



(51) International Patent Classification:

F16L 1/235 (2006.01) *F16L 55/136* (2006.01)
F16L 55/11 (2006.01) *F16L 55/42* (2006.01)
F16L 55/128 (2006.01) *F16K 17/40* (2006.01)
F16L 55/134 (2006.01)

(21) International Application Number:

PCT/IB2017/001402

(22) International Filing Date:

11 October 2017 (11.10.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1617673.7 19 October 2016 (19.10.2016) GB

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(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, JO, JP, KE, KG, KH, KN, KP,

(54) Title: PIPELINE SEALING ASSEMBLY AND METHOD

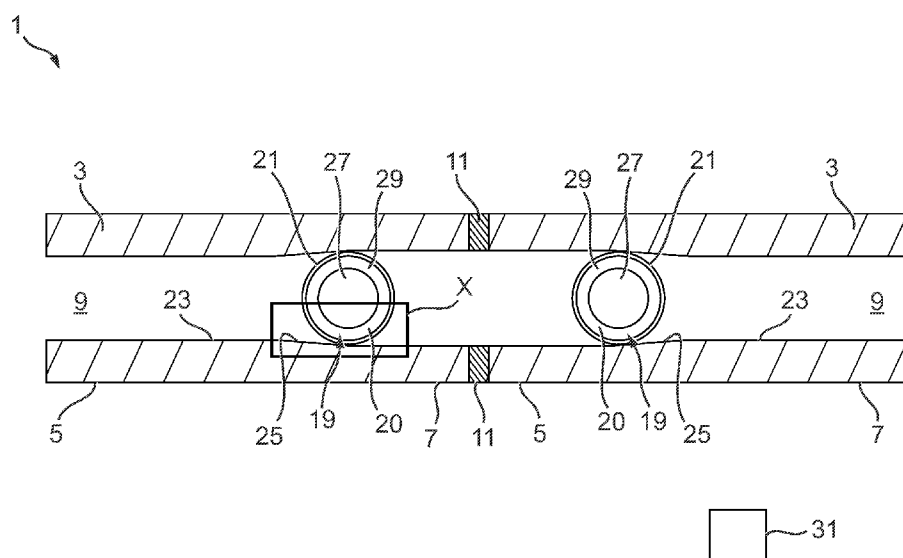


Fig. 1

(57) Abstract: An assembly (1) comprising a pipeline section (3) having opposite ends (5, 7) and an inner bore (9) extending between the ends; at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure (15); a sealing device (19) having one or more controllably disintegratable portions (29) being installed in the pipeline section (3), to seal the inner bore (9) of the pipeline section (3) to prevent flow through the inner bore (9); the sealing device (19) comprising an outer surface (21) in sealing contact with an inner surface (23) defining the inner bore (9) of the pipeline section (3). Optionally, the outer circumference of the sealing device (29) is reduced following the disintegration of the or each controllably disintegratable portion. Optionally a portion (25) of the inner surface (23) of the pipeline section (3) in contact with the outer surface (21) of the sealing device (19) is modified such that the sealing device (19) is installed with at least an interference fit into the pipeline section (3) to establish sealing contact between



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, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, 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))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

PIPELINE SEALING ASSEMBLY AND METHOD

BACKGROUND

5 The present invention relates to a sealing assembly and method for marine or subsea pipelines used for transporting fluids such as oil and gas. In particular, it relates to an assembly including a pipeline section (i.e. a length of pipe for assembling a longer pipeline therefrom) having one or more sealing devices sealing an inner bore of the pipeline section, certain sealing devices, and methods of sealing and unsealing a
10 pipeline including one or more such pipeline sections, as well as laying a pipeline.

Subsea pipelines are well-known in the art for transporting fluids such as hydrocarbons such as oil and gas. Often, such pipelines are laid completely on a seabed or seafloor for the passage of fluids between two sites, such as a production well or wellhead and an
15 adjacent production platform.

There are two common methods of laying underwater or submarine pipelines. The so-called 'stove piping method' involves assembling pipe sections on a pipe-laying vessel, and then welding each one as the laying progresses. In the so-called 'reel laying
20 method', the pipeline is assembled onshore and spooled onto a large reel, sometimes also termed a storage reel or drum. Once offshore, the pipeline is spooled off from the reel, straightened and/or aligned and finally laid on the seabed. With this method, no 'pipe-to-pipe' welding is required during the offshore operation, saving time for the vessel operation.

25 The reel laying method is faster and more economical than the stove piping method, such that it is preferred where possible, and pipes or pipelines which can be laid using this method are termed 'reelable' or 'reel-layable'.

30 During the laying of pipelines, irrespective of the method used, there always exists a probability of the pipeline flooding for unforeseen reasons such as local buckling, weld defect in end structure, faulty valve or human error (e.g. failure to close a valve). For any length of the pipeline where its bore is continuously 'open', i.e. without any break or stop, then any flooding will extend along the pipeline without break or stop.

Separately, a portion of a pipeline may be intentionally flooded to prevent buckling of the pipeline at a critical point or section, for example between a PipeLine End Termination (PLET) or FlowLine End Termination (FLET) and pipe plug or between
5 two pipe plugs. Intentional flooding of a critical section could also enable cost savings, by allowing the use of a thinner (and therefore less expensive) pipeline wall.

But, pipeline flooding can lead to severe increase of the laying tension, especially the lay catenary top tension, which in extreme cases can be close to or even exceed the laying
10 or other equipment capacity. For this reason, it is standard practice in the art to account for a possible flooding scenario, to ensure that in event of flooding, the laying vessel can still hold onto the pipeline, and eventually safely deal with the situation. It is of critical that the methodology can guarantee safety of personnel, and the integrity of the vessel and of the pipeline being installed. Although the likelihood of unintended
15 pipeline flooding is generally remote, the consequences of such flooding are very penalising in terms of environmental and economical damage.

Various plug arrangements are known for creating a physical barrier along the length of pipeline to prevent flooding, or the passage of water migrating from one part of a
20 pipeline to another. US 4,252,465 discloses a soluble gel plug for separating an air-filled section of a pipeline from a water-filled section thereof. US 4,360,290 and US 4,390,043 describe a pipeline plug for sealing a high pressure side of pipeline from a low pressure side thereof pipeline. The plug has mechanical parts gripping the pipe to seal the pipe and releasing at a set pressure to allow the plug to travel out of the pipe.
25 GB 2,195,738 discloses a plug created by freezing gel inside a pipe. GB 2,227,805 discloses spherical plugs which have a remotely electronically controlled mechanism for expanding and collapsing the spheres inside the pipe. WO2012/130320 discloses a remotely electronically controlled robotic pipeline plug. WO2012/137184 describes a modular train for plugging a pipeline. WO2014/001303 describes soluble gel plugs for
30 isolating a section of pipeline from the rest of the pipeline for repair or modification. All of these arrangements are complicated, bulky or difficult to install and then operate and/or remove, and are not suitable for practical reasons during laying and installation of a pipeline or attached pipeline structure.

SUMMARY

In accordance with a first aspect of the invention there is provided an assembly comprising:

5 a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;

 a sealing device having one or more controllably disintegrateable portions, and installed in the inner bore of the pipeline section to prevent flow through the inner
10 bore, the sealing device comprising an outer surface in sealing contact with an inner surface defining the inner bore of the pipeline section.

According to another aspect of the present invention, there is provided a pipeline comprising an assembly as defined herein in which at least one end of the pipeline
15 section of the assembly is connected to a respective end of a pipeline section of another such assembly and/or to a pipeline structure.

According to another aspect of the present invention, there is provided a method of sealing a pipeline section, the method comprising at least the steps of:

20 providing a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;

 providing at least one sealing device having one or more controllably disintegrateable portions for sealing the inner bore of the pipeline section; and

25 installing at least one said sealing device with an interference fit into the pipeline section into the pipeline section with an outer surface of the sealing device, and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section.

30 According to another aspect of the present invention, there is provided a method of unsealing a pipeline section sealed by a method as defined herein comprising at least the step of applying a controlled stimulus to cause the or each controllably disintegrateable portion of the sealing device to disintegrate into smaller parts in response to the controlled stimulus.

According to another aspect of the present invention, there is provided a method of laying a subsea pipeline comprising a plurality of pipeline sections, each pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section, comprising the steps of:

installing at least one sealing device as defined herein into a pipeline section and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section;

forming the pipeline by joining two or more of the pipeline sections;

laying the subsea pipeline; and

unsealing the pipeline by applying a controlled stimulus to cause the or each controllably disintegrateable portion of the or each sealing device to disintegrate in response to the controlled stimulus.

According to another aspect of the present invention, there is provided a method of laying a subsea pipeline section and pipeline structure the pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to the pipeline structure, comprising the steps of:

installing at least one sealing device as defined herein to into the pipeline section connectable to the pipeline structure, and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section;

joining the pipeline section and pipeline structure;

laying the pipeline section and pipeline structure; and

unsealing the pipeline section by applying a controlled stimulus to cause the or each controllably disintegrateable portion of the sealing device to disintegrate in response to the controlled stimulus.

According to another aspect of the present invention, there is provided a sealing device for sealing a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;

the sealing device having one or more controllably disintegrateable portions, and installable in the inner bore in the pipeline section to prevent flow through the

inner bore, the sealing device comprising an outer surface in sealing contact with an inner surface defining the inner bore of the pipeline section.

All essential, preferred or optional features or steps of each aspect of the invention can be provided in conjunction with the features of each other aspect of the invention described herein and vice versa where appropriate.

DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic cross-sectional side view of two assemblies in accordance with one embodiment of the present invention connected end-to-end;

Figure 2 is a schematic cross-sectional side view of an assembly in accordance with another embodiment of the present invention connected to a structure;

Figure 3 is an enlarged view of area X of Figure 1 showing a tapered portion of an inner surface of a pipeline section of the assembly;

Figure 4 is a variation of Figure 3 in which the tapered portion is roughened;

Figure 5 is similar to Figure 1, showing portions of a disintegrated sealing device of the assembly moving along the pipeline section of the assembly as indicated by arrows;

Figures 6a and 6b are schematic cross-sectional side views of an assembly and sealing device in accordance with other embodiments of the present invention during sealing.

Figures 7a and 7b are schematic cross-sectional side views of an assembly and sealing device in accordance with further other embodiments of the present invention, during sealing and after sealing respectively;

Figures 8a and 8b are schematic cross-sectional side views of an assembly and sealing device in accordance with further other embodiments of the present invention, during sealing and after sealing respectively; and

Figures 9a and 9b are schematic cross-sectional side views of an assembly and sealing device in accordance with yet further other embodiments of the present invention, during sealing and after sealing respectively.

DETAILED DESCRIPTION

In one aspect, the present invention provides an assembly comprising a pipeline section as defined herein, and a sealing device able to provide a temporary plug in the pipeline section, by having one or more controllably disintegrateable portions.

In this way, the assembly achieves a simple to install arrangement to seal and therefore prevent or limit the extent of any deliberate or accidental pipeline flooding either side of the sealing device. The provision of one or more said sealing devices positioned inside the inner bore of the pipeline section provides a safety feature which confines flooding of the pipe to a limited length, for example, during laying of pipeline or during pre-commissioning testing to ensure that tensions within pipeline remain within pre-set safety limits. The sealing device can also be easily disposed of following pipe laying or testing. The provision of any modified profile of the inner surface of the pipeline section ensures that reliable sealing and secure retention of the sealing device in the pipeline section are achieved.

Typically, one or more of the outer size, shape, circumference and/or diameter of the sealing device are reduced to unseal the bore of the pipeline following the disintegration of the or each controllably disintegrateable portion.

Optionally, one said sealing device is installed at or adjacent one end or each opposite end of the pipeline section. This ensures that the pipeline section is isolated in case of flooding and an adjacent pipeline section and/or structure.

The term "pipeline section" as used herein includes any pipe or pipeline or part thereof, having an inner bore for fluid transport or passage, which inner bore may have or may not have a constant or variable inner diameter or inner circumference. Optionally, the pipeline section is a length of pipe for assembling a longer pipeline. Rigid and flexible pipes, pipelines, and pipe sections or stalks are well known in the art, and typically have one or more concentric layers.

The structure and design of flexible pipes, pipelines and pipe sections are set out and described in API Recommended Practice 17B (5th Edition, May 2014) and API Specification 17J (4th Edition, May 2014).

- 5 A flexible pipe generally comprises at least one polymer sheet and one layer of wound wire. This can allow the flexible pipe to bend relatively easily and to be reeled with minimal plastic deformation.

- 10 A flexible pipe may be bonded or unbonded. A bonded pipe is normally a flexible pipe in which steel reinforcement is provided within and bonded to an (optionally Vulcanized) elastomeric material. A textile (eg a woven fabric) may be included in the structure in order to provide additional structural reinforcement or to separate elastomeric layers. In an unbonded pipe, the pipe construction normally comprises separate unbonded polymeric and metallic layers, which allows relative movement
15 between layers.

- A flexible pipe may comprise a carcass element (i.e. the innermost layer of the pipe) which may be configured to resist the differential of pressure between the interior and exterior of the flexible pipe.

20

In particular, a flexible pipe may comprise the following layers, from the exterior to the interior:

- a polymeric external sheath (called the external sheath);
- a retaining layer wound around an external tensile pressure armour layer. (The
25 retaining layer may comprise several strips, tapes or unitary elements wound in a short pitch around the external armour layer. This winding is generally contiguous or overlapping in order to increase the capacity to absorb the radial swelling forces. The unitary elements of the retaining layer have a high longitudinal tensile strength along their longitudinal axis);
- 30 - an external tensile pressure armour layer;
- an internal tensile pressure armour layer, wound in the opposite direction to the external tensile pressure armour layer. (The armour layers may be obtained by the long pitch winding of a series of metal or composite yarns, having a generally substantially rectangular cross section. The yarns may alternatively have a circular or

complex geometry cross section, for example of the self-interlocking T type. A pipe could also comprise one or more additional armour pairs. The armour layer is typically termed 'external' as it is the final layer from the interior of the pipe before the 'external sheath'. Any retaining layer is typically wound around the external layer, could also be

5 inserted between two tensile pressure armour layers);

- a pressure armour layer for absorbing the radial forces generated by the pressure of the fluid conveyed;

- a polymer internal sealing sheath; and

- an internal carcass for absorbing the radial crushing forces. (The carcass may be an interlocked metallic or composite construction that can be used as the innermost layer to prevent, totally or partially, collapse of the internal pressure sheath or pipe due to pipe decompression, external pressure, tensile armour pressure, and mechanical crushing loads).

15 In some embodiments, the pressure armour layer can be eliminated, provided that the helix angles of the yarns constituting the armour layers are close to 55 degrees and in opposite directions. The pressure vault (or 'pressure armour layer') may be configured to be resistant to bursting. A pressure armour layer is normally a structural layer with a lay angle close to 90 degrees, which increases the resistance of the flexible pipe to internal and external pressure and mechanical crushing loads. The lay angle is the angle between the wire forming the pressure armour and the axis of the pipe. In particular, the layer may also structurally support the internal pressure sheath and typically consists of an interlocked (i.e. the wire that forms the pressure armour is shaped such that each winding around the pipe locks to the previous adjacent winding) metallic or composite construction, which may be backed up by a flat metallic spiral layer.

The internal diameter of a flexible pipe may be less than 700mm, and typically greater than 100 mm. A flexible pipe has a Minimum Bending Radius (MBR) that is less than 7 times its internal diameter.

A rigid pipe is generally made from a sheet of metal having a tube shape. Rigid pipes can be reeled, and the reels for rigid pipes are normally larger (for example, around 21m in diameter) than those for flexible pipes (for example, around 5m in diameter).

A rigid pipe may have any suitable thickness or dimension, typically intended to achieve a certain degree of flexibility in the formed pipeline, especially reel-ability to assist with reel-laying.

5

A rigid pipe may comprise a main metal tube typically formed of steel, in particular carbon steel. It may also include a corrosion-resistant alloy or any other suitable metal. The main metal tubes provide resistance to hydrostatic pressure, and/or internal pressure of the hydrocarbon fluid. The main metal tube may be any length, including
10 typical section lengths of either 12m, 24m, 48m, possibly longer, or typical stalk lengths of either 1km, 2km, possibly longer, or even small pipe lengths of either 4m, 5m, 6m for typical connection to an In-Line Structure. The main metal tube may be any internal diameter from 100mm to 700mm or greater. The main metal tube may be any thickness from 5mm to 50mm or greater. The main metal tube may be formed by
15 extrusion. The main metal tube may be formed from metal ingots which are pierced, for example by broaching, elongated and calibrated, for example by rolling. The main metal tube may be formed from sheet bended generally with a U-shape break press then an O-shape break press, eventually expanded with an expander, and longitudinally seam welded. The main metal tube may be formed from the assembly of a series of
20 main metal tube section butts welded together.

A rigid pipe may comprise a liner on the inner surface of the main metal tube. The liner provides an effective corrosion-resistant barrier to the internal surface of the pipeline even in an aggressive single, dual and multiphase hydrocarbon environment at
25 temperatures up to 130°C and at high operating pressures. The liner may be formed of a metal, especially a corrosion resistant alloy (CRA) such as an alloy 316L, Super 13 Cr, 22 Cr duplex, 25 Cr duplex, Alloy 28, Alloy 825, Alloy 2550, Alloy 625, Alloy C-276, or any other suitable corrosion resistant alloy. The thickness of the metallic liner can be in the range 0.5 mm to 10 mm, or greater.

30

A liner may also be made from polymers which have high thermal and chemical resistance for example a semi-crystalline fluorinated polymers such as Polyvinylidene fluoride (PVDF), Polytetrafluoroethylene (PTFE), Perfluoroalkoxy (PFA), and Poly(Ethylene Chlorotrifluoroethylene) (ECTFE), or non-fluorinated polymers such as

thermoplastic polyurethane (PU), polyethylene (PE), cross linked polyethylene (XLPE), polyamide (PA), Polyetheretherketone (PEEK), Polyamide-Imide (PAI), Polysulfone (PSF), Polyethersulfone (PES) and Polyphenylsulfone (PPSU), or a formulation comprising of a combination of two or more of these plastics designed to satisfy the working requirements of the pipeline into which it will be deployed as a corrosion barrier.

A polymeric liner may be any thickness from 0.5 mm to 50 mm, or greater. The polymeric liner is preferably extruded.

A liner is normally bonded to the inner surface of the main metal tube of a rigid pipe. For this purpose, the liner can be pressurised from the inside, for example by injecting with a pump a pressurised fluid such as water or oil, so as to expand the liner circumferentially to form interference contact stress between the liner and the main metal tube. Generally during the expansion, the liner undergoes a plastic deformation while the main metal tube undergoes either an elastic or a plastic deformation, depending on the manufacturing process. One example of this comprises inserting the liner inside the main metal tube, and expanding the liner radially so that it comes into contact with the main metal tube, and then the main metal tube outer diameter will also expand together with the liner to a pre-determined strain level such that, following relaxation of the internal pressure, an interference contact stress between the liner and the main metal tube remains. Such a rigid pipe is generally known as a Mechanically Lined Pipe (MLP). When the liner is formed from metal, the liner can also be metallurgically bonded to the main metal tube. The liner can be metallurgically bonded at the extremities of the main metal tube or on the entire length, partially or entirely on the circumference of the main metal tube. The liner may be metallurgically bonded to the main metal tube by an electric resistance welding process, a pin laser welding process, a laser overlay welding process, or a laser overlay clad welding process, hot rolling, co-extrusion, explosive bonding, or any other suitable welding process or combination of these processes.

Rigid pipelines are typically formed onshore or during laying by combining a number of 'lengths' or section, typically 12m or 24m long.

Pipeline structures are also well known in the art, being apparatus, devices, assemblies, etc. intended to be added either at one end of a pipeline, or in-line, to provide a function other than passageway of a fluid. This includes PipeLine End Terminations (PLET), In line Structures (ILS), or any mid-line or final termination structures well known by the person skilled in the art, and the present invention is not limited thereto.

The sealing device may changeable or be free from moving parts.

In one embodiment, the sealing device is free from moving parts.

Optionally, the sealing device has a pre-determined and fixed shape, such as a stable shape which cannot be altered, prior to disintegration of the or each controllably disintegrateable portion. Thus, the sealing device does not change shape once installed in the pipeline section other than by partial disintegration.

Optionally, the sealing device has a pre-determined and first extended shape for sealing and prior to disintegration of the or each controllably disintegrateable portion, and a second contracted shape after disintegration.

Optionally, the or each controllably disintegrateable portion of the sealing device is disintegrateable in response to a controlled stimulus. Optionally, a control arrangement is provided for controllably providing a stimulus to the sealing device to operate disintegration.

Optionally, the external controlled stimulus comprises one or more selected from the group comprising: chemical, thermal, acoustic, and electromagnetic stimulus.

A chemical stimulus may be exposure to a chemical, optionally a pre-set concentration of a chemical product within an injected fluid.

A thermal stimulus may be exposure to given temperature, including injected fluid of a predetermined temperature, or localised heating, e.g. in a heated pipeline.

An acoustic stimulus may be a sound signal, e.g. sent externally from another device, e.g. a Remotely Operated Vehicle (ROV).

5 A electromagnetic stimulus may be a wave signal, e.g. sent externally from another device, e.g. a Remotely Operated Vehicle (ROV).

10 Optionally there is a controlled procedure to remove or dispose of the remainder of sealing device, i.e. that part or parts of the sealing device that is or are not the controllably disintegrateable portion(s), once pipeline laying or installation phase is complete, which also ensures an environmentally and economically friendly disposal.

15 The one or more controllably disintegrateable portions of the sealing device may comprise one or more different portions or parts of the sealing device. As such, the term “controllably disintegrateable portion” as used herein collectively relates to the ‘portion’ being singular or plural. Where the controllably disintegrateable portion comprises more than one portion or part of the sealing device, the portions or parts may have the same or different shape, size and design, and may have the same or different manner of disintegration.

20 Optionally, the or each controllably disintegrateable portion of the sealing device is configured to disintegrate into a smaller configuration, including but not limited to one or more of the group comprising: dissolution, dispersion, melting, granulating, powderising, shrinking, partly or fully dissolving, breaking into one or more parts or portions, including particles, or a combination of same. The disintegration may be
25 partial or fully, as long as the remainder of the sealing device is able to unseal the pipeline section or no longer seal the pipeline. The intention is to reduce the remainder of the sealing device to be sufficiently small or smaller to ensure that no blockage of pipeline occurs upon disposal of the sealing device, and optionally that no further cleaning of pipeline from debris is required as a result of the disintegration.

30 Thus, the disintegration of the controllably disintegrateable portion may include or be one or more of the group comprising: partial or full dissolution, partial or full dispersion, partial or full melting, partial or full granulating and partial or full powderising.

The sealing device may be formed from one or more materials, and be formed of one or more different parts, portions, section or layers, or a combination of same. Preferably the sealing device is formed from one or more solid materials prior to any
5 disintegration.

In one embodiment, the one or more controllably disintegrateable portions of the sealing device comprises one or more of the group comprising: an outer layer or layers, an outermost section or sections, an outermost segment or segments, an outer ring or
10 rings, or a circumferential structure; of the sealing device.

Optionally, all of the sealing device is controllably disintegrateable. Optionally, all the sealing device is formed of a material that is disintegrateable in response to one of or more that one of a controlled stimulus, such as those described herein.
15

Optionally, the sealing device is in the shape of a ball. Such a ball may have a completely spherical shape, or have a non-spherical shape that still provides an outer shape able to form a temporary plug in the pipeline section.

Optionally, the outer shape of the sealing device is a partly or wholly conical or frusto-conical shape, wherein the outer shape that is or has a conical or frusto-conical shape is able to form a temporary plug in the pipeline section.
20

The present invention is not limited by the nature and outer shape of the sealing device, as long as it can form a temporary plug in the pipeline section by its interaction therewith, and that such interaction can be released by the controllable disintegration.
25

Thus, according to another embodiment of the present invention, a portion of the inner surface of the pipeline section to be in contact with the outer surface of the sealing device is modified in relation to the remaining inner surface of the pipeline section, and wherein the outer shape of the sealing device is wholly or substantially complementary-shaped to match the modification of the inner surface of the pipeline section.
30

In another embodiment, the one or more controllably disintegrateable portions of the sealing device comprise one or more of the group comprising: plugs, ports, pins, bolts and screws; which are able to maintain an outer surface of the sealing device in sealing contact with an inner surface defining the inner bore of the pipeline section prior to disintegration. Optionally, the one or more controllably disintegrateable portions can maintain the outer surface of the sealing device in an inflated or expanded position or configuration, prior to disintegration.

Optionally, the sealing device comprises an inner structural core, and one or more outer or circumferential structures or apparatus, and one or more outer or circumferential structures or apparatus comprise the outer surface in sealing contact with an inner surface defining the inner bore of the pipeline section.

Optionally, the sealing device comprises a first element able to provide resistance to a pressure, optionally a hydrostatic pressure, inside the pipeline, and a second element able to locate and/or maintain location of the sealing device in the pipeline in use.

In some embodiments of the present invention, the first and second elements are the same.

In other embodiments of the present invention, the first and second elements are distinct, optionally separate. Optionally, where the first and second elements are distinct and/or separate, the first element may also provide some degree of or assist in being able to locate and/or maintain location of the sealing device in the pipeline in use, and the second element may also provide some degree of or assist in being able to provide resistance to a pressure, optionally a hydrostatic pressure, inside the pipeline.

The first and second elements may be formed from one or more materials, and be formed of one or more different parts, portions, section or layers, or a combination of same. Optionally, the one or more controllably disintegrateable portions of the sealing device is or comprises an outer layer, optionally more than one outer layer of the sealing device, and the sealing device comprises an inner structural core. Optionally, the inner structural core is a ball, and the controllably disintegrateable portion is an outer shell.

In an alternative embodiment, the one or more controllably disintegrateable portions of the sealing device is or comprises an inner part or parts, or inner section or sections, optionally within an inner structural core, able to act on one or more outer portions of the sealing device able to provide the sealing contact with an inner surface defining the inner bore of the pipeline section.

In one embodiment, the sealing device comprises an inner structural core as a pig, and the controllably disintegrateable portion is an outer ring.

In another embodiment, the sealing device comprises a pig.

The term "pig" as used herein refers to an apparatus or device generally known in the art for passage through a bore or internal passage of a pipeline, generally to carry out one or more actions within the pipeline, typically without other access thereto (such as not cutting the pipeline). Pigs are well known in the art, and are typically elongate, having a central body which can be wholly or substantially cylindrical in cross section, and one or more projections or extensions or outer parts, intended to engage with the inner surface of the pipeline, and provide positioning of the pig in the pipeline. This can include outer seals and other packers, typically able to provide a central and co-axial position of the pig in and along the inner surface of the pipeline.

Typically, a pig includes some functionality to enable it to carry out one or more designated tasks within the pipeline. Such functionality can include one or more moveable parts, typically one or more moveable parts between an extended position intended to engage with the inner surface of the pipeline, and a contracted position to allow movement of the pig along the pipeline.

Some pigs can be sophisticated engineering apparatus or devices, and may include a combination or compilation of features, including a number of moving and/or working parts.

Optionally, the one or more controllably disintegrateable portions of the sealing device are able to maintain one or more retractable outer segments or a complete outer

ring in contact with an inner surface defining the inner bore of the pipeline section prior to disintegration.

In another embodiment, the sealing device comprises an inner structural core as a pig, and at least one controllably disintegrateable portion is an internal bolt or plug, able to act on one or more retractable outer segments or complete outer ring.

Optionally, the one or more controllably disintegrateable portions of the sealing device are able to maintain a biased piston against a flexible disc to form the sealing contact with the inner surface defining the inner bore of the pipeline section.

Optionally, any retractable outer segments in the sealing device of the present invention provide a first element able to provide resistance to a pressure, optionally a hydrostatic pressure, inside the pipeline, and/or a second element able to locate and/or maintain location of the sealing device in the pipeline in use.

Optionally, the sealing device includes an inflatable packer or inflatable sealing outer ring to provide a sealing contact with an inner surface defining the inner bore of the pipeline section prior to disintegration.

In an alternative embodiment, a controllably disintegrateable portion of the sealing device comprises an inner structure or inner layer of the sealing device.

Optionally, the sealing device comprises one or more outer or circumferential rings or seals, able to locate the sealing device to a sealing position within the pipeline section, and/or a separable sealer, such as a flexible disc, able to form the sealing contact with the inner surface defining the inner bore of the pipeline section.

In one particular embodiment of the present invention there is provided a sealing device for sealing a pipeline having an inner surface defining an inner bore, comprising:
an inner structural pig,

a first element being an inflatable packer located around the circumference of the pig and having a first inflated configuration able to abut the pipeline inner surface and provide resistance to a hydrostatic pressure inside the pipeline, and a second

deflated configuration having an outer circumference less than the pipeline inner surface,

a second element comprising one or more outer segments able to locate the sealing device within the pipeline section, and having a first extended configuration able to maintain the location of the sealing device against the pipeline inner surface, and a second retracted configuration having an outer circumference less than the pipeline inner surface, and

one or more controllably disintegrateable plugs able to control the movement of the first and second elements from the first configuration to the second configuration.

In another particular embodiment of the present invention, there is provided a sealing device for sealing a pipeline having an inner surface defining an inner bore, the sealing device, comprising:

an inner structural pig comprising a longitudinal outer circular housing, and a central axis, and a piston moveable along the axis and within the housing,

a sealing disc having an expanded position able to provide sealing contact with the pipeline inner surface, and a collapsed position having an outer circumference less than the pipeline inner surface, and

one or more controllably disintegrateable bolts between the housing and the piston,

wherein the piston is biased against the sealing disc in first use to maintain the sealing disc in its extended position, and

wherein one or more controllably disintegrateable bolts are able to control movement of the sealing disc from its expanded position to its collapsed position.

Optionally, the sealing device is configured to become one or more smaller portions able to flow through the pipeline section.

Optionally, the or each controllably disintegrateable portion of the sealing device is partly, substantially or wholly formed from a composite of nanoparticles, such as reactive nanoparticles, which disintegrate in response to a controlled stimulus, such as an electrolyte, etc., sufficiently to unseal the pipeline section.

Optionally, the sealing device is configured to comply with any variation of the profile of the inner surface defining the inner bore of the pipeline section to ensure sealing contact is established between the sealing device and the inner surface. Variation of the inner surface defining the inner bore of the pipeline section can occur due to any variation in manufacture, as well as any defect due to ovality or welding. The present invention is able to accommodate such variation.

Optionally, a portion of the inner surface of the pipeline section intended to be in contact with the outer surface of the sealing device is modified in relation to the remaining inner surface of the pipeline section, such that the sealing device is installed with an interference fit into the pipeline section. The interference fit may include wedging the sealing device in the inner bore of the pipeline section. Wedging ensures that the sealing device is not further displaced from its position sealing the inner bore of the pipeline section.

Such an arrangement may ensure that a more reliable sealing contact between the outer surface of the sealing device and the inner surface defining the inner bore of the pipeline section is achieved and maintained, especially for a sealing device intended to withstand high pressures in the case of flooding of the pipeline section.

In one arrangement, the inner surface of the pipeline section in contact with the outer surface of the sealing device is modified in that it comprises a reduced diameter portion compared to the remainder of the pipeline section, optionally towards one end of the pipeline section. The reduced diameter may be a gradual or non-gradual or sharper change in the diameter of the pipeline section along its length, or a combination of same. The present invention is not limited by the length and/or angle of the change in diameter, only that the change in diameter provides a suitable location to locate a sealing device.

Optionally, the reduced diameter portion is at or adjacent an end of the pipeline section. Optionally, the inner surface of the pipeline section reduces diameter from the end of the pipeline section towards an interior of the pipeline section, and the sealing device is wedged in the reduced diameter portion.

The inner surface of the pipeline section, typically at or adjacent the end of the pipeline section, and in contact with the outer surface of the sealing device may additionally or alternatively be modified in that it may comprise a roughened portion, (optionally compared to the remaining inner surface of the pipeline section). This may be a predetermined surface roughness and the sealing device may be installed in the roughened portion.

The provision of the modified inner surface of the pipeline section, optionally at or adjacent the end of the pipeline section which in use is in sealing contact with the outer surface of the sealing device, ensures that reliable sealing and secure retention of the sealing device in the pipeline section are achieved.

Optionally, the outer surface of the sealing device has a predetermined outer diameter and/or a pre-determined surface roughness sufficient to enable the sealing device to be securely retained within the pipeline section upon installation and to ensure sealing contact is established between the sealing device and the inner surface of the pipeline section.

Optionally, the sealing device is configured to resist a predetermined pressure, optionally a hydrostatic pressure inside a pipeline.

Optionally, the outer diameter of the sealing device is configured to comply with any variation of the profile of the inner surface defining the inner bore of the pipeline section to ensure sealing contact between the sealing device and the inner surface.

In a second aspect, the present invention comprises a pipeline comprising an assembly as defined herein in which at least one end of the pipeline section of the assembly is connected to a respective end of a pipeline section of another such assembly and/or to a pipeline structure.

The present invention also provides a pipeline comprising a plurality of conjoined pipeline sections as defined herein, and one or more sealing devices defined herein.

The present invention also provides a method of sealing a pipeline section based on installing at least one sealing device defined herein into the pipeline section, optionally at or adjacent one end or each end of the pipeline section, and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section.

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Optionally, the method includes installing at least one said sealing device at or adjacent one end or each opposite end of the pipeline section.

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Optionally, the method includes the steps of modifying the inner surface of the pipeline section to be in contact with the outer surface of the sealing device.

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In one arrangement, the method includes the steps of providing the inner surface of the pipeline section to be in contact with the outer surface of the sealing device with a reduced diameter portion, such as a gradual or sharper tapered portion, and which optionally reduces diameter from the end of the pipeline section towards an interior of the pipeline section; and installing the sealing device in the reduced diameter portion.

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In another arrangement, the method includes the steps of providing the inner surface of the pipeline section to be in contact with the outer surface of the sealing device with a roughened portion (optionally compared to the remaining inner surface of the pipeline section) which has a predetermined surface roughness; and installing the sealing device in the roughened portion.

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The present invention also provides a method of unsealing a pipeline section sealed by a method defined herein, comprising at least the step of applying a controlled stimulus to cause the controllably disintegrateable portion of the sealing device to at least partially, optionally wholly or substantially, disintegrate in response to the controlled stimulus.

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Optionally, the method further comprises the step of removing the disintegrated smaller parts of the sealing device from the pipeline section.

The step of applying a controlled stimulus may comprise applying one or more of the group comprising: a chemical, e.g. exposure to a chemical product, optionally within an

injected fluid; or thermal, e.g. exposure to given temperature, including injected fluid of predetermined temperature, or localised heating, e.g. in a heated pipeline; or an acoustic signal or an electromagnetic stimulus, e.g. a wave signal, e.g. sent externally from another device, e.g. an ROV; or combination of same.

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The present invention also provides a method of laying a subsea pipeline based on installing at least one sealing device as defined herein into a pipeline section to establish a sealing contact with an inner surface defining the inner bore of the pipeline section; forming the pipeline by joining two or more of the pipeline sections; laying the subsea pipeline; and unsealing the pipeline by applying a controlled stimulus.

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The present invention also provides a method of laying a subsea pipeline section and connectable comprising the same steps.

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Referring now to the drawings, Figures 1 and 2 show a first assembly 1 according to a first embodiment of the present invention. Each first assembly 1 comprises a pipeline section 3, which could be rigid or flexible, having opposite ends 5, 7 and an inner bore 9 extending between the ends 5, 7.

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Each end 5, 7 could be connectable to a respective end of another pipeline section 3 and/or of a pipeline structure. That is, in a pipeline, a plurality of pipeline sections 3 with assemblies 1 are connected end-to-end. Or an assembly 1 may be connected to a PLET or an ILS.

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Thus, in Figure 1, two pipeline sections 3 are shown connected at their ends 5, 7 via a join 11, which is typically a welded join, but may also or alternatively be a mechanical join such as with a flange or quick connector, etc.

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And in Figure 2, a pipeline section 3 is shown connected at one end 7 to a structure 15 via a joint 17. The structure 15 may be a Pipe Line End Termination (PLET) or an In Line Structure (ILS), etc.

Figures 1 and 2 show a first sealing device 19 sealing the inner bore 9 of the pipeline section 3 to prevent flow through the inner bore 9. The sealing device 19 is shown installed near or adjacent one of the opposite ends 5, 7 of the pipeline section 3.

5 Optionally, there is a sealing device 19 at or adjacent each opposite end 5, 7 of the pipeline section 3, or at least regularly along a number of pipeline sections forming a longer pipeline or pipestalk. For example, a long (typically >500m and possibly up to several kilometres long) pipeline comprising a plurality of pipeline sections 3, may use a sealing device every 100m or so, (for example in every second pipe section being of
10 48m length, or in every fourth being pipe section of 24m length, etc). Or the skilled man may desire a sealing in every pipe section, or every nominated pipe section, etc. The length of the pipeline sections is typically predetermined to ensure that in case of pipeline flooding tensions within pipeline remain within pre-set safety limits.

15 The present invention is not limited by the number of sealing devices used per pipeline section, and the skilled man can see the use of a different number or density of sealing devices according to the parameters and conditions of the pipeline being laid.

20 The use of the sealing device ensures that the pipeline section is isolated in case of flooding, so that an adjacent (or downstream) pipeline section and/or structure remain unaffected.

25 The sealing device can be inserted at any suitable part of the pipeline section, either being at or adjacent a pipeline section end, or further down, along or inside of the pipeline section. For example, from one centimetre to several meters from a pipeline section end.

30 Optionally, a sealing device is arranged to be located close to any attached structure such as a PLET, to ease subsequent removal, and to avoid the effects of reeling.

The sealing device is also configured to resist a predetermined pressure, such as, for example hydrostatic pressure inside a pipeline, such as a pressure over 50 bar. For example, a water depth of 3000m involves withstanding a pressure of possibly 300 bar from any incoming flooding: and possibly 400 bar when working at a depth of 4000m.

In the first assembly 1 shown in Figures 1 and 2, the first sealing device 19 comprises an outer surface 21 in sealing contact with an inner surface 23 defining the inner bore 9 of the pipeline section 3, and a portion 25 of the inner surface 23 of the pipeline section 3 which is in contact with the outer surface 21 of the sealing device 19 is modified in relation to the remaining inner surface 23 of the pipeline section 3, such that the sealing device 19 is installed with an interference fit. Optionally the scope of the interference fit may be in the range 0.1mm to 5mm. That is, the outer diameter of the outer surface 21 is greater than the inner diameter of the inner surface 23 of the pipeline section 3 by 0.1mm, and up to 5mm

The seal created between the outer surface 21 of the sealing device 19 and the inner surface 23 of the pipeline section 3 should establish a reliable sealing contact, which is preferably watertight, but does not need to be wholly or substantially 'gas proof'. Typically, the inner bore of a pipeline section is never so perfect, (with an element of ovality, variable thickness, remaining roughness, etc.) due to fabrication limitations. The inner diameter of a pipeline section can have up to +/-5 mm variation, so that the outer surface 21 of the sealing device requires to be adaptable to match any such inner surface 23 "imperfections" that occur during manufacture.

Preferably, the seal created between the outer surface 21 of the sealing device 19 and the inner surface 23 of the pipeline section 3 can withstand high pressures in the case of flooding of the pipeline section 3, i.e. a pressure over 50 bar.

As shown in more detail in Figure 3, the portion 25 of the inner surface 23 of the pipeline section 3 meeting the outer surface 21 of the sealing device 19 tapers from the end 7 of the pipeline section 3, towards an interior of the pipeline section 3, and the sealing device 19 is wedged in the tapered portion 25. To fulfil the DNV-OS-F101 requirements, the tapering is preferably inferior to a ratio of 1:4. Optionally, the diameter of the inner surface 23 of the pipeline section portion 25 reduces between 1mm and 5mm, and the angle of diameter reduction can be any angle up to 90°, although optionally in the range of 1° to 20° or even 1° to 10° or similar to minimize any impaction on flowrate,, and can occur either gradually as shown in Figure 3, or non-gradually as described hereinafter.

Preferably, the sealing device is wedged into its sealing position. Wedging better ensures that the sealing device 19 is not displaced from its sealing position. The sealing device 19 could be wedged into position by a hydraulic press or similar, and a pressure test can be performed to seat the plug and ensure integrity.

As shown in Figure 4, the tapered portion 25 may also be roughened (compared to the remaining inner surface 23 of the pipeline section 3) to a predetermined surface roughness, such as in the range from 0.01 μ m to 5 μ m. The roughness may have any suitable form and dimension, for example being ribbed or ridged with elevations or ridges in the range from 1 μ m to 5 μ m compared to the remainder of the inner surface 23. The roughness can be achieved using any known technique such as cold spraying, sandblasting, optical etching, etc. The provision of the modified portion 25 assists achieving reliable sealing and secure retention of the sealing device 19 in the pipeline section 3.

The embodiment of the sealing device 19 shown in Figures 1-4 is formed from a solid shape which cannot be altered while the sealing device 19 is installed in the pipeline section 3. The sealing device 19 preferably comprises an inner core 27, generally having a stable shape, which may be formed of any suitable material or materials, such as metal, metal alloy, metal matrix composite, polymer, polymer composite, ceramic, waxes, or a combination of same. Examples include magnesium (Mg), magnesium alloy, magnesium composite, aluminium alloy, calcium (Ca), Ca-Mg, Ca-Al, and Ca-Zn.

The inner core 27 may also include a propellant. In one non-limiting configuration, the inner core 27 includes a water-reactive material such as lithium, sodium, potassium, lithium aluminium hydride, sodium aluminium hydride, potassium aluminium hydride, magnesium aluminium, hydride, lithium borohydride, sodium borohydride, calcium borohydride, magnesium hydride, nAl, borohydride mixed with alanates, metal hydrides, borohydrides, divalent cation alanates, and/or other water-reactive materials.

The inner core 27 may also include a reactive binder having a metal fuel and/or oxidizer composite which includes one or more of the following metals: magnesium,

zirconium, tantalum, titanium, hafnium, calcium, tungsten, molybdenum, chrome, manganese, silicon, germanium and/or aluminium that is mixed with an oxidizer or thermite pair (e.g., fluorinated or chlorinated polymers such as polytetrafluoroethylene, polyvinylidene difluoride, oxidizers such as bismuth oxide, potassium perchlorate, potassium or silver nitrate, iron oxide, tungsten or molybdenum oxide, and/or intermetallic thermite such as boron, aluminium, or silicon). The binder can alternatively include an intermetallic reactive material such as iron-aluminium, nickel-aluminium, titanium-boron, and/or other high energy intermetallic couple. In another or alternative non-limiting configuration, the binder can include a fuel, oxidizer, and/or a reactive polymeric material. In another or alternative non-limiting configuration, the reactive polymeric material can include aluminium-potassium perchlorate-polyvinylidene difluoride and/or tetrafluoroethylene (THV) polymer.

When the inner core 27 is a magnesium composite, aluminium composite, manganese composite, or a zinc composite, the inner core 27 can be formed of particles that are connected together by a binder. The inner core 27 can be formed for example by powder metallurgy techniques (e.g., solid state powder sinter-forging, solid state sinter-extrusion, and spark plasma or field assisted sintering in the solid or semi-solid state). The inner core 27 can alternatively be formed from melt casting, with or without subsequent deformation and heat treatment.

The disintegration of the core is optional.

The sealing device 19 also has an outer layer or shell 29, which may be formed from a composite of reactive nanoparticles, which disintegrate in response to an external controlled stimulus. Suitable nanoparticle materials include Zinc, Zinc Alloy, or a polymer.

The outer layer or shell 29 may include one or more additives in the group comprising: iron particles, carbon particles, tungsten particles, silicon particles, boron particles, tantalum particles, aluminum particles, zinc particles, iron particles, copper particles, molybdenum particles, silicon particles, ceramic particles, cobalt particles, nickel particles, rhenium particles, SiC particles, etc. (includes oxides and carbides thereof).

The controllably disintegrable outer layer or shell 29 of the sealing device 19 is disintegrateable in response to a controlled stimulus. Disintegration may, but is not limited to, include dissolution, dispersion, melting, granulating or powderising.

- 5 The controlled stimulus may comprise one or more of:
- a chemical, e.g. exposure to a pre-set concentration of chemical product within injected fluid. Examples include water, salt water, electrolytes (HCl, KCl, CaCl₂, CaBr₂, and ZnBr₂) and brine solution, etc. Other examples are glycol and/or MEG, which are also used in pipeline pre-commissioning.
 - 10 - thermal, e.g. exposure to a given temperature, including via an injected fluid of a certain temperature, such as over 30°C, preferably over 50°C, and optimally over 90°C: or
 - localised heating, e.g. in a 'heated' pipeline, especially a pipeline having an integrated heating system such as an electrical trace heating (ETH) or DEH, or via an
 - 15 auxiliary heating device mountable on the pipeline, or mounted on an ROV. Localised heating can also be provided by an integrated heating system triggered via an auxiliary device; or
 - electromagnetic stimulus, for example a magneto-rheological fluid, and suitable a wave signal, for example sent externally from another device, e.g. an ROV
 - 20 shown in Figure 2.

By way of example only, the sealing device 19 can further comprise two chambers, each storing a substance or chemical, configured to generate heat when they are mixed, such as a suitable mixture of magnesium and copper sulphate, which can be partially reacted

25 by adding sufficient water to cover the mixture. The two chambers can be separated via a valve that can be remotely triggered via wireless connection. Other chemical mix variations include copper-sulfate/magnesium powder mixtures, or magnesium/iron powder mixtures.

30 In another example, the sealing device 19 could further comprise electromagnetic particles, such as Fe, Ni, Co, Gd or alloys, that can generate heat when they are submitted to an electromagnetic field. The electromagnetic field can be generated by an ROV tool.

When an ROV is used, the location of a sealing device could be calculated or identified through a mark on the outer surface of the pipe section, or through a localisation device (for example an RFID tag) mounted on the pipe, or even directly integrated into the sealing device 19, and the ROV can have a device or detector able to detect the location of the localisation device.

The controlled stimulus is preferably provided by a controlled arrangement or procedure. For example, when the controlled stimulus is a chemical or chemical product, the control arrangement may be a valve, an injection pump, a PLET cap valve arrangement, or any apparatus that can inject in the pipe section with one or more of the chemicals involved.

When the controlled stimulus is a heat or electromagnetic signal, the control arrangement may be an umbilical or an ROV operating the heating or electromagnetic device.

Other controlled stimulus methods could use ultrasonic or resonance frequency waves, to break up the controllably disintegrateable portion of the sealing device.

As shown in Figure 5, the controlled stimulus is able to disintegrate the controllably disintegrateable portion 29 of the sealing device 21, so that the remainder of the sealing device, being the core 27, can then move freely along the pipeline section 3 as indicated by arrows in Figure 5, to be disposed of in an environmentally and economically friendly manner. The sealing device 19 is configured to disintegrate into particles sufficiently small to ensure that no blockage of pipeline occurs upon disposal of the remainder, and that no further cleaning of pipeline from debris is required.

The core 27 can includes particles including : iron particles, carbon particles, tungsten particles, silicon particles, boron particles, tantalum particles, aluminium particles, zinc particles, iron particles, copper particles, molybdenum particles, silicon particles, ceramic particles, cobalt particles, nickel particles, rhenium particles, SiC particles, etc., (including oxides and carbides thereof) : optionally having an average particle diameter size of about 5 to 50 microns and any value or range therebetween, (e.g., 5 microns, 5.01 microns, 5.02 microns, etc., extending to 49.98 microns, 49.99 microns, 50

microns), that are coated with about 0.3 to 3 microns coating thickness and any value or range therebetween, (e.g., 0.3 microns, 0.301 microns, 0.302 microns, etc., extending to 2.998 microns, 2.999 microns, 3 microns), in a matrix of magnesium, magnesium alloy, aluminium, aluminium alloy, manganese, manganese alloy, zinc and/or zinc alloy.

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Any sealing device debris can be removed by flushing, etc., or pigging, which is a standard pre-commissioning operation. A gel able to provide or form a suspension of any sealing device remnants or particles can also be employed. For example, Adapted Gels like 'Aubin Uptake Gel', known in the art to suspend and remove large volumes and weight of solids, such as sand, gravel, fine heavy powder, rust and heavy oils in one pass of a single slug, could also be used to assist removal of any remaining debris.

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The sealing device of the present invention is configured to comply with any variation of the profile of the inner surface of the pipeline section to ensure sealing contact is established between the sealing device and the inner surface. For example, the outer surface of the sealing device may have a predetermined outer diameter and/or a predetermined surface roughness sufficient to enable the sealing device to be securely retained within the pipeline section upon installation, and to ensure sealing contact is established between the sealing device and the inner surface of the pipeline section.

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For example, where the sealing device is wholly or substantially a ball or ball shape, the size of the ball can be calculated in relation to the expected pipe diameter at the point of contact. In the embodiment of the present invention shown in Figures 1-5, the sealing device 19 comprises a disintegrateable plug comprising an inner structural core 27 and an outer shell 29, optionally having a thickness in the range 0.2µm to 2cm.

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The core 27 of the plug 20 is configured to resist a predetermined pressure. The outer shell 29 is configured to comply with any variation of the profile of the inner surface 23 of the pipeline section 3 to ensure sealing contact is established between the sealing device 19 and the inner surface 23.

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In another example, where the sealing device is wholly or substantially cylindrical, or having a cylindrical outer surface, again the cylinder circumference can be calculated in relation to the expected pipe diameter at the point of contact, optionally against a

reduced diameter part of the pipeline section. The controllably disintegrateable portion of the sealing device may be an outer layer of the cylinder.

Where the core is also disintegrable, its remains can be removed in the same manner as described hereinabove.

Figure 6a shows another pipeline section 3a, which could be rigid or flexible, having opposite ends 5, 7 and an inner bore 9 extending between the ends 5, 7. The inner bore has an inner surface 23, and a portion 25 of the inner surface 23 tapers from one end 5 towards the other end 7.

In figure 6a, there is shown a further sealing device 33 having a wholly or substantially frusto-conical shape, and having flat ends and an outer surface thereinbetween, at least part of which is shaped or modified to wholly or substantially match in a complementary manner the tapered portion 25 of the pipeline section 3a. The sealing device 33 can be fitted into the pipeline 3a to provide a temporary plug or seal in the pipeline 3a in a manner previously described.

When the temporary seal is no longer required, one or more controlled stimuli can be used to partially or fully disintegrate the sealing device 33. For example, where the sealing device 33 is formed using one or more suitable material or materials described hereinabove, such as being formed from a composite of reactive nano-particles, the sealing device 33 can disintegrate to leave a remainder or core, or be completely dispersed etc., thereby unsealing the pipeline 3a.

Figure 6b shows a further embodiment using the same pipeline section 3a with ends 5, 7, and having an inner bore 9 with a tapering section or portion 25 of the inner surface 23. The pipeline section 3a has a further sealing device 35 located therewith. The further sealing device 35 can be fitted into the pipeline 3a to provide a temporary plug or seal in the pipeline 3a in a manner previously described.

The further sealing device 35 of Figure 6b has ends and the same or a similar frusto-conical outer shape compared with the sealing device 33 shown in Figure 6a, but also an internal cavity 36 extending from one end so as to reduce the amount of material of

the further sealing device 35 in comparison with the sealing device 33. This reduces the amount of material that may need to be disintegrated in order to end the further sealing device 35 forming a temporary plug in the inner bore 9. The internal cavity 36 does not reduce the effectiveness of the further sealing device 35.

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The skilled man can see that other shapes and designs of a sealing device can be provided with achieve the purpose of forming a temporary seal or plug in the inner bore of a pipeline or pipeline section in a manner as described herein, which seal or plug can be ended using one or more controlled stimuli to controllably disintegrate a portion(s) and/or all of the sealing device from its temporary fit or match within the inner bore.

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Where the core is non-disintegrable, the core could be flushed along and out of the pipeline like a pig.

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In other embodiments of the present invention, the core of the sealing device may even be a pig, or similar to a pig, having one or more outer disintegrable locking rings or segments, that could be tapered or not. For example: an inflatable rubber ring can be added to improve the sealing. The inflated rubber ring can be emptied through a remote valve or through a disintegrating plug.

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Figures 7a and 7b show further embodiments of the present invention, based on another assembly 38 comprising a first sealing device 40a installed in a pipeline or pipeline section 42. A portion 46 of the inner surface 44 of the pipeline section 42 has a reducing or tapering internal diameter along the bore of the pipe section 42.

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The first sealing device 40a has a core in the form of a first pig 48a. The sealing device 40a also includes a first element being an annular inflatable packer 54, optionally formed of a flexible material such as rubber, nesting in an annulus in the circumference of the pig 48a. The inflatable packer 54 is shown in Figure 7a in a first inflated configuration able to abut the inner surface 44 of the pipeline section 42. The inflatable packer 54 can be inflated to this first configuration by a suitable pressure fluid such as hydraulic fluid, through a first fluid line 55 extending from one accessible end of the pig 48a to a suitable internal location in the pig 48a to reach the inflatable packer 54.

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A first valve 56 is located along the first line 55 near an end of the pig 48a. The first valve 56 can be opened to allow the entry of a pressure fluid into the first line 55 to inflate the inflatable packer 54 using a pressurising device or tool such as a compressor. In this way, the inflatable packer 54 is inflated to abut the inner surface 44 of the pipeline section 42, making it able to provide resistance to a hydrostatic pressure inside the pipeline. Once the inflatable packer 54 is sufficiently inflated, the first valve 56 is shut and plugged with a first controllably disintegrable plug 57, and the first valve 56 is reopened. The first plug 57 maintains the pressure of the fluid within the inflatable packer 54.

The first pig 48a includes a second element comprising one or more outer ring segments 50. The outer ring segments 50 have a first extended configuration as shown in Figure 6a, whose position is controlled by first and second internal and lateral transfer pistons 58 extending from a central double piston cylinder 59 located within the pig 48a. The double piston cylinder 59 is supplied with a suitable pressure fluid such as pressurised hydraulic fluid, provided through a second line 60 extending from the cylinder 59, through a second valve 61, and also ending at one end of the pig 48a. In an alternative arrangement (not shown), the transfer pistons 58 could be controlled by separate cylinders or other suitable actuators.

In a similar manner to the filling of the inflatable packer 54, opening of the second valve 61 allows the entry of a pressure fluid using a pressuring tool such as a compressor (not shown), to pass into the double piston cylinder 59 and push out the pistons 58 to extend the outer ring segments 50 to their first extended configuration as shown in Figure 6a, to meet and wedge against the tapering diameter portion 46 of the pipeline section 42. Optionally, the circumference of the outer ring segments 50 is shaped to complement the shape of the tapering diameter portion 46 to increase the contactable surface thereinbetween.

Once the outer ring segments 50 are extended, the second valve 61 is shut and plugged with a second controllably disintegrable plug 57, and the second valve 61 is reopened. The second plug 57 maintains the pressure of the pressure fluid within the cylinder 59 and hence the ring segments 50.

The filling of the first and second lines 55, 60 can be carried out in either order.

The first and second plugs 57 can be formed from any suitable disintegrable material, such as a composite of reactive nanoparticles, which disintegrate in response to an external controlled stimulus. Suitable nanoparticle materials include Zinc, Zinc Alloy, or a polymer.

Preferably, the first sealing device 40a is wedged in the reducing diameter portion 46 by a hydraulic press or similar, and a pressure test can be performed to seat the sealing device 40a and ensure integrity.

The sealing device 40a may include one or more plastic, rubber or similar flexible or semi-flexible outer seals or discs 52 to help locate the pig 48a in the pipeline section 42, particularly in the smaller diameter portion of the pipeline.

Once the sealing device 40a has achieved this purpose of providing a temporary seal or plug along the pipeline 42, a controlled stimulus as described herein can be applied to controllable disintegrate the disintegrable plugs 57. Disintegration may, but is not limited to, include dissolution, dispersion, melting, granulating or powderising. The controlled stimulus may comprise one or more of: a chemical, thermal, localised heating, acoustic or electromagnetic stimulus. The controlled stimulus is preferably provided by a controlled arrangement or procedure. For example, when the controlled stimulus is a chemical or chemical product, the control arrangement may be a valve, an injection pump, a PLET cap valve arrangement, or any apparatus that can inject in the pipe section with one or more of the chemicals involved.

Figure 7b shows the controllable disintegration of the first and second disintegrable plugs 57 into clouds or dispersions of smaller particles 49, opening the first and second lines 55, 60 to release the pressure fluid therewithin. The release of fluid from the first line 55 changes the inflatable packer 54 from its first inflated position to a second deflated configuration, such that its outer edge or surface is no longer abutting the inner surface 44 of the pipeline 42. Meanwhile, release of the pressure fluid from within the second line 60 and the double piston cylinder 59, allows the pistons 58 to move inwardly, changing the positions of the outer ring segments 50 from their first

extended configuration shown in Figure 6a, to a second retracted configuration shown in Figure 6b, wherein the extent of the outer ring segments 50 is less than the circumference of the smaller internal diameter inner surface 44. The pig 48a is then able to travel along the pipeline 42.

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In a first additional and/or alternative embodiment, the outer ring segments 50 are themselves formed of a controllably disintegrateable material that can either be fixed around the pig 48a, or held in place by a piston and cylinder arrangement shown in Figure 6a. When the temporary plug or seal of the pipeline 42 is no longer required, the same or a different controlled stimulus can controllably disintegrate the outer ring segments themselves into smaller particles (shown as dispersions 45 in Figure 7b), to reduce the outer diameter of the sealing device and allow its movement along the pipeline 42.

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The first sealing device 40a is also reusable once recovered from the pipeline 42.

The nature of the first pig 48a allows it to be useable in relation to different bore sized pipelines, and/or different tapering internal diameters along the bore of a pipe section. The inflatable packer 54 and/or sections 50 can be extended by different amounts or degrees.

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The skilled man can also see that other arrangements of the outer ring segments 50 and cylinder 59 could be provided to achieve the same affect as shown in figure 7a, i.e. maintaining an extended and sealing position for the pig 48a in the pipeline 42 using a suitable pressure fluid, which can be released by controlled disintegration of a suitable plug etc. once the temporary seal provided by the sealing device 40a is no longer required.

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The first sealing device 40a provides the general requirement to have a sealing device having one or more controllably disintegrateable portions, which portions can comprise one or more devices, items or pieces, able to be controllably disintegrated once flow through the inner bore of the pipeline is desired.

30

Figures 8a and 8b shows further embodiments of the present invention, similar to those shown in Figures 7a and 7b.

In Figure 8a, a second sealing device 40b uses a complete annular outer ring 47 formed of a controllably disintegrateable material around a circumferential groove in a second pig 48b, the ring 47 located against a reducing diameter portion 46 of the pipeline section 42, and which could be used as a second element of the sealing device shown in Figure 7a.

When the temporary plug or seal of the pipeline 42 is no longer required, a controlled stimulus can controllably disintegrate the annular outer ring 47 into a dispersion of smaller particles 51 as shown in Figure 8b, to reduce the outer diameter of the sealing device 40b and allow movement of the pig 48b along the pipeline 42.

The skilled man can again see that other similar arrangements of the outer ring 47 could be provided to achieve the same affect as shown in Figure 8a, i.e. maintaining an extended and sealing position for the second pig 48b in the pipeline 42, which can be released by controlled disintegration of the outer ring 47 once the temporary seal provided by the sealing device 40b is no longer required.

Figure 9a shows yet further embodiments of the present invention, wherein an assembly comprises a third example sealing device 63 installed in a pipeline section 64.

The third sealing device 63 can again be based on a pig so as to be passable along the internal passage of a pipeline, such as a pipeline section 64 as shown in Figure 9a. As with the first and second pigs discussed above, the third sealing device 63 has a first configuration able to form a temporary seal in the pipeline section 64, and a second configuration following controlled disintegration of one or more portions of the sealing device 63, to allow it to travel along the pipeline 64.

Whilst the third sealing device 63 is shown and described in relation to configuring with a reducing diameter portion 74 of the inner surface 78 of the pipeline section 64, the skilled man can see that the arrangement of the sealing device 63 is able to work with other arrangements of the internal circumference, bore or cross section of a pipeline section, such that the present invention is not limited to the nature, size or other adaptations or changes in the internal bore, etc of the pipeline section.

The third sealing device 63 has an outer cylinder housing 66 having a diameter less than the pipeline section 64, a back end 86, an open front end, and a number of circumferential flexible seals 68 around the cylinder housing 66. The sealing device 63 includes a central axis 87 and a moveable piston 76 within a bore 77 in the housing 66.

5 The piston 76 is slidable along the axis 87.

The diameter of the outer cylinder housing 66 is preferably less than the smallest internal bore of the pipeline section if the internal bore changes along the length of the pipeline section. Typically the cylinder housing 66 is formed of a strong material such as steel, which also allows the cylinder housing 66 to have added functionality both internally and externally. Thus, the cylinder housing 66 can be arranged to have an internal bore 77 formed from one end, and to have a solid central axis 87 able to extend part way beyond the end of the cylinder housing 66 having the internal bore 77. This provides a complementary location and housing for the piston 76, generally formed in a machined cylindrical arrangement, having a central bore intended to match the diameter of the central axis 87 so as to be slidable there along. The piston 76 can have one or more, optionally 2, 3 or 4, borelines through the piston 76 as discussed further below.

20 The sealing device 63 also comprises a flexible disc 70, for example formed of a plastic such as polyurethane, having a front plate 81, and whose outer portion 72 is able to be located in use against a portion 74 of the inner surface 78 of the pipeline section 64 having a reducing internal diameter along the length of the pipeline section 64.

25 The front plate 81 is typically formed of a hard metal such as steel or other corrosion resistant alloy, and the flexible disc 70 optionally has a substantive thickness in order to withstand pressures expected as part of the temporary seal. Optionally, the outer end of the piston 76 is bevelled or has a frusto-conical shape or conic shape as discussed further below.

30 Prior to installation of the sealing device 63 in the pipeline 64, the piston 76 is mounted to slide along the axis 87, the front spring 82 is mounted around the axis 87, and the front plate 81 and flexible disk 70 combination are fixed on the axis 87.

The sealing device 63 also comprises a hydraulic actuator having a piston rod 88 extending from a chamber 92 in the cylindrical housing 66, and biased by an internal chamber spring 96. The chamber 92 can be pressurised by a suitable pressure fluid provided through a suitable line 90 and valve 91 from the back end 86 of the cylindrical housing 66. As the chamber 92 is filled, the piston rod 88 is forced outwardly to abut the piston 76 and force it against the front spring 82. As the front spring 82 is crushed between the piston 76 and the front plate 81, the conic part of the piston 76 pushes the flexible disc 70 against the portion 74 of the inner surface 78 of the tapering portion 74 of the pipeline section 64. This creates the required seal in the pipeline section 64 as shown in Figure 8a.

The skilled man can see that the biasing provided by the piston rod 88 to force the piston 76 against the flexible disc 70 can be provided by one or more alternative or additional biasing arrangements, including hydraulic actuators.

Optionally, the piston 76 has a circumferential seal 99, such as an O-ring or D-ring or the like, able to assist controlled location and movement of the piston 76 in and out of the housing 77 and to provide some tolerance in relation to the movement of the piston 76 in the pressure environment of the use of the third sealing device 63 to provide a temporary seal within the pipeline section 64.

Figure 9a shows one arrangement of using a moveable part (piston 76) within or as part of a pig or pig device, to bias a suitable seal against the inner surface 78 of the pipeline section 64 to provide a temporary seal. The skilled man can see that a pig can have one or more other moveable parts, both longitudinally, transversely, able to provide the required biasing force against the flexible disc to create the temporary seal.

The requirement of the present invention is that the sealing device has a controllably disintegrateable portion or portions, which portion or portions are able to transform the sealing device from providing a temporary seal within the pipeline section to not providing a seal within the pipeline section following the controlled disintegration of the controllably disintegrateable portion or portions.

Thus in Figure 9a, the front of the piston 76 can be alternatively or additionally maintained against the flexible disc 70 by the insertion of two controllably disintegrable bolts 84 fixed between the back end 86 of the sealing device 63 and the piston 76.

5

In the arrangement shown in Figure 9a and as described herein below, the sealing device one or more of the group comprising plugs, ports, pins, bolts and screws; able to maintain an outer surface of the sealing device in sealing contact with an inner surface defining the inner bore of the pipeline section prior to disintegration. As discussed herein above, it is possible to form any reasonable shape from a material that is controllably disintegratable, including bolts, pins etc, able to sustain sufficient force in use to achieve a temporary seal within a pipeline section.

10

15

Optionally, the present invention is further advantageous in having a sealing device wherein at least one, optionally the or each controllably disintegratable portion, is replaceable after each use of the sealing device to provide a seal to prevent flow through the inner bore of the pipeline section. By way of example only, and with reference to the examples shown in Figures 7-9, replacement portions, rings, plugs and bolts can be used to reset the first, second and third pigs shown such that they are reusable many times.

20

In particular, Figure 9a shows a sealing device 63 as an amalgamation of a steel bodied pig that has been designed to provide sealing in both the pipeline and PLET internal diameters, with a mechanical or hydraulically set sealing taper.

25

When it is desired to unseal the pipeline section 64, a controlled stimulus, such as described hereinabove, is applied to controllably disintegrate one or more parts of the sealing device 63. In one arrangement, the controlled stimulus is applied to controllably disintegrate the bolts 84.

30

In another arrangement, the controlled stimulus is applied to controllably disintegrate a disintegrable plug at the end of the line 90. In yet another arrangement, the controlled stimulus is applied to controllably disintegrate disintegrable plugs 97 at each

end of borelines 98 through the piston 76. The present invention is not limited by the number or location of controllably disintegratable portions of the sealing device.

Figure 9b shows the controllable disintegration of the bolts 84 and disintegrable plugs 97 in the piston 76, which make dispersions of smaller particles 100. This releases the piston 76 against the flexible disc 70, and moves it into the bore 77 under the influence of the front spring 82, (and the chamber spring 96 with release of fluid in the chamber 92), such that the flexible disc 70 is no longer held in its position against the portion 74 of the inner surface 78 of the pipeline section 64 having a reducing diameter. This allows passage of the remainder, being the all parts shown in Figure 8b to travel along the pipeline section 64 and be collected, ready for reuse with new controllably disintegratable bolts.

Figures 7-9 show embodiments of the present invention being both an assembly, and a sealing device for sealing a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure. with the sealing device having one or more controllably disintegrateable portions, and installable in the inner bore in the pipeline section to prevent flow through the inner bore, the sealing device comprising an outer surface in sealing contact with an inner surface defining the inner bore of the pipeline section.

Figures 1-9 show examples of temporary plugs or seals that can be provided in any internal bore or section of a pipeline or pipeline section, to provide a temporary seal therein during connection of at least one end to a respective end of another pipeline section and/or a pipeline structure. The temporary seal can withstand significant pressure, and then be released using a suitable control device, mechanism or process, with optional recovery of the sealing device for future or repeated use.

Whilst the forming of the temporary seal by the sealing device may be assisted by one or more biased or forced positions, the purpose of the present invention is that the release of the sealing device from its location forming a temporary seal is easily achievable by controllable disintegration of one or more portions of the sealing device, independent of whether one or more of the controllably disintegrateable portions are

directly forming the seal between the sealing device and the inner bore of the pipeline section or are assisting one or more other parts or portions of the sealing device to form the temporary seal. That is, the present invention is not limited by the one or more controllably disintegrateable portions directly forming the temporary seal.

5

The present invention provides a the sealing device positioned inside the inner bore of the pipeline section provides a safety feature which confines flooding of the pipe to a limited length, for example, during laying of pipeline or during pre-commissioning testing to ensure that tensions within pipeline remain within pre-set safety limits. In particular, to ensure that in the event of pipeline flooding, the tension in the pipeline remains below the Safe Working Load of the pipelay equipment.

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The controllably disintegrateable sealing device can be easily disposed of following pipe laying or testing. The provision of the modified profile of the inner surface of the pipeline section ensures that reliable sealing and secure retention of the sealing device in the pipeline section are achieved.

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CLAIMS:

1. An assembly comprising:

5 a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;

10 a sealing device having one or more controllably disintegrateable portions, and installed in the inner bore of the pipeline section to prevent flow through the inner bore, the sealing device comprising an outer surface in sealing contact with an inner surface defining the inner bore of the pipeline section.

15 2. An assembly as claimed in claim 1 wherein a portion of the inner surface of the pipeline section to be in contact with the outer surface of the sealing device is modified in relation to the remaining inner surface of the pipeline section such that the sealing device is installed with an interference fit into the pipeline section.

20 3. An assembly as claimed in claim 2 wherein the inner surface of the pipeline section in contact with the outer surface of the sealing device is modified such that the sealing device is wedged in the inner bore of the pipeline section.

4. An assembly as claimed in claim 2 or claim 3 wherein the inner surface of the pipeline section in contact with the outer surface of the sealing device comprises a reduced diameter portion compared to the remainder of the pipeline section.

25 5. An assembly as claimed in claim 4 wherein reduced diameter portion is at or adjacent an end of the pipeline section, and the sealing device is wedged in the reduced diameter portion.

30 6. An assembly as claimed in any one of the preceding claims wherein the inner surface of the pipeline section in contact with the outer surface of the sealing device comprises a roughened portion.

7. An assembly as claimed in any one of the preceding claims wherein at least one said sealing device is installed at or adjacent one end or each opposite end of the pipeline section.

5 8. An assembly as claimed in any one of the preceding claims wherein the sealing device has a pre-determined and fixed shape prior to disintegration of the or each controllably disintegrateable portion.

9. An assembly as claimed in any one of the preceding claims wherein the or
10 each controllably disintegrateable portion of the sealing device is disintegrateable in response to a controlled stimulus.

10. An assembly as claimed in claim 9 wherein the controlled stimulus comprises one or more selected from the group comprising: chemical, thermal, acoustic, and
15 electromagnetic stimulus.

11. An assembly as claimed in claim 9 or claim 10 wherein the disintegration of the or each controllably disintegrateable portion includes one or more of the group comprising: partial or full dissolution, partial or full dispersion, partial or full
20 melting, partial or full granulating and partial or full powderising.

12. An assembly as claimed in any one of the preceding claims wherein the or each controllably disintegrateable portion of the sealing device comprises one or more of the group comprising: an outer layer, an outermost section, an outer ring, or
25 a circumferential structure; of the sealing device.

13. An assembly as claimed in claim 12 wherein a controllably disintegrateable portion is an outer layer and the sealing device comprises an inner structural core.

30 14. An assembly as claimed in claim 13 wherein the inner structural core is a ball, and the controllably disintegrateable portion is an outer shell.

15. An assembly as claimed in claim 12 wherein all of the sealing device is controllably disintegratable.

16. An assembly as claimed in claim 15 wherein the sealing device is in the shape of a ball

17. An assembly as claimed in claim 15 wherein the outer shape of the sealing device is a partly or wholly conical or frusto-conical shape.

18. An assembly as claimed in any one of the preceding claims wherein a portion of the inner surface of the pipeline section to be in contact with the outer surface of the sealing device is modified in relation to the remaining inner surface of the pipeline section, and wherein the outer shape of the sealing device is wholly or substantially complementary-shaped to match the modification of the inner surface of the pipeline section.

19. An assembly as claimed in claim 13 wherein the inner structural core is a pig, and a controllably disintegratable portion is an outer ring.

20. An assembly as claimed in any one of claims 1 to 11 wherein a controllably disintegratable portion of the sealing device comprises an inner structure or inner layer of the sealing device.

21. An assembly as claimed in claim 20 wherein the controllably disintegratable portion comprises one or more internal support pins or bolts or screws.

22. An assembly as claimed in claim 20 or claim 21 wherein the sealing device comprises a flexible disc able to form the sealing contact with the inner surface defining the inner bore of the pipeline section.

23. An assembly as claimed in any one of claims 12 to 22 wherein the or each controllably disintegrateable portion of the sealing device is formed from a composite of reactive nanoparticles able to disintegrate in response to a controlled stimulus.

5

24. An assembly as claimed in any one of the preceding claims wherein the outer circumference of the sealing device is reduced following the disintegration of the or each controllably disintegrateable portion.

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25. An assembly as claimed in any one of the preceding claims wherein the sealing device is configured to become one or more smaller portions able to flow through the pipeline section.

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26. A pipeline comprising an assembly as claimed in any one of claims 1 to 25 in which at least one end of the pipeline section of the assembly is connected to a respective end of a pipeline section of another such assembly and/or to a pipeline structure.

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27. A pipeline as claimed in claim 26 comprising a plurality of pipeline sections and sealing devices as defined in any one of claims 1 to 25.

28. A method of sealing a pipeline section, the method comprising at least the steps of:

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providing a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;

providing at least one sealing device having one or more controllably disintegrateable portions for sealing the inner bore of the pipeline section; and

30

installing the at least one sealing device with an interference fit into the pipeline section with an outer surface of the sealing device, and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section.

29. A method as claimed in claim 28 wherein the method includes installing at least one said sealing device at or adjacent one end or each opposite end of the pipeline section.

5 30. A method as claimed in claim 28 or claim 29 further comprising the step of:
modifying a portion of the inner surface of the pipeline section of the pipeline section to be in contact with the outer surface of the sealing device to allow the sealing device to be installed with at least an interference fit into the pipeline section.

10

31. A method of unsealing a pipeline section sealed by a method as claimed in any one of claims 28 to 30 comprising at least the step of applying a controlled stimulus to cause the or each controllably disintegrateable portion of the sealing device to disintegrate into smaller parts in response to the controlled stimulus.

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32. A method as claimed in claim 30 further comprising the step of removing the disintegrated smaller parts of the sealing device from the pipeline section.

20

33. A method of laying a subsea pipeline comprising a plurality of pipeline sections, each pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section, comprising the steps of:

25

installing at least one sealing device as defined in any one of claims 1 to 25 into a pipeline section and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section;

forming the pipeline by joining two or more of the pipeline sections;

laying the subsea pipeline; and

30

unsealing the pipeline by applying a controlled stimulus to cause the or each controllably disintegrateable portion of the or each sealing device to disintegrate in response to the controlled stimulus.

34. A method of laying a subsea pipeline section and pipeline structure the pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to the pipeline structure, comprising the steps of:

- 5 installing at least one sealing device as defined in any one of claims 1 to 25 into the pipeline section connectable to the pipeline structure, and establishing a sealing contact with an inner surface defining the inner bore of the pipeline section;
- joining the pipeline section and pipeline structure;
- laying the pipeline section and pipeline structure; and
- 10 unsealing the pipeline section by applying a controlled stimulus to cause the or each controllably disintegrateable portion of the sealing device to disintegrate in response to the controlled stimulus.

35. A sealing device for sealing a pipeline section having opposite ends and an inner bore extending between the ends, at least one end being connectable to a respective end of another pipeline section and/or of a pipeline structure;
- 15 the sealing device having one or more controllably disintegrateable portions, and installable in the inner bore of the pipeline section to prevent flow through the inner bore, the sealing device comprising an outer surface able to be in sealing contact with an inner surface defining the inner bore of the pipeline section.
- 20

36. The sealing device of claim 35 wherein the one or more controllably disintegrateable portions of the sealing device comprises one or more of the group comprising: plugs, ports, pins, bolts and screws: able to maintain an outer surface of the sealing device in sealing contact with an inner surface defining the inner bore of the pipeline section prior to disintegration.
- 25

37. The sealing device of claim 35 or claim 36 wherein the one or more controllably disintegrateable portions of the sealing device are able to maintain one or more retractable outer segments or complete outer ring in contact with an inner surface defining the inner bore of the pipeline section prior to disintegration.
- 30

38. The sealing device of claim 35 or claim 36 wherein the controllably disintegrateable portion(s) of the sealing device are able to maintain a biased piston against a flexible disc to form the sealing contact with the inner surface defining the inner bore of the pipeline section.

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39. The sealing device of any one of claims 35 to 38 wherein the sealing device comprises a pig.

10

40. The sealing device of any one of claims 35 to 39 wherein the sealing device includes an inflatable sealing outer ring to provide a sealing contact with an inner surface defining the inner bore of the pipeline section prior to disintegration.

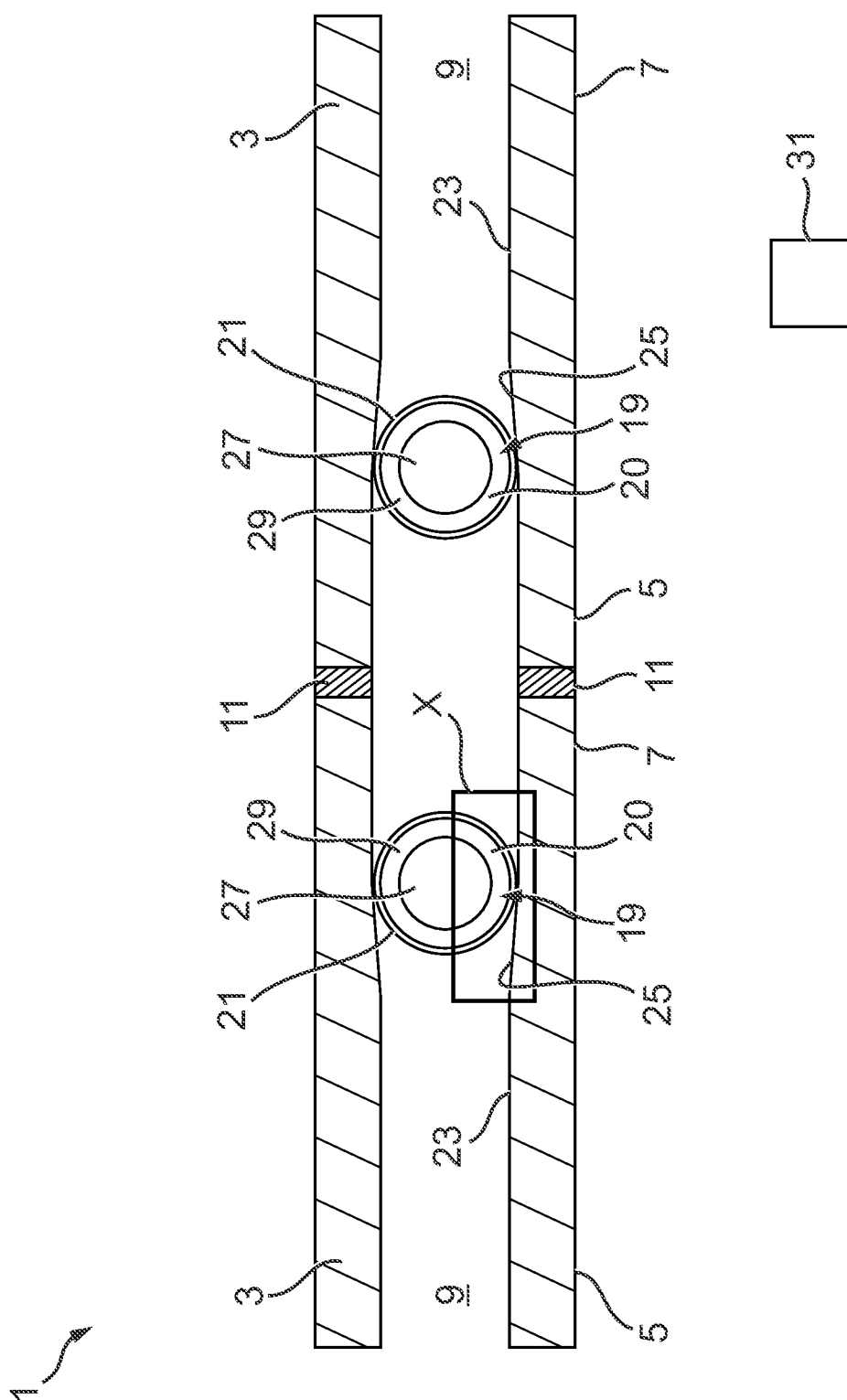


Fig. 1

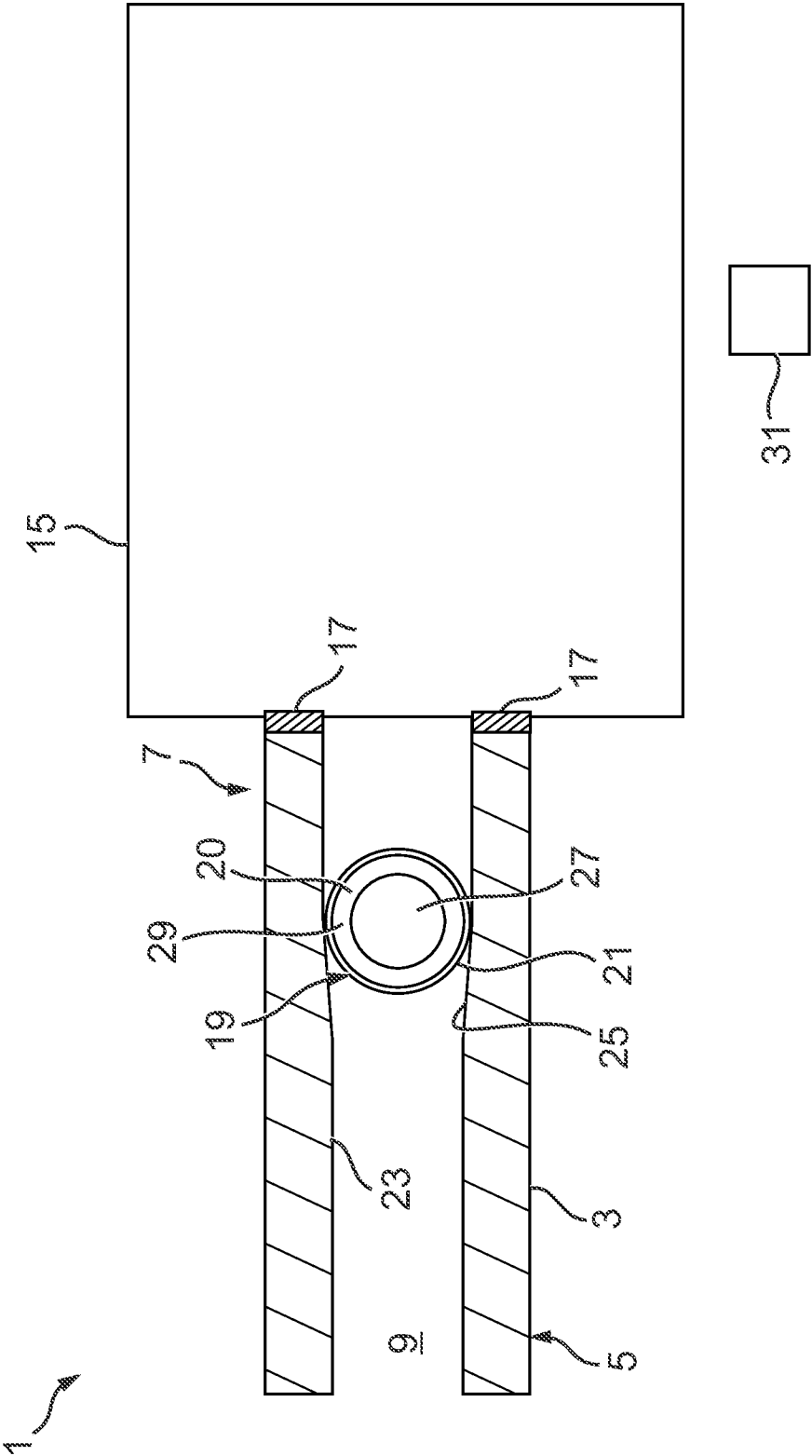


Fig. 2

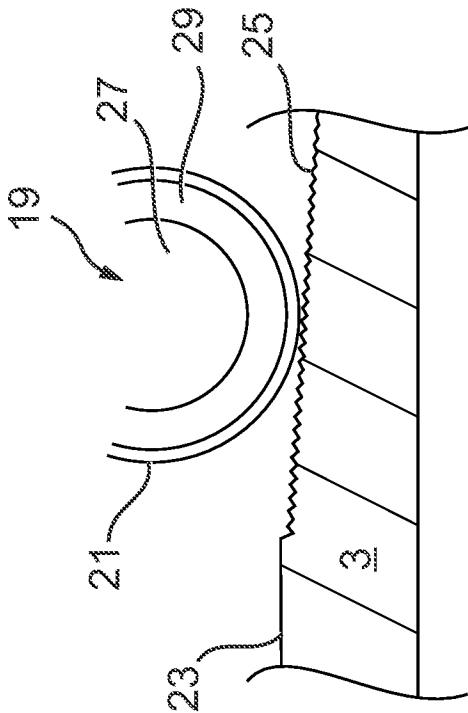


Fig. 3

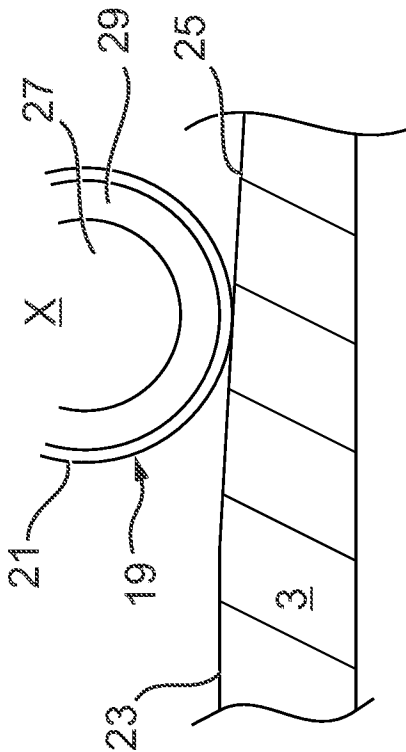


Fig. 4

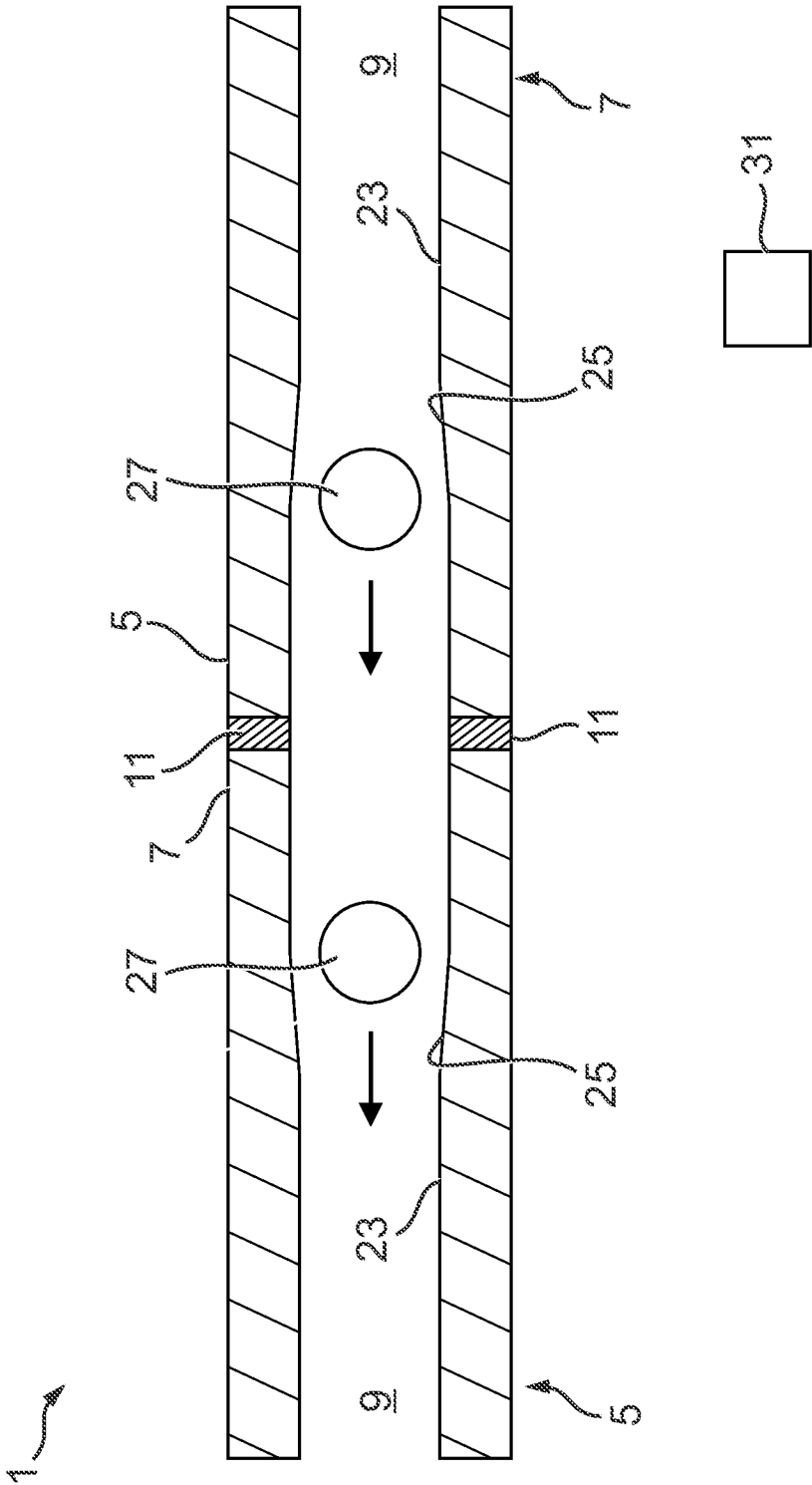
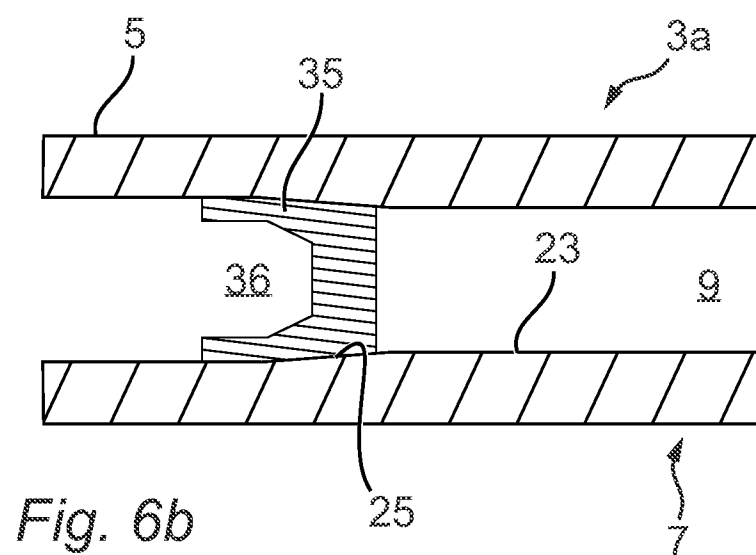
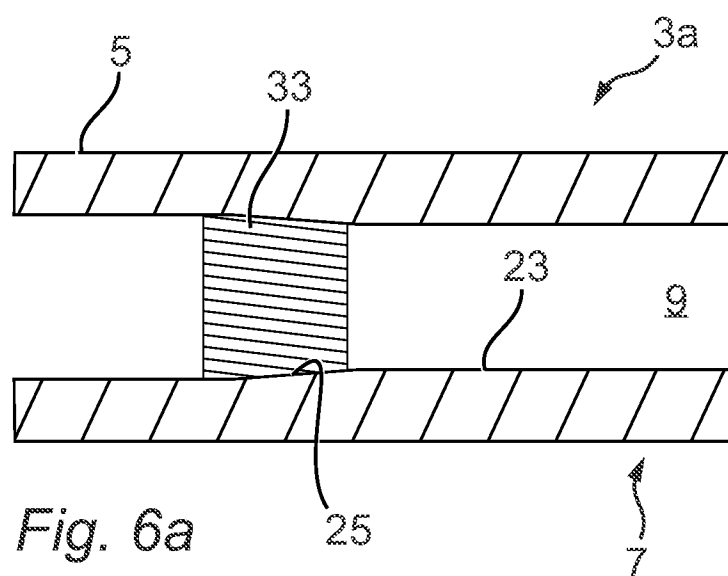


Fig. 5

5/11



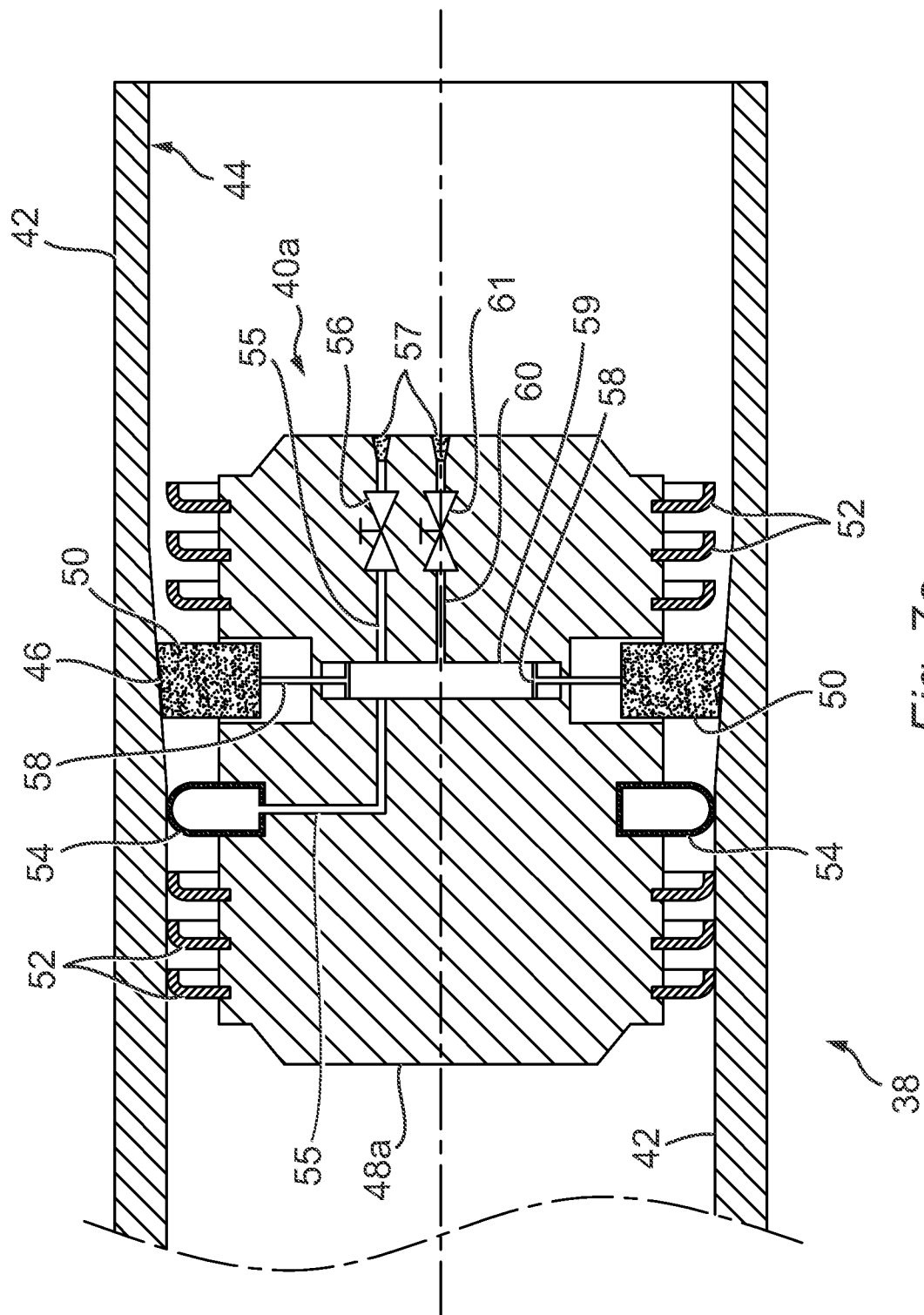


Fig. 7a

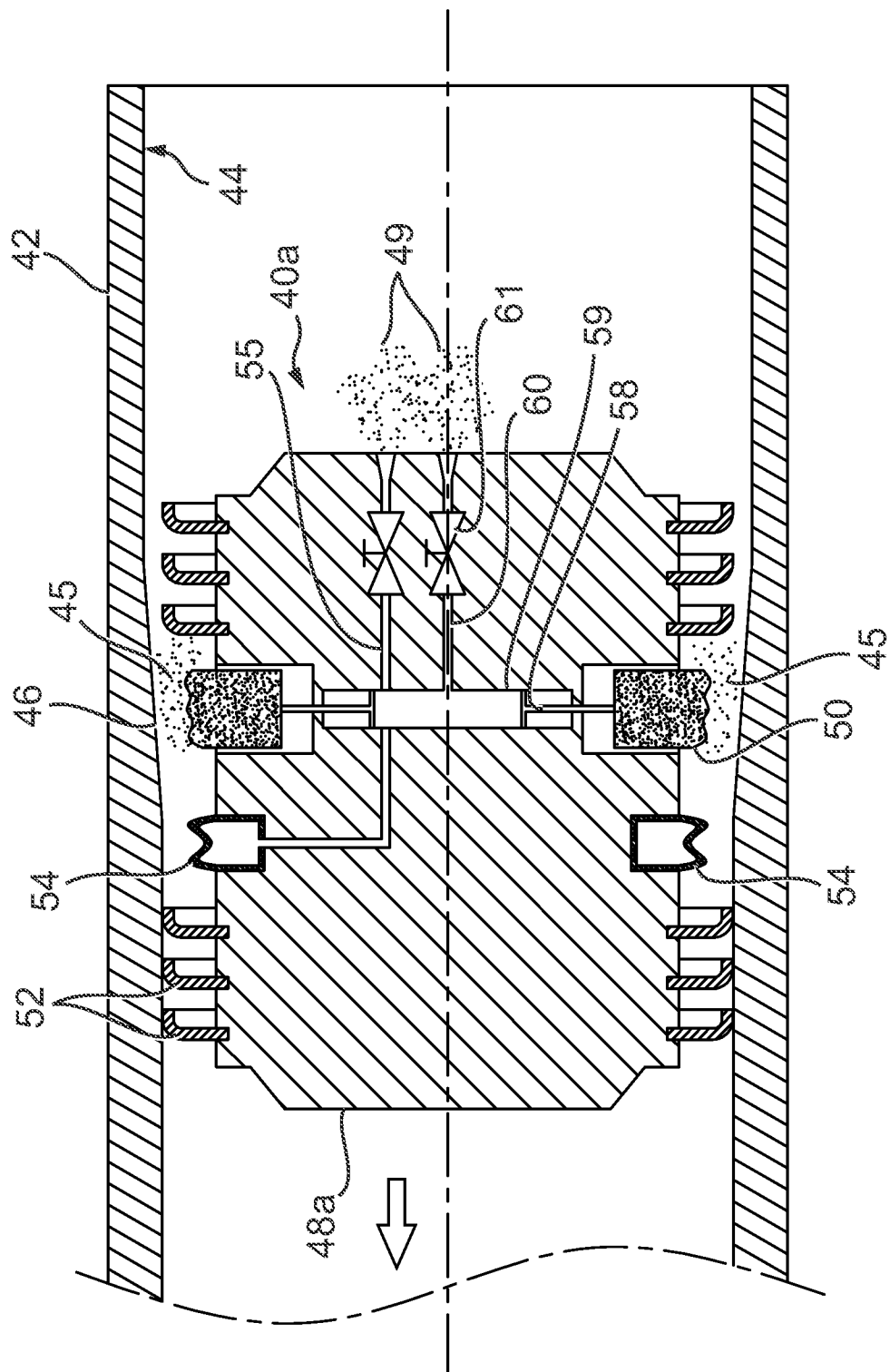


Fig. 7b

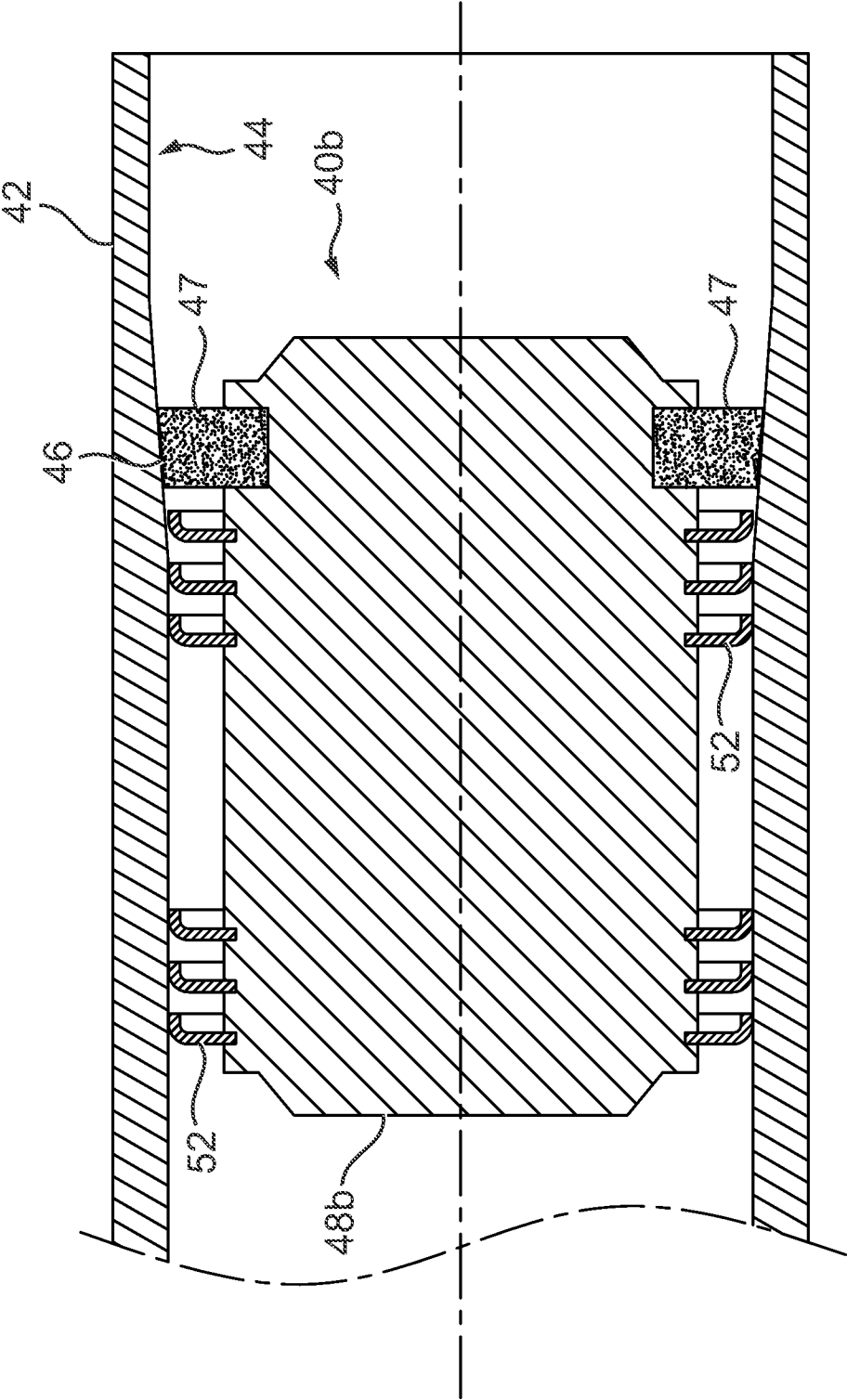


Fig. 8a

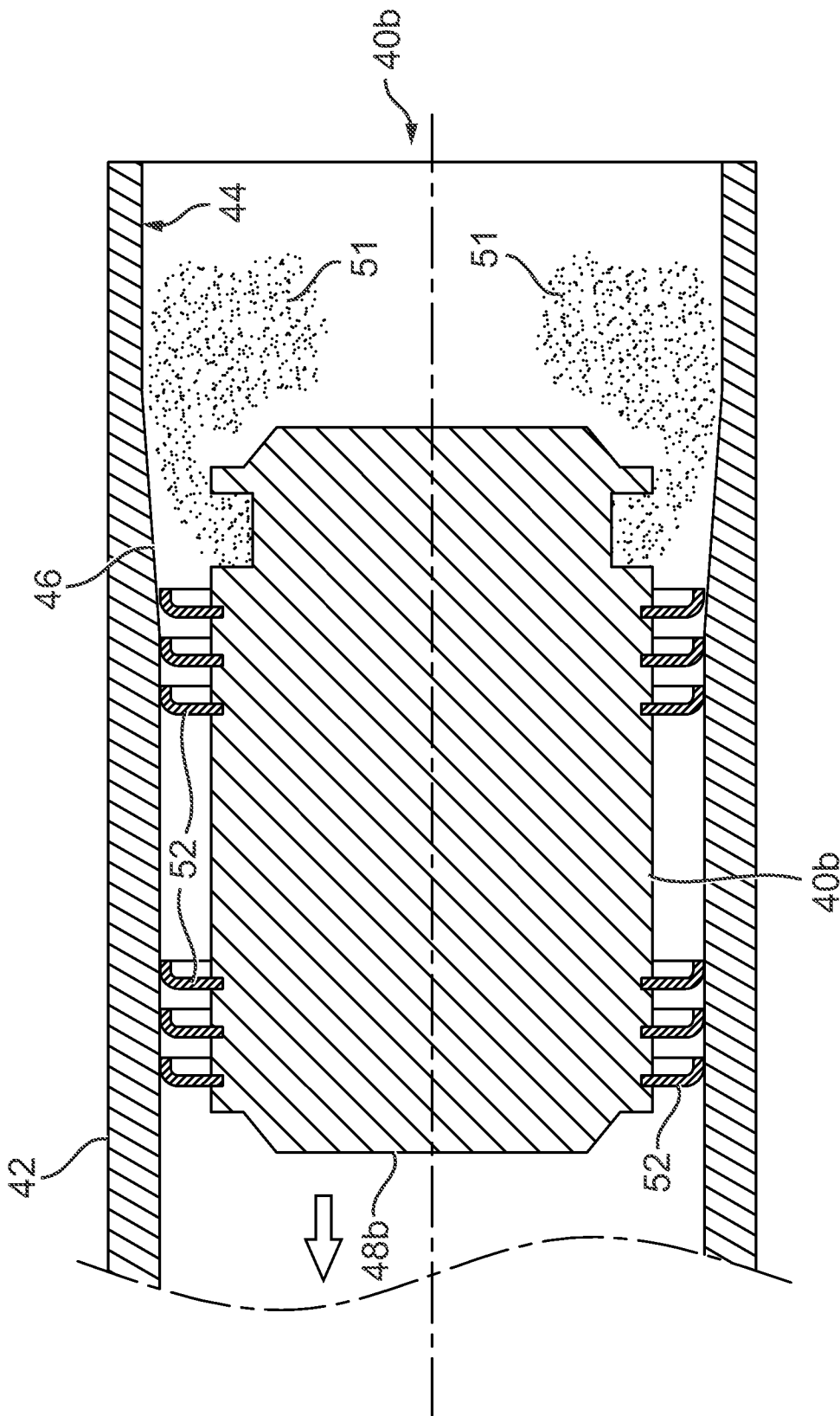


Fig. 8b

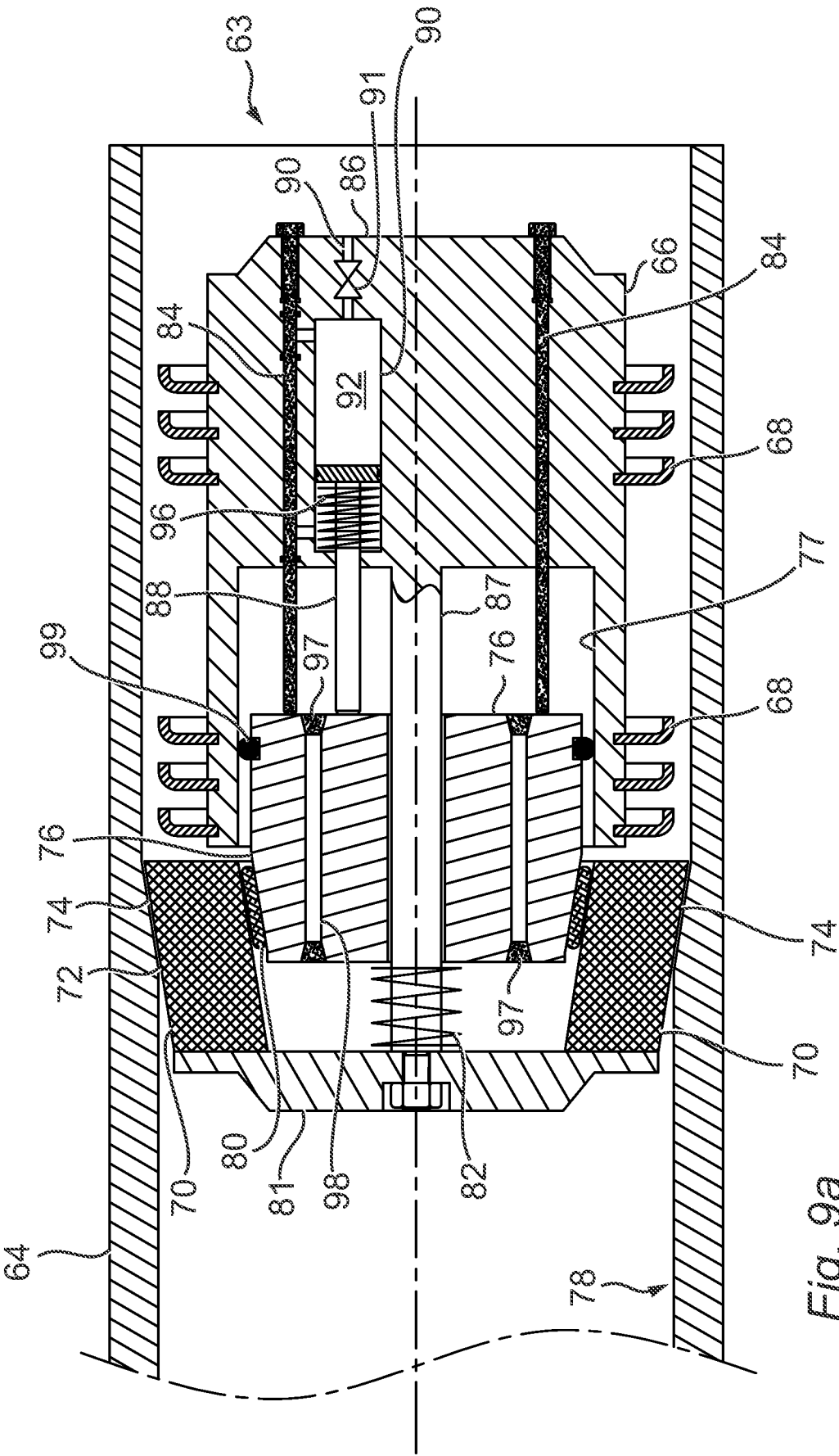


Fig. 9a

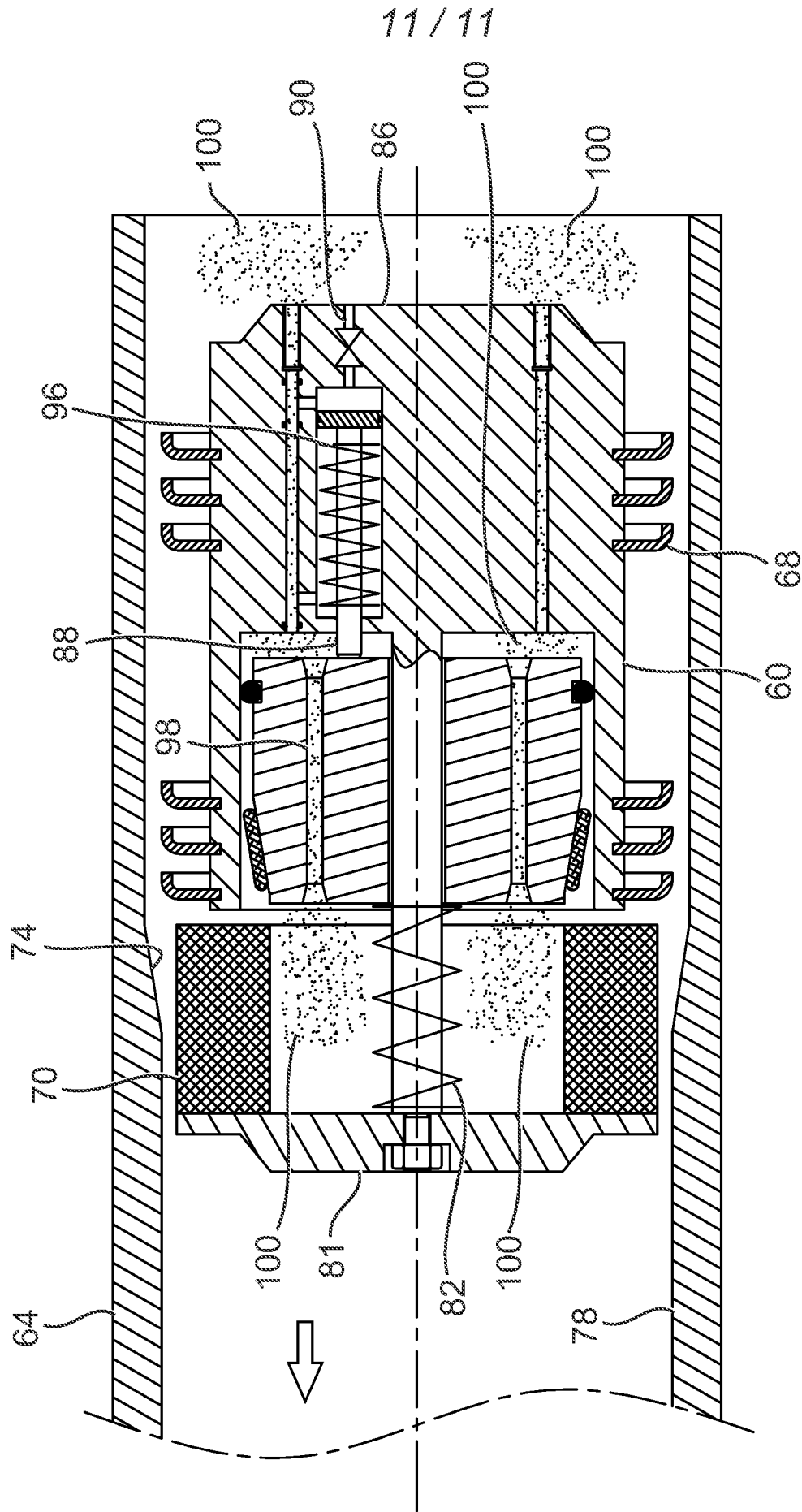


Fig. 9b

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/001402

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16L1/235 F16L55/11 F16L55/128 F16L55/134 F16L55/136
F16L55/42 F16K17/40

ADD.

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)

F16L F16K

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 2015 201 520 A1 (BHAT SHREEPAD) 8 October 2015 (2015-10-08)	1-3, 7-17, 19-40
A	paragraph [0001] - paragraph [0023] paragraph [0035] - paragraph [0009] figures 1-8	4-6, 18
X	US 3 496 952 A (AMENDOLA MICHAEL R) 24 February 1970 (1970-02-24) column 2, line 3 - column 3, line 19 figures ----- -/--	1-5, 7-13, 15, 17-20, 24-31, 35-39



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"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

6 February 2018

Date of mailing of the international search report

16/02/2018

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/001402

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 100 830 A (PETROLES CIE FRANCAISE [FR]) 6 January 1983 (1983-01-06)	1-3, 8-20, 24-26, 28,29, 31,32, 35-40
A	page 1, line 35 - page 2, line 64 figure -----	4-7,27, 30,33,34
X	US 5 186 214 A (SAVARD DONALD D [CA]) 16 February 1993 (1993-02-16) column 1, line 6 - column 2, line 44 figures -----	1-16,18, 20,22-40
X	US 4 607 664 A (CARNEY JOSEPH H [US] ET AL) 26 August 1986 (1986-08-26) column 2, line 31 - column 4, line 51 figures -----	1-12,15, 17,18, 20,22, 24-31, 35-39
A	GB 2 500 677 A (TECHNIP FRANCE [FR]) 2 October 2013 (2013-10-02) page 1, line 5 - page 10, line 27 figures -----	1-40

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2017/001402

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
AU 2015201520	A1	08-10-2015	NONE
US 3496952	A	24-02-1970	NONE
GB 2100830	A	06-01-1983	CA 1192148 A 20-08-1985 FR 2508139 A1 24-12-1982 GB 2100830 A 06-01-1983 IT 1151657 B 24-12-1986 MX 158288 A 20-01-1989 NO 822083 A 27-12-1982 OA 7128 A 31-03-1984 US 4436120 A 13-03-1984
US 5186214	A	16-02-1993	CA 2019946 A1 27-12-1991 US 5186214 A 16-02-1993
US 4607664	A	26-08-1986	CA 1229053 A 10-11-1987 US 4607664 A 26-08-1986
GB 2500677	A	02-10-2013	GB 2500677 A 02-10-2013 WO 2013144724 A2 03-10-2013