



(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:
31.05.2017 Bulletin 2017/22

(51) Int Cl.:
E21B 43/12^(2006.01)

(43) Date of publication A2:
08.02.2017 Bulletin 2017/06

(21) Application number: **16183114.4**

(22) Date of filing: **05.08.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **05.08.2015 PCT/US2015/043694**
02.12.2015 US 201514956545
02.12.2015 US 201514956527
02.12.2015 US 201514956601
02.12.2015 US 201514956863

(71) Applicants:
• **Weatherford Technology Holdings, LLC**
Houston, TX 77056 (US)
• **Amfields, LP**
Houston, TX 77073 (US)

(72) Inventors:
• **SCHMITT, Kenneth J.**
Houston, TX Texas TX 77041 (US)
• **ROBISON, Clark E.**
Houston, TX Texas TX 77041 (US)
• **MCDONALD, Robert G.**
Shenandoah, TX Texas TX 77385 (US)
• **TRAPANI, James. S**
Houston, TX Texas TX 77056 (US)
• **THOMAS, Benson**
Katy, TX Texas TX 77493 (US)

(74) Representative: **Hagmann-Smith, Martin P.**
Marks & Clerk LLP
Fletcher House
Heatley Road
The Oxford Science Park
Oxford OX4 4GE (GB)

(54) **PUMPING SYSTEM AND METHOD**

(57) A hydraulic pumping system can include a hydraulic actuator with a magnet that displaces with a piston, and a sensor that continuously detects a position of the magnet. A ferromagnetic wall of the hydraulic actuator is positioned between the magnet and the sensor. A hydraulic pumping method can include incrementally lowering a lower stroke extent of a rod string reciprocation over multiple reciprocation cycles of the rod string, and automatically varying the lower stroke extent or an upper stroke extent of the rod string reciprocation, in response to a measured vibration. Another hydraulic pumping method can include solving a wave equation in the rod string, and automatically varying a reciprocation speed of the rod string in response to a change in work performed during reciprocation cycles of the hydraulic actuator or a change in detected force versus displacement in different reciprocation cycles of the hydraulic actuator.

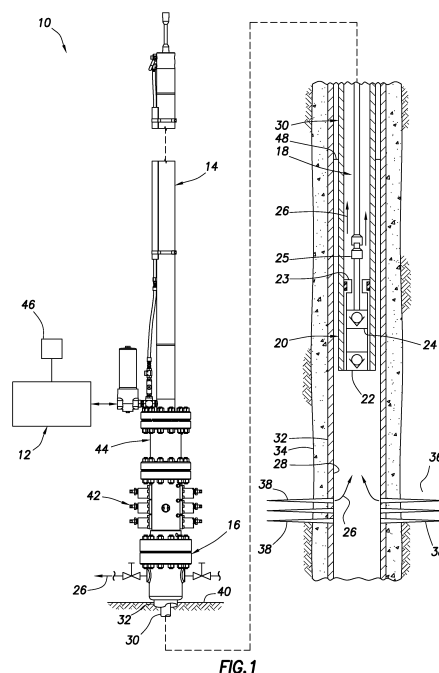


FIG. 1



EUROPEAN SEARCH REPORT

Application Number
EP 16 18 3114

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2014/328664 A1 (HEARN DAVID DEWITT [US]) 6 November 2014 (2014-11-06)	1-3,5,6,9,10	INV. E21B43/12
Y	* paragraphs [0020] - [0033] * * figures 1-5 *	4,7,8,11,15	
X	T.A. EVERITT ET AL: "An Improved Finite-Difference Calculation of Downhole Dynamometer Cards for Sucker-Rod Pumps", SPE PRODUCTION ENGINEERING, vol. 7, no. 01, 1 February 1992 (1992-02-01), pages 121-127, XP055217402, ISSN: 0885-9221, DOI: 10.2118/18189-PA	12-14,16-19,23-25	
Y	* the whole document *	4,11,15,20-22,26-28	
Y	US 2009/194291 A1 (FESI MICHAEL A [US] ET AL) 6 August 2009 (2009-08-06)	7,8,20-22,26-28	
	* paragraphs [0051] - [0054] * * figure 7 *		TECHNICAL FIELDS SEARCHED (IPC)
A	US 2014/231093 A1 (HOELL R LEE [US]) 21 August 2014 (2014-08-21)	1-11	E21B
	* paragraphs [0063] - [0113] * * figures 1-4C *		
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 April 2017	Examiner Kecman, Ivan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



Application Number

EP 16 18 3114

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 16 18 3114

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-11

A hydraulic actuator including a piston that displaces in response to pressure in the actuator, a magnet that displaces with the piston, and at least one sensor that continuously detects a position of the magnet as the magnet displaces with the piston.

2. claims: 12-28

A hydraulic pumping method of varying the speed and stroke extents of the reciprocating piston in response to performed displacements as well as forces and vibrations involved in the pumping process.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 18 3114

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-04-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014328664 A1	06-11-2014	NONE	
US 2009194291 A1	06-08-2009	AU 2009209264 A1	06-08-2009
		BR PI0906624 A2	14-07-2015
		CA 2750337 A1	06-08-2009
		EA 201001215 A1	28-02-2011
		EP 2250340 A2	17-11-2010
		US 2009194291 A1	06-08-2009
		WO 2009097338 A2	06-08-2009
US 2014231093 A1	21-08-2014	NONE	