

	Espacio reservado para el adhesivo de radicación
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DIRECCIÓN DE NUEVAS CREACIONES
Procedimiento acelerado de exámenes de patente (PPH)

1	NÚMERO DE SOLICITUD ANTE LA SIC NC2022/0004275		
2	GLOBAL - PPH ☒ PAÍS ESTADOS UNIDOS DE AMÉRICA	3	PCT – PPH ☐ PAÍS
4	PROSUR ☐ PAÍS	5	Alianza del Pacífico (AdP) ☐ PAÍS
6	OFICINA DE PRIMERA PRESENTACIÓN (OPP) ☐	7	OFICINA DE EXAMEN ANTERIOR (OEA) ☐
8	NÚMERO DE SOLICITUD O PUBLICACIÓN DE LA SOLICITUD (OPP) ☐ NÚMERO DE SOLICITUD EN OFICINA DE EXAMEN ANTERIOR (OEA): ☐ NÚMERO DE SOLICITUD PCT: ☐		1. US 16/705,517
9	☐ REPRESENTANTE LEGAL ☒ APODERADO		
APELLIDOS RINCÓN USCÁTEGUI		NOMBRES JOSÉ ANDRÉS	IDENTIFICACIÓN C.C .79.780.910 T.P .114.908
DIRECCIÓN Carrera 4 # 72A - 35		No. TELÉFONO	3473611
CIUDAD Bogotá, D.C.		CORREO ELECTRÓNICO	cavelier@cavelier.com
PAÍS COLOMBIA		No. RADICACIÓN O PROTOCOLO DE PODER GENERAL	
10	CONDICIONES PARA ACCEDER A ESTE PROCESO:		
10.1. DATOS DE PRIORIDAD ☒ SI ☐ NO			
(33) PAÍS DE ORIGEN 1. ESTADOS UNIDOS DE AMÉRICA		CÓDIGO PAÍS US	(31) NÚMERO 16/705,517 (32) FECHA (AAAA/MM/DD) 2019/12/06
10.2. DATOS SOLICITUD INTERNACIONAL PCT ☐ SI ☐ NO			
Solicitud Internacional No. PCT/US2019/065108		Fecha	2019/12/06
Publicación Internacional No. WO/2021/112883		Fecha	2021/06/10
*El solicitante presenta una copia de la(s) reivindicación(es) patentable(s) u otorgable(s) de la solicitud de la Oficina de Primera Presentación que profirió el examen de patentabilidad, junto con una traducción al castellano. ☒ SI ☐ NO *El solicitante presenta los resultados de búsqueda de la Oficina de Examen Anterior, junto con una traducción al castellano ☐ SI ☐ NO			
REQUISITOS PARA EL RECONOCIMIENTO DE LOS RESULTADOS DE EXÁMENES DE PATENTABILIDAD EFECTUADOS A SOLICITUDES EXTRANJERAS Para que la Superintendencia de Industria y Comercio pueda reconocer los resultados de exámenes de patentabilidad producidos por otras Oficinas de Propiedad Industrial se debe cumplir con las siguientes condiciones: (a) Al momento de solicitar el examen de patentabilidad, si el solicitante pide que se reconozcan exámenes de patentabilidad de otras oficinas extranjeras, deberá aportar junto con el pago de la tasa correspondiente, los siguientes anexos: (i) Copia de las resoluciones, fallos o decisiones que han sido relevantes para la determinación de la patentabilidad de la(s) solicitud(es) en la Oficina que haya proferido el examen de patentabilidad que contienen reivindicaciones patentables u otorgables que son la base de la petición, y si es del caso, su traducción al castellano. ☒ SI ☐ NO (ii) Copia de todas las reivindicaciones determinadas como patentables u otorgables en la Oficina que profirió el examen de patentabilidad y, si es del caso, su traducción al castellano. ☒ SI ☐ NO (iii) Copia de los antecedentes, información o documentos citados por el examinador de la Oficina de Primera Presentación del examen de patentabilidad, en las resoluciones, fallos o decisiones correspondientes, incluyendo la literatura no patente. Los documentos de patente deberán presentarse siempre y cuando no estén disponibles para la Superintendencia de Industria y Comercio mediante el simple acceso a bases de datos gratuitas. ☐ SI ☒ NO (iv) Una tabla de correspondencias de las reivindicaciones que han sido determinadas como patentables u otorgables en la solicitud de la Oficina que haya proferido el examen de patentabilidad. ☒ SI ☐ NO			
11	FIRMA DEL SOLICITANTE, DEL APODERADO O DEL REPRESENTANTE LEGAL Junto a cada firma, indicar el nombre del firmante y su calidad (si tal calidad no es obvia al leer el petitorio)		
 ANDRÉS RINCÓN USCÁTEGUI C.C. No. 79.780.910 de Bogotá T.P.A. No. 114.908 del C.S.J.			

10 (iv)	TABLA DE CORRESPONDENCIA DE REIVINDICACIONES		
Reivindicaciones en la solicitud en Colombia		Reivindicaciones otorgables en la solicitud internacional	Explicación sobre la suficiente correspondencia ó Comentarios que explican la correspondencia
1		1	Las reivindicaciones 1 a 15 del capítulo reivindicatorio de la solicitud de patente NC2022/0004275 presentadas corresponden a las reivindicaciones 1 a 20, respectivamente, concedidas por la USPTO.
2		2 y 4	
3		3	
4		5 y 6	
5		7 y 8	
6		9	
7		10 y 11	
8		12 y 13	
9		14	
10		15	
11		16	
12		17	
13		18	
14		19	
15		20	

4. Copia de las reivindicaciones concedidas por la USPTO con su respectiva traducción al español;

5. Finalmente, a continuación, se encuentra la tabla donde se consigna la correspondencia de las reivindicaciones que han sido concedidas por la USPTO y las actualmente presentadas ante la SIC.

TABLA DE CORRESPONDENCIA

Reivindicaciones presentadas ante la SIC como OSP	Reivindicaciones consideradas patentables por la USPTO
1	1
2	2 y 4
3	3
4	5 y 6
5	7 y 8
6	9
7	10 y 11
8	12 y 13
9	14
10	15
11	16
12	17
13	18
14	19
15	20

Se considera entonces, que las reivindicaciones presentadas son “suficientemente correspondientes” a las concedidas por la USPTO, ya que las reivindicaciones presentadas ante la SIC se refieren a la misma materia que aquella consideradas como otorgables por la Oficina de Examen Anterior (OEA).

Cumpliendo así lo dispuesto para que una solicitud sea aceptada en el procedimiento acelerado de exámenes de patente entre la USPTO actuando como Oficina de Examen Anterior (OEA) y la SIC como Oficina de Segunda Presentación, atentamente solicito que se continúe con el trámite correspondiente a esta solicitud de patente de invención.

Señora Directora,

ANDRÉS RINCÓN USCÁTEGUI

CC 79.780.910 de Bogotá

TP 114.908



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

NOTICE OF ALLOWANCE AND FEE(S) DUE

49431 7590 11/16/2021
Locke Lord LLP
P.O. Box 55874
Boston, MA 02205

EXAMINER

WOOD, DOUGLAS S

ART UNIT

PAPER NUMBER

3679

DATE MAILED: 11/16/2021

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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16/705,517

12/06/2019

Trevor Alan KOPECKY

2019-IPM-103369
(493US1)

7362

TITLE OF INVENTION: CHARACTERIZATION OF DOWNHOLE GAS HANDLING SYSTEMS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
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nonprovisional

UNDISCOUNTED

\$1200

\$0.00

\$0.00

\$1200

02/16/2022

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

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

HOW TO REPLY TO THIS NOTICE:

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

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

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

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

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

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

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

PART B - FEE(S) TRANSMITTAL

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

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

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

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

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

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.

49431 7590 11/16/2021
Locke Lord LLP
P.O. Box 55874
Boston, MA 02205

Certificate of Mailing or Transmission

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

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

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/705,517	12/06/2019	Trevor Alan KOPECKY	2019-IPM-103369 (493US1)	7362

TITLE OF INVENTION: CHARACTERIZATION OF DOWNHOLE GAS HANDLING SYSTEMS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1200	\$0.00	\$0.00	\$1200	02/16/2022

EXAMINER	ART UNIT	CLASS-SUBCLASS
WOOD, DOUGLAS S	3679	073-152290

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

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

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

2. For printing on the patent front page, list

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

1 _____

(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.

2 _____

3 _____

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

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

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

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

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

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

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

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

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

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/705,517	12/06/2019	Trevor Alan KOPECKY	2019-IPM-103369	7362
49431	7590	11/16/2021	(493US1)	
Locke Lord LLP P.O. Box 55874 Boston, MA 02205			EXAMINER WOOD, DOUGLAS S	
			ART UNIT	PAPER NUMBER
			3679	
DATE MAILED: 11/16/2021				

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 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

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

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

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

Notice of Allowability	Application No. 16/705,517	Applicant(s) KOPECKY et al.	
	Examiner DOUGLAS S WOOD	Art Unit 3679	AIA (FITF) Status Yes

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

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

1. ☒ This communication is responsive to documents filed 12/6/2019.
☐ 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 1-20. 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 <u>1/13/2021</u> . 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 _____.
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/Matthew Troutman/
Supervisory Patent Examiner, Art Unit 3679

DETAILED ACTION

Notice of Pre-AIA or AIA Status

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

Allowable Subject Matter

2. Claims 1-20 are allowed.
3. The following is an examiner's statement of reasons for allowance: For claim 1, the inclusion of a hollow cylindrical housing constructed at least partly of a transparent or translucent material, in combination with the other apparatus or method limitations of the independent claims is sufficient to distinguish the applicant's invention from prior art.

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

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to DOUGLAS S WOOD whose telephone number is (571)270-5954. The examiner can normally be reached on Monday through Thursday 8:30 AM - 7:00 PM EST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an

interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Troutman can be reached on (571) - 270 - 3654. 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 <https://ppair-my.uspto.gov/pair/PrivatePair>. 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.

DOUGLAS S. WOOD
Examiner
Art Unit 3679

/DOUGLAS S WOOD/
Examiner, Art Unit 3679

/Matthew Troutman/
Supervisory Patent Examiner, Art Unit 3679

ACCIÓN DETALLADA

[...]

Materia Permitida

2. Se admiten las reivindicaciones 1-20.
3. La siguiente es una declaración del examinador de las razones para la concesión: Para la reivindicación 1, la inclusión de una carcasa cilíndrica hueca está construida al menos parcialmente de un material transparente o translúcido, en combinación con las otras limitaciones del aparato o método de las reivindicaciones independientes, es suficiente para distinguir la invención del solicitante del arte previo.

[...]



US011255177B2

(12) **United States Patent**
Kopecky et al.

(10) **Patent No.:** **US 11,255,177 B2**
(45) **Date of Patent:** **Feb. 22, 2022**

(54) **CHARACTERIZATION OF DOWNHOLE GAS HANDLING SYSTEMS**

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CPC **E21B 43/38** (2013.01)

(58) **Field of Classification Search**

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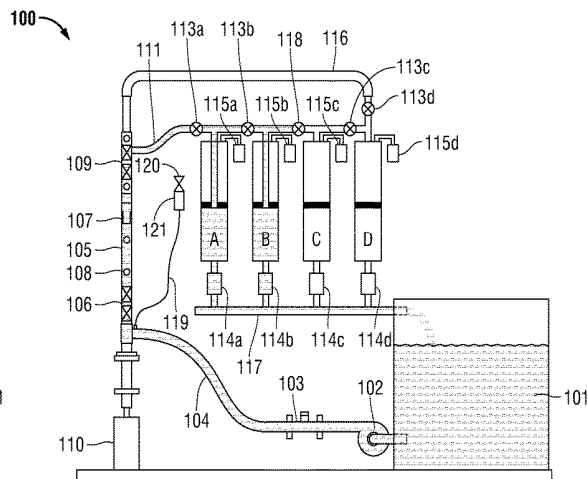
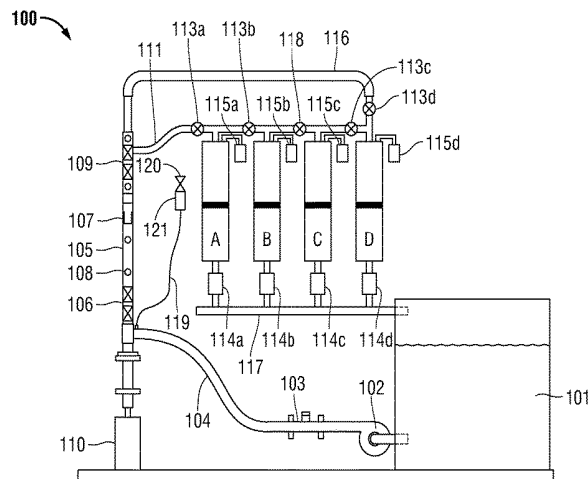
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(57) **ABSTRACT**

An apparatus for testing of downhole multiphase fluid handling systems used in oil and gas production allows test personnel to visually observe the testing. The apparatus is constructed from housings and/or casings made partly or entirely of a see-through material. The see-through material allows for unaided visual observation of the flow regime of the fluid flowing through fluid handling equipment. This eliminates most all of the assumptions that typically need to be made about how well the equipment operates. The ability to clearly observe the flow regimes unassisted allows for accurate study of individual equipment effects, vortices interactions and formation, the effects of different velocities of fluid flow, the optimization of flow paths, remixing and flow regimes external of a system, slug creation, and other parameters known to those skilled in the art.

20 Claims, 6 Drawing Sheets



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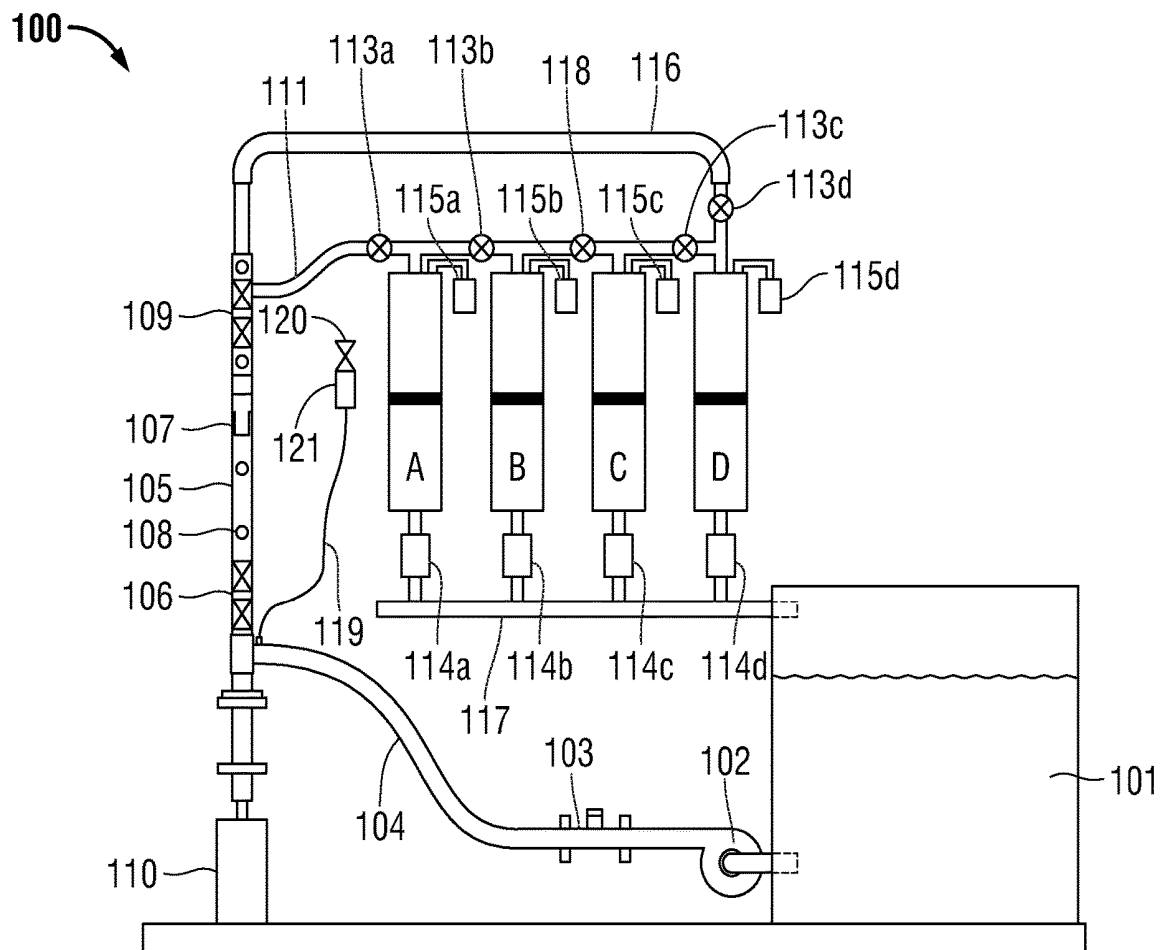


FIG. 1A

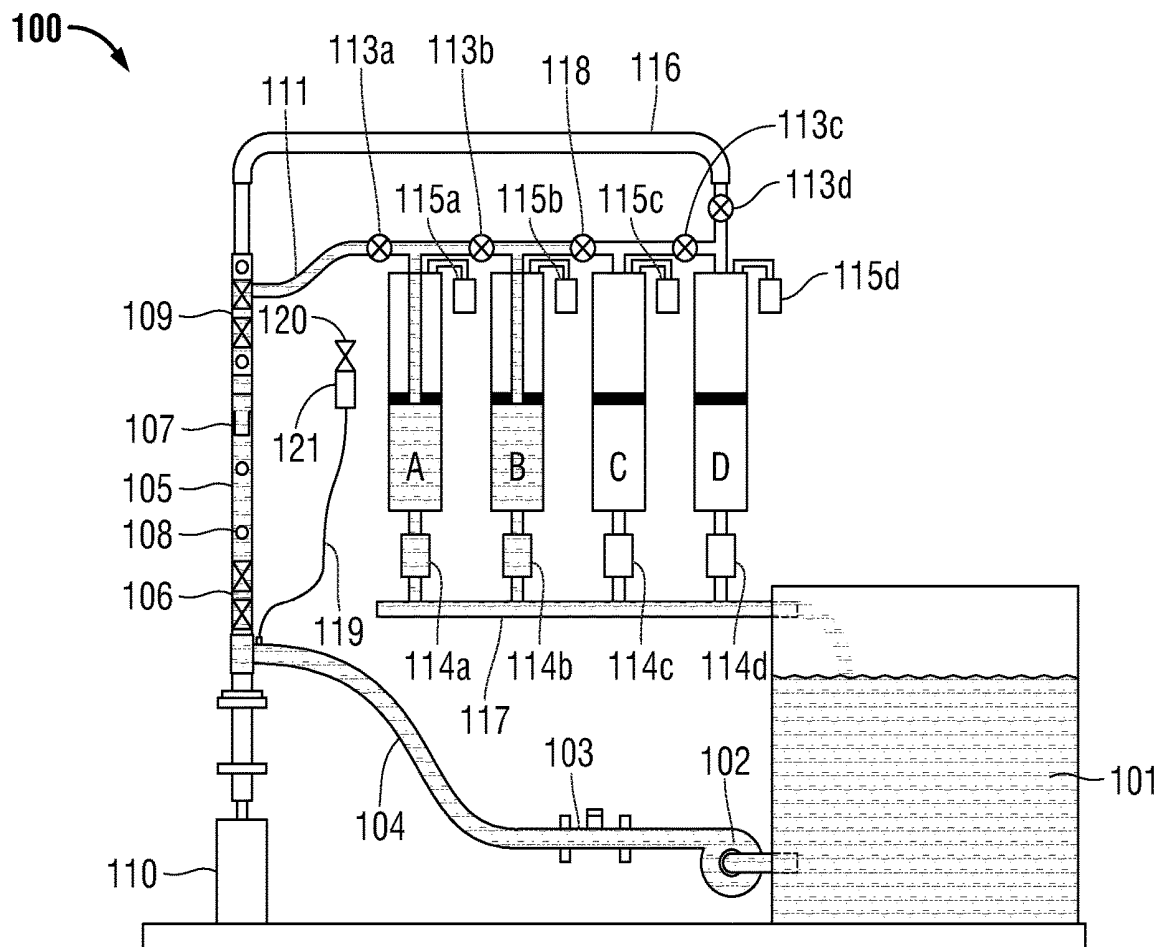


FIG. 1B

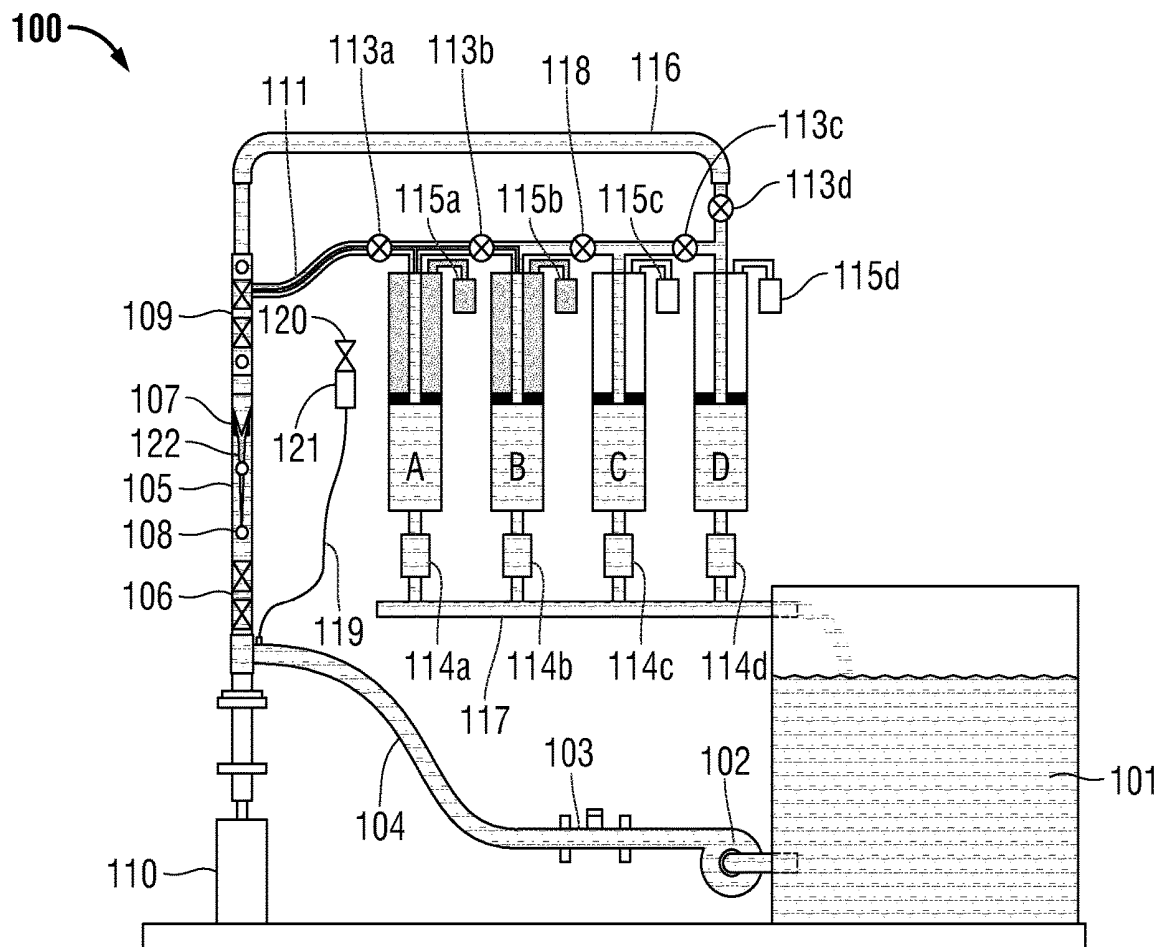


FIG. 1C

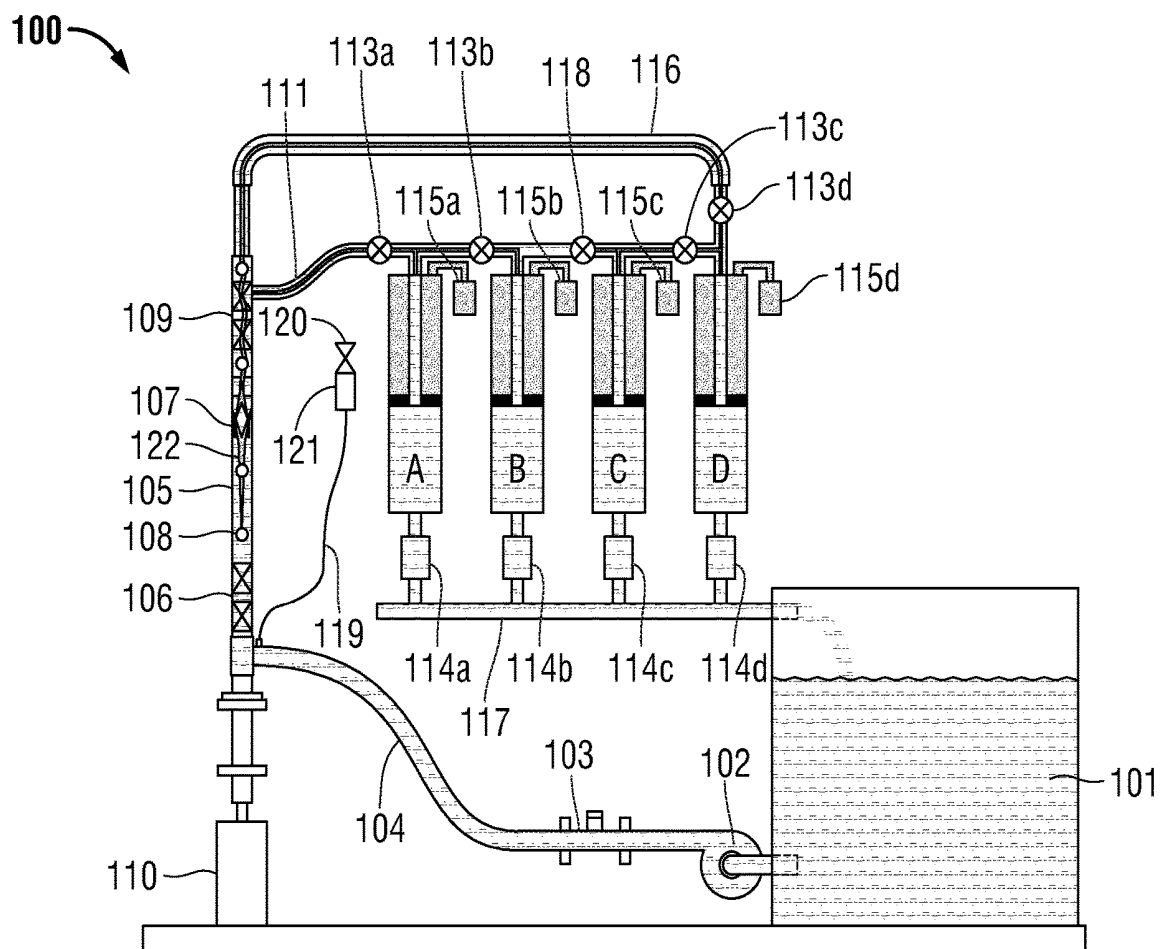


FIG. 1D

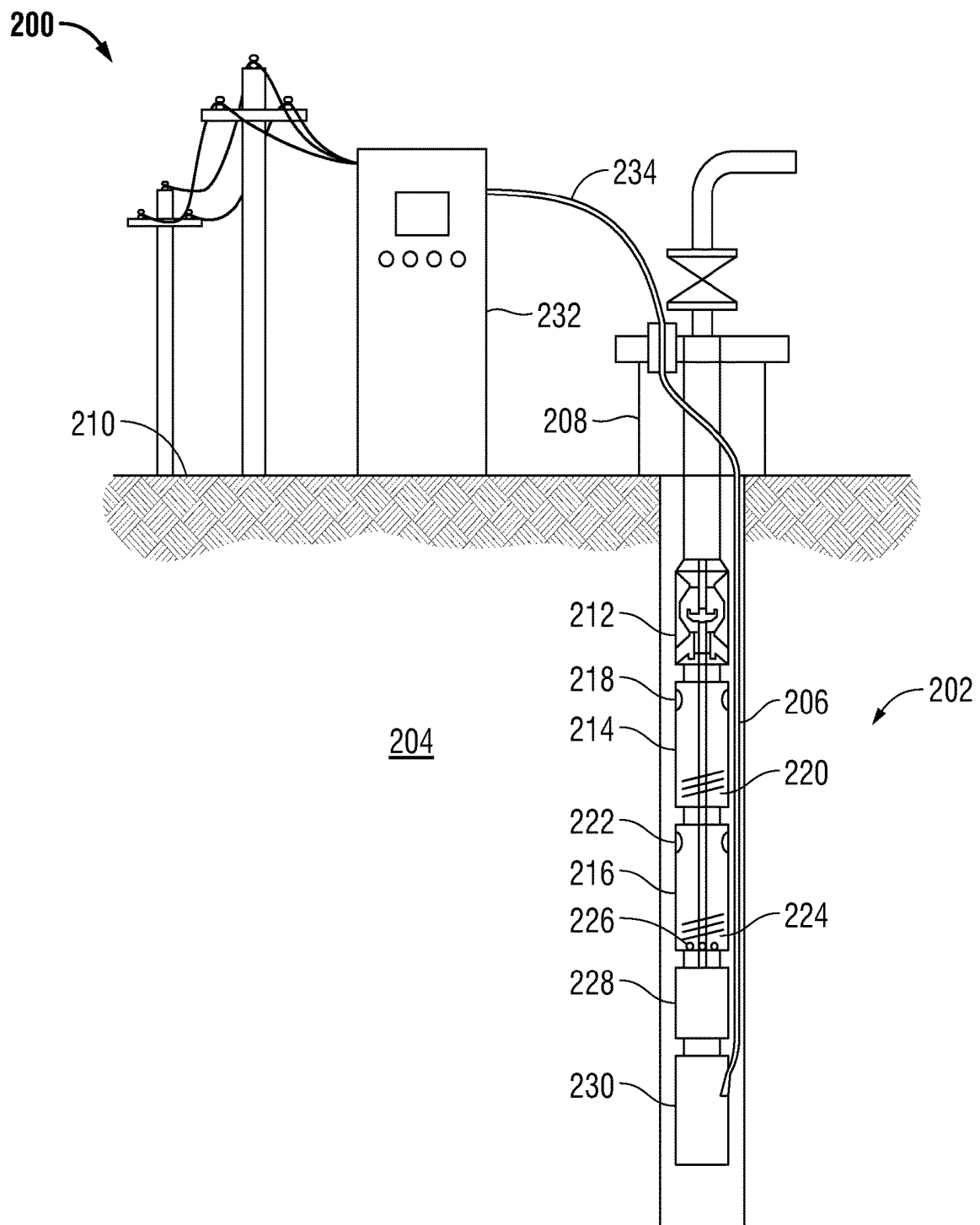
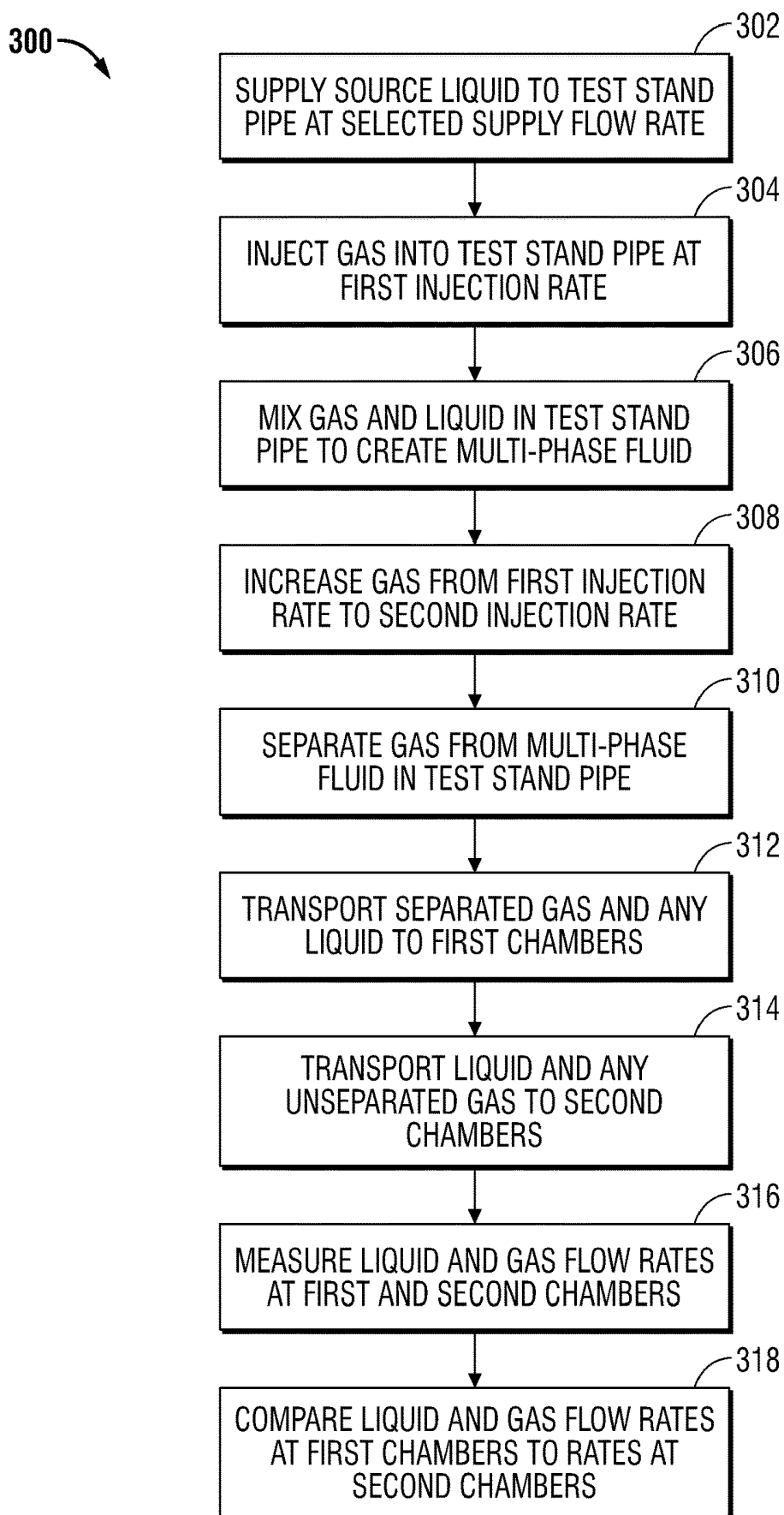


FIG. 2

**FIG. 3**

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CHARACTERIZATION OF DOWNHOLE GAS
HANDLING SYSTEMS

TECHNICAL FIELD

The exemplary embodiments disclosed herein relate to production of oil and gas from a wellbore and, more particularly, to apparatuses and methods for analyzing and testing downhole multiphase fluid handling systems used in such oil and gas production.

BACKGROUND

In the oil and gas industry, fluids from a subterranean formation typically contain a multiphase mixture of oil, gas, water, and other liquids. Production of the oil and gas involves pumping the multiphase mixture up the wellbore, separating the different phases, and transporting them through pipelines for processing downstream. Separation is done using a multiphase fluid handling system comprised of various fluid handling equipment, such as gas separators, pumps, valves, and the like, strategically positioned at certain points both downhole in the wellbore and at the surface. Understanding the effects of the fluid handling equipment on the fluid's flow regime, including flow velocity, whether the flow is laminar or turbulent, and the like, is important in being able to design efficient multiphase fluid handling systems.

Existing techniques for testing the effects of multiphase fluid handling equipment typically entail putting the equipment into a two-phase test loop. The two-phase test loop is designed for testing downhole gas handling equipment and thus is usually constructed from steel or metal casing. Various sensors and instruments are positioned in the test loop to monitor fluid flow through the gas handling equipment and thereby understand the flow and performance characteristics thereof. These sensors and instruments allow those skilled in the art to make educated assumptions about the effectiveness and/or hindrance of the equipment with respect to the flow regimes. While these assumptions are sufficient in many instances, a high probability of error exists due to the complexity of multiphase fluid density differences, the interactions of the multiple phases, and how individual equipment actually affects the flow regime at different velocities.

Therefore, a need exists for improvements in the analysis and testing of downhole multiphase fluid handling systems used in oil and gas production.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the exemplary disclosed embodiments, and for further advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which:

FIGS. 1A-1D are schematic diagrams showing an apparatus for analyzing fluid flow through downhole fluid handling systems according to embodiments of the present disclosure;

FIG. 2 is a schematic diagram showing an exemplary well site that uses downhole fluid handling systems tested according to embodiments of the disclosure; and

FIG. 3 is a flow diagram showing a method for analyzing fluid flow through downhole fluid handling systems according to embodiments of the present disclosure.

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DESCRIPTION OF EXEMPLARY
EMBODIMENTS

The following discussion is presented to enable a person ordinarily skilled in the art to synthesize and use the exemplary disclosed embodiments. Various modifications will be readily apparent to those skilled in the art, and the general principles described herein may be applied to embodiments and applications other than those detailed below without departing from the spirit and scope of the disclosed embodiments as defined herein. Accordingly, the disclosed embodiments are not intended to be limited to the particular embodiments shown, but are to be accorded the widest scope consistent with the principles and features disclosed herein.

Embodiments of the present disclosure provide an apparatus and method for testing multiphase (e.g., two-phase) fluid handling systems that allow test personnel to visually observe the fluid handling equipment therein. The apparatus is constructed from housings and/or casings made partly or entirely of a see-through material. The see-through material, which can include a transparent (i.e., clear and translucent) material herein, advantageously allows for unaided visual observation of the flow regime of the fluid flowing through the fluid handling equipment. This eliminates most all of the assumptions that typically need to be made about how well the equipment operates. In some embodiments, the same sensors and instruments typically used in steel or metal test loops may be incorporated into the see-through housings as well. The ability to clearly observe the flow regimes unassisted allows for accurate study of individual equipment effects, vortices interactions and formation, the effects of different velocities of fluid flow, the optimization of flow paths, remixing and flow regimes external of a system, slug creation, and other parameters known to those skilled in the art. In short, embodiments of the present disclosure allow for the re-creation of virtually all aspects of an operational oil well in a visually observable test environment.

In addition to the use of various see-through housings and other components, embodiments of the disclosure also provide an arrangement of components that allows for enhanced flexibility in separating and controlling oil and gas flows.

Referring now to FIG. 1A, an apparatus 100 for visually observing and determining the characteristics of fluid flow through oil and gas handling equipment according to embodiments of the disclosure is shown. The apparatus 100 includes a fluid holding tank 101. Fluid holding tank 101 provides the source fluid for the apparatus 100 that may be used for testing purposes. Near the bottom of fluid holding tank 101 is an outlet (not expressly labeled) that is connected to a boost pump 102. Boost pump 102 pumps the source fluid from holding tank 101 through a flow meter 103 and into a system supply pipe 104. System supply pipe 104 carries the source fluid to a test stand pipe 105.

Test stand pipe 105 simulates a tubing or casing in a wellbore or a pipeline in the analysis of a fluid handling system. To model the tubing, casing, or pipeline, test stand pipe 105 resembles or takes the form of a generally hollow cylindrical housing having a generally uniform thickness defining a generally straight flow path therethrough. In accordance with embodiments of the disclosure, the cylindrical housing/test stand pipe 105 is constructed partly or entirely of a see-through material. Suitable material that may be used for the test stand pipe 105 include Plexiglas, Lucite, and other transparent plastics known to those skilled in the art as well as glass materials. The term "transparent" is used herein to also encompass translucent materials.

Test stand pipe **105** houses various fluid handling equipment, such as fluid flow separators and pumps, that are desired to be characterized in connection with the flow of fluids through a fluid handling system. In the embodiment shown, test stand pipe **105** is provided with a mechanical gas separator **106**. Mechanical gas separator **106** may be a two-stage separator that creates a vortex within the fluid being supplied from holding tank **101** through system supply pipe **104**. Test stand pipe **105** is also provided with gas separator **107** located between mechanical gas separator **106** and an upstream multistage pump **109**. Pump **109** may have any suitable number of pump stages, such as a two-stage pump, as shown in the example embodiment. In some embodiments, a motor drive **110** coupled to test stand pipe **105** drives or otherwise provides power to the pump **109** and other fluid handling equipment in the test stand pipe **105**.

Gas separator **107** functions to remove or separate gas from the fluid in the test stand pipe **105** to prevent gas from entering the upstream multistage pump **109**. Gas separator **107** is considered to be functioning properly if no gas from the fluid flow enters pump **109**. Several different gas separator designs exist and may be tested in test stand pipe **105**. In the present example, gas separator **107** uses a design where gas exits into an annulus (not expressly shown) between an inner wall of test stand pipe **105** and gas separator **107**. In preferred embodiments, one or more of gas separator **107**, multistage pump **109**, and mechanical gas separator **106** also have an outer housing that is constructed partly or entirely of a transparent material to enable visual observation thereof.

A first chamber supply line **111** is connected to the test stand pipe **105** at or near the annulus where gas exits gas separator **107**. The first chamber supply line **111** transports the separated gas along with any fluid in the annulus to a series of four chambers, labeled A, B, C, and D, respectively. The first chamber supply line **111** thus represents or simulates a gas discharge path for gas separated from a multiphase fluid by gas separator **107**. A second chamber supply line **116** is connected to the test stand pipe **105** upstream of pump **109**. The second chamber supply line **116** transports fluid flowing through pump **109** along with any unseparated gas to the chambers A, B, C, and D. In the present example, supply line **116** represents a well head path from the output of the multistage pump **109** as it would be arranged in actual production operations. In preferred embodiments, each of the first and second chamber supply lines **111** and **116** and the chambers A, B, C, and D is constructed partly or entirely of a transparent material.

Fluid from holding tank **101** may be pumped through test stand pipe **105**, first and second chamber supply lines **111** and **116**, and into one or more of the chambers A, B, C, and D, respectively. The chambers A, B, C, and D are provided with four chamber valves **113a-113d** positioned in the first and second chamber supply lines **111** and **116** as shown. These chamber valves **113a-113d** can be individually opened and closed in conjunction with each other to control the supply of fluid into one or more of the chambers A, B, C, and D. The height of the fluid level in each of the chambers A, B, C, and D may be controlled as desired during operation of the apparatus **100** by adjusting the flow rate from boost pump **102**.

Each of the chambers A, B, C, and D is also provided with an outlet (not expressly labeled) that is connected to a return line **117** for returning fluid to holding tank **101**. Fluid flow meters **114a-114d** mounted at the fluid outlets measure the flow rate of liquid flowing through each individual chamber

A, B, C, and D, respectively, as fluid from each chamber returns through return line **117** back to holding tank **101**.

Each chamber A, B, C, and D is also provided with a gas outlet (not expressly labeled) near the top of each chamber. Gas carried by first supply line **111** or second supply line **116**, or both, to the chambers A, B, C, and D subsequently exits each chamber A, B, C, and D through the outlets. The exiting gas passes through a respective gas flow meter **115a-115d** that measures the gas flow rate of the gas exiting from each chamber A, B, C, and D.

The apparatus **100** is also provided with an isolation valve **118** between the middle two chambers B and C. Isolation valve **118** is operable to isolate and divide the four chambers A, B, C, and D into two pairs, one pair composed of the first and second chambers A and B and another pair composed of the third and fourth chambers C and D. This allows the chambers to be operated as sets of pairs, as will be described further herein. Further, apparatus **100** is provided with gas supply line **119** that allows gas to be injected into the test stand pipe **105**. A valve **120** allows an operator to control the injection rate at which gas is injected into the test stand pipe **105**. A gas flow meter **121** is provided to allow measurement of the flow rate of the gas flowing through gas supply line **119**.

It will be appreciated that the number of chambers A, B, C, and D is adjustable for a particular application. Thus, chambers may be removed or added as needed such that fewer than four (e.g., three, two, etc.) chambers or more than four (e.g., five, six, etc.) chambers may be used with test stand pipe **105** in some embodiments, with corresponding chamber valves, isolation valves, fluid flow meters, gas flow meters, and the like, positioned as appropriate for the particular application, within the scope of the present disclosure.

Embodiments of the present disclosure also provide methods of using apparatus **100** to analyze the performance characteristics of specific gas separators and other fluid handling equipment in test stand pipe **105**. The methods generally begin when boost pump **102** is activated and fluid is transported from holding tank **101** through system supply line **104** and into test stand pipe **105**. This can be seen in FIG. 1B. The rate of flow from holding tank **101** is measured by flow meter **103**. Chamber valves **113a** and **113b** are opened while isolation valve **118** is closed. Pump **109** and mechanical gas separator **106** are inactive at this time. Fluid from holding tank **101** flows through test stand pipe **105**, through gas separator **107**, into first chamber supply line **111** and into chambers A and B. The fluid subsequently exits chambers A and B through fluid flow meters **114a** and **114b** and returns via return line **117** to holding tank **101**, thereby forming a flow loop as indicated in FIG. 1B. The liquid height in chambers A and B may be maintained by controlling the flow rate through system supply line **104**.

Next, chamber valves **113d** and **113c** are opened in preparation for activation of pump **109**. Once valves **113d** and **113c** are opened, mechanical gas separator **106** and pump **109** are activated. Mechanical gas separator **106** creates a vortex in the fluid flow through test stand pipe **105**. According to embodiments of the disclosure, test stand pipe **105** is made from a transparent material, such as Plexiglas, so that the vortex created by mechanical gas separator **106** can be visually observed, as well as other flow characteristics of the fluid flow through the other components in test stand pipe **105**. Visual observation may be particularly useful in understanding the flow regime, which can be affected by factors such as emulsification of the gas in the fluid, or by changes in temperature or pressure, which could

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require visual observation over a time period. In addition, being able to visually locate the vortex in test stand pipe **105** allows a pressure sensor (not expressly shown) to be inserted in the test stand pipe **105** to obtain data about the vortex itself. One or more resealable holes **108** may be formed at selected locations longitudinally and/or circumferentially along the test stand pipe **105** for inserting the pressure sensor and other sensors into the test stand pipe **105**.

Referring now to FIG. 1C, when pump **109** is activated, fluid begins flowing into second chamber supply line **116**. As mentioned, this supply line **116** simulates a well head path from the output of the multistage pump **109** as it would be arranged in actual production operations. The flow from the second chamber supply line **116** is divided among chambers C and D, with valve **118** still closed at this time. The fluid in chambers C and D exits through flow meters **114c** and **114d** and returns to holding tank **101** via return line **117**, thus forming a second system flow loop. Analysis of the performance characteristics of certain fluid handling equipment, such as pump **109**, may be visually conducted at this point. The analysis may determine, for example, how efficiently pump **109** operates under given conditions, such as temperature and pressure, by comparing the amount of flow through the pump **109** versus the amount of flow through flow channel **110**. Further, because test stand pipe **105** is preferably made from a clear material, the actual flow regime may be observed during the testing.

Still with reference to FIG. 1C, gas may be added to the fluid to create a two-phase flow to analyze the characteristics of the gas separator **107** and other equipment in the system. Injection valve **120**, coupled to a supply of gas (not expressly shown), is slowly opened to allow gas into gas supply line **119** and into test stand pipe **105**. An injection flow meter **121** is coupled to gas supply line **119** to measure the flow rate of gas flowing through injection valve **120**. Mechanical gas separator **106**, a two-stage separator in this example, creates a vortex **122** within test stand pipe **105** that may be seen and analyzed through the transparent material used to construct test stand pipe **105**. The vortex helps to mix the injected gas with the fluid to create a two-phase fluid. The two-phase fluid is subsequently separated by gas separator **107**. The separated gas is then shunted into the first chamber supply line **111** by gas separator **107**. The gas in first chamber supply line **111** is transported into chambers A and B. Subsequently, the gas exits chambers A and B through flow meters **115a** and **115b**, which measure the gas flow rates. The gas flow rates measured at flow meters **115a** and **115b**, theoretically, should match the flow rate measured at injection flow meter **121**.

Referring now to FIG. 1D, the gas flow rate through gas supply line **119** may be gradually increased by further opening injection valve **120**. The increase in gas enlarges the vortex **122**. To understand the performance parameters of the gas handling system, such as the failure limits thereof, the flow of gas may be increased until the gas separator **107** is overloaded and fails to adequately separate all gas from the fluid stream. At this point, gas also begins to travel through the pump **109** in a gas stream **123** into second chamber supply line **116**. This gas then travels into chambers C and D, then out through flow meters **115c** and **115d**, which measures the gas flow rates therethrough. The amount of gas flowing through pump **109** and second chamber supply line **116** under overload conditions may then be measured and compared to the amount of gas flowing through first chamber supply line **111** for analysis.

While quantitative measurements are, of course, important in embodiments of the disclosure, the test stand pipe **105**

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as well as chambers A, B, C, and D, first and second chamber supply lines **111** and **116**, and/or other components of the apparatus **100** may also be made from a see-through plastic or other material that allows real-time, visual observation of the two-phase flow regime to allow for more accurate study of the internal equipment under test and allows a better understanding of how the internal system components operate.

Referring now to FIG. 2, a schematic diagram of an exemplary well site **200** is shown in which gas separators that were tested according to embodiments of the present disclosure may be used. As can be seen, a wellbore **202** has been drilled into a subterranean formation **204** at the well site **200** and tubing **206** has been lowered into the wellbore **202**. The tubing **206** extends from a wellhead **208** installed at the surface **210** to facilitate production of wellbore fluid from the subterranean formation **204**. Production in this example is driven primarily by an electric semisubmersible pump (ESP) **212**.

Performance of the ESP **212** can be significantly degraded by the presence of gas in the wellbore fluid. Therefore, an upper gas separator **214** and a lower separator **216** have been provided in the tubing **206** to perform gas separation. Such gas separators **214** and **216** are well known in the art and are thus described only generally here. In general, the upper gas separator **214** includes one or more gas exit ports **218** and a fluid mover **220**, and the lower separator **216** likewise includes one or more gas exit ports **222** and a fluid mover **224**. Intake ports **226** in the lower gas separator **216** allow wellbore fluid to enter for gas separation. The use of the upper and lower gas separators **214** and **216** in tandem as shown in FIG. 2 has been found to greatly improve gas removal from wellbore fluids compared to a single separator.

Because gas separators **214** and **216** have been tested and analyzed using embodiments of the disclosure, well operators can be confident that the separator exit design properties and effectiveness, and/or any recirculation of fluid from the separator exit to the separator intake and the conditions which create said recirculation, will perform as intended downhole. A motor seal **228** prevents wellbore fluid from contaminating a drive motor **230** that drives the gas separators **214** and **216** and other equipment.

Following now in FIG. 3 is a method **300** that may be used to visually analyze and test fluid handling equipment according to embodiments of the present disclosure. The method **300** generally begins at block **302** where a source liquid from a holding tank is supplied to the test stand pipe at the selected flow rate. As mentioned, the test stand pipe is preferably constructed partly or entirely of a transparent or translucent material. At block **304**, gas is injected into the test stand pipe from a gas supply line at the first injection rate. At block **306**, the gas and the source liquid are mixed in the test stand pipe to create a multiphase fluid. In some embodiments, the mixing may be done by a mechanical gas separator that generates a vortex in the test stand pipe. At block **308**, the injection of gas into the test stand pipe is increased from the first flow rate to a second flow rate.

While the gas is being injected, a gas separator positioned upstream of the mechanical gas separator attempts to separate the gas from the multiphase fluid at block **310**. When the gas is injected at the first injection rate, the gas separator is able to separate substantially (e.g., within 10 percent) all the gas from the fluid. However, when the gas injection rate is increased to the second injection rate, the gas separator can no longer separate substantially all gas from the fluid.

At block **312**, the gas that was separated by the gas separator is transported along with any liquid to a set of first

chambers. The transport may be done using a first chamber supply line that couples the test stand pipe to the set of first chambers. At block 314, any gas that was not separated by the gas separator is pumped by a multistage pump along with the liquid to a set of second chambers. This transport may be done using a second chamber supply line that couples the test stand pipe to the set of second chambers. At block 316, the liquid and gas flow rates at the sets of first and second chambers are measured, for example, using liquid and gas flow meters coupled to liquid and gas outlets at the sets of first and second chambers. At block 318, the liquid and gas flow rates measured at the set of first chambers are compared to the liquid and gas flow rates measured at the set of second chambers for analysis of gas separator performance and characteristics.

In some embodiments, in addition to the test stand pipe, the first and second chamber supply lines and/or the sets of first and second chambers may also be constructed of a transparent or translucent material. Likewise, the gas separator and the multistage pump may have outer housings composed of a transparent or translucent material.

Accordingly, as set forth herein, embodiments of the present disclosure may be implemented in a number of ways. For example, in one aspect, embodiments of the present disclosure relate to an apparatus for characterizing downhole fluid handling systems. The apparatus comprises, among other things, a hollow cylindrical housing arranged to selectively receive a multiphase fluid containing a gas and a liquid therein, the hollow cylindrical housing constructed at least partly of a transparent or translucent material. The apparatus also comprises a gas separator positioned within the hollow cylindrical housing at a specified location, and a multistage pump positioned upstream of the gas separator at a specified location within the hollow cylindrical housing. The apparatus additionally comprises a first chamber supply line coupled to the hollow cylindrical housing between the gas separator and the multistage pump and arranged to transport gas separated by the gas separator and any liquid away from the hollow cylindrical housing, and a second chamber supply line coupled to the hollow cylindrical housing upstream of the multistage pump and arranged to transport liquid and any gas unseparated by the gas separator from the multistage pump away from the hollow cylindrical housing. The apparatus further comprises at least one first chamber coupled to the first chamber supply line and arranged to receive the gas and any liquid transported by the first chamber supply line, and at least one second chamber coupled to the second chamber supply line and arranged to receive the liquid and any gas transported by the second chamber supply line. A liquid flow meter is coupled to each of the at least one first and second chambers, each liquid flow meter arranged to measure a flow rate of liquid at the at least one first and second chambers, respectively, and a gas flow meter is coupled to each of the at least one first and second chambers, each gas flow meter arranged to measure a flow rate of gas at the at least one first and second chambers, respectively.

In accordance with any one or more of the foregoing embodiments, the apparatus further comprises a mechanical separator positioned downstream of the gas separator within the hollow cylindrical housing, the mechanical separator arranged to induce a vortex in the hollow cylindrical housing; and/or a gas supply line coupled to the hollow cylindrical housing and arranged to selectively inject gas into the hollow cylindrical housing.

In accordance with any one or more of the foregoing embodiments, the apparatus further comprises a holding

tank and a liquid supply line coupling the holding tank to the hollow cylindrical housing, the liquid supply line arranged to selectively supply liquid from the holding tank to the hollow cylindrical housing; and optionally a return line coupled to each liquid flow meter, the return line arranged to return liquid exiting from the at least one first and second chambers to the holding tank.

In accordance with any one or more of the foregoing embodiments, a plurality of chamber valves is coupled to the first and second chamber supply lines, each chamber valve individually operable in conjunction with one another to selectively control fluid flow into the at least one first and second chambers; and/or an isolation valve is coupled to the first chamber supply line and operable to selectively isolate the at least one first chamber from the at least one second chamber.

In accordance with any one or more of the foregoing embodiments, the hollow cylindrical housing has one or more resealable holes formed therein, the one or more resealable holes allowing a sensor to be inserted in the hollow cylindrical housing.

In accordance with any one or more of the foregoing embodiments, each of the at least one first and second chambers includes a gas outlet and each gas flow meter is coupled to a respective each gas outlet; and/or each of the at least one first and second chambers includes a liquid outlet and each liquid flow meter is coupled to a respective liquid outlet.

In accordance with any one or more of the foregoing embodiments, the first chamber supply line and the at least one first chamber form a first closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing; and/or the second chamber supply line and the at least one second chamber form a second closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing.

In accordance with any one or more of the foregoing embodiments, the gas separator has a transparent or translucent outer housing, and/or the multistage pump has a transparent or translucent outer housing.

In accordance with any one or more of the foregoing embodiments, the first chamber supply line, the second chamber supply line, the at least one first chamber, and/or the at least one second chamber is constructed of a transparent or translucent material.

In general, in another aspect, embodiments of the present disclosure relate to a method for testing fluid handling equipment used in oil and gas production. The method comprises, among other things, supplying a liquid to a hollow cylindrical housing at a selected supply flow rate from a liquid supply line, the hollow cylindrical housing constructed at least partly of a transparent or translucent material. The method also comprises injecting a gas into the hollow cylindrical housing at a first injection rate from a gas supply line, mixing the gas and the liquid to create a multiphase fluid, and increasing injection of gas into the hollow cylindrical housing from the first injection rate to a second injection rate. The method additionally comprises separating the gas in a gas separator positioned within the hollow cylindrical housing, wherein the gas separator separates all the gas injected at the first injection rate from the multiphase fluid, and wherein the gas separator fails to separate all the gas injected at the second injection rate from the multiphase fluid. The method further comprises transporting gas separated by the gas separator and any liquid to at least one first chamber through a first chamber supply line

coupled to the hollow cylindrical housing, and transporting liquid and any gas unseparated by the gas separator from a multistage pump to at least one second chamber through a second chamber supply line coupled to the hollow cylindrical housing. A liquid flow rate and a gas flow rate are measured at the at least one first and second chambers, and the liquid flow rate and the gas flow rate at the at least one first chamber are compared to the liquid flow rate and the gas flow rate at the at least one second chamber.

In accordance with any one or more of the foregoing embodiments, the method further comprises inserting a sensor into the hollow cylindrical housing through one or more resealable holes formed therein.

In accordance with any one or more of the foregoing embodiments, mixing the gas and the liquid to create a multiphase fluid is performed by a mechanical separator positioned downstream of the gas separator within the hollow cylindrical housing, the mechanical separator arranged to induce a vortex in the hollow cylindrical housing.

In accordance with any one or more of the foregoing embodiments, the liquid is supplied to the hollow cylindrical housing from a holding tank, the holding arranged to receive liquid from the at least first and second chambers through a return line; the first chamber supply line and the at least one first chamber form a first closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing; and/or the second chamber supply line and the at least one second chamber form a second closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing.

In accordance with any one or more of the foregoing embodiments, the gas separator has a transparent or translucent outer housing, and/or the multistage pump has a transparent or translucent outer housing.

In accordance with any one or more of the foregoing embodiments, the first chamber supply line, the second chamber supply line, the at least one first chamber, and/or the at least one second chamber is constructed of a transparent or translucent material.

Further, although reference has been made to uphole and downhole directions, it will be appreciated that this refers to the run-in direction of the tool, and that the tool is useful in horizontal casing run applications, and the use of the terms of uphole and downhole are not intended to be limiting as to the position of the plug assembly within the downhole formation.

While the disclosure has been described with reference to one or more particular embodiments, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the description. Each of these embodiments and obvious variations thereof is contemplated as falling within the spirit and scope of the claimed disclosure, which is set forth in the following claims.

What is claimed is:

1. An apparatus for characterizing downhole fluid handling systems, comprising:

- a hollow cylindrical housing arranged to selectively receive a multiphase fluid containing a gas and a liquid therein, the hollow cylindrical housing constructed at least partly of a transparent or translucent material;
- a gas separator positioned within the hollow cylindrical housing at a specified location;

a multistage pump positioned upstream of the gas separator at a specified location within the hollow cylindrical housing;

a first chamber supply line coupled to the hollow cylindrical housing between the gas separator and the multistage pump and arranged to transport gas separated by the gas separator and any liquid away from the hollow cylindrical housing;

a second chamber supply line coupled to the hollow cylindrical housing upstream of the multistage pump and arranged to transport liquid and any gas unseparated by the gas separator from the multistage pump away from the hollow cylindrical housing;

at least one first chamber coupled to the first chamber supply line and arranged to receive the gas and any liquid transported by the first chamber supply line;

at least one second chamber coupled to the second chamber supply line and arranged to receive the liquid and any gas transported by the second chamber supply line;

a liquid flow meter coupled to each of the at least one first and second chambers, each liquid flow meter arranged to measure a flow rate of liquid at the at least one first and second chambers, respectively; and

a gas flow meter coupled to each of the at least one first and second chambers, each gas flow meter arranged to measure a flow rate of gas at the at least one first and second chambers, respectively.

2. The apparatus of claim 1, further comprising a mechanical separator positioned downstream of the gas separator within the hollow cylindrical housing, the mechanical separator arranged to induce a vortex in the hollow cylindrical housing.

3. The apparatus of claim 1, wherein the hollow cylindrical housing has one or more resealable holes formed therein, the one or more resealable holes allowing a sensor to be inserted in the hollow cylindrical housing.

4. The apparatus of claim 1, further comprising a gas supply line coupled to the hollow cylindrical housing and arranged to selectively inject gas into the hollow cylindrical housing.

5. The apparatus of claim 1, wherein each of the at least one first and second chambers includes a gas outlet and each gas flow meter is coupled to a respective each gas outlet.

6. The apparatus of claim 1, wherein each of the at least one first and second chambers includes a liquid outlet and each liquid flow meter is coupled to a respective liquid outlet.

7. The apparatus of claim 6, further comprising a holding tank and a liquid supply line coupling the holding tank to the hollow cylindrical housing, the liquid supply line arranged to selectively supply liquid from the holding tank to the hollow cylindrical housing.

8. The apparatus of claim 7, further comprising a return line coupled to each liquid flow meter, the return line arranged to return liquid exiting from the at least one first and second chambers to the holding tank.

9. The apparatus of claim 8, wherein the first chamber supply line and the at least one first chamber form a first closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing, and/or wherein the second chamber supply line and the at least one second chamber form a second closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing.

10. The apparatus of claim 1, further comprising a plurality of chamber valves coupled to the first and second chamber supply lines, each chamber valve individually

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operable in conjunction with one another to selectively control fluid flow into the at least one first and second chambers.

11. The apparatus of claim 1, further comprising an isolation valve coupled to the first chamber supply line and operable to selectively isolate the at least one first chamber from the at least one second chamber.

12. The apparatus of claim 1, wherein the gas separator has a transparent or translucent outer housing, and/or the multistage pump has a transparent or translucent outer housing.

13. The apparatus of claim 1, wherein the first chamber supply line, the second chamber supply line, the at least one first chamber, and/or the at least one second chamber is constructed of a transparent or translucent material.

14. A method for testing fluid handling equipment used in oil and gas production, comprising:

supplying a liquid to a hollow cylindrical housing at a selected supply flow rate from a liquid supply line, the hollow cylindrical housing constructed at least partly of a transparent or translucent material;

injecting a gas into the hollow cylindrical housing at a first injection rate from a gas supply line;

mixing the gas and the liquid to create a multiphase fluid; increasing injection of gas into the hollow cylindrical housing from the first injection rate to a second injection rate;

separating the gas in a gas separator positioned within the hollow cylindrical housing, wherein the gas separator separates all the gas injected at the first injection rate from the multiphase fluid, and wherein the gas separator fails to separate all the gas injected at the second injection rate from the multiphase fluid;

transporting gas separated by the gas separator and any liquid to at least one first chamber through a first chamber supply line coupled to the hollow cylindrical housing;

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transporting liquid and any gas unseparated by the gas separator from a multistage pump to at least one second chamber through a second chamber supply line coupled to the hollow cylindrical housing;

measuring a liquid flow rate and a gas flow rate at the at least one first and second chambers; and

comparing the liquid flow rate and the gas flow rate at the at least one first chamber to the liquid flow rate and the gas flow rate at the at least one second chamber.

15. The method of claim 14, wherein mixing the gas and the liquid to create a multiphase fluid is performed by a mechanical separator positioned downstream of the gas separator within the hollow cylindrical housing, the mechanical separator arranged to induce a vortex in the hollow cylindrical housing.

16. The method of claim 14, further comprising inserting a sensor into the hollow cylindrical housing through one or more resealable holes formed therein.

17. The method of claim 14, wherein the liquid is supplied to the hollow cylindrical housing from a holding tank, the holding arranged to receive liquid from the at least first and second chambers through a return line.

18. The method of claim 17, wherein the first chamber supply line and the at least one first chamber form a first closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing, and/or wherein the second chamber supply line and the at least one second chamber form a second closed test loop together with the return line, the holding tank, the liquid supply line, and the hollow cylindrical housing.

19. The method of claim 14, wherein the gas separator has a transparent or translucent outer housing, and/or the multistage pump has a transparent or translucent outer housing.

20. The method of claim 14, wherein the first chamber supply line, the second chamber supply line, the at least one first chamber, and/or the at least one second chamber is constructed of a transparent or translucent material.

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REIVINDICACIONES

1. Un aparato para caracterizar los sistemas de manipulación de fluidos en el fondo de pozo, que comprende:

una carcasa cilíndrica hueca dispuesta para recibir selectivamente un fluido multifase que contiene un gas y un líquido en este, en donde la carcasa cilíndrica hueca está construida al menos parcialmente de un material transparente o translúcido;

un separador de gas colocado dentro de la carcasa cilíndrica hueca en una ubicación especificada;

una bomba multietapa colocada corriente arriba del separador de gas en una ubicación especificada dentro de la carcasa cilíndrica hueca;

una línea de suministro de primera cámara acoplada a la carcasa cilíndrica hueca entre el separador de gas y la bomba multietapa y dispuesta para transportar el gas separado por el separador de gas y cualquier líquido lejos de la carcasa cilíndrica hueca;

una línea de suministro de segunda cámara acoplada a la carcasa cilíndrica hueca corriente arriba de la bomba multietapa y dispuesta para transportar el líquido y cualquier gas no separado por el separador de gas de la bomba multietapa lejos de la carcasa cilíndrica hueca;

al menos una primera cámara acoplada a la línea de suministro de primera cámara y dispuesta para recibir el gas y cualquier líquido transportado por la línea de suministro de primera cámara;

al menos una segunda cámara acoplada a la línea de suministro de segunda cámara y dispuesta para recibir el líquido y cualquier gas transportado por la línea de suministro de segunda cámara;

un medidor de flujo de líquido acoplado a cada uno de la al menos una primera y segunda cámara, en donde cada medidor de flujo de líquido está dispuesto para medir una velocidad de flujo de líquido en la al menos una primera y segunda cámara, respectivamente; y

un medidor de flujo de gas acoplado a cada uno de la al menos una primera y segunda cámara, en donde cada medidor de flujo de gas está dispuesto para medir una velocidad de flujo de gas en la al menos una primera y segunda cámara, respectivamente.

2. El aparato de acuerdo con la reivindicación 1, que comprende además un separador mecánico colocado corriente abajo del separador de gas dentro de la carcasa cilíndrica hueca, en donde el separador mecánico está dispuesto para inducir un vórtice en la carcasa cilíndrica hueca.

3. El aparato de acuerdo con la reivindicación 1, en donde la carcasa cilíndrica hueca tiene uno o más orificios herméticos formados en este, en donde el uno o más orificios herméticos permiten que un sensor se inserte en la carcasa cilíndrica hueca.
4. El aparato de acuerdo con la reivindicación 1, que comprende además una línea de suministro de gas acoplada a la carcasa cilíndrica hueca y dispuesta para inyectar selectivamente gas dentro de la carcasa cilíndrica hueca.
5. El aparato de acuerdo con la reivindicación 1, en donde cada una de la al menos una primera y segunda cámara incluye una salida de gas y cada medidor de flujo de gas se acopla a una salida de gas respectiva.
6. El aparato de acuerdo con la reivindicación 1, en donde cada una de la al menos una primera y segunda cámara incluye una salida de líquido y cada medidor de flujo de líquido se acopla a una salida de líquido respectiva.
7. El aparato de acuerdo con la reivindicación 6, que comprende además un tanque de retención y una línea de suministro de líquido que acopla el tanque de retención a la carcasa cilíndrica hueca, en donde la línea de suministro de líquido está dispuesta para suministrar selectivamente líquido desde el tanque de retención hasta la carcasa cilíndrica hueca.
8. El aparato de acuerdo con la reivindicación 7, que comprende además una línea de retorno acoplada a cada medidor de flujo de líquido, en donde la línea de retorno está dispuesta para devolver el líquido que sale de la al menos una primera y segunda cámara hacia el tanque de retención.
9. El aparato de acuerdo con la reivindicación 8, en donde la línea de suministro de primera cámara y la al menos una primera cámara forman un primer bucle de prueba cerrado junto con la línea de retorno, el tanque de retención, la línea de suministro de líquido y la carcasa cilíndrica hueca, y/o en donde la línea de suministro de segunda cámara y la al menos una segunda cámara forman un segundo bucle de prueba cerrado junto con la línea de retorno, el tanque de retención, la línea de suministro de líquido y la carcasa cilíndrica hueca.
10. El aparato de acuerdo con la reivindicación 1, que comprende además una pluralidad de válvulas de cámara acopladas a las líneas de suministro de primera y segunda cámara, en donde cada válvula de cámara se puede operar individualmente en conjunto entre sí para controlar selectivamente el flujo de fluido dentro de la al menos una primera y segunda cámara.
11. El aparato de acuerdo con la reivindicación 1, que comprende además una válvula de aislamiento acoplada a la línea de suministro de primera cámara y se puede operar

selectivamente para aislar la al menos una primera cámara de la al menos una segunda cámara.

12. El aparato de acuerdo con la reivindicación 1, en donde el separador de gas tiene una carcasa externa transparente o translúcida, y/o la bomba multietapa tiene una carcasa externa transparente o translúcida.

13. El aparato de acuerdo con la reivindicación 1, en donde la línea de suministro de primera cámara, la línea de suministro de segunda cámara, la al menos una primera cámara y/o la al menos una segunda cámara se construyen a partir de un material transparente o translúcido.

14. Un método para evaluar el equipo de manipulación de fluidos utilizado en la producción de petróleo y gas, que comprende:

- suministrar un líquido a una carcasa cilíndrica hueca a una velocidad de flujo de suministro seleccionada a partir de una línea de suministro de líquido, en donde la carcasa cilíndrica hueca está construida al menos parcialmente de un material transparente o translúcido;

- inyectar un gas dentro de la carcasa cilíndrica hueca a una primera velocidad de inyección desde una línea de suministro de gas;

- mezclar el gas y el líquido para crear un fluido multifase;

- aumentar la inyección de gas dentro de la carcasa cilíndrica hueca desde la primera velocidad de inyección hasta una segunda velocidad de inyección;

- separar el gas en un separador de gas colocado dentro de la carcasa cilíndrica hueca, en donde el separador de gas separa todo el gas inyectado a la primera velocidad de inyección del fluido multifase, y en donde el separador de gas no logra separar todo el gas inyectado a la segunda velocidad de inyección del fluido multifase.

- transportar el gas separado por el separador de gas y cualquier líquido a al menos una primera cámara a través de una línea de suministro de primera cámara acoplada a la carcasa cilíndrica hueca;

- transportar el líquido y cualquier gas no separado por el separador de gas desde una bomba multietapa hasta al menos una segunda cámara a través de una línea de suministro de segunda cámara acoplada a la carcasa cilíndrica hueca;

- medir una velocidad de flujo de líquido y una velocidad de flujo de gas en la al menos una primera y segunda cámara; y

- comparar la velocidad de flujo de líquido y la velocidad de flujo de gas en la al menos una primera cámara con la velocidad de flujo de líquido y la velocidad de flujo de gas en la

al menos una segunda cámara.

15. El método de acuerdo con la reivindicación 14, en donde la mezcla de gas y el líquido para crear un fluido multifase se realiza con un separador mecánico colocado corriente abajo del separador de gas dentro de la carcasa cilíndrica hueca, en donde el separador mecánico está dispuesto para inducir un vórtice en la carcasa cilíndrica hueca.

16. El método de acuerdo con la reivindicación 14, que comprende además insertar un sensor dentro de la carcasa cilíndrica hueca a través de uno o más orificios herméticos formados en esta.

17. El método de acuerdo con la reivindicación 14, en donde el líquido se suministra a la carcasa cilíndrica hueca desde un tanque de retención, en donde la retención está dispuesta para recibir líquido de la al menos primera y segunda cámara a través de una línea de retorno.

18. El método de acuerdo con la reivindicación 17, en donde la línea de suministro de primera cámara y la al menos una primera cámara forman un primer bucle de prueba cerrado junto con la línea de retorno, el tanque de retención, la línea de suministro de líquido y la carcasa cilíndrica hueca, y/o en donde la línea de suministro de segunda cámara y la al menos una segunda cámara forman un segundo bucle de prueba cerrado junto con la línea de retorno, el tanque de retención, la línea de suministro de líquido y la carcasa cilíndrica hueca.

19. El método de acuerdo con la reivindicación 14, en donde el separador de gas tiene una carcasa externa transparente o translúcida, y/o la bomba multietapa tiene una carcasa externa transparente o translúcida.

20. El método de acuerdo con la reivindicación 14, en donde la línea de suministro de primera cámara, la línea de suministro de segunda cámara, la al menos una primera cámara y/o la al menos una segunda cámara se construyen a partir de un material transparente o translúcido.