(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
05 August 2021 (05.08.2021)

WIPO | PCT

(10) International Publication Number
WO 2021/155372 A1

(51) International Patent Classification:
G01M 3/24 (2006.01) *G01M 3/02* (2006.01)
G01M 3/00 (2006.01) *G01M 3/04* (2006.01)

(21) International Application Number:
PCT/US2021/016086

(22) International Filing Date:
01 February 2021 (01.02.2021)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/967,773 30 January 2020 (30.01.2020) US

(71) Applicant: **QUEST INTEGRITY GROUP, LLC** [US/US]; 13131 Dairy Ashford Rd., Sugar Land, TX 77478 (US).

(72) Inventors: **MAURIER, Ron**; 13131 Dairy Ashford Rd., Sugar Land, TX 77478 (US). **DE LORENZO, Robert**; 13131 Dairy Ashford Rd., Sugar Land, TX 77478 (US).

(74) Agent: **HSIEH, Meng-Tien** et al.; Boulware & Valoir, 2603 Augusta Dr., Ste. 1350, Houston, TX 77057 (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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, 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, ST, 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).

Published:
— *with international search report (Art. 21(3))*

(54) Title: GEL PIGGING IMPROVEMENT

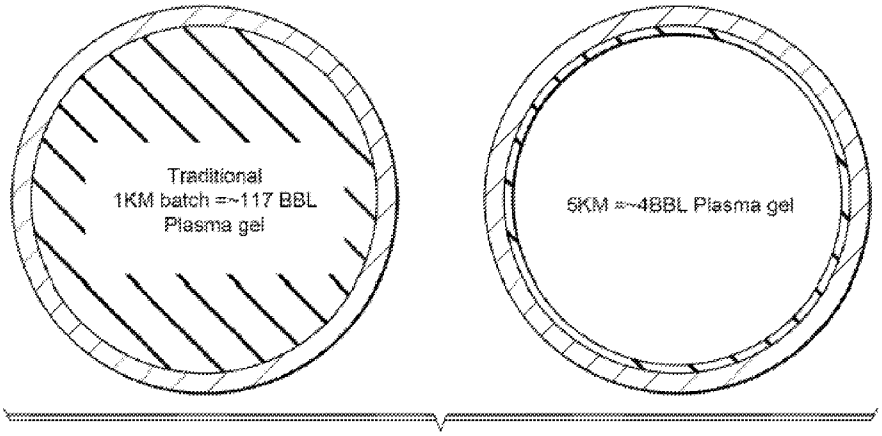


FIG. 1

(57) Abstract: A method for performing ultrasonic inspection to a pipe is described, comprising: introducing an in-line inspection tool assembly into a pipe, wherein the in-line inspection tool assembly comprises a gel reservoir and an ultrasonic inspection tool flanked by a pair of batching pigs, wherein the gel reservoir holds a first gel couplant; and driving the in-line inspection tool assembly along the pipe while performing ultrasonic inspection; wherein a gel slug is formed between the pair of batching pigs, and the gel slug facilitates the ultrasonic inspection.

WO 2021/155372 A1

GEL PIGGING IMPROVEMENT

PRIOR RELATED APPLICATIONS

[1] This application claims priority to U.S. Provisional Application No. 62/967,773, filed January 30, 2020, which is incorporated by reference in its entirety for all purposes.

FIELD OF INVENTION

[2] In general, the disclosure describes a system and methodology for inspecting tubes/pipes used for transporting petroleum products, such as natural gas (NG).

BACKGROUND OF INVENTION

[3] Pigging of pipes or pipelines is performed to remove internal fouling, to inspect for defects in a pipe or to map the geographic location of the pipe. Pigging is done by pumping a device, i.e. a pig, through a pipe. Intelligent pigs have sensors that can record information on the condition of the pipe.

[4] Presently, transport lines such as NG lines are typically inspected using Magnetic Flux Leakage technology (MFL), spot-checked using manual, external ultrasonic sensors, or inspected using conventional ultrasonic (UT) in-line-inspection (ILI) tools during static pressure testing, when the pipes or tubes are flooded with water.

[5] MFL data only provides a qualitative measurement of the health of the pipes. It reflects the general health of the pipes, but does not provide a quantitative measurement of wall thickness or corrosion.

[6] Spot checking only examines a very small sample of the entire pipeline. Furthermore, it requires the asset to be accessible by a person.

[7] Static pressure testing is performed infrequently, and presents a great cost to the customer. Flooding the line with water during any other time is not desired, due to increased operational costs, and asset down-time.

[8] Batched inspections using water have not been successful. The batching pigs were not adequate to smoothly flow through the line, which led to pressure surges on the launching and receiving ends. Furthermore, using water as a couplant left large quantities of water in the line after the inspection was completed, even with the batching pigs.

[9] What is needed, therefore, is a more reliable method and system for inspecting a petroleum product transport lines, such as NG lines.

SUMMARY

[10] This summary is provided to introduce a selection of concepts that are further described below in the detailed description. However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims. This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limited the scope of the claimed subject matter.

[11] In one aspect of this disclosure, a method for performing ultrasonic inspection to a pipe is described, comprising: introducing an in-line inspection tool assembly into a pipe, wherein the in-line inspection tool assembly comprises a gel reservoir and an ultrasonic inspection tool flanked by a pair of batching pigs, wherein the gel reservoir holds a first gel couplant; and driving the in-line inspection tool assembly along the pipe while performing ultrasonic inspection; wherein a gel slug is formed between the pair of batching pigs, and the gel slug facilitates the ultrasonic inspection.

[12] In another aspect of this disclosure, a method for performing ultrasonic inspection of a pipe is described, comprising: introducing an in-line inspection tool assembly into the pipe, wherein the in-line inspection tool assembly comprises an ultrasonic inspection tool between a pair of batching pigs; and driving the in-line inspection tool assembly along the pipe while performing ultrasonic inspection; wherein the ultrasonic inspection tool is surrounded by a gel couplant to facilitate ultrasonic inspection, and wherein the gel couplant is semi-rigid.

[13] In another aspect of this disclosure, an in-line inspection tool assembly for performing ultrasonic inspection of a pipe is described. The inspection tool assembly comprises a first batching pig, a second batching pig, and an ultrasonic inspection tool operatively coupled with a gel reservoir that holds a first gel couplant, wherein the ultrasonic inspection tool and the gel reservoir are located between the first batching pig and the second batching pig, and wherein a gel slug is formed around the ultrasonic inspection tool to facilitate ultrasonic inspection.

[14] In another aspect of this disclosure, an in-line inspection tool assembly for performing ultrasonic inspection in a pipe is disclosed. The in-line inspection tool assembly comprises a

first batching pig, a second batching pig, and an ultrasonic inspection tool operatively coupled between the first batching pig and the second batching pig, wherein the ultrasonic inspection tool is surround by a semi-rigid gel couplant.

BRIEF DESCRIPTION OF THE FIGURES

[15] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It is emphasized that, in accordance with standard practice in the industry, various features are not drawn to scale. In fact, the dimensions of various features may be arbitrarily increased or reduced for clarity of discussion. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[16] Figure 1 is a comparison of the amount of couplant gel required between a traditional ultrasonic inspection and an embodiment of this disclosure.

[17] Figure 2 is a cross-sectional view of one embodiment of this disclosure as applied to a pipeline.

[18] Figure 3 is a cross-sectional view of another embodiment of this disclosure as applied to a pipeline.

[19] Figure 4 is a cross-sectional view of another embodiment of this disclosure as applied to a pipe.

DETAILED DESCRIPTION

[20] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. It is to be understood that the following disclosure provides many different embodiments, or examples, for implementing different features of various embodiments. Specific examples of components and arrangements are described below to simplify the disclosure. These are, of course, merely examples and are not intended to be limiting. In addition, the disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. However, it will be understood by those of ordinary skill in the art that the system

and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments are possible. This description is not to be taken in a limiting sense, but rather made merely for the purpose of describing general principles of the implementations. The scope of the described implementations should be ascertained with reference to the issued claims.

[21] As used herein, the terms “connect”, “connection”, “connected”, “in connection with”, and “connecting” are used to mean “in direct connection with” or “in connection with via one or more elements”; and the term “set” is used to mean “one element” or “more than one element”. Further, the terms “couple”, “coupling”, “coupled”, “coupled together”, and “coupled with” are used to mean “directly coupled together” or “coupled together via one or more elements”. As used herein, the terms "up" and "down"; "upper" and "lower"; "top" and "bottom"; and other like terms indicating relative positions to a given point or element are utilized to more clearly describe some elements. As used herein, the terms “pipes”, and “tubes” are used individually or in combination to mean the transport elements for petroleum products.

[22] As used herein, "in-line inspection" or ILI refers to the evaluation of pipes and pipelines using non-destructive testing techniques to detect and measure any internal defect or flaw. ILI measures and records irregularities in pipelines including corrosion, cracks, deformation or other defects.

[23] As used herein, the term "ultrasonic transducer" refers to a device that converts a pulse of electrical energy into mechanical energy in the form of sound waves. For nondestructive testing, the high-frequency sound waves are generated and received by the ultrasonic transducers, and the corresponding data is then processed to determine if any flaw exists. Typically the active element of an ultrasonic transducer is a thin disk, square or rectangle piezoelectric ceramic or composite that converts electrical energy into acoustic energy, and vice versa.

[24] As used herein, the term "couplant" refers to a material that is capable of providing acoustic coupling between the ultrasonic transducer and a test subject. Couplant is required due to the acoustic impedance mismatch between air in the interface with the transducer and the test object. As known in the field, for ultrasonic inspection, the couplant is typically a gel, and can include a variety of different compositions. Several selection criteria may be considered:

corrosion inhibition, acoustic impedance, viscosity, temperature range, and drying time or evaporation time.

[25] Specifically, the couplant used herein should not cause any corrosion to the piping or the coating/plating of the equipment in order to avoid any failure of the part due to hydrogen embrittlement, stress corrosion cracking, or deep pitting.

[26] Furthermore, the couplant used herein preferably reduces surface noise and improves the coupling on rough or curved metal surface. Couplants having high acoustic impedance provide improved results for concrete testing and metals of less than perfect surface conditions.

[27] Viscosity of couplants may also affect the testing results. Couplants having higher viscosity provide enhanced coupling and reduces surface noise on curved surfaces, while exposure, adhesion to the part, and ease of application are also factors affecting couplant selection.

[28] The operating temperature range of the couplants would also be considered. For example, temperature of the part to be tested, or length of time of inspection would impact the choice of couplant.

[29] Drying time or evaporation time is another factor to be considered, because it affects how often the couplant needs to be re-applied, especially when performing a lengthy inspection. Petroleum product pipelines typically extend for miles and therefore couplants having longer drying time would be preferred.

[30] As used herein, "gel reservoir" refers to a storage unit of the in-line inspection tool assembly to store additional couplant gel, such that the couplant gel can be quickly re-applied when needed. The location of the gel reservoir in the in-line inspection tool assembly can vary, as long as the actuation mechnism can introduce the additional couplant gel to the intended area.

[31] As used herein, "pig" refers to a solid or semi-solid fluid-driven entities that are pumped through a pipeline from one point to another where launching and receiving facilities exist. "Batching pig" or "batch pig" refers to a pig with a seal in the pipeline to separate the liquid from the gas or medium in the pipeline. The batching pig used in this disclosure has a profile

that conforms with the inner wall of the pipeline to minimize the amount of couplant residue after the inspection is completed.

[32] As used herein, "gel slug" refers to a relatively short section within the pipeline that is occupied primarily by gel.

[33] As used herein, "gel recovery device" refers to a device that recovers couplant after testing has been completed for the area. For example, a scraper disk may be included in the in-line inspection tool assembly behind the ultrasound transducer, such that once the ultrasonic transducer passes through one section of the pipe, the scrape disk can scrape the inner wall of the pipe to collect and substantially remove the couplant. In some embodiment, the scraped couplant is collected and re-supplied to the front of in-line inspection tool assembly. Other gel recovery device may be used.

[34] The use of the word “a” or “an” when used in conjunction with the term “comprising” in the claims or the specification means one or more than one, unless the context dictates otherwise.

[35] The term “about” means the stated value plus or minus the margin of error of measurement or plus or minus 10% if no method of measurement is indicated.

[36] The use of the term “or” in the claims is used to mean “and/or” unless explicitly indicated to refer to alternatives only or if the alternatives are mutually exclusive.

[37] The terms “comprise”, “have”, “include” and “contain” (and their variants) are open-ended linking verbs and allow the addition of other elements when used in a claim.

[38] The phrase “consisting of” is closed, and excludes all additional elements.

[39] The phrase “consisting essentially of” excludes additional material elements, but allows the inclusions of non-material elements that do not substantially change the nature of the invention.

[40] The present disclosure describes a system and methodology used to inspect tubes/pipes used for transporting petroleum products, primarily natural gas (NG), using a gel-like substance. NG pipes and tubes are a common asset within the power, oil and gas industries, and routine inspection is required for properly maintaining, repairing and/or replacing the

pipes. Ultrasonic inspection, while widely used, was problematic in natural gas pipeline because ultrasonic inspection tools typically requires a gel couplant surrounding the tools to obtain accurate readings, and gel couplant residue within the gas pipeline poses performance as well as safety issues. Filling the pipeline, often miles long, with gel couplant for ultrasonic inspection is time consuming and economically burdensome.

[41] Therefore, an in-line inspection tool assembly capable of inspecting a natural gas pipeline using minimum amount of gel couplant is described. A method of inspecting the petroleum product pipeline using the in-line inspection tool assembly is also described herein.

[42] Referring to Fig. 2, which shows a self-contained inline couplant (SLIC) embodiment of the present disclosure. In Fig. 2, an in-line inspection (ILI) tool assembly **200** is introduced inside a petroleum product, such as natural gas, pipeline **220**. A couplant gel slug or gel train may be first introduced in the pipeline **220**, after which the ILI tool assembly **200** is inserted in the gel slug. Alternatively, the gel slug may be injected from a gel reservoir **211** within the ILI tool assembly **200**. In Fig. 2, the flow direction inside the pipeline **220** is toward the right, and the product, such as natural gas, **201** behind the ILI tool assembly **200** drives it downstream. The ILI tool assembly **200** comprises a first batching pig **203** at the leading end, and a second batching pig **205** at the trailing end. Both batching pigs **203**, **205** provide an annular seal such that the product **201** would not leak into the space between the batching pigs **203, 205**. An ultrasonic inspection tool **207** is placed between the batch pigs **203, 205**.

[43] For the ultrasonic inspection tool **207** to obtain accurate readings, a pressurized couplant plasma gel storage unit **211** is provided, along with a plasma gel extruder **209**, such that a small amount of plasma gel couplant **215** is provided around the ultrasonic inspection tool **207**. To reduce the amount of plasma gel used, gel containment seals **213** are provided in front and behind the ultrasonic inspection tool **207**. The gel containment seals **213** provide additional annular seal to form a closed chamber encompassing the ultrasonic inspection tool **207** and prevents the plasma gel couplant **215** from escaping the chamber as the assembly **200** moves within the pipeline **220**. This configuration enables ultrasonic inspection within a petroleum product pipeline **220**, while reducing the amount of plasma gel couplant **215** used to an economically acceptable range.

[44] The gel couplant **215** used will minimize residue left in the pipeline **220** because the containment seals effectively contain and carry the gel couplant **215** as the ILI tool assembly

200 moves along the pipeline **220**. The gel will be used as a couplant for ultrasonic inspection of the pipeline **220**, and it will not contribute any damaging effects to the pipeline **220**.

[45] In some embodiments, since pipelines **220** are periodically treated with chemicals that inhibit corrosion and other damaging effects, the plasma gel couplant **215** can also comprise the necessary chemicals for treating the pipelines **220** in addition to being used as a couplant.

[46] Referring to Fig. 1, which shows comparison of plasma gel used between traditional method and embodiments of this disclosure for a specific set of conditions. As shown in Fig. 1, for the same set of pipeline conditions, a traditional ultrasonic inspection, required approximately 117 BBL of plasma gel per kilometer because the entire section of pipes needed to be flooded with water, and under such condition a large amount of gel couplant was required. By contrast, for that same set of conditions, using the method of the present disclosure, only 4 BBL of plasma gel would be required per 5 kilometers, which translates into a 145-fold reduction in the amount of gel required for the ultrasonic inspection.

[47] Referring now to Fig. 3, which shows another embodiment of this disclosure. The batching pigs can be designed for each pipe to be inspected in such a way as to minimize the amount of gel-residue left in the line. As shown in Fig. 3, an in-line inspection (ILI) tool assembly **300** is introduced inside a pipeline, such as a natural gas pipeline, **320**. The flow direction inside the pipeline **320** is toward the right, and the product, such as natural gas, **301** behind the ILI tool assembly **300** drives it downstream. The ILI tool assembly **300** comprises a first batch pig **303** at the leading end, and a second batch pig **305** at the trailing end. An ultrasonic inspection tool **307** is located between the batching pigs **303**, **305**.

[48] Unlike Fig. 2, the ILI tool assembly **300** further comprises a plasma gel recovery scraper disk **317** to remove and recapture gel residue from the inner wall of the pipeline **320**.

[49] The batching pigs and/or the ILI tool **300** comprises gel reservoirs **311** of the gel in order to replenish any gel couplant **315** not captured by the trailing batch pig **305**. The extruder **309** can inject additional gel **315** into the pipeline from the reservoir **311**. The batching pigs **303, 305** and/or the ILI tool **300** may be designed in such a way as to recirculate, re-use or recapture the gel/couplant **315** that is no longer in the vicinity of the UT sensors. For example, a pump (not shown) may be included in the ILI tool assembly **300** to transfer the gel **315** collected by the scraper disk **317** to the leading end of the ILI tool assembly **300**.

[50] Referring to Fig. 4, which shows another embodiment of this disclosure. The ultrasonic portion of the ultrasonic inspect tool **407** may be encapsulated in a more rigid gel **410** in order to reduce the quantity of fluid gel **415** needed to perform the inspection. In this embodiment, semi-rigid gel **410** will encapsulate the ultrasonic inspection tool **407** and be used to transmit the ultra-sonic signal to the pipe wall, thus reducing, or possibly eliminating the need for additional couplant **415**. Semi-rigid gels are less likely to be depleted or otherwise escape the space between the first and second batching pigs **403, 405**.

[51] The inspection method of the present disclosure has the advantage of using only limited amount of a gel-like couplant introduced into the pipe or pipeline in a contained manner. In this way, the gel couplant is only present in a small area of the pipe. The UT tool is then introduced into this gel, and the contained gel "slug" is propelled through the pipe or pipeline via pressure from natural gas or air.

[52] The gel used will minimize residue left in the inspected pipe, and it will be conductive to ultrasonic signals. The gel will be used as a couplant for ultrasonic inspection of the pipe, and it will not contribute any damaging effects to the pipe. Preferably the gel has long drying time to reduce the time needed for reapplication, and a wide operating temperature range to avoid any. Currently, pipelines are periodically treated with chemicals that inhibit corrosion and other damaging effects. The gel can also be used to apply this treatment, while it is also being used as a couplant.

[53] The quantity of gel used for each individual pipe or line will be calculated and optimized, to reduce the total quantity used as much as possible. This will be calculated as a function of the diameter of the pipe or line, the length of the pipe or line being inspected, and the amount of gel-residue left in the pipe or line after the final batching pig has passed.

[54] The inspection method can be implemented in such a way as to minimized or eliminate leakage of the gel into any "take-off's" or other lines attached to the pipe or line currently under inspection. In the SLIC method, the ILI tool is sealed on both the leading and trailing ends to carry the couplant with it while inspecting, in order to prevent leaking. Additionally, the gel couplant may be recovered and recirculated through active and/or passive processes.

[55] The inspection method of this disclosure enables effective and efficient inspection of petroleum assets, such as NG pipelines, using ultrasonic ILI tools, while minimizing the amount of fluid/gel/couplant required for performing the ultrasonic inspection. Furthermore,

this method provides a comprehensive, quantitative measurement of the remaining asset life of the pipelines.

[56] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims. The scope of the invention should be determined only by the language of the claims that follow. The term "comprising" within the claims is intended to mean "including at least" such that the recited listing of elements in a claim are an open group. The terms "a," "an" and other singular terms are intended to include the plural forms thereof unless specifically excluded.

CLAIMS

What is claimed is:

1. A method for performing ultrasonic inspection of a pipe, comprising:

   a) introducing an in-line inspection tool assembly into the pipe, wherein the in-line inspection tool assembly comprises a gel reservoir and an ultrasonic inspection tool flanked by a pair of batching pigs, wherein the gel reservoir holds a first gel couplant; and

   b) driving the in-line inspection tool assembly along the pipe while performing ultrasonic inspection;

   wherein a gel slug is formed between the pair of batching pigs, and said gel slug facilitates the ultrasonic inspection.

2. The method of claim 1, wherein the gel slug is formed by releasing the gel from the gel reservoir into the pipe between the pair of batching pigs.

3. The method of claim 1, wherein the in-line inspection tool assembly further comprises seals adjacent to the ultrasonic inspection tool to form a closed chamber encompassing the ultrasonic inspection tool.

4. The method of claim 3, wherein the gel slug is formed within the closed chamber.

5. The method of claim 1, wherein the gel serves as couplant for ultrasonic inspection.

6. The method of claim 1, wherein the in-line inspection tool assembly further comprising a gel recovery device to collect and recycle the gel.

7. The method of claim 6, wherein the gel recovery device comprises a scraper disk.

8. The method of claim 6, wherein the gel recovery device recovers gel after the ultrasonic inspection tool passes, and the recovered gel is re-supplied in front of the ultrasonic inspection tool.

9. The method of claim 1, further comprising, prior to step (a):

   introducing a first gel couplant into the pipe.

10. The method of claim 1, wherein the ultrasonic inspection tool is further surrounded by a second gel couplant, wherein the second gel couplant has a different composition than the first gel couplant.

11. The method of claim 10, wherein the second gel couplant is semi-rigid.

12. The method of claim 1, further comprising: supplying the first gel couplant between the first and the second batching pigs from the gel reservoir.

13. A method for performing ultrasonic inspection of a pipe, comprising:

a) introducing an in-line inspection tool assembly into the pipe, wherein the in-line inspection tool assembly comprises an ultrasonic inspection tool between a pair of batching pigs; and

b) driving the in-line inspection tool assembly along the pipe while performing ultrasonic inspection;

wherein the ultrasonic inspection tool is surrounded by a gel couplant for ultrasonic inspection, and wherein the gel couplant is semi-rigid.

14. An in-line inspection tool assembly for performing ultrasonic inspection in a pipe, said in-line inspection tool assembly comprises a first batching pig, a second batching pig, and an ultrasonic inspection tool operatively coupled with a gel reservoir that holds a first gel couplant, wherein the ultrasonic inspection tool and the gel reservoir are located between the first batching pig and the second batching pig, and wherein a gel slug is formed around the ultrasonic inspection tool to facilitate ultrasonic inspection.

15. The inspection tool assembly of claim 14~~13~~, further comprising a first seal and a second seal, wherein the first and second seals flank the ultrasonic inspection tool to form a closed chamber encompassing the ultrasonic inspection tool.

16. The inspection tool assembly of claim 15~~14~~, wherein the gel slug is formed within the closed chamber.

17. The inspection tool assembly of claim 14, further comprising a gel recovery device between the first and the second batching pigs, wherein said gel recovery device recovers gel couplant after the ultrasonic inspection passes.

18. The inspection tool assembly of claim 17, wherein the recovered gel is re-supplied in front of the ultrasonic inspection tool.

19. The inspection tool assembly of claim 14, further comprising a second gel couplant surrounding the ultrasonic inspection tool, wherein the second gel couplant has a different composition than the first gel couplant.

20. An in-line inspection tool assembly for performing ultrasonic inspection in a pipe, said in-line inspection tool assembly comprises a first batching pig, a second batching pig, and an ultrasonic inspection tool operatively coupled between the first batching pig and the second batching pig, wherein the ultrasonic inspection tool is surround by a semi-rigid gel couplant.

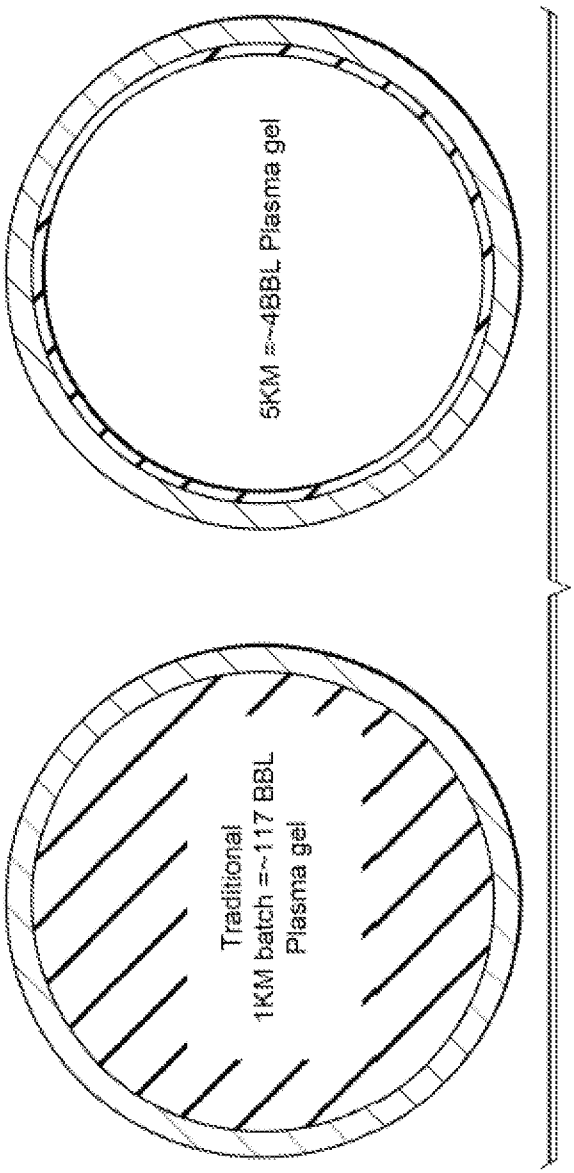

5KM =~4BBL Plasma gel
Traditional
1KM batch =~117 BBL
Plasma gel

FIG. 1

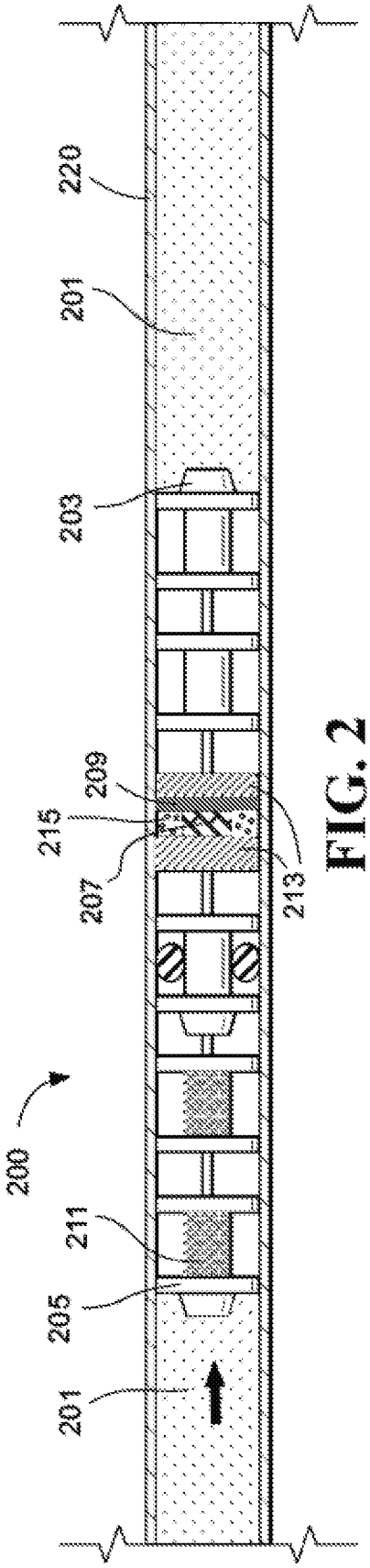

220
201
203
209
215
207
213
200
211
205
201

FIG. 2

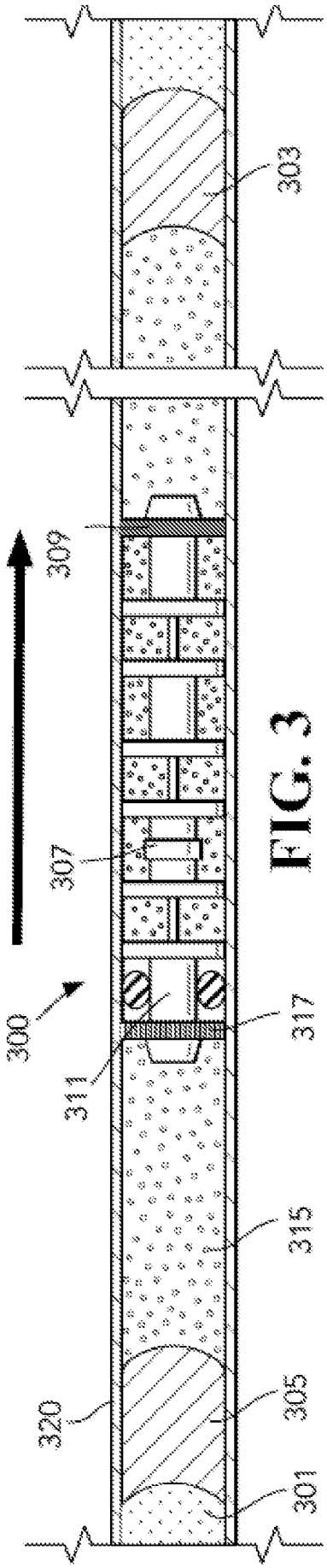


FIG. 3

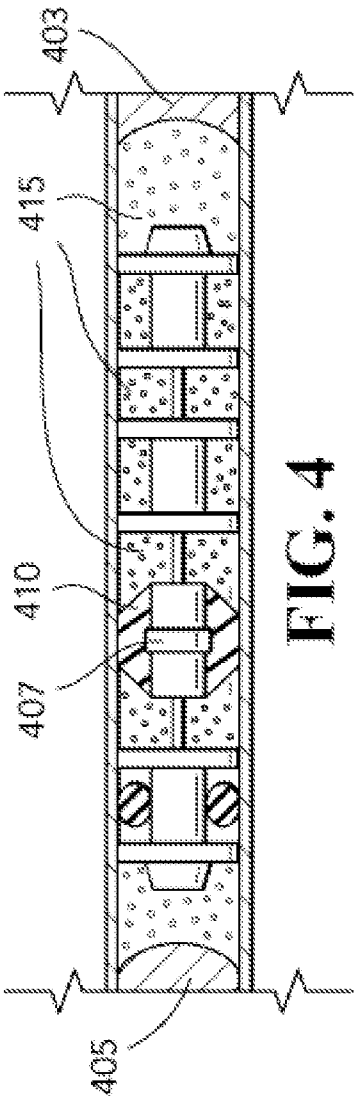


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2021/016086

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G01M 3/24; G01M 3/00; G01M 3/02; G01M 3/04 (2021.01)
CPC - G01M 3/243; G01M 3/00; G01M 3/02; G01M 3/04; G01M 3/24 (2021.02)

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

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008/0148856 A1 (GEORGESON et al) 26 June 2008 (26.06.2008) entire document	1-5, 9-12, 14-16, 19
Y	US 2007/0113622 A1 (BUCKLEY et al) 24 May 2007 (24.05.2007) entire document	1-5, 9-16, 19, 20
Y	US 2009/0043205 A1 (PELISSIER et al) 12 February 2009 (12.02.2009) entire document	10, 11, 13, 19, 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
"D" document cited by the applicant in the international application
"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
02 April 2021	APR 23 2021
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	Authorized officer Blaine R. Copenheaver Telephone No. PCT Helpdesk: 571-272-4300