric pumps are mounted on vehicles, and can be ported from one well to another.

6. The system of claim 5, wherein the generators are mounted on vehicles, and can be ported from one well to another.

7. The system of claim 6, wherein the vehicles are trucks having at least five axles.

8. A system for fracturing a rock formation in an oil or gas well by pumping hydraulic fracturing fluid into the well, the system comprising:

a pump for pumping the hydraulic fracturing fluid into the well, and then from the well into the formation, the pump capable of pumping the hydraulic fracturing fluid at high pressure to crack the formation;

an electric motor having a high-strength steel or steel alloy shaft attached to the pump and configured to drive the pump;

a variable frequency drive connected to the electric motor to control the speed of the motor; and

a natural gas powered generator connected to the electric motor that provides electric power to the electric motor.

9. The system of claim 8, wherein the pump is a triplex or a quinteplex pump rated at about 2250 hydraulic horsepower or more.

10. The system of claim 9, wherein the pump has 4.5 inch diameter plungers with an eight inch stroke.

11. The system of claim 8, wherein the electric motor has a maximum continuous power output of about 1750 brake horsepower or more.

12. The system of claim 11, wherein the electric motor has a maximum continuous torque of about 8750 lb-ft or more.

13. The system of 12, wherein the electric motor has a high temperature rating of about 1100 degrees C or more.

14. The system of 13, wherein the shaft of the electric motor is composed of 4340 alloy steel.

15. The system of 8, wherein the variable frequency drive frequently performs electric motor diagnostics to prevent damage to the electric motor if it becomes grounded or shorted.

16. The system of 15, wherein the natural gas powered generator is a turbine generator.

17. The system of 8, wherein the variable frequency drive includes power semiconductor heat sinks having one or more thermal sensors monitored by a microprocessor to prevent semiconductor damage caused by excessive heat.

18. A system for hydraulically fracturing an underground formation in an oil or gas well to extract oil or gas from the formation, the oil or gas well having a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

a trailer for attachment to a truck;

two or more electric pumps attached to the trailer and fluidly connected to the well, the electric pumps configured to pump fluid into the wellbore at high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation;

one or more electric motors attached to the electric pumps to drive the pumps, the electric motors attached to the trailer; and

a natural gas powered generator for connection to the electric motor that provides electric power to the electric motor.

19. The system of claim 18, further comprising:

a variable frequency drive attached to the trailer and connected to the electric motor to control the speed of the motor.

20. The system of claim 18, further comprising:

a skid to which at least one of the electric pumps, the one or more electric motors, and the variable frequency drives are attached.

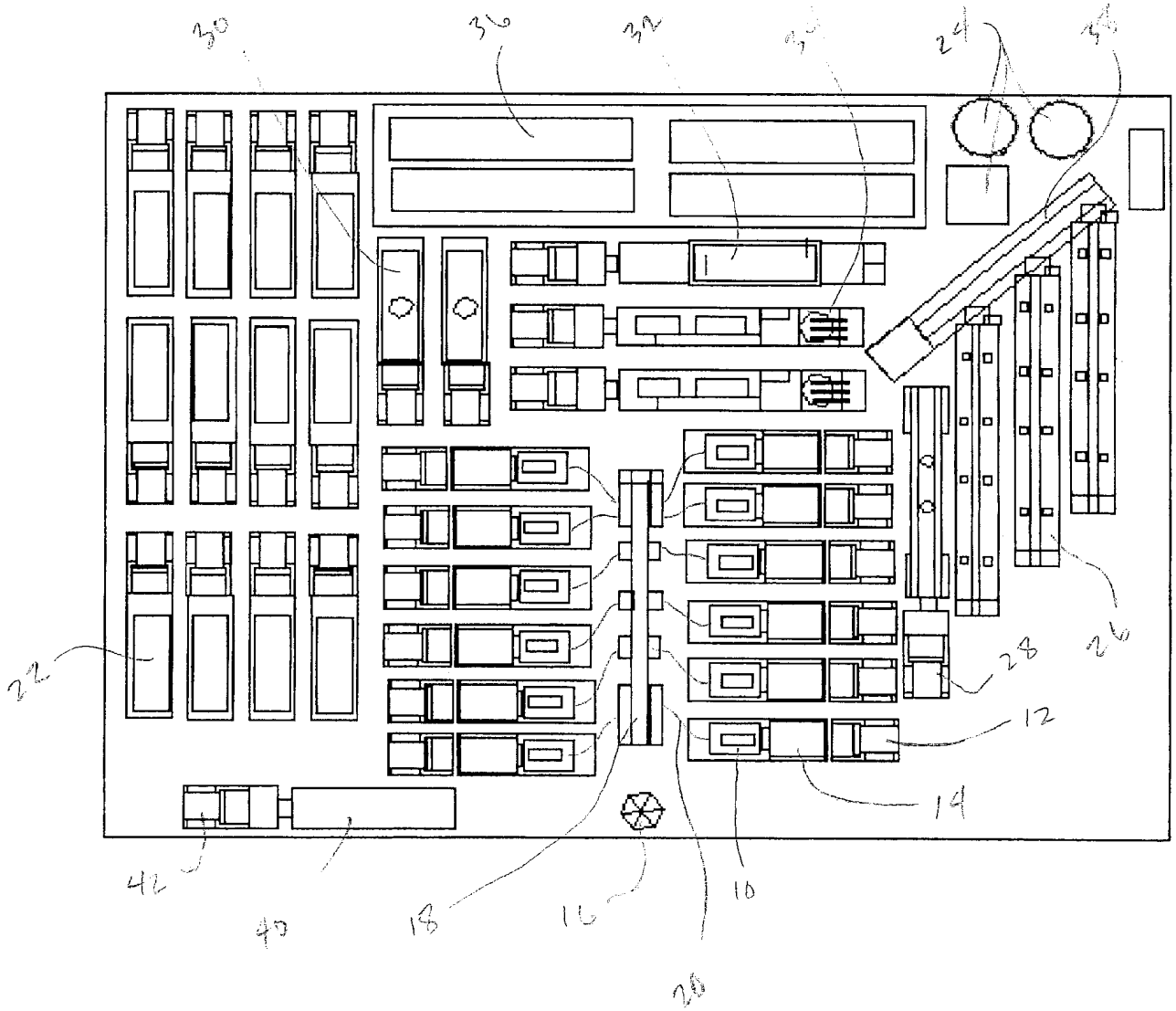


FIG. 1

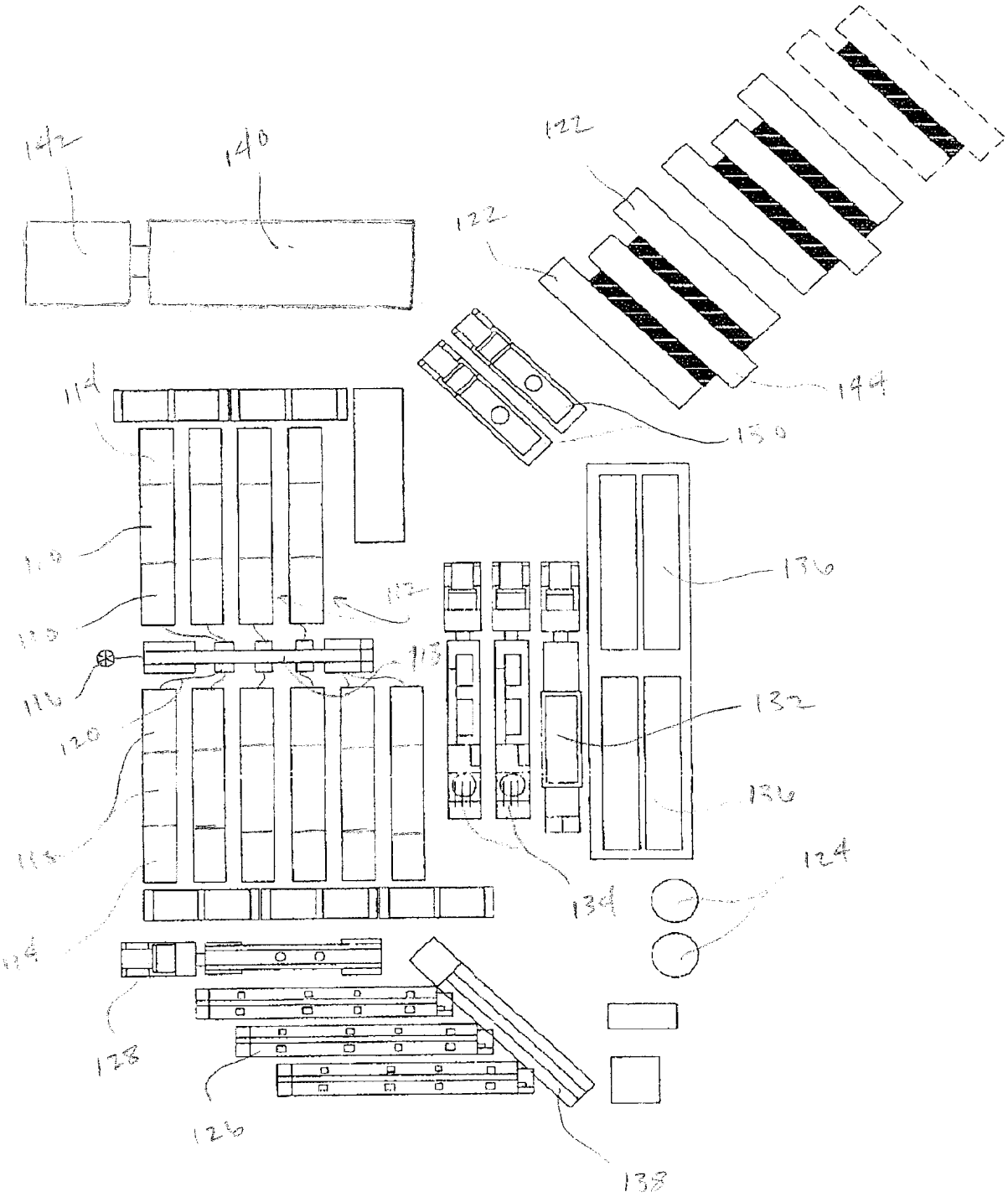
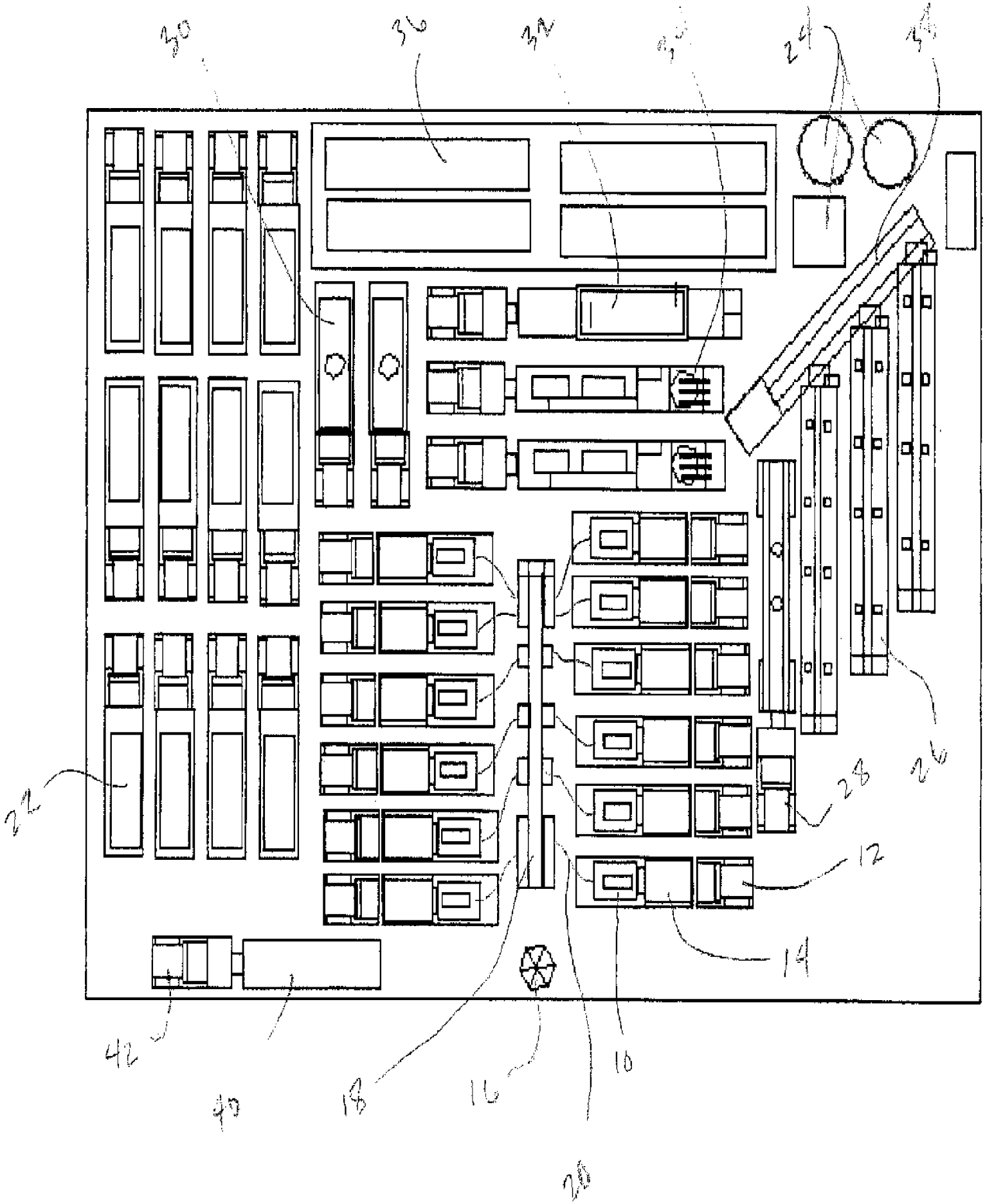

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FIG. 2


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CA 2955706 A1 2012/10/07

(21) 2 955 706

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2012/04/10

(41) Mise à la disp. pub./Open to Public Insp.: 2012/10/07

(62) Demande originale/Original Application: 2 835 904

(30) Priorité/Priority: 2011/04/07 (US61/472,861)

(51) Cl.Int./Int.Cl. *E21B 43/26* (2006.01),
E21B 41/00 (2006.01)

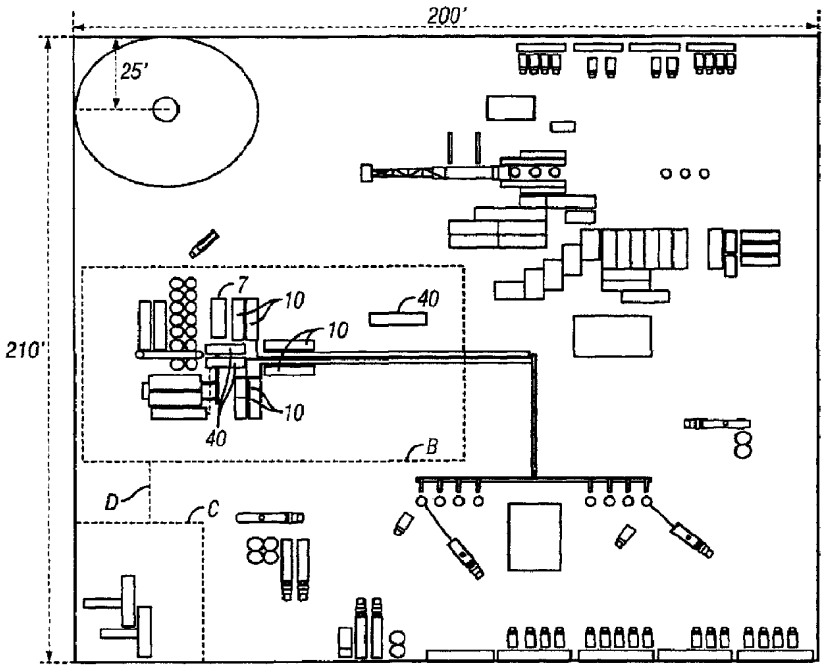
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(54) Titre : SYSTEME ELECTRIQUE MOBILE ET MODULAIRE UTILISE POUR FRACTURER DES FORMATIONS SOUTERRAINES

(54) Title: MOBILE, MODULAR, ELECTRICALLY POWERED SYSTEM FOR USE IN FRACTURING UNDERGROUND FORMATIONS



(57) Abrégé/Abstract:
The present invention provides a method and system for providing on-site electrical power to a fracturing operation, and an electrically powered fracturing system. Natural gas can be used to drive a turbine generator in the production of electrical power. A scalable, electrically powered fracturing fleet is provided to pump fluids for the fracturing operation, obviating the need for a constant supply of diesel fuel to the site and reducing the site footprint and infrastructure required for the fracturing operation, when compared with conventional systems.

ABSTRACT

The present invention provides a method and system for providing on-site electrical power to a fracturing operation, and an electrically powered fracturing system. Natural gas can be used to drive a turbine generator in the production of electrical power. A scalable, electrically powered fracturing fleet is provided to pump fluids for the fracturing operation, obviating the need for a constant supply of diesel fuel to the site and reducing the site footprint and infrastructure required for the fracturing operation, when compared with conventional systems.

MOBILE, MODULAR, ELECTRICALLY POWERED SYSTEM FOR USE IN FRACTURING UNDERGROUND FORMATIONS

[0001] This application is a divisional application of Canadian Patent Application No. 2,835,904 filed April 10, 2012 which is a divisional of Canadian Patent Application No. 2,773,843 filed April 10, 2012.

BACKGROUND

2. Field of Invention

[0002] This invention relates generally to hydraulic stimulation of underground hydrocarbon-bearing formations, and more particularly, to the generation and use of electrical power to deliver fracturing fluid to a wellbore.

3. Description of the Related Art

[0003] Over the life cycle of a typical hydrocarbon-producing wellbore, various fluids (along with additives, proppants, gels, cement, etc...) can be delivered to the wellbore under pressure and injected into the wellbore. Surface pumping systems must be able to accommodate these various fluids. Such pumping systems are typically mobilized on skids or tractor-trailers and powered using diesel motors.

[0004] Technological advances have greatly improved the ability to identify and recover unconventional oil and gas resources. Notably, horizontal drilling and multi-stage fracturing have led to the emergence of new opportunities for natural gas production from shale formations. For example, more than twenty

fractured intervals have been reported in a single horizontal wellbore in a tight natural gas formation. However, significant fracturing operations are required to recover these resources.

[0005] Currently contemplated natural gas recovery opportunities require considerable operational infrastructure, including large investments in fracturing equipment and related personnel. Notably, standard fluid pumps require large volumes of diesel fuel and extensive equipment maintenance programs. Typically, each fluid pump is housed on a dedicated truck and trailer configuration. With average fracturing operations requiring as many as fifty fluid pumps, the on-site area, or "footprint", required to accommodate these fracturing operations is massive. As a result, the operational infrastructure required to support these fracturing operations is extensive. Greater operational efficiencies in the recovery of natural gas would be desirable.

[0006] When planning large fracturing operations, one major logistical concern is the availability of diesel fuel. The excessive volumes of diesel fuel required necessitates constant transportation of diesel tankers to the site, and results in significant carbon dioxide emissions. Others have attempted to decrease fuel consumption and emissions by running large pump engines on "Bi-Fuel", blending natural gas and diesel fuel together, but with limited success. Further, attempts to decrease the number of personnel on-site by implementing remote monitoring and operational control have not been successful, as personnel are still required on-site to transport the equipment and fuel to and from the location.

SUMMARY

[0007] Various illustrative embodiments of a system and method for hydraulic stimulation of underground hydrocarbon-bearing formations are provided herein. In accordance with an aspect of the disclosed subject matter, a method of delivering fracturing fluid to a wellbore is provided. The method can comprise the steps of: providing a dedicated source of electric power at a site containing a wellbore to be fractured; providing one or more electric fracturing modules at the site, each electric fracturing module comprising an electric motor and a coupled fluid pump, each electric motor operatively associated with the dedicated source of electric power; providing a wellbore treatment fluid for pressurized delivery to a wellbore, wherein the wellbore treatment fluid can be continuous with the fluid pump and with the wellbore; and operating the fracturing unit using electric power from the dedicated source to pump the treatment fluid to the wellbore.

[0008] In certain illustrative embodiments, the dedicated source of electrical power is a turbine generator. A source of natural gas can be provided, whereby the natural gas drives the turbine generator in the production of electrical power. For example, natural gas can be provided by pipeline, or natural gas produced on-site. Liquid fuels such as condensate can also be provided to drive the turbine generator.

[0009] In certain illustrative embodiments, the electric motor can be an AC permanent magnet motor and/or a variable speed motor. The electric motor can be capable of operation in the range of up to 1500 rpms and up to 20,000 ft/lbs of torque. The pump can be a triplex or quintiplex plunger style fluid pump.

[0010] In certain illustrative embodiments, the method can further comprise the steps of: providing an electric blender module continuous and/or operatively associated with the fluid pump, the blender module comprising: a fluid source, a fluid additive source, and a centrifugal blender tub, and supplying electric

power from the dedicated source to the blender module to effect blending of the fluid with fluid additives to generate the treatment fluid.

[0011] In accordance with another aspect of the disclosed subject matter, a system for use in delivering pressurized fluid to a wellbore is provided. The system can comprise: a well site comprising a wellbore and a dedicated source of electricity; an electrically powered fracturing module operatively associated with the dedicated source of electricity, the electrically powered fracturing module comprising an electric motor and a fluid pump coupled to the electric motor; a source of treatment fluid, wherein the treatment fluid can be continuous with the fluid pump and with the wellbore; and a control system for regulating the fracturing module in delivery of treatment fluid from the treatment fluid source to the wellbore.

[0012] In certain illustrative embodiments, the source of treatment fluid can comprise an electrically powered blender module operatively associated with the dedicated source of electricity. The system can further comprise a fracturing trailer at the well site for housing one or more fracturing modules. Each fracturing module can be adapted for removable mounting on the trailer. The system can further comprise a replacement pumping module comprising a pump and an electric motor, the replacement pumping module adapted for removable mounting on the trailer. In certain illustrative embodiments, the replacement pumping module can be a nitrogen pumping module, or a carbon dioxide pumping module. The replacement pumping module can be, for example, a high torque, low rate motor or a low torque, high rate motor.

[0013] In accordance with another aspect of the disclosed subject matter, a fracturing module for use in delivering pressurized fluid to a wellbore is provided. The fracturing module can comprise: an AC permanent magnet motor capable of operation in the range of up to 1500 rpms and up to 20,000 ft/lbs of torque; and a plunger-style fluid pump coupled to the motor.

[0014] In accordance with another aspect of the disclosed subject matter, a method of blending a fracturing fluid for delivery to a wellbore to be fractured is provided. A dedicated source of electric power can be provided at a site containing a wellbore to be fractured. At least one electric blender module can be provided at the site. The electric blender module can include a fluid source, a fluid additive source, and a blender tub. Electric power can be supplied from the dedicated source to the electric blender module to effect blending of a fluid from the fluid source with a fluid additive from the fluid additive source to generate the fracturing fluid. The dedicated source of electrical power can be a turbine generator. A source of natural gas can be provided, wherein the natural gas is used to drive the turbine generator in the production of electrical power. The fluid from the fluid source can be blended with the fluid additive from the fluid additive source in the blender tub. The electric blender module can also include at least one electric motor that is operatively associated with the dedicated source of electric power and that effects blending of the fluid from the fluid source with the fluid additive from the fluid additive source.

[0015] In certain illustrative embodiments, the electric blender module can include a first electric motor and a second electric motor, each of which is operatively associated with the dedicated source of electric power. The first electric motor can effect delivery of the fluid from the fluid source to the blending tub. The second electric motor can effect blending of the fluid from the fluid source with the fluid additive from the fluid additive source in the blending tub. In certain illustrative embodiments, an optional third electric motor may also be present, that can also be operatively associated with the dedicated source of electric power. The third electric motor can effect delivery of the fluid additive from the fluid additive source to the blending tub.

[0016] In certain illustrative embodiments, the electric blender module can include a first blender unit and a second blender unit, each disposed adjacent to the other on the blender module and each capable of

independent operation, or collectively capable of cooperative operation, as desired. The first blender unit and the second blender unit can each include a fluid source, a fluid additive source, and a blender tub. The first blender unit and the second blender unit can each have at least one electric motor that is operatively associated with the dedicated source of electric power and that effects blending of the fluid from the fluid source with the fluid additive from the fluid additive source. Alternatively, the first blender unit and the second blender unit can each have a first electric motor and a second electric motor, both operatively associated with the dedicated source of electric power, wherein the first electric motor effects delivery of the fluid from the fluid source to the blending tub and the second electric motor effects blending of the fluid from the fluid source with the fluid additive from the fluid additive source in the blending tub. In certain illustrative embodiments, the first blender unit and the second blender unit can each also have a third electric motor operatively associated with the dedicated source of electric power, wherein the third electric motor effects delivery of the fluid additive from the fluid additive source to the blending tub.

[0017] In a broad aspect, the invention pertains to an electric blender module for fracturing operations. The electric blender module comprises a first electrically driven blender unit, a first inlet manifold coupled to the first electrically driven blender unit and capable of delivering an unblended fracturing fluid thereto, a first outlet manifold coupled to the first electrically driven blender unit and capable of delivering the blended fracturing fluid away therefrom, a second electrically driven blender unit, and a second inlet manifold coupled to the second electrically driven blender unit and capable of delivering the unblended fracturing fluid thereto. A second outlet manifold is coupled to the second electrically driven blender unit and is capable of delivering the blended fracturing fluid away therefrom. An inlet crossing line is coupled to the first inlet manifold and the second inlet manifold such that unblended fracturing fluid that enters the first inlet manifold is capable of being delivered to both the first electrically driven blender unit and the second electrically driven blender unit. An outlet crossing line couples the first electrically driven blender unit to the first outlet manifold and the second outlet manifold.

[0017a] In accordance with another aspect, there is provided a system for hydraulically fracturing an underground hydrocarbon bearing formation at a wellbore that pumps fluid from the wellbore into the formation, the system comprising: a plurality of pumps powered by one or more electric motors and fluidly connected to the wellbore, the pumps configured to pump fluid into the wellbore at a pressure sufficient so that the fluid passes from the wellbore into the formation, and fractures the formation; at least one variable frequency drive connected to the electric motors to control the speed of the motors, the at least one variable frequency drive capable of performing monitoring and controlling of the electric motors; and one or more generators electrically connected to the plurality of pumps to provide electrical power to the pumps.

[0017b] In accordance with another aspect, there is provided a system for fracturing an underground hydrocarbon bearing formation in an oil or gas well by pumping hydraulic fracturing fluid into the wellbore, the system comprising: a pump for pumping the hydraulic fracturing fluid into the wellbore, and then from the wellbore into the formation, the pump mounted on a trailer and capable of pumping the hydraulic fracturing fluid at a pressure sufficient to crack the formation; an electric motor attached to the pump and configured to drive the pump; a variable frequency drive connected to the electric motor to control the speed of the motor, the variable frequency drive capable of performing monitoring and controlling of the electric motor; and a generator connected to the electric motor that provides electric power to the electric motor.

[0017c] In accordance with another aspect, there is provided a system for hydraulically fracturing an underground hydrocarbon bearing formation at a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising: a trailer; two or more pumps attached to the trailer and fluidly connected to the well, the pumps configured to pump fluid into the wellbore at a high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation; one or more electric motors attached to the pumps to drive the pumps; at least one variable frequency drive connected to the electric motors to control the speed of the motors, the at least one variable frequency drive capable of performing monitoring and controlling of the electric motors; and a generator for connection to the one or more electric motors that provides electric power to the one or more electric motors.

[0018] Other aspects and features of the present invention will become apparent to those of ordinary skill in the art upon review of the following detailed description in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] A better understanding of the presently disclosed subject matter can be obtained when the following detailed description is considered in conjunction with the following drawings, wherein:

[0020] Figure 1 is a schematic plan view of a traditional fracturing site;

[0021] Figure 2 is a schematic plan view of a fracturing site in accordance with certain illustrative embodiments described herein;

[0022] Figure 3 is a schematic perspective view of a fracturing trailer in accordance with certain illustrative embodiments described herein;

[0023] Figure 4A is a schematic perspective view of a fracturing module in accordance with certain illustrative embodiments described herein;

[0024] Figure 4B is a schematic perspective view of a fracturing module with maintenance personnel in accordance with certain illustrative embodiments described herein;

[0025] Figure 5A is a schematic side view of a blender module in accordance with certain illustrative embodiments described herein;

[0026] Figure 5B is an end view of the blender module shown in Figure 4A;

[0027] Figure 5C is a schematic top view of a blender module in accordance with certain illustrative embodiments described herein;

[0028] Figure 5D is a schematic side view of the blender module shown in Figure 5C;

[0029] Figure 5E is a schematic perspective view of the blender module shown in Figure 5C;

[0030] Figure 6 is a schematic top view of an inlet manifold for a blender module in accordance with certain illustrative embodiments described herein; and

[0031] Figure 7 is a schematic top view of an outlet manifold for a blender module in accordance with certain illustrative embodiments described herein.

DETAILED DESCRIPTION

[0032] The presently disclosed subject matter generally relates to an electrically powered fracturing system and a system and method for providing on-site electrical power and delivering fracturing fluid to a wellbore at a fracturing operation.

[0033] In a conventional fracturing operation, a "slurry" of fluids and additives is injected into a hydrocarbon bearing rock formation at a wellbore to propagate fracturing. Low pressure fluids are mixed with chemicals, sand, and, if necessary, acid, and then transferred at medium pressure and high rate to vertical and/or deviated portions of the wellbore via multiple high pressure, plunger style pumps driven by diesel fueled prime movers. The majority of the fluids injected will be flowed back through the wellbore and recovered, while the sand will remain in the newly created fracture, thus "propping" it open and providing a permeable membrane for hydrocarbon fluids and gases to flow through so they may be recovered.

[0034] According to the illustrative embodiments described herein, natural gas (either supplied to the site or produced on-site) can be used to drive a dedicated source of electrical power, such as a turbine generator, for hydrocarbon-producing wellbore completions. A scalable, electrically powered fracturing fleet is provided to deliver pressurized treatment fluid, such as fracturing fluid, to a wellbore in a fracturing operation, obviating the need for a constant supply of diesel fuel to the site and reducing the site footprint and infrastructure required for the fracturing operation, when compared with conventional operations. The treatment fluid provided for pressurized delivery to the wellbore can be continuous with the wellbore and with one or more components of the fracturing fleet, in certain illustrative embodiments. In these embodiments, continuous generally means that downhole hydrodynamics are dependent upon constant flow (rate and pressure) of the delivered fluids, and that there should not be any interruption in fluid flow during delivery to the wellbore if the fracture is to propagate as desired. However, it should not

be interpreted to mean that operations of the fracturing fleet cannot generally be stopped and started, as would be understood by one of ordinary skill in the art.

[0035] With reference to Figure 1, a site plan for a traditional fracturing operation on an onshore site is shown. Multiple trailers 5 are provided, each having at least one diesel tank mounted or otherwise disposed thereon. Each trailer 5 is attached to a truck 6 to permit refueling of the diesel tanks as required. Trucks 6 and trailers 5 are located within region A on the fracturing site. Each truck 6 requires a dedicated operator. One or more prime movers are fueled by the diesel and are used to power the fracturing operation. One or more separate chemical handling skids 7 are provided for housing of blending tanks and related equipment.

[0036] With reference to Figure 2, an illustrative embodiment of a site plan for an electrically powered fracturing operation on a onshore site is shown. The fracturing operation includes one or more trailers 10, each housing one or more fracturing modules 20 (see Figure 3). Trailers 10 are located in region B on the fracturing site. One or more natural gas-powered turbine generators 30 are located in region C on the site, which is located a remote distance D from region B where the trailers 10 and fracturing modules 20 are located, for safety reasons. Turbine generators 30 replace the diesel prime movers utilized in the site plan of Figure 1. Turbine generators 30 provide a dedicated source of electric power on-site. There is preferably a physical separation between the natural gas-based power generation in region C and the fracturing operation and wellbore located in region B. The natural gas-based power generation can require greater safety precautions than the fracturing operation and wellhead. Accordingly, security measures can be taken in region C to limit access to this more hazardous location, while maintaining separate safety standards in region B where the majority of site personnel are typically located. Further, the natural gas powered supply of electricity can be monitored and regulated remotely such that, if desired, no personnel are required to be within region C during operation.

[0037] Notably, the setup of Figure 2 requires significantly less infrastructure than the setup shown in Figure 1, while providing comparable pumping capacity. Fewer trailers 10 are present in region B of Figure 2 than the trucks 6 and trailers 5 in region A of Figure 1, due to the lack of need for a constant diesel fuel supply. Further, each trailer 10 in Figure 2 does not need a dedicated truck 6 and operator as in Figure 1. Fewer chemical handling skids 7 are required in region B of Figure 2 than in region A of Figure 1, as the skids 7 in Figure 2 can be electrically powered. Also, by removing diesel prime movers, all associated machinery necessary for power transfer can be eliminated, such as the transmission, torque converter, clutch, drive shaft, hydraulic system, etc ...., and the need for cooling systems, including circulating pumps and fluids, is significantly reduced. In an illustrative embodiment, the physical footprint of the on-site area in region B of Figure 2 is about 80% less than the footprint for the conventional system in region A of Figure 1.

[0038] With reference to the illustrative embodiments of Figure 3, trailer 10 for housing one or more fracturing modules 20 is shown. Trailer 10 can also be a skid, in certain illustrative embodiments. Each fracturing module 20 can include an electric motor 21 and a fluid pump 22 coupled thereto. During fracturing, fracturing module 20 is operatively associated with turbine generator 30 to receive electric power therefrom. In certain illustrative embodiments, a plurality of electric motors 21 and pumps 22 can be transported on a single trailer 10. In the illustrative embodiments of Figure 3, four electric motors 21 and pumps 22 are transported on a single trailer 10. Each electric motor 21 is paired to a pump 22 as a single fracturing module 20. Each fracturing module 20 can be removably mounted to trailer 10 to facilitate ease of replacement as necessary. Fracturing modules 20 utilize electric power from turbine generator 30 to pump the fracturing fluid directly to the wellbore.

[0039] Electrical Power Generation

[0040] The use of a turbine to directly drive a pump has been previously explored. In such systems, a transmission is used to regulate turbine power to the pump to allow for speed and torque control. In the present operation, natural gas is instead used to drive a dedicated power source in the production of electricity. In illustrative embodiments, the dedicated power source is an on-site turbine generator. The need for a transmission is eliminated, and generated electricity can be used to power the fracturing modules, blenders, and other on-site operations as necessary.

[0041] Grid power may be accessible on-site in certain fracturing operations, but the use of a dedicated power source is preferred. During startup of a fracturing operation, massive amounts of power are required such that the use of grid power would be impractical. Natural gas powered generators are more suitable for this application based on the likely availability of natural gas on-site and the capacity of natural gas generators for producing large amounts of power. Notably, the potential for very large instantaneous adjustments in power drawn from the grid during a fracturing operation could jeopardize the stability and reliability of the grid power system. Accordingly, a site-generated and dedicated source of electricity provides a more feasible solution in powering an electric fracturing system. In addition, a dedicated on-site operation can be used to provide power to operate other local equipment, including coiled tubing systems, service rigs, etc...

[0042] In an illustrative embodiment, a single natural gas powered turbine generator 30, as housed in a restricted area C of Figure 2, can generate sufficient power (for example 31 MW at 13,800 volts AC power) to supply several electric motors 21 and pumps 22, avoiding the current need to deliver and operate each fluid pump from a separate diesel-powered truck. A turbine suitable for this purpose is a TM2500+ turbine generator sold by General Electric. Other generation packages could be supplied by Pratt & Whitney or Kawasaki for example. Multiple options are available for turbine power generation,

depending on the amount of electricity required. In an illustrative embodiment, liquid fuels such as condensate can also be provided to drive turbine generator 30 instead of, or in addition to, natural gas. Condensate is less expensive than diesel fuels, thus reducing operational costs.

[0043] Fracturing Module

[0044] With reference to Figures 4A and 4B, an illustrative embodiment of fracturing module 20 is provided. Fracturing module 20 can include an electric motor 21 coupled to one or more electric pumps 22, in certain illustrative embodiments. A suitable pump is a quintiplex or triplex plunger style pump, for example, the SWGS-2500 Well Service Pump sold by Gardner Denver, Inc.

[0045] Electric motor 21 is operatively associated with turbine generator 30, in certain embodiments. Typically, each fracturing module 20 will be associated with a drive housing for controlling electric motor 21 and pumps 22, as well as an electrical transformer and drive unit 50 (see Figure 3) to step down the voltage of the power from turbine generator 30 to a voltage appropriate for electric motor 21. The electrical transformer and drive unit 50 can be provided as an independent unit for association with fracturing module 20, or can be permanently fixed to the trailer 10, in various embodiments. If permanently fixed, then transformer and drive unit 50 can be scalable to allow addition or subtraction of pumps 22 or other components to accommodate any operational requirements.

[0046] Each pump 22 and electric motor 21 are modular in nature so as to simplify removal and replacement from fracturing module 20 for maintenance purposes. Removal of a single fracturing module 20 from trailer 10 is also simplified. For example, any fracturing module 20 can be unplugged and unpinned from trailer 10 and removed, and another fracturing module 20 can be installed in its place in a matter of minutes.

[0047] In the illustrative embodiment of Figure 3, trailer 10 can house four fracturing modules 20, along with a transformer and drive unit 50. In this particular configuration, each single trailer 10 provides more

pumping capacity than four of the traditional diesel powered fracturing trailers 5 of Figure 1, as parasitic losses are minimal in the electric fracturing system compared to the parasitic losses typical of diesel fueled systems. For example, a conventional diesel powered fluid pump is rated for 2250 hp. However, due to parasitic losses in the transmission, torque converter and cooling systems, diesel fueled systems typically only provide 1800 hp to the pumps. In contrast, the present system can deliver a true 2500 hp directly to each pump 22 because pump 22 is directly coupled to electric motor 21. Further, the nominal weight of a conventional fluid pump is up to 120,000 lbs. In the present operation, each fracturing module 20 weighs approximately 28,000 lbs., thus allowing for placement of four pumps 22 in the same physical dimension (size and weight) as the spacing needed for a single pump in conventional diesel systems, as well as allowing for up to 10,000 hp total to the pumps. In other embodiments, more or fewer fracturing modules 20 may be located on trailer 10 as desired or required for operational purposes.

[0048] In certain illustrative embodiments, fracturing module 20 can include a electric motor 21 that is an AC permanent magnet motor capable of operation in the range of up to 1500 rpms and up to 20,000 ft/lbs of torque. Fracturing module 20 can also include a pump 22 that is a plunger-style fluid pump coupled to electric motor 21. In certain illustrative embodiments, fracturing module 20 can have dimensions of approximately 136" width x 108" length x 100" height. These dimensions would allow fracturing module 20 to be easily portable and fit with a ISO intermodal container for shipping purposes without the need for disassembly. Standard sized ISO container lengths are typically 20' , 40' or 53'. In certain illustrative embodiments, fracturing module 20 can have dimensions of no greater than 136" width x 108" length x 100" height. These dimensions for fracturing module 20 would also allow crew members to easily fit within the confines of fracturing module 20 to make repairs, as illustrated in Figure 4b. In certain illustrative embodiments, fracturing module 20 can have a width of no greater than 102" to fall within shipping configurations and road restrictions. In a specific embodiment, fracturing module 20 is

capable of operating at 2500 hp while still having the above specified dimensions and meeting the above mentioned specifications for rpms and ft/lbs of torque.

[0049] Electric Motor

[0050] With reference to the illustrative embodiments of Figures 2 and 3, a medium low voltage AC permanent magnet electric motor 21 receives electric power from turbine generator 30, and is coupled directly to pump 22. In order to ensure suitability for use in fracturing, electric motor 21 should be capable of operation up to 1,500 rpm with a torque of up to 20,000 ft/lbs, in certain illustrative embodiments. A motor suitable for this purpose is sold under the trademark TeraTorq® and is available from Comprehensive Power, Inc. of Marlborough, Massachusetts. A compact motor of sufficient torque will allow the number of fracturing modules 20 placed on each trailer 10 to be maximized.

[0051] Blender

[0052] For greater efficiency, conventional diesel powered blenders and chemical addition units can be replaced with electrically powered blender units. In certain illustrative embodiments as described herein, the electrically powered blender units can be modular in nature for housing on trailer 10 in place of fracturing module 20, or housed independently for association with each trailer 10. An electric blending operation permits greater accuracy and control of fracturing fluid additives. Further, the centrifugal blender tubs typically used with blending trailers to blend fluids with proppant, sand, chemicals, acid, etc... prior to delivery to the wellbore are a common source of maintenance costs in traditional fracturing operations.

[0053] With reference to Figures 5A-5E and Figures 6-7, illustrative embodiments of a blender module 40 and components thereof are provided. Blender module 40 can be operatively associated with turbine generator 30 and capable of providing fractioning fluid to pump 22 for delivery to the wellbore. In certain embodiments, blender module 40 can include at least one fluid additive source 44, at least one fluid

source 48, and at least one centrifugal blender tub 46. Electric power can be supplied from turbine generator 30 to blender module 40 to effect blending of a fluid from fluid source 48 with a fluid additive from fluid additive source 44 to generate the fracturing fluid. In certain embodiments, the fluid from fluid source 48 can be, for example, water, oils or methanol blends, and the fluid additive from fluid additive source 44 can be, for example, friction reducers, gellents, gellent breakers or biocides.

[0054] In certain illustrative embodiments, blender module 40 can have a dual configuration, with a first blender unit 47a and a second blender unit 47b positioned adjacent to each other. This dual configuration is designed to provide redundancy and to facilitate access for maintenance and replacement of components as needed. In certain embodiments, each blender unit 47a and 47b can have its own electrically-powered suction and tub motors disposed thereon, and optionally, other electrically-powered motors can be utilized for chemical additional and/or other ancillary operational functions, as discussed further herein.

[0055] For example, in certain illustrative embodiments, first blender unit 47a can have a plurality of electric motors including a first electric motor 43a and a second electric motor 41a that are used to drive various components of blender module 40. Electric motors 41a and 43a can be powered by turbine generator 30. Fluid can be pumped into blender module 40 through an inlet manifold 48a by first electric motor 43a and added to tub 46a. Thus, first electric motor 43a acts as a suction motor. Second electric motor 41a can drive the centrifugal blending process in tub 46a. Second electric motor 41a can also drive the delivery of blended fluid out of blender module 40 and to the wellbore via an outlet manifold 49a. Thus, second electric motor 41a acts as a tub motor and a discharge motor. In certain illustrative embodiments, a third electric motor 42a can also be provided. Third electric motor 42a can also be powered by turbine generator 30, and can power delivery of fluid additives to blender 46a. For example,

proppant from a hopper 44a can be delivered to a blender tub 46a, for example, a centrifugal blender tub, by an auger 45a, which is powered by third electric motor 42a.

[0056] Similarly, in certain illustrative embodiments, second blender unit 47b can have a plurality of electric motors including a first electric motor 43b and a second electric motor 41b that are used to drive various components of blender module 40. Electric motors 41b and 43b can be powered by turbine generator 30. Fluid can be pumped into blender module 40 through an inlet manifold 48b by first electric motor 43b and added to tub 46b. Thus, second electric motor 43a acts as a suction motor. Second electric motor 41b can drive the centrifugal blending process in tub 46b. Second electric motor 41b can also drive the delivery of blended fluid out of blender module 40 and to the wellbore via an outlet manifold 49b. Thus, second electric motor 41b acts as a tub motor and a discharge motor. In certain illustrative embodiments, a third electric motor 42b can also be provided. Third electric motor 42b can also be powered by turbine generator 30, and can power delivery of fluid additives to blender 46b. For example, proppant from a hopper 44b can be delivered to a blender tub 46b, for example, a centrifugal blender tub, by an auger 45b, which is powered by third electric motor 42b.

[0057] Blender module 40 can also include a control cabin 53 for housing equipment controls for first blender unit 47a and second blender unit 47b, and can further include appropriate drives and coolers as required.

[0058] Conventional blenders powered by a diesel hydraulic system are typically housed on a forty-five foot tractor trailer and are capable of approximately 100 bbl/min. In contrast, the dual configuration of blender module 40 having first blender unit 47a and second blender unit 47b can provide a total output capability of 240 bbl/min in the same physical footprint as a conventional blender, without the need for a separate backup unit in case of failure.

[0059] Redundant system blenders have been tried in the past with limited success, mostly due to problems with balancing weights of the trailers while still delivering the appropriate amount of power. Typically, two separate engines, each approximately 650 hp, have been mounted side by side on the nose of the trailer. In order to run all of the necessary systems, each engine must drive a mixing tub via a transmission, drop box and extended drive shaft. A large hydraulic system is also fitted to each engine to run all auxiliary systems such as chemical additions and suction pumps. Parasitic power losses are very large and the hosing and wiring is complex.

[0060] In contrast, the electric powered blender module 40 described in certain illustrative embodiments herein can relieve the parasitic power losses of conventional systems by direct driving each piece of critical equipment with a dedicated electric motor. Further, the electric powered blender module 40 described in certain illustrative embodiments herein allows for plumbing routes that are unavailable in conventional applications. For example, in certain illustrative embodiments, the fluid source can be an inlet manifold 48 that can have one or more inlet crossing lines 51 (see Figure 6) that connect the section of inlet manifold 48 dedicated to delivering fluid to first blender unit 47a with the section of inlet manifold 48 dedicated to delivering fluid to second blender unit 47b. Similarly, in certain illustrative embodiments, outlet manifold 49 can have one or more outlet crossing lines 50 (see Figure 7) that connect the section of outlet manifold 49 dedicated to delivering fluid from first blender unit 47a with the section of outlet manifold 49 dedicated to delivering fluid from second blender unit 47b. Crossing lines 50 and 51 allow flow to be routed or diverted between first blender unit 47a and second blender unit 47b. Thus, blender module 40 can mix from either side, or both sides, and/or discharge to either side, or both sides, if necessary. As a result, the attainable rates for the electric powered blender module 40 are much larger that of a conventional blender. In certain illustrative embodiments, each side (i.e., first blender unit 47a and second blender unit 47b) of blender module 40 is capable of approximately 120 bbl/min. Also, each

side (i.e., first blender unit 47a and second blender unit 47b) can move approximately 15 t/min of sand, at least in part because the length of auger 45 is shorter (approximately 6') as compared to conventional units (approximately 12').

[0061] In certain illustrative embodiments, blender module 40 can be scaled down or "downsized" to a single, compact module comparable in size and dimensions to fracturing module 20 described herein. For smaller fracturing or treatment jobs requiring fewer than four fracturing modules 20, a downsized blender module 40 can replace one of the fracturing modules 20 on trailer 10, thus reducing operational costs and improving transportability of the system.

[0062] Control System

[0063] A control system can be provided for regulating various equipment and systems within the electric powered fractioning operation. For example, in certain illustrative embodiments, the control system can regulate fracturing module 20 in delivery of treatment fluid from blender module 30 to pumps 22 for delivery to the wellbore. Controls for the electric-powered operation described herein are a significant improvement over that of conventional diesel powered systems. Because electric motors are controlled by variable frequency drives, absolute control of all equipment on location can be maintained from one central point. When the system operator sets a maximum pressure for the treatment, the control software and variable frequency drives calculate a maximum current available to the motors. Variable frequency drives essentially "tell" the motors what they are allowed to do.

[0064] Electric motors controlled via variable frequency drive are far safer and easier to control than conventional diesel powered equipment. For example, conventional fleets with diesel powered pumps utilize an electronically controlled transmission and engine on the unit. There can be up to fourteen different parameters that need to be monitored and controlled for proper operation. These signals are typically sent via hardwired cable to an operator console controlled by the pump driver. The signals are

converted from digital to analog so the inputs can be made via switches and control knobs. The inputs are then converted from analog back to digital and sent back to the unit. The control module on the unit then tells the engine or transmission to perform the required task and the signal is converted to a mechanical operation. This process takes time.

[0065] Accidental over-pressures are quite common in these conventional operations, as the signal must travel to the console, back to the unit and then perform a mechanical function. Over-pressures can occur in milliseconds due to the nature of the operations. These are usually due to human error, and can be as simple as a single operator failing to react to a command. They are often due to a valve being closed, which accidentally creates a "deadhead" situation.

[0066] For example, in January of 2011, a large scale fractioning operation was taking place in the Horn River Basin of north-eastern British Columbia, Canada. A leak occurred in one of the lines and a shutdown order was given. The master valve on the wellhead was then closed remotely. Unfortunately, multiple pumps were still rolling and a system over-pressure ensued. Treating iron rated for 10,000 psi was taken to well over 15,000 psi. A line attached to the well also separated, causing it to whip around. The incident caused a shutdown interruption to the entire operation for over a week while investigation and damage assessment were performed.

[0067] The control system provided according to the present illustrative embodiments, being electrically powered, virtually eliminates these types of scenarios from occurring. A maximum pressure value set at the beginning of the operation is the maximum amount of power that can be sent to electric motor 21 for pump 22. By extrapolating a maximum current value from this input, electric motor 21 does not have the available power to exceed its operating pressure. Also, because there are virtually no mechanical systems between pump 22 and electric motor 21, there is far less "moment of inertia" of gears and clutches to deal with. A near instantaneous stop of electric motor 21 results in a near instantaneous stop of pump 22.

[0068] An electrically powered and controlled system as described herein greatly increases the ease in which all equipment can be synced or slaved to each other. This means a change at one single point will be carried out by all pieces of equipment, unlike with diesel equipment. For example, in conventional diesel powered operations, the blender typically supplies all the necessary fluids to the entire system. In order to perform a rate change to the operation, the blender must change rate prior to the pumps changing rates. This can often result in accidental overflow of the blender tubs and/or cavitation of the pumps due to the time lag of each piece of equipment being given manual commands.

[0069] In contrast, the present operation utilizes a single point control that is not linked solely to blender operations, in certain illustrative embodiments. All operation parameters can be input prior to beginning the fractioning. If a rate change is required, the system will increase the rate of the entire system with a single command. This means that if pumps 22 are told to increase rate, then blender module 40 along with the chemical units and even ancillary equipment like sand belts will increase rates to compensate automatically.

[0070] Suitable controls and computer monitoring for the entire fracturing operation can take place at a single central location, which facilitates adherence to pre-set safety parameters. For example, a control center 40 is indicated in Figure 2 from which operations can be managed via communications link 41. Examples of operations that can be controlled and monitored remotely from control center 40 via communications link 41 can be the power generation function in Area B, or the delivery of treatment fluid from blender module 40 to pumps 22 for delivery to the wellbore.

[0071] Comparison Example

[0072] Table 1, shown below, compares and contrasts the operational costs and manpower requirements for a conventional diesel powered operation (such as shown in Figure 1) with those of a electric powered operation (such as shown in Figure 2).

[0073] **Table 1**

[0074] **Comparison of Conventional Diesel Powered Operation vs. Electric Powered Operation**

Diesel Powered Operation	Electric Powered Operation
Total fuel cost (diesel) - about $80,000 per day	Total fuel cost (natural gas) - about $2,300 per day
Service interval for diesel engines - about every 200-300 hours	Service interval for electric motor - about every 50,000 hours
Dedicated crew size - about 40 people	Dedicated crew size - about 10 people

[0075] In Table 1, the "Diesel Powered Operation" utilizes at least 24 pumps and 2 blenders, and requires at least 54,000 hp to execute the fracturing program on that location. Each pump burns approximately 300-400 liters per hour of operation, and the blender units burn a comparable amount of diesel fuel. Because of the fuel consumption and fuel capacity of this conventional unit, it requires refueling during operation, which is extremely dangerous and presents a fire hazard. Further, each piece of conventional equipment needs a dedicated tractor to move it and a driver/operator to run it. The crew size required to operate and maintain a conventional operation such as the one in Figure 1 represents a direct cost for the site operator.

[0076] In contrast, the electric powered operation as described herein utilizes a turbine that only consumes about 6mm scf of natural gas per 24 hours. At current market rates (approximately $2.50 per mmbtu), this equates to a reduction in direct cost to the site operator of over $77,000 per day compared to

the diesel powered operation. Also, the service interval on electric motors is about 50,000 hours, which allows the majority of reliability and maintainability costs to disappear. Further, the need for multiple drivers/operators is reduced significantly, and electric powered operation means that a single operator can run the entire system from a central location. Crew size can be reduced by around 75%, as only about 10 people are needed on the same location to accomplish the same tasks as conventional operations, with the 10 people including off-site personnel maintenance personnel. Further, crew size does not change with the amount of equipment used. Thus, the electric powered operation is significantly more economical.

[0077] Modular Design and Alternate Embodiments

[0078] As discussed above, the modular nature of the electric powered fracturing operation described herein provides significant operational advantages and efficiencies over traditional fracturing systems. Each fracturing module 20 sits on trailer 10 which houses the necessary mounts and manifold systems for low pressure suctions and high pressure discharges. Each fracturing module 20 can be removed from service and replaced without shutting down or compromising the fractioning spread. For instance, pump 22 can be isolated from trailer 10, removed and replaced by a new pump 22 in just a few minutes. If fracturing module 20 requires service, it can be isolated from the fluid lines, unplugged, un-pinned and removed by a forklift. Another fracturing module 20 can be then re-inserted in the same fashion, realizing a drastic time savings. In addition, the removed fracturing module 20 can be repaired or serviced in the field. In contrast, if one of the pumps in a conventional diesel powered system goes down or requires service, the tractor/trailer combination needs to be disconnected from the manifold system and driven out of the location. A replacement unit must then be backed into the line and reconnected. Maneuvering these units in these tight confines is difficult and dangerous.

[0079] The presently described electric powered fracturing operation can be easily adapted to accommodate additional types of pumping capabilities as needed. For example, a replacement pumping

module can be provided that is adapted for removable mounting on trailer 10. Replacement pumping module can be utilized for pumping liquid nitrogen, carbon dioxide, or other chemicals or fluids as needed, to increase the versatility of the system and broaden operational range and capacity. In a conventional system, if a nitrogen pump is required, a separate unit truck/trailer unit must be brought to the site and tied into the fractioning spread. In contrast, the presently described operation allows for a replacement nitrogen module with generally the same dimensions as fractioning module 20, so that the replacement module can fit into the same slot on the trailer as fractioning module 20 would. Trailer 10 can contain all the necessary electrical power distributions as required for a nitrogen pump module so no modifications are required. The same concept would apply to carbon dioxide pump modules or any other pieces of equipment that would be required. Instead of another truck/trailer, a specialized replacement module can instead be utilized.

[0080] Natural gas is considered to be the cleanest, most efficient fuel source available. By designing and constructing "fit for purpose equipment" that is powered by natural gas, it is expected that the fracturing footprint, manpower, and maintenance requirements can each be reduced by over 60% when compared with traditional diesel-powered operations.

[0081] In addition, the presently described electric powered fracturing operation resolves or mitigates environmental impacts of traditional diesel-powered operations. For example, the presently described natural gas powered operation can provide a significant reduction in carbon dioxide emissions as compared to diesel-powered operations. In an illustrative embodiment, a fractioning site utilizing the presently described natural gas powered operation would have a carbon dioxide emissions level of about 2200 kg/hr, depending upon the quality of the fuel gas, which represents an approximately 200% reduction from carbon dioxide emissions of diesel-powered operations. Also, in an illustrative embodiment, the presently described natural gas powered operation would produces no greater than about

80 decibels of sound with a silencer package utilized on turbine 30, which meets OSHA requirements for noise emissions. By comparison, a conventional diesel-powered fractioning pump running at full rpm emits about 105 decibels of sound. When multiple diesel-powered fractioning pumps are running simultaneously, noise is a significant hazard associated with conventional operations.

[0082] In certain illustrative embodiments, the electric-powered fractioning operation described herein can also be utilized for offshore oil and gas applications, for example, fracturing of a wellbore at an offshore site. Conventional offshore operations already possess the capacity to generate electric power on-site. These vessels are typically diesel over electric, which means that the diesel powerplant on the vessel generates electricity to meet all power requirements including propulsion. Conversion of offshore pumping services to run from an electrical power supply will allow transported diesel fuel to be used in power generation rather than to drive the fracturing operation, thus reducing diesel fuel consumption. The electric power generated from the offshore vessel's power plant (which is not needed during station keeping) can be utilized to power one or more fracturing modules 10. This is far cleaner, safer and more efficient than using diesel powered equipment. Fracturing modules 10 are also smaller and lighter than the equipment typically used on the deck of offshore vessels, thus removing some of the current ballast issues and allowing more equipment or raw materials to be transported by the offshore vessels.

[0083] In a deck layout for a conventional offshore stimulation vessel, skid based, diesel powered pumping equipment and storage facilities on the deck of the vessel create ballast issues. Too much heavy equipment on the deck of the vessel causes the vessel to have higher center of gravity. Also, fuel lines must be run to each piece of equipment greatly increasing the risk of fuel spills. In illustrative embodiments of a deck layout for an offshore vessel utilizing electric-powered fractioning operations as described herein, the physical footprint of the equipment layout is reduced significantly when compared to the conventional layout. More free space is available on deck, and the weight of equipment is

dramatically decreased, thus eliminating most of the ballast issues. A vessel already designed as diesel-electric can be utilized. When the vessel is on station at a platform and in station keeping mode, the vast majority of the power that the ship's engines are generating can be run up to the deck to power modules. The storage facilities on the vessel can be placed below deck, further lowering the center of gravity, while additional equipment, for instance, a 3-phase separator, or coiled tubing unit, can be provided on deck, which is difficult in existing diesel-powered vessels. These benefits, coupled with the electronic control system, give a far greater advantage over conventional vessels.

[0084] While the present description has specifically contemplated a fracturing system, the system can be used to power pumps for other purposes, or to power other oilfield equipment. For example, high rate and pressure pumping equipment, hydraulic fracturing equipment, well stimulation pumping equipment and/or well servicing equipment could also be powered using the present system. In addition, the system can be adapted for use in other art fields requiring high torque or high rate pumping operations, such as pipeline cleaning or dewatering mines.

[0085] It is to be understood that the subject matter herein is not limited to the exact details of construction, operation, exact materials, or illustrative embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. Accordingly, the subject matter is therefore to be limited only by the scope of the appended claims.

CLAIMS

What is claimed is:

1. A system for hydraulically fracturing an underground hydrocarbon bearing formation at a wellbore that pumps fluid from the wellbore into the formation, the system comprising:

a plurality of pumps powered by one or more electric motors and fluidly connected to the wellbore, the pumps configured to pump fluid into the wellbore at a pressure sufficient so that the fluid passes from the wellbore into the formation, and fractures the formation;

at least one variable frequency drive connected to the electric motors to control the speed of the motors, the at least one variable frequency drive capable of performing monitoring and controlling of the electric motors; and

one or more generators electrically connected to the plurality of pumps to provide electrical power to the pumps.

2. The system of claim 1, wherein the at least one variable frequency drive is capable of performing monitoring and controlling of the electric motors by regulating a maximum current available to the electric motors.

3. The system of claim 1, wherein at least some of the plurality of generators are powered by a fuel selected from a group consisting of natural gas and liquid fuel.

4. The system of claim 1, wherein at least some of the plurality of generators are turbine generators.

5. The system of claim 1, further comprising a control system.

6. The system of claim 1, wherein the plurality of pumps are mounted on a trailer and transportable on the trailer.

7. The system of claim 1, further comprising a plurality of variable frequency drives attached to the electrical motors coupled to the plurality of pumps.

8. A system for fracturing an underground hydrocarbon bearing formation in an oil or gas well by pumping hydraulic fracturing fluid into the wellbore, the system comprising:

a pump for pumping the hydraulic fracturing fluid into the wellbore, and then from the wellbore into the formation, the pump mounted on a trailer and capable of pumping the hydraulic fracturing fluid at a pressure sufficient to crack the formation;

an electric motor attached to the pump and configured to drive the pump;

a variable frequency drive connected to the electric motor to control the speed of the motor, the variable frequency drive capable of performing monitoring and controlling of the electric motor; and

a generator connected to the electric motor that provides electric power to the electric motor.

9. The system of claim 8, wherein the variable frequency drive is capable of performing monitoring and controlling of the electric motors by regulating a maximum current available to the electric motor.

10. The system of claim 8, wherein the pump is a plunger-style fluid pump.

11. The system of claim 8, wherein the pump is a triplex or a quintuplex pump rated up to about 2500 horsepower.

12. The system of claim 8, wherein the electric motor has a power output of up to about 2500 horsepower.

13. The system of claim 8, wherein the electric motor has a torque of up to about 20,000 foot per pound (ft/lb).

14. The system of claim 8, wherein the generator is a turbine generator.

15. The system of claim 8, wherein the variable frequency drive is mounted to the trailer.

16. The system of claim 8, wherein the trailer has three axles.

17. The system of claim 8, wherein the electric motor is attached to the trailer.

18. The system of claim 8, wherein the trailer has mounts attaching the variable frequency drive to the trailer.

19. A system for hydraulically fracturing an underground hydrocarbon bearing formation at a wellbore that permits passage of fluid from the wellbore into the formation, the system comprising:

a trailer;

two or more pumps attached to the trailer and fluidly connected to the well, the pumps configured to pump fluid into the wellbore at a high pressure so that the fluid passes from the wellbore into the formation, and fractures the formation;

one or more electric motors attached to the pumps to drive the pumps;

at least one variable frequency drive connected to the electric motors to control the speed of the motors, the at least one variable frequency drive capable of performing monitoring and controlling of the electric motors; and

a generator for connection to the one or more electric motors that provides electric power to the one or more electric motors.

20. The system of claim 19, wherein the at least one variable frequency drive is capable of performing monitoring and controlling of the electric motors by regulating a maximum current available to the electric motors.

21. The system of claim 19, wherein the two or more pumps are attached to the trailer.

22. The system of claim 19, wherein the one or more electric motors are attached to the trailer.

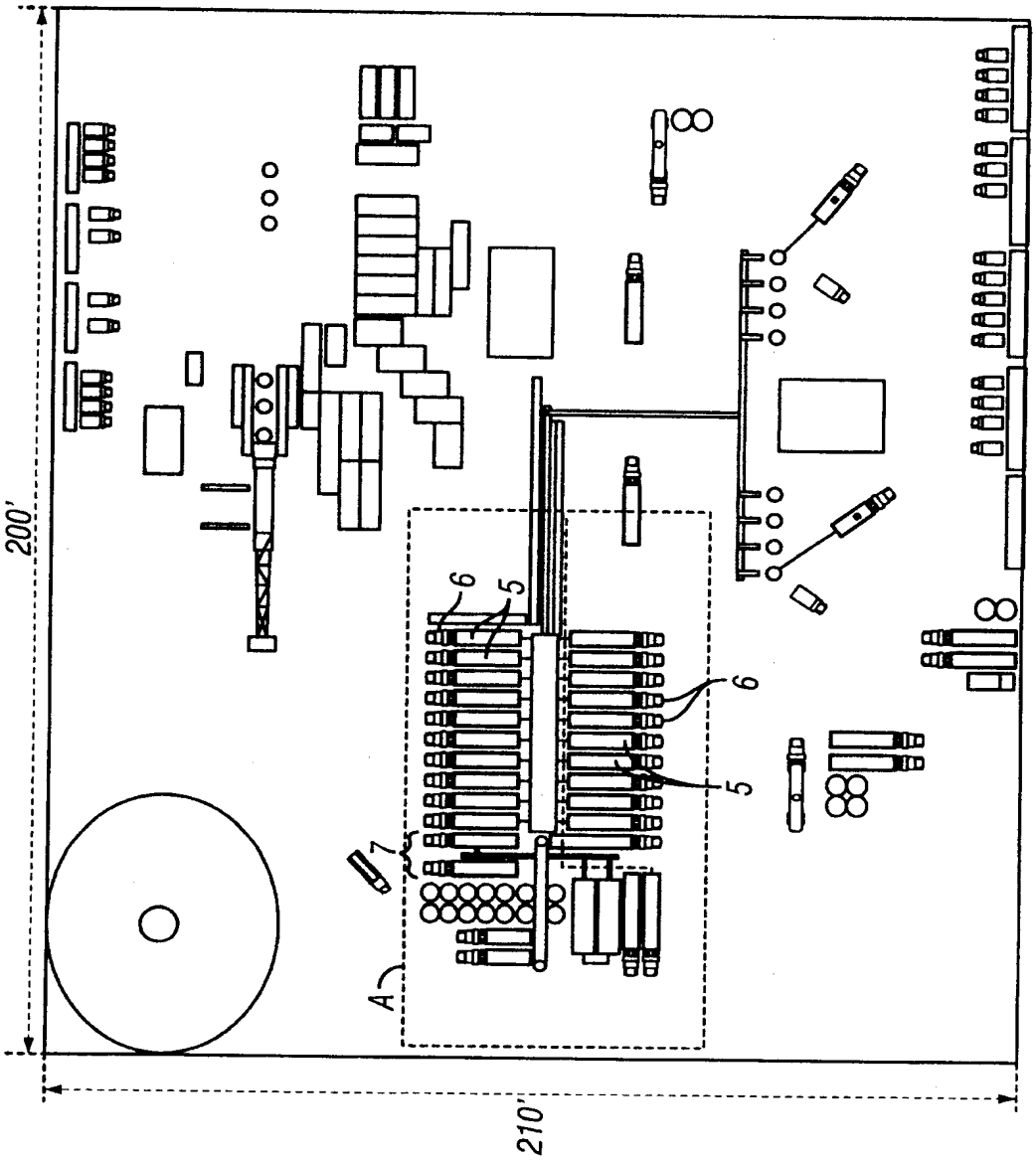


FIG. 1
(Prior Art)

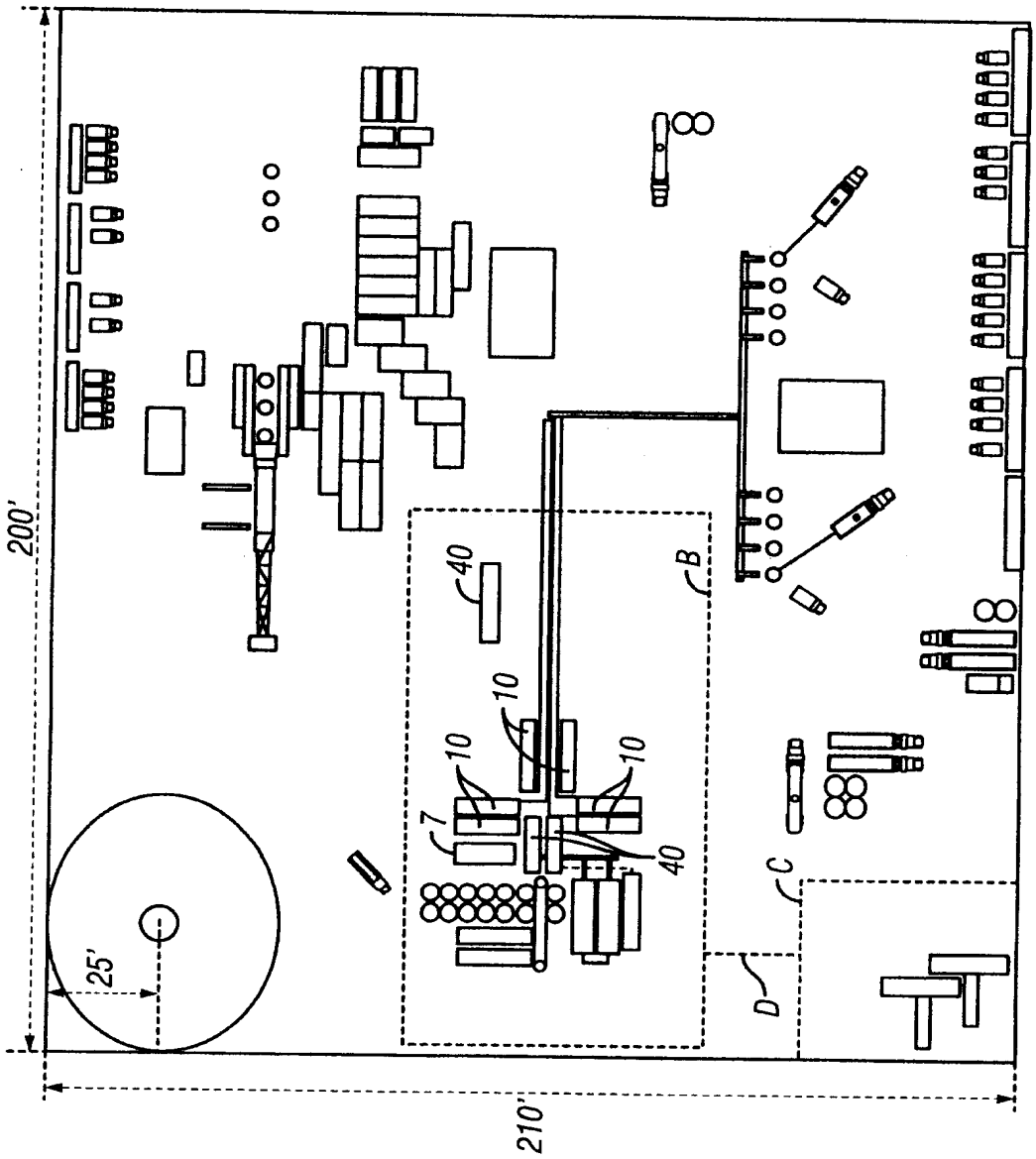


FIG. 2

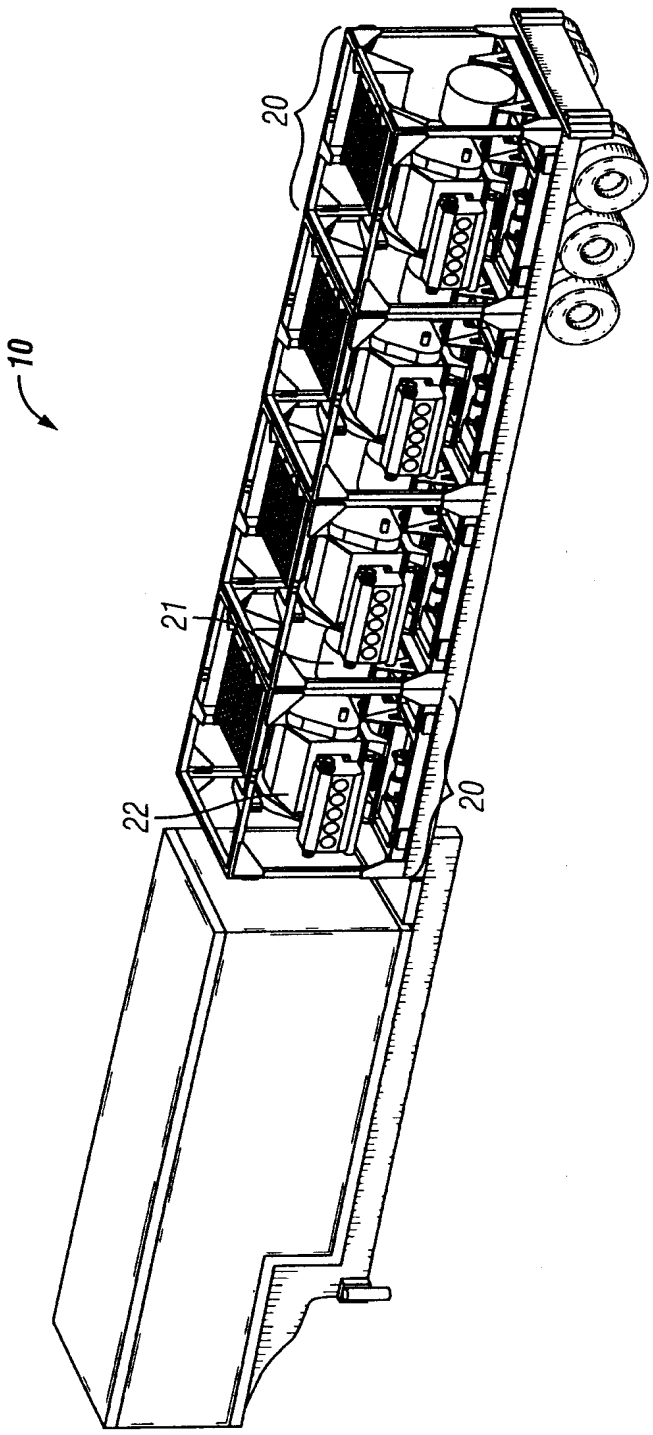


FIG. 3

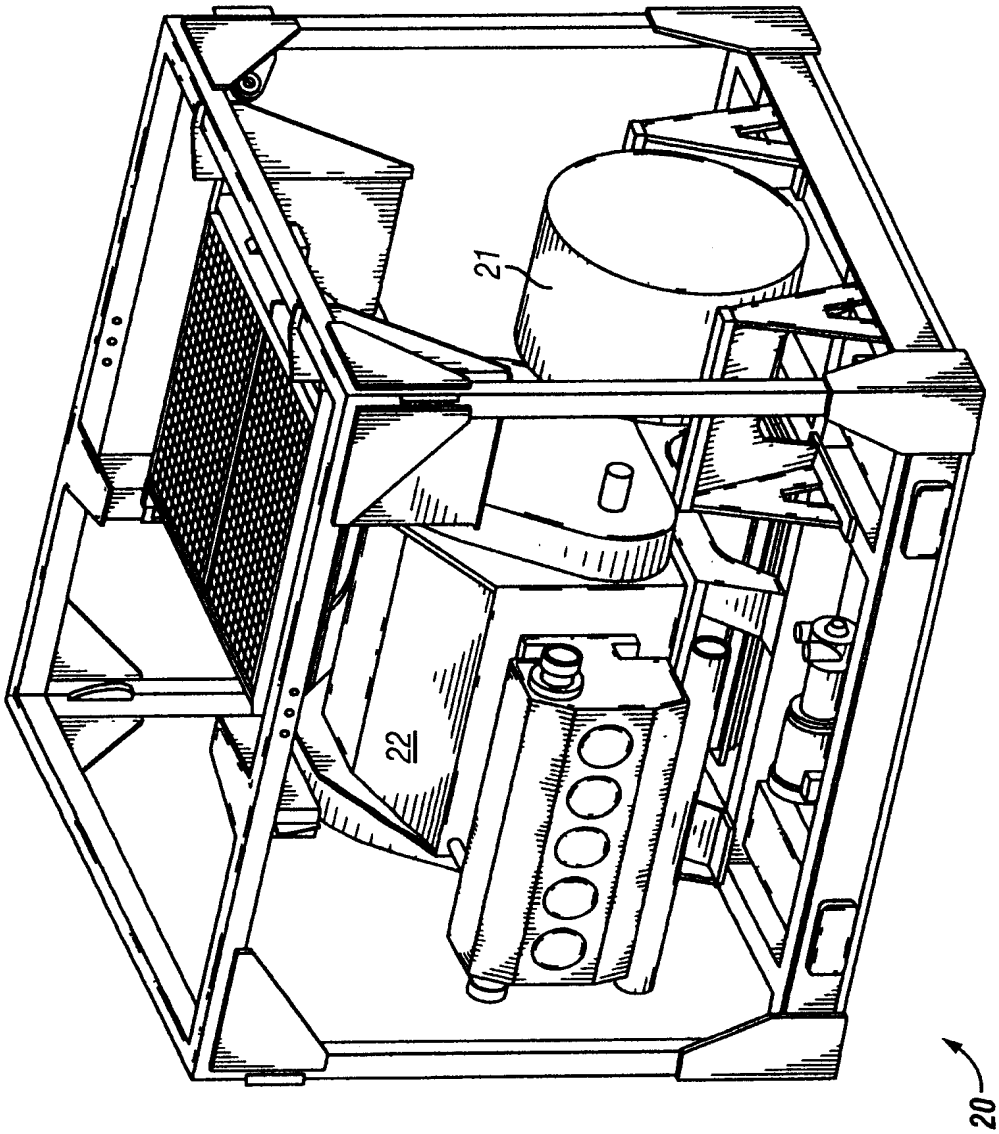


FIG. 4A

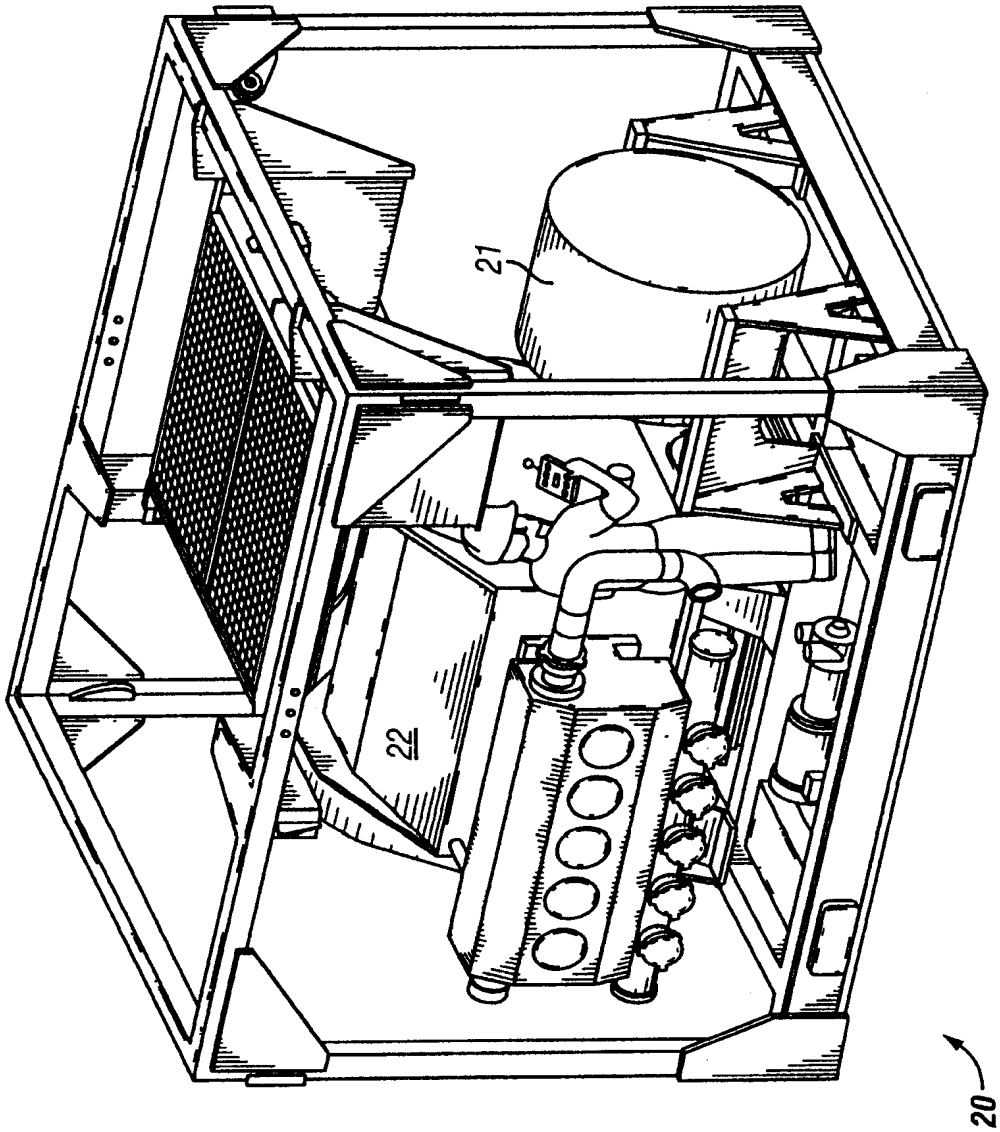


FIG. 4B

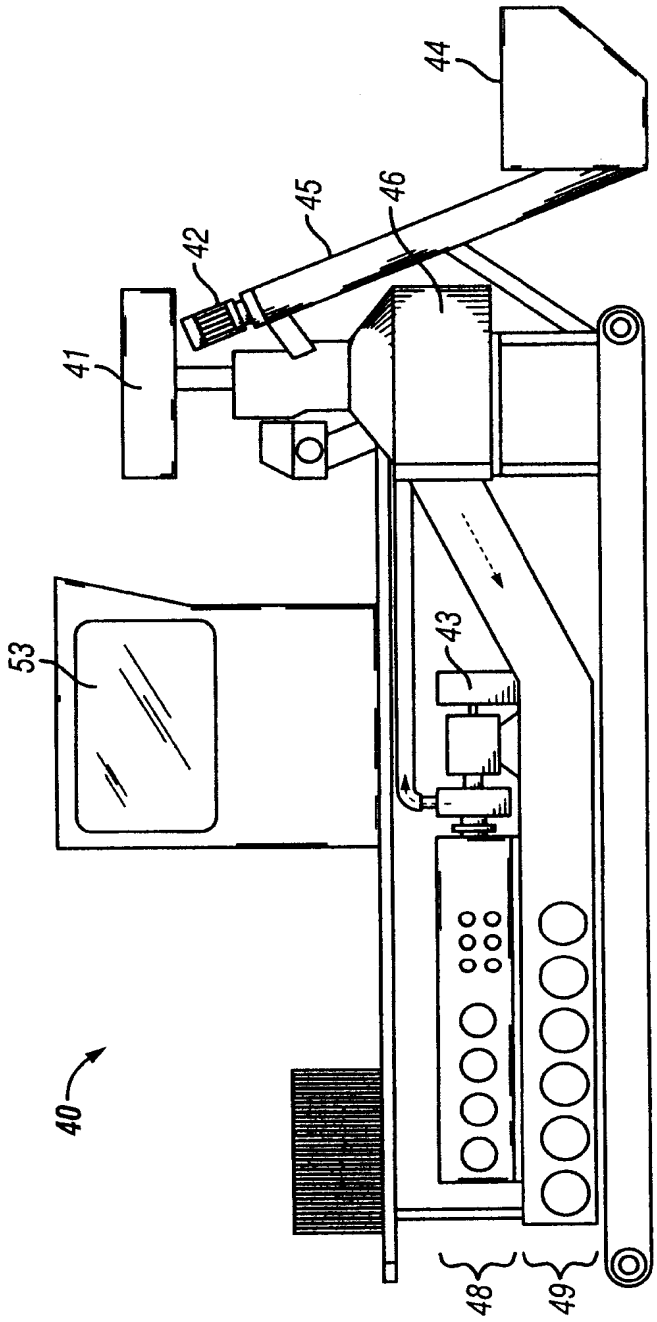


FIG. 5A

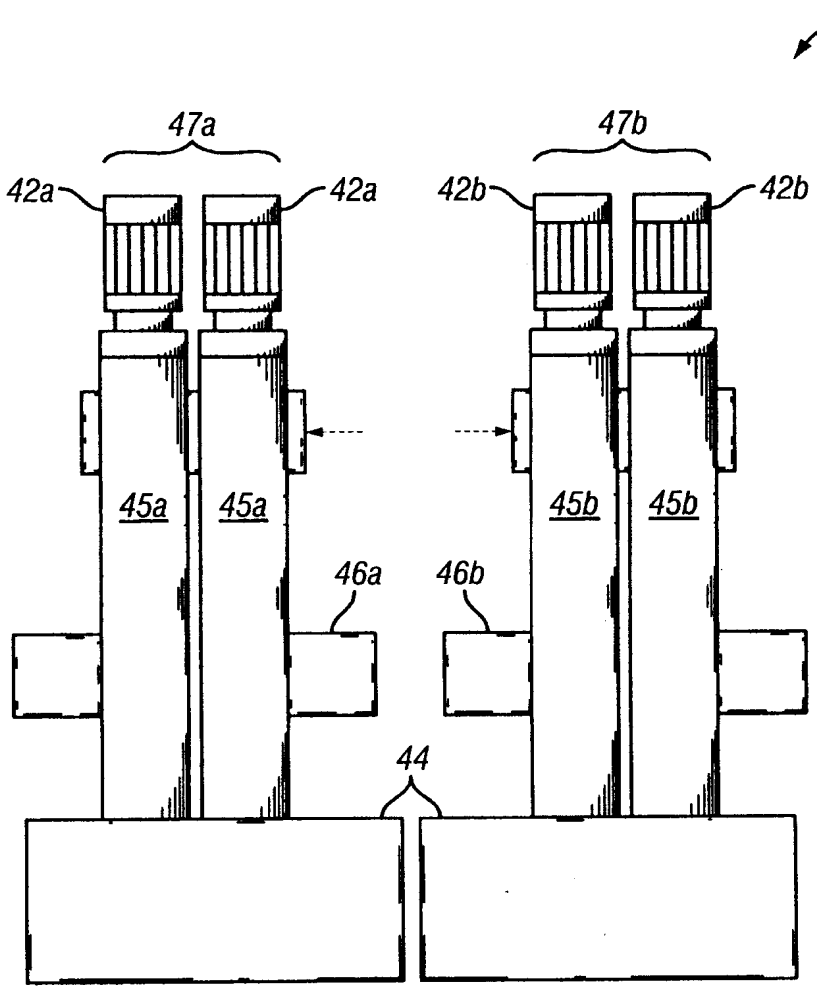


FIG. 5B

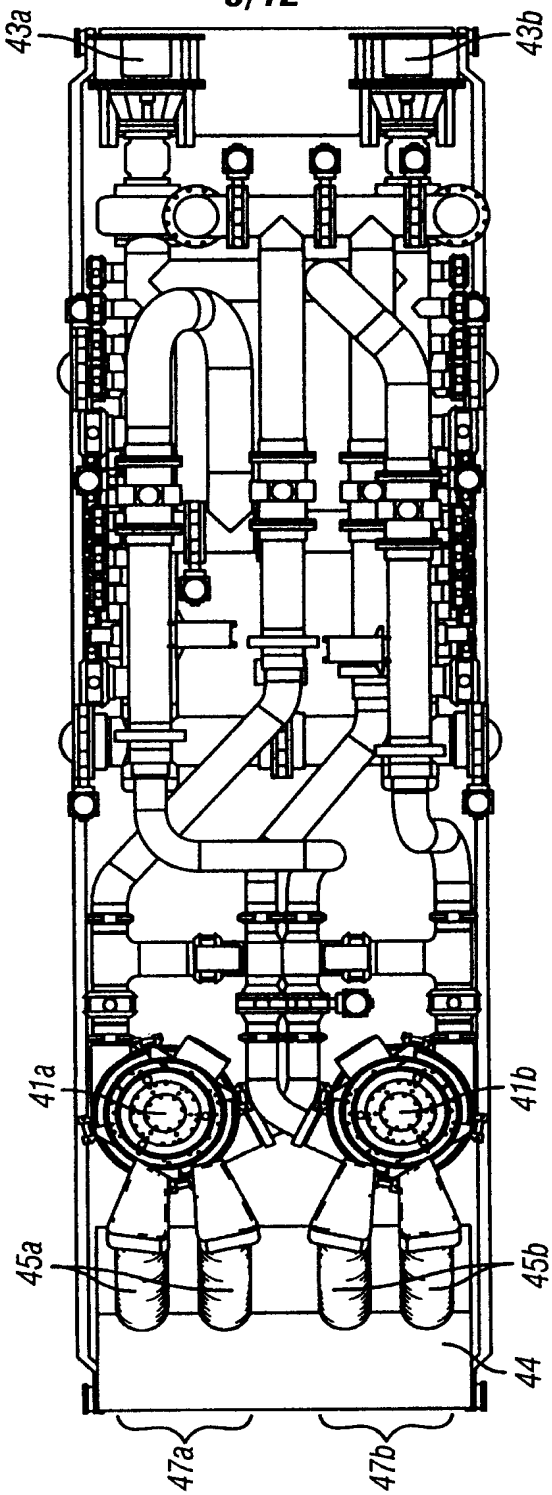


FIG. 5C

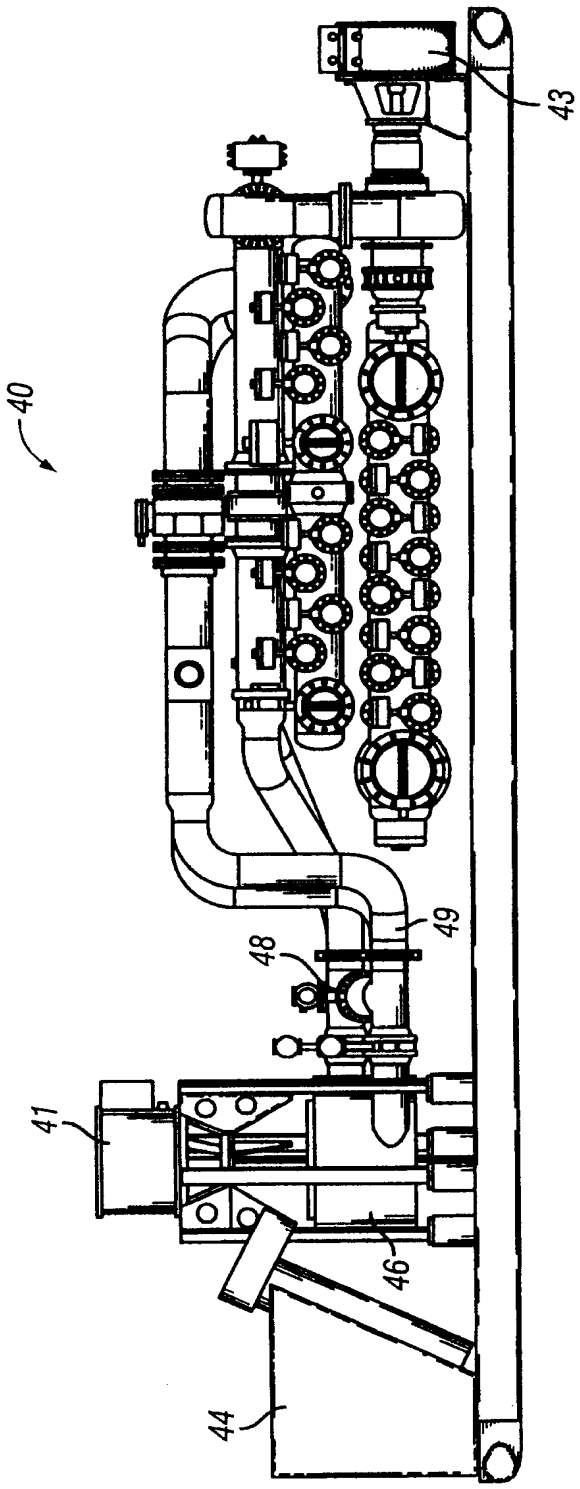


FIG. 5D

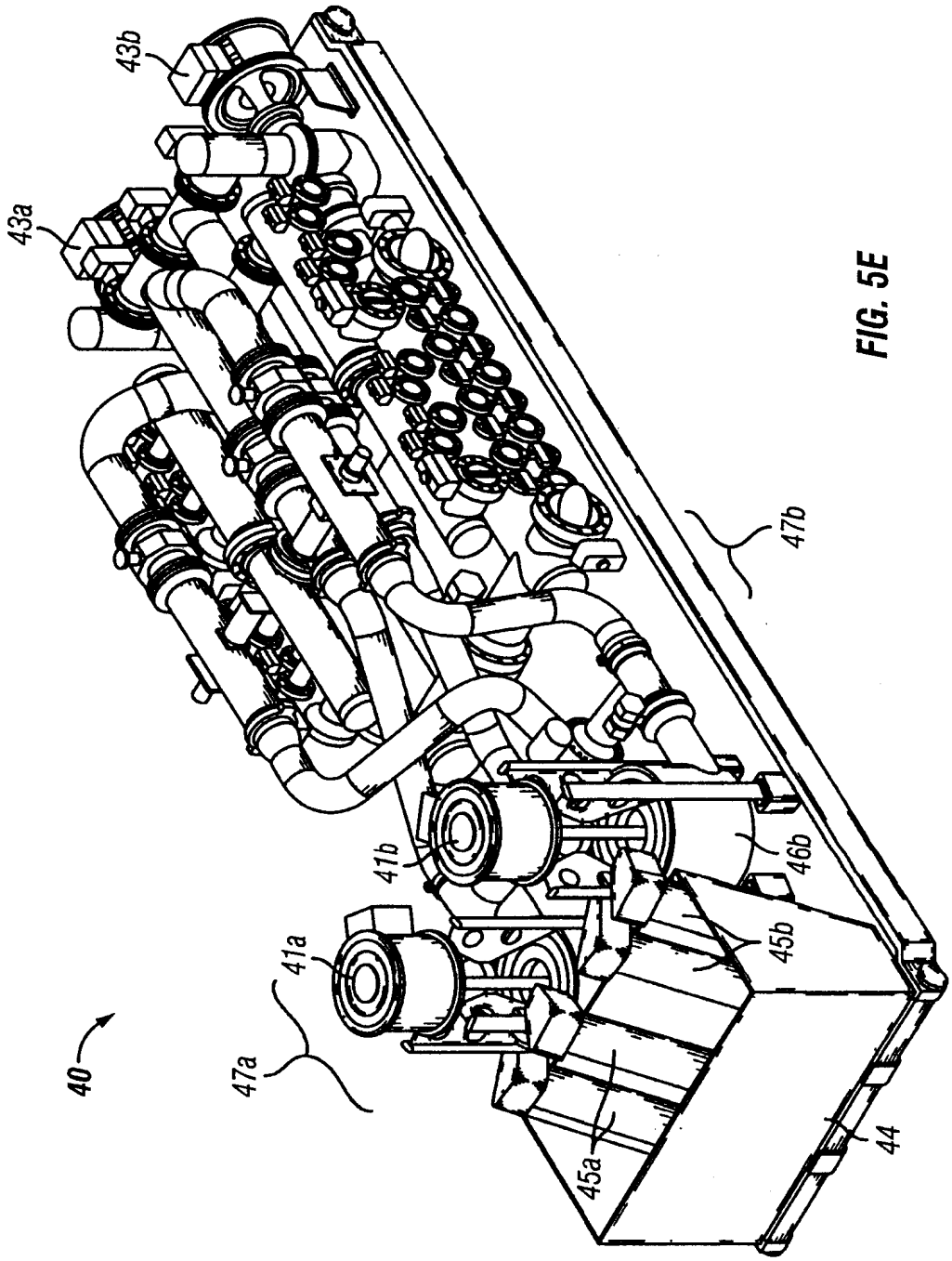


FIG. 5E

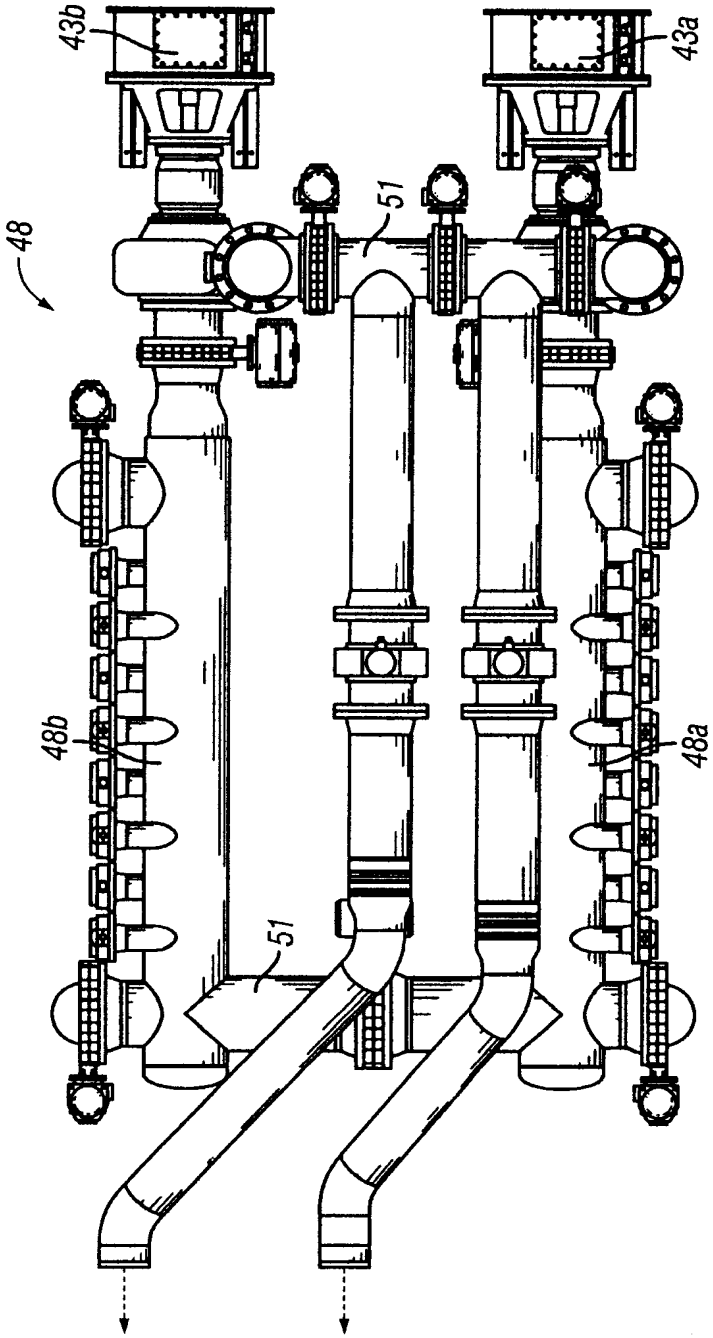


FIG. 6

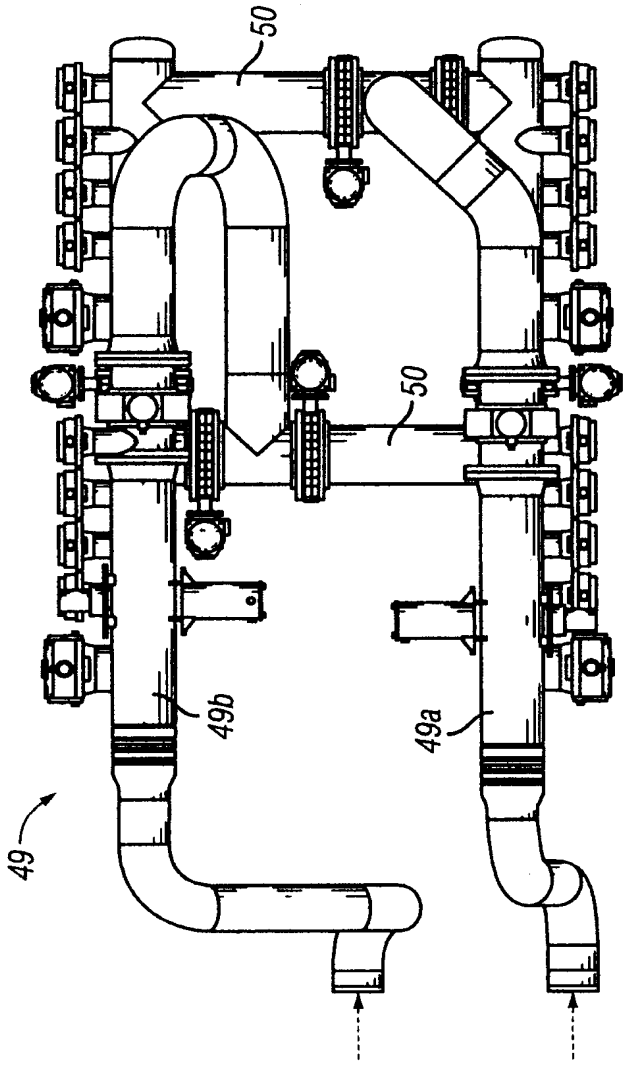
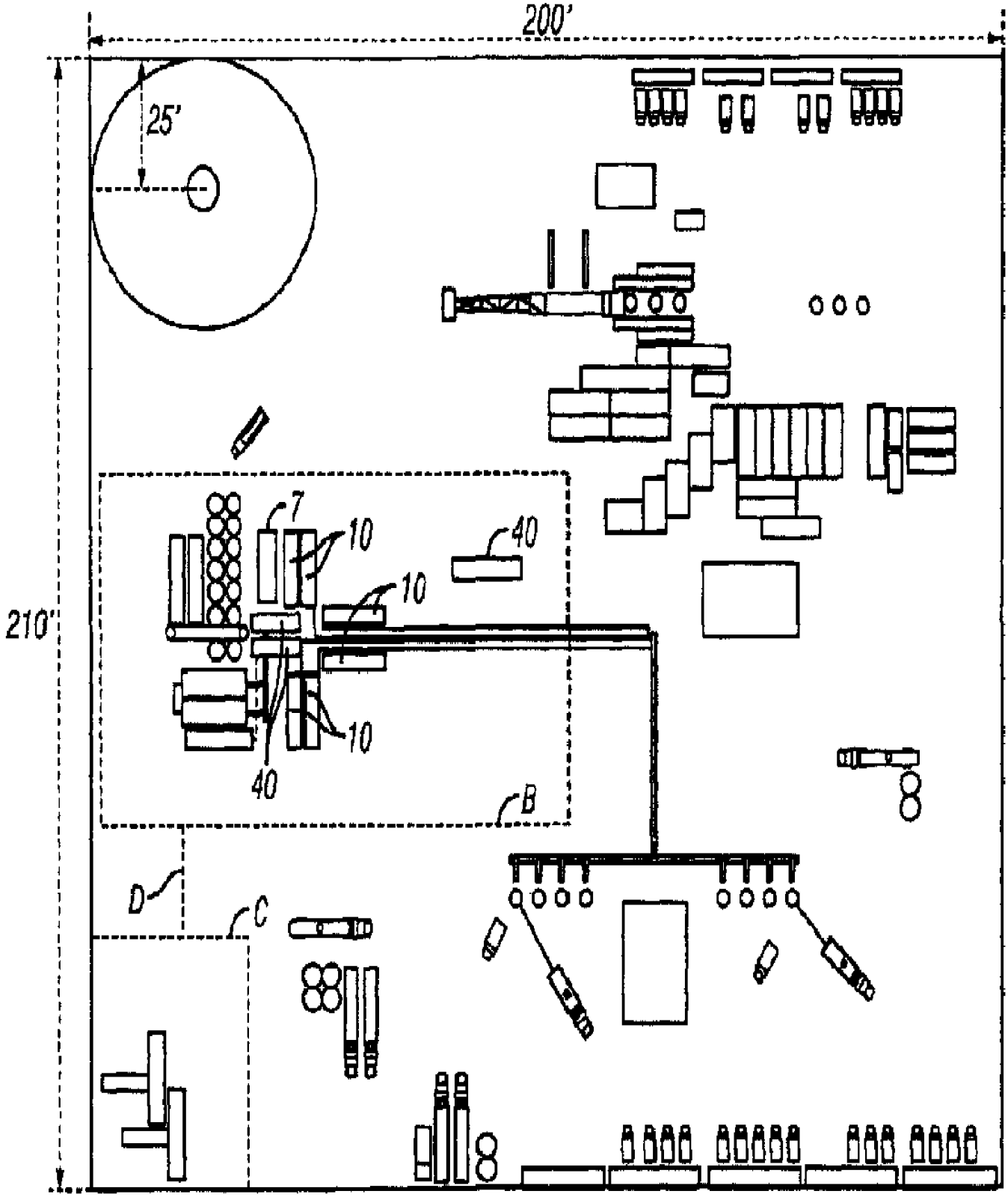


FIG. 7


200'
25'
210'
7
10
10
10
40
40
B
D
C

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

	Date of mailing *(day/month/year)* 15 FEB 2019
Applicant's or agent's file reference 047158.500036	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US2018/063977	International filing date *(day/month/year)* 05 December 2018
Applicant U.S. WELL SERVICES, INC.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may **submit comments on an informal basis on the written opinion of the International Searching Authority** to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

   Shortly after the expiration of **18 months from the priority date, the international application will be published** by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within 22 months from the priority date, the applicant may request that a supplementary international search be carried out by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 Telephone No. PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 047158.500036	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2018/063977	International filing date *(day/month/year)* 05 December 2018	(Earliest) Priority Date *(day/month/year)* 05 December 2017
Applicant U.S. WELL SERVICES, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

   a. the figure of the **drawings** to be published with the abstract is Figure No. 1

   ☐ as suggested by the applicant.

   ☒ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/063977

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; E21B 33/068; F04B 15/00 (2019.01)
CPC - E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; F04B 47/02; F04B 49/06 (2019.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 166/66.4; 166/177.5; 166/250.1; 166/271; 166/308.1; 417/410.1 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/0177675 A1 (EVOLUTION WELL SERVICES, LLC) 23 June 2016 (23.06.2016) entire document	1-20
A	US 2007/0277982 A1 (SHAMPINE et al) 06 December 2007 (06.12.2007) entire document	1-20
A	US 2016/0258267 A1 (STEWART & STEVENSON, LLC) 08 September 2016 (08.09.2016) entire document	1-20
A	US 2014/0138079 A1 (US WELL SERVICES LLC) 22 May 2014 (22.05.2014) entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 January 2019	15 FEB 2019
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: TAYLOR P. EVANS
HOGAN LOVELLS US LLP
609 MAIN STREET, SUITE 4200
HOUSTON, TX 77002

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

	Date of mailing *(day/month/year)* 15 FEB 2019
Applicant's or agent's file reference 047158.500036	FOR FURTHER ACTION See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2018/063977	05 December 2018	05 December 2017

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; E21B 33/068; F04B 15/00 (2019.01)
CPC - E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; F04B 47/02; F04B 49/06 (2019.01)

Applicant U.S. WELL SERVICES, INC.

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [ ] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	24 January 2019	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (January 2015)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2018/063977

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2018/063977

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	None	YES
	Claims	1-20	NO
Inventive step (IS)	Claims	None	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	None	NO

2. Citations and explanations:

Claims 1-20 lack novelty under PCT Article 33(2) as being anticipated by Evolution Well Services, Llc.

Regarding Claim 1, Evolution Well Services, Llc discloses a hydraulic fracturing system for fracturing a subterranean formation (a system for pumping and pressurizing fracturing fluid, Para. [0008]), comprising: an electric pump, arranged on a first support structure (fracturing pump transport 108 (first support structure) includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), the electric pump coupled to a well associated with the subterranean formation and powered by at least one electric motor (a plurality of fracturing pump transports 108 that deliver fracturing fluid through wellhead 101 to subsurface geological formations, Para. [0043] & Fig. 2), and configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (a mobile fracturing system 103 may be moved onto the well site 100 to perform fracturing operations that force relatively high pressure fracturing fluid through wellhead 101 into subsurface geological formations to create fissures and cracks within the rock, Para. [0041] & Fig. 1); and support equipment, arranged on a second support structure, electrically coupled to the electric pump (auxiliary power transport 106 integral with drive power transports 104 (second support structure) may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2), wherein the support equipment includes at least a transformer for distributing power to the electric pump (auxiliary power transport 106 integral with drive power transports 104 may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2, and, drive power transports 104 may be configured to monitor and control one or more electrical motors located on the fracturing pump transports 106 via a plurality of connections, such as electrical connections (e.g., copper wires), fiber optics, wireless, and/or combinations thereof, Para. [0045] & Fig. 2), the power being received from at least one generator at a voltage higher than an operating voltage of the electric pump (mobile fracturing system comprises an auxiliary gas turbine generator transport 206, Para. [0050] & Fig. 2, and, auxiliary power transport 106 may receive the 13.8 KV electrical connection and step down the voltage to 4.6 KV, which is provided to other fracturing equipment, such as the fracturing pump transport 108, Para. [0044] & Fig. 2).

Regarding Claim 2, Evolution Well Services, Llc discloses the system of claim 1, wherein the second support structure is separated from and distinct from the first support structure (auxiliary power transport 106 integral with drive power transports 104 (second support structure) separate from fracturing pump transport 108 (first support structure), Fig. 2).

Regarding Claim 3, Evolution Well Services, Llc discloses the system of claim 1, wherein the first support structure and the second support structure are at least one of a trailer, a skid, a pad, a truck bed, or a combination thereof (the term "transport" refers to any transportation assembly, including, but not limited to, a trailer, truck, skid, and/or barge used to transport relatively heavy structures, such as fracturing equipment, Para. [0032]).

Regarding Claim 4, Evolution Well Services, Llc discloses the system of claim 1, further comprising: a variable frequency drive connected to the at least one electric motor to control the speed of the at least one electric motor (one or more electrical motors located on the fracturing pump transports 108, one or more variable frequency drives (VFDs) used to monitor and control the prime movers on the fracturing pump transports 108, Para. [0045] & Fig. 2).

Regarding Claim 5, Evolution Well Services, Llc discloses the system of 4, wherein the variable frequency drive is mounted on the second support structure (each of the drive power transports 104 comprise one or more variable frequency drives (VFDs) integral with auxiliary power transport 106(second support structure), Para. [0045] & Fig. 2).

Regarding Claim 6, Evolution Well Services, Llc discloses the system of claim 1, wherein the first support structure includes a plurality of electric pumps (fracturing pump transport 108 may receive the electric power received from the drive power transport 104 to power a prime mover, the prime mover converts electric power to mechanical power for driving one or more pumps, Para. [0046] & Fig. 2), the plurality of electric pumps having a combined horsepower of between 5,000 and 6,000 horsepower (a fracturing pump transport that comprises a dual shaft electric motor configured to drive at least two pumps, each of the pumps may be configured to operate within a desired mechanical power range, such as about 1,500 HP to about 5,000 HP, to discharge fracturing fluid at relatively high pressures, Para. [0039]).

Regarding Claim 7, Evolution Well Services, Llc discloses the system of claim 1, further comprising: a switch gear (switch gear transport 112, Fig. 2) positioned separate from the second support structure and between the at least one generator and the transformer (switch gear transport 112 located between auxiliary gas turbine generator transport 206 and auxiliary power transport 106 integral with drive power transports 104 (second support structure), Fig. 2).

LIBERTY EXHIBIT 1002, Page 1400

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding Claim 8, Evolution Well Services, Llc discloses a hydraulic fracturing system for fracturing a subterranean formation (a system for pumping and pressurizing fracturing fluid, Para. [0006]), comprising: a first support structure, forming a pumping trailer (fracturing pump transport 108 (first support structure) includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), comprising: an electric pump fluidly connected to a well associated with the subterranean formation and configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (fracturing pump transport 108 (first support structure) includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2, and, a mobile fracturing system 103 may be moved onto the well site 100 to perform fracturing operations that force relatively high pressure fracturing fluid through wellhead 101 into subsurface geological formations to create fissures and cracks within the rock, Para. [0041] & Fig. 1); at least one electric motor providing operational energy to the electric pump (a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2); and a first support component, the first support component regulating operation of the electric pump (drive power transports 104 (first support) may be configured to monitor and control one or more electrical motors located on the fracturing pump transports 108 via a plurality of connections, such as electrical connections (e.g., copper wires), fiber optics, wireless, and/or combinations thereof, Para. [0045] & Fig. 2); and a second support structure, forming a support trailer (auxiliary power transport 106 (second support), Para. [0044] & Fig. 2, and, the term "transport" refers to any transportation assembly, including, but not limited to, a trailer, truck, skid, and/or barge used to transport relatively heavy structures, such as fracturing equipment, Para. [0032]), comprising: a second support component, the second support component regulating electric power transmission to the electric pump (auxiliary power transport 106 may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2).

Regarding Claim 9, Evolution Well Services, Llc discloses the system of claim 8, wherein the second support component comprises at least one of a transformer, a variable frequency drive, or a motor control center (auxiliary power transport 106 may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2).

Regarding Claim 10, Evolution Well Services, Llc discloses the system of claim 8, wherein the first support structure and the second support structure are separate components arranged remote from and not in contact with one another (drive power transports 104 (first support) and auxiliary power transport 106 (second support) located separate from one another, Fig. 2).

Regarding Claim 11, Evolution Well Services, Llc discloses the system of claim 8, wherein the first support structure and the second support structure are at least one of a trailer, a skid, a pad, a truck bed, or a combination thereof (drive power transports 104 (first support) and auxiliary power transport 106 (second support), Fig. 2, and, the term "transport" refers to any transportation assembly, including, but not limited to, a trailer, truck, skid, and/or barge used to transport relatively heavy structures, such as fracturing equipment, Para. [0032]).

Regarding Claim 12, Evolution Well Services, Llc discloses the system of claim 8, wherein the second support component is a transformer for distributing power to the electric pump (auxiliary power transport 106 may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2), the power being received from at least one generator at a voltage higher than an operating voltage of the electric pump (mobile fracturing system comprises an auxiliary gas turbine generator transport 206, Para. [0050] & Fig. 2, and, auxiliary power transport 106 may receive the 13.8 KV electrical connection and step down the voltage to 4.8 KV, which is provided to other fracturing equipment, such as the fracturing pump transport 108, Para. [0044] & Fig. 2).

Regarding Claim 13, Evolution Well Services, Llc discloses the system of claim 8, wherein the first support structure includes a plurality of electric pumps (fracturing pump transport 108 (first support structure) includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), the plurality of electric pumps having a combined horsepower of between 5,000 and 6,000 horsepower (a fracturing pump transport that comprises a dual shaft electric motor configured to drive at least two pumps, each of the pumps may be configured to operate within a desired mechanical power range, such as about 1,500 HP to about 5,000 HP, to discharge fracturing fluid at relatively high pressures, Para. [0039]).

Regarding Claim 14, Evolution Well Services, Llc discloses the system of claim 8, wherein the electric pump has a horsepower rating of between approximately 1,750 and approximately 3,000 (each of the pumps may be configured to operate within a desired mechanical power range, such as about 1,500 HP to about 5,000 HP, Para. [0039]).

Regarding Claim 15, Evolution Well Services, Llc discloses the system of claim 8, further comprising a plurality of pumping trailers and a plurality of support trailers arranged at well site (plural fracturing pump transports 108, drive power transports 104 (first support) and auxiliary power transports 106 (second support), Fig. 2, and, the term "transport" refers to any transportation assembly, including, but not limited to, a trailer, truck, skid, and/or barge used to transport relatively heavy structures, such as fracturing equipment, Para. [0032]), wherein a combined horsepower of the respective electric pumps of the plurality of pumping trailers is approximately 30,000 (fracturing pump transport 108 includes prime mover may be a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2, and, each dual shaft electric motor may be an electric motor configured to operate within a desired mechanical power range, such as about 1,500 horsepower (HP) to about 10,000 HP, Para. [0039] & Fig. 2).

Regarding Claim 16, Evolution Well Services, Llc discloses the system of claim 8, wherein the first support component comprises at least one of a transformer, a variable frequency drive, or a motor control center (drive power transports 104 (first support) may be configured to monitor and control one or more electrical motors (motor control center) located on the fracturing pump transports 108 via a plurality of connections, such as electrical connections (e.g., copper wires), fiber optics, wireless, and/or combinations thereof, Para. [0045] & Fig. 2).

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:

Regarding Claim 17, Evolution Well Services, Llc discloses a hydraulic fracturing system for fracturing a subterranean formation (a system for pumping and pressurizing fracturing fluid, Para. [0006]), comprising: at least one generator (turbine generator transport 206, Para. [0050] & Fig. 2); at least one switch gear receiving electrical power from the generator (switch gear transport 112 may receive the electricity generated from the mobile source of electric power via one or more electrical connections, Para. [0043] & Fig. 1 and 2); an electric pump, arranged on a first support structure (fracturing pump transport 106 (first support structure) includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), the electric pump coupled to a well associated with the subterranean formation and powered by at least one electric motor arranged on the first support structure (fracturing pump transport 106 (first support structure) associated with wellhead 101 includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), the electric pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (fracturing pump transport 106 (first support structure) associated with wellhead 101 includes a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2, and, mobile fracturing system 103 may be moved onto the well site 100 to perform fracturing operations that force relatively high pressure fracturing fluid through wellhead 101 into subsurface geological formations to create fissures and cracks within the rock, Para. [0041] & Fig. 1 and 2); and a transformer, arranged on a second support structure (auxiliary power transport 106 (second support structure) may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, Para. [0044] & Fig. 2), positioned between the switch gear and at least one electric motor (auxiliary power transport 106 (second support structure) positioned between switch gear transport 112 and fracturing pump transport 108 including a dual shaft electric motor that drives two different pumps, Para. [0046] & Fig. 2), the transformer reducing a voltage output from the at least one switch gear (auxiliary power transport 106 (second support structure) may comprise a transformer and a control system to control, monitor, and provide power to the electrically connected fracturing equipment, auxiliary power transport 106 may receive the 13.8 KV electrical connection and step down the voltage to 4.8 KV, which is provided to other fracturing equipment, such as the fracturing pump transport 108, Para. [0044] & Fig. 2).

Regarding Claim 18, Evolution Well Services, Llc discloses the system of claim 17, wherein the first support structure and the second support structure are separate components arranged remote from and not in contact with one another (drive power transports 104 (first support) and auxiliary power transport 106 (second support) located separate from one another, Fig. 2).

Regarding Claim 19, see claim 3.

Regarding Claim 20, see claim 6.

Claims 1-20 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

Search History:

Limited Classification Search

The Patent Analyst performed a limited classification search within the following US, IPC, CPC, ECLA, or F-Term classification areas:

CPC Class/Subclass(es): E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; F04B 47/02; F04B 49/06 (2019.01)

IPC (8) Class/Subclass(es): E21B 43/12; E21B 43/26; B60P 3/00; B62D 63/06; E21B 33/068; F04B 15/00; F04B 17/03; F04B 47/02; F04B 49/06; F04D 13/06 (2019.01)

U.S. Class/Subclass(es): 166/66.4; 166/177.5; 166/250.1; 166/271; 166/308.1; 417/410.1

See Global Search Results.

Global Patent Literature Text Search

The Patent Analyst performed the following global text search, which was not limited by classification but may or may not have been limited by other criteria:

Minesoft PatBase: https//www.patbase.com

#	Search query	Results
1	INV=(OEHRING, JARED)	7
2	PN=(US10020711 BB OR US10036238 BB OR US10107086 BB OR US10119381 BB OR US2017028368 AA OR US9650879 BB OR US9745840 BB OR US9840901 BB OR US9893500 BB OR US9970278 BB OR US9995218 BB OR US9650871 BB)	2
3	INV=(HINDERLITER, BRANDON)	6
4	INV=(ROBINSON, LON)	11
5	PA=(US WELL SERVICES)	8
6	PN=(US20120255734)	1
7	UC=(166/177.5)	304
8	UC=(166/308.1)	1405
9	UC=(166/308.1) and (support structure or trailer or skid or pad or truck bed)	312
10	9 not 7	261
11	UC=(166/308.1) and transformer% and variable frequency drive%	9
12	UC=(166/308.1) and generator and (switch gear or switchgear)	3
13	UC=(166/308.1) and voltage and pump	43
14	13 not (9 or 7)	23
15	UC=(166/66.4)	470

16	UC=(166/66.4) and (fracturing or fracking)	28
17	UC=(166/271)	409
18	UC=(166/271) and pump%	170
19	18 not (13 or 9 or 7)	157
20	UC=(166/250.1)	392
21	UC=(166/250.1) and pump%	234
22	21 not (18 or 13 or 9 or 7)	180
23	UC=(417/410.1)	1545
24	UC=(417/410.1) and (fracturing or fracking)	4
25	IC=(E21B43/26)	9399
26	IC=(E21B43/26) and (support structure or trailer or skid or pad or truck bed) and electr* and pump%	548
27	26 not (21 or 18 or 13 or 9 or 7)	397
28	IC=(E21B43/26) and (support structure or trailer or skid or pad or truck bed) and transformer% and variable frequency drive%	19
29	IC=(E21B43/26) and (support structure or trailer or skid or pad or truck bed) and generator and (switch gear or switchgear)	10
30	IC=(E21B43/26) and electr* and pump% and motor and high pressure	309
31	30 not (26 or 21 or 18 or 13 or 9 or 7)	113
32	IC=(E21B43/26) and (generator w10 voltage)	47
33	32 not (30 or 26 or 21 or 18 or 13 or 9 or 7)	26
34	IC=(E21B43/12)	9614
35	IC=(E21B43/12) and (fracturing or fracking) and transformer% and variable frequency drive% and pump%	8
36	IC=(E21B43/12) and (fracturing or fracking) and generator and (switch gear or switchgear) and pump%	3
37	IC=(E21B43/12) and (fracturing or fracking) and (support structure or trailer or skid or pad or truck bed) and electr* and pump%	81
38	37 not (32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	48
39	IC=(E21B33/068)	963
40	IC=(E21B33/068) and (fracturing or fracking)	235
41	40 not (37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	192
42	IC=(F04B15/00)	4818
43	IC=(F04B15/00) and (fracturing or fracking)	21
44	IC=(F04B17/03)	7519
45	IC=(F04B17/03) and (fracturing or fracking)	44

46	45 not (43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	27
47	IC=(F04B47/02)	4535
48	IC=(F04B47/02) and (fracturing or fracking)	32
49	IC=(F04B49/06)	18587
50	IC=(F04B49/06) and (fracturing or fracking)	78
51	50 not (45 or 43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	53
52	IC=(F04B49/06) and ((support structure or trailer or skid or pad or truck bed) w10 remote)	10
53	IC=(F04D13/06)	17197
54	IC=(F04D13/06) and (fracturing or fracking)	18
55	IC=(B62D63/06)	6299
56	IC=(B62D63/06) and (fracturing or fracking)	13
57	IC=(B60P3/00)	17890
58	IC=(B60P3/00) and (fracturing or fracking)	63
59	58 not (50 or 45 or 43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	55
60	CPC=(E21B43/26)	4421
61	CPC=(E21B43/26) and (support structure or trailer or skid or pad or truck bed)	799
62	61 not (58 or 50 or 45 or 43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	272
63	CPC=(E21B43/26) and electr* and pump% and transformer% and variable frequency drive% and generator and (switch gear or switchgear)	8
64	CPC=(E21B43/26) and (generator w10 voltage)	32
65	CPC=(E21B43/26) and transformer% and variable frequency drive% and (remote or wireless)	13
66	CPC=(E21B43/12)	1952
67	CPC=(E21B43/12) and (fracturing or fracking) and (support structure or trailer or skid or pad or truck bed)	38
68	CPC=(F04B49/06)	3514
69	CPC=(F04B49/06) and (fracturing or fracking) and (support structure or trailer or skid or pad or truck bed) and electr* and pump%	13
70	CPC=(F04B49/06) and electr* and pump% and transformer% and variable frequency drive% and generator and (switch gear or switchgear)	2
71	CPC=(F04B47/02)	1601
72	CPC=(F04B47/02) and (fracturing or fracking) and electr* and pump%	41
73	72 not (61 or 58 or 50 or 45 or 43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	14

74	CPC=(B62D63/06)	807
75	CPC=(B62D63/06) and (fracturing or fracking)	4
76	CPC=(B60P3/00)	2073
77	CPC=(B60P3/00) and (fracturing or fracking)	13
78	RF=(18_63977)	22
79	ctb=78 or ctf=78	1068
80	79 not (78 or 72 or 61 or 58 or 50 or 45 or 43 or 40 or 37 or 32 or 30 or 26 or 21 or 18 or 13 or 9 or 7)	887
81	80 and (fracturing or fracking)	191

Google Patents: https://patents.google.com

#	Search query	Results
1	hydraulic fracturing electric pump support equipment (trailer OR skid OR pad OR truck bed)	3783
2	fracturing electric pump motor transformer generator voltage	664
3	fracturing electric pump motor remote trailer power source	436
4	fracturing transformer variable frequency drive trailer	121
5	hydraulic fracking pumps electric motors	1466
6	hydrofracturing modular pumps electric drive	599
7	hydraulic fracturing independent skids	1635

Computer Accessed Text Databases Searched

The Patent Analyst searched the following computer accessed text databases:

Google: https://www.google.com/

#	Search query	Results
1	US WELL SERVICES hydraulic fracturing support equipment structure	31900000
2	hydraulic fracturing electric pump support equipment skids	784000

Google Scholar: https://scholar.google.com/

#	Search query	Results
1	US WELL SERVICES hydraulic fracturing support equipment structure	32500

YouTube: https://youtube.com

#	Search query	Results
1	US WELL SERVICES hydraulic fracturing support equipment structure	N/A

Date search was completed: 24 January 2019

RP/SS

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: Taylor P. Evans
Hogan Lovells US LLP
609 Main Street, Suite 4200
Houston, TX 77002
United States of America

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

(PCT Rule 44.1)

Applicant's or agent's file reference 047158.500035	Date of mailing *(day/month/year)* 05 MAR 2019 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US18/63970	International filing date *(day/month/year)* 05 December 2018 (05.12.2018)
Applicant U.S. Well Services, Inc.	

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

   Filing of amendments and statement under Article 19:
   The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

   When? The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

   How? Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

   For more detailed instructions, see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 – 9.011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:
   ☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.
   ☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

   The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. These comments will be made available to the public after international publication. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established.

   Shortly after the expiration of 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

   Within 19 months from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for **entry into the national phase** before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

   Within 22 months from the priority date, the applicant may request that a supplementary international search be carried out by a different International Searching Authority that offers this service (Rule 45*bis*.1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/220 (July 2017)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 047158.500035	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US18/63970	International filing date *(day/month/year)* 05 December 2018 (05.12.2018)	(Earliest) Priority Date *(day/month/year)* 05 December 2017 (05.12.2017)
Applicant U.S. Well Services, Inc.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 2 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. ☐ **Certain claims were found unsearchable** (see Box No. II).

3. ☐ **Unity of invention is lacking** (see Box No. III).

4. With regard to the **title**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

   ☒ the text is approved as submitted by the applicant.

   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. With regard to the **drawings**,

   a. the figure of the drawings to be published with the abstract is Figure No. 1

   ☐ as suggested by the applicant.

   ☒ as selected by this Authority, because the applicant failed to suggest a figure.

   ☐ as selected by this Authority, because this figure better characterizes the invention.

   b. ☐ none of the figures is to be published with the abstract.

LIBERTY EXHIBIT 1002, Page 1409

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US18/63970

A. CLASSIFICATION OF SUBJECT MATTER

IPC - E21B 43/20, 43/26, 37/00; F04B 49/20, 15/02, 47/02, 17/03; F16H 39/02 (2019.01)

CPC - E21B 43/20, 43/26, 37/00; F04B 49/20, 15/02, 47/02, 17/03, 53/006, 9/045; F04D 25/028; F16H 39/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2017/0051732 A1 (BAKER HUGHES INCORPORATED) 23 February 2017; Figures 1-5; Paragraphs [0016] and [0021]	1-20
Y	US 4,100,822 A (ROSMAN, A) 18 July 1978; Figures 3-5; Column 4, Lines 57-59	1-20
Y	US 8,851,860 B1 (MAIL, J) 07 October 2014; Figure 1; Column 1, Lines 29-33, 39-48, 53-54, 64-67 and Column 2, Lines 1-3	4-5, 14 and 18
Y	US 2016/0258267 A1 (STEWART & STEVENSON, LLC) 08 September 2016; Figure 6; Paragraph [0062]	8-14 and 19-20
A	US 2016/0341281 A1 (ONESUBSEA IP UK LIMITED) 24 November 2016; Figure 5; entire document	1-20
A	US 2005/0274508 A1 (FOLK, R et al.) 15 December 2005; Figure 1; entire document	1-20
A	US 2007/0131410 A1 (HILL, F et al.) 14 June 2007; Figure 9; entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 January 2019 (26.01.2019)	05 MAR 2019
Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (January 2015)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: Taylor P. Evans
Hogan Lovells US LLP
609 Main Street, Suite 4200
Houston, TX 77002
United States of America

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)* 05 MAR 2019

Applicant's or agent's file reference
047158.500035

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US18/63970	05 December 2018 (05.12.2018)	05 December 2017 (05.12.2017)

International Patent Classification (IPC) or both national classification and IPC
IPC - E21B 43/20, 43/26, 37/00; F04B 49/20, 15/02, 47/02, 17/03; F16H 39/02 (2019.01)
CPC - E21B 43/20, 43/26, 37/00; F04B 49/20, 15/02, 47/02, 17/03, 53/006, 9/045; F04D 25/028; F16H 39/02

Applicant U.S. Well Services, Inc.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☒ Box No. VIII Certain observations on the international application

2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	26 January 2019 (26.01.2019)	Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/237 (cover sheet) (January 2015)

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US18/63970

Box No. I Basis of this opinion

1. With regard to the language, this opinion has been established on the basis of:

☒ the international application in the language in which it was filed.

☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the rectification of an obvious mistake authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this opinion has been established on the basis of a sequence listing:

a. ☐ forming part of the international application as filed:

☐ in the form of an Annex C/ST.25 text file.

☐ on paper or in the form of an image file.

b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US18/63970

Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	NONE	YES
	Claims	1-20	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations:

Claims 1-3, 6-7 and 10-17 lack an inventive step under PCT Article 33(3) as being obvious over US 2017/0051732 A1 to BAKER HUGHES INCORPORATED, hereinafter "BAKER", in view of US 4,100,822 A (ROSMAN).

As per claim 1, Baker discloses a hydraulic fracturing system for fracturing a subterranean formation (pump system 10 for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean); Figure 1; Paragraph [0016] and [0021]) comprising: a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation (pump 50 for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean), which may be a quintuplex pump having five pistons 146 (plungers); Figure 3; Paragraphs [0016] and [0021]), the multi-plunger pump (50) configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (pump 50 for pumping pressurized fluid into a borehole (wellbore) in an adjacent earthen formation (subterranean) for hydraulic fracturing; Figure 3; Paragraphs [0016] and [0021]); a plurality of motors positioned to power the multi-plunger pump (motors 34, 58 positioned to power the pump 50 (multi-plunger pump); Figure 1); and a planetary gear train having an input pinion gear in rotational contact with the plurality of motors (planetary gear system 170 having a input pinion sun gear 174 in rotational contact with motor 58 through drive shaft 60 and motor 34 through gear train 62 to drive shaft 52; Figures 1 and 4; Paragraph [0024]), wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operate are selected so as to limit a maximum pump speed associated with the multi-plunger pump (the gear ratio of planetary gear system 170 allows for gear reduction, allowing for the rotational speed of the drive shaft 60 to convert to a slower rotational speed on the drive shaft 52 of the pump 50 (thereby limiting maximum pump speed); Figures 1 and 4; Paragraph [0024]). Baker fails to disclose a plurality of input pinion gears in rotational contact with each of the plurality of motors. Rosman discloses a plurality of motors and a plurality of input pinion gears in rotational contact with each of the plurality of motors (see Figures 3-5 wherein pinions 23 having gear teeth 34 are connected rotationally to hydraulic drive motors 21). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the planetary gearing of Baker by having a motor for each associated planet gear as taught by Rosman for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59).

As per claim 2, Baker as modified by Rosman discloses the system of claim 1. Baker fails to disclose the system further comprising a plurality of speed reduction gearboxes positioned between the plurality of input pinion gears and the plurality of motors so as to achieve a desired pump rate. Rosman discloses a plurality of speed reduction gearboxes positioned between a plurality of input pinion gears and a plurality of motors (gear boxes 22 are positioned between a plurality of pinions 23 having gear teeth 23 and a plurality of hydraulic drive motors 21; gear boxes are designed to increase torque while reducing speed of the output shaft; Figures 3-5; Column 4, Lines 46-62). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the gearing of Baker by having a motor for each associated planet gear as well as gear boxes as taught by Rosman resulting in a desired pump rate for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59) and developing the amount of torque necessary to rotate ring members with high loads (Rosman; Column 4, Lines 60-62)).

As per claim 3, Baker as modified by Rosman discloses the system of claim 1. Baker fails to disclose wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors. Rosman discloses wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors (hydraulic drive motors 21; Figure 4). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the motor of Baker with the plurality of hydraulic motors as taught by Rosman for the purpose of utilizing a motor which can generate high torques without excessive size.

As per claim 6, Baker as modified by Rosman discloses the system of claim 1. Baker further discloses wherein the hydraulic pump comprises an odd number of plungers greater than or equal to five plungers (pump 50 for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean) with five pistons 146 (plungers); Figure 3; Paragraphs [0016] and [0021]).

As per claim 7, Baker as modified by Rosman discloses the system of claim 6, wherein a stroke length of each of the plungers associated with the hydraulic pump is selected to inversely relate to a pump speed associated with the hydraulic pump so as to achieve a predetermined flow rate (see Figure 3 wherein the distance the crosshead 148 travels (stroke length) of the piston 146 (plunger) associated with the pump system 10 would be in a inversely related relation to pump speed since the longer the stroke length is, the lower the pump speed required to achieve a given flow rate; Figures 3-5; Paragraphs [0026] and [0019]).

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WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US18/63970

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claims 4-10, 14 and 18-20 are objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because claims 4-10, 14 and 18-20 are indefinite for the following reason: Claims 4-10, 14 and 18-20 refer to "the plurality of hydraulic pumps". There is a lack of antecedent basis for "the plurality of hydraulic pumps". For the purpose of this opinion, as best understood, the claim is interpreted to read "the hydraulic pump".

Claim 11 is objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because claim 11 is indefinite for the following reason: Claim 11 refers to "the plurality of electric motors" in line 8. There is a lack of antecedent basis for "electric motors". For the purpose of this opinion, as best understood, the claim is interpreted to read "the plurality of motors".

Claim 20 is objected to under PCT Rule 66.2(a)(v) as lacking clarity under PCT Article 6 because claim 20 is indefinite for the following reason: Claim 20 refers to "the plurality of VFDs" in line 3. There is a lack of antecedent basis for "the plurality of VFDs". For the purpose of this opinion, as best understood, the claim is interpreted to read "the VFD".

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
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-***-Continued from Box V: Citations and Explanations-***-
As per claim 15, Baker discloses a method for pumping fluid into a wellbore associated with a subterranean formation (pump system 10 for hydraulic (fluid) fracturing of a borehole in an adjacent earthen formation (subterranean); Figure 1; Paragraph [0016] and [0021]), the method comprising: fluidly connecting a multi-plunger hydraulic fracturing pump to a well associated with the subterranean formation (pump 50 is fluidly connected to a borehole and is used for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean), which may be a quintuplex pump having five pistons 146 (plungers); Figure 3; Paragraphs [0016] and [0021]) such that the multi-plunger pump pumps fluid into the wellbore at a high pressure so that fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (pump 50 for pumping pressurized fluid into a borehole (wellbore) in an adjacent earthen formation (subterranean) for hydraulic fracturing; Figure 3; Paragraphs [0016] and [0021]); powering the multi-plunger pump with a plurality of motors (motors 34, 58 positioned to power the pump 50 (multi-plunger pump); Figure 1); and a planetary gear train having an input pinion gear in rotational contact with the plurality of motors (planetary gear system 170 having a input pinion sun gear 174 in rotational contact with motor 58 through drive shaft 60 and motor 34 through gear train 62 to drive shaft 52; Figure 4; Paragraph [0024]) so as to translate power from the plurality of motors into a desired pump rate of the multi-plunger pump (planetary gear system 170, allows for gear reduction of the power coming from motor 34, allowing for the rotational speed of the drive shaft 60 connected to motor 58, to convert to a slower rotational speed on the drive shaft 52 of the pump 50 (desired pump rate); Figures 1 and 4; Paragraph [0024]). Baker fails to disclose a plurality of input pinion gears in rotational contact with each of the plurality of motors. Rosman discloses a plurality of motors and a plurality of input pinion gears in rotational contact with each of the plurality of motors (see Figures 3-5 wherein pinions 23 having gear teeth 34 are connected rotationally to hydraulic drive motors 21). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the planetary gearing of Baker by having a motor for each associated planet gear as taught by Rosman for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59).

As per claim 16, Baker as modified by Rosman discloses the method of claim 15. Baker fails to disclose further comprising: positioning a plurality of speed reduction gearboxes between the plurality of input pinion gears and the plurality of motors so as to achieve the desired pump rate. Rosman discloses positioning a plurality of speed reduction gearboxes between a plurality of input pinion gears and a plurality of motors (gear boxes 22 are positioned between a plurality of pinions 23 having gear teeth 23 and a plurality of hydraulic drive motors 21; gear boxes are designed to increase torque while reducing speed of the output shaft; Figures 3-5; Column 4, Lines 46-62). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the gearing of Baker by having a motor for each associated planet gear as well as gear boxes as taught by Rosman resulting in a desired pump rate for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59) and developing the amount of torque necessary to rotate ring members with high loads (Rosman; Column 4, Lines 60-62)).

As per claim 17, Baker as modified by Rosman discloses the method of claim 15. Baker fails to disclose wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors. Rosman discloses wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors (hydraulic drive motors 21; Figure 4). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the motor of Baker with the plurality of hydraulic motors as taught by Rosman for the purpose of utilizing a motor which can generate high torques without excessive size.

Claims 4-5 and 18 lack an inventive step under PCT Article 33(3) as being obvious over BAKER in view of ROSMAN further in view of US 8,851,860 B1 (MAIL).

As per claim 4, Baker as modified by Rosman discloses the system of claim 1. Baker fails to disclose wherein the maximum pump speed correlates to a critical plunger speed associated with the hydraulic pump. Mail discloses wherein a maximum pump speed correlates to a critical plunger speed associated with a hydraulic pump (mainstream methods of subsurface downhole pumping (hydraulic pump) include mounted reciprocating mechanisms (plunger) in a casing tube; optimal speeds of up and down strokes can be defined as maximum speeds that will not cause overstressing of pump rod (critical plunger speed); therefore maximum pumping speed correlates to an operation at optimal up and down stroke speed (critical plunger speed) associated with the hydraulic pump; Column 1, Lines 29-33, 39-48, 53-54, 64-67 and Column 2, Lines 1-3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the maximum pump speed of Baker by correlating it to the critical plunger speed as taught by Mail for the purpose of avoiding overstressing of structural parts and premature damage (Baker; Column 1, Lines 64-67 and Column 2, Lines 1-3).

As per claim 5, Baker as modified by Rosman discloses the system of claim 1. Baker fails to disclose wherein the maximum pump speed is 5% or less over a critical plunger speed associated with hydraulic pump. Mail discloses wherein the maximum pump speed is 5% or less over a critical plunger speed associated with hydraulic pump (mainstream methods of subsurface downhole pumping (hydraulic pump) include mounted reciprocating mechanisms (plunger) in a casing tube; optimal speeds of up and down strokes can be defined as maximum speeds that will not cause overstressing of pump rod (critical plunger speed); therefore maximum pumping speed would equate (less than 5%) to an operation at optimal up and down stroke speed (critical plunger speed) associated with the hydraulic pump; Column 1, Lines 29-33, 39-48, 53-54, 63-67 and Column 2, Lines 1-3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the maximum pump speed of Baker by equating it to the critical plunger speed as taught by Mail for the purpose of avoiding overstressing of structural parts and premature damage (Baker; Column 1, Lines 63-67 and Column 2, Lines 1-3).

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Supplemental Box

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As per claim 18, Baker as modified by Rosman discloses the method of claim 15. Baker fails to disclose wherein the maximum pump speed correlates to a critical plunger speed associated with the hydraulic pump. Mail discloses wherein a maximum pump speed correlates to a critical plunger speed associated with a hydraulic pump (mainstream methods of subsurface downhole pumping (hydraulic pump) include mounted reciprocating mechanisms (plunger) in a casing tube; optimal speeds of up and down strokes can be defined as maximum speeds that will not cause overstressing of pump rod (critical plunger speed); therefore maximum pumping speed correlates to an operation at optimal up and down stroke speed (critical plunger speed) associated with the hydraulic pump; Column 1, Lines 29-33, 39-48, 53-54, 64-67 and Column 2, Lines 1-3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the maximum pump speed of Baker by correlating it to the critical plunger speed as taught by Mail for the purpose of avoiding overstressing of structural parts and premature damage (Baker; Column 1, Lines 64-67 and Column 2, Lines 1-3).

Claims 8-13 and 19-20 lack an inventive step under PCT Article 33(3) as being obvious over BAKER in view of ROSMAN further in view of US 2016/0258267 A1 to STEWART & STEVENSON, LLC, hereinafter "STEWART".

As per claim 8, Baker as modified by Rosman discloses the system of claim 1. Baker discloses further comprising: a variable frequency drive (VFD) connected to a motor to control the speed of the motor, wherein the VFD is positioned to accelerate or decelerate pump rotational speeds associated with the hydraulic pump (variable frequency drive (VFD) 76 connected to motor 34 to control the speed thereof, wherein the VFD is positioned to adjust operating speeds of pump 50; Figure 2; Paragraph [0019-0020]). Baker fails to disclose a variable frequency drive (VFD) connected to a plurality of motors. Stewart discloses a variable frequency drive (VFD) connected to a plurality of motors (controlling, using one or more variable frequency drives (VFDs), a plurality of electrical motors to drive at least one fluid pump of the at least one hydraulic fracturing pump unit; Claim 31). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the other motor of Baker to be connected to the VFD as taught by Stewart for the purpose of utilizing the benefits of a VFD to the other motors in the system, the benefits including contributing to energy savings, increasing the efficiency and life of the motor, reducing mechanical wear upon the motor and thus the need for repair (Baker; Paragraph [0019]).

As per claim 9, Baker as modified by Rosman and Stewart discloses the system of claim 8. Baker further discloses a variable frequency drive (VFD), wherein the VFD is positioned to accelerate or decelerate pump rotational speeds associated with the hydraulic pump (variable frequency drive (VFD) 76 connected to motor 34 to control the speed thereof, wherein the VFD is positioned to adjust operating speeds of pump 50; Figure 2; Paragraph [0019-0020]). Baker fails to disclose wherein the VFD comprises a plurality of VFDs connected to a plurality of motors, wherein the plurality of VFDs are configured to share a load required to power the hydraulic pump. Stewart discloses wherein the VFD comprises a plurality of VFDs connected to a plurality of motors, wherein the plurality of VFDs are configured to share a load required to power the hydraulic pump (controlling, using one or more (plurality) variable frequency drives (VFDs), a plurality of electrical motors to drive at least one fluid pump of the at least one hydraulic fracturing pump unit (sharing the load); Claim 31). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the other motor of Baker to have a VFD for the purpose utilizing the benefits of a VFD to the other motors in the system, the benefits including contributing to energy savings, increasing the efficiency and life of the motor, reducing mechanical wear upon the motor and thus the need for repair (Baker; Paragraph [0019]).

As per claim 10, Baker as modified by Rosman and Stewart discloses the system of claim 9. Baker fails to disclose wherein a plurality of VFDs are configured to automatically shut off in the event of an overpressure event with respect to the plurality of hydraulic pumps. Stewart discloses wherein a plurality of VFDs are configured to automatically shut off in the event of an overpressure event with respect to a hydraulic pump (a RUN/STOP will control the fracturing pump unit 700 a in which an e-stop will be supplied to stop the entire fracturing pump unit 700 a, shutting down frac VFDs 410 a, 410 b of motors 411 a, 411 b; the RUN/STOP is initiated when frac VFD 410 a detects the discharge pressure exceeds a overpressure setpoint with respect to hydraulic fracturing pump 710 a, it stops the frac motor 411 as it activates a shutdown; Figures 3 and 6; Paragraphs [0054] and [0062]). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the VFD of Baker to automatically shut down during an overpressure event as taught by Stewart for the purpose of avoiding catastrophic failure in the system.

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Supplemental Box

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-***-Continued from Previous Supplemental Box-***-
As per claim 11, Baker discloses a hydraulic fracturing system for fracturing a subterranean formation (pump system 10 for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean); Figure 1; Paragraph [0016] and [0021]) comprising: a multi-plunger hydraulic fracturing pump fluidly connected to a well associated with the subterranean formation (pump 50 for hydraulic fracturing of a borehole in an adjacent earthen formation (subterranean), which may be a quintuplex pump having five pistons 146 (plungers); Figure 3; Paragraphs [0016] and [0021]), the multi-plunger pump configured to pump fluid into a wellbore associated with the well at a high pressure so that the fluid passes from the wellbore into the subterranean formation and fractures the subterranean formation (pump 50 for pumping pressurized fluid into a borehole (wellbore) in an adjacent earthen formation (subterranean) for hydraulic fracturing; Figure 3; Paragraphs [0016] and [0021]); a plurality of motors positioned to power the multi-plunger pump (motors 34, 58 positioned to power the pump 50 (multi-plunger pump); Figure 1); a variable frequency drive connected to a motor to control the speeds of the motor (variable frequency drive (VFD) 76 connected to motor 34 to control the speed thereof, wherein the VFD is positioned to adjust operating speeds of pump 50; Figure 2; Paragraph [0019-0020]); and a planetary gear train having an input pinion gear in rotational contact with the plurality of motors (planetary gear system 170 having a input pinion sun gear 174 in rotational contact with motor 58 through drive shaft 60 and motor 34 through gear train 62 to drive shaft 52; Figure 4; Paragraph [0024]), wherein a gear ratio of the planetary gear train and a speed at which the plurality of motors operates are selected so as to limit a maximum pump speed associated with the multi-plunger pump (the gear ratio of planetary gear system 170 allows for gear reduction, allowing for the rotational speed of the drive shaft 60 to convert to a slower rotational speed on the drive shaft 52 of the pump 50 (thereby limiting maximum pump speed); Figures 1 and 4; Paragraph [0024]). Baker fails to disclose a plurality of input pinion gears in rotational contact with each of the plurality of motors. Baker also fails to disclose a variable frequency drive (VFD) connected to a plurality of motors. Rosman discloses a plurality of motors and a plurality of input pinion gears in rotational contact with each of the plurality of motors (see Figures 3-5 wherein pinions 23 having gear teeth 34 are connected rotationally to hydraulic drive motors 21). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the planetary gearing of Baker by having a motor for each associated planet gear as taught by Rosman for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59). Stewart discloses a variable frequency drive (VFD) connected to a plurality of motors (controlling, using one or more variable frequency drives (VFDs), a plurality of electrical motors to drive at least one fluid pump of the at least one hydraulic fracturing pump unit; Claim 31). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the other motor of Baker to be connected to the VFD as taught by Stewart for the purpose of utilizing the benefits of a VFD to the other motors in the system, the benefits including contributing to energy savings, increasing the efficiency and life of the motor, reducing mechanical wear upon the motor and thus the need for repair (Baker; Paragraph [0019]).

As per claim 12, Baker as modified by Rosman and Stewart discloses the system of claim 11. Baker fails to disclose the system further comprising a plurality of speed reduction gearboxes positioned between the plurality of input pinion gears and the plurality of motors so as to achieve a desired pump rate. Rosman discloses a plurality of speed reduction gearboxes positioned between a plurality of input pinion gears and a plurality of motors (gear boxes 22 are positioned between a plurality of pinions 23 having gear teeth 23 and a plurality of hydraulic drive motors 21; gear boxes are designed to increase torque while reducing speed of the output shaft; Figures 3-5; Column 4, Lines 46-62). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the gearing of Baker by having a motor for each associated planet gear as well as gear boxes as taught by Rosman resulting in a desired pump rate for the purpose of having smaller motors wherein there is an advantage that the system is less expensive with respect to initial capitalization and maintenance (Rosman; Column 4, Lines 57-59) and developing the amount of torque necessary to rotate ring members with high loads (Rosman; Column 4, Lines 60-62)).

As per claim 13, Baker as modified by Rosman and Stewart discloses the system of claim 11. Baker fails to disclose wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors. Rosman discloses wherein a plurality of motors comprises one of a plurality of electric motors or a plurality of hydraulic motors (hydraulic drive motors 21; Figure 4). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the motor of Baker with the plurality of hydraulic motors as taught by Rosman for the purpose for the purpose of utilizing a motor which can generate high torques without excessive size.

As per claim 19, Baker as modified by Rosman discloses the method of claim 15. Baker discloses further comprising: connecting a variable frequency drive (VFD) to the motor so as to control the speed of the motor, wherein the VFD is positioned to accelerate or decelerate pump rotational speeds associated with each of the hydraulic pump (variable frequency drive (VFD) 76 connected to motor 34 to control the speed thereof, wherein the VFD is positioned to adjust operating speeds of pump 50; Figure 2; Paragraph [0019-0020]). Baker fails to disclose a variable frequency drive (VFD) connected to a plurality of motors. Stewart discloses a variable frequency drive (VFD) connected to a plurality of motors (controlling, using one or more variable frequency drives (VFDs), a plurality of electrical motors to drive at least one fluid pump of the at least one hydraulic fracturing pump unit; Claim 31). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the other motor of Baker to be connected to the VFD as taught by Stewart for the purpose of utilizing the benefits of a VFD to the other motors in the system, the benefits including contributing to energy savings, increasing the efficiency and life of the motor, reducing mechanical wear upon the motor and thus the need for repair (Baker; Paragraph [0019]).

As per claim 20, Baker as modified by Rosman and Stewart discloses the method of claim 19. Baker fails to disclose detecting an overpressure event with respect to the hydraulic pump; and automatically shutting off the VFD. Stewart discloses wherein a VFD is configured to automatically shut off in the event of an overpressure event with respect to a hydraulic pump (when frac VFD 410 detects the discharge pressure exceeds a overpressure setpoint with respect to hydraulic fracturing pump 710 a, it stops the frac motor 411 as it activates a shutdown; Figure 6; Paragraph [0062]). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the VFD of Baker to automatically shut down during an overpressure event as taught by Stewart for the purpose of avoiding catastrophic failure in the system.

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Claim 14 lacks an inventive step under PCT Article 33(3) as being obvious over BAKER in view of ROSMAN further in view of STEWART further in view of MAIL.

As per claim 14, Baker as modified by Rosman and Stewart discloses the system of claim 11. Baker fails to disclose wherein the maximum pump speed correlates to a critical plunger speed associated with each of the plurality of hydraulic pumps. Mail discloses wherein a maximum pump speed correlates to a critical plunger speed associated with a hydraulic pump (mainstream methods of subsurface downhole pumping (hydraulic pump) include mounted reciprocating mechanisms (plunger) in a casing tube; optimal speeds of up and down strokes can be defined as maximum speeds that will not cause overstressing of pump rod (critical plunger speed); therefore maximum pumping speed correlates to an operation at optimal up and down stroke speed (critical plunger speed) associated with the hydraulic pump; Column 1, Lines 29-33, 39-48, 53-54, 64-67 and Column 2, Lines 1-3). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the maximum pump speed of Baker by correlating it to the critical plunger speed as taught by Mail for the purpose of avoiding overstressing of structural parts and premature damage (Baker; Column 1, Lines 64-67 and Column 2, Lines 1-3).

Claims 1-20 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.

Electronic Acknowledgement Receipt

EFS ID:	35441473
Application Number:	16170695
International Application Number:	
Confirmation Number:	6906
Title of Invention:	SMART FRACTURING SYSTEM AND METHOD
First Named Inventor/Applicant Name:	Jared Oehring
Customer Number:	132858
Filer:	Taylor P. Evans/Stephanie McDonough
Filer Authorized By:	Taylor P. Evans
Attorney Docket Number:	047158.100032
Receipt Date:	15-MAR-2019
Filing Date:	25-OCT-2018
Time Stamp:	17:03:57
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Information Disclosure Statement (IDS) Form (SB08)	047158-100032_IDS.pdf	1035222 b1f58bc5d7c1a972fbc3f8f3d79688dec9dc8ff8	no	5

Warnings:

Information:					
2	Foreign Reference	CA2833711A1.pdf	739512 e1128f7f4deda30ec9d49369571c9de7d6525686	no	24
Warnings:					
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The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
4	Other Reference-Patent/App/Search documents	NPL2.pdf	614235 ea5d6da1e4f084a6ff03eaa3338bdf5908f28e76	no	13
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Information:					
5	Other Reference-Patent/App/Search documents	NPL3.pdf	291386 d47df5a4343cde8839c857746827e9466edc16d6	no	9
Warnings:					
Information:					
6	Other Reference-Patent/App/Search documents	NPL4.pdf	589124 eb5e7aa2178ef3188004acf9d9cdec98383d39e6	no	11
Warnings:					
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Information:					
7	Other Reference-Patent/App/Search documents	NPL5.pdf	254035 f9e4d9dbeeb5db1ff93fad2164d580669784a45c	no	8
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8	Other Reference-Patent/App/Search documents	NPL6.pdf	191754 1ec9a64cedf4d439ccc5d68864249c23ffd5741d	no	4
Warnings:					
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9	Other Reference-Patent/App/Search documents	NPL7.pdf	169683 2c9185c3afce9bea1ed978846116a35631002a87	no	3
Warnings:					
Information:					
			Total Files Size (in bytes):	5445284	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/170,695	10/25/2018	Jared Oehring	047158.100032	6906

132858 7590 02/12/2019

Hogan Lovells US LLP
609 Main Street
Suite 4200
Houston, TX 77002

EXAMINER	
GAY, JENNIFER HAWKINS	

ART UNIT	PAPER NUMBER
3676	

NOTIFICATION DATE	DELIVERY MODE
02/12/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

danny.vara@hoganlovells.com
hlusdocketing@hoganlovells.com
stephanie.mcdonough@hoganlovells.com

Office Action Summary	Application No. 16/170,695	Applicant(s) Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	AIA Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-20 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 10/25/18 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Drawings

2. The drawings were received on October 25, 2018. These drawings are accepted.

Claim Rejections - 35 USC § 112

3. The following is a quotation of 35 U.S.C. 112(b):

> (b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

4. Claims 2, 3, 5, 6, 8, and 16 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Regarding claims 2, 3, and 5: Alternate expressions are permitted if they present no uncertainty or ambiguity with respect to the question of scope or clarity of the claims. On acceptable form of alternative expression, or Markush group, recites

members as being "selected from the group consisting of A, B, or C." See Ex parte Markush, 1925 C.D. 126 (Comm'r5 Pat. 1925). (See MPEP 2173.05(h))

Regarding claim 6: Claim 6 is rejected due to its dependence on claim 5.

Regarding claim 8: Claim 8 is rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. See MPEP § 2172.01. The omitted steps are: the step(s) or other language linking the "detecting" step and the "adjusting" step. As written, claim 8 does not require that the adjusting or turning off of the pump has anything do with any of the other steps or features in the claims.

Regarding claim 16: Claim 16 is recited as depending from claim 17. A claim cannot depend from higher number claim. Further there is insufficient antecedent basis for "the distribution system". For these reasons it is suggested that claim 16 was intended to depend from claim 15 and it will be treated as such for the purpose of examination.

Claim Rejections - 35 USC § 102

5. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (a)(2) the claimed invention was described in a patent issued under section 151, or in an application for patent published or deemed published under section 122(b), in which the patent or application, as the case may be, names another inventor and was effectively filed before the effective filing date of the claimed invention.

7. Claim(s) 1-7, 11, 12, and 14-18 is/are rejected under 35 U.S.C. 102(a)(2) as being anticipated by Omont et al. (US 2017/0226842, Omont).

Regarding claim 1: Omont discloses a hydraulic fracturing system **100 – [0017]**, comprising:

a plurality of pumps **150** positioned at a wellsite **102** and configured to pressurize a fracturing fluid **[0023]**;

a distribution system **142** fluidly coupled to receive and consolidate fracturing fluid from the plurality of pumps for injection **[0023]** into a wellhead **for well 104**; and

a control system **170/300** comprising:

a plurality of sensing devices **214, 222** configured to measure one or more parameters of the plurality of pumps **[0037], [0052], [0054], [0093]** and the distribution system **[0059]**;

one or more processing devices **306 – [0038], [0043]** configured to receive and analyze the one or more parameters measured by the plurality of sensing devices and generate control instructions based at least in part on the one or more parameter **[0038], [0043]**s; and

one or more control devices **226, 228** configured to receive the control instructions and control one or more aspects of the plurality of pumps **[0043]** or the distribution system based on the control instructions **[0059]**.

Regarding claim 2: Wherein the plurality of sensing devices are installed on the plurality of pumps and the distribution system, and include at least one of flow sensors **[0054]**, accelerometers, pressure transducer **[0054], [0057]**, or tachometers **"operating speed" – [0052]**.

Regarding claim 3: Wherein the plurality of pumps or the distribution system includes at least one of a gate **[0049]**, valve **244 – Fig 3, [0050]**, actuator **248, 256, 266 – Fig 3**, motor, suction pipe, discharge pipe, engine **252 – [0051]**, transmission, or temperature regulation device, controllable via the one or more control devices.

Regarding claim 4: The system further comprising:

a suction line **146** through which fracturing fluid is supplied **[0023]**; and

a discharge line **148** through which fracturing fluid is discharged **[0023]**, wherein the plurality of sensing devices includes one or more flow sensors configured to measure flow through the suction line and the discharge line **0054]**.

Regarding claim 5: The system further comprising one or more blenders **108, 128** configured to mix together one or more materials **110, 112** to form the fracturing

fluid, wherein the fracturing fluid is provided from the blender to the plurality of pumps via a manifold **distribution system include multiple components including a manifold – [0023]**, wherein the plurality of sensing devices includes one or more pressure or flow sensors for measuring flow **260 – [0054]** and/or pressure conditions **[0054], [0057]** at the one or more blenders **[0037]**, the manifold **[0059]**, the plurality of pumps **[0037], [0052], [0054]**, or the distribution system **[0059]**.

Regarding claim 6: Wherein the one or more control device is configured to control the one or more blenders **[0057]**, the manifold **[0059]**, the plurality of pumps **[0037], [0052], [0054]** and the distribution system **[0059]** based on the flow **260 – [0054]** and/or pressure conditions **[0054], [0057]**.

Regarding claim 7: Omont discloses a hydraulic fracturing method, comprising:

providing a fracturing fluid to a plurality of pumps **150 - [0017]**;

pumping the fracturing fluid into a distribution system **142 - [0018]**;

injecting the fracturing fluid into a wellhead **for well 104 – [0023]**;

measuring one or more parameters of the plurality of pumps **[0037], [0052], [0054]**, the distribution system **[0059]**, or the wellhead via a plurality of sensing devices **214, 222 – [0059]** instrumented thereon;

generating automated instructions **"automated" – [0096]** for one or more control devices **226, 228 – [0043]** based at least in part on the one or more parameters; and

controlling one or more functions of the plurality of pumps **[0043]**, the distribution system **[0059]**, or the wellhead based at least in part on the automated instructions.

Regarding claim 11: The method further comprising:

determining that the one or more parameters are indicative of a potential failure condition **[0067], [0084], [0099]**; and

determining a source of the potential failure condition **[0099], [0101]**.

Regarding claim 12: The method further comprising generating an alert or notification indicative of the potential failure condition and the source **[0090], [0094], [0099]**.

Regarding claim 14: Omont discloses a hydraulic fracturing method, comprising:

receiving a first data from a first sensing device **222 - [0037], [0052], [0054]** of a pump system **150** of a hydraulic fracturing system **100**, the first data indicative of a condition of the pump system **[0037], [0052], [0054]**;

receiving second data from a second sensing device **222 – [0037]** of a blender system **108, 128** of the hydraulic fracturing system, the blender system mixing together materials **110, 112** to form a fracturing fluid and delivering the fracturing fluid to the pump system **[0018], [0023]**, and the second data indicative of a condition of the blender system **[0037]**;

generating automated instructions **"automated" – [0096]** for one or more control devices **226, 228 – [0043]** of the pump system or the blender system based at least in part on the first and second data; and

controlling one or more functions of the pump system or the blender system based at least in part on the automated instructions **[0043], [0059]**.

Regarding claim 15: Wherein the pump system comprises:

one or more pumps **150**; and

a distribution system **142** that receives and consolidates the fracturing fluid from the one or more pumps for injection **[0023]** into a wellhead **for well 104**.

Regarding claim 16: The method further comprising controlling one or more functions of the distribution system based on the automated instructions **[0059]**.

Regarding claim 17: Wherein the pump system comprises a plurality of pumps **150- Fig 1**, and the first data includes measurements of each of the plurality of pumps **[0037], [0052], [0054], [0057]**.

Regarding claim 18: The method further comprising controlling one or more of the plurality of pumps individually based on the automated instructions **[0043], [0059]**.

Claim Rejections - 35 USC § 103

8. In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

9. This application currently names joint inventors. In considering patentability of the claims the examiner presumes that the subject matter of the various claims was commonly owned as of the effective filing date of the claimed invention(s) absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and effective filing dates of each claim that was not commonly owned as of the effective filing date of the later invention in order for the examiner to consider the applicability of 35 U.S.C. 102(b)(2)(C) for any potential 35 U.S.C. 102(a)(2) prior art against the later invention.

10. The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

11. Claims 8-10, 19, and 20 is/are rejected under 35 U.S.C. 103 as being unpatentable over Omont in view of Devine et al. (US 2014/0379300, Devine).

Regarding claims 8 and 19: Omont discloses that the method further comprises detecting that a first parameter of the one or more parameters is outside of an acceptable

threshold, wherein the first parameter is associated with a first pump of the plurality of pumps **[0094], [0119], [0121], [0122]-[0129]**.

Omont fails to disclose that the method further discloses automatically adjusting or turning off the first pump.

Devine discloses a method and system for determining pump efficiency **Abstract** where the method and system can be used in the oil sector **[0002]**. The method involves:

> detecting that a first parameter of the one or more parameters is outside of an acceptable threshold **[0015], [0051]**, wherein the first parameter is associated with a first pump of the plurality of pumps **plurality of pumps – [0116], [0146]**; and
>
> automatically adjusting or turning off the first pump **[0020]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified the method of Omont to include automatically adjusting or turning off the first pump in order to have been able to proactively replace the faulty pump before catastrophic events occur **[0031]**.

Regarding claims 9 and 20: The method Omont, as modified, further comprising adjusting one or more of the other pumps in the plurality of pumps to compensate for the first pump **[0151] of Devine**.

Regarding claim 10: Omont, as modified, discloses all of the limitations of the above claim(s) except for the method further comprising selecting the one or more of the other pumps to adjust based at least in part on the conditions of the other pumps as indicated by one or more of the one or more parameters. However the system and method of Omont is designed to monitor the operation and efficiency of a plurality of pumps and as such it would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, that the system would have chosen to turn on or adjust another pump that was operating efficiently. This would have achieved the predictable result of ensuring that the pump that was turned on or adjusted would operate as long as possible before failure.

12. Claim 13 is/are rejected under 35 U.S.C. 103 as being unpatentable over Omont in view of Thomeer et al. (US 2014/0095114, Thom).

Omont discloses that the system and method includes a logging tool **560 – [0115]** that logs such parameters as operating time **[0120], [0121]** and relays this information to a maintenance terminal unit **[0118], [0131]**.

Omont discloses all of the limitations of the above claim(s) except for that the tool logs such things as number of strokes and that a maintenance schedule was determined based at least in part on the operation data.

Thom discloses a system and method for tracking the operation of equipment used in an oil field **Abstract**. The method includes the steps of:

a logging tool **606 – [0081]** that logs such parameters as flow rate of the pump or number of barrels per minute passing through the pump, i.e. number of strokes **[0076]** performed by a pump of a plurality pumps **101**; and

determining a maintenance schedule based at least in part on the operation data **[0047], [0049]**.

It would have been considered obvious to one of ordinary skill in the art, before the effective filing date of the claimed invention, to have modified Omont so that the logging tool logged such things as number of strokes and that a maintenance schedule was determined based at least in part on the operation data as taught by Thom in order to have avoid needing to stop the fracturing operation due to failing pumps **[0007]**.

Conclusion

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to JENNIFER H GAY whose telephone number is (571)272-7029. The examiner can normally be reached on Monday through Thursday, 6-3:30 and every other Friday 6-11.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Waseem Moorad can be reached on 571-270-3436. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/JENNIFER H GAY/
Primary Examiner, Art Unit 3676

JHG
2/7/19

Notice of References Cited	Application/Control No. 16/170,695	Applicant(s)/Patent Under Reexamination Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	Page 1 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8774972-B2	07-2014	Rusnak; Dennis M.	F04D15/0066	415/122.1
*	B	US-20170292513-A1	10-2017	Haddad; Gilbert	E21B41/0092	1/1
*	C	US-20140095114-A1	04-2014	Thomeer; Hubertus V.	G06Q10/20	702/187
*	D	US-20170226842-A1	08-2017	OMONT; Gregoire	E21B33/13	1/1
*	E	US-20160032703-A1	02-2016	Broussard; Joel N.	E21B43/26	166/250.01
*	F	US-9970278-B2	05-2018	Broussard; Joel N.	E21B43/26	1/1
*	G	US-20140379300-A1	12-2014	Devine; Thomas W.	F04B51/00	702/182
*	H	US-20180320483-A1	11-2018	Zhang; Yanchai	E21B41/0092	1/1
*	I	US-20180038216-A1	02-2018	ZHANG; Yanchai	E21B43/26	1/1
*	J	US-20160102537-A1	04-2016	Lopez; Miguel Angel	E21B43/26	700/282
*	K	US-20140290768-A1	10-2014	Randle; Coy	E21B43/26	137/565.16
*	L	US-20140277772-A1	09-2014	Lopez; Miguel	F04D13/12	700/282
*	M	US-20170096885-A1	04-2017	Oehring; Jared	E21B43/26	1/1

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
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	Q					
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	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
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	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Notice of References Cited	Application/Control No. 16/170,695	Applicant(s)/Patent Under Reexamination Oehring et al.	
	Examiner JENNIFER H GAY	Art Unit 3676	Page 2 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-9840901-B2	12-2017	Oehring; Jared	E21B43/26	1/1
*	B	US-20170022788-A1	01-2017	OEHRING; Jared	E21B41/0021	1/1
*	C	US-9650871-B2	05-2017	Oehring; Jared	E21B41/0021	1/1
*	D	US-20170037717-A1	02-2017	Oehring; Jared	F04B23/00	1/1
*	E	US-10119381-B2	11-2018	Oehring; Jared	F04B23/00	1/1
*	F	US-20170030178-A1	02-2017	Oehring; Jared	F04B47/02	1/1
*	G	US-20170028368-A1	02-2017	Oehring; Jared	B28C9/04	1/1
*	H	US-20160290114-A1	10-2016	OEHRING; Jared	E21B43/26	1/1
*	I	US-20160208592-A1	07-2016	Oehring; Jared	H02K9/04	1/1
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FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	16/170,695	Oehring et al.
	Examiner	Art Unit
	JENNIFER H GAY	3676

CPC - Searched*		
Symbol	Date	Examiner
E21B 21/062, 43/26,267, 44/00	02/07/2019	JHG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
E21B 21/062, 43/26,267, 44/00 - text search only	02/07/2019	JHG
Consulted 16/160708, 15/145414, 15/291842, 13/631492	02/07/2019	JHG
EAST text search	02/07/2019	JHG
Backward/forward search	02/07/2019	JHG

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner

LIBERTY EXHIBIT 1002, Page 1436

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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S18	24839	e21b43/26,267.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:55
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S20	36059	S17 or S18 or S19	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:55
S21	18346	S20 and (frac$3 fractur$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:55
S22	3060	S21 and sensor	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:56
S23	2023	S22 and (processor computer controller)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2019/02/06 09:56

			DERWENT; IBM_TDB			
S24	1597	S23 and pump	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:56
S25	507	S24 and blend$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:56
S26	374	S25 and (control$3 with pump)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 09:56
S27	22	(US-20170292513-$ or US-20140095114-$ or US-20170226842-$ or US-20160032703-$ or US-20140379300-$ or US-20170037717-$ or US-20170030178-$ or US-20170028368-$ or US-20160290114-$ or US-20160208592-$ or US-20170096885-$ or US-20170022788-$ or US-20180320483-$ or US-20180038216-$ or US-20160102537-$ or US-20140290768-$ or US-20140277772-$).did. or (US-9840901-$ or US-9650871-$ or US-8774972-$ or US-10119381-$ or US-9970278-$).did.	US-PGPUB; USPAT	OR	ON	2019/02/06 16:09
S28	20	S27 and (pump with (control$4 adjust$4 off))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 16:09
S29	7	S27 and (pump with (adjust$4 off))	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2019/02/06 16:11
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EAST Search History (Interference)

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