PTO/AIA/123 (08-12)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

CHANGE OF CORRESPONDENCE ADDRESS
Patent

Address to:
Mail Stop Post Issue
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Alexandria, VA 22313-1450

Patent Number	9,383,029
Issue Date	July 5, 2016
Application Number	14/374473
Filing Date	September 25, 2013
First Named Inventor	Bruce Edward Scott
Attorney Docket Number	087638-0949

Please change the Correspondence Address for the above-identified patent to:

☑ The address associated with Customer Number: 7576

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☐ **Firm *or* Individual Name**

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This form cannot be used to change the data associated with a Customer Number. To change the data associated with an existing Customer Number use "Request for Customer Number Data Change" (PTO/SB/124).

This form will not affect any "fee address" provided for the above-identified patent. To change a "fee address" use the "Fee Address Indication Form" (PTO/SB/47).

I am the:

☐ Patentee.

☐ If the Patentee was not the applicant for patent (37 CFR 1.42), then a Statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is enclosed or was filed on _____. See 37 CFR 3.71.

☑ Attorney or agent of record. Registration Number 53086.

☐ Patent practitioner acting in a representative capacity whose correspondence address is the correspondence address of record. Notice has been given to the patentee or owner. Registration Number 53086.

Signature /Iona N. Kaiser/

Typed or Printed Name Iona N. Kaiser

Date July 15, 2016 | Telephone 713-653-1724

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.33. 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 3 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: Mail Stop Post Issue, Commissioner for Patents, 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.

Electronic Acknowledgement Receipt

EFS ID:	26363864
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Wendy Netherton
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	087638-0949
Receipt Date:	15-JUL-2016
Filing Date:	24-JUL-2014
Time Stamp:	14:53:19
Application Type:	U.S. National Stage under 35 USC 371

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	Change of Address	chgadd.pdf	176259 ee909a7c95a3c5f0dbed457f8c443a0f672777c4	no	1

Warnings:

Information:	
Total Files Size (in bytes):	176259

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/05/2016	9383029	087638-0949	7621

99633 7590 06/15/2016

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

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

The Patent Term Adjustment is 42 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

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 Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Bruce Edward Scott, Mckinney, TX;
Halliburton Energy Services, Inc., Houston, TX;

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

99633 7590 03/16/2016
McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Kaylen Gonzalez	(Depositor's name)
/Kaylen Gonzalez/	(Signature)
via EFS web June 6, 2016	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US	7621

TITLE OF INVENTION: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/16/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
ROST, ANDREW J	3753	251-062000

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 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list McDermott Will & Emery LLP
(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 Scott Richardson
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 has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Halliburton Energy Services, Inc.
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Houston, Texas

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

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 500417 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
  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.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
  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.
- ☐ Applicant changing to regular undiscounted fee 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 /Iona N. Kaiser/ Date June 6, 2016
Typed or printed name Iona N. Kaiser Registration No. 53086

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Electronic Patent Application Fee Transmittal

Application Number:	14374473
Filing Date:	24-Jul-2014
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Filer:	Iona Niven Kaiser/Kaylen Gonzalez
Attorney Docket Number:	2013-IP-072581 U1 US

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

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:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt

EFS ID:	25975859
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Kaylen Gonzalez
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	06-JUN-2016
Filing Date:	24-JUL-2014
Time Stamp:	13:07:59
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$960
RAM confirmation Number	11556
Deposit Account	500417
Authorized User	KAISER, IONA NIVEN
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	087638-0949_IssueFeePayment.pdf	88334 1f7055555b8c597ea41fe9f916f430ca19e68c4ce	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30797 5296dc07ea2cb98c2879db1144c0f733eeed729d	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	119131		

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

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

NOTICE OF ALLOWANCE AND FEE(S) DUE

99633 7590 03/16/2016

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

EXAMINER
ROST, ANDREW J

ART UNIT	PAPER NUMBER
3753	

DATE MAILED: 03/16/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US	7621

TITLE OF INVENTION: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/16/2016

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: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (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)

99633 7590 03/16/2016
McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

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 facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US	7621

TITLE OF INVENTION: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	06/16/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
ROST, ANDREW J	3753	251-062000

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 03-02 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 has been filed for recordation as set forth in 37 CFR 3.11. 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. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — 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.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — 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.
- ❑ Applicant changing to regular undiscounted fee 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. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US	7621

99633 7590 03/16/2016

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

EXAMINER	
ROST, ANDREW J	

ART UNIT	PAPER NUMBER
3753	

DATE MAILED: 03/16/2016

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.

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 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, 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:

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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 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. 14/374,473	Applicant(s) SCOTT, BRUCE EDWARD	
	Examiner Andrew J. Rost	Art Unit 3753	AIA (First Inventor to File) 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 *the amendment filed 2/4/2016*.
   ☐ 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 *1,4-9,11-17,19 and 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 _____.

/A. J. R./ Examiner, Art Unit 3753	/JOHN K FRISTOE JR/ Supervisory Patent Examiner, Art Unit 3753

DETAILED ACTION

1. This action is in response to the amendment filed 2/4/2016. Claims 1, 6, 13 and 17 are currently amended. No claims are newly added. Claims 2, 3, 10 and 18 have been canceled. Presently, claims 1, 4-9, 11-17, 19 and 20 are pending.

Notice of Pre-AIA or AIA Status

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

Drawings

3. The drawings were received on 7/24/2014 and 4/21/2015. These drawings are acceptable.

Allowable Subject Matter

4. Claims 1, 4-9, 11-17, 19 and 20 are allowed.

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

Regarding claim 1, the prior art of record does not disclose or suggest a safety valve having a housing that defines a central flow passage, a valve closure device arranged within the central flow passage, a piston bore defined in a sidewall of the housing to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston

bore wherein the piston assembly includes an upper piston that sealingly engages the upper bore and a lower piston that sealingly engages the lower bore, a connecting rod coupling the upper and lower pistons with a cavity defined between the upper and lower pistons and the connecting rod extending within the cavity and a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing in combination with the other limitations of the claim;

Regarding claim 13, the prior art of record does not disclose or suggest a method of actuating a safety valve including conveying hydraulic fluid pressure to a piston bore defined in a sidewall of a housing and providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore with the piston assembly having an upper piston sealingly engaging the upper bore and a lower piston sealingly engaging the lower bore, axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity, and maintaining pressure equilibrium within the cavity and an annulus region with a conduit defined in the housing in combination with the other limitations of the claim.

Additionally, applicant's arguments filed 2/4/2016 are persuasive.

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

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Andrew J. Rost, whose telephone number 571-272-2711. The examiner can normally be reached on Monday-Friday (8:00AM-4:30PM EST).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisors can be reached by phone. **John Fristoe** can be reached at 571-272-4926, **Craig Schneider** can be reached at 571-272-3607 or **Mary McManmon** can be reached at 571-272-6007. 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.

/A. J. R./
Examiner, Art Unit 3753

/JOHN K FRISTOE JR/
Supervisory Patent Examiner, Art Unit 3753

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BIB DATA SHEET

CONFIRMATION NO. 7621

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/374,473	07/24/2014	251	3753	2013-IP-072581 U1 US

APPLICANTS
Halliburton Energy Services, Inc., Houston, TX;

INVENTORS
Bruce Edward Scott, Mckinney, TX;

**** CONTINUING DATA ***************************
This application is a 371 of PCT/US2013/061546 09/25/2013

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
07/27/2015

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /ANDREW J ROST/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		TX	4	17	2

ADDRESS

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001
UNITED STATES

TITLE

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

FILING FEE RECEIVED		
1480	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14374473	SCOTT, BRUCE EDWARD
	Examiner	Art Unit
	ANDREW J ROST	3753

CPC- SEARCHED

Symbol	Date	Examiner
F16K 31/1225	10/7/2015	AJR
F16K 17/18	10/7/2015	AJR
E21B 34/10	10/7/2015	AJR
E21B 34/066	10/7/2015	AJR
E21B 2034/005	10/7/2015	AJR
F16K 31/122	10/7/2015	AJR
F16K 31/1226	10/7/2015	AJR

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
251	62, 77	10/7/2015	AJR
137	155	10/7/2015	AJR
166	319, 320	10/7/2015	AJR
251	31	10/13/2015	AJR
251	62	10/20/2015	AJR
166	332.8, 334.4	3/8/2016	AJR

SEARCH NOTES

Search Notes	Date	Examiner
Inventor Name Search	10/7/2015	AJR
forward/backward citation search	10/20/2015	AJR
keyword search	10/20/2015	AJR
See Attached BRS Search Report	10/27/2015	AJR
Updated BRS Search Report	2/24/2016	AJR
See Attached BRS Search Report	3/9/2016	AJR

/A.J.R./ Examiner.Art Unit 3753	

INTERFERENCE SEARCH			
US Class/ CPC Symbol	**US Subclass / CPC Group**	**Date**	**Examiner**
251	62, 77, 31	3/8/2016	AJR
137	155	3/8/2016	AJR
166	320, 319, 332.8, 334.4	3/8/2016	AJR
F16K	31/122; 31/1225; 17/18; 31/1226	3/8/2016	AJR
E21b	34/10; 34/066; 2034/005	3/8/2016	AJR
ALL	See Attached Interference Search Report	3/9/2016	AJR

/A.J.R./ Examiner.Art Unit 3753	

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14374473	SCOTT, BRUCE EDWARD
	Examiner	**Art Unit**
	ANDREW J ROST	3753

CPC						
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F16K		31	/	1225	F	2013-01-01
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E21B		34	/	10	I	2013-01-01
E21B		34	/	101	I	2013-01-01
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CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
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/ANDREW J ROST/ Examiner.Art Unit 3753	03/09/2016	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	16	
/JOHN K FRISTOE JR/ Supervisory Patent Examiner.Art Unit 3753	03/10/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2A

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
14374473	SCOTT, BRUCE EDWARD
Examiner	**Art Unit**
ANDREW J ROST	3753

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
251	62

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
166	319	320			

INTERNATIONAL CLASSIFICATION					
CLAIMED					NON-CLAIMED
F	1	6	K	31 / 122	

/ANDREW J ROST/ Examiner.Art Unit 3753	03/09/2016	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	16	
/JOHN K FRISTOE JR/ Supervisory Patent Examiner.Art Unit 3753	03/10/2016	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2A

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14374473	SCOTT, BRUCE EDWARD
	Examiner	**Art Unit**
	ANDREW J ROST	3753

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

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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/ANDREW J ROST/ Examiner.Art Unit 3753 (Assistant Examiner)	03/09/2016 (Date)	**Total Claims Allowed:** 16	
/JOHN K FRISTOE JR/ Supervisory Patent Examiner.Art Unit 3753 (Primary Examiner)	03/10/2016 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 2A

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	166	((Bruce) near2 (Scott)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2015/10/07 09:07
S2	18	((Bruce) near2 (Scott)).INV.	EPO; JPO; DERWENT	OR	ON	2015/10/07 09:07
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S4	534	f16k17/18.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 13:27
S5	66	("6098714" | "3469503" | "20030205389" | "6003605" | "20130092396" | "5284205" | "4161219" | "4234043" | "5598864" | "4252197" | "20060196669" | "20130043039" | "20080128137" | "6427778" | "4986357" | "8006753").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 13:57
S6	28	("20080237993" | "20090050327" | "20130062071" | "20130092396" | "4429620" | "4986357" | "7694742" | "8016035" | "8360751").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:17
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S8	2161	e21b34/066.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:22
S9	3165	e21b2034/005.cpc.	US-PGPUB; USPAT;	OR	ON	2015/10/07 14:23

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S10	2138	f16k31/122.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:23
S11	370	f16k31/1226.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:23
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S13	1397	(251/77).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S14	604	(137/155).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S15	317	(166/320).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S16	1006	(166/319).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S17	1410	(251/31).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/13 17:39
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S20	437	("1612007" | "20010045290" | "20020046845" | "20020108747" | "20020108788" | "20020158217" | "20020192090" | "20040007683" |	US-PGPUB; USPAT; USOCR	OR	ON	2015/10/20 13:51

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S21	615	(251/62).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/20 14:26
S22	214449	pressure near3 regulat$3	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	ON	2015/10/20 15:06
S23	43	S21 and S22	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	ON	2015/10/20 15:06
S24	10047	balance near3 piston	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:11
S25	27268	(float$3 balance) near3 piston	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:11
S26	2383	S22 and S25	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:12
S27	22	S25 and S21	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:12
S28	1053	f16k31/1225.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO;	OR	ON	2016/02/24 15:51

			DERWENT; IBM_TDB			
S29	566	f16k17/18.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:51
S30	4905	e21b34/10.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:51
S31	2278	e21b34/066.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:51
S32	3257	e21b2034/005.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:51
S33	2217	f16k31/122.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:51
S34	390	f16k31/1226.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2016/02/24 15:52
S35	617	(251/62).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S36	1397	(251/77).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S37	604	(137/155).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S38	321	(166/320).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52

S39	1021	(166/319).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S40	1410	(251/31).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S41	617	(251/62).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/02/24 15:52
S42	372	(166/332.8).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/03/08 08:52
S43	300	(166/334.4).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2016/03/08 08:52

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	356	(valv$3 and piston and (rod shaft stem member) and (passage conduit path pathway open$3) and saf$3).clm.	US-PGPUB	OR	ON	2016/03/09 10:47
S44	116	f16k31/1225.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S45	31	f16k17/18.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S46	546	e21b34/10.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S47	223	e21b34/066.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S48	333	e21b2034/005.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S49	170	f16k31/122.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S50	47	f16k31/1226.cpc.	US-PGPUB	OR	ON	2016/03/08 14:38
S51	85	(251/62).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S52	18	(251/77).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S53	15	(137/155).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S54	72	(166/320).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S55	363	(166/319).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S56	7	(251/31).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S57	85	(251/62).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38

S58	137	(166/332.8).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38
S59	33	(166/334.4).CCLS.	US-PGPUB	OR	OFF	2016/03/08 14:38

3/9/2016 10:57:31 AM
C:\Users\arost\Documents\EAST\Workspaces\14374473.wsp

TRANSMITTAL FORM

First Named Inventor:	Docket Number:	
Bruce Edward Scott	**2013-IP-072581 U1 US**	
Application Number:	Art Unit:	Conf. Number:
14/374,473	**3753**	**7621**
Filing Date:	Examiner:	
July 24, 2014	**Andrew J. Rost**	

Title:
Multiple Piston Pressure Intensifier for a Safety Valve

ENCLOSURES (*Check all that apply*)

☐ Fee Transmittal	☐ Drawings	☐ After Allowance Communication to Technology Center
☐ Fee Attached	☐ Licensing-Related Papers	☐ Appeal Communication
☒ Amendment / Reply	☐ Petition	☐ Proprietary Information
☐ After Final	☐ Petition to Convert Provisional Application	☐ Status Letter
☐ Affidavit / Declaration	☐ Power of Attorney, Revocation. Change of Correspondence Address	☐ Other Enclosure(s) (identified below):
☐ Extension of Time Request	☐ Terminal Disclaimer	
☐ Express Abandonment	☐ Request for Refund	
☐ Information Disclos. Stmt.	☐ CD, No. of CD's **0**	
☐ Certified Priority Documents	☐ Landscape Table on CD	
☐ Reply to Missing Parts	Remarks:	

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

I am the

☐ applicant / inventor

☐ assignee of record of the entire interest.
See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed

☒ attorney or agent of record or acting under 37 CFR 1.34.

Registration Number: 53,086

Signature
/Iona N. Kaiser/

Printed Name
Iona N. Kaiser

Telephone Number
713-653-1724

Date
February 4, 2016

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE RESPONSE TO OFFICE ACTION		
First Named Inventor: **Bruce Edward Scott**	Docket Number: **2013-IP-072581 U1 US**	
Application Number: **14/374,473**	Art Unit: **3753**	Conf. Number: **7621**
Filing Date: **July 24, 2014**	Examiner: **Andrew J. Rost**	
Title: **Multiple Piston Pressure Intensifier for a Safety Valve**		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENTS AND RESPONSE UNDER 37 C.F.R. § 1.111 TO NON-FINAL OFFICE ACTION, MAILED NOVEMBER 5, 2015

Dear Honorable Commissioner:

In response to the Office Action mailed on November 5, 2015 (the "Office Action"), Applicant submits the following:

Amendments to the Claims, which begin on page 2 of this paper; and

Remarks/Arguments, which begin on page 6 of this paper.

AMENDMENTS TO THE CLAIMS

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

Claims:

1. (Currently Amended) A safety valve, comprising:

a housing that defines a central flow passage ~~having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter~~;

a valve closure device movably arranged within the central flow passage;

a piston bore defined in a sidewall of the housing to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and operably coupled to the valve closure device, the piston assembly comprising an upper piston that ~~arranged in and configured to~~ sealingly engages ~~engage~~ the upper bore and a lower piston that ~~arranged in and configured to~~ sealingly engages ~~engage~~ the lower bore;

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity; and

a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing, wherein ~~the cavity contains a fluid~~ movement of the piston assembly correspondingly moves the valve closure device.

2. (Canceled)

3. (Canceled)

4. (Previously Presented) The safety valve of claim 1, further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. (Original) The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. (Currently Amended) The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore; and

a flow tube operably coupled to the piston rod and movably arranged within [[a]] the central flow passage ~~defined in the safety valve~~ in response to the movement of the piston assembly~~; and a~~,

wherein movement of the flow tube moves the valve closure device ~~movable~~ between an open position and a closed position ~~and adapted~~ to ~~restrict~~ regulate fluid flow through the central flow passage ~~when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions~~.

7. (Original) The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. (Original) The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. (Original) The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. (Canceled)

11. (Original) The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. (Original) The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. (Currently Amended) A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore defined in a sidewall of a housing and providing ~~that provides~~ an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston ~~arranged in and~~ sealingly engaging the upper bore and a lower piston ~~arranged in and~~ sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity; [[and]]

maintaining pressure equilibrium within ~~fluidly communicating~~ the cavity and an annulus region with a conduit defined in [[a]] the housing ~~that houses the piston assembly, wherein the cavity contains a fluid~~; and

moving a valve closure device as the piston assembly moves within the piston bore, the valve closure device being arranged within a central flow passage defined in the housing and operably coupled to the piston assembly.

14. (Original) The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. (Original) The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially

displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. (Original) The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. (Currently Amended) The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving [[a]] the valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. (Canceled)

19. (Previously Presented) The method of claim 13, further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. (Original) The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

REMARKS / ARGUMENTS

I. General Remarks and Disposition of the Claims

Please consider the application in view of the following remarks. Applicant thanks the Examiner for careful consideration of this application, including the references that Applicant has submitted in this case.

At the time of the Office Action, claims 1, 4-17, 19 and 20 were pending in this application. Claims 1, 4, 5, 7, 8, 12-16, 19 and 20 were rejected and claims 6, 9-11 and 17 were objected to in the Office Action.

By this paper, claims 1, 6, 13, and 17 have been amended, claim 10 has been canceled, and no claims have been added. These amendments are supported by the specification as filed. All the amendments are made in a good faith effort to advance the prosecution on the merits of this case. It should not be assumed that the amendments made herein were made for reasons related to patentability. Applicant requests that the above amendments be entered and further requests reconsideration in light of the amendments and remarks contained herein.

II. Remarks Regarding Objections to the Drawings

The drawings have been objected to under 37 CFR 1.83(a) as failing to show every feature of the invention specified in the claims. Office Action at pg. 2. More particularly, the Examiner objects to the limitations of claim 10 that recite that the first and second upper bores are angularly offset from each other about a circumference of the housing since such features are not shown in the drawings. Applicant has canceled claim 10, thereby obviating the objection.

III. Remarks Regarding Rejections under 35 U.S.C. § 102

A. Rejections over *Nutter*

Claims 1, 5, 7, 8, 12-16 and 20 stand rejected under 35 U.S.C. § 102(a)(1) and 102 (a)(2) as being anticipated by U.S. Patent 3,901,314 (hereinafter "*Nutter*"). Applicant respectfully disagrees and submits that the cited reference does not disclose each and every limitation of independent claims 1 and 13, as required to anticipate these claims under 35 U.S.C. § 102.

In particular, claim 1 requires "a housing that defines a central flow passage," "a valve closure device movably arranged within the central flow

passage," "a piston bore defined in a sidewall of the housing," and "a piston assembly movably arranged within the piston bore and operably coupled to the valve closure device." Claim 13 includes similar method limitations and *Nutter* fails to teach, show, or suggest such limitations. Indeed, *Nutter* is entirely silent as to a valve closure device being arranged within a central flow passageway and movable through movement of a piston assembly, as required by the claimed invention. Accordingly, *Nutter* does not disclose each and every limitation of claims 1 and 13.

Therefore, Applicant respectfully asserts that independent claims 1 and 13 and their respective dependent claims are not anticipated by *Nutter*. Accordingly, Applicant respectfully requests withdrawal of this rejection with respect to claims 1, 5, 7, 8, 12-16 and 20.

IV. Remarks Regarding Rejections under 35 U.S.C. § 103(a)

A. Rejections over *Nutter* in view of *Barrington*

Dependent claims 4 and 19 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Nutter* in view of U.S. Patent 4,448,254 (hereinafter "*Barrington*").

Nutter has been discussed and distinguished above with respect to independent claims 1 and 13, from which claims 4 and 19 depend, respectively. More particularly, *Nutter* fails to teach or suggest "a housing that defines a central flow passage," "a valve closure device movably arranged within the central flow passage," "a piston bore defined in a sidewall of the housing," and "a piston assembly movably arranged within the piston bore and operably coupled to the valve closure device," as required in claim 1 and similarly required in claim 13. Moreover, *Barrington* does not remedy the deficiencies of *Nutter*. Rather, the Examiner merely relies on *Barrington* for its alleged teaching of "a pressure regulator." Office Action at pp. 7-8.

Claims 4 and 19 depend from independent claims 1 and 13, respectively, and all dependent claims include all of the limitations of the independent claim from which they depend. Thus, claims 4 and 19 are patentable over the combination of *Nutter* and *Barrington* and Applicant respectfully requests withdrawal of this rejection.

V. Allowable Subject Matter

In the Office Action, the Examiner noted that dependent claims 6, 9-11 and 17 would be "allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims." Office Action at pg. 9. Applicant gratefully acknowledges the Examiner's indication that claims 6, 9-11 and 17 would be allowable if rewritten in independent form. However, since Applicant has traversed the rejections of claims 1 and 13, from which claims 6, 9-11 and 17 depend, Applicant respectfully submits that all remaining pending claims are allowable as well.

VI. No Waiver

All of Applicant's arguments and amendments are without prejudice or disclaimer. Applicant has merely discussed example distinctions from the cited references. Other distinctions may exist, and Applicant reserves the right to discuss these additional distinctions in a later Response or on Appeal, if appropriate. By not responding to additional statements made by the Examiner, Applicant does not acquiesce to the Examiner's additional statements, such as, for example, any statements relating to what would be obvious to a person of ordinary skill in the art.

SUMMARY

In light of the above, Applicant respectfully requests reconsideration and withdrawal of the outstanding rejections. Applicant further submits that the application is now in condition for allowance. Should the Examiner have any questions, comments or suggestions, the Examiner is invited to contact the attorney of record by telephone, facsimile, or electronic mail.

Applicant believes that no fees are due with this response. Should the Commissioner deem that any fees are due, including any fees for extensions of time, Applicant requests that the Commissioner accept this as a Petition Therefore, and directs that any additional fees be charged to McDermott Will & Emery's Deposit Account No. 500417, Order Number 087638-0949.

Respectfully submitted,

/Iona N. Kaiser/

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Date: February 4, 2016

Electronic Acknowledgement Receipt

EFS ID:	24817487
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Debbie Allen
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	04-FEB-2016
Filing Date:	24-JUL-2014
Time Stamp:	10:05:42
Application Type:	U.S. National Stage under 35 USC 371

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	Amendment/Req. Reconsideration-After Non-Final Reject	0876380949ROA.pdf	123639 92631459368d27aa8586da85fd4cb34164fc47f1	no	10

Warnings:	
Information:	

Total Files Size (in bytes):	123639

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.

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
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.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/374,473	Filing Date 07/24/2014	☐ 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 $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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 **02/04/2016**

	(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))	* 15	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	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

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 $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ 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.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** 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.

LIE
/BRENDA HINES/

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US	7621

99633 7590 11/05/2015

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

EXAMINER	
ROST, ANDREW J	

ART UNIT	PAPER NUMBER
3753	

NOTIFICATION DATE	DELIVERY MODE
11/05/2015	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):

mweipdocket@mwe.com

Office Action Summary	Application No. 14/374,473	Applicant(s) SCOTT, BRUCE EDWARD	
	Examiner Andrew J. Rost	Art Unit 3753	AIA (First Inventor to File) 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 *7/24/2014*.

☐ 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) *1,4-17,19 and 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) *1,4,5,7,8,12-16,19 and 20* is/are rejected.

8)☒ Claim(s) *6,9-11 and 17* 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 *7/24/2015* 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

1. This action is in response to the preliminary amendment filed 7/24/2014. Claims 1, 4, 13 and 19 are currently amended. Claims 2, 3 and 18 have been canceled. No claims are newly added. Presently, claims 1, 4-17, 19 and 20 are pending.

Notice of Pre-AIA or AIA Status

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

Information Disclosure Statement

3. The information disclosure statements filed 7/24/2014 and 4/21/2015 are acknowledged and have been considered by the examiner.

Drawings

4. The drawings were received on 7/24/2014. These drawings are not acceptable.

5. The drawings are objected to under 37 CFR 1.83(a). The drawings must show every feature of the invention specified in the claims. Therefore, the first and second upper bores are angularly offset from each other about a circumference of the housing (claim 10) must be shown or the feature(s) canceled from the claim(s). No new matter should be entered.

Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended

replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. The figure or figure number of an amended drawing should not be labeled as “amended.” If a drawing figure is to be canceled, the appropriate figure must be removed from the replacement sheet, and where necessary, the remaining figures must be renumbered and appropriate changes made to the brief description of the several views of the drawings for consistency. Additional replacement sheets may be necessary to show the renumbering of the remaining figures. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either “Replacement Sheet” or “New Sheet” pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 102

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)(1) the claimed invention was patented, described in a printed publication, or in public use, on sale or otherwise available to the public before the effective filing date of the claimed invention.

(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. Claims 1, 5, 7, 8, 12-16 and 20 are rejected under 35 U.S.C. 102(a)(1) and 102(a)(2) as being anticipated by Nutter (US 3901314).

Regarding claim 1, the Nutter reference discloses a valve assembly having a housing (35, 35') having a piston bore (considered the central passage through the housing) configured to receive hydraulic fluid pressure from a control line (through the line to operate the valve; col. 1, lines 31-37) from a control line, the piston bore providing an upper bore (93) having a first diameter and a lower bore (58) having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston (91) arranged in and configured to sealingly engage the upper bore (with the seal 92) and a lower piston (57) arranged in and configured to sealingly engage the lower bore (with the seal 59), a connecting rod (44) coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity (considered the space between the upper surface of the piston 61 and the lower surface of the shoulder 55) is defined between the upper and lower pistons and the connecting rod extends within the cavity, and a conduit (60) defined in the housing that fluidly communicates the cavity with a region surrounding the housing and wherein the cavity contains a fluid (col. 6, lines 20-26).

In regards to claim 5, the Nutter reference discloses wherein the upper and lower pistons (91 and 57, respectively) each comprise one or more dynamic seals (92 and 59,

respectively) to seal against corresponding inner walls of the upper and lower bores, respectively.

In regards to claim 7, the Nutter reference discloses a spring (63) located within a lower chamber (see figure 2) within the housing and configured to bias the piston assembly upwardly within the piston bore.

In regards to claim 8, the Nutter reference discloses wherein the upper bore is divided into a first upper bore (93) and a second upper piston bore (49) and wherein the upper piston comprises a first upper piston (91) and a second upper piston (47).

In regards to claim 12, the Nutter reference discloses wherein a combined piston are of the first and second upper pistons is greater than a piston area of the lower piston (see at least figure 2).

Regarding claim 13, the Nutter reference discloses the structure of a valve assembly having a method of making and/or using including conveying hydraulic fluid pressure to a piston bore (considered the central passage through the housing) that provides an upper bore (93) having a first diameter and a lower bore (58) having a second diameter smaller than the first diameter (see figure 2), wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston (91) arranged in and sealingly engaging the upper bore (with the seal 92) and a lower piston (57) arranged in and sealingly engaging the lower bore (with the seal 59), axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston (see at least col. 1, lines 31-37), wherein a connecting rod (44) couples the upper and lower pistons such that simultaneous movement of each piston is

achieved when the piston assembly moves within the piston bore, and wherein a cavity (considered the space between the upper surface of the piston 61 and the lower surface of the shoulder 55) is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity and fluidly communicating the cavity and an annulus region with a conduit (60) defined in a housing (35, 35') that houses the piston assembly and wherein the cavity contains a fluid (col. 6, lines 20-26).

In regards to claim 14, the Nutter reference discloses wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid t the piston bore via a control line.

In regards to claim 15, the Nutter reference discloses wherein a piston area of the upper piston is greater than a piston area of the lower piston (based on the different diameters of the pistons 91 and 57).

In regards to claim 16, the Nutter reference discloses wherein the upper and lower pistons (91 and 57, respectively) each comprise one or more dynamic seals (92 and 59, respectively) to seal against corresponding inner walls of the upper and lower bores, respectively.

In regards to claim 20, the Nutter reference discloses wherein the upper bore is divided into a first upper bore (93) and a second upper piston bore (49) and wherein the upper piston comprises a first upper piston (91) and a second upper piston (47) and wherein the first upper bore is sealingly engaged by the first upper piston (with the seal 92) and the second upper bore is sealingly engaged with the second upper piston (with

the seal 48) and wherein a combined piston are of the first and second upper pistons is greater than a piston area of the lower piston (see at least figure 2).

Claim Rejections - 35 USC § 103

8. 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 of this title, 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.

9. Claims 4 and 19 are rejected under 35 U.S.C. 103 as being unpatentable over Nutter (US 3901314) in view of Barrington (US 4448254).

In regards to claim 4, the Nutter reference does not disclose a pressure regulator arranged within the conduit. However, the Barrington reference teaches a tester valve assembly having a equalizing chamber (258) in communication with an equalizing port (292) wherein the equalizing chamber is divided into a first zone and a second zone by a floating piston (282) wherein the floating piston in the equalizing chamber may move in either of two opposite directions to either increase or decrease a volume of a first zone of the equalizing chamber to allow for either expansion or contraction of a compressible liquid due to pressure and temperature changes as the tester valve assembly is placed into a desired position (col. 10, lines 42-50). Therefore, it would have been obvious to one of ordinary skill in the art to provide the valve assembly of the Nutter reference with a floating piston (i.e., pressure regulator) in fluid communication

with the conduit (it is considered that the conduit can extend from and include the equalizing chamber to the outside of the housing) as taught by the Barrington reference in order to allow for either expansion or contraction of a compressible liquid due to pressure and temperature changes as the valve assembly is placed into a desired position.

In regards to claim 19, the Nutter reference does not disclose balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit. However, the Barrington reference teaches a tester valve assembly having a equalizing chamber (258) in communication with an equalizing port (292) wherein the equalizing chamber is divided into a first zone and a second zone by a floating piston (282) wherein the floating piston in the equalizing chamber may move in either of two opposite directions to either increase or decrease a volume of a first zone of the equalizing chamber to allow for either expansion or contraction of a compressible liquid due to pressure and temperature changes as the tester valve assembly is placed into a desired position (col. 10, lines 42-50). Therefore, it would have been obvious to one of ordinary skill in the art to provide the valve assembly of the Nutter reference with a floating piston (i.e., pressure regulator) in fluid communication with the conduit (it is considered that the conduit can extend from and include the equalizing chamber to the outside of the housing) as taught by the Barrington reference in order to allow for either expansion or contraction of a compressible liquid due to pressure and temperature changes as the valve assembly is placed into a desired position.

Allowable Subject Matter

10. Claims 6, 9-11 and 17 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

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

In regards to claim 6, the prior art of record does not disclose or suggest wherein the safety valve of claim 1 includes a piston rod that extends longitudinally from the lower piston through at least portion of the piston bore, a flow tube operably coupled to the piston rod and a valve closure device movable between an open and closed position wherein the flow tube is adapted to shift the valve closure device between the open and closed positions in combination with the piston assembly having an upper piston and a lower piston coupled together by a connecting rod and defining a cavity and a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing and further in combination with the other limitations of the claim;

In regards to claim 9, the prior art of record does not disclose or suggest wherein the first and second upper bores are radially offset from each other within the housing in combination with the other limitations of the claim;

In regards to claim 10, the prior art of record does not disclose or suggest wherein the first and second upper bores are angularly offset from each other about a circumference of the housing in combination with the other limitations of the claim;

In regards to claim 11, the prior art of record does not disclose or suggest wherein the connecting rod splits and extends into each of the first and second bores and attached to each of the first and second upper pistons in combination with the other limitations of the claim;

In regards to claim 17, the prior art of record does not disclose or suggest the method of actuating a safety valve of claim 13 wherein the piston assembly further includes a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube wherein the flow tube is axially displaced as the piston assembly moves within the piston bore and moving a valve closure device with the flow tube from a closed position to an open position in combination with the piston assembly having an upper piston and a lower piston coupled together by a connecting rod and defining a cavity and a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing and further in combination with the other limitations of the claim.

Conclusion

12. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Jonas (US 7451825), McCalvin (US 7231971) and Page, Jr. (US 4069871) disclose various valve assemblies having a piston assembly having an upper piston and a lower piston and a connecting rod coupling the upper and lower pistons together.

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Andrew J. Rost, whose telephone number 571-272-2711. The examiner can normally be reached on Monday-Friday (8:00AM-4:30PM EST).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisors can be reached by phone. **John Fristoe** can be reached at 571-272-4926, **Craig Schneider** can be reached at 571-272-3607 or **Mary McManmon** can be reached at 571-272-6007. 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.

/A. J. R./
Examiner, Art Unit 3753

/JOHN K FRISTOE JR/
Supervisory Patent Examiner, Art Unit 3753

Notice of References Cited	Application/Control No. 14/374,473	Applicant(s)/Patent Under Reexamination SCOTT, BRUCE EDWARD	
	Examiner Andrew J. Rost	Art Unit 3753	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-3,901,314 A	08-1975	Nutter; Benjamin P.	E21B34/10	166/152
*	B	US-4,448,254 A	05-1984	Barrington; Burchus Q.	E21B34/108	166/321
*	C	US-7,451,825 B2	11-2008	Jonas; Jason K.	E21B34/08	166/316
*	D	US-7,231,971 B2	06-2007	McCalvin; David E.	E21B34/10	166/250.01
*	E	US-4,069,871 A	01-1978	Page, Jr.; John S.	E21B34/10	137/458
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

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
	14374473	SCOTT, BRUCE EDWARD
	Examiner	Art Unit
	ANDREW J ROST	3753

CPC- SEARCHED

Symbol	Date	Examiner
F16K 31/1225	10/7/2015	AJR
F16K 17/18	10/7/2015	AJR
E21B 34/10	10/7/2015	AJR
E21B 34/066	10/7/2015	AJR
E21B 2034/005	10/7/2015	AJR
F16K 31/122	10/7/2015	AJR
F16K 31/1226	10/7/2015	AJR

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner
251	62, 77	10/7/2015	AJR
137	155	10/7/2015	AJR
166	319, 320	10/7/2015	AJR
251	31	10/13/2015	AJR
251	62	10/20/2015	AJR

SEARCH NOTES

Search Notes	Date	Examiner
Inventor Name Search	10/7/2015	AJR
forward/backward citation search	10/20/2015	AJR
keyword search	10/20/2015	AJR
See Attached BRS Search Report	10/27/2015	AJR

INTERFERENCE SEARCH

/A.J.R./ Examiner.Art Unit 3753	

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

/A.J.R./ Examiner.Art Unit 3753	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2014-07-24
First Named Inventor	Bruce SCOTT
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	2013-IP-072581 U1 US

U.S.PATENTS

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	4429620		1984-02-07	Burkhardt et al.	
	2	4986357		1991-01-22	Pringle	
	3	7694742		2010-04-13	Bane et al.	
	4	8016035		2011-09-13	Strattan et al.	
	5	8360751		2013-01-29	Duncan	

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

U.S.PATENT APPLICATION PUBLICATIONS

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	20080237993		2008-10-02	Bane et al.	

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /A.R./

Receipt date: 07/24/2014	Application Number	14374473 - GAU: 3753
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Filing Date	2014-07-24
(Not for submission under 37 CFR 1.99)	First Named Inventor	Bruce SCOTT
	Art Unit	N/A
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	2013-IP-072581 U1 US

	2	20090050327		2009-02-26	Anderson et al.	
	3	20130062071		2013-03-14	Rytlewski et al.	
	4	20130092396		2013-04-18	Webber et al.	

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

FOREIGN PATENT DOCUMENTS

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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NON-PATENT LITERATURE DOCUMENTS

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 for PCT/US2013/061546 dated June 26, 2014	☐

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EXAMINER SIGNATURE

Examiner Signature	/Andrew Rost/	Date Considered	10/27/2015

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Receipt date: 07/24/2014	Application Number	14374473 - GAU: 3753
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2014-07-24
	First Named Inventor	Bruce SCOTT
	Art Unit	N/A
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	2013-IP-072581 U1 US

[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. /A.R./

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BIB DATA SHEET

CONFIRMATION NO. 7621

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/374,473	07/24/2014	251	3753	2013-IP-072581 U1 US

APPLICANTS
Halliburton Energy Services, Inc., Houston, TX;

INVENTORS
Bruce Edward Scott, Mckinney, TX;

**** CONTINUING DATA ***************************
This application is a 371 of PCT/US2013/061546 09/25/2013

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****
07/27/2015

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /ANDREW J ROST/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		TX	4	17	2

ADDRESS

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001
UNITED STATES

TITLE

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

FILING FEE RECEIVED		
1480	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Receipt date: 04/21/2015

14374473 - GAU: 3753

Doc code: IDS

Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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U.S.PATENTS

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FOREIGN PATENT DOCUMENTS

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	2015047235	WO	A1	2015-04-02	Halliburton Energy Services, Inc.		☒

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NON-PATENT LITERATURE DOCUMENTS

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]

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Receipt date: 04/21/2015	Application Number	14374473 14374473 - GAU: 3753
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Filing Date	2014-07-24
	First Named Inventor	Bruce SCOTT
	Art Unit	N/A
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	2013-IP-072581 U1 US

	1		☐

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EXAMINER SIGNATURE

Examiner Signature	/Andrew Rost/	Date Considered	10/27/2015

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[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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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	166	((Bruce) near2 (Scott)).INV.	US-PGPUB; USPAT; USOCR	OR	ON	2015/10/07 09:07
S2	18	((Bruce) near2 (Scott)).INV.	EPO; JPO; DERWENT	OR	ON	2015/10/07 09:07
S3	979	f16k31/1225.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 13:27
S4	534	f16k17/18.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 13:27
S5	66	("6098714" | "3469503" | "20030205389" | "6003605" | "20130092396" | "5284205" | "4161219" | "4234043" | "5598864" | "4252197" | "20060196669" | "20130043039" | "20080128137" | "6427778" | "4986357" | "8006753").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 13:57
S6	28	("20080237993" | "20090050327" | "20130062071" | "20130092396" | "4429620" | "4986357" | "7694742" | "8016035" | "8360751").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:17
S7	4622	e21b34/10.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:22
S8	2161	e21b34/066.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:22
S9	3165	e21b2034/005.cpc.	US-PGPUB; USPAT;	OR	ON	2015/10/07 14:23

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S10	2138	f16k31/122.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:23
S11	370	f16k31/1226.cpc.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/07 14:23
S12	615	(251/62).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S13	1397	(251/77).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S14	604	(137/155).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S15	317	(166/320).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S16	1006	(166/319).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/07 14:23
S17	1410	(251/31).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/13 17:39
S18	1	("8701782").PN.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/20 13:51
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S20	437	("1612007" | "20010045290" | "20020046845" | "20020108747" | "20020108788" | "20020158217" | "20020192090" | "20040007683" |	US-PGPUB; USPAT; USOCR	OR	ON	2015/10/20 13:51

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S21	615	(251/62).CCLS.	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	OFF	2015/10/20 14:26
S22	214449	pressure near3 regulat$3	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	ON	2015/10/20 15:06
S23	43	S21 and S22	US-PGPUB; USPAT; USOCR; EPO; JPO	OR	ON	2015/10/20 15:06
S24	10047	balance near3 piston	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:11
S25	27268	(float$3 balance) near3 piston	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:11
S26	2383	S22 and S25	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:12
S27	22	S25 and S21	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2015/10/20 15:12

EAST Search History (Interference)

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10/27/2015 12:43:54 PM

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/374,473	07/24/2014	Bruce Edward Scott	2013-IP-072581 U1 US

CONFIRMATION NO. 7621

99633
McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

PUBLICATION NOTICE

OC000000078498128

Title:MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

Publication No.US-2015-0316170-A1
Publication Date:11/05/2015

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/374,473

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	480
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	17 minus 20 =	*			OR	x 80 =	0.00
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 420 =	0.00
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).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1480

APPLICATION AS AMENDED - PART II

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

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

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** 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 found in the appropriate box in column 1.

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U.S. APPLICATION NUMBER NO.	FIRST NAMED INVENTOR	ATTY. DOCKET NO.
14/374,473	Bruce Edward Scott	2013-IP-072581 U1 US

99633
McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

INTERNATIONAL APPLICATION NO.	
PCT/US2013/061546	
I.A. FILING DATE	PRIORITY DATE
09/25/2013	

CONFIRMATION NO. 7621
371 ACCEPTANCE LETTER

OC000000076529107

Date Mailed: 07/29/2015

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office, in its capacity as a Designated / Elected Office (37 CFR 1.495), has ACCEPTED the above identified international application for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above. A Filing Receipt will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE or 371(c) DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1) and (c)(2) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN BELOW.** The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363)

07/24/2014
DATE OF RECEIPT OF 35 U.S.C.
371(c)(1) and (c)(2) REQUIREMENTS

The following items have been received:

- Copy of the International Application filed on 07/24/2014
- English Translation of the IA filed on 07/24/2014
- Copy of the International Search Report filed on 07/24/2014
- Copy of IPE Report filed on 07/24/2014
- Preliminary Amendments filed on 07/24/2014
- Information Disclosure Statements filed on 07/24/2014
- Inventor's Oath or Declaration filed on 07/24/2014
- Request for Immediate Examination filed on 07/24/2014
- U.S. Basic National Fees filed on 07/24/2014
- Assignee Statement for PGPUB filed on 07/24/2014
- Power of Attorney filed on 07/24/2014
- Authorization to Permit Access filed on 07/24/2014
- Application Data Sheet (37 CFR 1.76) filed on 07/24/2014

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

PATRICIA A BOOKER

Telephone: (571) 272-3882

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/374,473	07/24/2014		1480	2013-IP-072581 U1 US	17	2

CONFIRMATION NO. 7621

FILING RECEIPT

99633
McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

OC000000078529108

Date Mailed: 07/29/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Bruce Edward Scott, Mckinney, TX;

Applicant(s)

Halliburton Energy Services, Inc., Houston, TX;

Assignment For Published Patent Application

Halliburton Energy Services, Inc., Houston, TX

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/US2013/061546 09/25/2013

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 07/27/2015
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/374,473**
Projected Publication Date: 11/05/2015
Non-Publication Request: No
Early Publication Request: No

Title

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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PTO/SB/08a (01-10)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	14374473
Filing Date	2014-07-24
First Named Inventor	Bruce SCOTT
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	2013-IP-072581 U1 US

U.S.PATENTS

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
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
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	Filing Date	2014-07-24
	First Named Inventor	Bruce SCOTT
	Art Unit	N/A
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	2013-IP-072581 U1 US

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(54) **Title**: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

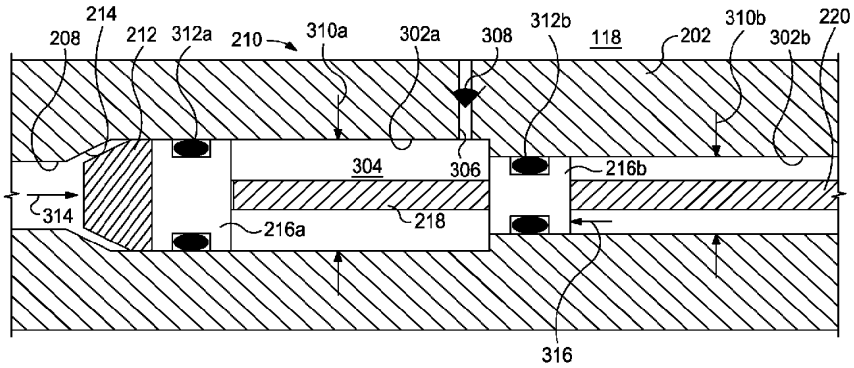

FIG. 3A

(57) **Abstract**: Disclosed are subsurface safety valves having multiple pistons used to increase the opening force. One safety valve includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons, wherein a cavity is defined between the upper and lower pistons within the piston bore and the piston rod extends within the cavity.

WO 2015/047235 A1

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

BACKGROUND

[0001] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0002] Subsurface safety valves are well known in the oil and gas industry and act as a failsafe to prevent the uncontrolled release of reservoir fluids in the event of a worst-case scenario surface disaster. Typical subsurface safety valves are flapper-type valves that are opened and closed with the help of a flow tube moving telescopically within the production tubular. The flow tube is often controlled hydraulically from the surface and is forced into its open position using a piston and rod assembly that may be hydraulically charged via a control line linked directly to a hydraulic manifold or pressure control system at the well surface. When sufficient hydraulic pressure is conveyed to the subsurface safety valve via the control line, the piston and rod assembly forces the flow tube downwards, which compresses a spring and simultaneously pushes the flapper downwards to the open position. When the hydraulic pressure is removed from the control line, the spring pushes the flow tube back up, which allows the flapper to move into its closed position.

[0003] Depending on the size and depth of the safety valve deployed, the components of the pressure control system used to operate the safety valve can be quite expensive. The cost of a pressure control system may increase as required pressure ratings for the control line and/or the pump equipment increase, which is usually related to the operating depth of the safety valve. There are practical limits to the size and rating of pressure control systems, past which a well operator may not be able to economically or feasibly employ a subsurface safety valve. Accordingly, there is always a need in the industry for the ability to use lower rated pressure control systems for operating subsurface safety valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The following figures are included to illustrate certain aspects of the present disclosure, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, without departing from the scope of this disclosure.

[0005] FIG. 1 illustrates a well system that incorporates one or more principles of the present disclosure, according to one or more embodiments.

[0006] FIGS. 2A and 2B illustrate cross-sectional side views of the exemplary safety valve of FIG. 1, according to one or more embodiments.

[0007] FIGS. 3A and 3B illustrate enlarged cross-sectional side views of an exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

[0008] FIG. 4A and 4B illustrate enlarged cross-sectional side views of another exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

DETAILED DESCRIPTION

[0009] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0010] Disclosed is a subsurface safety valve configured to reduce the pressure required to open the valve at depth. The safety valve includes a piston assembly having a multiple piston configuration including a control pressure piston coupled to a section pressure piston such that the two pistons move simultaneously within a piston bore of the safety valve. The control pressure piston exhibits a larger piston area than the section pressure piston. As a result, hydraulic fluid provided to the piston bore via a control line will work on the larger piston area of the control pressure piston while the section pressure below the piston assembly will work on the smaller piston area of the section pressure piston. Since the piston area of the control pressure piston is enlarged, the control pressure is intensified such that lower rated pressure control systems may be employed.

[0011] Referring to FIG. 1, illustrated is a well system 100 that incorporates one or more principles of the present disclosure, according to one or more embodiments. As illustrated, the well system 100 may include a riser 102 extending from a wellhead installation 104 arranged at a sea floor 106. The riser 102 may extend, for example, to an offshore oil and gas platform (not shown). A wellbore 108 extends downward from the wellhead installation 104 through various subterranean formations 110. The wellbore 108 is depicted as being cased, but it could equally be an uncased wellbore 108, without departing from the scope of the disclosure. Although FIG. 1 depicts the well system 100 in the context of an offshore oil and gas application, it will be appreciated by those skilled in the art that the various embodiments disclosed herein are equally well suited for use in or on oil and gas rigs or service rigs, such as land-based oil and gas rigs or rigs located at any other geographical site. Thus, it should be understood that the disclosure is not limited to any particular type of well.

[0012] The well system 100 may further include a safety valve 112 interconnected with a tubing string 114 arranged within the wellbore 108 and extending from the wellhead installation 104. The tubing string 114 may be configured to communicate fluids derived from the wellbore 108 and the surrounding subterranean formations 110 to the well surface via the wellhead installation 104. A control line 116 may extend from the well surface and into the wellhead installation 104 which, in turn, conveys the control line 116 into an annulus 118 defined between the wellbore 108 and the tubing string 114. The control line 116 may extend downward within the annulus 118 and eventually become communicably coupled to the safety valve 112. As discussed in more detail below, the control line 116 may be configured to actuate the safety valve 112, for example, to maintain the safety valve 112 in an open position, or otherwise to close the safety valve 112 and thereby prevent a blowout in the event of an emergency.

[0013] The control line 116 may be a hydraulic conduit that provides hydraulic fluid pressure to the safety valve 112. In operation, hydraulic fluid may be applied to the control line 116 from a hydraulic pressure control system arranged at a remote location, such as at a production platform or a subsea control station. When properly applied, the hydraulic pressure derived from the control line 116 may be configured to open and maintain the safety valve 112 in its open position, thereby allowing production fluids to flow through the safety

valve 112, through the tubing string 114, and upwards towards the rig. To move the safety valve 112 from its open position and into a closed position, the hydraulic pressure in the control line 116 may be reduced or otherwise eliminated.

[0014] Although the control line 116 is depicted in FIG. 1 as being arranged external to the tubing string 114, it will be readily appreciated by those skilled in the art that any arrangement or configuration of the control line 116 may be used to convey actuation pressure to the safety valve 112. For example, the control line 116 could be arranged internal to the tubing string 114, or otherwise formed in a sidewall of the tubing string 114. The control line 116 could extend from a remote location, such as from the earth's surface, or another location in the wellbore 108. In yet other embodiments, the pressure required to actuate the safety valve 112 may be derived from a pressure control system located downhole and communicably coupled to the control line 116 at a location.

[0015] In the following description of the representative embodiments of the disclosure, directional terms such as "above", "below", "upper", "lower", etc., are used for convenience in referring to the accompanying drawings. In general, "above", "upper", "upward" and similar terms refer to a direction toward the earth's surface along the wellbore 108, and "below", "lower", "downward" and similar terms refer to a direction away from the earth's surface along the wellbore 108.

[0016] Referring now to FIGS. 2A and 2B, with continued reference to FIG. 1, illustrated are cross-sectional side views of an exemplary embodiment of the safety valve 112, according to one or more embodiments. In particular, the safety valve 112 is depicted in FIGS. 2A and 2B in successive sectional views, where FIG. 2A depicts an upper portion of the safety valve 112 and FIG. 2B depicts a lower portion of the safety valve 112. As illustrated, the safety valve 112 may include a housing 202 that is able to be coupled to the tubing string 114 at opposing ends of the housing 202 (tubing string 114 shown only in FIG. 2B).

[0017] A control line port 204 may be defined or otherwise provided in the housing 202 for connecting the control line 116 (FIG. 1) to the safety valve 112. The port 204 is shown in FIG. 2A as being plugged with a set screw 206 or other type of plugging device. However, when the control line 116 is

appropriately connected to the first port 204 the control line 116 is placed in fluid communication with a piston bore 208 and able to convey hydraulic fluid pressure thereto. The piston bore 208 may be an elongate channel or conduit defined within the housing 202 and configured to extend longitudinally along a portion of the axial length of the safety valve 112.

[0018] A piston assembly 210 may be arranged within the piston bore 208 and configured to translate axially therein. The piston assembly 210 may include a piston head 212 configured to mate with and otherwise bias an up stop 214 defined within the piston bore 208 when the piston assembly 210 is forced upwards in the direction of the control line port 204. The up stop 214 may be a radial shoulder defined within the piston bore 208 and having a reduced diameter and an axial surface configured to engage a corresponding axial surface of the piston head 212. In other embodiments, the up stop 214 may be any device or means arranged within the piston bore 208 that is configured to stop the axial movement of the piston assembly 210 as it advances upward within the piston bore and toward the control line port 204.

[0019] The piston assembly 210 may also include a first or upper piston 216a and a second or lower piston 216b coupled thereto via a connecting rod 218. The lower piston 216b may be coupled to a piston rod 220 that extends longitudinally from the piston assembly 210 through at least a portion of the piston bore 208. At a distal end thereof, the piston rod 220 may be coupled to an actuator sleeve 222, which may be configured to effectively couple the piston assembly 210 to a flow tube 224 that is movably arranged within the safety valve 112. More particularly, the actuator sleeve 222 may engage a biasing device 226 (*e.g.*, a compression spring, a series of Belleville washers, or the like) arranged axially between the actuator sleeve 222 and an actuation flange 228 that forms part of the proximal end of the flow tube 224. As the actuator sleeve 222 acts on the biasing device 226 (*e.g.*, axial force), the actuation flange 228 and the flow tube 224 correspondingly move.

[0020] Referring to FIG. 2B, the safety valve 112 may also include a valve closure device 230 that selectively opens and closes a flow passage 232 defined through the interior of the safety valve 112. The valve closure device 230 may be a flapper, as generally known to those skilled in the art. It should be noted, however, that although the safety valve 112 is depicted as being a flapper-type safety valve, those skilled in the art will readily appreciate that any

type of closure device 230 may be employed, without departing from the scope of the disclosure. For example, in some embodiments, the closure device 230 could instead be a ball, a sleeve, etc.

[0021] As shown in FIG. 2B, the closure device 230 is in its closed position whereby the closure device 230 is able to substantially block fluid flow into and through the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B). A torsion spring 234 biases the closure device 230 to pivot to its closed position. As described below, the piston assembly 210 is used to displace the flow tube 224 downward (*i.e.*, to the right in FIG. 2B) to engage the closure device 230 and overcome the spring force of the torsion spring 234. When the flow tube 224 is extended to its downward position, it engages the closure device 230 and moves the closure device 230 from its closed position to an open position (shown in phantom as dashed lines). When the flow tube 224 is displaced back upward (*i.e.*, to the left in FIG. 2B), the torsion spring 234 is able to pivot the closure device 230 back to its closed position. Axial movement of the piston assembly 210 within the piston bore 208 will force the flow tube 224 to correspondingly move axially within the flow passage 232, and either open the closure device 230 or allow it to close, depending on its relative position.

[0022] The safety valve 112 may further define a lower chamber 236 within the housing 202. In some embodiments, the lower chamber 236 may form part of the piston bore 208, such as being an elongate extension thereof. A power spring 238, such as a coil or compression spring, may be arranged within the lower chamber 236. The power spring 238 may be configured to bias the actuation flange 228 and actuation sleeve 222 upwardly which, in turn, biases the piston assembly 210 in the same direction. Accordingly, expansion of the power spring 238 will cause the piston assembly 210 to move upwardly within the piston bore 208.

[0023] It should be noted that while the power spring 238 is depicted as a coiled compression spring, any type of biasing device may be used instead of, or in addition to, the power spring 238, without departing from the scope of the disclosure. For example, a compressed gas, such as nitrogen, with appropriate seals may be used in place of the power spring 238. In other embodiments, the compressed gas may be contained in a separate chamber and tapped when needed.

[0024] In exemplary operation, the safety valve 112 may be actuated in order to open the closure device 230. This may be accomplished by conveying a hydraulic fluid under pressure to the control line port 204 via the control line 116 (FIG. 1). As hydraulic pressure is provided to the piston bore 208, the piston assembly 210 may be forced to move axially downward within the piston bore 208. As the piston assembly 210 moves, the piston rod 220 mechanically transfers the hydraulic force to the actuation sleeve 222 and the actuation flange 228, thereby correspondingly displacing the flow tube 224 in the downward direction. In other words, as the piston assembly 210 moves axially within the piston bore 208, the flow tube 224 correspondingly moves in the same direction. As the flow tube 224 moves downward, it engages the closure device 230, overcomes the spring force of the torsion spring 234, and thereby pivots the closure device 230 to its open position to permit fluids to enter the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B).

[0025] Moreover, as the piston assembly 210 moves axially downward within the piston bore 208, the power spring 238 is compressed within the lower chamber 236 and progressively builds spring force. In at least one embodiment, the piston assembly 210 will continue its axial movement in the downward direction, and thereby continue to compress the power spring 238, until engaging a down stop 240 (FIG. 2A) arranged within the piston bore 208. A metal-to-metal seal may be created between the piston assembly 210 and the down stop 240 such that the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough is generally prevented.

[0026] Upon reducing or eliminating the hydraulic pressure provided via the control line 116, the spring force built up in the power spring 238 may be allowed to release and displace the piston assembly 210 upwards within the piston bore 208, thereby correspondingly moving the flow tube 224 in the same direction. The section pressure within the safety valve 112 below the lower piston 216b also serves to move the piston assembly 210 upwards within the piston bore 208. As the flow tube 224 moves axially upwards, it will eventually move out of engagement with the closure device 230. Once free from engagement with the flow tube 224, the spring force of the torsion spring 234 will pivot the closure device 230 back into its closed position.

[0027] In at least one embodiment, the piston assembly 210 will continue its axial movement in the upward direction until the piston head 212 of

the piston assembly 210 engages the up stop 214 and effectively prevents the piston assembly 210 from further upward movement. Engagement between the piston head 212 and the up stop 214 may generate a mechanical metal-to-metal seal between the two components to prevent the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough.

[0028] When the safety valve 112 is deployed downhole, the "section" pressure, or fluid pressure present within the wellbore 108 (FIG. 1) and annulus 118 (FIG. 1) at depth, cooperatively act on the piston assembly 210. More specifically, the section pressure acts on the downhole end of the piston assembly 210 via the piston bore 208, and provides a corresponding closing force on the safety valve 112 that urges the piston assembly 210 toward the up stop 214. In order to open the safety valve 112, the piston assembly 210 must effectively overcome the section pressure and the spring force of the power spring 238. To do this, the hydraulic fluid pressure ("control" pressure) conveyed into the piston bore 208 via the control line 116 (FIG. 1) must be supplied at a pressure that exceeds the combined force of the section pressure and the power spring 238. Moreover, this hydraulic pressure must incrementally increase as the piston assembly 210 translates downward within the piston bore 208 to counteract the increasing spring force that builds as the power spring 238 is compressed. As indicated above, this oftentimes requires expensive pressure control systems that may be infeasible or uneconomical for some applications.

[0029] According to one or more embodiments of the present disclosure, the pressure required to open the safety valve 112 may be reduced or otherwise minimized by increasing the downward force derived from the control pressure and simultaneously decreasing the upward force derived from the section pressure. This can be accomplished by having a multiple piston configuration in the piston assembly 210 whereby the control pressure piston (*i.e.*, the first piston 216a) exhibits a larger piston area than the section pressure piston (*i.e.*, the second piston 216b). As a result, the control pressure will work on the larger piston area of the control pressure piston and the section pressure will work on the smaller piston area of the section pressure piston, thereby intensifying the available force from the control pressure.

[0030] Referring now to FIGS. 3A and 3B, with continued reference to FIGS. 2A and 2B, illustrated are enlarged cross-sectional side views of an exemplary embodiment of the piston assembly 210, according to one or more

embodiments. Like numerals in FIGS. 3A and 3B that are used in prior figures indicate like elements and/or components that will not be described again in detail. FIG. 3A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 3B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0031] As illustrated, the piston assembly 210 may be arranged within the piston bore 208 defined in the housing 202 of the safety valve 112 (FIGS. 2A-2B). The piston bore 208 may be divided into a first or upper bore 302a and a second or lower bore 302b. The first piston 216a may be generally arranged in the upper bore 302a, and the second piston 216b may be generally arranged in the lower bore 302b. The first and second pistons 216a,b may be axially offset from each other within the piston bore 208 and coupled together using the connecting rod 218. The connecting rod 218 may threadably or mechanically attach the first and second pistons 216a,b to each other such that simultaneous movement of each piston 216a,b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0032] With the first and second pistons 216a,b structurally coupled via the connecting rod 218, a chamber or cavity 304 may be defined therebetween within the piston bore 208. The cavity 304 may be configured to correspondingly move with the first and second pistons 216a,b when the piston assembly 210 moves within the piston bore 208. In some embodiments, the cavity 304 may be filled with a fluid. In one or more embodiments, for example, the cavity 304 may be filled with a gas, such as air or an inert gas (*e.g.*, nitrogen, argon, etc.). In other embodiments, however, the cavity 304 may be filled with a hydraulic fluid, a wellbore fluid, water (*i.e.*, brine, fresh water, etc.), or any other liquid.

[0033] In one or more embodiments, the cavity 304 may be ported to the annulus 118 within the wellbore 108 (FIG. 1) where the safety valve 112 (FIGS. 2A-2B) is to be located. More particularly, the piston assembly 210 may further include a conduit 306 defined in the housing 202 that places the cavity 304 in fluid communication with the annulus 118 surrounding the safety valve 112. Porting the cavity 304 to the annulus 118 may help compensate for expansion and contraction of the fluid within the cavity 304 as the wellbore 108 heats up or cools down. At increased temperatures, the pressure within the

cavity 304 will increase and porting the fluid to the annulus 118 may help maintain a safe operating pressure equilibrium. Porting the fluid to the annulus 118 may also prevent the first and second pistons 216a,b from locking under vacuum as temperatures decrease in the cavity 304 and the pressure correspondingly decreases.

[0034] In at least one embodiment, a pressure regulator 308 may be arranged within the conduit 306. The pressure regulator 308 may be used to generally separate the fluid within the cavity 304 from any fluids present in the annulus 118. In operation, the pressure regulator 308 may be configured to axially translate within the conduit 306, thereby separating the fluid within the cavity 304 from fluids in the annulus 118, but also compensate for expansion and contraction of the fluid within the cavity 304 and thereby help maintain safe operating pressure equilibrium. In some embodiments, the pressure regulator 308 may be a balance piston. In other embodiments, however, the pressure regulator 308 may be a floating piston, or the like, without departing from the scope of the disclosure.

[0035] The upper bore 302a may exhibit a first diameter 310a and the lower bore 302b may exhibit a second diameter 310b that is smaller or less than the first diameter 310a. The first piston 216a may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the upper bore 302a, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first piston 216a may include one or more first dynamic seals 312a and the second piston 216b may include one or more second dynamic seals 312b.

[0036] As used herein, the term "dynamic seal" is used to indicate a seal that provides pressure isolation between members that have relative displacement therebetween, for example, a seal which seals against a displacing surface, or a seal carried on one member and sealing against the other member, etc. A dynamic seal may comprise a material selected from the following: elastomeric materials, non-elastomeric materials, metals, composites, rubbers, ceramics, derivatives thereof, and any combination thereof. A dynamic seal may be attached to each of the relatively displacing members, such as a bellows or a flexible membrane. A dynamic seal may be attached to either of the relatively displacing members, such as in the case of a floating piston.

[0037] The first and second dynamic seals 312a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the first dynamic seal 312a may be configured to seal against the inner wall of the upper bore 302a as the first piston 216a moves therein, and the second dynamic seal 312b may be configured to seal against the inner wall of the lower bore 302b as the second piston 216b moves therein. As a result, the first and second dynamic seals 312a,b may be configured to prevent any fluids from migrating past the first and second pistons 216a,b respectively. In some embodiments, one or both of the first and second dynamic seals 312a,b may be O-rings or the like, as illustrated. In other embodiments, however, one or both of the first and second dynamic seals 312a,b may be v-rings or CHEVRON® packing rings or other appropriate seal configurations (*e.g.*, seals that are round, v-shaped, u-shaped, square, oval, t-shaped, etc.), as generally known to those skilled in the art.

[0038] In exemplary operation, hydraulic pressure or "control" pressure (generally indicated by the arrow 314) is introduced into the piston bore 208 via the control line 116 (FIG. 1) and associated port 204 (FIG. 2A). The control pressure 314 communicates with and otherwise acts on the first piston 216a, thereby separating the piston head 212 from the up stop 214 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 3A and 3B). An opposing "section" pressure (generally indicated by the arrow 316) communicates with and otherwise acts on the second piston 216b. As mentioned above, the section pressure 316 and the spring force of the power spring 238 (FIGS. 2A-2B) cooperatively act against the control pressure 314.

[0039] Referring to FIG. 3B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the cavity 304 defined between the first and second pistons 216a,b. As generally described above, while the piston assembly 210 moves from its first position into its second position, the piston rod 220 mechanically transfers the hydraulic force of the control pressure 314 to the flow tube 224 (FIGS. 2A-2B), thereby correspondingly displacing the flow tube 224 in the downward direction and opening the closure device 230 (FIG. 2B). Moreover, while the piston assembly 210 moves from its first position into its second position, the first and second dynamic seals 312a,b sealingly engage the inner walls of the upper and lower bores 302a,b, respectively.

[0040] Since the piston area of the first piston 216a is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 is correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area, the section pressure 316 applied to the second piston 216b is minimized with respect to the first piston 216a and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ a smaller or reduced pressure control system used to convey the control pressure 314 to the safety valve 112, including using control lines and pump equipment that exhibit lower pressure ratings than would otherwise be used in a safety valve at similar depths. Smaller or reduced pressure control systems may be advantageous for safety reasons (*i.e.*, lower pressures are typically safer than higher pressures), cost (*i.e.*, reducing the size of the pump and the pressure rating of the pump and control lines can result in significant cost savings), and physical restraints (*i.e.*, lower pressure equipment normally exhibits a smaller footprint than higher pressure equipment).

[0041] Referring now to FIGS. 4A and 4B, with continued reference to FIGS. 2A-2B and 3A-3B, illustrated are enlarged cross-sectional side views of another exemplary embodiment of the piston assembly 210, according to one or more embodiments. Like numerals are used to indicate like elements and/or components from prior figures that will not be described again in detail. FIG. 4A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 4B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0042] Similar to the piston assembly 210 depicted in FIGS. 3A-3B, the piston assembly 210 in FIGS. 4A-4B is arranged within the piston bore 208 defined in the housing 202 and the piston bore 208 includes an upper bore 302a and a lower bore 302b. The upper bore 302a in FIGS. 4A-4B, however, may be divided into a first upper bore 402a and a second upper bore 402b to accommodate a first upper piston 404a and a second upper piston 404b. In some embodiments, the first and second upper bores 402a,b may be radially offset from each other within the housing 202 (*i.e.*, radially offset from each other with respect to the longitudinal central axis of the safety valve 112). In other embodiments, the first and second upper bores 402a,b may be angularly or circumferentially offset from each other within the housing 202. In other

words, the first and second upper bores 402a,b may also be laterally offset from each other about the circumference of the housing 202, without departing from the scope of the disclosure.

[0043] The first and second upper pistons 404a,b may be operably coupled to each other with a connecting rod 406. The connecting rod 406 may be u-shaped and/or otherwise connected at an intermediate point such that it is able to extend into each of the first and second upper bores 402a,b and attach to the first and second upper pistons 404a,b. As a result, the first and second upper pistons 404a,b are able to move simultaneously and thereby act as a single piston member. The connecting rod 406 may also be coupled to the second or lower piston 216b. The connecting rod 406 may threadably or mechanically attach the first and second upper pistons 404a,b to the second piston 216b such that simultaneous movement of each piston 404a,b and 216b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0044] A cavity 408 may be defined between the first and second upper pistons 404a,b and the second piston 216b within the piston bore 208. The cavity 408 may be configured to correspondingly move or shift within the piston bore 208 when the piston assembly 210 moves therein. Similar to the cavity 304 of FIGS. 3A-3B, the cavity 408 may be filled with a fluid, such as a gas (*e.g.*, air, an inert gas, etc.), or a liquid (*e.g.*, hydraulic fluid, wellbore fluid, water, such as brine or fresh water), combinations thereof, or the like. As illustrated, the cavity 408 may also be ported to the annulus 118 via the conduit 306 in order to place the cavity 408 in fluid communication with the annulus 118. In some embodiments, the pressure regulator 308 may be arranged within the conduit 306 in order to maintain pressure equilibrium within the cavity 408.

[0045] The first upper bore 402a may exhibit a first diameter 410a, the second upper bore 402b may exhibit a second diameter 410b, and the lower bore 302b may exhibit a third diameter 410c. In some embodiments, the first and second diameters 410a,b may be the same. In other embodiments, the first and second diameters 410a,b may be different. Moreover, in some embodiments, one or both of the first and second diameters 410a,b may be greater than the third diameter 410c. In other embodiments, one or both of the first and second diameters 410a,b may be smaller than the third diameter 410c. In any event, the combined sizing of the first and second diameters 410a,b is

greater than the third diameter 410c, such that the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b.

[0046] The first and second upper pistons 404a,b may be sized or otherwise configured to sealingly engage the inner walls of the first and second upper bores 402a,b, respectively, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first and second upper pistons 404a,b may include one or more first dynamic seals 412a and the second piston 216b may include one or more second dynamic seals 412b. Similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the dynamic seal 412a of the first upper piston 404a may be configured to seal against the inner wall of the first upper bore 402a, the dynamic seal 412a of the second upper piston 404b may be configured to seal against the inner wall of the second upper bore 402b, and the dynamic seal 412b of the second piston 216b may be configured to seal against the inner wall of the lower bore 302b. Moreover, similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be one of an O-ring, one or more v-rings or CHEVRON® packing rings, or other appropriate seal configurations described herein.

[0047] In exemplary operation, hydraulic control pressure 314 is introduced into the piston bore 208 in order to act on the piston assembly 210 and move the safety valve 112 (FIGS. 2A-2B) into the open position. More particularly, the control pressure 314 may be provided to the control line port 204 (FIG. 2A) via the control line 116 (FIG. 1), and the control line port 204 may feed the hydraulic fluid into the piston bore 208, which splits and feeds the control pressure 314 into the first and second upper bores 402a,b. The control pressure 314 communicates with and otherwise acts on the first and second upper pistons 404a,b, thereby separating the piston head 212 of each first and second upper piston 404a,b from corresponding up stops 214 defined in the piston bore 208 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 4A and 4B). The opposing section pressure 316 communicates with and otherwise acts on the second piston 216b.

[0048] As shown in FIG. 4B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the flow tube 224 (FIGS. 2A-2B) in the downward direction and opening the closure device 230 (FIG. 2B), as generally described above. Moreover, while the piston assembly 210 moves from the first position into the second position, the dynamic seals 412a,b sealingly engage the inner walls of the first and second upper bores 402a,b and the lower bore 302b, respectively.

[0049] Adding additional pistons to the piston assembly 210 increases the piston area available for the control pressure 314 to act on in moving the piston assembly 210 from its first position (FIG. 4A) to its second position (FIG. 4B). Since the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 has been correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area than the combined piston areas of the first and second upper pistons 404a,b, the section pressure 316 applied to the second piston 216b is minimized with respect to the first and second upper pistons 404a,b and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ smaller or less expensive pressure control equipment used to convey the control pressure 314 to the safety valve 112.

[0050] Furthermore, by employing additional upper pistons in the piston assembly 210, an operator may be able to obtain a desired ratio between the upper and lower pistons, thereby allowing for smaller upper pistons. Smaller upper pistons can reduce the effective cross section of the upper piston section, which can effectively reduce the outer diameter of the subsurface safety valve. As a result, the overall cost of the safety valve may correspondingly be reduced and allow the safety valve to be used in a greater number of wells. Moreover, a smaller outer diameter fort he safety valve allows the operator to run smaller casing whereas a larger outer diameter safety valve requires the operator to run larger casing which increases well completion costs.

[0051] While FIGS. 4A and 4B depict first and second upper pistons 404a,b being used in the piston assembly 210, it will be appreciated that more than two upper pistons (*e.g.*, first pistons 302a) may be employed without departing from the scope of the disclosure. Each additional upper piston may be operatively coupled to the control rod 406 and effectively increase the piston

area available for the control pressure 314 to act on, thereby reducing the required amount of control pressure 314 to open the safety valve.

[0052] Embodiments disclosed herein include:

[0053] A. A safety valve that includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

[0054] B. A method of actuating a safety valve that includes conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore, axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

[0055] Each of embodiments A and B may have one or more of the following additional elements in any combination: Element 1: wherein the cavity contains a fluid. Element 2: further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. Element 3: further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing. Element 4: wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively. Element 5: further comprising a piston rod

that extends longitudinally from the lower piston through at least a portion of the piston bore, a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly, and a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions. Element 6: further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore. Element 7: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. Element 8: wherein the first and second upper bores are radially offset from each other within the housing. Element 9: wherein the first and second upper bores are angularly offset from each other about a circumference of the housing. Element 10: wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons. Element 11: wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0056] Element 12: wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line. Element 13: wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston. Element 14: wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively. Element 15: wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising axially displacing the flow tube as the piston assembly moves within the piston bore, compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure, and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position. Element 16: wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. Element 17: further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit. Element 18: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising sealingly engaging the first upper bore with the first upper piston, and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0057] Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of

values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

What is claimed is:

1. A safety valve, comprising:

a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore; and

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

2. The safety valve of claim 1, wherein the cavity contains a fluid.

3. The safety valve of claim 2, further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing.

4. The safety valve of claim 3, further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore;

a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly; and

a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage

when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions.

7. The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. The safety valve of claim 8, wherein the first and second upper bores are angularly offset from each other about a circumference of the housing.

11. The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston,

wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

14. The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. The method of claim 13, wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly.

19. The method of claim 18, further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

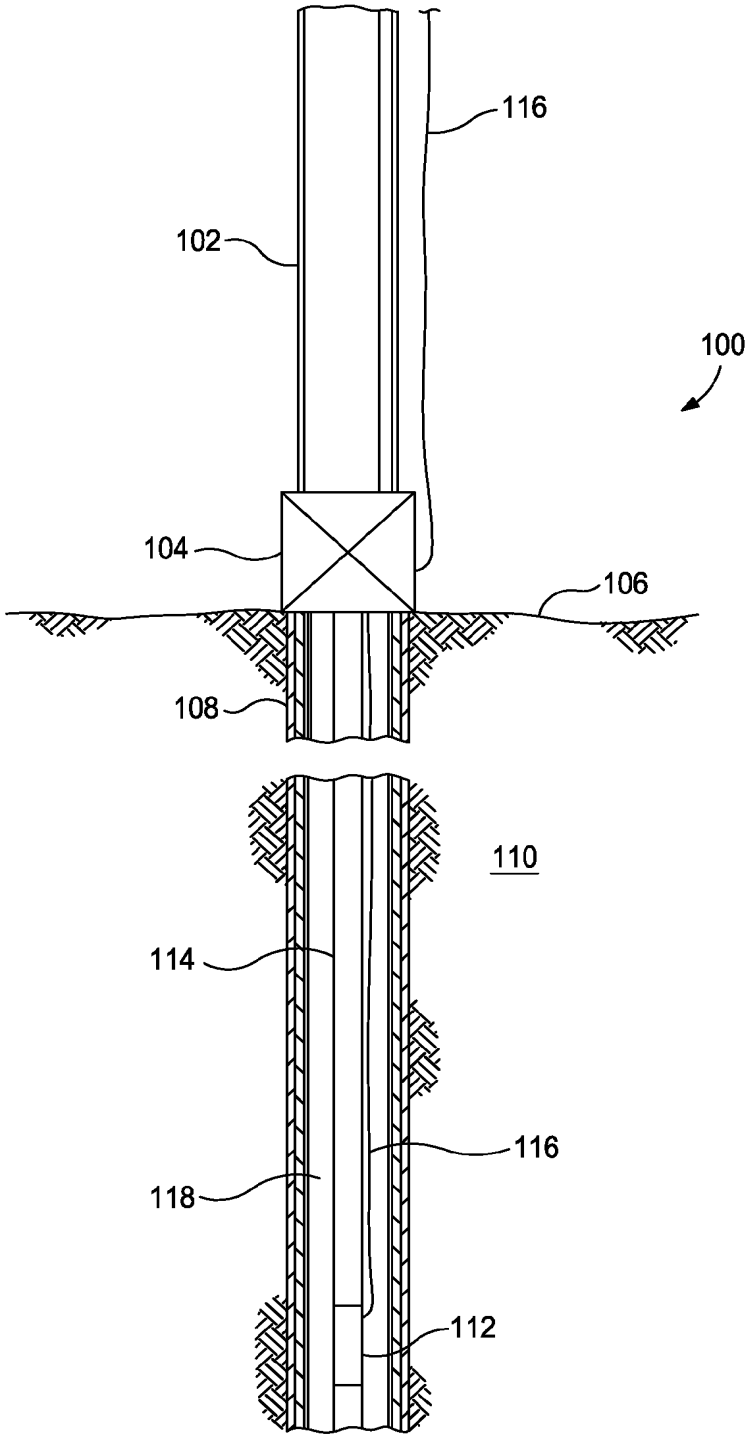

FIG. 1

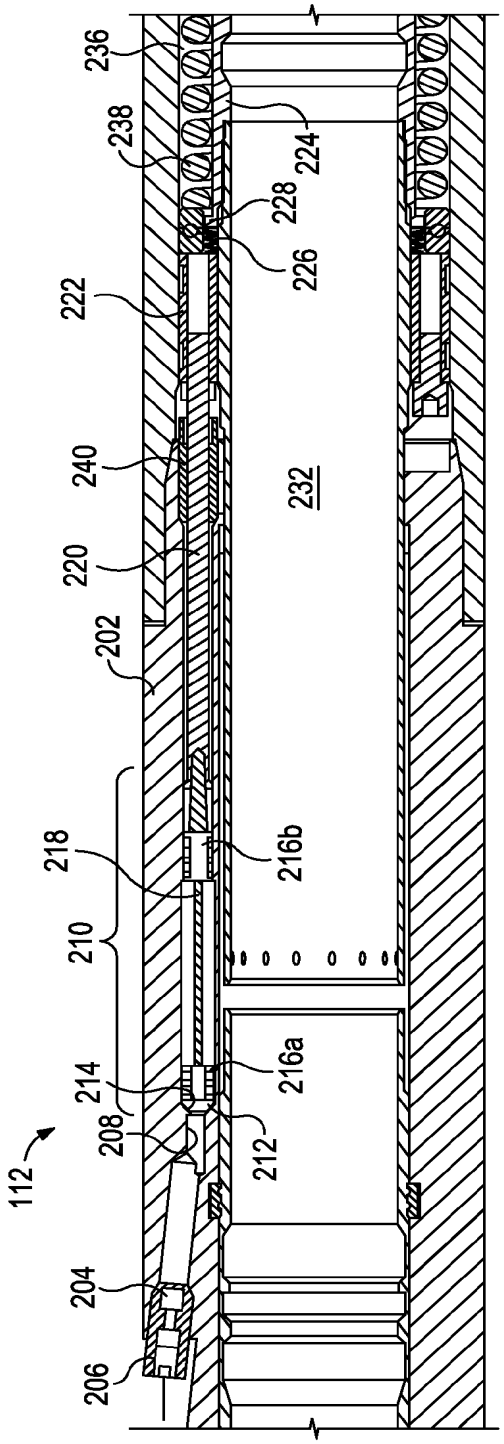
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FIG. 2A

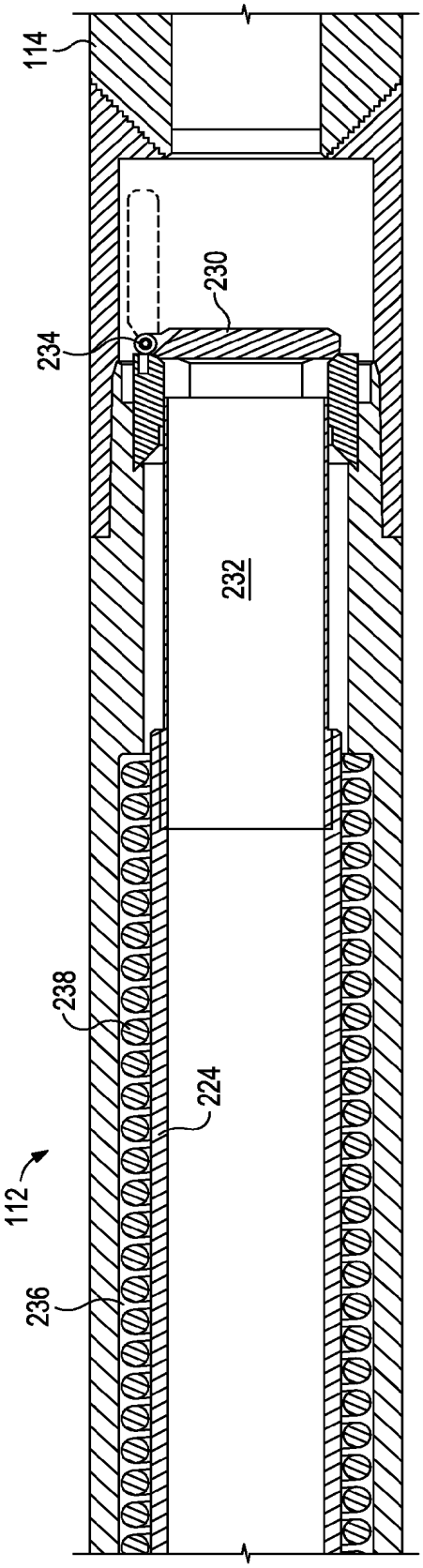
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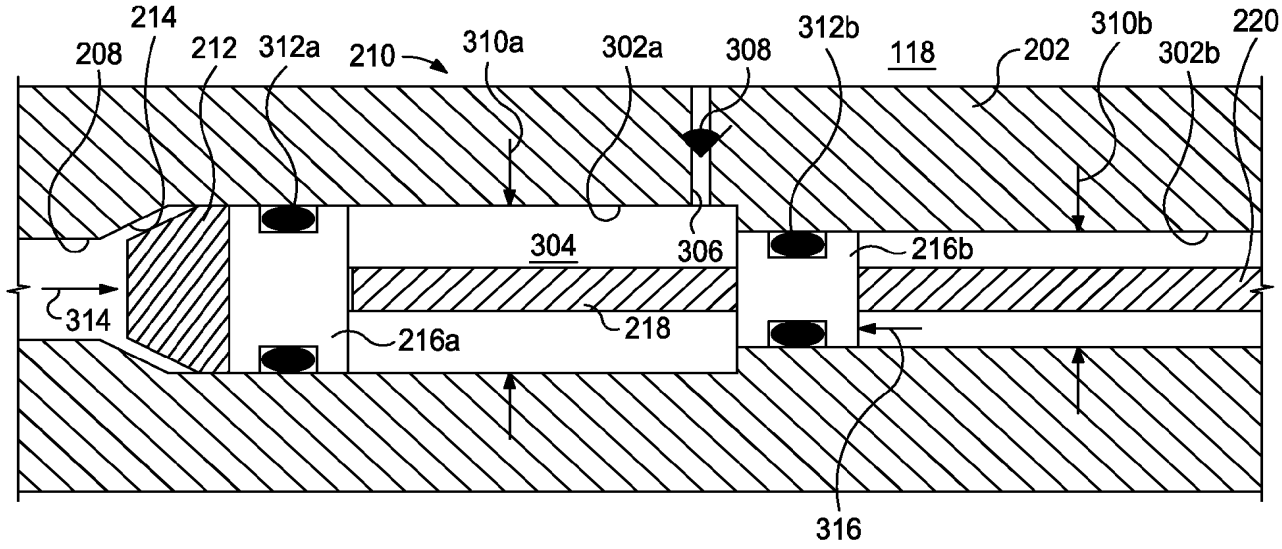
FIG. 2B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216a
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FIG. 3A

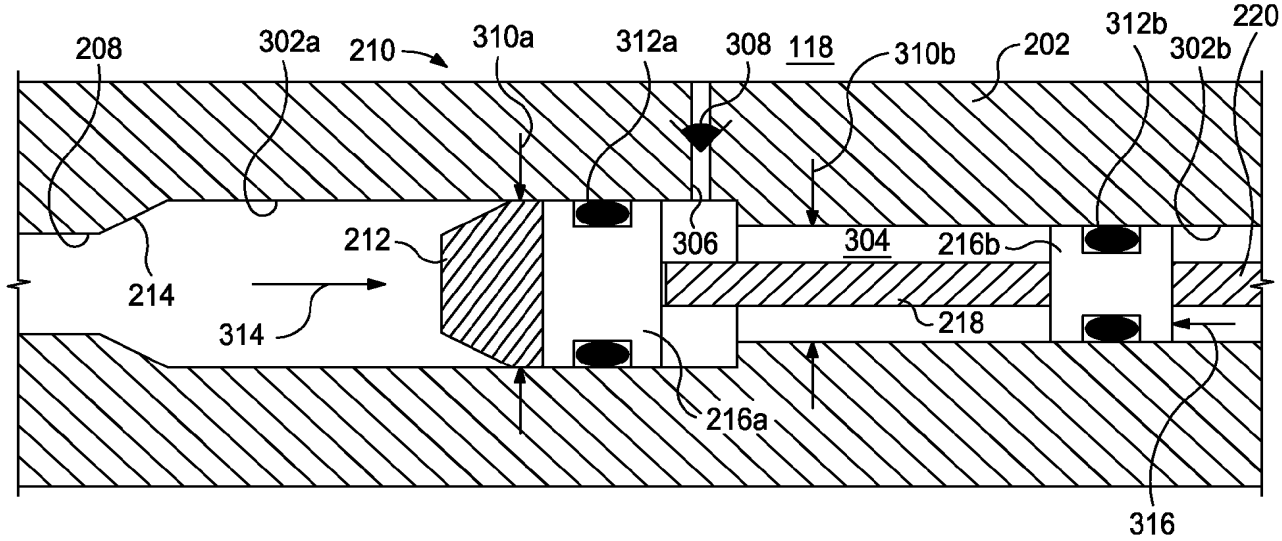
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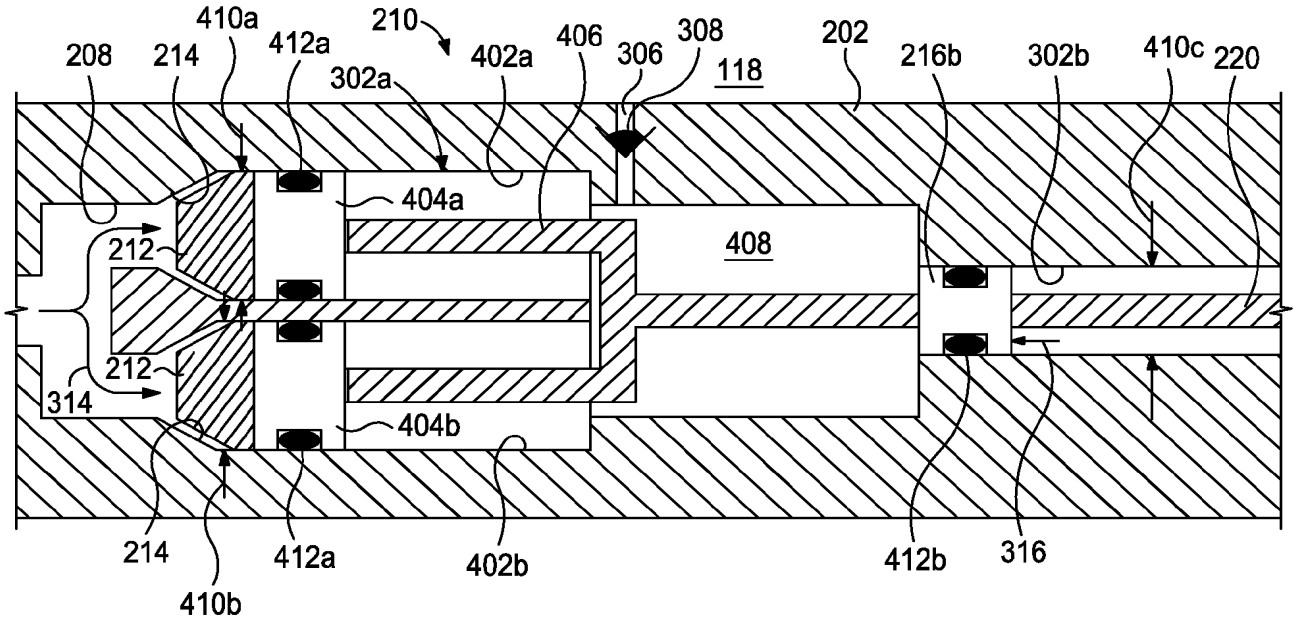
FIG. 3B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402b
412b
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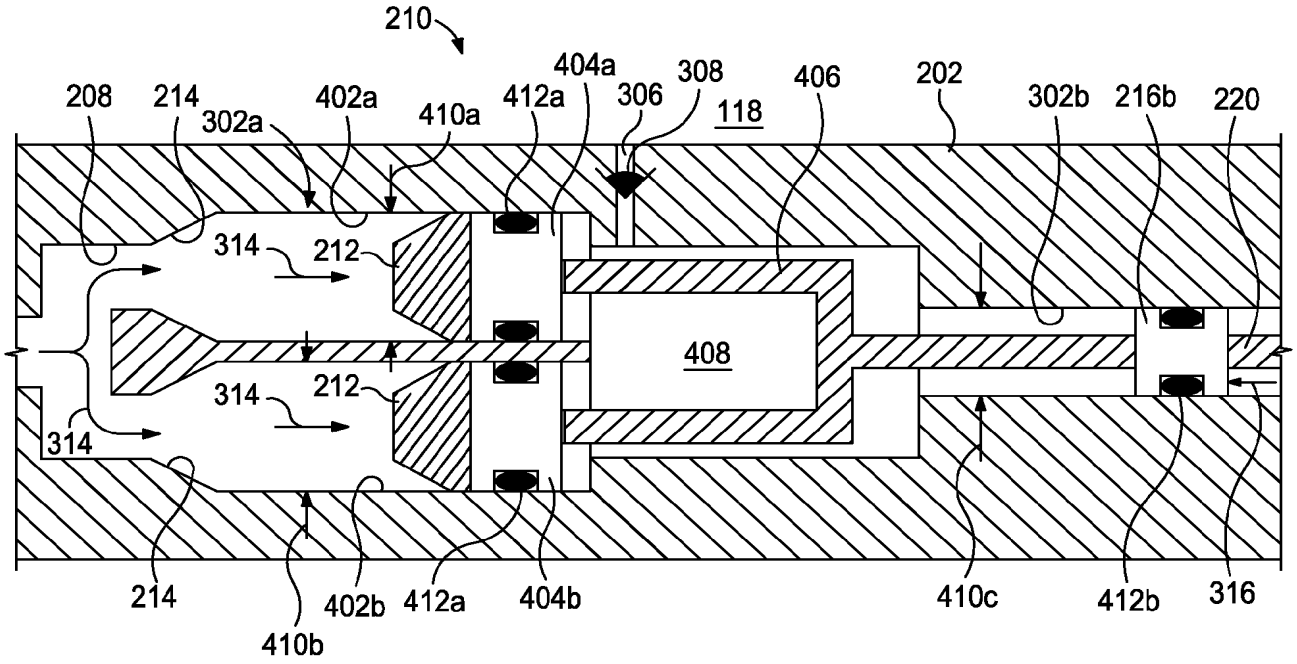
410b

FIG. 4A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314
314
214
402b
412a
404b
410c
412b
316
410b

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/061546

A. CLASSIFICATION OF SUBJECT MATTER

E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

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)
E21B 34/06; E21B 47/10; E21B 33/128; B23P 17/00; E21B 34/10; E21B 34/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:safety valve, piston, spring, control line, power spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0237993 A1 (BANE et al.) 02 October 2008 See paragraphs [0002]-[0003], [0017]-[0023] and figures 2-7.	1-2,5-7,13-17
A		3 4,8 12,18 20
A	US 2013-0092396 A1 (WEBBER et al.) 18 April 2013 See paragraphs [0019]-[0060] and figures 2-8.	1-20
A	US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013 See paragraphs [0013]-[0030] and figures 1-8.	1-20
A	US 8016035 B2 (STRATTAN et al.) 13 September 2011 See claims 1-4 and figures 1-3.	1-20
A	US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009 See paragraphs [0016]-[0022] and figures 1-7.	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
25 June 2014 (25.06.2014)	**26 June 2014 (26.06.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

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LEE, Chang Ho
Telephone No. +82-42-481-8398

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/061546

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		RU 2335620 C2	10/10/2008
		US 2005-0098210 A1	12/05/2005
		US 2007-0277878 A1	06/12/2007
		WO 2005-045182 A1	19/05/2005
US 2009-0050327 A1	26/02/2009	US 7762335 B2	27/07/2010
		WO 2009-026217 A2	26/02/2009
		WO 2009-026217 A3	16/04/2009

Electronic Acknowledgement Receipt

EFS ID:	22125699
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Debbie Allen
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	21-APR-2015
Filing Date:	
Time Stamp:	16:16:49
Application Type:	U.S. National Stage under 35 USC 371

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)	0876380949IDS.pdf	61052 b762d74d55d4f154f999e7483567fa9143dcbaae	no	3

Warnings:	
Information:	

This is not an USPTO supplied IDS fillable form					
2	Foreign Reference	0876380949IDSRef.pdf	1411531 60b140d0df8384e8175f446403a2f0ae79710930	no	30

Warnings:	
Information:	
Total Files Size (in bytes):	1472583

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.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/374,473		Bruce Edward Scott	2013-IP-072581 U1 US	7621

99633 7590 11/20/2014

McDermott Will & Emery LLP
The McDermott Building
500 North Capitol Street, N.W.
Washington, DC 20001

EXAMINER	
ART UNIT	PAPER NUMBER

NOTIFICATION DATE	DELIVERY MODE
11/20/2014	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):

mweipdocket@mwe.com

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

In re Application of	: DECISION ON REQUEST TO
Bruce Edward Scott	: PARTICIPATE IN THE PATENT
Application No. 14/374,473	: PROSECUTION HIGHWAY
Filed: July 24, 2014	: PROGRAM AND PETITION
Attorney Docket No. 2013-IP-072581 U1 US	: TO MAKE SPECIAL UNDER : 37 CFR 1.102(a)
For: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

This is a decision on the request to participate in the Patent Prosecution Highway (PPH) program and the petition under 37 CFR 1.102(a), filed July 24, 2014, to make the above-identified application special.

The request and petition are **GRANTED**.

DISCUSSION

A grantable request to participate in the PPH pilot program and petition to make special require:

1. The U.S. application for which participation in the Global/IP5 PPH pilot program is requested must have the same earliest date, whether this is the priority date or filing date, as that of a corresponding national or regional application filed with another Global/IP5 PPH participating office or a corresponding PCT international application for which one of the Global/IP5 PPH participating offices was the International Searching Authority (ISA) or the International Preliminary Examining Authority (IPEA).

2. Applicant must:
    a. Ensure all the claims in the U.S. application must sufficiently correspond or be amended to sufficiently correspond to the allowable/patentable claim(s) in the corresponding Office of Earlier Examination (OEE) application and
    b. Submit a claims correspondence table in English;
3. Examination of the U.S. application has not begun;
4. Applicant must submit:
    a. Documentation of prior office action:

i. a copy of the office action(s) just prior to the "Decision to Grant a Patent" from each of the Global/IP5 PPH participating office application(s) containing the allowable/patentable claim(s) or
ii. if the allowable/patentable claims(s) are from a "Notification of Reasons for Refusal" then the Notification of Reasons for Refusal or
iii. if the Global/IP5 PPH participating office application is a first action allowance then no office action from the Global/IP5 PPH participating office is necessary should be indicated on the request/petition form or
iv. the latest work product in the international phase of the OEE PCT application;

b. An English language translation of the Global/IP5 PPH participating office action or work product from (4)(a)(i)-(ii) or (iv) above;

5. Applicant must submit:
   a. An IDS listing the documents cited by the Global/IP5 PPH participating office examiner in the Global/IP5 PPH participating office action or work product (unless already submitted in this application)
   b. Copies of the documents except U.S. patents or U.S. patent application publications (unless already submitted in this application);

The request to participate in the PPH pilot program and petition comply with the above requirements. Accordingly, the above-identified application has been accorded "special" status.

Telephone inquiries concerning this decision should be directed to the undersigned at (571) 272-3208.

All other inquiries concerning the examination or status of the application is accessible in the PAIR system at http://www.uspto.gov/ebc.index.html.

This application will be forwarded to the examiner for action on the merits commensurate with this decision once this application's formality reviews have been completed.

/KOC/
Karen Creasy
Paralegal Specialist
Office of Petitions

Office of Petitions: Decision Count Sheet

Mailing Month

Application No. 14374473

14374473

For US serial numbers: enter number only, no slashes or commas. Ex: 10123456
For PCT: enter "51+single digit of year of filing+last 5 numbers", Ex. for PCT/US05/12345, enter 51512345

Deciding Official: KAREN CREASY

Count (1) - Palm Credit 14/374,473

Decision: GRANT

FINANCE WORK NEEDED
☐ Select Check Box for YES

GRANT

Decision Type: 652 - Petition to make special-PPH

652

Notes:

Count (2)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Count (3)

Decision: n/a

FINANCE WORK NEEDED
☐ Select Check Box for YES

Decision Type: NONE

Notes:

Initials of Approving Official (if required)

If more than 3 decisions, attach 2nd count sheet & mark this box ☐

Printed on: *11/17/2014*

Office of Petitions: Routing Sheet

Application No. 14/374,473

This application is being forwarded to your office for further processing. A decision has been rendered on a petition filed in this application.

[x] **GRANTED**

[ ] **DISMISSED**

[ ] **DENIED**

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Bruce	Edward	Scott	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	McKinney	State/Province	TX	Country of Residence	US

Mailing Address of Inventor:

Address 1	7220 Oakbury Lane		
Address 2			
City	McKinney	State/Province	TX
Postal Code	75071	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	99633		
Email Address	mweipdocket@mwe.com	Add Email	Remove Email

Application Information:

Title of the Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE		
Attorney Docket Number	2013-IP-072581 U1 US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	

Filing By Reference :

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

Only compete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	99633		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/US13/61546	2013-09-25

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

(•) Assignee	( ) Legal Representative under 35 U.S.C. 117	( ) Joint Inventor
( ) Person to whom the inventor is obligated to assign.	( ) Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Halliburton Energy Services, Inc.

Mailing Address Information For Applicant:

Address 1	10200 Bellaire Boulevard		
Address 2			
City	Houston	**State/Province**	TX
Country	US	Postal Code	77072
Phone Number		Fax Number	

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
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.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Halliburton Energy Services, Inc.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	10200 Bellaire Boulevard		
Address 2			
City	Houston	**State/Province**	TX
Country i	US	Postal Code	77072
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

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

Signature	/Iona N. Kaiser/			Date (YYYY-MM-DD)	2014-07-28
First Name	Iona N.	Last Name	Kaiser	Registration Number	53086

Additional Signature may be generated within this form by selecting the Add button.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

Electronic Acknowledgement Receipt

EFS ID:	19694098
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Debbie Allen
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	28-JUL-2014
Filing Date:	
Time Stamp:	08:37:11
Application Type:	U.S. National Stage under 35 USC 371

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	Application Data Sheet	0876380949RevADS.PDF	388694 522bc3cd805ba74a565e1de6ff47dae5f648e45c	no	6

Warnings:	
Information:	

This is not an USPTO supplied ADS fillable form	
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	
Total Files Size (in bytes):	388694

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

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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.

PTO-1390 (06-13)
Approved for use through 6/30/2013. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
2013-IP-072581 U1 US	

International Application No.	International Filing Date	Priority Date Claimed
PCT/US2013/61546	September 25, 2013	

Title of Invention
MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

First Named Inventor
Bruce Edward Scott

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☐ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☑ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/US2013/61546	2013-IP-072581 U1 US

17. ☐ Other items or information:

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480	
TOTAL OF 18, 19, and 20 =	$ 1480	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
Fee for each additional 50 sheets of paper or fraction thereof **$400**

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/ 50 =		x **$400**	$

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =		x **$80**	$	
Independent claims	- 3 =		x **$420**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$780**	$	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
TOTAL OF ABOVE CALCULATIONS =				$	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
TOTAL NATIONAL FEE =				$ 1480	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property. +				$	
TOTAL FEES ENCLOSED =				$ 1480	
				Amount to be refunded:	$
				Amount to be charged:	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☑ Please charge my Deposit Account No. 500417 in the amount of $ 1480 to cover the above fees.

c. ☑ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 500417 as follows:

i. ☑ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File)Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013, and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE 1: By providing this statement under 37 CFR 1.55 or 1.78, **this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☑ The address associated with Customer Number: 99633 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/Iona N. Kaiser/	Date	July 24, 2014
Name (Print/Type)	Iona N. Kaiser	Registration No. (Attorney/Agent)	53086

PTO-1390 (06-13)
Approved for use through 6/30/2013. OMB 0651-0021
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371

Attorney Docket No.	U.S. Application No. (if known, see 37 CFR 1.5)
2013-IP-072581 U1 US	

International Application No.	International Filing Date	Priority Date Claimed
PCT/US2013/61546	September 25, 2013	

Title of Invention
MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

First Named Inventor
Bruce Edward Scott

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☑ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.
2. ☐ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).
3. An English language translation of the International Application (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))
   a. ☑ is attached.
   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).
6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).
7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☑ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
10. ☑ A preliminary amendment.
11. ☑ An Application Data Sheet under 37 CFR 1.76.
12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).
13. ☐ A power of attorney and/or change of address letter.
14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.
15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee: _____
16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

U.S. APPLN. No. (if known – see 37 CFR 1.5)	INTERNATIONAL APPLICATION No.	ATTORNEY DOCKET No.
	PCT/US2013/61546	2013-IP-072581 U1 US

17. ☐ Other items or information:

The following fees have been submitted.	CALCULATIONS	PTO USE ONLY
18. ☑ Basic national fee (37 CFR 1.492(a)) **$280**	$ 280	
19. ☑ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** All other situations **$720**	$ 720	
20. ☑ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the international preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) ..... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority .....**$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB .....**$480** All other situations **$600**	$ 480	
TOTAL OF 18, 19, and 20 =	$ 1480	

☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)).
Fee for each additional 50 sheets of paper or fraction thereof **$400**

Total Sheets	Extra Sheets	Number of each addition 50 or fraction thereof (round **up** to a whole number)	RATE	
- 100 =	/ 50 =		x **$400**	$

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =		x **$80**	$	
Independent claims	- 3 =		x **$420**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$780**	$	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +				$	
TOTAL OF ABOVE CALCULATIONS =				$	
☐ **Applicant asserts small entity status.** See 37 CFR 1.27. Fees above are reduced by ½.					
☐ **Applicant certifies micro entity status.** See 37 CFR 1.29. Fees above are reduced by ¾. Applicant must attach form PTO/SB/15A or B or equivalent.					
TOTAL NATIONAL FEE =				$ 1480	
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TOTAL FEES ENCLOSED =				$ 1480	
				Amount to be refunded:	$
				Amount to be charged:	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

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i. ☑ any required fee.

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File)Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013, and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

NOTE 1: By providing this statement under 37 CFR 1.55 or 1.78, **this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA**.

NOTE 2: A U.S. national stage application may not claim priority to the international application of which it is the national phase. The filing date of a U.S. national stage application is the international filing date. See 35 U.S.C. 363.

Correspondence Address

☑ The address associated with Customer Number: 99633 **OR** ☐ Correspondence address below

Name					
Address					
City		State		Zip Code	
Country		Telephone			
Email					

Signature	/Iona N. Kaiser/	Date	July 24, 2014
Name (Print/Type)	Iona N. Kaiser	Registration No. (Attorney/Agent)	53086

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Bruce	Edward	Scott	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	McKinney	State/Province	TX	Country of Residence	US

Mailing Address of Inventor:

Address 1	7220 Oakbury Lane		
Address 2			
City	McKinney	State/Province	TX
Postal Code	75071	Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	99633		
Email Address	mweipdocket@mwe.com	Add Email	Remove Email

Application Information:

Title of the Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE		
Attorney Docket Number	2013-IP-072581 U1 US	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	4	Suggested Figure for Publication (if any)	

Filing By Reference :

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

Only compete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	99633		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the application number blank.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	a 371 of international	PCT/US13/61546	2014-09-25

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date o f filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

Organization Name	Halliburton Energy Services, Inc.

Mailing Address Information For Applicant:

Address 1	10200 Bellaire Boulevard		
Address 2			
City	Houston	**State/Province**	TX
Country	US	Postal Code	77072
Phone Number		Fax Number	

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

Email Address	

Additional Applicant Data may be generated within this form by selecting the Add button.

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

If the Assignee or Non-Applicant Assignee is an Organization check here. ☒

Organization Name	Halliburton Energy Services, Inc.

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1	10200 Bellaire Boulevard		
Address 2			
City	Houston	**State/Province**	TX
Country i	US	Postal Code	77072
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.

Signature:

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

Signature	/Iona N. Kaiser/			Date (YYYY-MM-DD)	2014-07-24
First Name	Iona N.	Last Name	Kaiser	Registration Number	53086

Additional Signature may be generated within this form by selecting the Add button.

PTO/AIA/14 (12-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	2013-IP-072581 U1 US
	Application Number	
Title of Invention	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE	

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

TRANSMITTAL FORM

I hereby certify that this correspondence is being transmitted to the United States Patent & Trademark Office via electronic filing (EFS) on the date shown at the bottom of this form: Signature: / Debbie Allen / Printed Name: Debbie Allen	First Named Inventor: **Bruce Edward Scott**	Docket Number: **2013-IP-072581 U1 US**	
	Application Number: **unknown**	Art Unit: **unknown**	Confirmation No.: **unknown**
	Filing Date: **July 24, 2014**	Examiner: **unknown**	
	Title: **Multiple Piston Pressure Intensifier for a Safety Valve**		

ENCLOSURES (*Check all that apply*)

☐ Fee Transmittal	☐ Drawings	☐ After Allowance Communication to Technology Center
☐ Fee Attached	☐ Licensing-Related Papers	☐ Appeal Communication
☐ Amendment / Reply	☐ Petition	☐ Proprietary Information
☐ After Final	☐ Petition to Convert Provisional Application	☐ Status Letter
☐ Affidavit / Declaration	☐ Power of Attorney, Revocation, Change of Correspondence Address	☒ Other Enclosure(s) (identified below): **Preliminary Amendment**
☐ Extension of Time Request	☐ Terminal Disclaimer	
☐ Express Abandonment	☐ Request for Refund	
☐ Information Disclosure Stmt.	☐ CD, No. of CD's 0	
☐ Certified Priority Documents	☐ Landscape Table on CD	
☐ Reply to Missing Parts	Remarks:	

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

I am the

☐ applicant / inventor

☐ assignee of record of the entire interest.
See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed

☒ attorney or agent of record or acting under 37 CFR 1.34.

Registration Number: 53,086

Signature
/Iona N. Kaiser/

Printed Name
Iona N. Kaiser

Telephone Number
713-653-1724

Date
July 24, 2014

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE		
First Named Inventor: **Bruce Edward Scott**	Docket Number: **2013-IP-072581 U1 US**	
Application Number: **unknown**	Art Unit: **unknown**	Confirmation No.: **unknown**
Filing Date: **July 24, 2014**	Examiner: **unknown**	
Title: **Multiple Piston Pressure Intensifier for a Safety Valve**		

MAIL STOP AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Commissioner:

Prior to examination of the above-referenced application, please amend the application as follows:

Cross Reference to Related Application begins on page 2 of this paper;
Amendments to the Claims begin on page 3 of this paper; and
Remarks begin on page 7 of this paper.

CROSS REFERENCE TO RELATED APPLICATIONS

Please add the following before the first paragraph:

This application is a National Stage entry of and claims priority to International Application No. PCT/US2013/061546, filed on September 25, 2013.

PRELIMINARY AMENDMENT TO THE CLAIMS

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

1. (Currently Amended) A safety valve, comprising:

a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore; ~~and~~

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity; and

a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing, wherein the cavity contains a fluid.

2. (Canceled)

3. (Canceled)

4. (Currently Amended) The safety valve of claim 1 [[3]], further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. (Original) The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. (Original) The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore;

a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly; and

a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions.

7. (Original) The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. (Original) The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. (Original) The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. (Original) The safety valve of claim 8, wherein the first and second upper bores are angularly offset from each other about a circumference of the housing.

11. (Original) The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. (Original) The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. (Currently Amended) A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper

piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity; and

fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly, wherein the cavity contains a fluid.

14. (Original) The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. (Original) The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. (Original) The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. (Original) The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. (Canceled)

19. (Currently Amended) The method of claim 13 [[18]], further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. (Original) The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

REMARKS

Pursuant to the present paper, claims 1, 4, 13, and 19 have been amended and claims 2, 3, and 18 have been canceled. No claims have been added. The amendments submitted herein contain no new matter and are supported by the new application as filed. Applicant respectfully requests that the amendments be entered in the instant application. Should the Examiner have any questions, the Examiner is invited to contact an attorney of record by telephone, facsimile, or electronic mail.

Applicant submits herewith fees associated with filing a new application, charged to McDermott Will & Emery's Deposit Account No. 500417, Order Number 087638-0949. Should the Commissioner deem that any additional fees are due, Applicant respectfully requests that the Commissioner accept this as a Petition Therefore, and directs that any additional fees be charged to McDermott Will & Emery's Deposit Account No. 500417, Order Number 087638-0949.

Respectfully submitted,

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MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

BACKGROUND

[0001] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0002] Subsurface safety valves are well known in the oil and gas industry and act as a failsafe to prevent the uncontrolled release of reservoir fluids in the event of a worst-case scenario surface disaster. Typical subsurface safety valves are flapper-type valves that are opened and closed with the help of a flow tube moving telescopically within the production tubular. The flow tube is often controlled hydraulically from the surface and is forced into its open position using a piston and rod assembly that may be hydraulically charged via a control line linked directly to a hydraulic manifold or pressure control system at the well surface. When sufficient hydraulic pressure is conveyed to the subsurface safety valve via the control line, the piston and rod assembly forces the flow tube downwards, which compresses a spring and simultaneously pushes the flapper downwards to the open position. When the hydraulic pressure is removed from the control line, the spring pushes the flow tube back up, which allows the flapper to move into its closed position.

[0003] Depending on the size and depth of the safety valve deployed, the components of the pressure control system used to operate the safety valve can be quite expensive. The cost of a pressure control system may increase as required pressure ratings for the control line and/or the pump equipment increase, which is usually related to the operating depth of the safety valve. There are practical limits to the size and rating of pressure control systems, past which a well operator may not be able to economically or feasibly employ a subsurface safety valve. Accordingly, there is always a need in the industry for the ability to use lower rated pressure control systems for operating subsurface safety valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The following figures are included to illustrate certain aspects of the present disclosure, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, without departing from the scope of this disclosure.

[0005] FIG. 1 illustrates a well system that incorporates one or more principles of the present disclosure, according to one or more embodiments.

[0006] FIGS. 2A and 2B illustrate cross-sectional side views of the exemplary safety valve of FIG. 1, according to one or more embodiments.

[0007] FIGS. 3A and 3B illustrate enlarged cross-sectional side views of an exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

[0008] FIG. 4A and 4B illustrate enlarged cross-sectional side views of another exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

DETAILED DESCRIPTION

[0009] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0010] Disclosed is a subsurface safety valve configured to reduce the pressure required to open the valve at depth. The safety valve includes a piston assembly having a multiple piston configuration including a control pressure piston coupled to a section pressure piston such that the two pistons move simultaneously within a piston bore of the safety valve. The control pressure piston exhibits a larger piston area than the section pressure piston. As a result, hydraulic fluid provided to the piston bore via a control line will work on the larger piston area of the control pressure piston while the section pressure below the piston assembly will work on the smaller piston area of the section pressure piston. Since the piston

area of the control pressure piston is enlarged, the control pressure is intensified such that lower rated pressure control systems may be employed.

[0011] Referring to FIG. 1, illustrated is a well system 100 that incorporates one or more principles of the present disclosure, according to one or more embodiments. As illustrated, the well system 100 may include a riser 102 extending from a wellhead installation 104 arranged at a sea floor 106. The riser 102 may extend, for example, to an offshore oil and gas platform (not shown). A wellbore 108 extends downward from the wellhead installation 104 through various subterranean formations 110. The wellbore 108 is depicted as being cased, but it could equally be an uncased wellbore 108, without departing from the scope of the disclosure. Although FIG. 1 depicts the well system 100 in the context of an offshore oil and gas application, it will be appreciated by those skilled in the art that the various embodiments disclosed herein are equally well suited for use in or on oil and gas rigs or service rigs, such as land-based oil and gas rigs or rigs located at any other geographical site. Thus, it should be understood that the disclosure is not limited to any particular type of well.

[0012] The well system 100 may further include a safety valve 112 interconnected with a tubing string 114 arranged within the wellbore 108 and extending from the wellhead installation 104. The tubing string 114 may be configured to communicate fluids derived from the wellbore 108 and the surrounding subterranean formations 110 to the well surface via the wellhead installation 104. A control line 116 may extend from the well surface and into the wellhead installation 104 which, in turn, conveys the control line 116 into an annulus 118 defined between the wellbore 108 and the tubing string 114. The control line 116 may extend downward within the annulus 118 and eventually become communicably coupled to the safety valve 112. As discussed in more detail below, the control line 116 may be configured to actuate the safety valve 112, for example, to maintain the safety valve 112 in an open position, or otherwise to close the safety valve 112 and thereby prevent a blowout in the event of an emergency.

[0013] The control line 116 may be a hydraulic conduit that provides hydraulic fluid pressure to the safety valve 112. In operation, hydraulic fluid may be applied to the control line 116 from a hydraulic pressure control system

arranged at a remote location, such as at a production platform or a subsea control station. When properly applied, the hydraulic pressure derived from the control line 116 may be configured to open and maintain the safety valve 112 in its open position, thereby allowing production fluids to flow through the safety valve 112, through the tubing string 114, and upwards towards the rig. To move the safety valve 112 from its open position and into a closed position, the hydraulic pressure in the control line 116 may be reduced or otherwise eliminated.

[0014] Although the control line 116 is depicted in FIG. 1 as being arranged external to the tubing string 114, it will be readily appreciated by those skilled in the art that any arrangement or configuration of the control line 116 may be used to convey actuation pressure to the safety valve 112. For example, the control line 116 could be arranged internal to the tubing string 114, or otherwise formed in a sidewall of the tubing string 114. The control line 116 could extend from a remote location, such as from the earth's surface, or another location in the wellbore 108. In yet other embodiments, the pressure required to actuate the safety valve 112 may be derived from a pressure control system located downhole and communicably coupled to the control line 116 at a location.

[0015] In the following description of the representative embodiments of the disclosure, directional terms such as "above", "below", "upper", "lower", etc., are used for convenience in referring to the accompanying drawings. In general, "above", "upper", "upward" and similar terms refer to a direction toward the earth's surface along the wellbore 108, and "below", "lower", "downward" and similar terms refer to a direction away from the earth's surface along the wellbore 108.

[0016] Referring now to FIGS. 2A and 2B, with continued reference to FIG. 1, illustrated are cross-sectional side views of an exemplary embodiment of the safety valve 112, according to one or more embodiments. In particular, the safety valve 112 is depicted in FIGS. 2A and 2B in successive sectional views, where FIG. 2A depicts an upper portion of the safety valve 112 and FIG. 2B depicts a lower portion of the safety valve 112. As illustrated, the safety valve 112 may include a housing 202 that is able to be coupled to the tubing string 114 at opposing ends of the housing 202 (tubing string 114 shown only in FIG. 2B).

[0017] A control line port 204 may be defined or otherwise provided in the housing 202 for connecting the control line 116 (FIG. 1) to the safety valve 112. The port 204 is shown in FIG. 2A as being plugged with a set screw 206 or other type of plugging device. However, when the control line 116 is appropriately connected to the first port 204 the control line 116 is placed in fluid communication with a piston bore 208 and able to convey hydraulic fluid pressure thereto. The piston bore 208 may be an elongate channel or conduit defined within the housing 202 and configured to extend longitudinally along a portion of the axial length of the safety valve 112.

[0018] A piston assembly 210 may be arranged within the piston bore 208 and configured to translate axially therein. The piston assembly 210 may include a piston head 212 configured to mate with and otherwise bias an up stop 214 defined within the piston bore 208 when the piston assembly 210 is forced upwards in the direction of the control line port 204. The up stop 214 may be a radial shoulder defined within the piston bore 208 and having a reduced diameter and an axial surface configured to engage a corresponding axial surface of the piston head 212. In other embodiments, the up stop 214 may be any device or means arranged within the piston bore 208 that is configured to stop the axial movement of the piston assembly 210 as it advances upward within the piston bore and toward the control line port 204.

[0019] The piston assembly 210 may also include a first or upper piston 216a and a second or lower piston 216b coupled thereto via a connecting rod 218. The lower piston 216b may be coupled to a piston rod 220 that extends longitudinally from the piston assembly 210 through at least a portion of the piston bore 208. At a distal end thereof, the piston rod 220 may be coupled to an actuator sleeve 222, which may be configured to effectively couple the piston assembly 210 to a flow tube 224 that is movably arranged within the safety valve 112. More particularly, the actuator sleeve 222 may engage a biasing device 226 (*e.g.*, a compression spring, a series of Belleville washers, or the like) arranged axially between the actuator sleeve 222 and an actuation flange 228 that forms part of the proximal end of the flow tube 224. As the actuator sleeve 222 acts on

the biasing device 226 (*e.g.*, axial force), the actuation flange 228 and the flow tube 224 correspondingly move.

[0020] Referring to FIG. 2B, the safety valve 112 may also include a valve closure device 230 that selectively opens and closes a flow passage 232 defined through the interior of the safety valve 112. The valve closure device 230 may be a flapper, as generally known to those skilled in the art. It should be noted, however, that although the safety valve 112 is depicted as being a flapper-type safety valve, those skilled in the art will readily appreciate that any type of closure device 230 may be employed, without departing from the scope of the disclosure. For example, in some embodiments, the closure device 230 could instead be a ball, a sleeve, etc.

[0021] As shown in FIG. 2B, the closure device 230 is in its closed position whereby the closure device 230 is able to substantially block fluid flow into and through the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B). A torsion spring 234 biases the closure device 230 to pivot to its closed position. As described below, the piston assembly 210 is used to displace the flow tube 224 downward (*i.e.*, to the right in FIG. 2B) to engage the closure device 230 and overcome the spring force of the torsion spring 234. When the flow tube 224 is extended to its downward position, it engages the closure device 230 and moves the closure device 230 from its closed position to an open position (shown in phantom as dashed lines). When the flow tube 224 is displaced back upward (*i.e.*, to the left in FIG. 2B), the torsion spring 234 is able to pivot the closure device 230 back to its closed position. Axial movement of the piston assembly 210 within the piston bore 208 will force the flow tube 224 to correspondingly move axially within the flow passage 232, and either open the closure device 230 or allow it to close, depending on its relative position.

[0022] The safety valve 112 may further define a lower chamber 236 within the housing 202. In some embodiments, the lower chamber 236 may form part of the piston bore 208, such as being an elongate extension thereof. A power spring 238, such as a coil or compression spring, may be arranged within the lower chamber 236. The power spring 238 may be configured to bias the actuation flange 228 and actuation sleeve 222 upwardly which, in turn, biases the piston assembly

210 in the same direction. Accordingly, expansion of the power spring 238 will cause the piston assembly 210 to move upwardly within the piston bore 208.

[0023] It should be noted that while the power spring 238 is depicted as a coiled compression spring, any type of biasing device may be used instead of, or in addition to, the power spring 238, without departing from the scope of the disclosure. For example, a compressed gas, such as nitrogen, with appropriate seals may be used in place of the power spring 238. In other embodiments, the compressed gas may be contained in a separate chamber and tapped when needed.

[0024] In exemplary operation, the safety valve 112 may be actuated in order to open the closure device 230. This may be accomplished by conveying a hydraulic fluid under pressure to the control line port 204 via the control line 116 (FIG. 1). As hydraulic pressure is provided to the piston bore 208, the piston assembly 210 may be forced to move axially downward within the piston bore 208. As the piston assembly 210 moves, the piston rod 220 mechanically transfers the hydraulic force to the actuation sleeve 222 and the actuation flange 228, thereby correspondingly displacing the flow tube 224 in the downward direction. In other words, as the piston assembly 210 moves axially within the piston bore 208, the flow tube 224 correspondingly moves in the same direction. As the flow tube 224 moves downward, it engages the closure device 230, overcomes the spring force of the torsion spring 234, and thereby pivots the closure device 230 to its open position to permit fluids to enter the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B).

[0025] Moreover, as the piston assembly 210 moves axially downward within the piston bore 208, the power spring 238 is compressed within the lower chamber 236 and progressively builds spring force. In at least one embodiment, the piston assembly 210 will continue its axial movement in the downward direction, and thereby continue to compress the power spring 238, until engaging a down stop 240 (FIG. 2A) arranged within the piston bore 208. A metal-to-metal seal may be created between the piston assembly 210 and the down stop 240 such that the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough is generally prevented.

[0026] Upon reducing or eliminating the hydraulic pressure provided via the control line 116, the spring force built up in the power spring 238 may be allowed to release and displace the piston assembly 210 upwards within the piston bore 208, thereby correspondingly moving the flow tube 224 in the same direction. The section pressure within the safety valve 112 below the lower piston 216b also serves to move the piston assembly 210 upwards within the piston bore 208. As the flow tube 224 moves axially upwards, it will eventually move out of engagement with the closure device 230. Once free from engagement with the flow tube 224, the spring force of the torsion spring 234 will pivot the closure device 230 back into its closed position.

[0027] In at least one embodiment, the piston assembly 210 will continue its axial movement in the upward direction until the piston head 212 of the piston assembly 210 engages the up stop 214 and effectively prevents the piston assembly 210 from further upward movement. Engagement between the piston head 212 and the up stop 214 may generate a mechanical metal-to-metal seal between the two components to prevent the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough.

[0028] When the safety valve 112 is deployed downhole, the "section" pressure, or fluid pressure present within the wellbore 108 (FIG. 1) and annulus 118 (FIG. 1) at depth, cooperatively act on the piston assembly 210. More specifically, the section pressure acts on the downhole end of the piston assembly 210 via the piston bore 208, and provides a corresponding closing force on the safety valve 112 that urges the piston assembly 210 toward the up stop 214. In order to open the safety valve 112, the piston assembly 210 must effectively overcome the section pressure and the spring force of the power spring 238. To do this, the hydraulic fluid pressure ("control" pressure) conveyed into the piston bore 208 via the control line 116 (FIG. 1) must be supplied at a pressure that exceeds the combined force of the section pressure and the power spring 238. Moreover, this hydraulic pressure must incrementally increase as the piston assembly 210 translates downward within the piston bore 208 to counteract the increasing spring force that builds as the power spring 238 is compressed. As indicated above, this

oftentimes requires expensive pressure control systems that may be infeasible or uneconomical for some applications.

[0029] According to one or more embodiments of the present disclosure, the pressure required to open the safety valve 112 may be reduced or otherwise minimized by increasing the downward force derived from the control pressure and simultaneously decreasing the upward force derived from the section pressure. This can be accomplished by having a multiple piston configuration in the piston assembly 210 whereby the control pressure piston (*i.e.*, the first piston 216a) exhibits a larger piston area than the section pressure piston (*i.e.*, the second piston 216b). As a result, the control pressure will work on the larger piston area of the control pressure piston and the section pressure will work on the smaller piston area of the section pressure piston, thereby intensifying the available force from the control pressure.

[0030] Referring now to FIGS. 3A and 3B, with continued reference to FIGS. 2A and 2B, illustrated are enlarged cross-sectional side views of an exemplary embodiment of the piston assembly 210, according to one or more embodiments. Like numerals in FIGS. 3A and 3B that are used in prior figures indicate like elements and/or components that will not be described again in detail. FIG. 3A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 3B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0031] As illustrated, the piston assembly 210 may be arranged within the piston bore 208 defined in the housing 202 of the safety valve 112 (FIGS. 2A-2B). The piston bore 208 may be divided into a first or upper bore 302a and a second or lower bore 302b. The first piston 216a may be generally arranged in the upper bore 302a, and the second piston 216b may be generally arranged in the lower bore 302b. The first and second pistons 216a,b may be axially offset from each other within the piston bore 208 and coupled together using the connecting rod 218. The connecting rod 218 may threadably or mechanically attach the first and second pistons 216a,b to each other such that simultaneous movement of each

piston 216a,b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0032] With the first and second pistons 216a,b structurally coupled via the connecting rod 218, a chamber or cavity 304 may be defined therebetween within the piston bore 208. The cavity 304 may be configured to correspondingly move with the first and second pistons 216a,b when the piston assembly 210 moves within the piston bore 208. In some embodiments, the cavity 304 may be filled with a fluid. In one or more embodiments, for example, the cavity 304 may be filled with a gas, such as air or an inert gas (*e.g.*, nitrogen, argon, etc.). In other embodiments, however, the cavity 304 may be filled with a hydraulic fluid, a wellbore fluid, water (*i.e.*, brine, fresh water, etc.), or any other liquid.

[0033] In one or more embodiments, the cavity 304 may be ported to the annulus 118 within the wellbore 108 (FIG. 1) where the safety valve 112 (FIGS. 2A-2B) is to be located. More particularly, the piston assembly 210 may further include a conduit 306 defined in the housing 202 that places the cavity 304 in fluid communication with the annulus 118 surrounding the safety valve 112. Porting the cavity 304 to the annulus 118 may help compensate for expansion and contraction of the fluid within the cavity 304 as the wellbore 108 heats up or cools down. At increased temperatures, the pressure within the cavity 304 will increase and porting the fluid to the annulus 118 may help maintain a safe operating pressure equilibrium. Porting the fluid to the annulus 118 may also prevent the first and second pistons 216a,b from locking under vacuum as temperatures decrease in the cavity 304 and the pressure correspondingly decreases.

[0034] In at least one embodiment, a pressure regulator 308 may be arranged within the conduit 306. The pressure regulator 308 may be used to generally separate the fluid within the cavity 304 from any fluids present in the annulus 118. In operation, the pressure regulator 308 may be configured to axially translate within the conduit 306, thereby separating the fluid within the cavity 304 from fluids in the annulus 118, but also compensate for expansion and contraction of the fluid within the cavity 304 and thereby help maintain safe operating pressure equilibrium. In some embodiments, the pressure regulator 308 may be a balance

piston. In other embodiments, however, the pressure regulator 308 may be a floating piston, or the like, without departing from the scope of the disclosure.

[0035] The upper bore 302a may exhibit a first diameter 310a and the lower bore 302b may exhibit a second diameter 310b that is smaller or less than the first diameter 310a. The first piston 216a may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the upper bore 302a, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first piston 216a may include one or more first dynamic seals 312a and the second piston 216b may include one or more second dynamic seals 312b.

[0036] As used herein, the term "dynamic seal" is used to indicate a seal that provides pressure isolation between members that have relative displacement therebetween, for example, a seal which seals against a displacing surface, or a seal carried on one member and sealing against the other member, etc. A dynamic seal may comprise a material selected from the following: elastomeric materials, non-elastomeric materials, metals, composites, rubbers, ceramics, derivatives thereof, and any combination thereof. A dynamic seal may be attached to each of the relatively displacing members, such as a bellows or a flexible membrane. A dynamic seal may be attached to either of the relatively displacing members, such as in the case of a floating piston.

[0037] The first and second dynamic seals 312a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the first dynamic seal 312a may be configured to seal against the inner wall of the upper bore 302a as the first piston 216a moves therein, and the second dynamic seal 312b may be configured to seal against the inner wall of the lower bore 302b as the second piston 216b moves therein. As a result, the first and second dynamic seals 312a,b may be configured to prevent any fluids from migrating past the first and second pistons 216a,b respectively. In some embodiments, one or both of the first and second dynamic seals 312a,b may be O-rings or the like, as illustrated. In other embodiments, however, one or both of the first and second dynamic seals 312a,b may be v-rings or CHEVRON® packing rings or other appropriate seal

configurations (*e.g.*, seals that are round, v-shaped, u-shaped, square, oval, t-shaped, etc.), as generally known to those skilled in the art.

[0038] In exemplary operation, hydraulic pressure or "control" pressure (generally indicated by the arrow 314) is introduced into the piston bore 208 via the control line 116 (FIG. 1) and associated port 204 (FIG. 2A). The control pressure 314 communicates with and otherwise acts on the first piston 216a, thereby separating the piston head 212 from the up stop 214 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 3A and 3B). An opposing "section" pressure (generally indicated by the arrow 316) communicates with and otherwise acts on the second piston 216b. As mentioned above, the section pressure 316 and the spring force of the power spring 238 (FIGS. 2A-2B) cooperatively act against the control pressure 314.

[0039] Referring to FIG. 3B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the cavity 304 defined between the first and second pistons 216a,b. As generally described above, while the piston assembly 210 moves from its first position into its second position, the piston rod 220 mechanically transfers the hydraulic force of the control pressure 314 to the flow tube 224 (FIGS. 2A-2B), thereby correspondingly displacing the flow tube 224 in the downward direction and opening the closure device 230 (FIG. 2B). Moreover, while the piston assembly 210 moves from its first position into its second position, the first and second dynamic seals 312a,b sealingly engage the inner walls of the upper and lower bores 302a,b, respectively.

[0040] Since the piston area of the first piston 216a is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 is correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area, the section pressure 316 applied to the second piston 216b is minimized with respect to the first piston 216a and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ a smaller or reduced pressure control system used to convey the control pressure 314 to the safety valve 112, including using control lines and pump equipment that exhibit lower pressure ratings than would otherwise be used in a safety valve at similar depths. Smaller or reduced pressure control systems may

be advantageous for safety reasons (*i.e.*, lower pressures are typically safer than higher pressures), cost (*i.e.*, reducing the size of the pump and the pressure rating of the pump and control lines can result in significant cost savings), and physical restraints (*i.e.*, lower pressure equipment normally exhibits a smaller footprint than higher pressure equipment).

[0041] Referring now to FIGS. 4A and 4B, with continued reference to FIGS. 2A-2B and 3A-3B, illustrated are enlarged cross-sectional side views of another exemplary embodiment of the piston assembly 210, according to one or more embodiments. Like numerals are used to indicate like elements and/or components from prior figures that will not be described again in detail. FIG. 4A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 4B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0042] Similar to the piston assembly 210 depicted in FIGS. 3A-3B, the piston assembly 210 in FIGS. 4A-4B is arranged within the piston bore 208 defined in the housing 202 and the piston bore 208 includes an upper bore 302a and a lower bore 302b. The upper bore 302a in FIGS. 4A-4B, however, may be divided into a first upper bore 402a and a second upper bore 402b to accommodate a first upper piston 404a and a second upper piston 404b. In some embodiments, the first and second upper bores 402a,b may be radially offset from each other within the housing 202 (*i.e.*, radially offset from each other with respect to the longitudinal central axis of the safety valve 112). In other embodiments, the first and second upper bores 402a,b may be angularly or circumferentially offset from each other within the housing 202. In other words, the first and second upper bores 402a,b may also be laterally offset from each other about the circumference of the housing 202, without departing from the scope of the disclosure.

[0043] The first and second upper pistons 404a,b may be operably coupled to each other with a connecting rod 406. The connecting rod 406 may be u-shaped and/or otherwise connected at an intermediate point such that it is able to extend into each of the first and second upper bores 402a,b and attach to the first and second upper pistons 404a,b. As a result, the first and second upper pistons

404a,b are able to move simultaneously and thereby act as a single piston member. The connecting rod 406 may also be coupled to the second or lower piston 216b. The connecting rod 406 may threadably or mechanically attach the first and second upper pistons 404a,b to the second piston 216b such that simultaneous movement of each piston 404a,b and 216b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0044] A cavity 408 may be defined between the first and second upper pistons 404a,b and the second piston 216b within the piston bore 208. The cavity 408 may be configured to correspondingly move or shift within the piston bore 208 when the piston assembly 210 moves therein. Similar to the cavity 304 of FIGS. 3A-3B, the cavity 408 may be filled with a fluid, such as a gas (*e.g.*, air, an inert gas, etc.), or a liquid (*e.g.*, hydraulic fluid, wellbore fluid, water, such as brine or fresh water), combinations thereof, or the like. As illustrated, the cavity 408 may also be ported to the annulus 118 via the conduit 306 in order to place the cavity 408 in fluid communication with the annulus 118. In some embodiments, the pressure regulator 308 may be arranged within the conduit 306 in order to maintain pressure equilibrium within the cavity 408.

[0045] The first upper bore 402a may exhibit a first diameter 410a, the second upper bore 402b may exhibit a second diameter 410b, and the lower bore 302b may exhibit a third diameter 410c. In some embodiments, the first and second diameters 410a,b may be the same. In other embodiments, the first and second diameters 410a,b may be different. Moreover, in some embodiments, one or both of the first and second diameters 410a,b may be greater than the third diameter 410c. In other embodiments, one or both of the first and second diameters 410a,b may be smaller than the third diameter 410c. In any event, the combined sizing of the first and second diameters 410a,b is greater than the third diameter 410c, such that the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b.

[0046] The first and second upper pistons 404a,b may be sized or otherwise configured to sealingly engage the inner walls of the first and second upper bores 402a,b, respectively, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the

lower bore 302b. To accomplish this, the first and second upper pistons 404a,b may include one or more first dynamic seals 412a and the second piston 216b may include one or more second dynamic seals 412b. Similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the dynamic seal 412a of the first upper piston 404a may be configured to seal against the inner wall of the first upper bore 402a, the dynamic seal 412a of the second upper piston 404b may be configured to seal against the inner wall of the second upper bore 402b, and the dynamic seal 412b of the second piston 216b may be configured to seal against the inner wall of the lower bore 302b. Moreover, similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be one of an O-ring, one or more v-rings or CHEVRON® packing rings, or other appropriate seal configurations described herein.

[0047] In exemplary operation, hydraulic control pressure 314 is introduced into the piston bore 208 in order to act on the piston assembly 210 and move the safety valve 112 (FIGS. 2A-2B) into the open position. More particularly, the control pressure 314 may be provided to the control line port 204 (FIG. 2A) via the control line 116 (FIG. 1), and the control line port 204 may feed the hydraulic fluid into the piston bore 208, which splits and feeds the control pressure 314 into the first and second upper bores 402a,b. The control pressure 314 communicates with and otherwise acts on the first and second upper pistons 404a,b, thereby separating the piston head 212 of each first and second upper piston 404a,b from corresponding up stops 214 defined in the piston bore 208 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 4A and 4B). The opposing section pressure 316 communicates with and otherwise acts on the second piston 216b.

[0048] As shown in FIG. 4B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the flow tube 224 (FIGS. 2A-2B) in the downward direction and opening the closure device 230 (FIG. 2B), as generally described above. Moreover, while the piston assembly 210 moves from the first position into the second position, the dynamic seals 412a,b sealingly

engage the inner walls of the first and second upper bores 402a,b and the lower bore 302b, respectively.

[0049] Adding additional pistons to the piston assembly 210 increases the piston area available for the control pressure 314 to act on in moving the piston assembly 210 from its first position (FIG. 4A) to its second position (FIG. 4B). Since the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 has been correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area than the combined piston areas of the first and second upper pistons 404a,b, the section pressure 316 applied to the second piston 216b is minimized with respect to the first and second upper pistons 404a,b and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ smaller or less expensive pressure control equipment used to convey the control pressure 314 to the safety valve 112.

[0050] Furthermore, by employing additional upper pistons in the piston assembly 210, an operator may be able to obtain a desired ratio between the upper and lower pistons, thereby allowing for smaller upper pistons. Smaller upper pistons can reduce the effective cross section of the upper piston section, which can effectively reduce the outer diameter of the subsurface safety valve. As a result, the overall cost of the safety valve may correspondingly be reduced and allow the safety valve to be used in a greater number of wells. Moreover, a smaller outer diameter fort he safety valve allows the operator to run smaller casing whereas a larger outer diameter safety valve requires the operator to run larger casing which increases well completion costs.

[0051] While FIGS. 4A and 4B depict first and second upper pistons 404a,b being used in the piston assembly 210, it will be appreciated that more than two upper pistons (*e.g.*, first pistons 302a) may be employed without departing from the scope of the disclosure. Each additional upper piston may be operatively coupled to the control rod 406 and effectively increase the piston area available for the control pressure 314 to act on, thereby reducing the required amount of control pressure 314 to open the safety valve.

[0052] Embodiments disclosed herein include:

[0053] A. A safety valve that includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

[0054] B. A method of actuating a safety valve that includes conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore, axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

[0055] Each of embodiments A and B may have one or more of the following additional elements in any combination: Element 1: wherein the cavity contains a fluid. Element 2: further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. Element 3: further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing. Element 4: wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and

lower bores, respectively. Element 5: further comprising a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore, a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly, and a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions. Element 6: further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore. Element 7: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. Element 8: wherein the first and second upper bores are radially offset from each other within the housing. Element 9: wherein the first and second upper bores are angularly offset from each other about a circumference of the housing. Element 10: wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons. Element 11: wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0056] Element 12: wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line. Element 13: wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston. Element 14: wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively. Element 15: wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a

flow passage defined in the safety valve, the method further comprising axially displacing the flow tube as the piston assembly moves within the piston bore, compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure, and moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position. Element 16: wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. Element 17: further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit. Element 18: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising sealingly engaging the first upper bore with the first upper piston, and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0057] Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a

numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

What is claimed is:

1. A safety valve, comprising:

a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore; and

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

2. The safety valve of claim 1, wherein the cavity contains a fluid.

3. The safety valve of claim 2, further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing.

4. The safety valve of claim 3, further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore;

a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly; and

a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions.

7. The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. The safety valve of claim 8, wherein the first and second upper bores are angularly offset from each other about a circumference of the housing.

11. The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston,

wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is

defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

14. The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. The method of claim 13, wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly.

19. The method of claim 18, further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

ABSTRACT

Disclosed are subsurface safety valves having multiple pistons used to increase the opening force. One safety valve includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons, wherein a cavity is defined between the upper and lower pistons within the piston bore and the piston rod extends within the cavity.

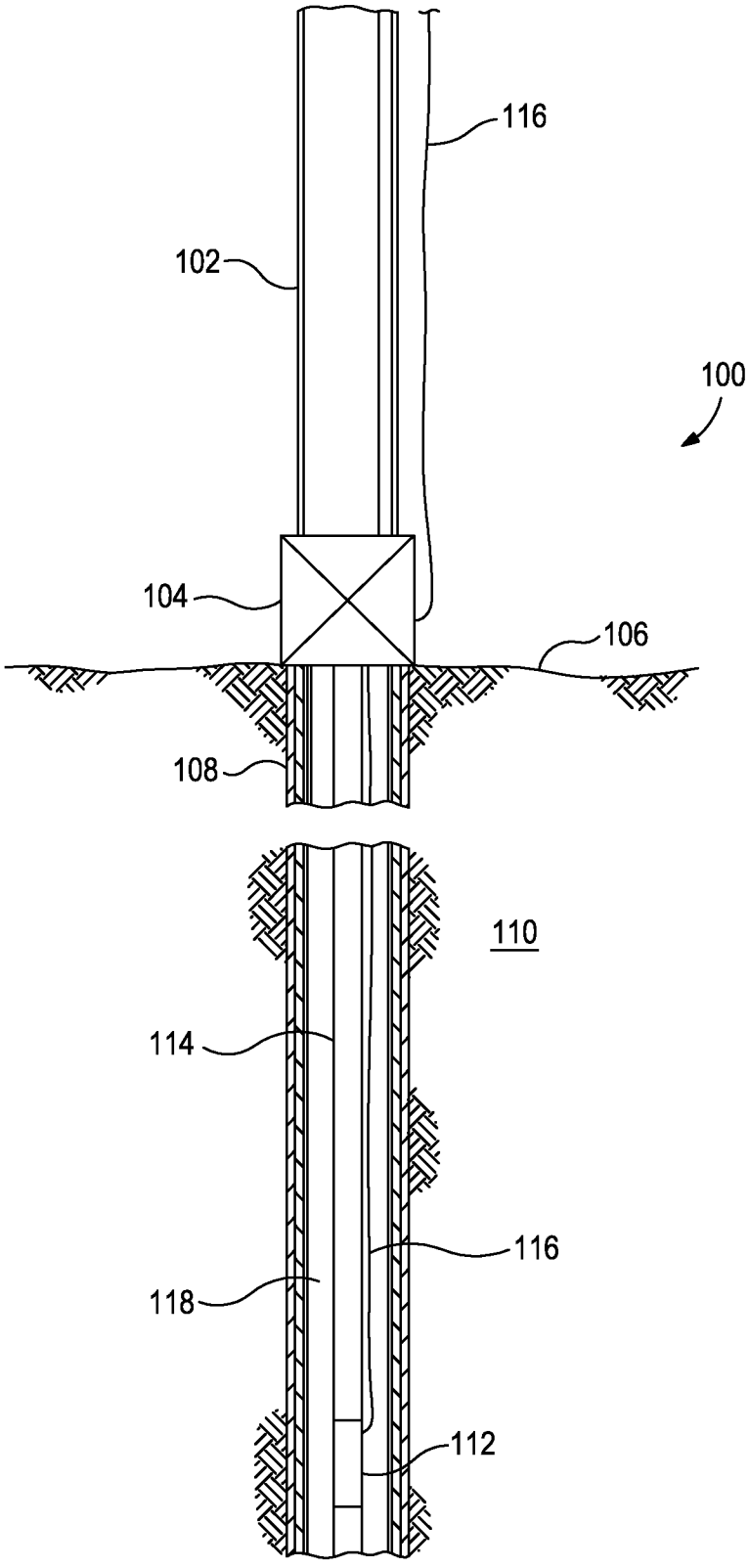

FIG. 1

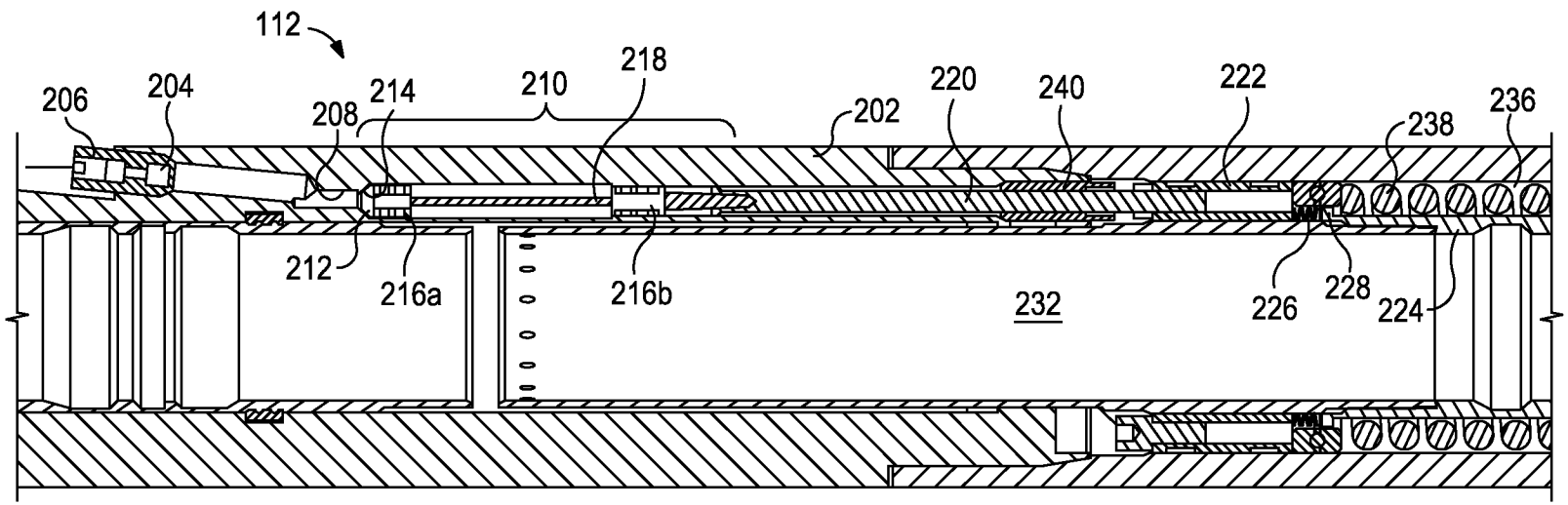
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FIG. 2A

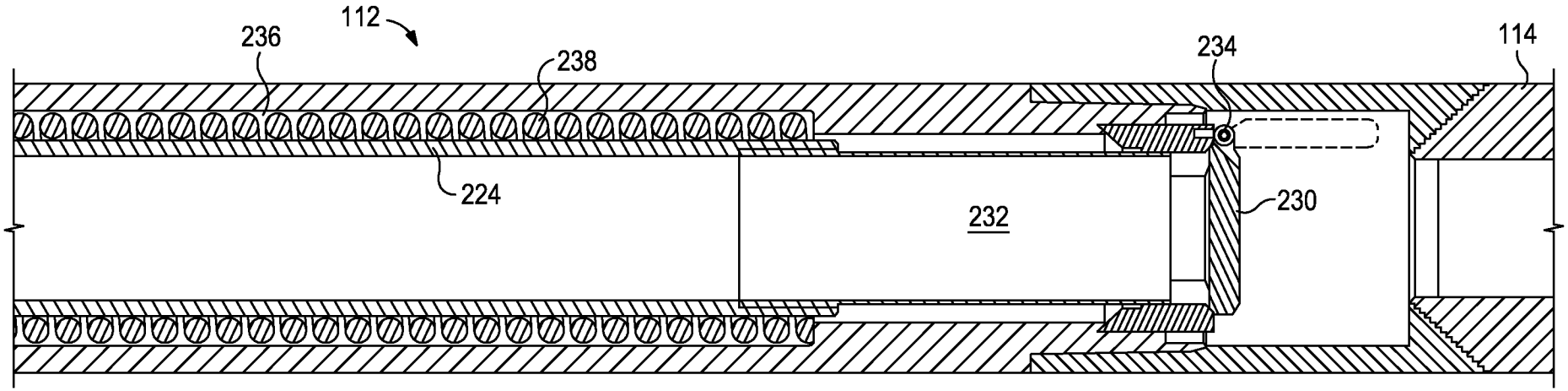
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FIG. 2B

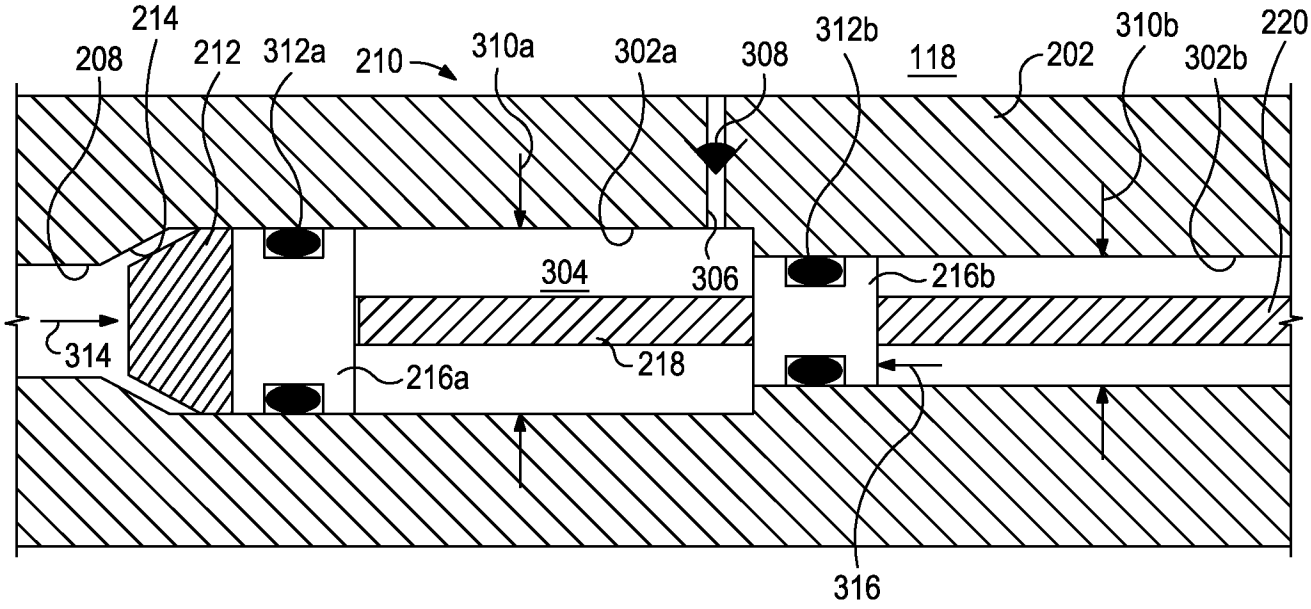
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FIG. 3A

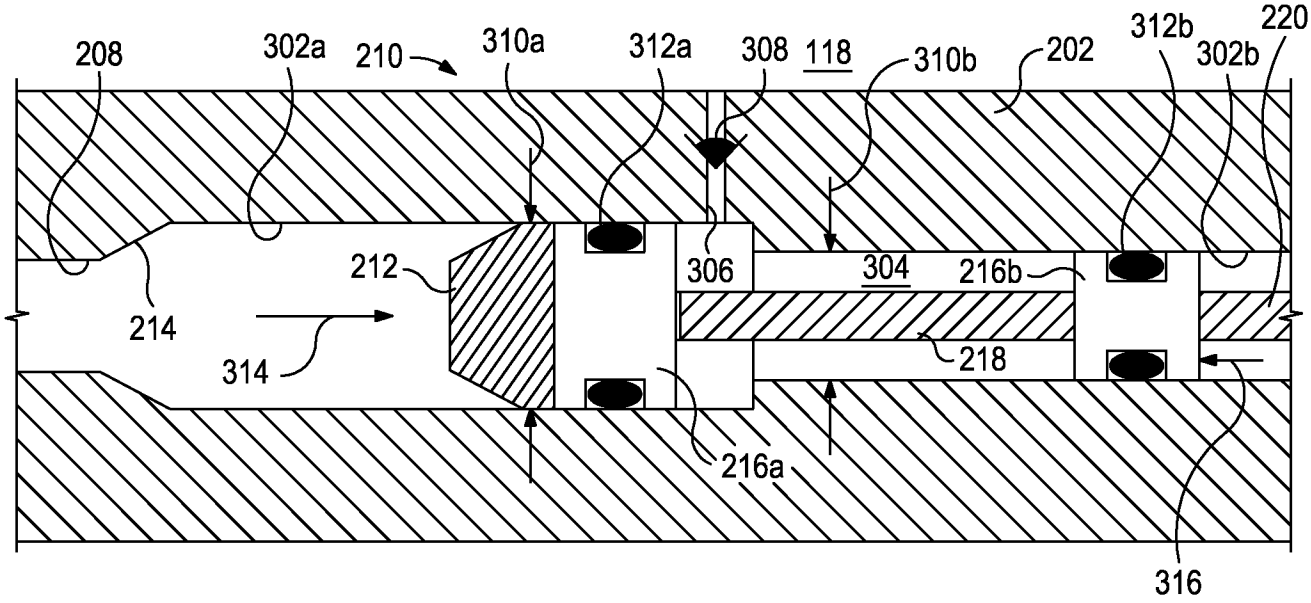
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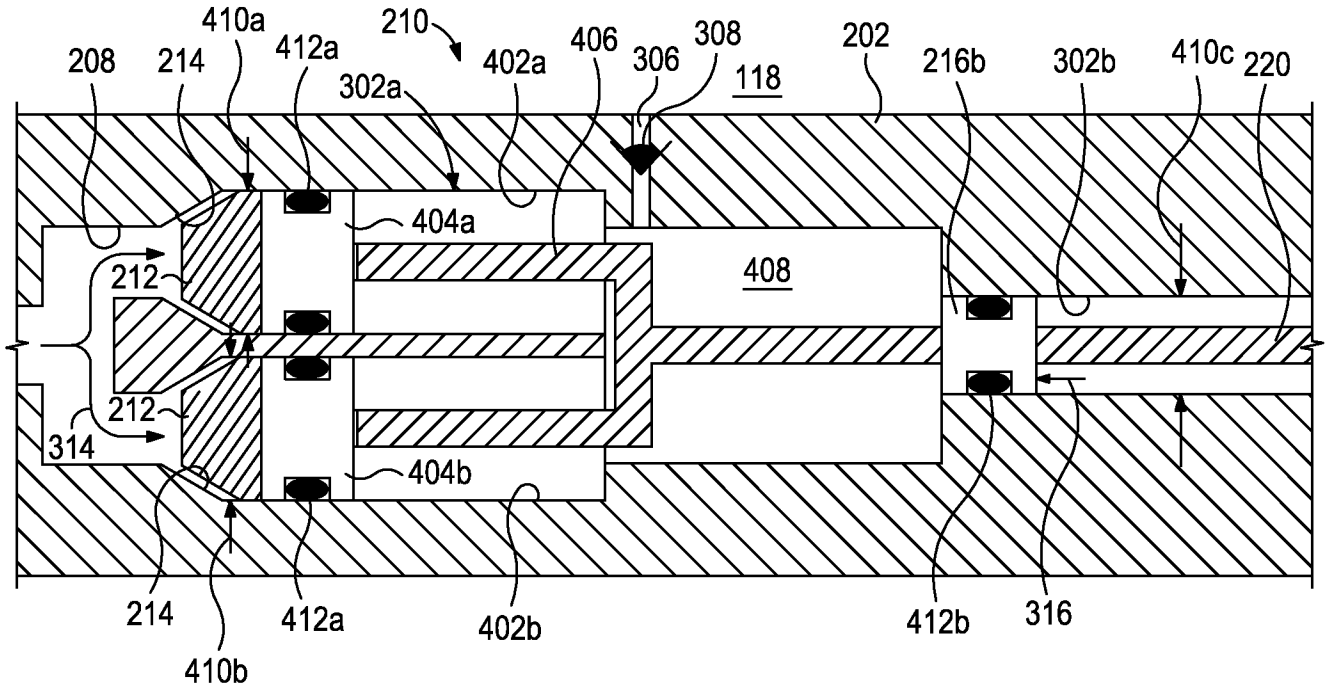
FIG. 3B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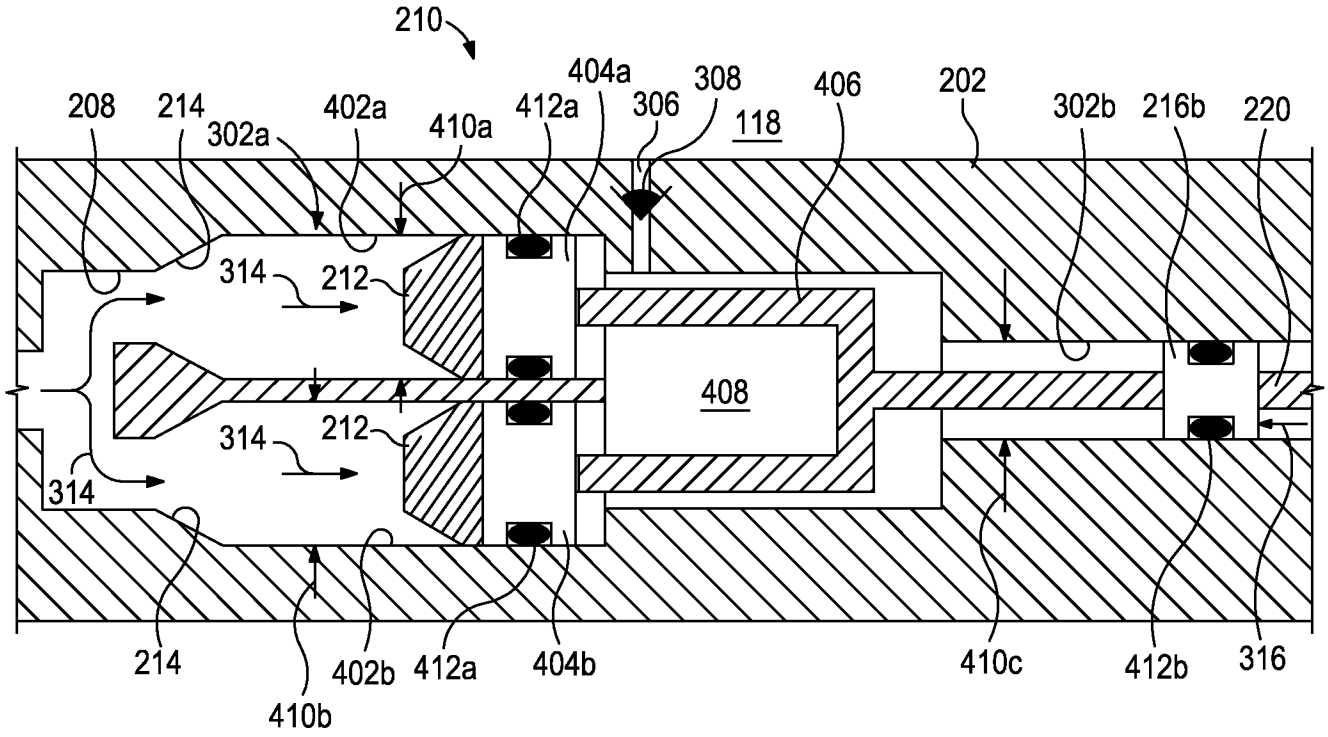
410b

FIG. 4A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402b
412a
404b
410c
412b
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410b

FIG. 4B

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2014-07-24
First Named Inventor	Bruce SCOTT
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	2013-IP-072581 U1 US

U.S.PATENTS

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	4429620		1984-02-07	Burkhardt et al.	
	2	4986357		1991-01-22	Pringle	
	3	7694742		2010-04-13	Bane et al.	
	4	8016035		2011-09-13	Strattan et al.	
	5	8360751		2013-01-29	Duncan	

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U.S.PATENT APPLICATION PUBLICATIONS

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	20080237993		2008-10-02	Bane et al.	

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	
	Filing Date	2014-07-24
	First Named Inventor	Bruce SCOTT
	Art Unit	N/A
	Examiner Name	Not Yet Assigned
	Attorney Docket Number	2013-IP-072581 U1 US

	2	20090050327		2009-02-26	Anderson et al.	
	3	20130062071		2013-03-14	Rytlewski et al.	
	4	20130092396		2013-04-18	Webber et al.	

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	1							☐

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	1	International Search Report and Written Opinion for PCT/US2013/061546 dated June 26, 2014	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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(Not for submission under 37 CFR 1.99)

Application Number	
Filing Date	2014-07-24
First Named Inventor	Bruce SCOTT
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	2013-IP-072581 U1 US

[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	
Filing Date	2014-07-24
First Named Inventor	Bruce SCOTT
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	2013-IP-072581 U1 US

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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	/Iona N. Kaiser/	Date (YYYY-MM-DD)	2014-07-24
Name/Print	Iona N. Kaiser	Registration Number	53086

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PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
KAISER IONA N.

MCDERMOTT WILL & EMERY LLP 500 NORTH CAPITOL STREET, N.W. WASHINGTON DC 20001 USA

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 2013IP072581	Date of mailing *(day/month/year)* 26 June 2014 (26.06.2014) **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. **PCT/US2013/061546**	International filing date *(day/month/year)* **25 September 2013 (25.09.2013)**

Applicant

HALLIBURTON ENERGY 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.

Where? Directly to the International Bureau of WIPO, 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. 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. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

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 90bis.1 and 90bis.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 19months.

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.

Name and mailing address of the ISA/KR International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-8755

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for six months(expire date : **2014.12.27**) from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Services => PCT Services

ID : PCT international application number
PW : **26GKX99P**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com

Email: ipkc@ipkcenter.com

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2013IP072581	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. **PCT/US2013/061546**	International filing date *(day/month/year)* **25 September 2013 (25.09.2013)**	(Earliest) Priority Date *(day/month/year)*

Applicant

HALLIBURTON ENERGY 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 **3** 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. **3A**
      ☐ 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/US2013/061546

A. CLASSIFICATION OF SUBJECT MATTER

E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

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)
E21B 34/06; E21B 47/10; E21B 33/128; B23P 17/00; E21B 34/10; E21B 34/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:safety valve, piston, spring, control line, power spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0237993 A1 (BANE et al.) 02 October 2008 See paragraphs [0002]-[0003], [0017]-[0023] and figures 2-7.	1-2,5-7,13-17
A		3-4,8-12,18-20
A	US 2013-0092396 A1 (WEBBER et al.) 18 April 2013 See paragraphs [0019]-[0060] and figures 2-8.	1-20
A	US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013 See paragraphs [0013]-[0030] and figures 1-8.	1-20
A	US 8016035 B2 (STRATTAN et al.) 13 September 2011 See claims 1-4 and figures 1-3.	1-20
A	US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009 See paragraphs [0016]-[0022] and figures 1-7.	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
25 June 2014 (25.06.2014)	**26 June 2014 (26.06.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
LEE, Chang Ho
Telephone No. +82-42-481-8398

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/061546

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0237993 A1	02/10/2008	US 8701782 B2	22/04/2014
		WO 2008-118916 A2	02/10/2008
		WO 2008-118916 A3	24/12/2008
		WO 2008-118916 A4	05/03/2009
US 2013-0092396 A1	18/04/2013	WO 2013-055330 A1	18/04/2013
US 2013-0062071 A1	14/03/2013	None	
US 8016035 B2	13/09/2011	AU 2004-287079 A1	19/05/2005
		AU 2004-287079 B2	08/07/2010
		CA 2547200 A1	19/05/2005
		CA 2645607 A1	19/05/2005
		CA 2645607 C	12/02/2013
		GB 0610645 D0	05/07/2006
		GB 0722763 D0	02/01/2008
		GB 2423783 A	06/09/2006
		GB 2423783 B	26/03/2008
		NO 20062406 A	28/06/2006
		RU 2006118152 A	20/12/2007
		RU 2335620 C2	10/10/2008
		US 2005-0098210 A1	12/05/2005
		US 2007-0277878 A1	06/12/2007
		WO 2005-045182 A1	19/05/2005
US 2009-0050327 A1	26/02/2009	US 7762335 B2	27/07/2010
		WO 2009-026217 A2	26/02/2009
		WO 2009-026217 A3	16/04/2009

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KAISER IONA N.

MCDERMOTT WILL & EMERY LLP 500 NORTH
CAPITOL STREET, N.W. WASHINGTON DC 20001 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**26 June 2014 (26.06.2014)**
Applicant's or agent's file reference 20131P072581	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/061546	**25 September 2013 (25.09.2013)**	

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

E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

Applicant
HALLIBURTON ENERGY 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 43bis.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 66.1bis(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/KR	Date of completion of this opinion	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	25 June 2014 (25.06.2014)	LEE, Chang Ho Telephone No. +82-42-481-8398

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/061546

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 filed or furnished:

   a. (means)

   ☐ on paper

   ☐ in electronic form

   b. (time)

   ☐ in the international application as filed.

   ☐ together with the international application in electronic form.

   ☐ subsequently to this Authority for the purposes of search.

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 additioanl copies is identical to that in 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/US2013/061546

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

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	3-4,8-12,18-20	YES
	Claims	1-2,5-7,13-17	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2008-0237993 A1 (BANE et al.) 02 October 2008

D2: US 2013-0092396 A1 (WEBBER et al.) 18 April 2013

D3: US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013

D4: US 8016035 B2 (STRATTAN et al.) 13 September 2011

D5: US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009

1. Novelty and Inventive Step

1.1 Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a safety valve (10) comprising: a housing (100) which has cylindrical ports (104 and 108), wherein hydraulic fluid (liquid) acts on the opposite side of an actuating piston via a control line; pistons (84) being in slidable sealing engagement with the cylindrical ports (104, 108) and comprising an upper piston and a lower piston; and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves, wherein a cavity(122) is defined between the upper and lower pistons and the connecting rod extends within the cavity(122)(see paragraphs [0002]-[0003], [0017], [0022]-[0023] and figures 2, 6-7). Claim 1 differs from D1 in that the piston bore provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

(114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 1 does not involve an inventive step under PCT Article 33(3).

1.2 Dependent Claims 2-12

1.2.1 Concerning Claim 2

The additional feature of claim 2, characterized in that the cavity contains a fluid, is not disclosed in D1. However, this feature is virtually suggested by D1 considering that the cavity (122) is fluidically connected through porting not shown to the control line(see paragraph [0023] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 2 does not involve an inventive step under PCT Article 33(3).

1.2.2 Concerning Claim 3

The additional feature of claim 3 differs from the features of D1-D5 in that the safety valve further comprises a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 3 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

1.2.3 Concerning Claim 4

Claim 4 is dependent on claim 3 and therefore meets the requirements of PCT Article 33(2) and 33(3).

1.2.4 Concerning Claim 5

The additional feature of claim 5 is identical to the feature of D1 in that the seals (90, 92) are in sealing engagement with the upper and lower pistons (84) and are in slidable sealing engagement with the cylindrical ports (104, 108)(see paragraphs [0022]-[0023] and figures 6-7). Accordingly, this claim would have been obvious by D1. Therefore, claim 5 does not involve an inventive step under PCT Article 33(3).

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Supplemental Box

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

1.2.5 Concerning Claim 6

The additional feature of claim 6 is identical to the feature of D1 in that the safety valve comprises: a piston rod that extends longitudinally from the lower piston; a flow tube (18) functionally engaging with the actuating pistons (42) such that movement of the actuating pistons (42) in a downhole direction causes a corresponding movement of the flow tube (18) in a downhole direction; and a flapper (22), wherein when the safety valve (10) is in the closed position (not shown), the flapper (22) is pivoted 90° such that the flapper (22) is substantially perpendicular to the axis of the flow tube (18) and seals against a seat (38)(see paragraphs [0018], [0020] and figures 2-5, 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 6 does not involve an inventive step under PCT Article 33(3).

1.2.6 Concerning Claim 7

he additional feature of claim 7 is identical to the feature of D1 in that the power spring (26) is positioned between the housing (30) and a shoulder (34) of the flow tube (18) such that it presents a biasing force to urge the flow tube (18) in the uphole direction toward the closed valve position, wherein the actuating piston (42) is functionally engaged with the flow tube (18)(see paragraphs [0018], [0020] and figures 2-5). Accordingly, this claim would have been obvious by D1. Therefore, claim 7 does not involve an inventive step under PCT Article 33(3).

1.2.7 Concerning Claim 8

The additional feature of claim 8 differs from the features of D1-D5 in that the upper bore is divided into a first upper bore and a second upper bore and that the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 8 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

1.2.8 Concerning Claims 9-12

Claims 9-12 are dependent on claim 8 and therefore meet the requirements of PCT Article 33(2) and 33(3).

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Supplemental Box

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

1.3 Independent Claim 13

D1, which is considered to be the closest prior art to the subject matter of claim 13, discloses a method of actuating a safety valve (10) comprising: making hydraulic fluid (liquid) act on the opposite side of an actuating piston in the cylindrical ports (104, 108) that are in slidable sealing engagement with the upper and lower piston (84), wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves, and wherein a cavity(122) is defined between the upper and lower pistons and the connecting rod extends within the cavity(122)(see paragraphs [0002]-[0003], [0022]-[0023] and figures 2, 6-7). Claim 13 differs from D1 in that the piston bore provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion (114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 13 does not involve an inventive step under PCT Article 33(3).

1.4 Dependent Claims 14-20

1.4.1 Concerning Claim 14

The additional feature of claim 14 is identical to the feature of D1 in that the actuating piston moves a flow tube in a downhole direction in response to a pressure increase supplied from surface via a control line(see paragraph [0017] and figure 2). Accordingly, this claim would have been obvious by D1. Therefore, claim 14 does not involve an inventive step under PCT Article 33(3).

1.4.2 Concerning Claim 15

The additional feature of claim 15, characterized in that a piston area of the upper piston is greater than a piston area of the lower piston, and that axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston, is not disclosed in D1. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second

Continued on The Next Page

Supplemental Box

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

portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion (114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 15 does not involve an inventive step under PCT Article 33(3).

1.4.3 Concerning Claim 16

The additional feature of claim 16 is identical to the feature of D1 in that the seals (90, 92) are in sealing engagement with the upper and lower pistons (84) and are in slidable sealing engagement with the cylindrical ports (104, 108)(see paragraphs [0022]-[0023] and figures 6-7). Accordingly, this claim would have been obvious by D1. Therefore, claim 16 does not involve an inventive step under PCT Article 33(3).

1.4.4 Concerning Claim 17

The additional feature of claim 17 is identical to the feature of D1 in that the safety valve comprises: a piston rod that extends longitudinally from the lower piston; a flow tube (18) functionally engaging with the actuating pistons (42) such that movement of the actuating pistons (42) in a downhole direction causes a corresponding movement of the flow tube (18) in a downhole direction; a power spring (26) positioned between the housing (30) and a shoulder (34) of the flow tube (18) such that it presents a biasing force to urge the flow tube (18) in the uphole direction toward the closed valve position; and a flapper (22), wherein when the safety valve (10) is in the closed position (not shown), the flapper (22) is pivoted 90° such that the flapper (22) is substantially perpendicular to the axis of the flow tube (18) and seals against a seat (38)(see paragraphs [0018], [0020] and figures 2-5, 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 17 does not involve an inventive step under PCT Article 33(3).

1.4.5 Concerning Claim 18

The additional feature of claim 18 differs from the features of D1-D5 in that the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 18 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

Continued on The Next Page

Supplemental Box

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

1.4.6 Concerning Claim 19

Claim 19 is dependent on claim 18 and therefore meets the requirements of PCT Article 33(2) and 33(3).

1.4.7 Concerning Claim 20

The additional feature of claim 20 differs from the features of D1-D5 in that the upper bore is divided into a first upper bore and a second upper bore, that the upper piston comprises a first upper piston and a second upper piston, and that the method further comprises: sealingly engaging the first upper bore with the first upper piston; and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 20 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

2. Industrial Applicability

Claims 1-20 are industrially applicable under PCT Article 33(4).

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Filer:	Iona Niven Kaiser/Debbie Allen
Attorney Docket Number:	2013-IP-072581 U1 US

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
National Stage Fee	1631	1	280	280
Natl Stage Search Fee - Report provided	1642	1	480	480
National Stage Exam - all other cases	1633	1	720	720
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**1480**

Electronic Acknowledgement Receipt

EFS ID:	19677465
Application Number:	14374473
International Application Number:	PCT/US13/61546
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Customer Number:	99633
Filer:	Iona Niven Kaiser/Debbie Allen
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	24-JUL-2014
Filing Date:	
Time Stamp:	17:12:15
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1480
RAM confirmation Number	3805
Deposit Account	500417
Authorized User	

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

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.20 (Post Issuance fees)

Charge any Additional Fees required under 37 C.F.R. Section 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		0876380949PatAppl.pdf	1707973 3640b4610328e23c7c6718a44ddc0f43214b86cc	yes	55

Multipart Description/PDF files in .zip description

Document Description	Start	End
Transmittal of New Application	1	3
Application Data Sheet	4	9
Preliminary Amendment	10	17
Specification	18	37
Claims	38	41
Abstract	42	42
Drawings-only black and white line drawings	43	46
Power of Attorney	47	47
Assignee showing of ownership per 37 CFR 3.73.	48	49
Oath or Declaration filed	50	51
Information Disclosure Statement (IDS) Form (SB08)	52	55

Warnings:

Information:

2	Non Patent Literature	0876380949IDSRef.PDF	744835 27387ca32bff64ae9a0e46b5492f9e9014ab0e7e	no	13

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	Fee Worksheet (SB06)	fee-info.pdf	33344 cd24a8ce99f665138c14663bdffdac298e83bd00	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	2486152

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.

2013-IP-072581 U1 US (087638-0949)

PTO/AIA/80 (07-12)
Approved for use through 11/30/2014. OMB 0651-0035
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 displays a valid OMB control number.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:

■ Practitioners associated with Customer Number: 99633

OR

☐ Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number	Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:

■ The address associated with Customer Number: 99633

OR

☐	Firm or Individual Name		
	Address		
	City	State	Zip
	Country		
	Telephone	Email	

Assignee Name and Address: Halliburton Energy Services, Inc.
10200 Bellaire Boulevard
Houston, TX 77072

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be Filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record
The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	7/23/2014
Name	Clive D. Menezes	Telephone	281-871-4374
Title	Vice President and Chief Patent Counsel, Halliburton Energy Services, Inc.		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 3 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.**

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

REVIEWED
LEGAL
DATE 9/17/14

PTO/AIA/96 (08-12)
Approved for use through 01/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Halliburton Energy Services, Inc.

Application No./Patent No.: Filed Concurrently Herewith Filed/Issue Date: July 24, 2014

Titled: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

Halliburton Energy Services, Inc., a corporation

(Name of Assignee) (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.

2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):

   ☐ The extent (by percentage) of its ownership interest is _____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.

   ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (*e.g.*, bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

   The document was recorded in the United States Patent and Trademark Office at

   Reel _____, Frame _____, or for which a copy thereof is attached.

STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at

Reel _____, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Iona N. Kaiser/	July 24, 2014
Signature	Date
Iona N. Kaiser	53086
Printed or Typed Name	Title or Registration Number

DECLARATION AND ASSIGNMENT

As the below named inventor, I hereby declare that:

This declaration is directed to:

☒ The attached application to be filed as a United States application or PCT international application, or

☐ United States application or PCT international application number PCT/US13/61546 filed on 9/25/2013 ; and,

entitled "MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE." Regarding that application, I declare the following:

- The above-identified application was made, or authorized to be made, by me.
- I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.
- I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.
- I have reviewed and understand the subject matter of the above-identified application, including the claims.
- I am aware of and acknowledge my duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability under 37 CFR 1.56; including, for continuation-in-part applications, material information that became available between the filing of the prior application and the filing of the continuation-in-part application.

Moreover, Whereas, HALLIBURTON ENERGY SERVICES, INC., a Delaware Corporation, having a place of business at 10200 Bellaire Boulevard, Houston, TX 77072 (hereinafter "Assignee") is desirous of acquiring an interest therein;

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, We, by these presents do sell, assign and transfer and convey unto Assignee, its successors and assigns, the full and exclusive right, for the United States of America and its territorial possessions and for any and all foreign countries, in and to the said invention, described in the Patent Application identified above, and any divisional, continuing or reissue application based on the present application preparatory to obtaining Letters Patent

of the United States therefore; said invention, application and any and all Letters Patent issuing there from to be held and enjoyed by Assignee, for its own use and benefit, and for its legal representatives, successors and assigns, to the full end of the term for which said Letters Patent may be granted, as fully and entirely as the same would have been held by me and had this assignment and sale not been made.

And I do further agree to sign all papers, make all rightful oaths and do all requisite acts for the filing of any disclaimer or for the filing and assignment of any divisional, continuing or reissue application or applications for patent based on the present application, as well as for any other U.S. or foreign application for patent which relates to the said invention.

And I do further agree to communicate to Assignee, its successors, assign or other legal representatives, such facts relating to the invention disclosed in the present application or Letters Patent issuing thereon as may be known to me, and to testify as to such facts in any interference or other litigation.

Executed this 25th day of September, 2013

BRUCE EDWARD SCOTT

STATE OF TEXAS)
)
COUNTY OF DALLAS)

Before me personally appeared said BRUCE EDWARD SCOTT and acknowledged the foregoing instrument to be a free act and deed this 25th day of September, 2013.

Seal

RUTHINE LIEBMAN
Notary Public, State of Texas
My Commission Expires
December 21, 2014

(Notary)

PTO/SB/20GLBL (01-14)
Approved for use through 01/31/2015. OMB 0651-0058
U.S. Patent and Trademark Office; U.S DEPARTMENT OF COMMERCE

REQUEST FOR PARTICIPATION IN THE GLOBAL/IP5 PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM IN THE USPTO

Application No.:	14/374,473	First Named Inventor:	Bruce Edward Scott
Filing Date:	July 24, 2014	Attorney Docket No.:	2013-IP-072581 U1 US
Title of the Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE		

THIS REQUEST FOR PARTICIPATION IN THE PPH PILOT PROGRAM ALONG WITH THE REQUIRED DOCUMENTS MUST BE SUBMITTED VIA EFS-WEB. INFORMATION REGARDING EFS-WEB IS AVAILABLE AT HTTP://WWW.USPTO.GOV/PATENTS/PROCESS/FILE/EFS/.

APPLICANT HEREBY REQUESTS PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM AND PETITIONS TO MAKE THE ABOVE-IDENTIFIED APPLICATION SPECIAL UNDER THE PPH PILOT PROGRAM.

Office of earlier examination (OEE): Korea (Korean Intellectual Property Office)

OEE application number: PCT/US2013/61546

Both the OEE application and the above-identified U.S. application have the following earliest date (filing or priority date): September 25, 2013

Type of OEE work product relied upon: Written Opinion of the International Searching Authority (WO/ISA)

Mailing date of OEE work product: _____

I. Required Documents:

a. **A copy of the most recent office action prior to the decision to grant a patent or the most recent PCT work product (along with an English translation, if not in the English language):**

- ☐ is attached.
- ☒ is already present in the U.S. application.
- ☐ is not attached because it is available to the USPTO via the Dossier Access System or WIPO's PATENTSCOPE system.
- ☐ is not attached because the decision to grant a patent was the first office action.

b. **(1) An information disclosure statement listing the documents cited in the OEE work product:**

- ☐ is attached.
- ☒ has already been filed in the U.S. application.
- ☐ is not attached because no references were cited in the document in section a. above.

(2) Copies of all cited documents (except for U.S. patents or U.S. patent application publications)

- ☐ are attached.
- ☒ have already been filed in the U.S. application.
- ☐ are not attached because no references were cited in the document in section a. above.

REQUEST FOR PARTICIPATION IN THE GLOBAL/IP5 PPH PILOT PROGRAM IN THE USPTO
(continued)

Application No.:	14/374,473	First Named Inventor:	Bruce Edward Scott

II. Claims Correspondence Table:

Claims in US Application	Patentable Claims in OEE Application	Explanation regarding the correspondence
1	1	Same, except allowable subject matter from PCT claims 2 and 3 is amended in
4	4	Same, except amended to remedy claim dependency
5-12	5-12	Same
13	13	Same, except allowable subject matter from PCT claim18 is amended in
14-17	14-17	Same
19	19	ame, except amended to remedy claim dependency
20	20	Same

III. All the claims in the US application sufficiently correspond to the patentable/allowable claims in the OEE application.

Signature /Iona N. Kaiser/	Date July 24, 2014
Name (Print/Typed) Iona N. Kaiser	Registration Number 53,086

Electronic Acknowledgement Receipt

EFS ID:	19677629
Application Number:	14374473
International Application Number:	
Confirmation Number:	7621
Title of Invention:	MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE
First Named Inventor/Applicant Name:	Bruce Edward Scott
Correspondence Address:	McDermott Will & Emery LLP - The McDermott Building 500 North Capitol Street, N.W. Washington DC 20001 US 202 756 8000 mweipdocket@mwe.com
Filer:	Iona Niven Kaiser/Debbie Allen
Filer Authorized By:	Iona Niven Kaiser
Attorney Docket Number:	2013-IP-072581 U1 US
Receipt Date:	24-JUL-2014
Filing Date:	
Time Stamp:	17:20:06
Application Type:	U.S. National Stage under 35 USC 371

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	Petition to make Special under PCT-Patent Pros Hwy	0876380949PPHReq.pdf	170782 eae1893cfec70262018edf14d90ee13f9fae0183	no	2

Warnings:	
Information:	
Total Files Size (in bytes):	170782

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.

PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT2953138

SUBMISSION TYPE:	NEW ASSIGNMENT
NATURE OF CONVEYANCE:	ASSIGNMENT

CONVEYING PARTY DATA

Name	Execution Date
BRUCE EDWARD SCOTT	09/25/2013

RECEIVING PARTY DATA

Name:	HALLIBURTON ENERGY SERVICES, INC.
Street Address:	10200 BELLAIRE BOULEVARD
City:	HOUSTON
State/Country:	TEXAS
Postal Code:	77072

PROPERTY NUMBERS Total: 1

Property Type	Number
Application Number:	14374473

CORRESPONDENCE DATA

Fax Number: (202)756-8087

Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.

Phone: 202 756 8000
Email: mweipdocket@mwe.com
Correspondent Name: MCDERMOTT WILL & EMERY LLP
Address Line 1: THE MCDERMOTT BUILDING
Address Line 2: 500 NORTH CAPITOL STREET, N.W.
Address Line 4: WASHINGTON, D.C. 20001

ATTORNEY DOCKET NUMBER:	087638-0949
NAME OF SUBMITTER:	DEBBIE ALLEN
SIGNATURE:	/Debbie Allen/
DATE SIGNED:	07/24/2014
	This document serves as an Oath/Declaration (37 CFR 1.63).

Total Attachments: 2
source=0876380949DeclAssign#page1.tif
source=0876380949DeclAssign#page2.tif

DECLARATION AND ASSIGNMENT

As the below named inventor, I hereby declare that:

This declaration is directed to:

☒ The attached application to be filed as a United States application or PCT international application, or

☐ United States application or PCT international application number PCT/US13/61546 filed on 9/25/2013 ; and,

entitled "MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE." Regarding that application, I declare the following:

- The above-identified application was made, or authorized to be made, by me.
- I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.
- I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.
- I have reviewed and understand the subject matter of the above-identified application, including the claims.
- I am aware of and acknowledge my duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability under 37 CFR 1.56; including, for continuation-in-part applications, material information that became available between the filing of the prior application and the filing of the continuation-in-part application.

Moreover, Whereas, HALLIBURTON ENERGY SERVICES, INC., a Delaware Corporation, having a place of business at 10200 Bellaire Boulevard, Houston, TX 77072 (hereinafter "Assignee") is desirous of acquiring an interest therein;

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, We, by these presents do sell, assign and transfer and convey unto Assignee, its successors and assigns, the full and exclusive right, for the United States of America and its territorial possessions and for any and all foreign countries, in and to the said invention, described in the Patent Application identified above, and any divisional, continuing or reissue application based on the present application preparatory to obtaining Letters Patent

of the United States therefore; said invention, application and any and all Letters Patent issuing there from to be held and enjoyed by Assignee, for its own use and benefit, and for its legal representatives, successors and assigns, to the full end of the term for which said Letters Patent may be granted, as fully and entirely as the same would have been held by me and had this assignment and sale not been made.

And I do further agree to sign all papers, make all rightful oaths and do all requisite acts for the filing of any disclaimer or for the filing and assignment of any divisional, continuing or reissue application or applications for patent based on the present application, as well as for any other U.S. or foreign application for patent which relates to the said invention.

And I do further agree to communicate to Assignee, its successors, assign or other legal representatives, such facts relating to the invention disclosed in the present application or Letters Patent issuing thereon as may be known to me, and to testify as to such facts in any interference or other litigation.

Executed this 25th day of September, 2013

BRUCE EDWARD SCOTT

STATE OF TEXAS)
)
COUNTY OF DALLAS)

Before me personally appeared said BRUCE EDWARD SCOTT and acknowledged the foregoing instrument to be a free act and deed this 25th day of September, 2013.

Seal

RUTHINE LIEBMAN
Notary Public, State of Texas
My Commission Expires
December 21, 2014

(Notary)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/061546

A. CLASSIFICATION OF SUBJECT MATTER

E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

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)
E21B 34/06; E21B 47/10; E21B 33/128; B23P 17/00; E21B 34/10; E21B 34/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:safety valve, piston, spring, control line, power spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0237993 A1 (BANE et al.) 02 October 2008 See paragraphs [0002]-[0003], [0017]-[0023] and figures 2-7.	1-2,5-7,13-17
A		3-4,8-12,18-20
A	US 2013-0092396 A1 (WEBBER et al.) 18 April 2013 See paragraphs [0019]-[0060] and figures 2-8.	1-20
A	US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013 See paragraphs [0013]-[0030] and figures 1-8.	1-20
A	US 8016035 B2 (STRATTAN et al.) 13 September 2011 See claims 1-4 and figures 1-3.	1-20
A	US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009 See paragraphs [0016]-[0022] and figures 1-7.	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
25 June 2014 (25.06.2014)	**26 June 2014 (26.06.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
LEE, Chang Ho
Telephone No. +82-42-481-8398

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2013/061546

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0237993 A1	02/10/2008	US 8701782 B2	22/04/2014
		WO 2008-118916 A2	02/10/2008
		WO 2008-118916 A3	24/12/2008
		WO 2008-118916 A4	05/03/2009
US 2013-0092396 A1	18/04/2013	WO 2013-055330 A1	18/04/2013
US 2013-0062071 A1	14/03/2013	None	
US 8016035 B2	13/09/2011	AU 2004-287079 A1	19/05/2005
		AU 2004-287079 B2	08/07/2010
		CA 2547200 A1	19/05/2005
		CA 2645607 A1	19/05/2005
		CA 2645607 C	12/02/2013
		GB 0610645 D0	05/07/2006
		GB 0722763 D0	02/01/2008
		GB 2423783 A	06/09/2006
		GB 2423783 B	26/03/2008
		NO 20062406 A	28/06/2006
		RU 2006118152 A	20/12/2007
		RU 2335620 C2	10/10/2008
		US 2005-0098210 A1	12/05/2005
		US 2007-0277878 A1	06/12/2007
		WO 2005-045182 A1	19/05/2005
US 2009-0050327 A1	26/02/2009	US 7762335 B2	27/07/2010
		WO 2009-026217 A2	26/02/2009
		WO 2009-026217 A3	16/04/2009

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2013IP072581	FOR FURTHER ACTION	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/US2013/061546	International filing date *(day/month/year)* 25 September 2013 (25.09.2013)	(Earliest) Priority Date *(day/month/year)*

Applicant

HALLIBURTON ENERGY 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 3 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. 3A
      ☐ 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/US2013/061546

A. CLASSIFICATION OF SUBJECT MATTER

E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

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)
E21B 34/06; E21B 47/10; E21B 33/128; B23P 17/00; E21B 34/10; E21B 34/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:safety valve, piston, spring, control line, power spring

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0237993 A1 (BANE et al.) 02 October 2008 See paragraphs [0002]-[0003], [0017]-[0023] and figures 2-7.	1-2,5-7,13-17
A		3-4,8-12,18-20
A	US 2013-0092396 A1 (WEBBER et al.) 18 April 2013 See paragraphs [0019]-[0060] and figures 2-8.	1-20
A	US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013 See paragraphs [0013]-[0030] and figures 1-8.	1-20
A	US 8016035 B2 (STRATTAN et al.) 13 September 2011 See claims 1-4 and figures 1-3.	1-20
A	US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009 See paragraphs [0016]-[0022] and figures 1-7.	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
25 June 2014 (25.06.2014)	**26 June 2014 (26.06.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea
Facsimile No. +82-42-472-7140

Authorized officer
LEE, Chang Ho
Telephone No. +82-42-481-8398

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2013/061546

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0237993 A1	02/10/2008	US 8701782 B2	22/04/2014
		WO 2008-118916 A2	02/10/2008
		WO 2008-118916 A3	24/12/2008
		WO 2008-118916 A4	05/03/2009
US 2013-0092396 A1	18/04/2013	WO 2013-055330 A1	18/04/2013
US 2013-0062071 A1	14/03/2013	None	
US 8016035 B2	13/09/2011	AU 2004-287079 A1	19/05/2005
		AU 2004-287079 B2	08/07/2010
		CA 2547200 A1	19/05/2005
		CA 2645607 A1	19/05/2005
		CA 2645607 C	12/02/2013
		GB 0610645 D0	05/07/2006
		GB 0722763 D0	02/01/2008
		GB 2423783 A	06/09/2006
		GB 2423783 B	26/03/2008
		NO 20062406 A	28/06/2006
		RU 2006118152 A	20/12/2007
		RU 2335620 C2	10/10/2008
		US 2005-0098210 A1	12/05/2005
		US 2007-0277878 A1	06/12/2007
		WO 2005-045182 A1	19/05/2005
US 2009-0050327 A1	26/02/2009	US 7762335 B2	27/07/2010
		WO 2009-026217 A2	26/02/2009
		WO 2009-026217 A3	16/04/2009

Sheet No. ..5...

Box No. VIII (ii) DECLARATION: ENTITLEMENT TO APPLY FOR AND BE GRANTED A PATENT

The declaration must conform to the standardized wording provided for in Section 212; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (ii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51*bis*.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate:

in relation to this international application

HALLIBURTON ENERGY SERVICES, INC., is entitled to apply for and be granted a patent by virtue of the following:

an assignment from:

SCOTT, Bruce Edward dated September 25, 2013, to HALLIBURTON ENERGY SERVICES, INC.

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (ii)".

WO 2015/047235
PCT/US2013/061546

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

FIRST NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION (TO DESIGNATED OFFICES WHICH DO NOT APPLY THE 30 MONTH TIME LIMIT UNDER ARTICLE 22(1))

(PCT Rule 47.1(c))

To:

KAISER, Iona, N.
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, DC 20001
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)* 30 April 2015 (30.04.2015)	
Applicant's or agent's file reference 2013IP072581	IMPORTANT NOTICE
International application No. PCT/US2013/061546	International filing date *(day/month/year)* 25 September 2013 (25.09.2013)
Priority date *(day/month/year)*	
Applicant HALLIBURTON ENERGY SERVICES, INC.	

1. **ATTENTION**: For any designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002 (30 months from the priority date), **does apply**, please see Form PCT/IB/308(Second and Supplementary Notice) (to be issued promptly after the expiration of 28 months from the priority date).

2. Notice is hereby given that the following designated Office(s), for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, has/have requested that the communication of the international application, as provided for in Article 20, be effected under Rule 93*bis*.1. The International Bureau has effected that communication on the date indicated below:
02 April 2015 (02.04.2015)

   None

   In accordance with Rule 47.1(c-*bis*)(i), those Offices will accept the present notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

3. The following designated Offices, for which the time limit under Article 22(1), as in force from 1 April 2002, **does not apply**, have not requested, as at the time of mailing of the present notice, that the communication of the international application be effected under Rule 93*bis*.1 :

   LU, TZ, UG

   In accordance with Rule 47.1(c-*bis*)(ii), those Offices accept the present notice as conclusive evidence that the Contracting State for which that Office acts as a designated Office does not require the furnishing, under Article 22, by the applicant of a copy of the international application.

4. **TIME LIMITS for entry into the national phase**

   For the designated Office(s) listed above, and unless a demand for international preliminary examination has been filed before the expiration of **19 months** from the priority date (see Article 39(1)), the applicable time limit for entering the national phase will, **subject to what is said in the following paragraph,** be **20 MONTHS** from the priority date.

   In practice, **time limits other than the 20-month time limit** will continue to apply, for various periods of time, in respect of certain of the designated Offices listed above. For **regular updates on the applicable time limits** (20 or 21 months, or other time limit), Office by Office, refer to the *PCT Gazette*, the *PCT Newsletter* and the *PCT Applicant's Guide*, Volume II, National Chapters, all available from WIPO's Internet site, at http://www.wipo.int/pct/en/index.html.

   It is the applicant's **sole responsibility** to monitor all these time limits.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Athina Nickitas-Etienne

e-mail: pt04.pct@wipo.int

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

PCT

To:
IONA N. KAISER
MCDERMOTT WILL & EMERY LLP
500 NORTH CAPITOL STREET, N.W.
WASHINGTON, DISTRICT OF COLUMBIA 20001

Confirmation No: 4019

NOTIFICATION OF THE INTERNATIONAL APPLICATION NUMBER AND OF THE INTERNATIONAL FILING DATE

(PCT Rule 20.2(c))

Date of mailing *(day/month/year)*	03 Oct 2013
Applicant's or agent's file reference: 2013IP072581	IMPORTANT NOTIFICATION

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/061546	25 Sep 2013	

Applicant
HALLIBURTON ENERGY SERVICES, INC.

Title of the invention
MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

1. The applicant is hereby notified that the international application has been accorded the international application number and the international filing date indicated above.

2. The applicant is further notified that the record copy of the international application:

☒ was transmitted to the International Bureau on 03 Oct 2013

☐ has not yet been transmitted to the International Bureau for the reason indicated below and a copy of this notification has been sent to the International Bureau*:

☐ because the necessary national security clearance has not yet been obtained.

☐ because *(reason to be specified)*:

* The International Bureau monitors the transmittal of the record copy by the receiving Office and will notify the applicant (with Form PCT/IB/301) of its receipt. Should the record copy not have been received by the expiration of 14 months from the priority date, the International Bureau will notify the applicant (Rule 22.1(c)).

3. FOREIGN TRANSMITTAL LICENSE INFORMATION Completed by: RD

☐ Additional license for foreign transmittal not required. This subject matter is covered by a license already granted or the equivalent U.S. national application. Refer to that license for information concerning its scope.

☐ License for foreign transmittal not required. 37 CFR 5.11(e)(1) or 37 CFR 5.11(e)(2). However, a license may be required for additional subject matter. See 37 CFR 5.15(b).

☒ Foreign transmittal license granted. 35 U.S.C. 184; 37 CFR 5.11 on 02 Oct 2013 (date)

☐ 37 CFR 5.15(a) ☒ 37 CFR 5.15(b)

Name and mailing address of the receiving Office	Authorized officer
Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450	Rita Dozier
Facsimile No: 571-273-3201	Telephone No. (571) 272-8669

Form PCT/RO/105 (July 2008)

2013-IP-072581U1 PCT (087638-0257)

DECLARATION AND ASSIGNMENT

As the below named inventor, I hereby declare that:

This declaration is directed to:

☒ The attached application to be filed as a United States application or PCT international application, or

☐ United States application or PCT international application number _____ filed on _____; and,

entitled "MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE." Regarding that application, I declare the following:

- The above-identified application was made, or authorized to be made, by me.
- I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.
- I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.
- I have reviewed and understand the subject matter of the above-identified application, including the claims.
- I am aware of and acknowledge my duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability under 37 CFR 1.56; including, for continuation-in-part applications, material information that became available between the filing of the prior application and the filing of the continuation-in-part application.

Moreover, Whereas, HALLIBURTON ENERGY SERVICES, INC., a Delaware Corporation, having a place of business at 10200 Bellaire Boulevard, Houston, TX 77072 (hereinafter "Assignee") is desirous of acquiring an interest therein;

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, We, by these presents do sell, assign and transfer and convey unto Assignee, its successors and assigns, the full and exclusive right, for the United States of America and its territorial possessions and for any and all foreign countries, in and to the said invention, described in the Patent Application identified above, and any divisional, continuing or reissue application based on the present application preparatory to obtaining Letters Patent

of the United States therefore; said invention, application and any and all Letters Patent issuing there from to be held and enjoyed by Assignee, for its own use and benefit, and for its legal representatives, successors and assigns, to the full end of the term for which said Letters Patent may be granted, as fully and entirely as the same would have been held by me and had this assignment and sale not been made.

And I do further agree to sign all papers, make all rightful oaths and do all requisite acts for the filing of any disclaimer or for the filing and assignment of any divisional, continuing or reissue application or applications for patent based on the present application, as well as for any other U.S. or foreign application for patent which relates to the said invention.

And I do further agree to communicate to Assignee, its successors, assign or other legal representatives, such facts relating to the invention disclosed in the present application or Letters Patent issuing thereon as may be known to me, and to testify as to such facts in any interference or other litigation.

Executed this 25th day of September, 2013

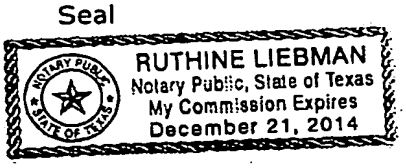
Bruce Scott

BRUCE EDWARD SCOTT

STATE OF TEXAS)
)
COUNTY OF DALLAS)

Before me personally appeared said BRUCE EDWARD SCOTT and acknowledged the foregoing instrument to be a free act and deed this 25th day of September, 2013.

Seal



Ruthine Liebman

(Notary)

WO 2015/047235
PCT/US2013/061546

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION CONCERNING
AVAILABILITY OF THE PUBLICATION
OF THE INTERNATIONAL APPLICATION

To:

KAISER, Iona, N.
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, DC 20001
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)* 02 April 2015 (02.04.2015)		
Applicant's or agent's file reference 2013IP072581	IMPORTANT NOTICE	
International application No. PCT/US2013/061546	International filing date *(day/month/year)* 25 September 2013 (25.09.2013)	Priority date *(day/month/year)*
Applicant HALLIBURTON ENERGY SERVICES, INC.		

The applicant is hereby **notified** that the International Bureau:

☒ has **published** the above-indicated international application on 02 April 2015 (02.04.2015) under No. WO 2015/047235

☐ has **republished** the above-indicated international application on under No. WO
For an explanation as to the reason for this republication of the international application, reference is made to INID codes (15), (48) or (88) (*as the case may be*) on the front page of the published international application.

A copy of the international application is available for viewing and downloading on WIPO's website at the following address: www.wipo.int/pctdb (in the appropriate field of the structured search, enter the PCT or WO number).

The applicant may also obtain a paper copy of the published international application from the International Bureau by sending an e-mail to patentscope@wipo.int or by submitting a written request to the contact details provided below.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer
Athina Nickitas-Etienne

e-mail: pt04.pct@wipo.int

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/US13/61546
International Application No.

25 SEPT 2013 (25/09/13)
International Filing Date

PCT INTERNATIONAL APPLICATION RO/US
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 2013IP072581U1PC

Box No. I TITLE OF INVENTION

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*
HALLIBURTON ENERGY SERVICES, INC.
10200 Bellaire Boulevard
Houston, TX 77072
UNITED STATES OF AMERICA

Telephone No.

Facsimile No.

Applicant's registration No. with the Office

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send, notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☐ as advance copies followed by paper notifications; or ☐ exclusively in electronic form (no paper notifications will be sent).

E-mail address:

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☒ all designated States ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
KAISER, Iona N. (Reg. No. 53,086)
JORDAN, Carey C. (Reg. No. 47,646)
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, D.C. 20001
UNITED STATES OF AMERICA

Telephone No.
202-756-8000

Facsimile No.
202-756-8087

Agent's registration No. with the Office
53,086

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send, notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☐ as advance copies followed by paper notifications; or ☒ exclusively in electronic form (no paper notifications will be sent).

E-mail address: mweipdocket@mwe.com

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

See Notes to the request form

Sheet No. . . 2 . . .

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SCOTT, Bruce Edward
7220 Oakbury Lane
McKinney, TX 75071
UNITED STATES OF AMERICA

This person is:

☐ applicant only

☐ applicant and inventor

☒ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:

☐ applicant only

☐ applicant and inventor

☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No. V DESIGNATIONS

The filing of this request **constitutes under Rule 4.9(a) the designation** of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

☐ DE Germany **is not designated** for any kind of national protection

☐ JP Japan **is not designated** for any kind of national protection

☐ KR Republic of Korea **is not designated** for any kind of national protection

(The check-boxes above may only be used to exclude (irrevocably) the designations concerned if, at the time of filing or subsequently under Rule 26bis.1, the international application contains in Box No. VI a priority claim to an earlier national application filed in the particular State concerned, in order to avoid the ceasing of the effect, under the national law, of this earlier national application.)

Box No. VI PRIORITY CLAIM AND DOCUMENT

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application: regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				

☐ Further priority claims are indicated in the Supplemental Box.

Furnishing the priority document(s):

☐ The **receiving Office** is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application(s) was filed with the receiving Office which, for the purposes of this international application, is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box

☐ The **International Bureau** is requested to obtain from a digital library a certified copy of the earlier application(s) identified above, using, where applicable, the access code(s) indicated below *(if the earlier application(s) is available to it from a digital library)*:

☐ item (1) access code _____ ☐ item (2) access code _____ ☐ item (3) access code _____ ☐ other, see Supplemental Box

Restore the right of priority: the receiving Office is requested to restore the right of priority for the earlier application(s) identified above or in the Supplemental Box as item(s) (_____). *(See also the Notes to Box No. VI; further information must be provided to support a request to restore the right of priority.)*

Incorporation by reference: where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if more than one International Searching Authority is competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA/ KR

See Notes to the request form

Continuation of Box No. VII **USE OF RESULTS OF EARLIER SEARCH, REFERENCE TO THAT SEARCH**

☐ The ISA indicated in Box No. VII is requested to take into account the results of the earlier search(es) indicated below (*see also Notes to Box VII; use of results of more than one earlier search*).

Filing date *(day/month/year)*	Application Number	Country *(or regional Office)*

☐ **Statement (Rule 4.12(ii))**: this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

☐ **Availability of documents**: the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12*bis*.1(f)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a translation of the earlier application into a language which is accepted by the ISA,
- ☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
- ☐ a copy of any document cited in the results of the earlier search. *(If known, please indicate below the document(s) available to the ISA):*

☐ **Transmit copy of results of earlier search and other documents** *(where the earlier search was not carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office)*: the **receiving Office** is requested to prepare and transmit to the ISA (Rule 12*bis*.1(c)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12*bis*.1(a)) (*See item 11. in the check-list and also Notes to Box No. VII*).

Filing date *(day/month/year)*	Application Number	Country *(or regional Office)*

☐ **Statement (Rule 4.12(ii))**: this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

☐ **Availability of documents**: the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12*bis*.1(f)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a translation of the earlier application into a language which is accepted by the ISA,
- ☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
- ☐ a copy of any document cited in the results of the earlier search. *(If known, please indicate below the document(s) available to the ISA):*

☐ **Transmit copy of results of earlier search and other documents** *(where the earlier search was not carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office)*: the **receiving Office** is requested to prepare and transmit to the ISA (Rule 12*bis*.1(c)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12*bis*.1(a)) (*See item 11. in the check-list and also Notes to Box No. VII*).

☐ Further earlier searches are indicated on a continuation sheet.

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*:			Number of declarations
☐	Box No. VIII (i)	Declaration as to the identity of the inventor :	
☒	Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent :	1
☐	Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application :	
☐	Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America) :	
☐	Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty :	

Sheet No. 6

Box No. IX CHECK LIST for EFS-Web filings - this sheet is only to be used when filing an international application with RO/US via EFS-Web

This international application **contains** the following:	Number of sheets
(a) request form PCT/RO/101 (including any declarations and supplemental sheets)	6
(b) description (excluding any sequence listing part of the description, see (f), below)	19
(c) claims	4
(d) abstract	1
(e) drawings (if any)	4
(f) sequence listing part of the description in the form of an **image file** (e.g. PDF)	
Total number of sheets (including the sequence listing part of the description if **filed as an image file**)	34

(g) sequence listing part of the description

- ☐ filed in the form of an **Annex C/ST.25 text file**
- ☐ WILL BE filed separately on physical data carrier(s), on the same day and in the form of an **Annex C/ST.25 text file**

Indicate type and number of physical data carrier(s) .....

This international application is **accompanied** by the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item)*:	Number of items
1. ☒ fee calculation sheet	1
2. ☐ original separate power of attorney	
3. ☐ original general power of attorney	
4. ☐ copy of general power of attorney; reference number:	
5. ☐ priority document(s) identified in Box No. VI as item(s)	
6. ☐ Translation of international application into *(language)*:	
7. ☐ separate indications concerning deposited microorganism or other biological material	
8. ☐ *(only where item (f) is marked in the left column)* copy of the sequence listing in electronic form (Annex C/ST.25 text file) not forming part of the international application but **furnished only for the purposes of international search** under Rule 13*ter*	
9. ☐ *(only where item (f) is marked in the left column)* a statement confirming that "the information recorded in electronic form submitted under Rule 13*ter* is identical to the sequence listing as contained in the international application" as filed via EFS-Web:	
10. ☐ copy of results of earlier search(es) (Rule 12*bis*.1(a))	
11. ☒ other *(specify)*: PCT Transmittal	1

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. X SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

/Iona N. Kaiser/
Iona N. Kaiser, Reg. No. 53,086

For receiving Office use only

1. Date of actual receipt of the purported international application: 25 SEPT 2013 (25/09/13)
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA / KR
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF RECEIPT OF RECORD COPY

(PCT Rule 24.2(a))

To:

KAISER, Iona, N.
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, DC 20001
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)*	IMPORTANT NOTIFICATION
23 October 2013 (23.10.2013)	
Applicant's or agent's file reference	International application No.
2013IP072581	PCT/US2013/061546

The applicant is hereby **notified** that the International Bureau has received the record copy of the international application as detailed below.

Name(s) of the applicant(s) and State(s) for which they are applicants:

HALLIBURTON ENERGY SERVICES, INC. (all designated States)

International filing date: 25 September 2013 (25.09.2013)
Priority date(s) claimed: None
Date of receipt of the record copy by the International Bureau: 05 October 2013 (05.10.2013)
List of designated Offices:

AP: BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW
EA: AM, AZ, BY, KG, KZ, RU, TJ, TM
EP: AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR
OA: BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG
National: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, 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, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW

ATTENTION: The applicant should carefully check the data appearing in this Notification. In case of any discrepancy between these data and the indications in the international application, the applicant should immediately inform the International Bureau. **In addition, the applicant's attention is drawn to:**

- time limits for entry into the national phase (see www.wipo.int/pct/en/texts/time_limits.htmland *PCT Applicant's Guide*, National Phase, especially Chapters 3 and 4)
- requirements regarding priority documents (if applicable) (see *PCT Applicant's Guide*, International Phase, paragraph 5.070)

A copy of this notification is being sent to the receiving Office and to the International Searching Authority.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 89 95

Authorized officer
Mandallaz Stephane
e-mail pt04.pct@wipo.int
Telephone No. +41 22 338 74 04

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
KAISER IONA N.

MCDERMOTT WILL & EMERY LLP 500 NORTH CAPITOL STREET, N.W. WASHINGTON DC 20001 USA

PCT

NOTIFICATION OF RECEIPT OF SEARCH COPY

(PCT Rule 25.1)

Date of mailing (*day/month/year*)	11 October 2013 (11.10.2013)
Applicant's or agent's file reference 2013IP072581	**IMPORTANT NOTIFICATION**

International application No.	International filing date (*day/month/year*)	Priority date (*day/month/year*)
PCT/US2013/061546	**25 September 2013 (25.09.2013)**	

Applicant
HALLIBURTON ENERGY SERVICES, INC.

1. **Where the International Searching Authority and the receiving Office are not the same Office:**
The applicant is hereby notified that the search copy of the international application was received by this International Searching Authority on the date indicated below.

Where the International Searching Authority and the receiving Office are the same Office:
The applicant is hereby notified that the search copy of the international application was received on the date indicated below.

08 October 2013 (08.10.2013) (*date of receipt*).

2. ☐ The search copy was accompanied by a nucleotide and/or amino acid sequence listing or tables related thereto in electronic form.

3. ☐ The search copy contained a nucleotide and/or amino acid sequence listing or tables related thereto in electronic form.

4. **Time limit for establishment of international search report and written opinion of the International Searching Authority**
The applicant is informed that the time limit for establishing the international search report and the written opinion of the International Searching Authority is three months from the date of receipt indicated above or nine months from the priority date, whichever time limit expires later (Rules 42.1 and 43bis.1(a)).

A copy of this Notification has been sent to the International Bureau and, where the first sentence of paragraph 1 applies, to the receiving Office.

Name and mailing address of the ISA/KR Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer COMMISSIONER Telephone No. 82-42-481-8552

PATENT COOPERATION TREATY

From the RECEIVING OFFICE

To:

IONA N. KAISER
MCDERMOTT WILL & EMERY LLP
500 NORTH CAPITOL STREET, N.W.
WASHINGTON, DISTRICT OF COLUMBIA 20001

PCT

NOTIFICATION CONCERNING PAYMENT OF PRESCRIBED FEES

(PCT Rules 12*bis*.1(c), 14, 15 and 16 and Administrative Instructions, Sections 102*bis*(c), 304, 323(b) and 707)

Date of mailing *(day/month/year)*	03 Oct 2013
Applicant's or agent's file reference: 2013IP072581	PAYMENT DUE: see item 3 for time limits

International application No.	International filing date/Date of receipt *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/061546	25 Sep 2013	

Applicant: HALLIBURTON ENERGY SERVICES, INC.

1. The applicant is hereby notified that this receiving Office has received:

☒ **the payment** of all the prescribed fees, and ☐ **an overpayment**, which will be refunded in due course.

☐ **no or insufficient payment** of the prescribed fees and the applicant is hereby **invited to pay the balance due**, as summarized under item 2, within the time limit(s) indicated under item 3.

2. **Fees and payment calculation:**

2,783.00	–	2,783.00	=	0.00
Total fees payable		Amount paid		Balance

☐ The details of the calculation are given in the Annex.

3. **Time limit(s) for payment and amount(s) payable (Rules 14.1, 15.3 and 16.1(f)):**

☐ within ONE MONTH from the date of receipt of the international application (**for the transmittal fee** (if any), **the search fee** and **the international filing fee**). The amount payable for each fee is the amount applicable on the date of receipt of the international application.

☐ within 16 MONTHS from the priority date (only for the fee for priority document). The applicant's attention is drawn to the fact that the request made by the applicant under Rule 17.1(b) will be considered not to have been made unless the fee is paid within that time limit.

4. Additional observations *(if necessary)*:

☐ The search copy will not be transmitted to the International Searching Authority until the search fee is paid (therefore the start of the international search will be delayed) (Rule 23.1(a) and (b)).

Name and mailing address of the receiving Office	Authorized officer
Mail Stop PCT, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450	Rita Dozier
Facsimile No. 571-273-3201	Telephone No. (571) 272-8669

Form PCT/RO/102 (July 2010)

ANNEX TO FORM PCT/RO/102
CALCULATION OF THE PRESCRIBED FEES

International application No.
PCT/US2013/061546

[T] Transmittal Fee

Prescribed amount:	240.00 [T]	☒ correct amount
Amount paid:	240.00	☐ overpayment
Balance:	0.00	☐ balance due

[S] Search Fee

Prescribed amount:	1,167.00 [S]	☒ correct amount
Amount paid:	1,167.00	☐ overpayment
Balance:	0.00	☐ balance due

[I] International Filing Fee

Fixed amount for first 30 sheets: 1,312.00 [i1]

4 (Number of sheets in excess of 30 *(excluding pages referred to in Section 707(a-bis))*) x 16.00 (Fee per sheet) = 64.00 [i2]

Reduction where the international application is filed *(See PCT Applicant's Guide, International Phase for details on the availability of this reduction)*:

on paper together with a copy in electronic form, in character coded format, of the request and the abstract	0.00 [r]
or in electronic form, the request not being in character coded format	0.00 [r]
or in electronic form, the request being in character coded format	0.00 [r]
or in electronic form, the request, description, claims and abstract being in character coded format	0.00 [r]

Sub-total: 1,376.00 [i1+i2-r]

Applicants from certain States are entitled to a reduction of 90% of the international filing fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 10% of the sub-total entered at (i1+i2-r); (see Notes to the Fee Calculation Sheet as annexed to the Request Form, PCT/RO/101, for details):

	1,376.00 [I]	
Amount paid:	1,376.00	☒ correct amount
Balance:	0.00	☐ overpayment
		☐ balance due

[P] Fee for Priority Document

Prescribed amount:	0.00 [P]	☒ correct amount
Amount paid:	0.00	☐ overpayment
Balance:	0.00	☐ balance due

[ES] Fee for Earlier Search Documents

Prescribed amount:	0.00 [ES]	☐ correct amount
Amount paid:	0.00	☐ overpayment
Balance:	0.00	☐ balance due

From the INTERNATIONAL BUREAU

PCT

INVITATION TO CORRECT
DECLARATIONS MADE IN THE REQUEST
UNDER PCT RULE 4.17

(PCT Rules 4.17 and 26*ter*.2(a))

To:

KAISER, Iona, N.
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, DC 20001
ETATS-UNIS D'AMERIQUE

Date of mailing *(day/month/year)* 23 October 2013 (23.10.2013)	
Applicant's or agent's file reference 2013IP072581	REPLY DUE See below
International application No. PCT/US2013/061546	International filing date *(day/month/year)* 25 September 2013 (25.09.2013)
Applicant HALLIBURTON ENERGY SERVICES, INC.	

1. The applicant is hereby **invited to submit to the International Bureau a corrected declaration** within the time limit indicated below and as explained in the Annex. The applicant's attention is drawn to the fact that the declaration has **not been examined** for compliance with national law requirements of the designated State(s) for which that declaration is made.

When? Within 16 months from the priority date, provided that any corrected declaration which is received by the International Bureau after the expiration of that time limit shall be considered to have been received on the last day of that time limit if it reaches it before the technical preparations for international publication have been completed (Rule 26*ter*.1).

How? By submitting a replacement sheet containing a corrected declaration accompanied by a letter explaining the correction (see Section 216). See Sections 211 to 215 for the applicable standardized wording.

Where? Directly to the International Bureau at the address indicated below.

If the corrected declaration is submitted to the receiving Office, that Office shall mark the date of receipt on it and transmit it promptly to the International Bureau. The declaration shall be considered to have been submitted to the International Bureau on the date marked (see Section 317).

2. **Failure to correct the declaration within the time limit** will result in the declaration, **as originally filed**, being published as part of the international application (Rule 48.2(a)(x)).

Any declaration received after the expiration of the time limit under Rule 26*ter*.1 will have to be submitted by the applicant directly to the designated Offices concerned; it is only in the case of a signed declaration of inventorship for the purposes of the designation of the United States of America (Rule 4.17(iv)) that the original declaration will be returned to the applicant (see Section 419(d)).

3. **In respect of national phase processing**, the applicant's attention is drawn to Rule 51*bis*.2 which provides that the designated Office shall not, unless it may reasonably doubt the veracity of the declaration concerned, require any document or evidence relating to the subject matter of any declaration complying with Rule 4.17(i) to (iv) which is contained in the request or submitted to the International Bureau or directly to the designated Office. Note, however, that Rule 51*bis*.2 may not apply in respect of certain States. For further information, see Notes to the request form, Box No. VIII.

4. A copy of this Invitation is being sent to the receiving Office.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 89 95

Authorized officer
Mandallaz Stephane
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Telephone No. +41 22 338 74 04

1/GVQVJGTQJLAZW0

ANNEX TO FORM PCT/IB/370

International application No.
PCT/US2013/061546

The International Bureau has found the following defect(s) in the declaration(s) listed below:

1. ☐ declaration as to the identity of the inventor (Rules 4.17(i) and 51*bis*.1(a)(i) and Section 211), in respect of:

2. ☐ declaration as to the applicant's entitlement, as at the international filing date, to apply for or be granted a patent (Rules 4.17(ii) and 51*bis*.1(a)(ii) and Section 212), in respect of:

3. ☐ declaration as to the applicant's entitlement, as at the international filing date, to claim priority of the earlier application (Rules 4.17(iii) and 51*bis*.1(a)(iii) and Section 213), in respect of:

4. ☒ declaration of inventorship (only for the purposes of the designation of the United States of America) (Rules 4.17(iv) and 51*bis*.1(a)(iv) and Section 214), in respect of:

   a. *(name(s) included in the declaration):*

   ☒ is not in the prescribed wording

   ☐ is not signed by all inventors named in the declaration

   ☐ other *(specify)*:

5. ☐ declaration as to non-prejudicial disclosures or exceptions to lack of novelty (Rules 4.17(v) and 51*bis*.1(a)(v) and Section 215), in respect of:

2/GVQVJGTQJLAZW0

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
2 April 2015 (02.04.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/047235 A1

(51) International Patent Classification:
E21B 34/06 (2006.01) *E21B 34/12* (2006.01)

(21) International Application Number:
PCT/US2013/061546

(22) International Filing Date:
25 September 2013 (25.09.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **HALLIBURTON ENERGY SERVICES, INC.** [US/US]; 10200 Bellaire Boulevard, Houston, TX 77072 (US).

(72) Inventor: **SCOTT, Bruce, Edward**; 7220 Oakbury Lane, McKinney, TX 75071 (US).

(74) Agents: **KAISER, Iona, N.** et al.; McDermott Will & Emery LLP, 500 North Capitol Street, N.W., Washington, DC 20001 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, 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, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

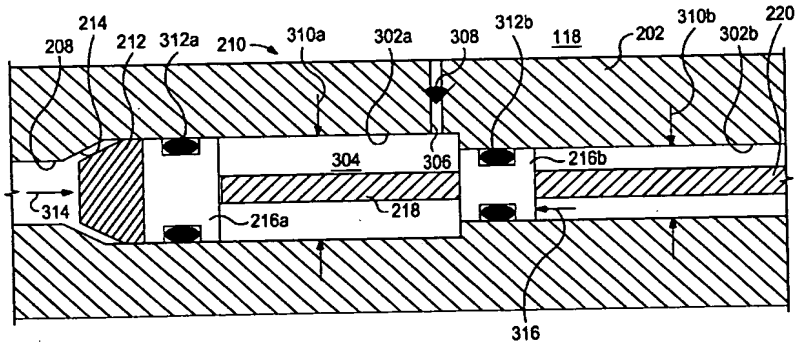

FIG. 3A

(57) Abstract: Disclosed are subsurface safety valves having multiple pistons used to increase the opening force. One safety valve includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons, wherein a cavity is defined between the upper and lower pistons within the piston bore and the piston rod extends within the cavity.

WO 2015/047235 A1

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

BACKGROUND

[0001] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0002] Subsurface safety valves are well known in the oil and gas industry and act as a failsafe to prevent the uncontrolled release of reservoir fluids in the event of a worst-case scenario surface disaster. Typical subsurface safety valves are flapper-type valves that are opened and closed with the help of a flow tube moving telescopically within the production tubular. The flow tube is often controlled hydraulically from the surface and is forced into its open position using a piston and rod assembly that may be hydraulically charged via a control line linked directly to a hydraulic manifold or pressure control system at the well surface. When sufficient hydraulic pressure is conveyed to the subsurface safety valve via the control line, the piston and rod assembly forces the flow tube downwards, which compresses a spring and simultaneously pushes the flapper downwards to the open position. When the hydraulic pressure is removed from the control line, the spring pushes the flow tube back up, which allows the flapper to move into its closed position.

[0003] Depending on the size and depth of the safety valve deployed, the components of the pressure control system used to operate the safety valve can be quite expensive. The cost of a pressure control system may increase as required pressure ratings for the control line and/or the pump equipment increase, which is usually related to the operating depth of the safety valve. There are practical limits to the size and rating of pressure control systems, past which a well operator may not be able to economically or feasibly employ a subsurface safety valve. Accordingly, there is always a need in the industry for the ability to use lower rated pressure control systems for operating subsurface safety valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The following figures are included to illustrate certain aspects of the present disclosure, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, without departing from the scope of this disclosure.

[0005] FIG. 1 illustrates a well system that incorporates one or more principles of the present disclosure, according to one or more embodiments.

[0006] FIGS. 2A and 2B illustrate cross-sectional side views of the exemplary safety valve of FIG. 1, according to one or more embodiments.

[0007] FIGS. 3A and 3B illustrate enlarged cross-sectional side views of an exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

[0008] FIG. 4A and 4B illustrate enlarged cross-sectional side views of another exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

DETAILED DESCRIPTION

[0009] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0010] Disclosed is a subsurface safety valve configured to reduce the pressure required to open the valve at depth. The safety valve includes a piston assembly having a multiple piston configuration including a control pressure piston coupled to a section pressure piston such that the two pistons move simultaneously within a piston bore of the safety valve. The control pressure piston exhibits a larger piston area than the section pressure piston. As a result, hydraulic fluid provided to the piston bore via a control line will work on the larger piston area of the control pressure piston while the section pressure below the piston assembly will work on the smaller piston area of the section pressure piston. Since the piston area of the control pressure piston is enlarged, the control pressure is intensified such that lower rated pressure control systems may be employed.

[0011] Referring to FIG. 1, illustrated is a well system 100 that incorporates one or more principles of the present disclosure, according to one or more embodiments. As illustrated, the well system 100 may include a riser 102 extending from a wellhead installation 104 arranged at a sea floor 106. The riser 102 may extend, for example, to an offshore oil and gas platform (not shown). A wellbore 108 extends downward from the wellhead installation 104 through various subterranean formations 110. The wellbore 108 is depicted as being cased, but it could equally be an uncased wellbore 108, without departing from the scope of the disclosure. Although FIG. 1 depicts the well system 100 in the context of an offshore oil and gas application, it will be appreciated by those skilled in the art that the various embodiments disclosed herein are equally well suited for use in or on oil and gas rigs or service rigs, such as land-based oil and gas rigs or rigs located at any other geographical site. Thus, it should be understood that the disclosure is not limited to any particular type of well.

[0012] The well system 100 may further include a safety valve 112 interconnected with a tubing string 114 arranged within the wellbore 108 and extending from the wellhead installation 104. The tubing string 114 may be configured to communicate fluids derived from the wellbore 108 and the surrounding subterranean formations 110 to the well surface via the wellhead installation 104. A control line 116 may extend from the well surface and into the wellhead installation 104 which, in turn, conveys the control line 116 into an annulus 118 defined between the wellbore 108 and the tubing string 114. The control line 116 may extend downward within the annulus 118 and eventually become communicably coupled to the safety valve 112. As discussed in more detail below, the control line 116 may be configured to actuate the safety valve 112, for example, to maintain the safety valve 112 in an open position, or otherwise to close the safety valve 112 and thereby prevent a blowout in the event of an emergency.

[0013] The control line 116 may be a hydraulic conduit that provides hydraulic fluid pressure to the safety valve 112. In operation, hydraulic fluid may be applied to the control line 116 from a hydraulic pressure control system arranged at a remote location, such as at a production platform or a subsea control station. When properly applied, the hydraulic pressure derived from the control line 116 may be configured to open and maintain the safety valve 112 in its open position, thereby allowing production fluids to flow through the safety

valve 112, through the tubing string 114, and upwards towards the rig. To move the safety valve 112 from its open position and into a closed position, the hydraulic pressure in the control line 116 may be reduced or otherwise eliminated.

[0014] Although the control line 116 is depicted in FIG. 1 as being arranged external to the tubing string 114, it will be readily appreciated by those skilled in the art that any arrangement or configuration of the control line 116 may be used to convey actuation pressure to the safety valve 112. For example, the control line 116 could be arranged internal to the tubing string 114, or otherwise formed in a sidewall of the tubing string 114. The control line 116 could extend from a remote location, such as from the earth's surface, or another location in the wellbore 108. In yet other embodiments, the pressure required to actuate the safety valve 112 may be derived from a pressure control system located downhole and communicably coupled to the control line 116 at a location.

[0015] In the following description of the representative embodiments of the disclosure, directional terms such as "above", "below", "upper", "lower", etc., are used for convenience in referring to the accompanying drawings. In general, "above", "upper", "upward" and similar terms refer to a direction toward the earth's surface along the wellbore 108, and "below", "lower", "downward" and similar terms refer to a direction away from the earth's surface along the wellbore 108.

[0016] Referring now to FIGS. 2A and 2B, with continued reference to FIG. 1, illustrated are cross-sectional side views of an exemplary embodiment of the safety valve 112, according to one or more embodiments. In particular, the safety valve 112 is depicted in FIGS. 2A and 2B in successive sectional views, where FIG. 2A depicts an upper portion of the safety valve 112 and FIG. 2B depicts a lower portion of the safety valve 112. As illustrated, the safety valve 112 may include a housing 202 that is able to be coupled to the tubing string 114 at opposing ends of the housing 202 (tubing string 114 shown only in FIG. 2B).

[0017] A control line port 204 may be defined or otherwise provided in the housing 202 for connecting the control line 116 (FIG. 1) to the safety valve 112. The port 204 is shown in FIG. 2A as being plugged with a set screw 206 or other type of plugging device. However, when the control line 116 is

appropriately connected to the first port 204 the control line 116 is placed in fluid communication with a piston bore 208 and able to convey hydraulic fluid pressure thereto. The piston bore 208 may be an elongate channel or conduit defined within the housing 202 and configured to extend longitudinally along a portion of the axial length of the safety valve 112.

[0018] A piston assembly 210 may be arranged within the piston bore 208 and configured to translate axially therein. The piston assembly 210 may include a piston head 212 configured to mate with and otherwise bias an up stop 214 defined within the piston bore 208 when the piston assembly 210 is forced upwards in the direction of the control line port 204. The up stop 214 may be a radial shoulder defined within the piston bore 208 and having a reduced diameter and an axial surface configured to engage a corresponding axial surface of the piston head 212. In other embodiments, the up stop 214 may be any device or means arranged within the piston bore 208 that is configured to stop the axial movement of the piston assembly 210 as it advances upward within the piston bore and toward the control line port 204.

[0019] The piston assembly 210 may also include a first or upper piston 216a and a second or lower piston 216b coupled thereto via a connecting rod 218. The lower piston 216b may be coupled to a piston rod 220 that extends longitudinally from the piston assembly 210 through at least a portion of the piston bore 208. At a distal end thereof, the piston rod 220 may be coupled to an actuator sleeve 222, which may be configured to effectively couple the piston assembly 210 to a flow tube 224 that is movably arranged within the safety valve 112. More particularly, the actuator sleeve 222 may engage a biasing device 226 (*e.g.*, a compression spring, a series of Belleville washers, or the like) arranged axially between the actuator sleeve 222 and an actuation flange 228 that forms part of the proximal end of the flow tube 224. As the actuator sleeve 222 acts on the biasing device 226 (*e.g.*, axial force), the actuation flange 228 and the flow tube 224 correspondingly move.

[0020] Referring to FIG. 2B, the safety valve 112 may also include a valve closure device 230 that selectively opens and closes a flow passage 232 defined through the interior of the safety valve 112. The valve closure device 230 may be a flapper, as generally known to those skilled in the art. It should be noted, however, that although the safety valve 112 is depicted as being a flapper-type safety valve, those skilled in the art will readily appreciate that any

type of closure device 230 may be employed, without departing from the scope of the disclosure. For example, in some embodiments, the closure device 230 could instead be a ball, a sleeve, etc.

[0021] As shown in FIG. 2B, the closure device 230 is in its closed position whereby the closure device 230 is able to substantially block fluid flow into and through the flow passage 232 from downhole (*i.e.*, from the right in FIG. 2B). A torsion spring 234 biases the closure device 230 to pivot to its closed position. As described below, the piston assembly 210 is used to displace the flow tube 224 downward (*i.e.*, to the right in FIG. 2B) to engage the closure device 230 and overcome the spring force of the torsion spring 234. When the flow tube 224 is extended to its downward position, it engages the closure device 230 and moves the closure device 230 from its closed position to an open position (shown in phantom as dashed lines). When the flow tube 224 is displaced back upward (*i.e.*, to the left in FIG. 2B), the torsion spring 234 is able to pivot the closure device 230 back to its closed position. Axial movement of the piston assembly 210 within the piston bore 208 will force the flow tube 224 to correspondingly move axially within the flow passage 232, and either open the closure device 230 or allow it to close, depending on its relative position.

[0022] The safety valve 112 may further define a lower chamber 236 within the housing 202. In some embodiments, the lower chamber 236 may form part of the piston bore 208, such as being an elongate extension thereof. A power spring 238, such as a coil or compression spring, may be arranged within the lower chamber 236. The power spring 238 may be configured to bias the actuation flange 228 and actuation sleeve 222 upwardly which, in turn, biases the piston assembly 210 in the same direction. Accordingly, expansion of the power spring 238 will cause the piston assembly 210 to move upwardly within the piston bore 208.

[0023] It should be noted that while the power spring 238 is depicted as a coiled compression spring, any type of biasing device may be used instead of, or in addition to, the power spring 238, without departing from the scope of the disclosure. For example, a compressed gas, such as nitrogen, with appropriate seals may be used in place of the power spring 238. In other embodiments, the compressed gas may be contained in a separate chamber and tapped when needed.

[0024] In exemplary operation, the safety valve 112 may be actuated in order to open the closure device 230. This may be accomplished by conveying a hydraulic fluid under pressure to the control line port 204 via the control line 116 (FIG. 1). As hydraulic pressure is provided to the piston bore 208, the piston assembly 210 may be forced to move axially downward within the piston bore 208. As the piston assembly 210 moves, the piston rod 220 mechanically transfers the hydraulic force to the actuation sleeve 222 and the actuation flange 228, thereby correspondingly displacing the flow tube 224 in the downward direction. In other words, as the piston assembly 210 moves axially within the piston bore 208, the flow tube 224 correspondingly moves in the same direction. As the flow tube 224 moves downward, it engages the closure device 230, overcomes the spring force of the torsion spring 234, and thereby pivots the closure device 230 to its open position to permit fluids to enter the flow passage 232 from downhole (*i.e.*, from the right in FIG. 2B).

[0025] Moreover, as the piston assembly 210 moves axially downward within the piston bore 208, the power spring 238 is compressed within the lower chamber 236 and progressively builds spring force. In at least one embodiment, the piston assembly 210 will continue its axial movement in the downward direction, and thereby continue to compress the power spring 238, until engaging a down stop 240 (FIG. 2A) arranged within the piston bore 208. A metal-to-metal seal may be created between the piston assembly 210 and the down stop 240 such that the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough is generally prevented.

[0026] Upon reducing or eliminating the hydraulic pressure provided via the control line 116, the spring force built up in the power spring 238 may be allowed to release and displace the piston assembly 210 upwards within the piston bore 208, thereby correspondingly moving the flow tube 224 in the same direction. The section pressure within the safety valve 112 below the lower piston 216b also serves to move the piston assembly 210 upwards within the piston bore 208. As the flow tube 224 moves axially upwards, it will eventually move out of engagement with the closure device 230. Once free from engagement with the flow tube 224, the spring force of the torsion spring 234 will pivot the closure device 230 back into its closed position.

[0027] In at least one embodiment, the piston assembly 210 will continue its axial movement in the upward direction until the piston head 212 of

the piston assembly 210 engages the up stop 214 and effectively prevents the piston assembly 210 from further upward movement. Engagement between the piston head 212 and the up stop 214 may generate a mechanical metal-to-metal seal between the two components to prevent the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough.

[0028] When the safety valve 112 is deployed downhole, the "section" pressure, or fluid pressure present within the wellbore 108 (FIG. 1) and annulus 118 (FIG. 1) at depth, cooperatively act on the piston assembly 210. More specifically, the section pressure acts on the downhole end of the piston assembly 210 via the piston bore 208, and provides a corresponding closing force on the safety valve 112 that urges the piston assembly 210 toward the up stop 214. In order to open the safety valve 112, the piston assembly 210 must effectively overcome the section pressure and the spring force of the power spring 238. To do this, the hydraulic fluid pressure ("control" pressure) conveyed into the piston bore 208 via the control line 116 (FIG. 1) must be supplied at a pressure that exceeds the combined force of the section pressure and the power spring 238. Moreover, this hydraulic pressure must incrementally increase as the piston assembly 210 translates downward within the piston bore 208 to counteract the increasing spring force that builds as the power spring 238 is compressed. As indicated above, this oftentimes requires expensive pressure control systems that may be infeasible or uneconomical for some applications.

[0029] According to one or more embodiments of the present disclosure, the pressure required to open the safety valve 112 may be reduced or otherwise minimized by increasing the downward force derived from the control pressure and simultaneously decreasing the upward force derived from the section pressure. This can be accomplished by having a multiple piston configuration in the piston assembly 210 whereby the control pressure piston (*i.e.*, the first piston 216a) exhibits a larger piston area than the section pressure piston (*i.e.*, the second piston 216b). As a result, the control pressure will work on the larger piston area of the control pressure piston and the section pressure will work on the smaller piston area of the section pressure piston, thereby intensifying the available force from the control pressure.

[0030] Referring now to FIGS. 3A and 3B, with continued reference to FIGS. 2A and 2B, illustrated are enlarged cross-sectional side views of an exemplary embodiment of the piston assembly 210, according to one or more

embodiments. Like numerals in FIGS. 3A and 3B that are used in prior figures indicate like elements and/or components that will not be described again in detail. FIG. 3A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 3B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0031] As illustrated, the piston assembly 210 may be arranged within the piston bore 208 defined in the housing 202 of the safety valve 112 (FIGS. 2A-2B). The piston bore 208 may be divided into a first or upper bore 302a and a second or lower bore 302b. The first piston 216a may be generally arranged in the upper bore 302a, and the second piston 216b may be generally arranged in the lower bore 302b. The first and second pistons 216a,b may be axially offset from each other within the piston bore 208 and coupled together using the connecting rod 218. The connecting rod 218 may threadably or mechanically attach the first and second pistons 216a,b to each other such that simultaneous movement of each piston 216a,b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0032] With the first and second pistons 216a,b structurally coupled via the connecting rod 218, a chamber or cavity 304 may be defined therebetween within the piston bore 208. The cavity 304 may be configured to correspondingly move with the first and second pistons 216a,b when the piston assembly 210 moves within the piston bore 208. In some embodiments, the cavity 304 may be filled with a fluid. In one or more embodiments, for example, the cavity 304 may be filled with a gas, such as air or an inert gas (*e.g.*, nitrogen, argon, etc.). In other embodiments, however, the cavity 304 may be filled with a hydraulic fluid, a wellbore fluid, water (*i.e.*, brine, fresh water, etc.), or any other liquid.

[0033] In one or more embodiments, the cavity 304 may be ported to the annulus 118 within the wellbore 108 (FIG. 1) where the safety valve 112 (FIGS. 2A-2B) is to be located. More particularly, the piston assembly 210 may further include a conduit 306 defined in the housing 202 that places the cavity 304 in fluid communication with the annulus 118 surrounding the safety valve 112. Porting the cavity 304 to the annulus 118 may help compensate for expansion and contraction of the fluid within the cavity 304 as the wellbore 108 heats up or cools down. At increased temperatures, the pressure within the

cavity 304 will increase and porting the fluid to the annulus 118 may help maintain a safe operating pressure equilibrium. Porting the fluid to the annulus 118 may also prevent the first and second pistons 216a,b from locking under vacuum as temperatures decrease in the cavity 304 and the pressure correspondingly decreases.

[0034] In at least one embodiment, a pressure regulator 308 may be arranged within the conduit 306. The pressure regulator 308 may be used to generally separate the fluid within the cavity 304 from any fluids present in the annulus 118. In operation, the pressure regulator 308 may be configured to axially translate within the conduit 306, thereby separating the fluid within the cavity 304 from fluids in the annulus 118, but also compensate for expansion and contraction of the fluid within the cavity 304 and thereby help maintain safe operating pressure equilibrium. In some embodiments, the pressure regulator 308 may be a balance piston. In other embodiments, however, the pressure regulator 308 may be a floating piston, or the like, without departing from the scope of the disclosure.

[0035] The upper bore 302a may exhibit a first diameter 310a and the lower bore 302b may exhibit a second diameter 310b that is smaller or less than the first diameter 310a. The first piston 216a may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the upper bore 302a, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first piston 216a may include one or more first dynamic seals 312a and the second piston 216b may include one or more second dynamic seals 312b.

[0036] As used herein, the term "dynamic seal" is used to indicate a seal that provides pressure isolation between members that have relative displacement therebetween, for example, a seal which seals against a displacing surface, or a seal carried on one member and sealing against the other member, etc. A dynamic seal may comprise a material selected from the following: elastomeric materials, non-elastomeric materials, metals, composites, rubbers, ceramics, derivatives thereof, and any combination thereof. A dynamic seal may be attached to each of the relatively displacing members, such as a bellows or a flexible membrane. A dynamic seal may be attached to either of the relatively displacing members, such as in the case of a floating piston.

[0037] The first and second dynamic seals 312a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the first dynamic seal 312a may be configured to seal against the inner wall of the upper bore 302a as the first piston 216a moves therein, and the second dynamic seal 312b may be configured to seal against the inner wall of the lower bore 302b as the second piston 216b moves therein. As a result, the first and second dynamic seals 312a,b may be configured to prevent any fluids from migrating past the first and second pistons 216a,b respectively. In some embodiments, one or both of the first and second dynamic seals 312a,b may be O-rings or the like, as illustrated. In other embodiments, however, one or both of the first and second dynamic seals 312a,b may be v-rings or CHEVRON® packing rings or other appropriate seal configurations (*e.g.*, seals that are round, v-shaped, u-shaped, square, oval, t-shaped, etc.), as generally known to those skilled in the art.

[0038] In exemplary operation, hydraulic pressure or "control" pressure (generally indicated by the arrow 314) is introduced into the piston bore 208 via the control line 116 (FIG. 1) and associated port 204 (FIG. 2A). The control pressure 314 communicates with and otherwise acts on the first piston 216a, thereby separating the piston head 212 from the up stop 214 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 3A and 3B). An opposing "section" pressure (generally indicated by the arrow 316) communicates with and otherwise acts on the second piston 216b. As mentioned above, the section pressure 316 and the spring force of the power spring 238 (FIGS. 2A-2B) cooperatively act against the control pressure 314.

[0039] Referring to FIG. 3B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the cavity 304 defined between the first and second pistons 216a,b. As generally described above, while the piston assembly 210 moves from its first position into its second position, the piston rod 220 mechanically transfers the hydraulic force of the control pressure 314 to the flow tube 224 (FIGS. 2A-2B), thereby correspondingly displacing the flow tube 224 in the downward direction and opening the closure device 230 (FIG. 2B). Moreover, while the piston assembly 210 moves from its first position into its second position, the first and second dynamic seals 312a,b sealingly engage the inner walls of the upper and lower bores 302a,b, respectively.

[0040] Since the piston area of the first piston 216a is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 is correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area, the section pressure 316 applied to the second piston 216b is minimized with respect to the first piston 216a and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ a smaller or reduced pressure control system used to convey the control pressure 314 to the safety valve 112, including using control lines and pump equipment that exhibit lower pressure ratings than would otherwise be used in a safety valve at similar depths. Smaller or reduced pressure control systems may be advantageous for safety reasons (*i.e.*, lower pressures are typically safer than higher pressures), cost (*i.e.*, reducing the size of the pump and the pressure rating of the pump and control lines can result in significant cost savings), and physical restraints (*i.e.*, lower pressure equipment normally exhibits a smaller footprint than higher pressure equipment).

[0041] Referring now to FIGS. 4A and 4B, with continued reference to FIGS. 2A-2B and 3A-3B, illustrated are enlarged cross-sectional side views of another exemplary embodiment of the piston assembly 210, according to one or more embodiments. Like numerals are used to indicate like elements and/or components from prior figures that will not be described again in detail. FIG. 4A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 4B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0042] Similar to the piston assembly 210 depicted in FIGS. 3A-3B, the piston assembly 210 in FIGS. 4A-4B is arranged within the piston bore 208 defined in the housing 202 and the piston bore 208 includes an upper bore 302a and a lower bore 302b. The upper bore 302a in FIGS. 4A-4B, however, may be divided into a first upper bore 402a and a second upper bore 402b to accommodate a first upper piston 404a and a second upper piston 404b. In some embodiments, the first and second upper bores 402a,b may be radially offset from each other within the housing 202 (*i.e.*, radially offset from each other with respect to the longitudinal central axis of the safety valve 112). In other embodiments, the first and second upper bores 402a,b may be angularly or circumferentially offset from each other within the housing 202. In other

words, the first and second upper bores 402a,b may also be laterally offset from each other about the circumference of the housing 202, without departing from the scope of the disclosure.

[0043] The first and second upper pistons 404a,b may be operably coupled to each other with a connecting rod 406. The connecting rod 406 may be u-shaped and/or otherwise connected at an intermediate point such that it is able to extend into each of the first and second upper bores 402a,b and attach to the first and second upper pistons 404a,b. As a result, the first and second upper pistons 404a,b are able to move simultaneously and thereby act as a single piston member. The connecting rod 406 may also be coupled to the second or lower piston 216b. The connecting rod 406 may threadably or mechanically attach the first and second upper pistons 404a,b to the second piston 216b such that simultaneous movement of each piston 404a,b and 216b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0044] A cavity 408 may be defined between the first and second upper pistons 404a,b and the second piston 216b within the piston bore 208. The cavity 408 may be configured to correspondingly move or shift within the piston bore 208 when the piston assembly 210 moves therein. Similar to the cavity 304 of FIGS. 3A-3B, the cavity 408 may be filled with a fluid, such as a gas (*e.g.*, air, an inert gas, etc.), or a liquid (*e.g.*, hydraulic fluid, wellbore fluid, water, such as brine or fresh water), combinations thereof, or the like. As illustrated, the cavity 408 may also be ported to the annulus 118 via the conduit 306 in order to place the cavity 408 in fluid communication with the annulus 118. In some embodiments, the pressure regulator 308 may be arranged within the conduit 306 in order to maintain pressure equilibrium within the cavity 408.

[0045] The first upper bore 402a may exhibit a first diameter 410a, the second upper bore 402b may exhibit a second diameter 410b, and the lower bore 302b may exhibit a third diameter 410c. In some embodiments, the first and second diameters 410a,b may be the same. In other embodiments, the first and second diameters 410a,b may be different. Moreover, in some embodiments, one or both of the first and second diameters 410a,b may be greater than the third diameter 410c. In other embodiments, one or both of the first and second diameters 410a,b may be smaller than the third diameter 410c. In any event, the combined sizing of the first and second diameters 410a,b is

greater than the third diameter 410c, such that the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b.

[0046] The first and second upper pistons 404a,b may be sized or otherwise configured to sealingly engage the inner walls of the first and second upper bores 402a,b, respectively, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first and second upper pistons 404a,b may include one or more first dynamic seals 412a and the second piston 216b may include one or more second dynamic seals 412b. Similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the dynamic seal 412a of the first upper piston 404a may be configured to seal against the inner wall of the first upper bore 402a, the dynamic seal 412a of the second upper piston 404b may be configured to seal against the inner wall of the second upper bore 402b, and the dynamic seal 412b of the second piston 216b may be configured to seal against the inner wall of the lower bore 302b. Moreover, similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be one of an O-ring, one or more v-rings or CHEVRON® packing rings, or other appropriate seal configurations described herein.

[0047] In exemplary operation, hydraulic control pressure 314 is introduced into the piston bore 208 in order to act on the piston assembly 210 and move the safety valve 112 (FIGS. 2A-2B) into the open position. More particularly, the control pressure 314 may be provided to the control line port 204 (FIG. 2A) via the control line 116 (FIG. 1), and the control line port 204 may feed the hydraulic fluid into the piston bore 208, which splits and feeds the control pressure 314 into the first and second upper bores 402a,b. The control pressure 314 communicates with and otherwise acts on the first and second upper pistons 404a,b, thereby separating the piston head 212 of each first and second upper piston 404a,b from corresponding up stops 214 defined in the piston bore 208 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 4A and 4B). The opposing section pressure 316 communicates with and otherwise acts on the second piston 216b.

[0048] As shown in FIG. 4B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the flow tube 224 (FIGS. 2A-2B) in the downward direction and opening the closure device 230 (FIG. 2B), as generally described above. Moreover, while the piston assembly 210 moves from the first position into the second position, the dynamic seals 412a,b sealingly engage the inner walls of the first and second upper bores 402a,b and the lower bore 302b, respectively.

[0049] Adding additional pistons to the piston assembly 210 increases the piston area available for the control pressure 314 to act on in moving the piston assembly 210 from its first position (FIG. 4A) to its second position (FIG. 4B). Since the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 has been correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area than the combined piston areas of the first and second upper pistons 404a,b, the section pressure 316 applied to the second piston 216b is minimized with respect to the first and second upper pistons 404a,b and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ smaller or less expensive pressure control equipment used to convey the control pressure 314 to the safety valve 112.

[0050] Furthermore, by employing additional upper pistons in the piston assembly 210, an operator may be able to obtain a desired ratio between the upper and lower pistons, thereby allowing for smaller upper pistons. Smaller upper pistons can reduce the effective cross section of the upper piston section, which can effectively reduce the outer diameter of the subsurface safety valve. As a result, the overall cost of the safety valve may correspondingly be reduced and allow the safety valve to be used in a greater number of wells. Moreover, a smaller outer diameter fort he safety valve allows the operator to run smaller casing whereas a larger outer diameter safety valve requires the operator to run larger casing which increases well completion costs.

[0051] While FIGS. 4A and 4B depict first and second upper pistons 404a,b being used in the piston assembly 210, it will be appreciated that more than two upper pistons (*e.g.*, first pistons 302a) may be employed without departing from the scope of the disclosure. Each additional upper piston may be operatively coupled to the control rod 406 and effectively increase the piston

area available for the control pressure 314 to act on, thereby reducing the required amount of control pressure 314 to open the safety valve.

[0052] Embodiments disclosed herein include:

[0053] A. A safety valve that includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

[0054] B. A method of actuating a safety valve that includes conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore, axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

[0055] Each of embodiments A and B may have one or more of the following additional elements in any combination: Element 1: wherein the cavity contains a fluid. Element 2: further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. Element 3: further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing. Element 4: wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively. Element 5: further comprising a piston rod

that extends longitudinally from the lower piston through at least a portion of the piston bore, a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly, and a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions. Element 6: further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore. Element 7: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. Element 8: wherein the first and second upper bores are radially offset from each other within the housing. Element 9: wherein the first and second upper bores are angularly offset from each other about a circumference of the housing. Element 10: wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons. Element 11: wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0056] Element 12: wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line. Element 13: wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston. Element 14: wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively. Element 15: wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising axially displacing the flow tube as the piston assembly moves within the piston bore, compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure, and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position. Element 16: wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. Element 17: further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit. Element 18: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising sealingly engaging the first upper bore with the first upper piston, and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0057] Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of

values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

What is claimed is:

1. A safety valve, comprising:

a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore; and

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

2. The safety valve of claim 1, wherein the cavity contains a fluid.

3. The safety valve of claim 2, further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing.

4. The safety valve of claim 3, further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore;

a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly; and

a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage

when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions.

7. The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. The safety valve of claim 8, wherein the first and second upper bores are angularly offset from each other about a circumference of the housing.

11. The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston,

wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

14. The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. The method of claim 13, wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly.

19. The method of claim 18, further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

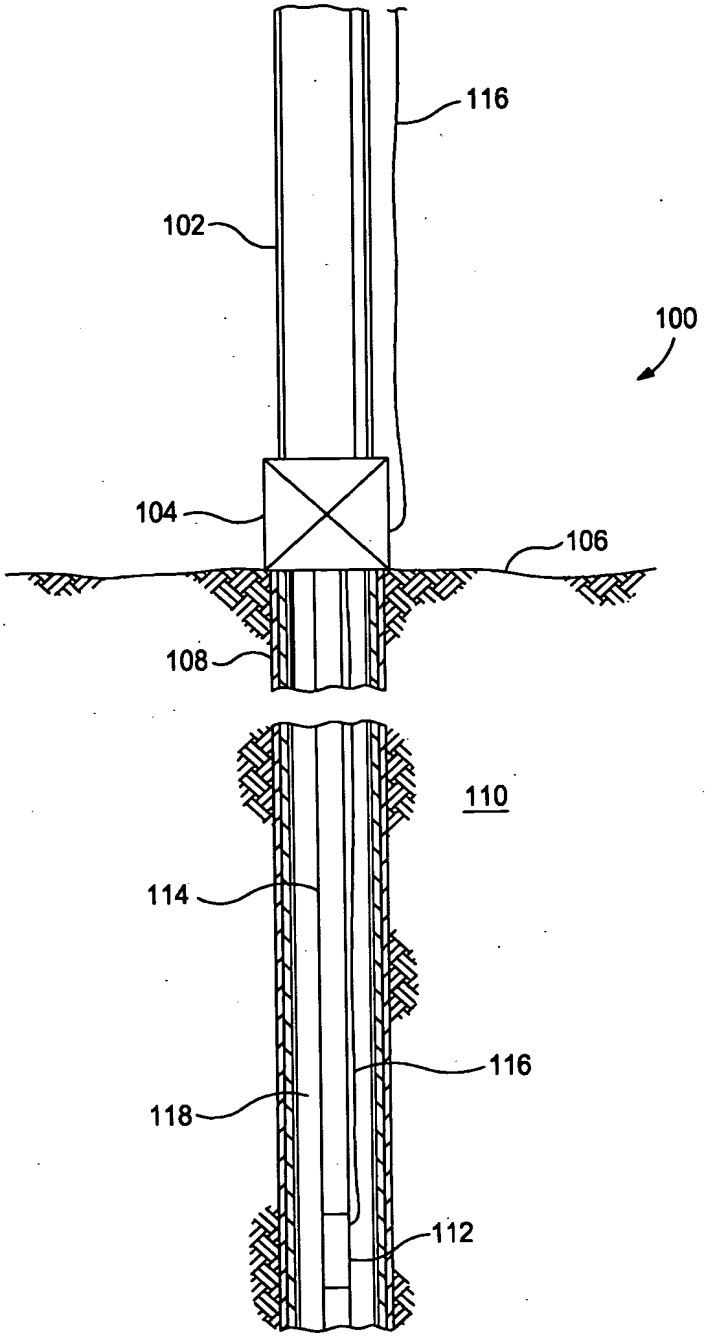

FIG. 1

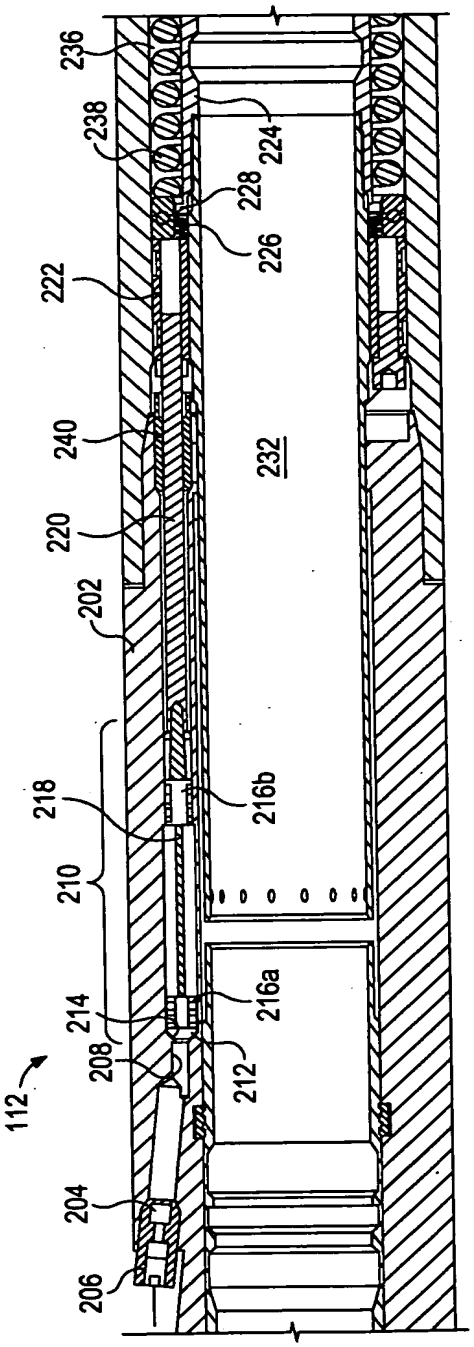
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FIG. 2A

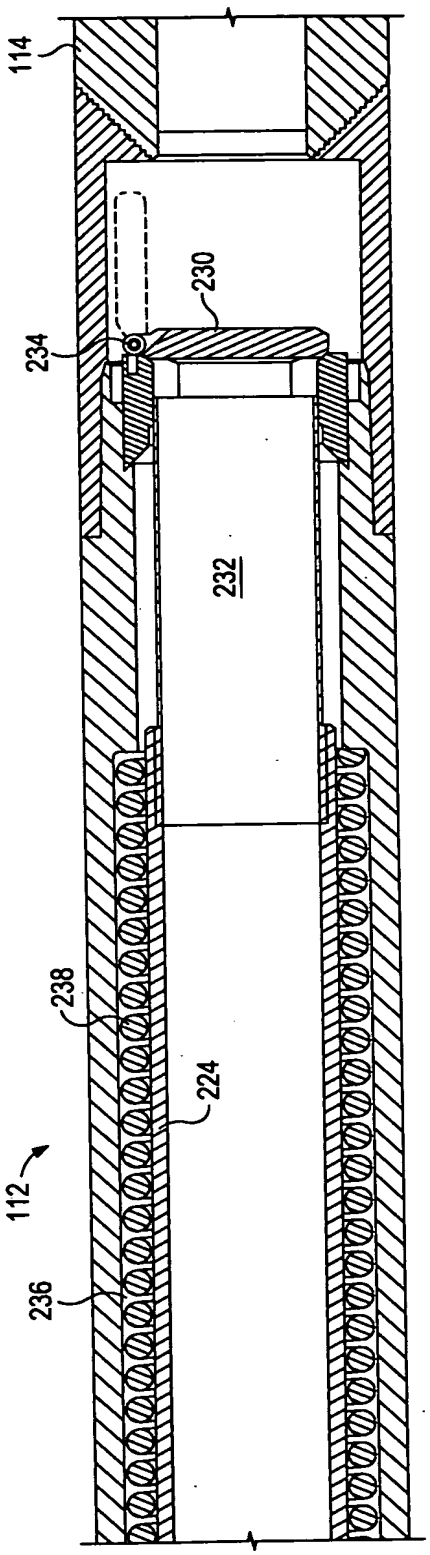
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FIG. 2B

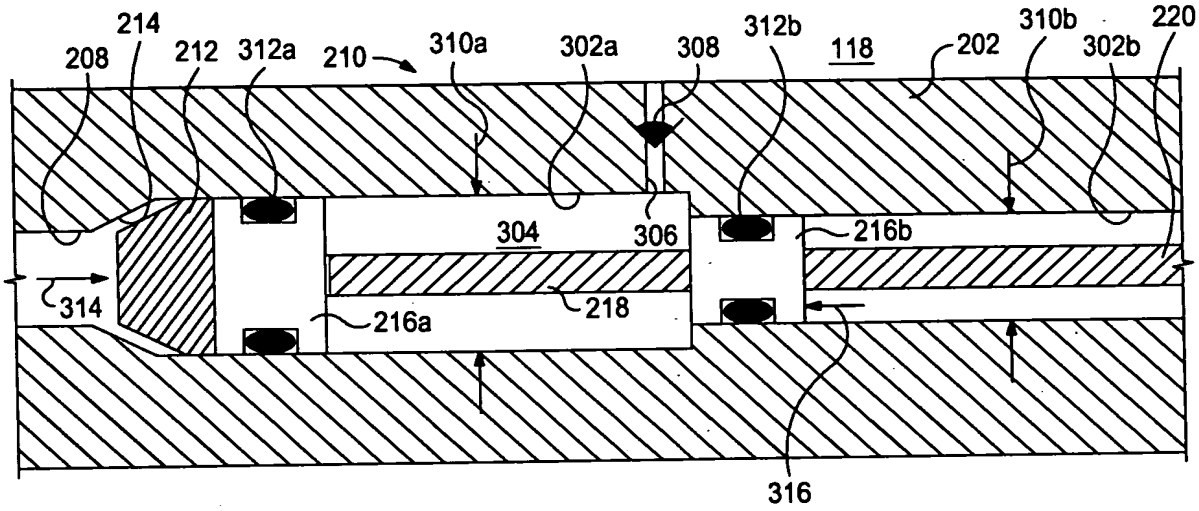
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FIG. 3A

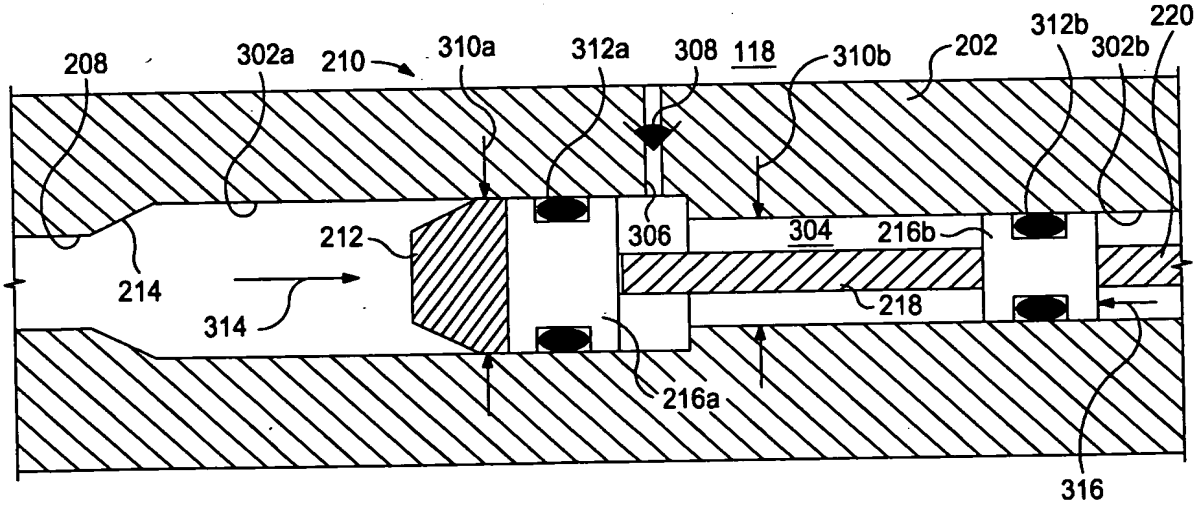
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FIG. 3B

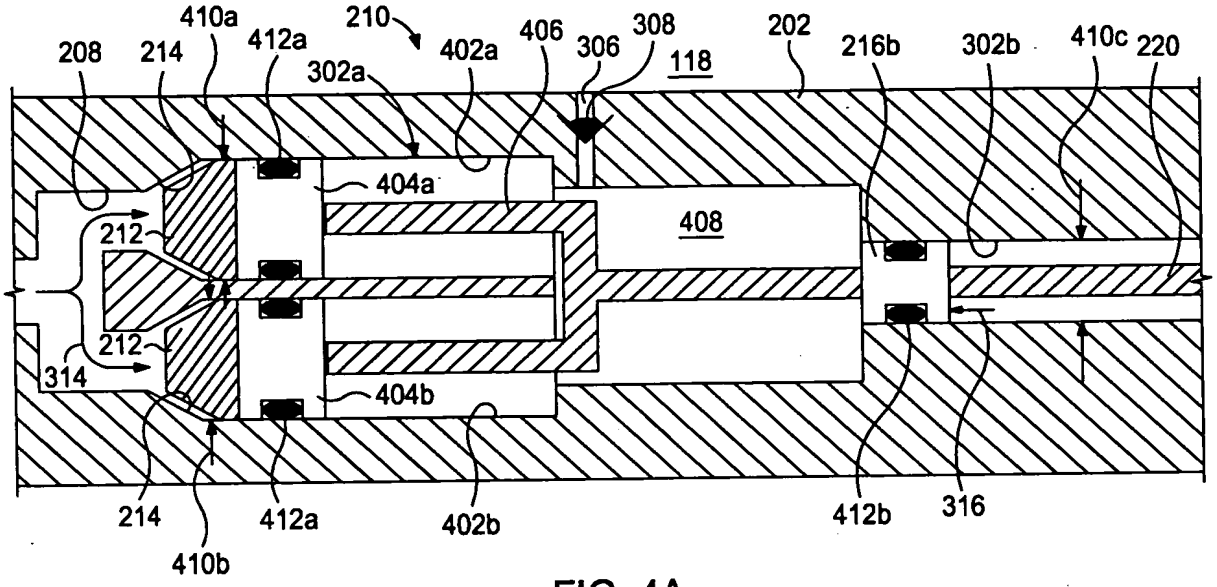
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FIG. 4A

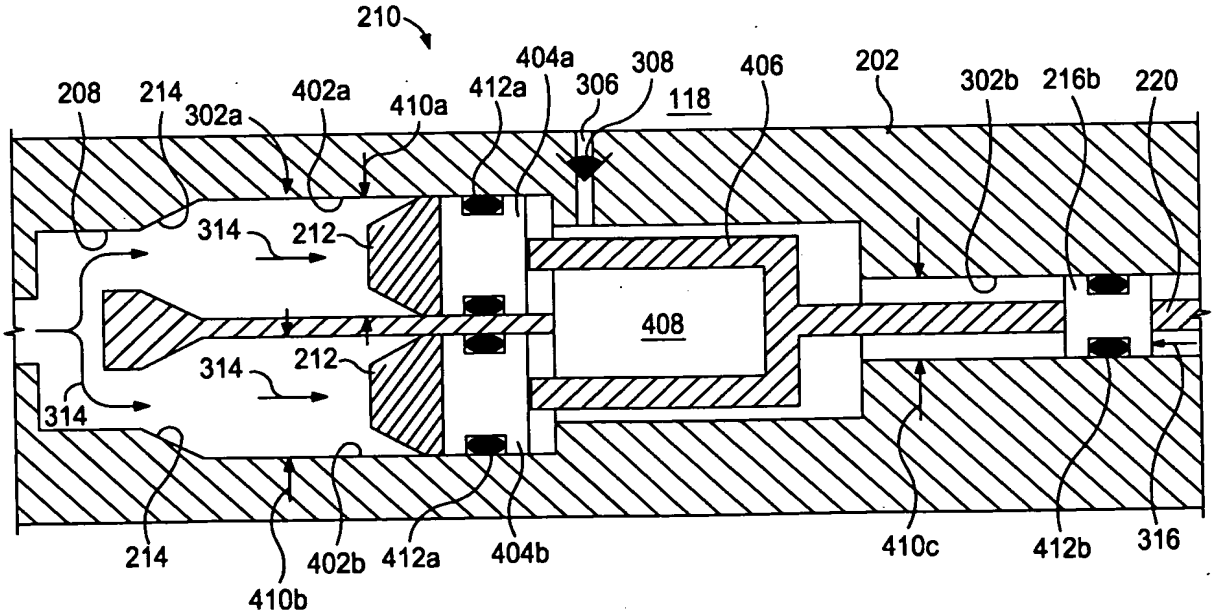
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FIG. 4B

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
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.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
14/374,473	07/24/2014	

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 $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ 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

07/24/2014	(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))	* 17	Minus	** 20	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	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

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 $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ 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.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** 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.

LIE
/CRYSTAL QUEEN/

Box No. VIII (ii) DECLARATION: ENTITLEMENT TO APPLY FOR AND BE GRANTED A PATENT

The declaration must conform to the standardized wording provided for in Section 212; see Notes to Boxes Nos. VIII, VIII (i) to (v) (in general) and the specific Notes to Box No. VIII (ii). If this Box is not used, this sheet should not be included in the request.

Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent (Rules 4.17(ii) and 51*bis*.1(a)(ii)), in a case where the declaration under Rule 4.17(iv) is not appropriate:

in relation to this international application

HALLIBURTON ENERGY SERVICES, INC., is entitled to apply for and be granted a patent by virtue of the following:

an assignment from:

SCOTT, Bruce Edward dated September 25, 2013, to HALLIBURTON ENERGY SERVICES, INC.

☐ This declaration is continued on the following sheet, "Continuation of Box No. VIII (ii)".

PCT

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/US13/61546
International Application No.

25 SEPT 2013 (25/09/13)
International Filing Date

PCT INTERNATIONAL APPLICATION RO/US
Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference *(if desired) (12 characters maximum)* 2013IP072581U1PC

Box No. I TITLE OF INVENTION

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

Box No. II APPLICANT ☐ This person is also inventor

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

HALLIBURTON ENERGY SERVICES, INC.
10200 Bellaire Boulevard
Houston, TX 77072
UNITED STATES OF AMERICA

Telephone No.

Facsimile No.

Applicant's registration No. with the Office

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send, notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☐ as advance copies followed by paper notifications; or ☐ exclusively in electronic form (no paper notifications will be sent).

E-mail address:

State *(that is, country)* of nationality: US

State *(that is, country)* of residence: US

This person is applicant for the purposes of: ☒ all designated States ☐ the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

☒ Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: ☒ agent ☐ common representative

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

KAISER, Iona N. (Reg. No. 53,086)
JORDAN, Carey C. (Reg. No. 47,646)
McDermott Will & Emery LLP
500 North Capitol Street, N.W.
Washington, D.C. 20001
UNITED STATES OF AMERICA

Telephone No. 202-756-8000

Facsimile No. 202-756-8087

Agent's registration No. with the Office 53,086

E-mail authorization: Marking one of the check-boxes below authorizes the receiving Office, the International Searching Authority, the International Bureau and the International Preliminary Examining Authority to use the e-mail address indicated in this Box to send, notifications issued in respect of this international application to that e-mail address if those offices are willing to do so.

☐ as advance copies followed by paper notifications; or ☒ exclusively in electronic form (no paper notifications will be sent).

E-mail address: mweipdocket@mwe.com

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

SCOTT, Bruce Edward
7220 Oakbury Lane
McKinney, TX 75071
UNITED STATES OF AMERICA

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☒ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)*

This person is:
- ☐ applicant only
- ☐ applicant and inventor
- ☐ inventor only *(If this check-box is marked, do not fill in below.)*

Applicant's registration No. with the Office

State *(that is, country)* of nationality:

State *(that is, country)* of residence:

This person is applicant for the purposes of: ☐ all designated States ☐ the States indicated in the Supplemental Box

☐ Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No. V DESIGNATIONS

The filing of this request **constitutes under Rule 4.9(a) the designation** of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.

However,

☐ DE Germany **is not designated** for any kind of national protection

☐ JP Japan **is not designated** for any kind of national protection

☐ KR Republic of Korea **is not designated** for any kind of national protection

(The check-boxes above may only be used to exclude (irrevocably) the designations concerned if, at the time of filing or subsequently under Rule 26bis.1, the international application contains in Box No. VI a priority claim to an earlier national application filed in the particular State concerned, in order to avoid the ceasing of the effect, under the national law, of this earlier national application.)

Box No. VI PRIORITY CLAIM AND DOCUMENT

The priority of the following earlier application(s) is hereby claimed:

Filing date of earlier application *(day/month/year)*	Number of earlier application	Where earlier application is:		
		national application: country or Member of WTO	regional application: regional Office	international application: receiving Office
item (1)				
item (2)				
item (3)				

☐ Further priority claims are indicated in the Supplemental Box.

Furnishing the priority document(s):

☐ The **receiving Office** is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) *(only if the earlier application(s) was filed with the receiving Office which, for the purposes of this international application, is the receiving Office)* identified above as:

☐ all items ☐ item (1) ☐ item (2) ☐ item (3) ☐ other, see Supplemental Box

☐ The **International Bureau** is requested to obtain from a digital library a certified copy of the earlier application(s) identified above, using, where applicable, the access code(s) indicated below *(if the earlier application(s) is available to it from a digital library)*:

☐ item (1) access code _____ ☐ item (2) access code _____ ☐ item (3) access code _____ ☐ other, see Supplemental Box

Restore the right of priority: the receiving Office is requested to restore the right of priority for the earlier application(s) identified above or in the Supplemental Box as item(s) (_____). *(See also the Notes to Box No. VI; further information **must** be provided to support a request to restore the right of priority.)*

Incorporation by reference: where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA) *(if more than one International Searching Authority is competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used)*:

ISA/ KR

Continuation of Box No. VII USE OF RESULTS OF EARLIER SEARCH, REFERENCE TO THAT SEARCH

☐ The ISA indicated in Box No. VII is requested to take into account the results of the earlier search(es) indicated below (*see also Notes to Box VII; use of results of more than one earlier search*).

Filing date *(day/month/year)*	Application Number	Country *(or regional Office)*

☐ **Statement (Rule 4.12(ii))**: this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

☐ **Availability of documents**: the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12*bis*.1(f)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a translation of the earlier application into a language which is accepted by the ISA,
- ☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
- ☐ a copy of any document cited in the results of the earlier search. *(If known, please indicate below the document(s) available to the ISA):*

☐ **Transmit copy of results of earlier search and other documents** *(where the earlier search **was not** carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office)*: the **receiving Office** is requested to prepare and transmit to the ISA (Rule 12*bis*.1(c)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12*bis*.1(a)) (*See item 11. in the check-list and also Notes to Box No. VII*).

Filing date *(day/month/year)*	Application Number	Country *(or regional Office)*

☐ **Statement (Rule 4.12(ii))**: this international application is the same, or substantially the same, as the application in respect of which the earlier search was carried out except, where applicable, that it is filed in a different language.

☐ **Availability of documents**: the following documents are available to the ISA in a form and manner acceptable to it and therefore do not need to be submitted by the applicant to the ISA (Rule 12*bis*.1(f)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a translation of the earlier application into a language which is accepted by the ISA,
- ☐ a translation of the results of the earlier search into a language which is accepted by the ISA,
- ☐ a copy of any document cited in the results of the earlier search. *(If known, please indicate below the document(s) available to the ISA):*

☐ **Transmit copy of results of earlier search and other documents** *(where the earlier search **was not** carried out by the ISA indicated above but by the same Office as that which is acting as the receiving Office)*: the **receiving Office** is requested to prepare and transmit to the ISA (Rule 12*bis*.1(c)):

- ☐ a copy of the results of the earlier search,*
- ☐ a copy of the earlier application,
- ☐ a copy of any document cited in the results of the earlier search.

* Where the results of the earlier search are neither available from a digital library nor transmitted by the receiving Office, the applicant is required to submit them to the receiving Office (Rule 12*bis*.1(a)) (*See item 11. in the check-list and also Notes to Box No. VII*).

☐ Further earlier searches are indicated on a continuation sheet.

Box No. VIII DECLARATIONS

The following **declarations** are contained in Boxes Nos. VIII (i) to (v) *(mark the applicable check-boxes below and indicate in the right column the number of each type of declaration)*:			Number of declarations
☐	Box No. VIII (i)	Declaration as to the identity of the inventor :	
☒	Box No. VIII (ii)	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent :	1
☐	Box No. VIII (iii)	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application :	
☐	Box No. VIII (iv)	Declaration of inventorship (only for the purposes of the designation of the United States of America) :	
☐	Box No. VIII (v)	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty :	

Box No. IX **CHECK LIST for EFS-Web filings** - this sheet is only to be used when filing an international application with RO/US via **EFS-Web**

This international application **contains** the following:	Number of sheets
(a) request form PCT/RO/101 (including any declarations and supplemental sheets)	6
(b) description (excluding any sequence listing part of the description, see (f), below)	19
(c) claims	4
(d) abstract	1
(e) drawings (if any)	4
(f) sequence listing part of the description in the form of an **image file** (e.g. PDF)	
Total number of sheets (including the sequence listing part of the description if **filed as an image file**)	34

(g) sequence listing part of the description

- ☐ filed in the form of an **Annex C/ST.25 text file**
- ☐ WILL BE filed separately on physical data carrier(s), on the same day and in the form of an **Annex C/ST.25 text file**

Indicate type and number of physical data carrier(s) .....

This international application is **accompanied by** the following item(s) *(mark the applicable check-boxes below and indicate in right column the number of each item):*	Number of items
1. ☒ fee calculation sheet	1
2. ☐ original separate power of attorney	
3. ☐ original general power of attorney	
4. ☐ copy of general power of attorney; reference number:	
5. ☐ priority document(s) identified in Box No. VI as item(s)	
6. ☐ Translation of international application into *(language)*:	
7. ☐ separate indications concerning deposited microorganism or other biological material	
8. ☐ *(only where item (f) is marked in the left column)* copy of the sequence listing in electronic form (Annex C/ST.25 text file) not forming part of the international application but **furnished only for the purposes of international search** under Rule 13*ter*	
9. ☐ *(only where item (f) is marked in the left column)* a statement confirming that "the information recorded in electronic form submitted under Rule 13*ter* is identical to the sequence listing as contained in the international application" as filed via EFS-Web:	
10. ☐ copy of results of earlier search(es) (Rule 12*bis*.1(a))	
11. ☒ other *(specify)*: PCT Transmittal	1

Figure of the drawings which should accompany the abstract:

Language of filing of the international application: English

Box No. X **SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

/Iona N. Kaiser/
Iona N. Kaiser, Reg. No. 53,086

For receiving Office use only

1. Date of actual receipt of the purported international application: 25 SEPT 2013 (25/09/13)
2. Drawings: ☐ received: ☐ not received:
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:
4. Date of timely receipt of the required corrections under PCT Article 11(2):
5. International Searching Authority (if two or more are competent): ISA / KR
6. ☐ Transmittal of search copy delayed until search fee is paid

For International Bureau use only

Date of receipt of the record copy by the International Bureau:

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference 2013IP072581	**FOR FURTHER ACTION** See item 4 below	
International application No. PCT/US2013/061546	International filing date *(day/month/year)* 25 September 2013 (25.09.2013)	Priority date *(day/month/year)*
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant HALLIBURTON ENERGY SERVICES, INC.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 9 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	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 Article 35(2) with regard to novelty, inventive step or 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

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 29 March 2016 (29.03.2016)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Athina Nickitas-Etienne e-mail: pt04.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KAISER IONA N.

MCDERMOTT WILL & EMERY LLP 500 NORTH
CAPITOL STREET, N.W. WASHINGTON DC 20001 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)* **26 June 2014 (26.06.2014)**

Applicant's or agent's file reference
2013IP072581

FOR FURTHER ACTION
See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/061546	**25 September 2013 (25.09.2013)**	

International Patent Classification (IPC) or both national classification and IPC
E21B 34/06(2006.01)i, E21B 34/12(2006.01)i

Applicant
HALLIBURTON ENERGY 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 43bis.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 66.1bis(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/KR	Date of completion of this opinion	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	25 June 2014 (25.06.2014)	LEE, Chang Ho Telephone No. +82-42-481-8398

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/061546

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 filed or furnished:

   a. (means)
   ☐ on paper
   ☐ in electronic form

   b. (time)
   ☐ in the international application as filed.
   ☐ together with the international application in electronic form.
   ☐ subsequently to this Authority for the purposes of search.

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 additioanl copies is identical to that in 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/US2013/061546

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

1. Statement

Novelty (N)	Claims	1-20	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	3-4,8-12,18-20	YES
	Claims	1-2,5-7,13-17	NO
Industrial applicability (IA)	Claims	1-20	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2008-0237993 A1 (BANE et al.) 02 October 2008

D2: US 2013-0092396 A1 (WEBBER et al.) 18 April 2013

D3: US 2013-0062071 A1 (RYTLEWSKI et al.) 14 March 2013

D4: US 8016035 B2 (STRATTAN et al.) 13 September 2011

D5: US 2009-0050327 A1 (ANDERSON et al.) 26 February 2009

1. Novelty and Inventive Step

1.1 Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a safety valve (10) comprising: a housing (100) which has cylindrical ports (104 and 108), wherein hydraulic fluid (liquid) acts on the opposite side of an actuating piston via a control line; pistons (84) being in slidable sealing engagement with the cylindrical ports (104, 108) and comprising an upper piston and a lower piston; and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves, wherein a cavity(122) is defined between the upper and lower pistons and the connecting rod extends within the cavity(122)(see paragraphs [0002]-[0003], [0017], [0022]-[0023] and figures 2, 6-7). Claim 1 differs from D1 in that the piston bore provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion

Continued on Supplemental Box

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

(114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 1 does not involve an inventive step under PCT Article 33(3).

1.2 Dependent Claims 2-12

1.2.1 Concerning Claim 2

The additional feature of claim 2, characterized in that the cavity contains a fluid, is not disclosed in D1. However, this feature is virtually suggested by D1 considering that the cavity (122) is fluidically connected through porting not shown to the control line(see paragraph [0023] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 2 does not involve an inventive step under PCT Article 33(3).

1.2.2 Concerning Claim 3

The additional feature of claim 3 differs from the features of D1-D5 in that the safety valve further comprises a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 3 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

1.2.3 Concerning Claim 4

Claim 4 is dependent on claim 3 and therefore meets the requirements of PCT Article 33(2) and 33(3).

1.2.4 Concerning Claim 5

The additional feature of claim 5 is identical to the feature of D1 in that the seals (90, 92) are in sealing engagement with the upper and lower pistons (84) and are in slidable sealing engagement with the cylindrical ports (104, 108)(see paragraphs [0022]-[0023] and figures 6-7). Accordingly, this claim would have been obvious by D1. Therefore, claim 5 does not involve an inventive step under PCT Article 33(3).

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
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1.2.5 Concerning Claim 6

The additional feature of claim 6 is identical to the feature of D1 in that the safety valve comprises: a piston rod that extends longitudinally from the lower piston; a flow tube (18) functionally engaging with the actuating pistons (42) such that movement of the actuating pistons (42) in a downhole direction causes a corresponding movement of the flow tube (18) in a downhole direction; and a flapper (22), wherein when the safety valve (10) is in the closed position (not shown), the flapper (22) is pivoted 90° such that the flapper (22) is substantially perpendicular to the axis of the flow tube (18) and seals against a seat (38)(see paragraphs [0018], [0020] and figures 2-5, 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 6 does not involve an inventive step under PCT Article 33(3).

1.2.6 Concerning Claim 7

he additional feature of claim 7 is identical to the feature of D1 in that the power spring (26) is positioned between the housing (30) and a shoulder (34) of the flow tube (18) such that it presents a biasing force to urge the flow tube (18) in the uphole direction toward the closed valve position, wherein the actuating piston (42) is functionally engaged with the flow tube (18)(see paragraphs [0018], [0020] and figures 2-5). Accordingly, this claim would have been obvious by D1. Therefore, claim 7 does not involve an inventive step under PCT Article 33(3).

1.2.7 Concerning Claim 8

The additional feature of claim 8 differs from the features of D1-D5 in that the upper bore is divided into a first upper bore and a second upper bore and that the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 8 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

1.2.8 Concerning Claims 9-12

Claims 9-12 are dependent on claim 8 and therefore meet the requirements of PCT Article 33(2) and 33(3).

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
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1.3 Independent Claim 13

D1, which is considered to be the closest prior art to the subject matter of claim 13, discloses a method of actuating a safety valve (10) comprising: making hydraulic fluid (liquid) act on the opposite side of an actuating piston in the cylindrical ports (104, 108) that are in slidable sealing engagement with the upper and lower piston (84), wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves, and wherein a cavity(122) is defined between the upper and lower pistons and the connecting rod extends within the cavity(122)(see paragraphs [0002]-[0003], [0022]-[0023] and figures 2, 6-7). Claim 13 differs from D1 in that the piston bore provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion (114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 13 does not involve an inventive step under PCT Article 33(3).

1.4 Dependent Claims 14-20

1.4.1 Concerning Claim 14

The additional feature of claim 14 is identical to the feature of D1 in that the actuating piston moves a flow tube in a downhole direction in response to a pressure increase supplied from surface via a control line(see paragraph [0017] and figure 2). Accordingly, this claim would have been obvious by D1. Therefore, claim 14 does not involve an inventive step under PCT Article 33(3).

1.4.2 Concerning Claim 15

The additional feature of claim 15, characterized in that a piston area of the upper piston is greater than a piston area of the lower piston, and that axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston, is not disclosed in D1. However, this feature is easily conceived from the disclosure of D1 considering that the cylindrical port (108) has two portions (112, 114), wherein the first portion (112) is dimensionally smaller than the second

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
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portion (114), and as such the seal (92) is sealably engagable with the first portion (112) while not being sealably engagable with the second portion (114)(see paragraph [0022] and figure 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 15 does not involve an inventive step under PCT Article 33(3).

1.4.3 Concerning Claim 16

The additional feature of claim 16 is identical to the feature of D1 in that the seals (90, 92) are in sealing engagement with the upper and lower pistons (84) and are in slidable sealing engagement with the cylindrical ports (104, 108)(see paragraphs [0022]-[0023] and figures 6-7). Accordingly, this claim would have been obvious by D1. Therefore, claim 16 does not involve an inventive step under PCT Article 33(3).

1.4.4 Concerning Claim 17

The additional feature of claim 17 is identical to the feature of D1 in that the safety valve comprises: a piston rod that extends longitudinally from the lower piston; a flow tube (18) functionally engaging with the actuating pistons (42) such that movement of the actuating pistons (42) in a downhole direction causes a corresponding movement of the flow tube (18) in a downhole direction; a power spring (26) positioned between the housing (30) and a shoulder (34) of the flow tube (18) such that it presents a biasing force to urge the flow tube (18) in the uphole direction toward the closed valve position; and a flapper (22), wherein when the safety valve (10) is in the closed position (not shown), the flapper (22) is pivoted 90° such that the flapper (22) is substantially perpendicular to the axis of the flow tube (18) and seals against a seat (38)(see paragraphs [0018], [0020] and figures 2-5, 7). Accordingly, this claim would have been obvious by D1. Therefore, claim 17 does not involve an inventive step under PCT Article 33(3).

1.4.5 Concerning Claim 18

The additional feature of claim 18 differs from the features of D1-D5 in that the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 18 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
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1.4.6 Concerning Claim 19

Claim 19 is dependent on claim 18 and therefore meets the requirements of PCT Article 33(2) and 33(3).

1.4.7 Concerning Claim 20

The additional feature of claim 20 differs from the features of D1-D5 in that the upper bore is divided into a first upper bore and a second upper bore, that the upper piston comprises a first upper piston and a second upper piston, and that the method further comprises: sealingly engaging the first upper bore with the first upper piston; and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston. And it is not obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 20 meets the requirements of PCT Article 33(2) and 33(3) with respect to novelty and inventive step.

2. Industrial Applicability

Claims 1-20 are industrially applicable under PCT Article 33(4).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
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(71) Applicant: **HALLIBURTON ENERGY SERVICES, INC.** [US/US]; 10200 Bellaire Boulevard, Houston, TX 77072 (US).

(72) Inventor: **SCOTT, Bruce, Edward**; 7220 Oakbury Lane, McKinney, TX 75071 (US).

(74) Agents: **KAISER, Iona, N.** et al.; McDermott Will & Emery LLP, 500 North Capitol Street, N.W., Washington, DC 20001 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, 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, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, 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, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

(54) Title: MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

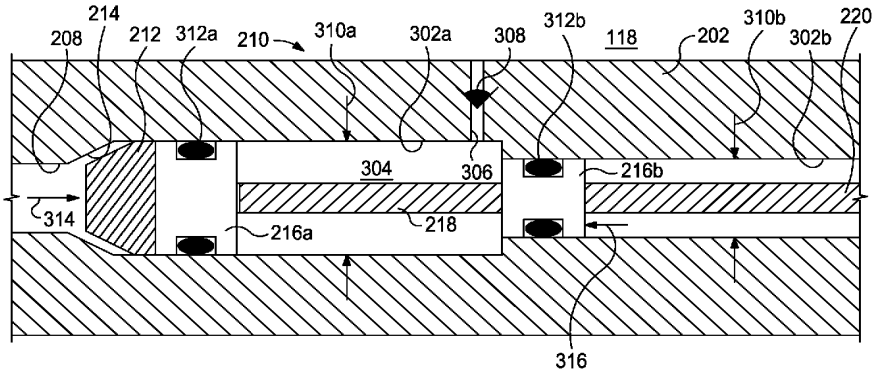

FIG. 3A

(57) Abstract: Disclosed are subsurface safety valves having multiple pistons used to increase the opening force. One safety valve includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons, wherein a cavity is defined between the upper and lower pistons within the piston bore and the piston rod extends within the cavity.

WO 2015/047235 A1

MULTIPLE PISTON PRESSURE INTENSIFIER FOR A SAFETY VALVE

BACKGROUND

[0001] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0002] Subsurface safety valves are well known in the oil and gas industry and act as a failsafe to prevent the uncontrolled release of reservoir fluids in the event of a worst-case scenario surface disaster. Typical subsurface safety valves are flapper-type valves that are opened and closed with the help of a flow tube moving telescopically within the production tubular. The flow tube is often controlled hydraulically from the surface and is forced into its open position using a piston and rod assembly that may be hydraulically charged via a control line linked directly to a hydraulic manifold or pressure control system at the well surface. When sufficient hydraulic pressure is conveyed to the subsurface safety valve via the control line, the piston and rod assembly forces the flow tube downwards, which compresses a spring and simultaneously pushes the flapper downwards to the open position. When the hydraulic pressure is removed from the control line, the spring pushes the flow tube back up, which allows the flapper to move into its closed position.

[0003] Depending on the size and depth of the safety valve deployed, the components of the pressure control system used to operate the safety valve can be quite expensive. The cost of a pressure control system may increase as required pressure ratings for the control line and/or the pump equipment increase, which is usually related to the operating depth of the safety valve. There are practical limits to the size and rating of pressure control systems, past which a well operator may not be able to economically or feasibly employ a subsurface safety valve. Accordingly, there is always a need in the industry for the ability to use lower rated pressure control systems for operating subsurface safety valves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The following figures are included to illustrate certain aspects of the present disclosure, and should not be viewed as exclusive embodiments. The subject matter disclosed is capable of considerable modifications, alterations, combinations, and equivalents in form and function, without departing from the scope of this disclosure.

[0005] FIG. 1 illustrates a well system that incorporates one or more principles of the present disclosure, according to one or more embodiments.

[0006] FIGS. 2A and 2B illustrate cross-sectional side views of the exemplary safety valve of FIG. 1, according to one or more embodiments.

[0007] FIGS. 3A and 3B illustrate enlarged cross-sectional side views of an exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

[0008] FIG. 4A and 4B illustrate enlarged cross-sectional side views of another exemplary embodiment of the piston assembly of FIG. 2A, according to one or more embodiments.

DETAILED DESCRIPTION

[0009] The present disclosure relates generally to operations performed and equipment utilized in conjunction with subterranean wells and, in particular, to subsurface safety valves having multiple pistons used to increase the opening force for the safety valve.

[0010] Disclosed is a subsurface safety valve configured to reduce the pressure required to open the valve at depth. The safety valve includes a piston assembly having a multiple piston configuration including a control pressure piston coupled to a section pressure piston such that the two pistons move simultaneously within a piston bore of the safety valve. The control pressure piston exhibits a larger piston area than the section pressure piston. As a result, hydraulic fluid provided to the piston bore via a control line will work on the larger piston area of the control pressure piston while the section pressure below the piston assembly will work on the smaller piston area of the section pressure piston. Since the piston area of the control pressure piston is enlarged, the control pressure is intensified such that lower rated pressure control systems may be employed.

[0011] Referring to FIG. 1, illustrated is a well system 100 that incorporates one or more principles of the present disclosure, according to one or more embodiments. As illustrated, the well system 100 may include a riser 102 extending from a wellhead installation 104 arranged at a sea floor 106. The riser 102 may extend, for example, to an offshore oil and gas platform (not shown). A wellbore 108 extends downward from the wellhead installation 104 through various subterranean formations 110. The wellbore 108 is depicted as being cased, but it could equally be an uncased wellbore 108, without departing from the scope of the disclosure. Although FIG. 1 depicts the well system 100 in the context of an offshore oil and gas application, it will be appreciated by those skilled in the art that the various embodiments disclosed herein are equally well suited for use in or on oil and gas rigs or service rigs, such as land-based oil and gas rigs or rigs located at any other geographical site. Thus, it should be understood that the disclosure is not limited to any particular type of well.

[0012] The well system 100 may further include a safety valve 112 interconnected with a tubing string 114 arranged within the wellbore 108 and extending from the wellhead installation 104. The tubing string 114 may be configured to communicate fluids derived from the wellbore 108 and the surrounding subterranean formations 110 to the well surface via the wellhead installation 104. A control line 116 may extend from the well surface and into the wellhead installation 104 which, in turn, conveys the control line 116 into an annulus 118 defined between the wellbore 108 and the tubing string 114. The control line 116 may extend downward within the annulus 118 and eventually become communicably coupled to the safety valve 112. As discussed in more detail below, the control line 116 may be configured to actuate the safety valve 112, for example, to maintain the safety valve 112 in an open position, or otherwise to close the safety valve 112 and thereby prevent a blowout in the event of an emergency.

[0013] The control line 116 may be a hydraulic conduit that provides hydraulic fluid pressure to the safety valve 112. In operation, hydraulic fluid may be applied to the control line 116 from a hydraulic pressure control system arranged at a remote location, such as at a production platform or a subsea control station. When properly applied, the hydraulic pressure derived from the control line 116 may be configured to open and maintain the safety valve 112 in its open position, thereby allowing production fluids to flow through the safety

valve 112, through the tubing string 114, and upwards towards the rig. To move the safety valve 112 from its open position and into a closed position, the hydraulic pressure in the control line 116 may be reduced or otherwise eliminated.

[0014] Although the control line 116 is depicted in FIG. 1 as being arranged external to the tubing string 114, it will be readily appreciated by those skilled in the art that any arrangement or configuration of the control line 116 may be used to convey actuation pressure to the safety valve 112. For example, the control line 116 could be arranged internal to the tubing string 114, or otherwise formed in a sidewall of the tubing string 114. The control line 116 could extend from a remote location, such as from the earth's surface, or another location in the wellbore 108. In yet other embodiments, the pressure required to actuate the safety valve 112 may be derived from a pressure control system located downhole and communicably coupled to the control line 116 at a location.

[0015] In the following description of the representative embodiments of the disclosure, directional terms such as "above", "below", "upper", "lower", etc., are used for convenience in referring to the accompanying drawings. In general, "above", "upper", "upward" and similar terms refer to a direction toward the earth's surface along the wellbore 108, and "below", "lower", "downward" and similar terms refer to a direction away from the earth's surface along the wellbore 108.

[0016] Referring now to FIGS. 2A and 2B, with continued reference to FIG. 1, illustrated are cross-sectional side views of an exemplary embodiment of the safety valve 112, according to one or more embodiments. In particular, the safety valve 112 is depicted in FIGS. 2A and 2B in successive sectional views, where FIG. 2A depicts an upper portion of the safety valve 112 and FIG. 2B depicts a lower portion of the safety valve 112. As illustrated, the safety valve 112 may include a housing 202 that is able to be coupled to the tubing string 114 at opposing ends of the housing 202 (tubing string 114 shown only in FIG. 2B).

[0017] A control line port 204 may be defined or otherwise provided in the housing 202 for connecting the control line 116 (FIG. 1) to the safety valve 112. The port 204 is shown in FIG. 2A as being plugged with a set screw 206 or other type of plugging device. However, when the control line 116 is

appropriately connected to the first port 204 the control line 116 is placed in fluid communication with a piston bore 208 and able to convey hydraulic fluid pressure thereto. The piston bore 208 may be an elongate channel or conduit defined within the housing 202 and configured to extend longitudinally along a portion of the axial length of the safety valve 112.

[0018] A piston assembly 210 may be arranged within the piston bore 208 and configured to translate axially therein. The piston assembly 210 may include a piston head 212 configured to mate with and otherwise bias an up stop 214 defined within the piston bore 208 when the piston assembly 210 is forced upwards in the direction of the control line port 204. The up stop 214 may be a radial shoulder defined within the piston bore 208 and having a reduced diameter and an axial surface configured to engage a corresponding axial surface of the piston head 212. In other embodiments, the up stop 214 may be any device or means arranged within the piston bore 208 that is configured to stop the axial movement of the piston assembly 210 as it advances upward within the piston bore and toward the control line port 204.

[0019] The piston assembly 210 may also include a first or upper piston 216a and a second or lower piston 216b coupled thereto via a connecting rod 218. The lower piston 216b may be coupled to a piston rod 220 that extends longitudinally from the piston assembly 210 through at least a portion of the piston bore 208. At a distal end thereof, the piston rod 220 may be coupled to an actuator sleeve 222, which may be configured to effectively couple the piston assembly 210 to a flow tube 224 that is movably arranged within the safety valve 112. More particularly, the actuator sleeve 222 may engage a biasing device 226 (*e.g.*, a compression spring, a series of Belleville washers, or the like) arranged axially between the actuator sleeve 222 and an actuation flange 228 that forms part of the proximal end of the flow tube 224. As the actuator sleeve 222 acts on the biasing device 226 (*e.g.*, axial force), the actuation flange 228 and the flow tube 224 correspondingly move.

[0020] Referring to FIG. 2B, the safety valve 112 may also include a valve closure device 230 that selectively opens and closes a flow passage 232 defined through the interior of the safety valve 112. The valve closure device 230 may be a flapper, as generally known to those skilled in the art. It should be noted, however, that although the safety valve 112 is depicted as being a flapper-type safety valve, those skilled in the art will readily appreciate that any

type of closure device 230 may be employed, without departing from the scope of the disclosure. For example, in some embodiments, the closure device 230 could instead be a ball, a sleeve, etc.

[0021] As shown in FIG. 2B, the closure device 230 is in its closed position whereby the closure device 230 is able to substantially block fluid flow into and through the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B). A torsion spring 234 biases the closure device 230 to pivot to its closed position. As described below, the piston assembly 210 is used to displace the flow tube 224 downward (*i.e.*, to the right in FIG. 2B) to engage the closure device 230 and overcome the spring force of the torsion spring 234. When the flow tube 224 is extended to its downward position, it engages the closure device 230 and moves the closure device 230 from its closed position to an open position (shown in phantom as dashed lines). When the flow tube 224 is displaced back upward (*i.e.*, to the left in FIG. 2B), the torsion spring 234 is able to pivot the closure device 230 back to its closed position. Axial movement of the piston assembly 210 within the piston bore 208 will force the flow tube 224 to correspondingly move axially within the flow passage 232, and either open the closure device 230 or allow it to close, depending on its relative position.

[0022] The safety valve 112 may further define a lower chamber 236 within the housing 202. In some embodiments, the lower chamber 236 may form part of the piston bore 208, such as being an elongate extension thereof. A power spring 238, such as a coil or compression spring, may be arranged within the lower chamber 236. The power spring 238 may be configured to bias the actuation flange 228 and actuation sleeve 222 upwardly which, in turn, biases the piston assembly 210 in the same direction. Accordingly, expansion of the power spring 238 will cause the piston assembly 210 to move upwardly within the piston bore 208.

[0023] It should be noted that while the power spring 238 is depicted as a coiled compression spring, any type of biasing device may be used instead of, or in addition to, the power spring 238, without departing from the scope of the disclosure. For example, a compressed gas, such as nitrogen, with appropriate seals may be used in place of the power spring 238. In other embodiments, the compressed gas may be contained in a separate chamber and tapped when needed.

[0024] In exemplary operation, the safety valve 112 may be actuated in order to open the closure device 230. This may be accomplished by conveying a hydraulic fluid under pressure to the control line port 204 via the control line 116 (FIG. 1). As hydraulic pressure is provided to the piston bore 208, the piston assembly 210 may be forced to move axially downward within the piston bore 208. As the piston assembly 210 moves, the piston rod 220 mechanically transfers the hydraulic force to the actuation sleeve 222 and the actuation flange 228, thereby correspondingly displacing the flow tube 224 in the downward direction. In other words, as the piston assembly 210 moves axially within the piston bore 208, the flow tube 224 correspondingly moves in the same direction. As the flow tube 224 moves downward, it engages the closure device 230, overcomes the spring force of the torsion spring 234, and thereby pivots the closure device 230 to its open position to permit fluids to enter the flow passage 232 from downhole (*i.e.,* from the right in FIG. 2B).

[0025] Moreover, as the piston assembly 210 moves axially downward within the piston bore 208, the power spring 238 is compressed within the lower chamber 236 and progressively builds spring force. In at least one embodiment, the piston assembly 210 will continue its axial movement in the downward direction, and thereby continue to compress the power spring 238, until engaging a down stop 240 (FIG. 2A) arranged within the piston bore 208. A metal-to-metal seal may be created between the piston assembly 210 and the down stop 240 such that the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough is generally prevented.

[0026] Upon reducing or eliminating the hydraulic pressure provided via the control line 116, the spring force built up in the power spring 238 may be allowed to release and displace the piston assembly 210 upwards within the piston bore 208, thereby correspondingly moving the flow tube 224 in the same direction. The section pressure within the safety valve 112 below the lower piston 216b also serves to move the piston assembly 210 upwards within the piston bore 208. As the flow tube 224 moves axially upwards, it will eventually move out of engagement with the closure device 230. Once free from engagement with the flow tube 224, the spring force of the torsion spring 234 will pivot the closure device 230 back into its closed position.

[0027] In at least one embodiment, the piston assembly 210 will continue its axial movement in the upward direction until the piston head 212 of

the piston assembly 210 engages the up stop 214 and effectively prevents the piston assembly 210 from further upward movement. Engagement between the piston head 212 and the up stop 214 may generate a mechanical metal-to-metal seal between the two components to prevent the migration of fluids (*e.g.*, hydraulic fluids, production fluids, etc.) therethrough.

[0028] When the safety valve 112 is deployed downhole, the "section" pressure, or fluid pressure present within the wellbore 108 (FIG. 1) and annulus 118 (FIG. 1) at depth, cooperatively act on the piston assembly 210. More specifically, the section pressure acts on the downhole end of the piston assembly 210 via the piston bore 208, and provides a corresponding closing force on the safety valve 112 that urges the piston assembly 210 toward the up stop 214. In order to open the safety valve 112, the piston assembly 210 must effectively overcome the section pressure and the spring force of the power spring 238. To do this, the hydraulic fluid pressure ("control" pressure) conveyed into the piston bore 208 via the control line 116 (FIG. 1) must be supplied at a pressure that exceeds the combined force of the section pressure and the power spring 238. Moreover, this hydraulic pressure must incrementally increase as the piston assembly 210 translates downward within the piston bore 208 to counteract the increasing spring force that builds as the power spring 238 is compressed. As indicated above, this oftentimes requires expensive pressure control systems that may be infeasible or uneconomical for some applications.

[0029] According to one or more embodiments of the present disclosure, the pressure required to open the safety valve 112 may be reduced or otherwise minimized by increasing the downward force derived from the control pressure and simultaneously decreasing the upward force derived from the section pressure. This can be accomplished by having a multiple piston configuration in the piston assembly 210 whereby the control pressure piston (*i.e.*, the first piston 216a) exhibits a larger piston area than the section pressure piston (*i.e.*, the second piston 216b). As a result, the control pressure will work on the larger piston area of the control pressure piston and the section pressure will work on the smaller piston area of the section pressure piston, thereby intensifying the available force from the control pressure.

[0030] Referring now to FIGS. 3A and 3B, with continued reference to FIGS. 2A and 2B, illustrated are enlarged cross-sectional side views of an exemplary embodiment of the piston assembly 210, according to one or more

embodiments. Like numerals in FIGS. 3A and 3B that are used in prior figures indicate like elements and/or components that will not be described again in detail. FIG. 3A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 3B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0031] As illustrated, the piston assembly 210 may be arranged within the piston bore 208 defined in the housing 202 of the safety valve 112 (FIGS. 2A-2B). The piston bore 208 may be divided into a first or upper bore 302a and a second or lower bore 302b. The first piston 216a may be generally arranged in the upper bore 302a, and the second piston 216b may be generally arranged in the lower bore 302b. The first and second pistons 216a,b may be axially offset from each other within the piston bore 208 and coupled together using the connecting rod 218. The connecting rod 218 may threadably or mechanically attach the first and second pistons 216a,b to each other such that simultaneous movement of each piston 216a,b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0032] With the first and second pistons 216a,b structurally coupled via the connecting rod 218, a chamber or cavity 304 may be defined therebetween within the piston bore 208. The cavity 304 may be configured to correspondingly move with the first and second pistons 216a,b when the piston assembly 210 moves within the piston bore 208. In some embodiments, the cavity 304 may be filled with a fluid. In one or more embodiments, for example, the cavity 304 may be filled with a gas, such as air or an inert gas (*e.g.*, nitrogen, argon, etc.). In other embodiments, however, the cavity 304 may be filled with a hydraulic fluid, a wellbore fluid, water (*i.e.*, brine, fresh water, etc.), or any other liquid.

[0033] In one or more embodiments, the cavity 304 may be ported to the annulus 118 within the wellbore 108 (FIG. 1) where the safety valve 112 (FIGS. 2A-2B) is to be located. More particularly, the piston assembly 210 may further include a conduit 306 defined in the housing 202 that places the cavity 304 in fluid communication with the annulus 118 surrounding the safety valve 112. Porting the cavity 304 to the annulus 118 may help compensate for expansion and contraction of the fluid within the cavity 304 as the wellbore 108 heats up or cools down. At increased temperatures, the pressure within the

cavity 304 will increase and porting the fluid to the annulus 118 may help maintain a safe operating pressure equilibrium. Porting the fluid to the annulus 118 may also prevent the first and second pistons 216a,b from locking under vacuum as temperatures decrease in the cavity 304 and the pressure correspondingly decreases.

[0034] In at least one embodiment, a pressure regulator 308 may be arranged within the conduit 306. The pressure regulator 308 may be used to generally separate the fluid within the cavity 304 from any fluids present in the annulus 118. In operation, the pressure regulator 308 may be configured to axially translate within the conduit 306, thereby separating the fluid within the cavity 304 from fluids in the annulus 118, but also compensate for expansion and contraction of the fluid within the cavity 304 and thereby help maintain safe operating pressure equilibrium. In some embodiments, the pressure regulator 308 may be a balance piston. In other embodiments, however, the pressure regulator 308 may be a floating piston, or the like, without departing from the scope of the disclosure.

[0035] The upper bore 302a may exhibit a first diameter 310a and the lower bore 302b may exhibit a second diameter 310b that is smaller or less than the first diameter 310a. The first piston 216a may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the upper bore 302a, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first piston 216a may include one or more first dynamic seals 312a and the second piston 216b may include one or more second dynamic seals 312b.

[0036] As used herein, the term "dynamic seal" is used to indicate a seal that provides pressure isolation between members that have relative displacement therebetween, for example, a seal which seals against a displacing surface, or a seal carried on one member and sealing against the other member, etc. A dynamic seal may comprise a material selected from the following: elastomeric materials, non-elastomeric materials, metals, composites, rubbers, ceramics, derivatives thereof, and any combination thereof. A dynamic seal may be attached to each of the relatively displacing members, such as a bellows or a flexible membrane. A dynamic seal may be attached to either of the relatively displacing members, such as in the case of a floating piston.

[0037] The first and second dynamic seals 312a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the first dynamic seal 312a may be configured to seal against the inner wall of the upper bore 302a as the first piston 216a moves therein, and the second dynamic seal 312b may be configured to seal against the inner wall of the lower bore 302b as the second piston 216b moves therein. As a result, the first and second dynamic seals 312a,b may be configured to prevent any fluids from migrating past the first and second pistons 216a,b respectively. In some embodiments, one or both of the first and second dynamic seals 312a,b may be O-rings or the like, as illustrated. In other embodiments, however, one or both of the first and second dynamic seals 312a,b may be v-rings or CHEVRON® packing rings or other appropriate seal configurations (*e.g.*, seals that are round, v-shaped, u-shaped, square, oval, t-shaped, etc.), as generally known to those skilled in the art.

[0038] In exemplary operation, hydraulic pressure or "control" pressure (generally indicated by the arrow 314) is introduced into the piston bore 208 via the control line 116 (FIG. 1) and associated port 204 (FIG. 2A). The control pressure 314 communicates with and otherwise acts on the first piston 216a, thereby separating the piston head 212 from the up stop 214 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 3A and 3B). An opposing "section" pressure (generally indicated by the arrow 316) communicates with and otherwise acts on the second piston 216b. As mentioned above, the section pressure 316 and the spring force of the power spring 238 (FIGS. 2A-2B) cooperatively act against the control pressure 314.

[0039] Referring to FIG. 3B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the cavity 304 defined between the first and second pistons 216a,b. As generally described above, while the piston assembly 210 moves from its first position into its second position, the piston rod 220 mechanically transfers the hydraulic force of the control pressure 314 to the flow tube 224 (FIGS. 2A-2B), thereby correspondingly displacing the flow tube 224 in the downward direction and opening the closure device 230 (FIG. 2B). Moreover, while the piston assembly 210 moves from its first position into its second position, the first and second dynamic seals 312a,b sealingly engage the inner walls of the upper and lower bores 302a,b, respectively.

[0040] Since the piston area of the first piston 216a is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 is correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area, the section pressure 316 applied to the second piston 216b is minimized with respect to the first piston 216a and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ a smaller or reduced pressure control system used to convey the control pressure 314 to the safety valve 112, including using control lines and pump equipment that exhibit lower pressure ratings than would otherwise be used in a safety valve at similar depths. Smaller or reduced pressure control systems may be advantageous for safety reasons (*i.e.*, lower pressures are typically safer than higher pressures), cost (*i.e.*, reducing the size of the pump and the pressure rating of the pump and control lines can result in significant cost savings), and physical restraints (*i.e.*, lower pressure equipment normally exhibits a smaller footprint than higher pressure equipment).

[0041] Referring now to FIGS. 4A and 4B, with continued reference to FIGS. 2A-2B and 3A-3B, illustrated are enlarged cross-sectional side views of another exemplary embodiment of the piston assembly 210, according to one or more embodiments. Like numerals are used to indicate like elements and/or components from prior figures that will not be described again in detail. FIG. 4A depicts the piston assembly 210 in a first position, where the safety valve 112 (FIGS. 2A-2B) is closed, as generally discussed above. FIG. 4B depicts the piston assembly 210 in a second position, where the safety valve 112 has been opened, as also generally discussed above.

[0042] Similar to the piston assembly 210 depicted in FIGS. 3A-3B, the piston assembly 210 in FIGS. 4A-4B is arranged within the piston bore 208 defined in the housing 202 and the piston bore 208 includes an upper bore 302a and a lower bore 302b. The upper bore 302a in FIGS. 4A-4B, however, may be divided into a first upper bore 402a and a second upper bore 402b to accommodate a first upper piston 404a and a second upper piston 404b. In some embodiments, the first and second upper bores 402a,b may be radially offset from each other within the housing 202 (*i.e.*, radially offset from each other with respect to the longitudinal central axis of the safety valve 112). In other embodiments, the first and second upper bores 402a,b may be angularly or circumferentially offset from each other within the housing 202. In other

words, the first and second upper bores 402a,b may also be laterally offset from each other about the circumference of the housing 202, without departing from the scope of the disclosure.

[0043] The first and second upper pistons 404a,b may be operably coupled to each other with a connecting rod 406. The connecting rod 406 may be u-shaped and/or otherwise connected at an intermediate point such that it is able to extend into each of the first and second upper bores 402a,b and attach to the first and second upper pistons 404a,b. As a result, the first and second upper pistons 404a,b are able to move simultaneously and thereby act as a single piston member. The connecting rod 406 may also be coupled to the second or lower piston 216b. The connecting rod 406 may threadably or mechanically attach the first and second upper pistons 404a,b to the second piston 216b such that simultaneous movement of each piston 404a,b and 216b is achieved when the piston assembly 210 axially translates within the piston bore 208.

[0044] A cavity 408 may be defined between the first and second upper pistons 404a,b and the second piston 216b within the piston bore 208. The cavity 408 may be configured to correspondingly move or shift within the piston bore 208 when the piston assembly 210 moves therein. Similar to the cavity 304 of FIGS. 3A-3B, the cavity 408 may be filled with a fluid, such as a gas (*e.g.*, air, an inert gas, etc.), or a liquid (*e.g.*, hydraulic fluid, wellbore fluid, water, such as brine or fresh water), combinations thereof, or the like. As illustrated, the cavity 408 may also be ported to the annulus 118 via the conduit 306 in order to place the cavity 408 in fluid communication with the annulus 118. In some embodiments, the pressure regulator 308 may be arranged within the conduit 306 in order to maintain pressure equilibrium within the cavity 408.

[0045] The first upper bore 402a may exhibit a first diameter 410a, the second upper bore 402b may exhibit a second diameter 410b, and the lower bore 302b may exhibit a third diameter 410c. In some embodiments, the first and second diameters 410a,b may be the same. In other embodiments, the first and second diameters 410a,b may be different. Moreover, in some embodiments, one or both of the first and second diameters 410a,b may be greater than the third diameter 410c. In other embodiments, one or both of the first and second diameters 410a,b may be smaller than the third diameter 410c. In any event, the combined sizing of the first and second diameters 410a,b is

greater than the third diameter 410c, such that the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b.

[0046] The first and second upper pistons 404a,b may be sized or otherwise configured to sealingly engage the inner walls of the first and second upper bores 402a,b, respectively, and the second piston 216b may be sized or otherwise configured such that it is able to sealingly engage the inner wall of the lower bore 302b. To accomplish this, the first and second upper pistons 404a,b may include one or more first dynamic seals 412a and the second piston 216b may include one or more second dynamic seals 412b. Similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be configured to "dynamically" seal against corresponding portions of the inner wall of the piston bore 208 as the piston assembly 210 moves axially therein. More particularly, the dynamic seal 412a of the first upper piston 404a may be configured to seal against the inner wall of the first upper bore 402a, the dynamic seal 412a of the second upper piston 404b may be configured to seal against the inner wall of the second upper bore 402b, and the dynamic seal 412b of the second piston 216b may be configured to seal against the inner wall of the lower bore 302b. Moreover, similar to the dynamic seals 312a,b of FIGS. 3A-3B, the dynamic seals 412a,b may be one of an O-ring, one or more v-rings or CHEVRON® packing rings, or other appropriate seal configurations described herein.

[0047] In exemplary operation, hydraulic control pressure 314 is introduced into the piston bore 208 in order to act on the piston assembly 210 and move the safety valve 112 (FIGS. 2A-2B) into the open position. More particularly, the control pressure 314 may be provided to the control line port 204 (FIG. 2A) via the control line 116 (FIG. 1), and the control line port 204 may feed the hydraulic fluid into the piston bore 208, which splits and feeds the control pressure 314 into the first and second upper bores 402a,b. The control pressure 314 communicates with and otherwise acts on the first and second upper pistons 404a,b, thereby separating the piston head 212 of each first and second upper piston 404a,b from corresponding up stops 214 defined in the piston bore 208 and moving the piston assembly 210 in the downward direction (*i.e.*, to the right in FIGS. 4A and 4B). The opposing section pressure 316 communicates with and otherwise acts on the second piston 216b.

[0048] As shown in FIG. 4B, the piston assembly 210 has moved to the second position, thereby correspondingly moving the flow tube 224 (FIGS. 2A-2B) in the downward direction and opening the closure device 230 (FIG. 2B), as generally described above. Moreover, while the piston assembly 210 moves from the first position into the second position, the dynamic seals 412a,b sealingly engage the inner walls of the first and second upper bores 402a,b and the lower bore 302b, respectively.

[0049] Adding additional pistons to the piston assembly 210 increases the piston area available for the control pressure 314 to act on in moving the piston assembly 210 from its first position (FIG. 4A) to its second position (FIG. 4B). Since the combined piston area of the first and second upper pistons 404a,b is greater than the piston area of the second piston 216b, the control pressure 314 required to open the safety valve 112 has been correspondingly reduced. Moreover, since the second piston 216b exhibits a smaller piston area than the combined piston areas of the first and second upper pistons 404a,b, the section pressure 316 applied to the second piston 216b is minimized with respect to the first and second upper pistons 404a,b and thereby more easily overcome by the control pressure 314. As a result, an operator may be able to employ smaller or less expensive pressure control equipment used to convey the control pressure 314 to the safety valve 112.

[0050] Furthermore, by employing additional upper pistons in the piston assembly 210, an operator may be able to obtain a desired ratio between the upper and lower pistons, thereby allowing for smaller upper pistons. Smaller upper pistons can reduce the effective cross section of the upper piston section, which can effectively reduce the outer diameter of the subsurface safety valve. As a result, the overall cost of the safety valve may correspondingly be reduced and allow the safety valve to be used in a greater number of wells. Moreover, a smaller outer diameter fort he safety valve allows the operator to run smaller casing whereas a larger outer diameter safety valve requires the operator to run larger casing which increases well completion costs.

[0051] While FIGS. 4A and 4B depict first and second upper pistons 404a,b being used in the piston assembly 210, it will be appreciated that more than two upper pistons (*e.g.*, first pistons 302a) may be employed without departing from the scope of the disclosure. Each additional upper piston may be operatively coupled to the control rod 406 and effectively increase the piston

area available for the control pressure 314 to act on, thereby reducing the required amount of control pressure 314 to open the safety valve.

[0052] Embodiments disclosed herein include:

[0053] A. A safety valve that includes a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore, and a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

[0054] B. A method of actuating a safety valve that includes conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore, axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston, wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

[0055] Each of embodiments A and B may have one or more of the following additional elements in any combination: Element 1: wherein the cavity contains a fluid. Element 2: further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing. Element 3: further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing. Element 4: wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively. Element 5: further comprising a piston rod

that extends longitudinally from the lower piston through at least a portion of the piston bore, a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly, and a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions. Element 6: further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore. Element 7: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore. Element 8: wherein the first and second upper bores are radially offset from each other within the housing. Element 9: wherein the first and second upper bores are angularly offset from each other about a circumference of the housing. Element 10: wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons. Element 11: wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0056] Element 12: wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line. Element 13: wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston. Element 14: wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively. Element 15: wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising axially displacing the flow tube as the piston assembly moves within the piston bore, compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure, and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position. Element 16: wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly. Element 17: further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit. Element 18: wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising sealingly engaging the first upper bore with the first upper piston, and sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

[0057] Therefore, the disclosed systems and methods are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the teachings of the present disclosure may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined, or modified and all such variations are considered within the scope of the present disclosure. The systems and methods illustratively disclosed herein may suitably be practiced in the absence of any element that is not specifically disclosed herein and/or any optional element disclosed herein. While compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of

values. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces. If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

CLAIMS

What is claimed is:

1. A safety valve, comprising:

a housing having a piston bore defined therein and configured to receive hydraulic fluid pressure from a control line, the piston bore providing an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter;

a piston assembly movably arranged within the piston bore and comprising an upper piston arranged in and configured to sealingly engage the upper bore and a lower piston arranged in and configured to sealingly engage the lower bore; and

a connecting rod coupling the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, wherein a cavity is defined between the upper and lower pistons and the connecting rod extends within the cavity.

2. The safety valve of claim 1, wherein the cavity contains a fluid.

3. The safety valve of claim 2, further comprising a conduit defined in the housing that fluidly communicates the cavity with a region surrounding the housing.

4. The safety valve of claim 3, further comprising a pressure regulator arranged within the conduit for balancing pressures between the cavity and the region surrounding the housing.

5. The safety valve of claim 1, wherein the upper and lower pistons each comprise one or more dynamic seals configured to seal against corresponding inner walls of the upper and lower bores, respectively.

6. The safety valve of claim 1, further comprising:

a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore;

a flow tube operably coupled to the piston rod and movably arranged within a flow passage defined in the safety valve in response to the movement of the piston assembly; and

a valve closure device movable between an open position and a closed position and adapted to restrict fluid flow through the flow passage

when in the closed position, wherein the flow tube is adapted to shift the valve closure device between open and closed positions.

7. The safety valve of claim 1, further comprising a power spring arranged within a lower chamber defined within the housing and configured to bias the piston assembly upwardly within the piston bore.

8. The safety valve of claim 1, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston arranged within and sealingly engaging the first upper bore and a second upper piston arranged within and sealing engaging the second upper bore.

9. The safety valve of claim 8, wherein the first and second upper bores are radially offset from each other within the housing.

10. The safety valve of claim 8, wherein the first and second upper bores are angularly offset from each other about a circumference of the housing.

11. The safety valve of claim 8, wherein the connecting rod splits and extends into each of the first and second upper bores and attaches to each of the first and second upper pistons.

12. The safety valve of claim 8, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

13. A method of actuating a safety valve, comprising:

conveying hydraulic fluid pressure to a piston bore that provides an upper bore having a first diameter and a lower bore having a second diameter smaller than the first diameter, wherein a piston assembly is movably arranged within the piston bore and comprises an upper piston arranged in and sealingly engaging the upper bore and a lower piston arranged in and sealingly engaging the lower bore;

axially displacing the piston assembly within the piston bore as the hydraulic fluid pressure acts on the upper piston,

wherein a connecting rod couples the upper and lower pistons such that simultaneous movement of each piston is achieved when the piston assembly moves within the piston bore, and wherein a cavity is defined between the upper and lower pistons within the piston bore and the connecting rod extends within the cavity.

14. The method of claim 13, wherein conveying the hydraulic fluid pressure to the piston bore comprises conveying hydraulic fluid to the piston bore via a control line.

15. The method of claim 13, wherein a piston area of the upper piston is greater than a piston area of the lower piston, and wherein axially displacing the piston assembly comprises overcoming an opposing section pressure acting on the lower piston.

16. The method of claim 13, wherein the upper and lower pistons each comprise one or more dynamic seals, the method further comprising sealingly engaging a corresponding inner walls of the upper and lower bores with the dynamic seals of the upper and lower pistons, respectively.

17. The method of claim 13, wherein the piston assembly further comprises a piston rod that extends longitudinally from the lower piston through at least a portion of the piston bore and is operably coupled to a flow tube movably arranged within a flow passage defined in the safety valve, the method further comprising:

axially displacing the flow tube as the piston assembly moves within the piston bore;

compressing a power spring as the piston assembly is axially displaced by the hydraulic fluid pressure; and

moving a valve closure device with the flow tube from a closed position which restricts fluid flow through the flow passage to an open position.

18. The method of claim 13, wherein the cavity contains a fluid and the method further comprises fluidly communicating the cavity and an annulus region with a conduit defined in a housing that houses the piston assembly.

19. The method of claim 18, further comprising balancing pressures between the cavity and the annulus region with a pressure regulator arranged within the conduit.

20. The method of claim 13, wherein the upper bore is divided into a first upper bore and a second upper bore and wherein the upper piston comprises a first upper piston and a second upper piston, the method further comprising:

sealingly engaging the first upper bore with the first upper piston; and

sealingly engaging the second upper bore with the second upper piston, wherein a combined piston area of the first and second upper pistons is greater than a piston area of the lower piston.

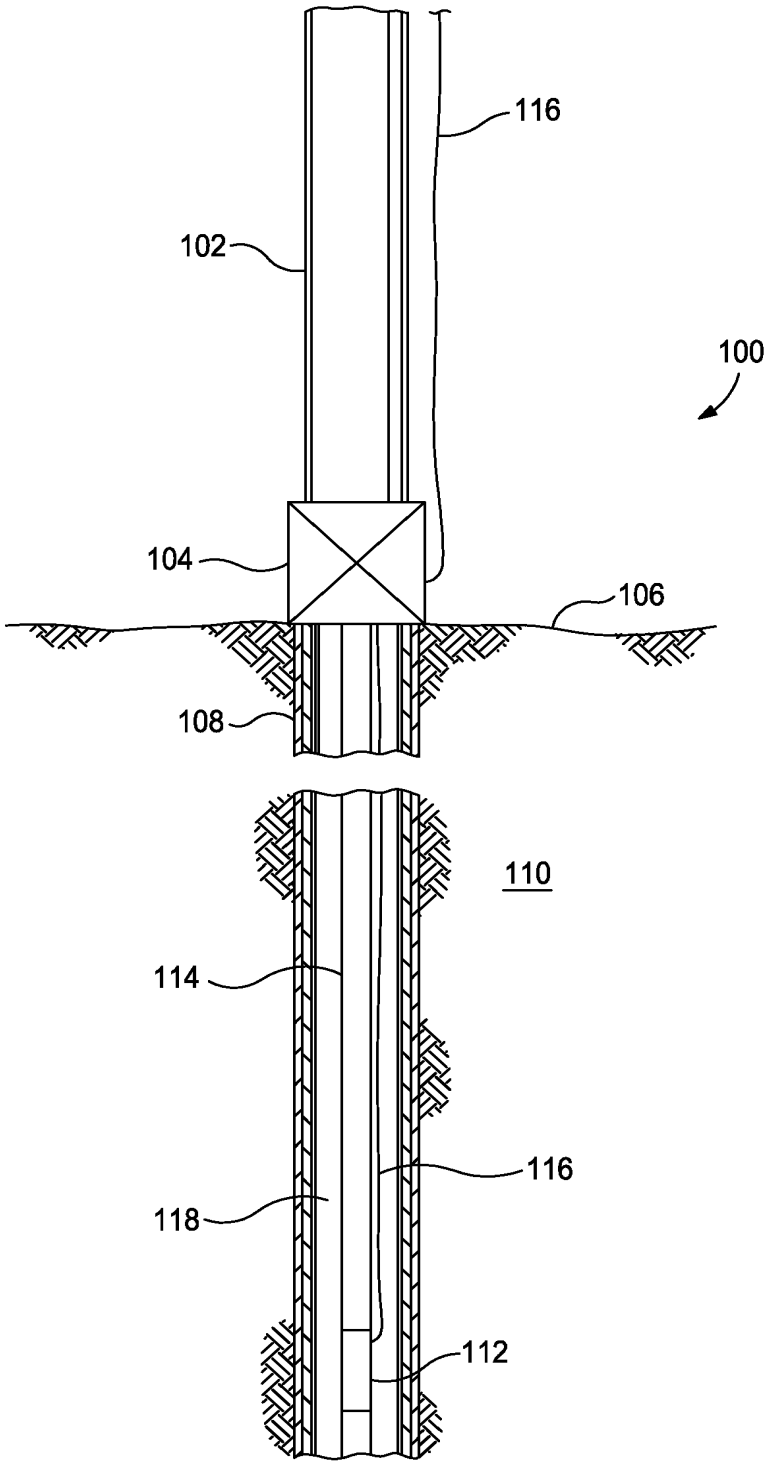

FIG. 1

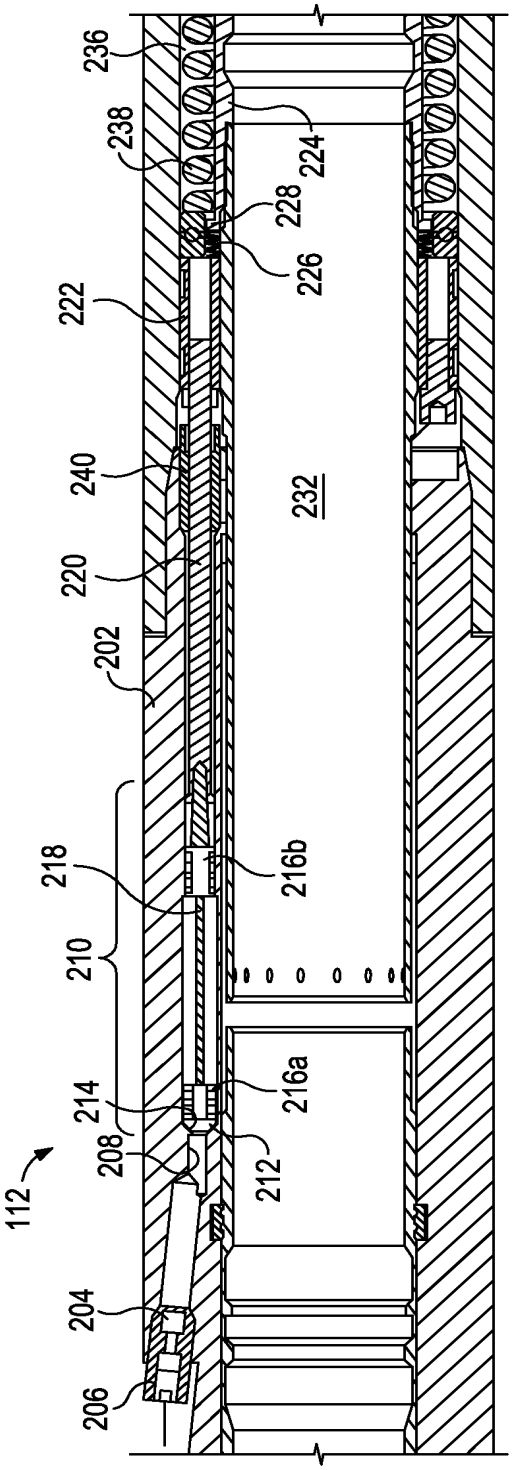
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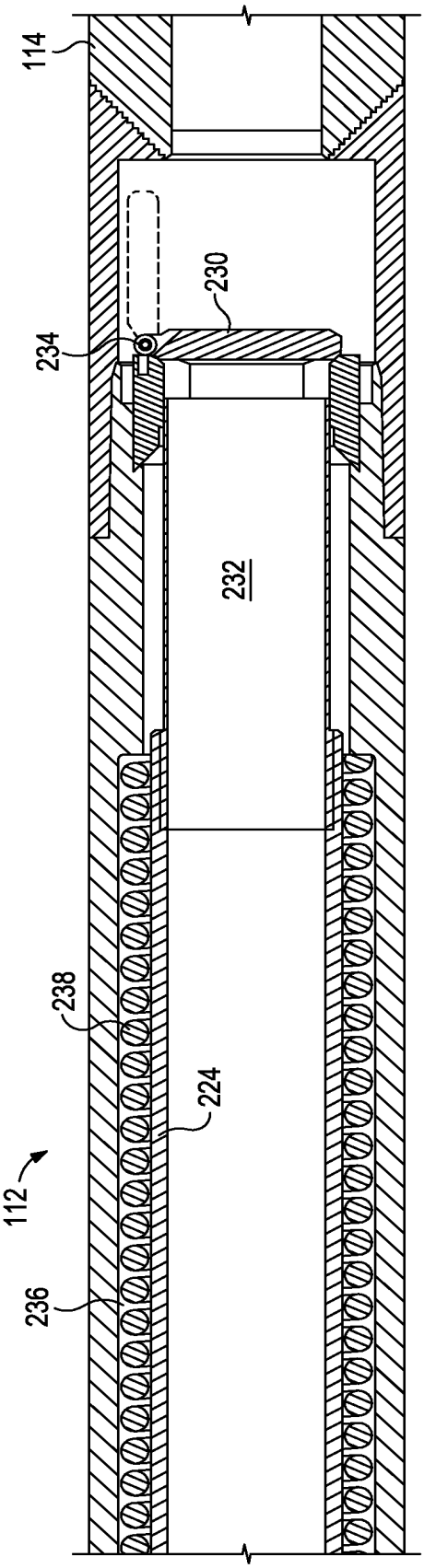
FIG. 2A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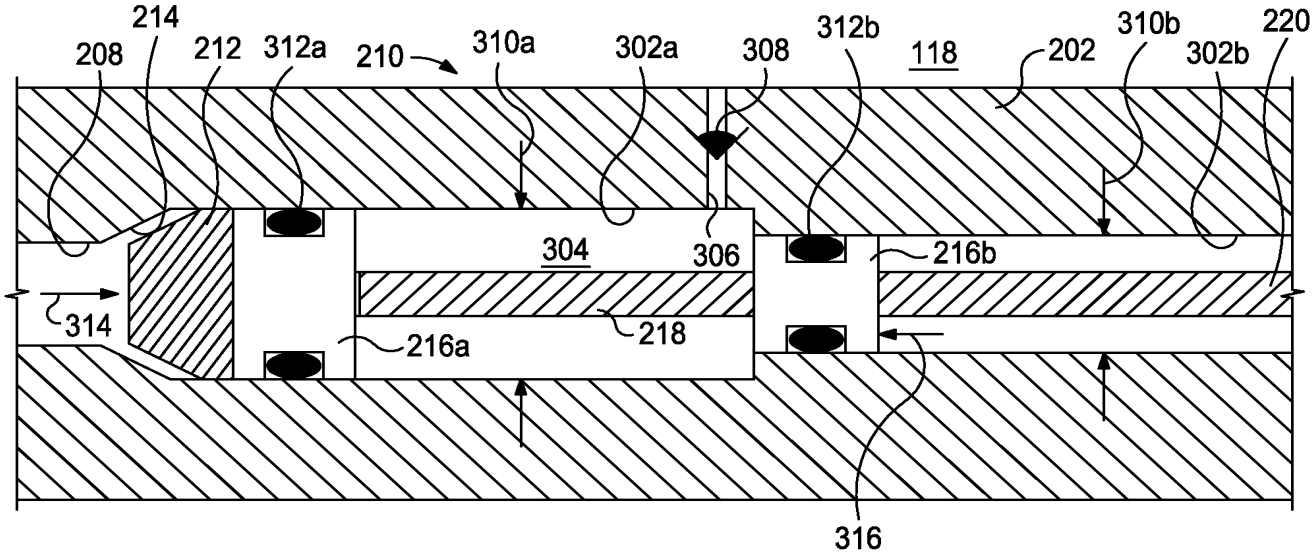
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FIG. 3A

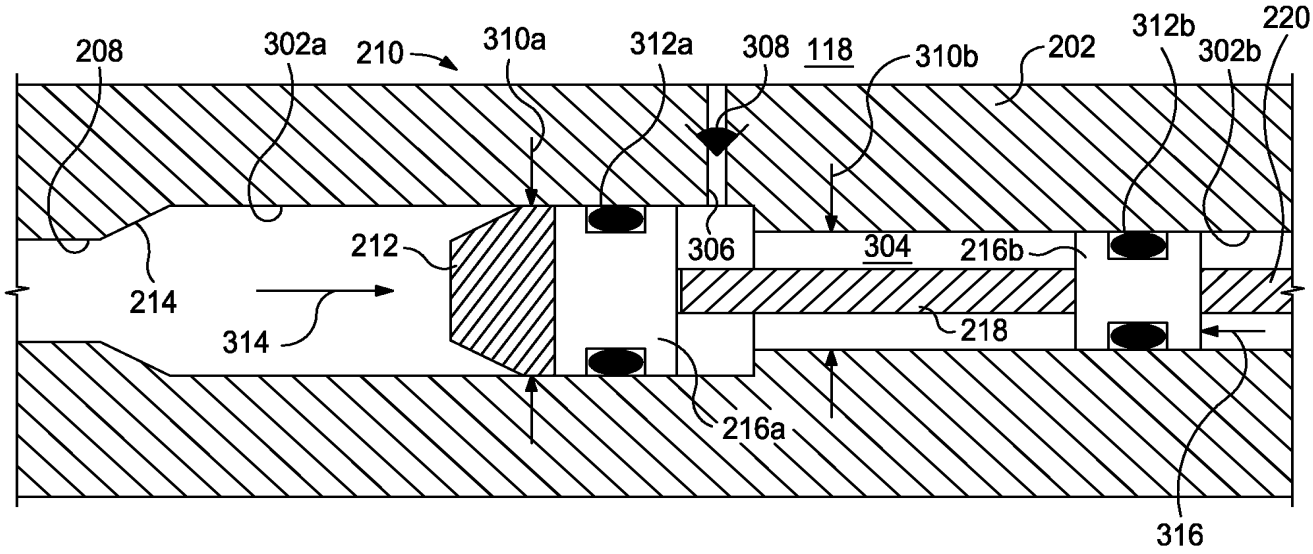
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FIG. 3B

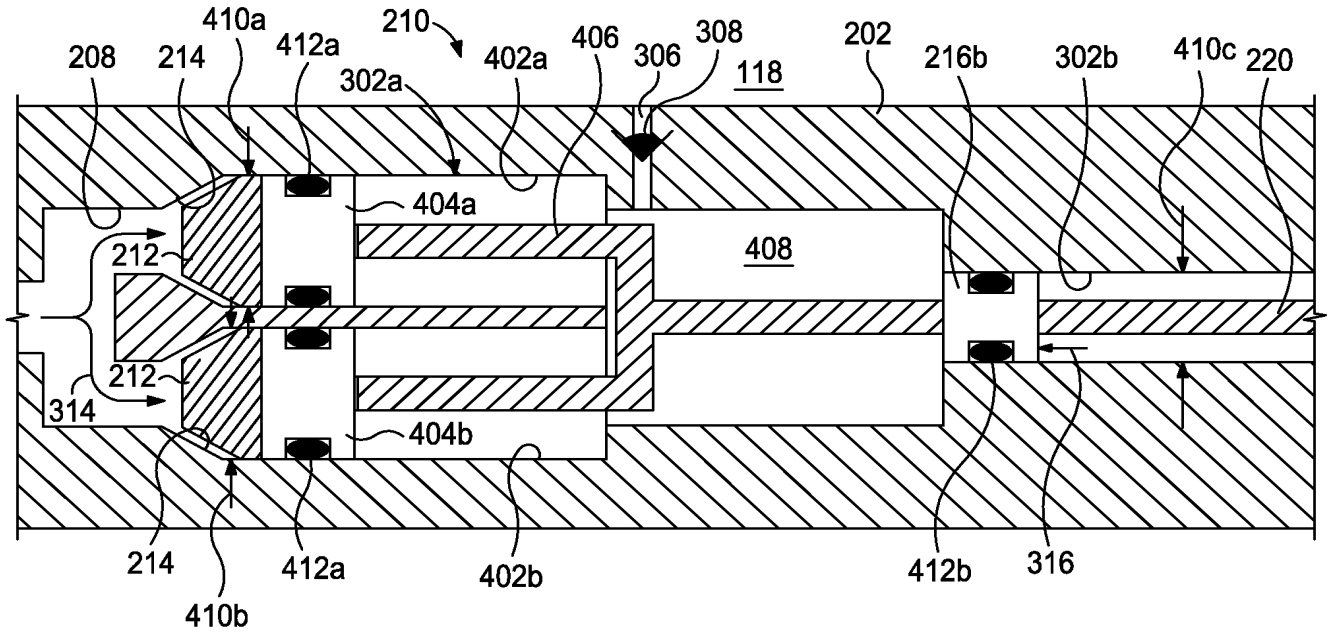
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FIG. 4A

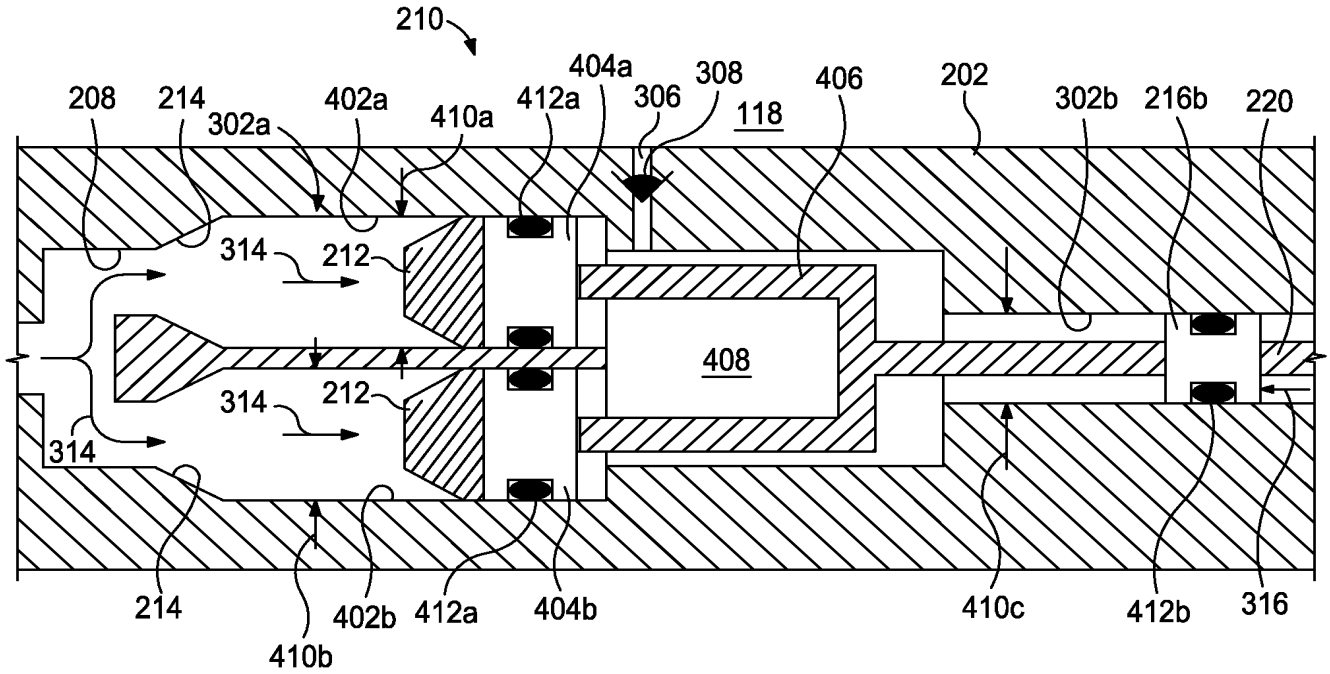
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FIG. 4B