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DE 019529782 A1

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Other: **EPODOC, WPI**

(54) Title of the Invention: **Apparatus and method**
Abstract Title: **Pipeline robot drive**

(57) A robot drive assembly 111B for moving a robot along a substantially cylindrical pipeline within the pipeline comprises a first body having a first axis arranged to be oriented, in use, substantially parallel to or coincident with a longitudinal axis of a pipeline; a motor drive 110M1 coupled to the first body; and a worm screw member 112WE coupled to the first body, the worm screw member 112WE carrying an external helical thread about a screw axis thereof, the motor drive 110M1 being arranged to cause rotation of the worm screw member 112WE about the screw axis relative to the first body; at least one drive wheel member 111R configured to engage an internal wall of the pipeline, the at least one drive wheel member 111R being arranged to be rotatably driven by the helical thread of the worm screw member 112WE to cause translation of the assembly within a pipeline.

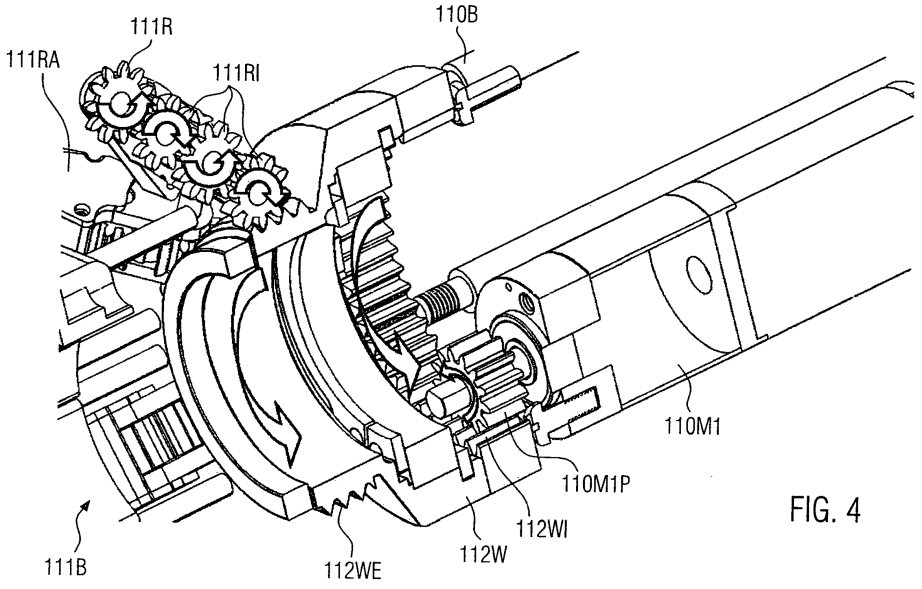

FIG. 4

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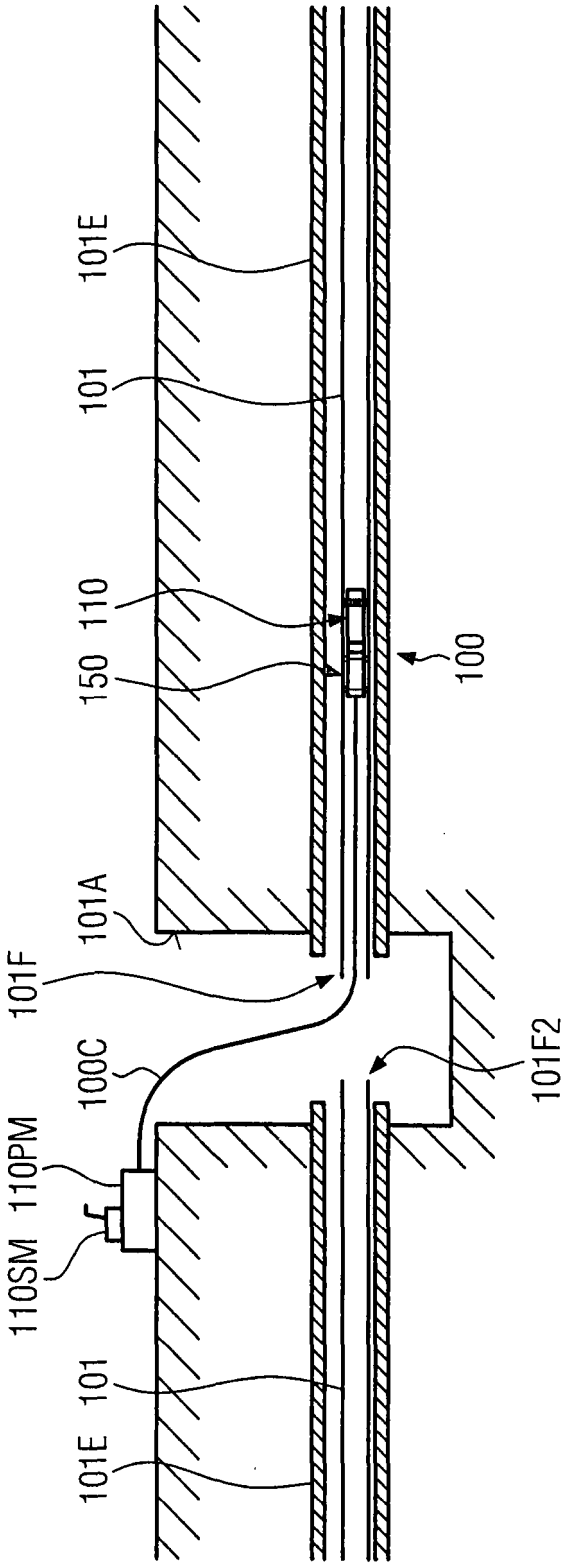
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The print reflects an assignment of the application under the provisions of Section 30 of the Patents Act 1977.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110
150
100
101A
101F
100C
101F2
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101
101E

FIG. 1

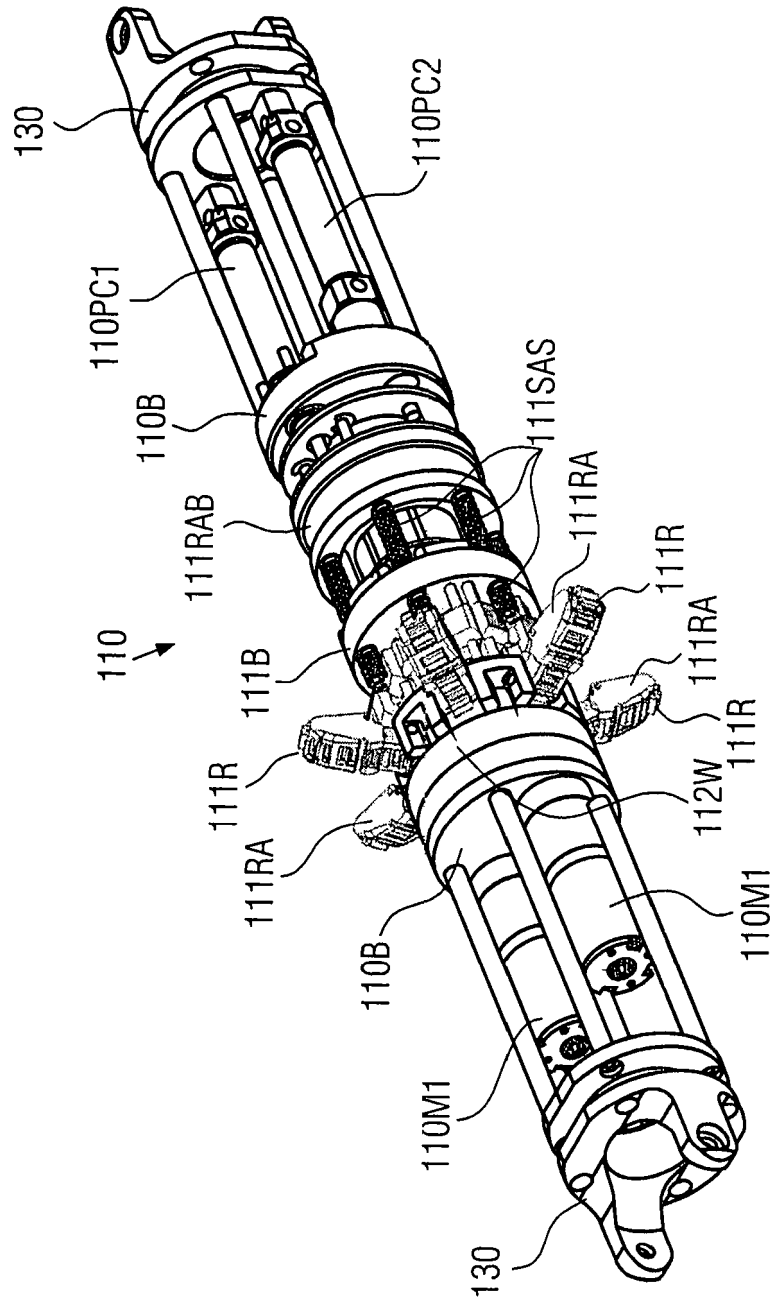

130
110PC2
110PC1
110B
111SAS
111RAB
111RA
111R
110
111B
111R
111RA
111R
111RA
112W
110B
110M1
110M1
130

FIG. 2

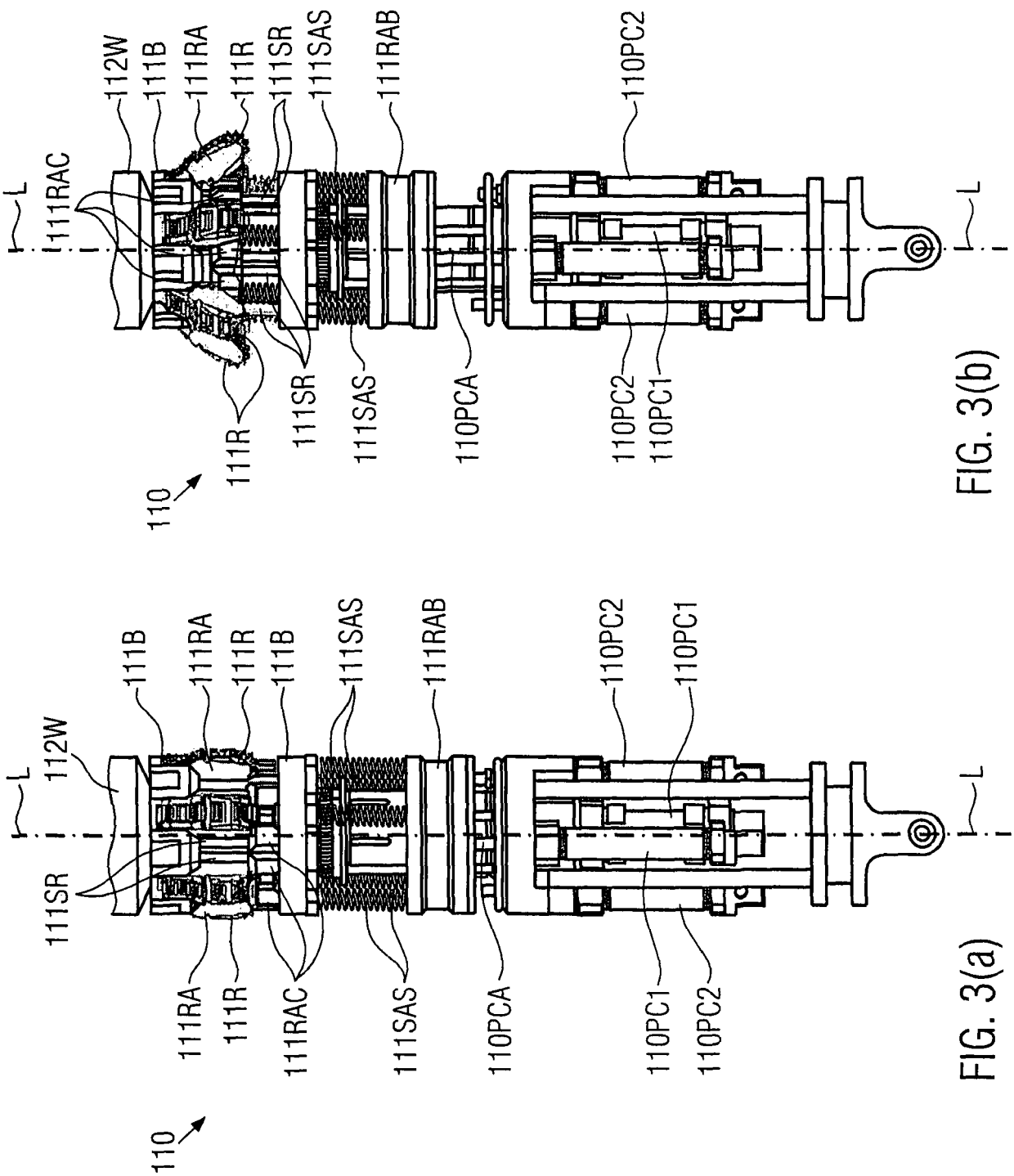

110
111SR
112W
L
111RA
111B
111R
111RAC
111B
111SAS
111RAB
110PC2
110PC1
110PCA
111RA
111R
111RAC
111SAS
110PCA
110PC1
110PC2
L

FIG. 3(a)

110
111R
111SR
111SAS
110PCA
110PC2
110PC1
L
111RAC
112W
111B
111RA
111R
111SR
111SAS
111RAB
110PC2
L

FIG. 3(b)

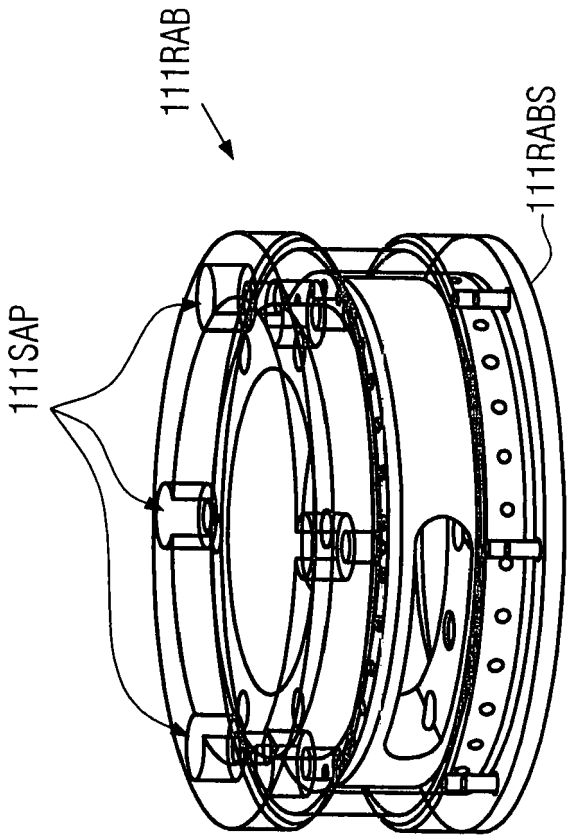


FIG. 3(c)

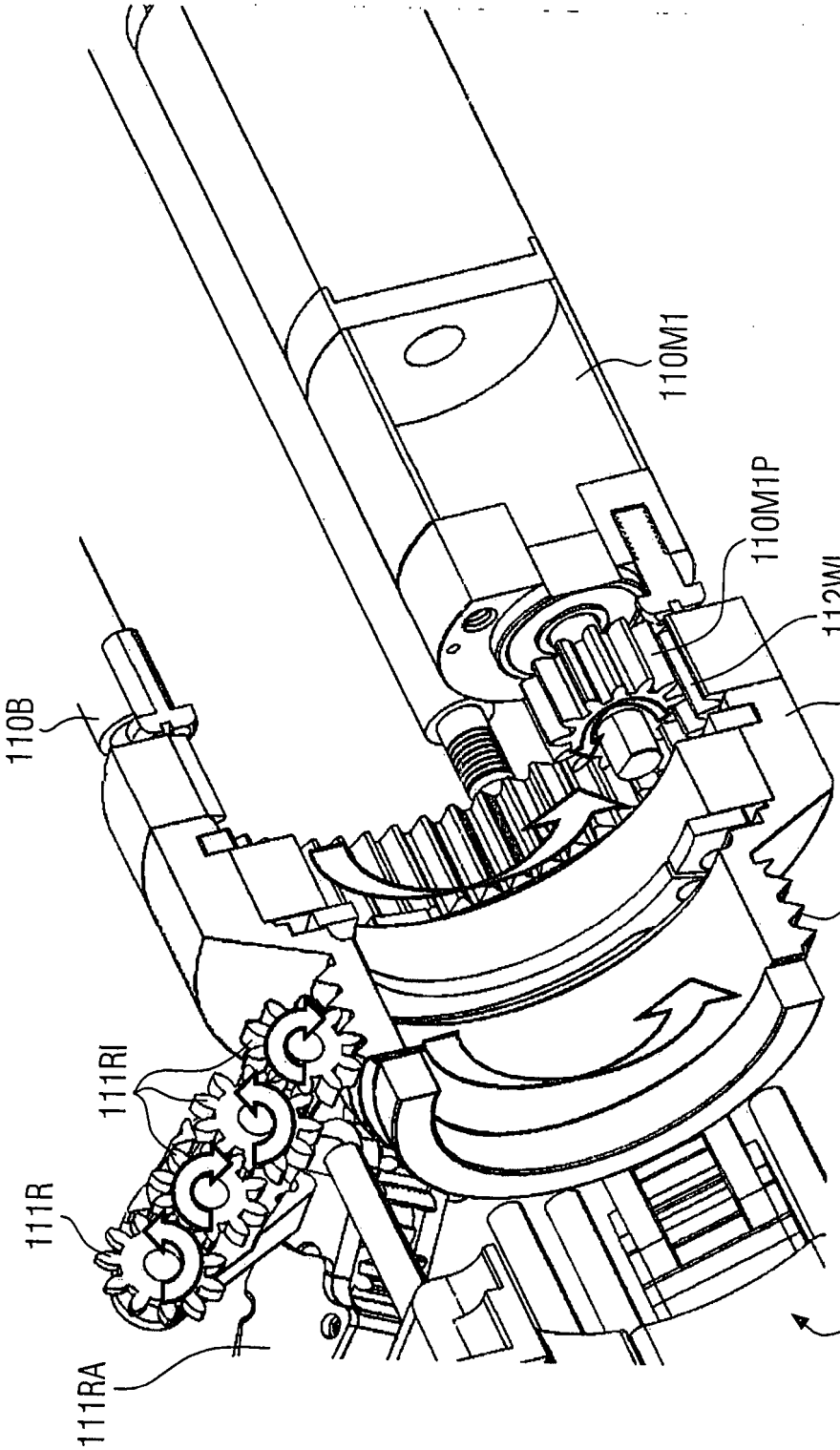
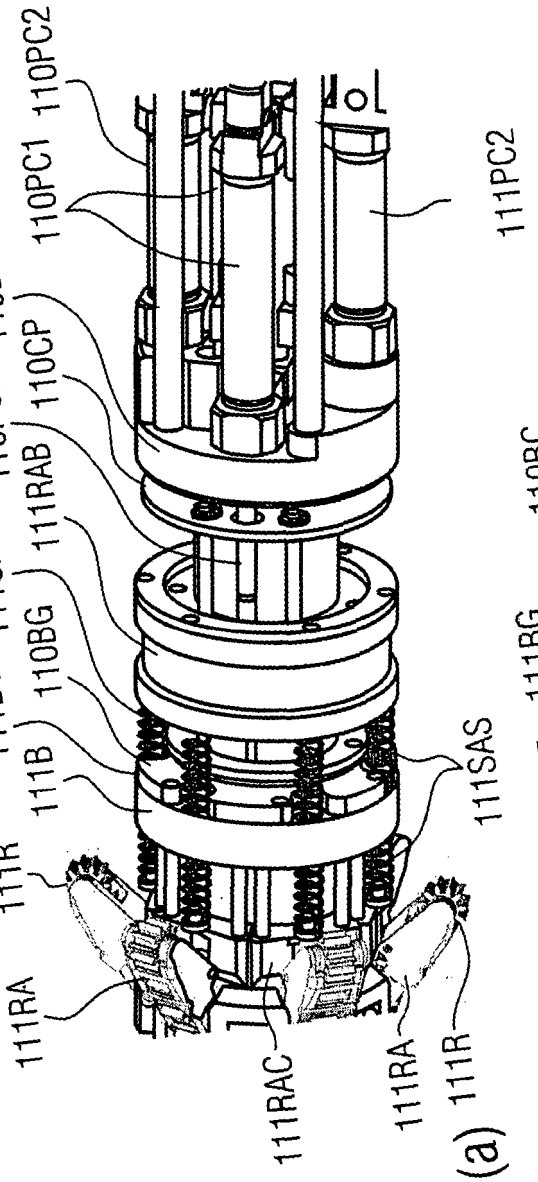


FIG. 4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110PC2
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110PCA
110CP
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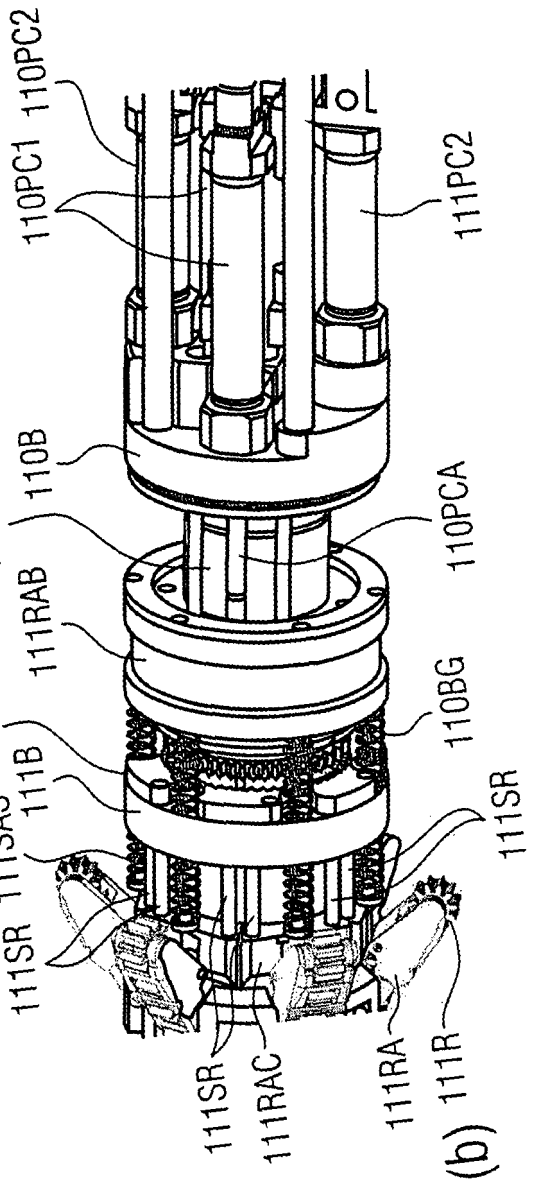
111RAB
111BG
110BG
111B
111R
111RA
111RAC
111PC2
111SAS
111R
111RA

FIG. 5(a)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110PC2
111PC2
110B
110BC
110PCA
111RAB
111BG
110BG
111B
111SAS
111SR
111SR
111RAC
111RA
111R

FIG. 5(b)

APPARATUS AND METHOD

TECHNICAL FIELD

The present invention relates to pipelines and in particular but not exclusively apparatus for use in the maintenance or installation of pipelines.

BACKGROUND

Maintenance, upgrading and replacement of ageing utilities pipeline infrastructures are major issues facing utilities companies such as water and gas utilities companies. Pipeline networks typically include main supply pipelines (also referred to as the 'mains' supply) and consumer service connection pipelines. The consumer service connection pipelines are connected to the main supply pipelines, typically by means of a T-connection, to deliver a supply of fluid such as water or gas to a consumer's premises from the main supply pipeline.

Utilities supply pipelines are typically located underground, presenting substantial access issues when maintenance, upgrading or replacement is required.

Ageing pipelines are vulnerable to failure and leakage of fluid from pipelines is a known hazard particularly in the case of gas leakage.

One solution to reducing the cost of replacement of pipelines is to install replacement pipeline within pre-existing pipeline, including the main pipeline and consumer service connection pipeline, leaving the pre-existing main pipeline and pre-existing consumer service connection pipeline in place. The replacement main pipeline has an external diameter that is smaller than the internal diameter of the pre-existing main pipeline, allowing it to fit within the pre-existing main pipeline infrastructure. Similarly, the replacement consumer service connection pipeline has a diameter that is smaller than the pre-existing consumer service connection pipeline. The replacement main pipeline may be referred to as a 'main pipeline liner' or 'mains liner' because it effectively lines the pre-existing main pipeline. Similarly the replacement consumer service connection pipeline may be referred to as a 'service connection liner' since it effectively lines the pre-existing consumer service connection pipeline. The consumer service connection pipeline may be of the Serviflex

(RTM) type, being a twin wall corrugated flexible polyethylene liner pipe supplied by Radius Systems Ltd, South Normanton, Alfreton, Derbyshire, UK.

In known methods of replacement pipeline installation, the replacement pipeline is installed within the pre-existing pipeline by pulling the replacement pipeline through the pre-existing pipeline. Connection of the replacement consumer service connection pipeline to the replacement main pipeline is made by excavating ground above the location at which the pre-existing service connection pipeline connects to the pre-existing main pipeline. Installer personnel may then remove a portion of the pre-existing main pipeline and pre-existing service connection pipeline in order to expose the replacement pipelines that have been installed therein. A T-connector is then installed on the replacement main pipeline and the replacement service connection pipeline coupled to the replacement main pipeline via the T-connector. The T-connector is typically attached to the main pipeline by forming an electrofusion bond between the T-connector and the main pipeline in a known manner.

It is an aim of the present invention to address disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Embodiments of the invention may be understood with reference to the appended claims.

Aspects of the present invention provide an apparatus, a robot, a system and a method.

In one aspect of the invention for which protection is sought there is provided a robot drive assembly for moving a robot along a substantially cylindrical pipeline within the pipeline, the assembly comprising:

a first body having a first axis arranged to be oriented, in use, substantially parallel to or coincident with a longitudinal axis of a pipeline;

a motor drive coupled to the first body; and

a worm screw member coupled to the first body, the worm screw member carrying an external helical thread about a screw axis thereof, the motor drive being arranged to cause rotation of the worm screw member about the screw axis relative to the first body;

at least one drive wheel member configured to engage an internal wall of the pipeline, the at least one drive wheel member being arranged to be rotatably driven by the helical thread of the worm screw member to cause translation of the assembly within a pipeline.

Embodiments of the invention have the advantage that a relatively compact drive assembly may be provided, increasing the amount of space available for packaging other components associated with the robot.

Some embodiments of the invention may be configured for operation in pipelines having a diameter of 1m or less, optionally in the range from 10mm to 1m. Some embodiments may be configured for operation in pipelines having a diameter in the range from 50mm to 200mm, optionally from 50mm to 100mm, optionally in the range from 75mm to 90 mm.

The at least one drive wheel member may be substantially directly coupled to the first body. Alternative the at least one drive wheel member may be coupled to the first body via a second body. As described in more detail below, the second body may be configured to be rotationally coupled to the first body. Alternatively or in addition the second body may be configured to be substantially rigidly coupled to the first body.

Optionally, the screw axis of the worm screw member is substantially parallel to or coincident with the first axis of the first body.

The assembly may comprise a plurality of drive wheel members provided at circumferentially spaced locations around the worm screw member, the drive wheel members being configured to engage an internal wall of the pipeline, the assembly being configured to allow the drive wheel members to be driven by the helical thread to cause translation of the assembly within a pipeline.

Optionally, the at least one drive wheel member is a toothed drive wheel member.

The at least one drive wheel member may for example be a toothed gear wheel.

Optionally, the at least one drive wheel member is arranged to be driven by the helical thread via one or more intermediate wheel members.

The one or more intermediate wheel members may each be in the form of a toothed gear wheel.

Optionally, the worm screw member is provided with an internal annular gear portion arranged to be driven by a pinion, the pinion being arranged to be driven by the motor drive to cause rotation of the worm screw member about the screw axis.

This feature has the advantage that the motor drive may be conveniently located within the body of the assembly away from a radially or axially central region in a region distal an axis of rotation of the worm screw member. This has the advantage that the axially central region may be reserved for packaging of required components such as cabling. Thus in some embodiments the axially central region may define a conduit portion for routing cabling and/or tubes such as pneumatic tubes carrying compressed gas such as compressed air for actuating one or more components.

In some embodiments having a plurality of drive wheel members, this feature has the advantage that the plurality of drive wheel members may be driven by a single component, in this case the worm screw member, if desired.

The worm screw member may be driven by a plurality of motor drives in some embodiments.

Optionally, the at least one drive wheel member is coupled to a second body, the assembly being operable in a first configuration in which the first and second bodies are locked in a substantially fixed orientation with respect to one another and a second configuration in which the second body is rotatable with respect to the first body about the first axis. Thus, in some embodiments the first and second bodies may be coupled, optionally for relative rotation.

This feature permits the assembly to be operated in a manner permitting rotation of a portion of the robot within a pipeline relative to a longitudinal axis of the pipeline, enabling the robot to be caused to assume a required rotational orientation within a pipeline.

It is to be understood that, whether the first and second bodies do rotate relative to one another when the assembly is in the second configuration may depend on the mass of the first body and the resistance to rotation by the worm screw member experienced by the at least one wheel member. If the resistance to rotation experienced by the at least one wheel member is sufficient to prevent rotation thereof, the first body portion may experience rotation relative to the second. This may allow the first body portion to rotate relative to the

pipeline, enabling an operator to control the assembly to cause the first body to assume a required rotational orientation relative to the pipeline, within the pipeline. It is to be understood that resistance to rotation may occur as a consequence of an inertial mass of the robot, and/or operation of two assemblies in an opposing manner. By opposing manner is meant that the assemblies are operated so that respective assemblies attempt to translate the robot in opposite directions along the pipeline, the drive forces cancelling one another so that no net translation occurs.

The assembly may comprise a clutch device configured releasably to couple the first and second bodies together to prevent relative rotation.

Optionally, the at least one drive wheel member is movably coupled to the second body to permit movement of the at least one drive wheel member towards and away from the second body.

In embodiments not having a second body member the at least one drive wheel may be movably coupled to the first body or any other suitable component.

The at least one drive wheel member may be movably coupled to the second body (or, in some embodiments, the first body) by means of a support arm. The support arm may be rotatably coupled to the second body, the second body portion being in turn coupled to the first body.

Optionally, the at least one drive wheel member is resiliently coupled to the second body by resilient coupling means, the resilient coupling means being configured to urge the at least one drive wheel member radially away from the second body and against an inner wall of the pipeline.

By radially away is meant a direction in which a radial distance from the first axis increases. The direction need not be a direction that is purely normal to the first axis with no component parallel to the first axis. The direction may involve rotation about the first axis in addition to movement radially away from the first axis.

It is to be understood that the notional first axis is common to the first and second bodies; the first and second bodies may overlap along the first axis, or the first axis of the second body may be an extension of the first axis of the first body.

In embodiments in which the at least one drive wheel member is supported by a support arm, the support arm may be spring-loaded such that the support-arm tends to be urged resiliently away from the second body. Movement of the support arm towards the second body, for example when negotiating a bend or encountering a change in gradient, may be opposed but accommodated by the spring-loading, ensuring that the drive wheel member remains in contact with a sidewall of the pipeline substantially at all times.

The assembly may comprise actuator means configured to move the at least one drive wheel member radially towards and away from the second body between a retracted position and a deployed position, the retracted position being located radially inwardly of the deployed position.

Thus it is to be understood that the actuator means may be configured to cause the at least one drive wheel member to be moved radially away from and towards the second body, for example between a retracted or collapsed position in which the at least one drive wheel member is relatively close to the second body, optionally at least partially enclosed by the second body, and a deployed or extended position in which the at least one drive wheel member is moved to a position radially away from the second body.

This feature may be useful when introducing the assembly into a pipeline. Alternatively or in addition this feature may be useful when operating the assembly in pipelines of different respective diameters, allowing the at least one drive wheel member to be moved conveniently from the retracted position to a deployed condition a suitable radial distance from the longitudinal axis of the assembly to contact the wall of the pipeline.

It is to be understood that the actuator means may cause the at least one drive wheel member to move in a path that is substantially straight, and linearly radially outward normal to a longitudinal axis of the assembly. Alternatively the path may be radially outward but at least partially curved, optionally in a circumferential direction, optionally in a longitudinal direction in addition or instead.

The assembly may comprise a plurality of drive wheel members provided at angularly spaced locations about the longitudinal axis of the second body.

In a further aspect of the invention for which protection is sought there is provided a pipeline robot comprising at least one drive assembly according to an aspect of the invention.

In a further aspect of the invention for which protection is sought there is provided a pipeline robot comprising first and second robot drive assemblies according to an aspect of the invention.

Optionally, the first and second robot drive assemblies are oriented in a respective opposite manner with respect to a longitudinal axis of the robot.

It is to be understood that, in some embodiments, the first and second robot drive assemblies may be operated such that the force generated by the first drive assembly to cause translation of the assembly along a pipeline in one direction is opposed by a force generated by the second drive assembly to cause translation of the assembly along the pipeline in the opposite direction. If the forces are substantially equal the apparatus may be configured to have no net translation along the pipeline, but remain substantially stationary with respect to longitudinal motion. It is to be understood that the first and second drive assemblies may be arranged to be driven towards one another, or away from one another, in order that no net translation occurs along the pipeline.

It is to be understood that, if any forces tending to cause rotation of the first body of each assembly about the longitudinal axis are not balanced in opposite directions, a net rotation of the first bodies of the assemblies may occur, with substantially no net translation. This feature may be useful in causing controlled rotation of the robot when required, since one or more modules of the robot to which the first body of the assemblies are coupled may be caused to rotate with the first bodies.

Optionally, the at least one drive assembly is coupled to at least one robot module and configured to cause translation of the drive assembly and module along a pipeline, the drive assembly being coupled to the at least one module by means of a flexible joint portion allowing pivoting of the module with respect to the drive portion about an axis substantially normal to a longitudinal axis of the assembly.

Optionally, the at least one drive assembly is coupled to the at least one module by means of a flexible joint portion allowing pivoting of the module with respect to the drive portion

about each of a pair of orthogonal axes substantially normal to a longitudinal axis of the assembly.

The flexible joint portion may be configured to allow independent pivoting of the module about each of the pair of orthogonal axes.

Optionally, the flexible joint portion is configured to prevent axial rotation of the module about a longitudinal axis of the assembly relative to the second body portion of the assembly.

This feature has the advantage that axial rotation of the first body of the at least one assembly with respect to a pipeline may be employed to cause axial rotation of the module. This may be useful in positioning the module at a required angular orientation within the pipeline, for example in order correctly to position a tool or sensor carried by the module such as a drill tool, a tool for installing a fitting, a camera or any other suitable tool or sensor.

In one aspect of the invention for which protection is sought there is provided a method of moving a robot along a substantially cylindrical pipeline within the pipeline, the method comprising providing a pipeline robot according to another aspect, and actuating the drive motor of at least one drive assembly of the robot to cause translation and/or rotation of a least a portion of the robot within the pipeline.

Within the scope of this application it is envisaged that the various aspects, embodiments, examples and alternatives, and in particular the individual features thereof, set out in the preceding paragraphs, in the claims and/or in the following description and drawings, may be taken independently or in any combination. For example features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

For the avoidance of doubt, it is to be understood that features described with respect to one aspect of the invention may be included within any other aspect of the invention, alone or in appropriate combination with one or more other features.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying figures in which:

FIGURE 1 is a cross-sectional view of a typical operating environment of a pipeline robot according to an embodiment of the present invention;

FIGURE 2 is a 3D view of a robot drive assembly according to an embodiment of the present invention;

FIGURE 3 is a side view of the robot drive assembly of FIG. 2 with the support arts 111RA in (a) a retracted and (b) an extended condition, and (c) a 3D view of a thrust bearing for use in embodiments of the invention;

FIGURE 4 is a 3D cutaway illustration of the manner in which drive rollers of the assembly of FIG. 2 are driven; and

FIGURE 5 is an enlarged 3D view of the assembly of FIG. 2 showing the clutch assembly in (a) a locked condition and (b) an unlocked condition.

DETAILED DESCRIPTION

FIG. 1 shows a typical operational environment of a pipeline robot 100 according to an embodiment of the present invention. It can be seen from FIG. 2 that, in the scenario illustrated, the robot 100 has been introduced into a newly installed main pipeline 101 that is located within pre-existing main pipeline 101E, via an underground inspection well 101A. It is to be understood that the free end 101F of the main pipeline 101 that is exposed to the well 101A may be coupled to the free end 101F2 of a second length of newly installed main pipeline 101 that also terminates in the well 101A once service connection pipelines have been connected to the main pipeline 101.

The robot 100 has a drive assembly 110 according to an embodiment of the invention and a module 150 coupled to the assembly 110 so that the module 150 can be pulled and pushed along the pipeline 101 by the drive assembly 110.

FIG. 2 is a 3D view of the drive assembly 110. The drive assembly 110 has a first body portion or frame 110B and a second body portion or frame 111B. The first body portion 110B runs substantially the entire length of the assembly and includes connector portions

130 at opposite longitudinal ends of the body portion 110B for coupling the assembly 110 to another assembly 110 or module 150.

The second body portion 111B is disposed between the opposite ends of the first body portion 110B and is substantially coaxial therewith. The second body portion 111B carries six roller support arms 111RA each of which carries a drive roller 111R at a first end thereof. A second end opposite the first is freely hingedly coupled to the second body portion 111B. The six roller support arms 111RA are disposed about a circumference of the second body portion 111B at substantially equal angular spacings of 60 degrees. The support arms 111RA may be swung between retracted and extended or deployed positions, in which the drive rollers 111R make contact with, and are urged against, an inside wall of a pipeline 101. The assembly 110 is shown with the support arms 111RA in the retracted positions in FIG. 3(a) and in the extended positions in FIG. 3(b). The support arms 111RA may be swung into the extended positions by means of respective slider cam elements 111RAC (see also FIG. 5). The slider cam elements 111RAC are each slidable on a pair of longitudinal disposed, substantially parallel slide rods 111SR that form part of the second body portion 111B. When the slider cam elements 111RAC are urged against the support arms 111RA, the support arms 111RA swing radially outwardly.

The slider cam elements 111RAC may each be urged against the support arms 111RA by compression of a respective spring element 111SAS that is coupled to the slider cam elements 111RAC, by means of a thrust bearing 111RAB that slidably receives free ends of the spring elements 111SAS in apertures 111SAP thereof. FIG. 3(c) is an enlarged 3D view of the thrust bearing 111RAB. The thrust bearing 111RAB may be translated axially against the action of the spring elements 111SAS by means of a first pair of pneumatic cylinder actuators 110PC1 that are fixedly attached to a portion of the first body portion 110B. The cylinder actuators 110PC1 each have a respective actuator shaft member 110PCA that abuts an end surface 111RABS of the thrust bearing 111RAB that is oriented normal to a longitudinal axis L of the assembly, the thrust bearing 111RAB being located substantially coaxial of the longitudinal axis L.

The actuators 110PC1 are configured to translate the respective actuator shaft member 110PCA in an axial direction to push against the thrust bearing 111RAB and cause it to move towards the slider cam elements 111RAC. This causes compression of the spring elements 111SAS and the application of pressure to the slider cam elements 111RAC. It is to be understood that, provided the spring elements 111SAS are not fully compressed when

the support arms 110RA are extended, the support arms 111RA may swing radially inwardly towards the second body portion 111B in response to variations in diameter or cross-sectional shape of the pipeline 101 through which the assembly 110 is moved, or during negotiation of bends or changes in gradient of the pipeline 101.

FIG. 4 is a schematic 3D cutaway view showing the manner in which the assembly 110 effects rotation of drive rollers 111R of the support arms 111RA. As noted above the roller support arms 111RA are hingedly coupled to the second body portion 111B and each carry a drive roller 111R at a free end thereof distal the second body portion 111B. Each drive roller 111R is coupled to a series of three intermediate gear elements 111RI disposed axially along a length of each support art 111RA that are in turn driven by a worm screw member 112W. The worm screw member 112W is in the form of a hollow annular member coaxial of the assembly 110 and mounted for rotation about the longitudinal axis of the assembly 110. The worm screw member 112W has an external worm screw thread 112WE therearound that is configured to engage and rotationally drive the series of three intermediate gear elements 111RI of each roller support art 111RA and, in turn, the drive roller 111R provided at the free end of each arm 111RA.

The worm screw member 112W has an internal screw thread 112WI around an inner circumferential surface at one end thereof that is configured to be rotationally driven by a pinion gear 110M1P that is driven by a first drive motor 110M1. The first drive motor 110M1 is attached to the first body portion 110B. In the present embodiment a pair of first drive motors 110M1 are provided at diametrically opposite positions, each configured to drive the worm screw member 112W by means of a respective pinion gear 110M1P.

It is to be understood that the use of a worm screw member 112W has the advantage that multiple drive rollers 111R located about a circumference of the assembly 110 may be conveniently driven, in the present embodiment by a single worm screw member 112W. Furthermore, the worm screw member 112W may be conveniently driven by one or more electric motors or other drives located away from a central, axial region of the assembly 110. This has the advantage that a relatively compact drive assembly may be provided that occupies a relatively small volume, freeing up volume capacity for the packaging of other components of the robot. It is to be understood that locating the means for driving the drive rollers 111R such as the worm screw member 112W and first drive motors 110M1 away from a central, axial region of the assembly 110 allows for the routing of electrical power

and/or data cables, and/or the provision of tubing such as pneumatic supply tubing, in and along the axial region of the assembly 110 if required.

It is to be understood that, in use, the first drive motors 110M1 are configured to rotationally drive the worm screw member 112W which in turns causes rotation of the drive roller 111R located at the free end of each of the roller arms 111RA.

The assembly 110 is operable to allow or to prevent relative rotation of the first and second body portions 110B, 111B by means of a clutch assembly. The clutch assembly includes a toothed clutch gear 110BG in the form of an external gear wheel that is fixedly coupled to the first body portion 110B and configured for rotation therewith about the longitudinal axis L of the assembly 110. The clutch gear 110BG is configured to engage a corresponding internal clutch gear 111BG of the second body portion 111B, fixedly coupled to the second body portion 111B, when the clutch gear 110BG of the first body portion 110B is slid axially towards the clutch gear 111BG of the second body portion 111B. The clutch gear 110BG of the first body portion 110B may be slid axially by means of a clutch thrust plate 110CP that is fixedly coupled to the clutch gear 110BG of the first body portion 110B. The thrust plate 110CP is configured to be moved axially by means of a second pair of pneumatic cylinders 110PC2. The pneumatic cylinders 110PC2, thrust plate 110CP and clutch gear 110BG of the first body portion 110B are located on a longitudinally opposite side of the second body portion 111B to the first drive motors 110M1, and in quadrature with the first pair of pneumatic cylinders 110PC1.

It is to be understood that, in some embodiments, either or both pairs of pneumatic cylinders 110PC1, 110PC2 may be replaced with electric motor drives in order to effect movement of the respective portions of the assembly 110 actuated by the cylinders 110PC1, 110PC2.

In use, the clutch gear 110BG of the first body portion 110B is slid axially towards the clutch gear 111BG of the second body portion 111B in order to engage or 'lock' the clutch assembly, and prevent relative rotation between the first and second body portions 110B, 111B. In this locked configuration, driving of the first drive motors 110M1 causes the worm screw member 112W to rotate relative to both the first and second body portions 110B, 111B, causing rotation of the drive rollers 111R. This in turn causes a translational force to be applied to the assembly 110 to induce translation of the assembly 110 along a pipeline 101.

If the clutch gear 110BG of the first body portion 110B is slid axially away from the clutch gear 111BG of the second body portion 111B in order to disengage or 'unlock' the clutch, the first and second body portions 110B, 111B are now permitted to rotate relative to one another. It is to be understood that, if in this condition the first drive motors 110M1 drive the worm screw member 112W but the drive rollers 111R are held stationary, rotation of the first body portion 110B relative to the second body portion 111B may occur. It is to be understood that the first drive rollers 111R may be maintained stationary if translational movement of the assembly 110 along a pipeline is opposed such that the assembly 110 remains substantially at the same longitudinal position, assuming the drive rollers 111R do not experience slip with respect to the internal surface of the pipeline 101. In this condition, the second body portion 111B may remain substantially stationary, experiencing neither translation nor rotation, whilst the first body portion 110B experiences rotation relative to the second 111B.

In an embodiment, a pair of drive assemblies 110 may be coupled together, optionally with one or more modules 150 intermediate the assemblies 110. It is to be understood that rotation of the first body portions 110B thereof, and in turn the modules 150, may be effected by disconnecting the clutch assemblies of the drive assemblies 110 and driving the worm screws in such a manner that the drive rollers 111R attempt to move the respective assemblies 110 in opposite directions. Provided the drive rollers 111R experience little or no slip with the pipeline sidewall, the first body portions will begin to rotate relative to the second body portions, which may remain at a substantially fixed axial position with respect to a longitudinal axis of the pipeline, and rotationally fixed position.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other moieties, additives, components, integers or steps.

Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be

understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

5

CLAIMS:

1. A robot drive assembly for moving a robot along a substantially cylindrical pipeline within the pipeline, the assembly comprising:

a first body having a first axis arranged to be oriented, in use, substantially parallel to or coincident with a longitudinal axis of a pipeline;

a motor drive coupled to the first body; and

a worm screw member coupled to the first body, the worm screw member carrying an external helical thread about a screw axis thereof, the motor drive being arranged to cause rotation of the worm screw member about the screw axis relative to the first body;

at least one drive wheel member configured to engage an internal wall of the pipeline, the at least one drive wheel member being arranged to be rotatably driven by the helical thread of the worm screw member to cause translation of the assembly within a pipeline.

2. An assembly according to claim 1 wherein the screw axis of the worm screw member is substantially parallel to or coincident with the first axis of the first body.

3. An assembly according to claim 2 comprising a plurality of drive wheel members provided at circumferentially spaced locations around the worm screw member, the drive wheel members being configured to engage an internal wall of the pipeline, the assembly being configured to allow the drive wheel members to be driven by the helical thread to cause translation of the assembly within a pipeline.

4. An assembly according to any preceding claim wherein the at least one drive wheel member is a toothed drive wheel member.

5. An assembly according to any preceding claim wherein the at least one drive wheel member is arranged to be driven by the helical thread via one or more intermediate wheel members.

6. An assembly according to any preceding claim wherein the worm screw member is provided with an internal annular gear portion arranged to be driven by a pinion, the pinion being arranged to be driven by the motor drive to cause rotation of the worm screw member about the screw axis.

7. An assembly according to any preceding claim wherein the at least one drive wheel member is coupled to a second body, the assembly being operable in a first configuration in which the first and second bodies are locked in a substantially fixed orientation with respect to one another and a second configuration in which the second body is rotatable with respect to the first body about the first axis.

8. An assembly according to claim 7 comprising a clutch device configured releasably to couple the first and second bodies together to prevent relative rotation.

9. An assembly according to claim 7 or claim 8 wherein the at least one drive wheel member is movably coupled to the second body to permit movement of the at least one drive wheel member towards and away from the second body.

10. An assembly according to claim 9 wherein the at least one drive wheel member is resiliently coupled to the second body by resilient coupling means, the resilient coupling means being configured to urge the at least one drive wheel member radially away from the second body and against an inner wall of the pipeline.

11. An assembly according to any one of claims 7 to 10 comprising actuator means configured to move the at least one drive wheel member towards and away from the second body between a retracted position and a deployed position, the retracted position being located radially inwardly of the deployed position.

12. An assembly according to any one of claims 7 to 11 comprising a plurality of drive wheel members provided at angularly spaced locations about the longitudinal axis of the second body.

13. A pipeline robot comprising at least one drive assembly according to any preceding claim.

14. A pipeline robot comprising first and second robot drive assemblies according to any one of claims 1 to 12.

15. A robot according to claim 14 wherein the first and second robot drive assemblies are oriented in a respective opposite manner with respect to a longitudinal axis of the robot.

16. A pipeline robot according to any one of claims 13 to 15 wherein the at least one drive assembly is coupled to at least one robot module and configured to cause translation of the drive assembly and module along a pipeline, the drive assembly being coupled to the at least one module by means of a flexible joint portion allowing pivoting of the module with respect to the drive portion about an axis substantially normal to a longitudinal axis of the assembly.

17. A pipeline robot according to claim 16 wherein the at least one drive assembly is coupled to the at least one module by means of a flexible joint portion allowing pivoting of the module with respect to the drive portion about each of a pair of orthogonal axes substantially normal to a longitudinal axis of the assembly.

18. A pipeline robot according to claim 16 or claim 17 wherein the flexible joint portion is configured to prevent axial rotation of the module about a longitudinal axis of the assembly relative to the second body portion of the assembly.

19. A method of moving a robot along a substantially cylindrical pipeline within the pipeline, the method comprising providing a pipeline robot according to any one of claims 13 to 18 and actuating the drive motor of at least one drive assembly of the robot to cause translation and/or rotation of a least a portion of the robot within the pipeline.

20. An assembly, apparatus, pipeline robot or method substantially as hereinbefore described with reference to the accompanying drawings.

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Claims searched:	1-20	**Date of search:**	26 March 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-3, 5, 13, 19	CN203585710 U (ZHANGJIAGANG) See English language abstract and figures
X	1-3, 5, 13, 19	CN102425709 A (CHINA PETROLEUM) See English lang
X	1, 2, 13, 14, 16-19	DE19529782 A1 (BABCOCK MONTAGEGERAETETECHNIK) See figures

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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F16L

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
F16L	0055/32	01/01/2006