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(54) Title: DEVICE AND METHOD FOR DEFORMING A CONDUIT

(57) Abstract: An aspect relates to deformation of an underground conduit. The cross- sectional shape of the conduit is deformed by enlarging a first cross- sectional dimension of the conduit. Another deformation may be established, at least partially undoing the first deformation and optionally increased a second cross-sectional dimension of the conduit. Yet a further deformation may be established, decreasing the dimension enlarged by previous deformations. Subsequently, the conduit may be removed from the ground. For deformation, a tool is used. The tool is arranged by exercising forces to the inner surface of the conduit, resulting in the increased dimension. The tool may comprise an elongated body and deformation members protruding from the body. The width of the deformation member is larger than the initial diameter of the conduit. At the end of the tool, viewed from the transportation direction of the tool, a further deformation member may be provided for reducing the dimensions.

Title: Device and method for deforming a conduit

TECHNICAL FIELD

The various aspects apply to the field of removal of conduits from a medium and removal of underground pipes in particular.

BACKGROUND

With changes in substances used in industrial processes and further consumption of substances, systems for transportation of the substances change. One of such substances is natural gas. Changes in supply and demand and changes in locations of supply and demand in particular results in changes in distribution infrastructure. Certain pipes are not used anymore. Alternatively, pipes need to be replaced from a maintenance perspective. As the pipes are made out of high-quality steel or alloys or other materials, reclaiming the materials comprised by those pipes may be advantageous.

Removing pipes from the ground may be done by digging ditches and lifting the pipe. During life time of the pipe line infrastructure, buildings , trees and others are placed on top of the pipe line buried in the soil. And or Digging is not preferred because of agricultural, or environmental demands which don't allow to dig

Alternatively, pits are dug along the track of the piping at regular intervals and pipes are pulled from the ground. As frictional forces between the ground and the pipes are high, the intervals between the pits should be short.

SUMMARY

It is preferred to be able to place the pits further away than possible using conventional methods for removing underground piping.

A first aspect provides a device for establishing a non-destructive deformation of a conduit having a cross-section having a cross-section dimension. The device comprises an elongated body having a body centre axis, a leading end and a trailing end, the body being arranged to be transported through the conduit with the leading end leading. The device further comprises a first deformation module provided at a first position of the body, the first deformation module comprising at least two protrusions defining a first deformation circle having a diameter larger than the cross-section dimension and a centre coinciding with the centre axis. And the device comprises a second deformation module provided between the first deformation module and the trailing end, the second deformation module comprising at least one deformation element extending outwardly from the body perpendicular to the centre axis, the deformation element defining a second deformation circle having a circle centre that substantially coincides with the centre axis and having a cross-section smaller than the first deformation circle.

By pulling the device through the conduit, like a pipe, and applying the specified forces, the conduit is deformed. In particular, the shape of the cross-section is deformed. More in particular, the cross-section of the conduit is enlarged in one direction by enlarging the cross-section dimension. With the conduit having a circularly shaped cross-section, the cross-section dimension is the diameter of the conduit. With a rectangular or square cross-section, the cross-section dimension may be a diagonal of the rectangle. Alternatively, the cross-section dimension may be substantially equal to the length of a side of the rectangle. More in general, the cross-section dimension may be the shortest possible length of a straight line through the centre of the conduit, from wall to wall of the conduit.

With for example only two - opposite - forces applied to a, for example, circular, conduit, the conduit will have an elliptical cross-section. This deformation may be elastic, plastic or a combination thereof. In case of

an elastic deformation, the pipe resumes its shape prior to the deformation once applied forces are removed. In case of a plastic deformation, the pipe maintains its deformed shape after removal of forces that caused the deformation.

By applying a subsequent deformation by means of the second deformation module, the first deformation is at least partially undone. This may result for example in reinstating the initial circular cross-section and in any case in reduction of the cross-section enlarged by means of the first deformation. But with reduction of that cross-section, the medium does not necessarily flow back at its original location: voids are left. And in those voids, there is no contact between the outer surface of the conduit and the medium. And therefore, the amount of friction between the conduit and the medium is reduced.

More importantly, due to the deformations, bonding between the medium and the outer surface of the conduit is broken for at least part of the surface and preferably most of the surface. Such bonding may be due to hydrodynamic forces, mechanical forces, chemical bonds, other, or a combination thereof. Hence, the deformation results in less contact between the outer wall of the conduit and the medium as a result of creation of voids and/or breaking of bonds between the medium and the conduit. For breaking the bond, an elastic deformation of the cross-section of the conduit may be sufficient. As a result, less force is required for removing the conduit from the medium. Or with the same amount of force, a larger segment of the conduit may be removed from the medium. The latter option is advantageous, as compared to the state of the art, less pits are required for removing a stretch of conduit with the same force.

An embodiment of the device comprises a third deformation module provided between the first deformation module and the second deformation module, the third deformation module comprising at least two protrusions defining a third deformation circle having a diameter larger than the cross-

section diameter, wherein the protrusions of the third deformation module are skewed over the centre axis relative to the protrusions of the first deformation module. This embodiment allows for creating of additional voids adjacent to the conduit, which results in a further reduction of the friction.

In another embodiment of the device, the first deformation module comprises a first deformation member and a second deformation member, the deformation members having a proximal deformation end connected to the body and a distal deformation end provided at a distance from the body, the deformation members being provided annularly and equidistantly spaced apart over the body centre axis.

In case of the first deformation module comprising two deformation members, the deformation members are spaced apart at 180 degrees, over the body centre axis. In case of three deformation members, the deformation members are spaced apart at 120 degrees and in case of five deformation members, the deformation members are spaced apart at 72 degrees over the body centre axis. This embodiment is relatively simple to manufacture and to use.

In a further embodiment, at least one of the deformation members is provided with a substantially circular rotation member that is rotatable mounted the distal deformation end of the at least one of the deformation members such that the rotation member extends beyond the distal deformation end, wherein the rotation axis of the rotation member is substantially perpendicular to the centre axis and substantially perpendicular to a line from the centre axis to the distal deformation end.

This embodiment reduces friction between the deformation members and the inner surface of the conduit.

In again another embodiment of the device, the second deformation module comprises a conically shaped deformation member having a cone axis that substantially coincides with the body centre axis, wherein the base

of the conically shaped deformation member is provided towards the trailing end of the body.

This embodiment enables brining the cross-section of the conduit back in its original shape, in particular with a conduit having initially a circularly shaped cross-section.

A second aspect provides a method of reducing friction between a conduit and a medium surrounding the conduit. The method comprises establishing a first deformation of the conduit by applying at least a first force and a second force having a component perpendicular to a centre axis of the conduit, the sum of the applied forces being substantially zero perpendicular to the centre axis. The method further comprises establishing a second deformation of the conduit, thereby at least partially undoing the first deformation.

Such method enables convenient removal of the conduit from the medium, as friction between the medium is reduced. The first deformation may be plastic, elastic or a combination thereof. In case of a substantially solely elastic first deformation, the second deformation is established by removing a force that established the first deformation. In case of a plastic deformation, the second deformation may be established by applying force to the conduit. A third aspect provides a method of removing a conduit from a medium. The method comprises the method according to the second aspect, executed by pushing or pulling a device according to the first aspect through the conduit; and removing the conduit from the medium by pulling and/or pushing the conduit relative to the medium.

BRIEF DESCRIPTION OF THE DRAWINGS

The various aspects and embodiments thereof will now be described in detail in conjunction with drawings. In the drawings,

Figure 1: a tool for applying a deformation of a conduit;

Figure 2: a medium with a conduit comprised therein;

Figure 3 A: a cross-section of a pipe in the ground;

Figure 3 B: a cross-section of a deformed pipe in the ground;

Figure 3 C: a cross-section of a further deformed pipe in the ground;

Figure 3 D: a pipe in the ground with adjacent voids;

Figure 4 A: a cross-section of a pipe in the ground;

Figure 4 B: a cross-section of a deformed pipe in the ground;

Figure 4 C: a cross-section of a further deformed pipe in the ground;

Figure 4 D: a pipe in the ground with adjacent voids;

Figure 5 A: a construction site with an underground pipe being deformed;

Figure 5 B: a construction site with a lubricant injector;

Figure 5 C: a construction site with an underground pipe being pulled out of the ground;

Figure 5 D: a construction site with segments of a pipe and optionally refilled hole;

Figure 6 A: a construction site with an underground pipe being heated;

Figure 6 B: a construction site with a coating being scraped off;

Figure 7 A: a detail of a coating scraper and a detail of a pipe with a minor unevenness; and

Figure 7 B: a detail of the coating scraper and a detail of a pipe with a major unevenness.

DETAILED DESCRIPTION

Figure 1 shows a device 100 for establishing a deformation of a conduit like a pipe. The device 100 comprises an elongated body 110. To the elongated body 110, a first deformation module 120, a second deformation

module 130 and a third deformation module 140 are connected. In extension of the elongated body 110, a connection rod 150 is provided. At the end of the connection rod 150, not connected to the elongated body 110, a device connector 152 is provided. The device connector 152 is arranged to be connected to a pulling or towing arrangement. Such pulling or towing arrangement is arranged for pulling the device 100 through a pipe.

The first deformation module 120 comprises a first wedge 122 and a second wedge 126 as deformation members, protruding from the elongated body 110. The first wedge 122 is provided opposite to the second wedge 126. This means the wedges are equidistantly and annularly spaced over the centre axis of the elongated body 110. Together with the centre axis of the elongated body 110, the outer ends of the wedges define a first virtual circle.

The first wedge 122 is provided with a first rotational deformation member 124. The first rotational deformation member 124 comprises two guiding wheels. The two guiding wheels that are rotatable mounted to the first wedge 122 via common axle. The two guiding wheels extend beyond the outer end of the first wedge and are preferably provided in steel or another metal or metal alloy. Alternatively, plastic guiding blocks comprising for example polyethylene or another organic polymer may be provided for reducing friction between the inner wall of a pipe and the first deformation module 120. The second wedge 126 is provided with a second rotational deformation member 128 in an equivalent way.

The second deformation module 130 comprises a third wedge 132 and a fourth wedge 136 as deformation members. The third wedge 132 is provided opposite to the fourth wedge 136. This means the wedges are equidistantly and annularly spaced over the centre axis of the elongated body 110. Together with the centre axis of the elongated body 110, the outer ends of the wedges of the second deformation module define a second circle. The second virtual circle preferably has a diameter substantially equal to that of the first circle.

The third wedge 132 and the fourth wedge 136 are skewed 90 degrees over the centre axis of the body 110, relative to the first wedge 122 and the second wedge 126. A skew over another angle may be envisaged as well. For example, if yet an additional deformation module comprising wedges would be provided, wedges of the deformation modules could be skewed 60 degrees relative to one another.

The third wedge 132 is provided with a third rotational deformation member 134. The third rotational deformation member 134 comprises two guiding wheels. The two guiding wheels that are rotatable mounted to the third wedge 132 via common axle. The two guiding wheels extend beyond the outer end of the third wedge. The fourth wedge 136 is provided with a fourth rotational deformation member 138 in an equivalent way.

The third deformation module 140 comprises a conical member 142 and a cylindrical member 144. The third deformation module 140 and the conical member 142 in particular extend outwardly from the elongated body 110. The conical member 142 preferably has a circular diameter smaller than the first circle defined by the outer ends of the wedges of the first deformation module 120 and the centre axis of the body 110. In further embodiments, the third deformation module 140 has a different shape. Preferably, the third deformation member 140 has a shape substantially equal to the initial shape of the cross-section of the conduit that is to be deformed.

Figure 2 shows a pipe 250 as a conduit. The pipe 250 is buried in the ground 200 as a medium. The ground 250 may comprise clay, sand, other matter or a combination thereof, either dry or containing water. The ground 250 is compressible. The pipe 250 may comprise steel, predominantly comprising iron and optionally further metals and other materials. The ground 200 exerts a slightly compressive force on the pipe 250. This results in a considerable frictional force between the ground 200

and the pipe 250. This makes it very difficult or even impossible to pull the pipe 250 out of the ground 200.

The device 100 is arranged for applying deformations to the pipe 250. To this purpose, the device 100 is pulled through the pipe 250. For enabling deformation of the pipe 250, the width of the first deformation module 120 and the second deformation module 130 is between 1 and pi/2 times the diameter of the pipe 250, preferably between 1,2 and 1,5. In a particularly preferred embodiment, the width of the first deformation module 120 and the second deformation module 130 is between 1,25 and 1,3 times the diameter of the pipe.

More in general, the width of the first deformation module should be more than the length of the shortest line from two points on the inner wall of the conduit to be deformed, which line is to cross a centre of the cross-section of the conduit. This condition holds also for conduits having a cross-section having a non-circular shape.

Figure 3 depicts a process of deforming the pipe 250 by means of the deformation tool 100. Referring to Figure 1 and Figure 2, the deformation tool 100 is pulled or pushed through the pipe 250. The connection rod 150 is at a leading end of the tool and the third deformation module 140 is at a trailing end.

Figure 3 A shows a cross-section of the pipe 250 in the ground 200. Figure 3 B shows a cross-section of the pipe 250 in the ground 200, with the deformation tool 100 inside. The cross-section shown by Figure 3 B is taken at a location of the first deformation module 120. The centre axis of the deformation tool 100 preferably coincides with the centre axis of the pipe 250. The rotational deformation members are not shown, but may yet be present when putting this example in practice.

The first wedge 122 exerts a first force on the pipe 250 having a component perpendicular to the central axis of the body 110 and the second wedge 126 exert a second force on the pipe 250 that is perpendicular to the

central axis of the body 110 as well. By virtue of the symmetry of the first deformation module 120, the sum of the applied forces, perpendicular to the centre axis of the pipe 250, is substantially zero at the centre axis. This means that the deformation tool 100 may be kept at a stable location, with the centre axis of the pipe 250 at substantially the same position at the centre axis of the deformation tool 100. As the deformation tool 100 is pushed or pulled through the pipe 250, forces exerted on the pipe 250 by the first deformation module will also have components parallel to the centre axis of the pipe 250.

The exerted forces result in a preferably non-destructive deformation of the cross-section of the pipe 250, as depicted by Figure 3 B. After the first deformation shown by Figure 3 B, the cross-section of the pipe 250 has a substantially elliptical shape.

Preferably, the width of the first deformation module 120 and the second deformation module 130 is chosen such that the cross-section of the pipe 250 is deformed only and not stretched. This means that the circumference of the pipe 250 after a deformation is substantially equal to the initial circumference of the pipe 250. A reason for this preference is that stretching of the diameter of the pipe 250 may result in weak spots in the pipe 250. This, in turn, may result in cracks and/or ruptures in the pipe, which may cause leakage of toxic contaminants in the ground 200. And this should be prevented.

Figure 3 C shows a cross-section of the pipe 250 in the ground 200, with the deformation tool 100 inside. The cross-section shown by Figure 3 C is taken at a location of the second deformation module 130. Due to forces exerted by the third wedge 132 and the fourth wedge 136 and due to the second deformation module 130 being skewed 90 degrees to the first deformation module 120, the cross-section of the pipe 250 is deformed again. As with the first deformation module 120, the sum of the applied forces applied by the second deformation module 130, perpendicular to the centre

axis of the pipe 250, is substantially zero at the centre axis. This is due to the symmetrical nature of the second deformation module 130.

This second deformation results in an elliptical shape of the cross-section of the pipe 250 as well. The ellipse resulting out of the second deformation is rotated by 90 degrees over the central axis of the pipe 250, relative to the elliptical shape resulting out of the first deformation. Furthermore, as shown by Figure 3 C, voids remain at the locations of the lobes of the ellipse that resulted out of the first deformation. Above the pipe 250, a first void 352 is located and below the pipe 250, a second void 354 is located.

After the second deformation, a third deformation is applied by means of the third deformation module 140. This is depicted by Figure 3 D. The conical member 142 of the third deformation module 140 preferably has a diameter substantially equal to or slightly smaller than the diameter of the pipe 250. As a result, the cross-section of the pipe 250 is brought back to its initial shape - or at least nearly brought back to that shape.

With the shape of the cross-section of the pipe 250 back or almost back to its initial shape, additional voids remain at locations where lobes of the second ellipse were located. In particular, a third void 362 and a fourth void 364 remain. In other embodiments, voids are provided all along or along the largest part of the outer wall of the pipe 250 and no specific indistinguishable voids exist around the circumference the pipe.

With voids surrounding the pipe 250 or in any case most of the pipe's outer perimeter, the amount of ground 200 in direct contact with the pipe 250 is significantly less than in the situation depicted by figure 3 A. Furthermore, due to the deformations, bonds between the pipe 250 and the ground 200 are broken. Such bonds are usually mechanical bonds due to fluid dynamics in the ground 200 and other forces. However, chemical bonds may be an issue as well and may be broken in the same way. This means that far less frictional forces - shear forces - exist between the outer surface

of the pipe 250 and the ground 200. Which means that less force is required for pulling the pipe 250 out of the ground 200.

Figure 4 shows another embodiment, using a different tool. Figure 4 A shows an initial situation, with the pipe 250 provided in the ground 200. Figure 4 B shows a cross-section at a location of a first deformation module. The first deformation module comprises a first protrusion 422, a second protrusion 424 and a third protrusion 426. The three protrusions of the first deformation module are annularly equidistantly spaced apart, at 120 degrees over a centre axis of an elongated body 410 of the tool 400. Pulling of the tool 400 through the pipe 250 results in the cross-section of the pipe 250 being deformed towards a substantially first triangular shape. It will be apparent that in a practical situation, the corners of the triangular shape will not be as sharp as depicted by Figure 4 B. Also in this embodiment, the sum of vertical components of forces exerted by the protrusions is zero at the centre axis of the elongated body 410.

Figure 4 C shows a cross-section at a location of a second deformation module comprised by the tool 400. Figure 4 C shows the second deformation module comprising a fourth protrusion 432, a fifth protrusion 434 and a sixth protrusion 436. Compared to the protrusions of the first deformation module, the protrusions are skewed 60 degrees. Alternatively stated, the second deformation module is a mirrored version of the first deformation module. The deformation established by the second deformation module results in second triangular shape of the cross-section of the pipe 250. The second deformation results in voids where the points of the first triangular shape were located; a first void 452, a second void 454 and a third void 456.

After passage of a third deformation module 440 having a circular shape defining a circle around the central axis of the body 414 as depicted by Figure 4 D, the cross-section of the pipe 250 is substantially back to its initial shape as depicted by Figure 4 A. Figure 4 D also shows additional

voids; a fourth void 462, a fifth void 464 and a sixth void 466. With the voids, there is less contact area between the ground 200 and the outer surface of the pipe 250. This results in a reduction of frictional forces between the pipe 250 and the ground 200, which mean less force is required for pulling the pipe 250 out of the ground 200. In other embodiments, voids are provided all along or along the largest part of the outer wall of the pipe 250 and no specific indistinguishable voids exist around the circumference the pipe.

So far, the device according to the first aspect has been discussed having a deformation module comprising two, three or five protrusions. A device having a deformation module comprising four or more than five protrusions may be envisaged as well. The larger the cross-sectional area of the pipe 250, the more protrusions are preferred. In particular for pipes having a very large diameter, up to 1,22 metres (48 inch), a device with a first deformation module having ten or more protrusions may be employed.

In the embodiments discussed so far, pulling the deformation tool 100 at a more or less constant speed through the pipe 250 is discussed. This results in forces exerted by the protrusions or wedges of the deformation modules in directions having components parallel to the centre axis of the deformation tool 100 and perpendicular to the centre axis of the deformation tool 100. Alternatively, a further tool is provided, comprising retractable protrusions. This allows the further tool to be pulled through the pipe 250 without significant force required, with retracted protrusions. At a location in the pipe 250 where deformation is required, the protrusions are expelled from the further tool. This may be done by means of hydraulic, mechanical or pneumatic force. After deformation, the protrusions are retracted and the further tool is moved to the next position where deformation is required.

Figure 5 schematically shows application of the deformation tool 100 in a construction site 500 for removing the pipe 250 from the ground 200. Figure 5 A shows the pipe 250 in the ground 200. In the ground 200, a

first construction pit 510 is provided. In the first construction pit 510, a pulling machine 540 is set up for pulling the deformation tool 100 through the pipe 250. The deformation tool 100 is loaded in the pipe 250 via a second construction pit 520.

Figure 5 B shows a lubricant injector 542 being provided in the second construction pit 520. The lubricant injector 542 is provided with two lubricant pipes 544 for injecting a lubricant in voids between the pipe 250 and the ground 200. The lubricant preferably comprises a liquid and water in particular. A bentonite emulsion is particularly preferred, though another suspension of water and small mineral particles may be used as well. With the optional action of providing a lubricant in the voids between the ground 200 and the pipe, less force may be required for pulling the pipe 250 out of the ground 200.

Figure 5 C shows the pipe 250 being pulled out of the ground 200. The pipe 250 is pulled out of the ground 200 by means of a pulling device (not shown). This may be a mechanically, hydraulically or pneumatically driven device, or a combination thereof. As the dimensions of the first construction pit 510 are preferably smaller than the length of the pipe 250, the pipe 250 is cut in segments. Figure 5 C shows a first segment 252 and a second segment 254.

After the pipe 250 has been removed in full or after the pipe 250 is at least partially withdrawn from the ground 200, a void left by the pipe 250 is filled with a filling material 530 as shown by Figure 5 D. The filling material may have a constitution similar to that of the ground 200. Alternatively, the filling material may have a different constitution.

In a preferred embodiment, the pipe 250 is cleaned prior to deforming and removal from the ground 200.

The tools and methods disclosed above may be employed for a wide range of pipe diameters. In practice, for example pipes for transporting gas and natural gas in particular have diameters ranging from 50.8 millimetres

(two inch) to 1219.2 millimetres (48 inch). The width of the deformation modules, as depicted by Figure 1, is preferably between 1,25 and 1,3 times the initial diameter of the conduit, as discussed above.

The distance between the various deformation modules may depend on the width of the deformation tool 100 and/or the width of the pipe 250. In a preferred embodiment, intended for a pipe having a diameter of 152,4 millimetres (6 inch), the distance between two deformation modules is preferably 540 millimetres. More generally, the ratio between the width of the deformation modules and the distance between the deformation modules is between 1/2D and 4D, wherein D is the diameter of the pipe 250. Furthermore, the ratio between the width of the deformation modules and the distance between the deformation modules may also depend on the ratio D/t, in which t is the thickness of the wall of the pipe. Preferably, the larger the diameter of the pipe is, the shorter the distance between the deformation modules.

The deformation modules have so far been discussed as comprising wedges, with optional rotating guiding wheels. In another embodiment, the deformation modules are provided as a single body. Such single body may, for example, by provided as an ellipsoid having a shape substantially identical to a desired shape of the cross-section of the pipe 250 after deformation. In yet another alternative, a deformation module comprises a pseudo-conical body. The top of that body points towards the leading end of the tool and the cross-section of the pseudo-conical body has a shape substantially identical to a desired shape of the cross-section of the pipe 250 after deformation. The lobes of the elliptical shape of such deformation module are protrusions that exercise a force on the pipe 250 that results in the deformation. Hence, protrusions comprised by deformation modules may be part of a single body or provided as separate members attached to the elongated main body 100.

Furthermore, whereas deformation by two deformation modules is preferred, followed by a deformation for restoring the initial diameter of the pipe 250, application of the method using a device with only one deformation module for deforming the initial circularly shaped cross-section may be envisaged as well. Alternatively, a device having more than two deformation modules may also be envisaged. In case the deformation provided by the first deformation module 120 is only an elastic deformation, restoration of the shape of the cross-section of the pipe 250 is not required. Within that context, it should be noted that with pipes having a very large diameter, up to 1,22 metres (48 inches), only a relatively small change of the diameter is required for breaking bonds between the outer wall of the pipe and earth or clay surrounding the pipe. Such small change may be effectuated by a small deformation of the diameter of the pipe that is that small the deformation is only an elastic deformation.

Figure 6 A shows the pipe 250 in the ground 200. Around the pipe 250, a coating 262 is provided. The coating 262 preferably comprises bitumen or a similar substance. Bitumen is a name for a group of large hydrocarbon compounds, comprising at least one of saturates, saturated hydrocarbons, naphthene aromatics, polar aromatics and asphaltenes.

While laying the pipe 250 in the ground 200, the coating 262 is stuck to the outside of the pipe 250. Over time, the coating 262 may break apart and additionally or alternatively lose adhesion with the pipe 250. When the pipe 250 is removed from the ground 200, the coating 262 may remain in the ground 200. In view of environmental safety, this is not preferred. Therefore, it is preferred to ensure the coating 262 or at least a significant part of the coat 262 is adhered or adhered again to the pipe 250.

Figure 6 A also shows a heating tool 600 that is arranged to be moved through the pipe 250 by means of the pulling machine 530 that pulls the heating tool 600 through the pipe 250. In the embodiment shown, the heating tool 600 is provided as a separate tool. In other embodiments, the

heating tool 600 is connected to the deformation tool 100. The heating tool 600 may be connected to either the leading end or the trailing end of the deformation tool 100. The heating tool 600 preferably comprises wheels and/or tracks or other guiding elements enabling movement of the heating tool 600 through the pipe 250 with relatively low friction.

The heating tool 600 is arranged for heating the pipe 250. The heating may be provided by providing the heating tool 600 with a burner arranged for oxidising a combustible. Such combustible may comprise methane, propane, butane or a similar hydrocarbon. Alternatively or additionally, electrical heating may be used by providing the heating tool 600 with an electrical heater. Such electrical heater preferably comprises a resistive element that heats up while conducting a current. Alternatively or additionally, a source of infrared radiation may be provided with the heating tool 600.

The heating tool 600 is preferably arranged to heat the pipe 250 such that the bitumen of the coating 262 at least partially melts to such level that it forms itself around the outer wall of the pipe 250 again and preferably adheres at least partially and preferably fully to the outer wall of the pipe 250. With respect to partially melting, it is noted bitumen, also known as asphalt, is a mixture of compounds that may have different melting points. If compounds with a lower melting point melt such that at least a substantial part of the bitumen is liquid, still solid compounds allow the bitumen to flow such that it flows to cover the outer wall of the pipe 250 and sticks to the outer wall of the pipe 250 to form a layer around the pipe 250.

The pipe 250 may be heated by providing thermal energy to the pipe 250, for example by means of electrical heating or providing a flame. Alternatively or additionally, other types of energy may be provided to the pipe 250 to heat up the pipe. Energy may be provided to the pipe 250 as electromagnetic or magnetic energy. This may be established by creating an

alternating magnetic field in the pipe 250, providing inductive heating of the pipe 250. It is noted inductive heating is particularly suitable if the pipe 250 comprises conductive materials. Alternatively or additionally, infra-red radiation - electromagnetic radiation in the infra-red spectrum - is radiated from the heating tool to the pipe 250.

The heating tool 600 is pulled or pushed through the pipe 250 at such speed that the pipe 250 is heated to the appropriate level to enable reflow of the bitumen. Preferably, the pipe is heated to a temperature between 80°C and 150°C and more preferably between 90°C and 120°C. In other embodiments, heating is provided in any interval having a lower boundary of 80°C, 85°C, 90°C or 95°C and an upper boundary of 100°C, 105°C, 110°C, 115°C, 120°C, 125°C, 130°C, 140°C or 150°C.

Figure 6 B shows a coating removal tool 550 provided in the second construction pit 510. The coating removal tool 550 is in this embodiment used in conjunction with a tool for pulling the pipe 250 out of the ground 200. Alternatively, the coating removal tool 550 is used on segments of the pipe 250 after they have been removed from the ground 200, at another location.

The costing scraping tool 550 comprises a first scraping knife 552 and a second scraping knife 554. The first scraping knife 552 and the second scraping knife 554 are provided around the outer wall of the pipe 250 and preferably such that the two knives close in around the circumference of the pipe 250 or at least around a substantial part thereof. In one embodiment, the two - or more - knives comprise plates in which a cut-out having a circular trajectory is provided. The radius of the circular cut-out is substantially the same as the radius of the outer wall of the pipe 250. This enables the knives to close in onto the outer wall of the pipe 250.

In this embodiment, the first scraping knife 552 is connected to a piston 558 of a hydraulic cylinder 556. The hydraulic cylinder 556 is

connected to a yoke of the coating removal tool 550. Also the second scraping knife 554 is connected to the yoke of the coating removal tool 550. The hydraulic cylinder 556 may be actively biased for applying pressure to the outer wall of the pipe 250 by the first knife 552. Alternatively to the hydraulic cylinder, other biasing means like a passive hydraulic cylinder, a pneumatic cylinder, either active or passive, a spring or another biasing suspension module may be used for enabling active and preferably biased enclosure of the pipe by means of two or more knives. In another embodiment, the second scraping knife 554 and/or further knives are also movably connected to the yoke.

With the knives biased towards the pipe 250, the preferably still warm but optionally already cooled down coating 262 around the pipe 250 is scraped off. The coating removal tool 500 preferably allows the removal of the pipe 250 and removal of the coating 262 to be executed in one run. This saves time and may remove need for a post-processing step of removal of the coating.

Figure 7 A shows a detail of the coating removal tool 550. Figure 7 A shows the first scraping knife 552. Above, a plate-shaped knife with a cut-out having a circular knife circumference was discussed. In that embodiment earlier discussed, the plate-shaped first knife 552 is preferably placed substantially perpendicular to the outer wall of the pipe 250. Figure 7 A shows the first scraping knife 552 having a different shape and being placed under an angle relative to the outer wall of the pipe 250. In the embodiment as shown by Figure 7 A, the scraping knives preferably together form a truncated cone, with each knife forming a partially circular part from the top to the bottom of the truncated cone. This allows at least most, if not all, of the outer wall of the pipe 250 to be enclosed by the knives.

Figure 7 A shows the first knife 552 connected to a detection wheel 562 that functions as a shape following module. The detection wheel 562 is provided such that if a small unevenness is detected, the first scraping knife

552 moves to compensate for the unevenness and preferably continues removing the coating 262 from the unevenness at the outer wall of the pipe 250. In the embodiment shown, this is enabled by providing a substantially rigid connection between the detection wheel 562 and the first scraping knife 552. The first scraping knife 552 and the detection wheel 562 are suspended relative to the pipe 250 to enable a movement of both in a direction having a component perpendicular to the outer wall of the pipe 250.

In another embodiment, movement of the detection wheel 562 is detected by means of a mechanical, an electrical or electronic sensor, another sensor or a combination thereof. In yet another embodiment, the detection wheel 562 also has a cutting function for cutting the coating 262. Optionally and preferably, the point at which the detection wheel 562 touches the outer wall of the pipe 250 coincides with or is just before the location at which the first scraping knife 552 touches the wall of the pipe 250. Preferably each scraping knife is provided with a detection wheel that may optionally perform a cutting function.

The detection generates signal and the signal is used, for example by a microcontroller or other processing unit to move the first scraping knife 552 to move accordingly to follow the outer shape of the pipe 250. Alternatively or additionally to the detection wheel 562, also other detectors may be used, contact and/or contactless, for example by using visible or non-visible light, in a broad spectrum or in a narrow spectrum like with a laser.

Figure 7 A shows a weld 256 as a small unevenness at the outer wall of the pipe 250. The weld 256 is small enough an unevenness to be handled by the first knife 552 for removing the coating 262. With the weld 256 approaching the detection wheel 256, the weld 256 is followed by the detection wheel 562. In this embodiment, the detection wheel 562 moves slightly upward upon encountering the weld 256, thereby lifting the first scraping knife 552 with substantially the same amount.

Figure 7 B shows the pipe 250 with a nipple 258, for example a venting nipple, as a large unevenness. The nipple 258 is too large to be properly followed by the first scraping knife 552. Furthermore, the nipple 258 may in some embodiments be that large that a pipe segment comprising the nipple 258 cannot handle the applicable pipe segment. Therefore, it is important to detect the nipple 258.

The nipple 258 may be detected as a large unevenness, sticking out from the pipe 250 with more than a pre-determined amount. This may be detected by the detection wheel 562 moving away from the pipe 250 with more than the pre-determined amount. Alternatively or additionally, a detector ring 564 is provided around the pipe 250. The detector ring 564 has an inner diameter that is substantially equal to the outer diameter of the pipe 250 plus two times the pre-determined amount as discussed above. the detector ring 564 is provided concentrically around the pipe 250.

An obstacle sticking out from the pipe 250 with less than the pre-determined amount will pass the detector ring 564 and the nipple 258 will make contact with the detector ring 564. Upon encountering a collision or, more in general, pressure or force, the detector ring 564 will activate the emergency sensor 566 for generating an emergency signal. The emergency signal indicates the pipe 250 has a protrusion that protrudes from the pipe wall with more than the pre-determined amount. The emergency signal is provides to a processing unit like a microprocessor by means of the connector 568. Upon receiving the emergency signal, the microprocessor may stop any actuator that pulls or pushes or otherwise moves the pipe 250.

Whereas application of the deformation tool 100 or similar tools has been discussed in conjunction with conduits having a circular cross-section, application to conduits having a differently shaped cross-section may be envisaged as well.

An aspect relates to deformation of an underground conduit. The cross-sectional shape of the conduit is deformed by enlarging a first cross-

sectional dimension of the conduit. Another deformation may be established, at least partially undoing the first deformation and optionally increased a second cross-sectional dimension of the conduit. Yet a further deformation may be established, decreasing the dimension enlarged by previous deformations. Subsequently, the conduit may be removed from the ground. For deformation, a tool is used. The tool is arranged by exercising forces to the inner surface of the conduit, resulting in the increased dimension. The tool may comprise an elongated body and deformation members protruding from the body. The width of the deformation member is larger than the initial diameter of the conduit. At the end of the tool, viewed from the transportation direction of the tool, a further deformation member may be provided for reducing the dimensions. The further deformation member may have a cross-section substantially identical to that of the initial cross-section of the conduit.

Expressions such as "comprise", "include", "incorporate", "contain", "is" and "have" are to be construed in a non-exclusive manner when interpreting the description and its associated claims, namely construed to allow for other items or components which are not explicitly defined also to be present. Reference to the singular is also to be construed in be a reference to the plural and vice versa. When data is being referred to as audio-visual data, it can represent audio only, video only or still pictures only or a combination thereof, unless specifically indicated otherwise in the description of the embodiments.

In the description above, it will be understood that when an element such as layer, region or substrate is referred to as being “on” or “onto” another element, the element is either directly on the other element, or intervening elements may also be present.

Furthermore, the invention may also be embodied with less components than provided in the embodiments described here, wherein one component carries out multiple functions. Just as well may the invention be

embodied using more elements than depicted in the Figures, wherein functions carried out by one component in the embodiment provided are distributed over multiple components.

A person skilled in the art will readily appreciate that various parameters disclosed in the description may be modified and that various embodiments disclosed and/or claimed may be combined without departing from the scope of the invention.

It is stipulated that the reference signs in the claims do not limit the scope of the claims, but are merely inserted to enhance the legibility of the claims.

Claims

1. Device for establishing a non-destructive deformation of a conduit having a cross-section having a cross-section dimension, the device comprising:
   - An elongated body having a body centre axis, a leading end and a trailing end, the body being arranged to be transported through the conduit with the leading end leading; and
   - A first deformation module provided at a first position of the body, the first deformation module comprising at least two protrusions defining a first deformation circle having a diameter larger than the cross-section diameter.

2. Device according to claim 1, further comprising a second deformation module provided between the first deformation module and the trailing end, the second deformation module comprising at least one deformation element extending outwardly from the body perpendicular to the centre axis, the deformation element defining a second deformation circle having a circle centre that substantially coincides with the centre axis and having a cross-section smaller than the first deformation circle.

3. Device according to claim 1 or 2, further comprising a third deformation module provided between the first deformation module and the second deformation module, the third deformation module comprising at least two protrusions defining a third deformation circle having a diameter larger than the cross-section diameter, wherein the protrusions of the third deformation module are skewed over the centre axis relative to the protrusions of the first deformation module.

4. Device according to claim 1, 2 or 3, wherein the first deformation module comprises a first deformation member and a second deformation member, the deformation members having a proximal deformation end connected to the body and a distal deformation end provided at a distance from the body, the deformation members being provided annularly and equidistantly spaced apart over the body centre axis.

5. Device according to claim 3, wherein the third deformation module comprises a third deformation member and a fourth deformation member, the deformation members having a proximal deformation end connected to the body and a distal deformation end provided at a distance from the body, the deformation members being provided annularly and equidistantly spaced apart over the body centre axis.

6. Device according to claim 4 or 5, wherein at least one of the deformation members is provided with a substantially circular rotation member that is rotatable mounted the distal deformation end of the at least one of the deformation members such that the rotation member extends beyond the distal deformation end, wherein the rotation axis of the rotation member is substantially perpendicular to the centre axis and substantially perpendicular to a line from the centre axis to the distal deformation end.

7. Device according to any of the claims 1 to 6, wherein the distance between the first deformation module and the second deformation module is approximately three times as large as the diameter of the first deformation circle.

8. Device according to any of the claims 3 or 5, wherein:
- The distance between the first deformation module and the third deformation module is approximately three times as large as the diameter of the first deformation circle; and
- The distance between the second deformation module and the third deformation module is approximately three times as large as the diameter of the first deformation circle.

9. Device according to any of the claims 1 to 6, wherein the second deformation module comprises a conically shaped deformation member having a cone axis that substantially coincides with the body centre axis, wherein the base of the conically shaped deformation member is provided towards the trailing end of the body.

10. Device according to any of the preceding claims, further comprising a heating module for heating the conduit, the heating module being connected to one of the trailing end and the leading end of the device.

11. Device according to claim 10, wherein the heating module comprises at least one of the following:
- An electrical heater module;
- A source of infra-red radiation;
- An induction module arranged to excite a current in the conduit; and
- A burner arranged for oxidisation of a combustible.

12. System for removing a conduit from a medium, the system comprising:
- a pulling engine for pulling at least a segment of the conduit from the medium;

- a first coat knife for removing a coating from an outer wall of the conduit, the first coat knife having a cutting edge having a shape substantially similar to at least a part of the conduit;
- a second coat knife for removing a coating from an outer wall of the conduit, the second coat knife having a cutting edge having a shape substantially similar to at least a part of the conduit;
- at least one biasing unit for biasing at least one of the first coat knife and the second coat knife towards the outer wall of the conduit;

Wherein the first coat knife and the second coat knife are position relative to the pulling engine such that when the segment of the conduit is pulled, the cutting edges are biased on the outer wall of the conduit.

13. System according to claim 12, further comprising a first wall detector for detecting protrusions on the outer wall of the conduit, wherein:
- the first wall detector is coupled to the first coat knife such that the first coat knife is arranged to substantially follow the contours of the protrusion upon the conduit being pulled.

14. System according to claim 13, wherein the first coat knife is mechanically coupled to the first wall detector.

15. System according to claim 13, wherein the first coat knife is electronically coupled to the first wall detector, the system further comprising a knife actuator for driving the first coat knife in response to a signal generated by the first wall detector upon detecting a protrusion.

16. System according to any of the claims 12 to 15, further comprising a third coat knife arranged to cut the coat in a direction substantially parallel to a centre line of the conduit.

17. System according to claim 16 to the extent dependent on claim 13, wherein the first wall detector is embodied as the third coat knife.

18. System according to any of the claims 12 to 17, wherein the first coat knife and the second coat knife comprise a blade that is provided perpendicularly to the outer wall of the conduit or are provided under an angle relative to the outer wall of the conduit.

19. System according to any of the claims 12 to 17, further comprising a second wall detector arranged to detect protrusions protruding from the outer wall of the conduit with more than a pre-determined length.

20. System according to claim 19, wherein the second wall detector is coupled to the pulling engine and wherein the system is arranged to stop the pulling engine upon detecting a protrusion protruding from the outer wall by more than the pre-determined length within a pre-determined distance from the first coat knife.

21. Method of reducing friction between a conduit and a medium surrounding the conduit, the method comprising:

- Establishing a first deformation of the conduit by applying at least a first force and a second force having a component perpendicular to a centre axis of the conduit, the sum of the applied forces being substantially zero perpendicular to the centre axis;
- Establishing a second deformation of the conduit, thereby at least partially undoing the first deformation.

22. Method according to claim 21, wherein the first force is substantially opposite to the second force.

23. Method according to claim 21 or 22, further comprising, prior to establishing the first deformation, applying a third deformation to the conduit by applying at least a third force and a fourth force having a component perpendicular to the centre axis of the conduit, the sum of the third force and the fourth being substantially zero perpendicular to the centre axis;

Wherein:

- The third force is annularly spaced apart from the first force and the fourth force, relative to the centre axis; and/or
- The fourth force is annularly spaced apart from the first force and the second force, relative to the centre axis.

24. Method according to claim 23, wherein the third force is substantially opposite to the fourth force.

25. Method according to claim 22 or 23, wherein the third force is substantially perpendicular to the first force and the fourth force is substantially perpendicular to the second force.

26. Method according to any of the claims 21 to 25, wherein establishing the second deformation of the conduit comprises bringing the conduit substantially back to its original shape.

27. Method according to any of the claims 21 to 26, further comprising heating of the conduit.

28. Method according to claim 27, wherein the conduit is heated to a temperature between 80°C to 150°C and more preferably between 90°C to 120°C.

29. Method of removing a conduit from a medium, the method comprising:

- The method according to any of the preceding claims 21 to 28, executed by pushing or pulling a device according to any of the claim 1 to 11 through the conduit; and
- Removing the conduit from the medium by pulling and/or pushing the conduit relative to the medium.

30. Method according to claim 29, further comprising, after executing the method according to any of the preceding claims 21 to 28, providing a lubricant between the medium and the outer wall, the lubricant preferably comprises a colloidal emulsion comprising water and mineral and more preferably comprising bentonite.

31. Method according to claim 29 or 30, wherein a coat is provided around the conduit, the method further comprising removing the coat by means of a system according to any of the claims 12 to 20.

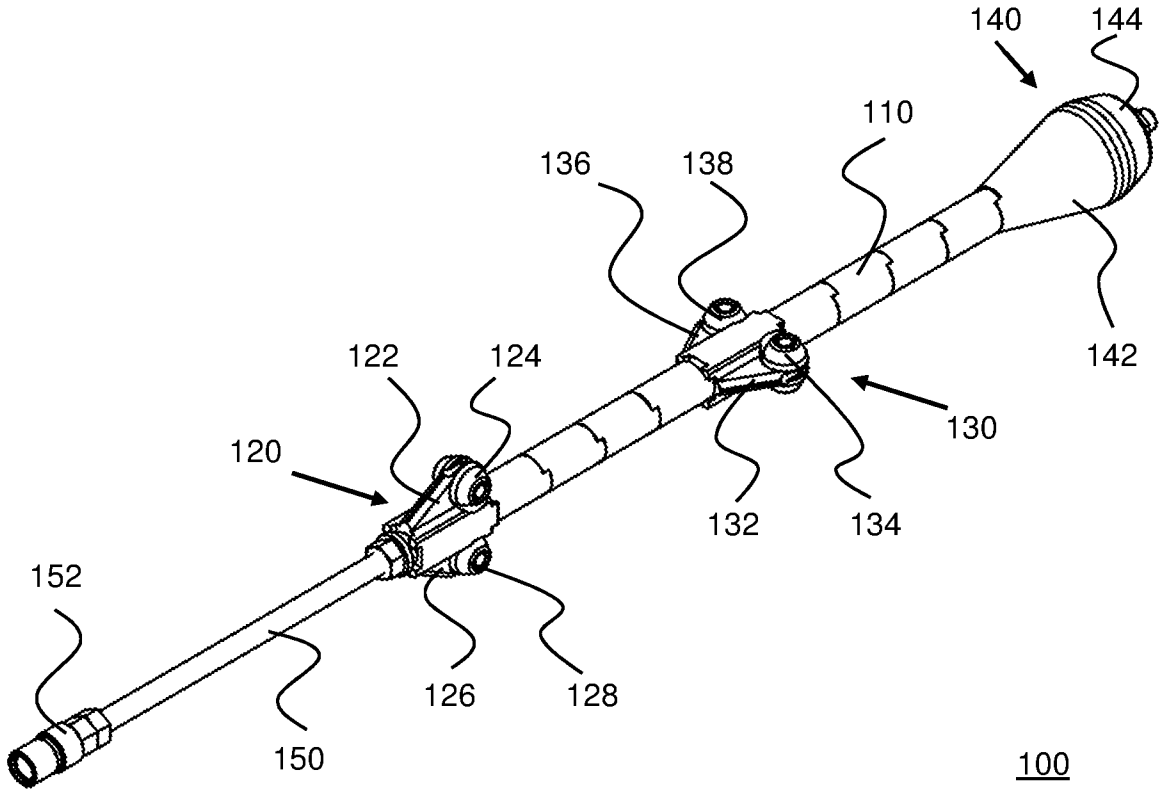
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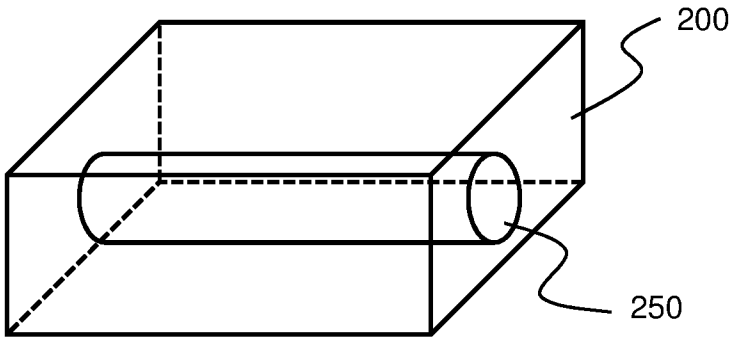
Fig. 1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250

Fig. 2

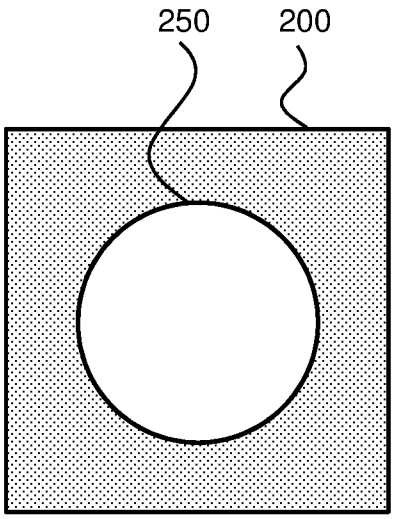

Fig. 3 A

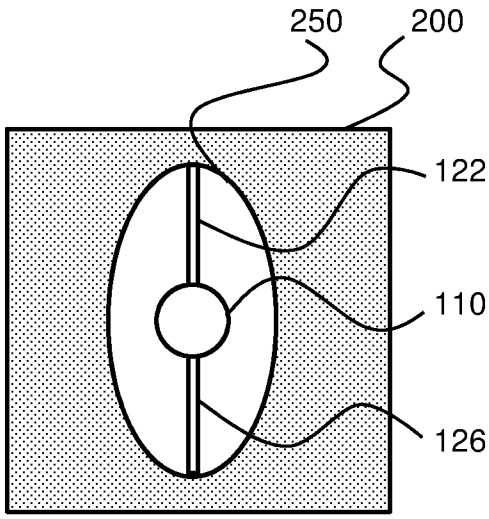

Fig. 3 B

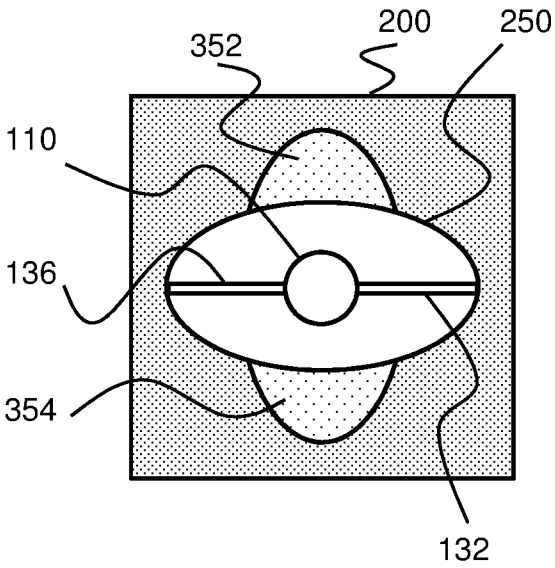

Fig. 3 C

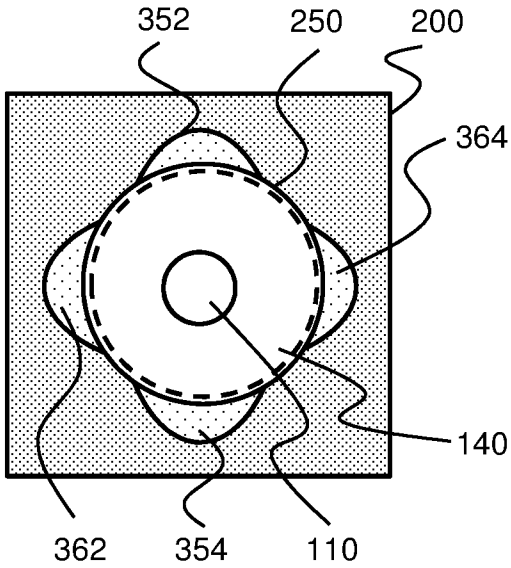

Fig. 3 D

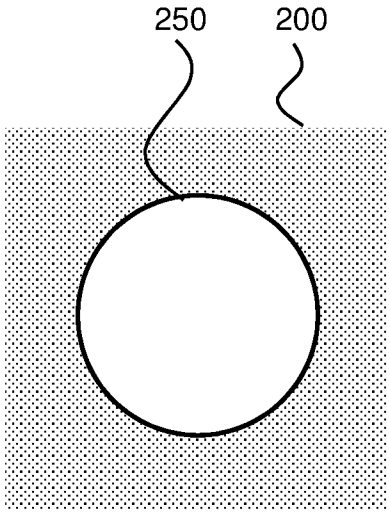

Fig. 4 A

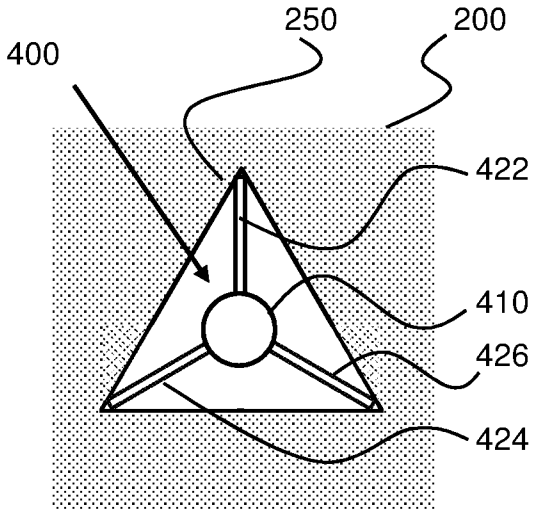

Fig. 4 B

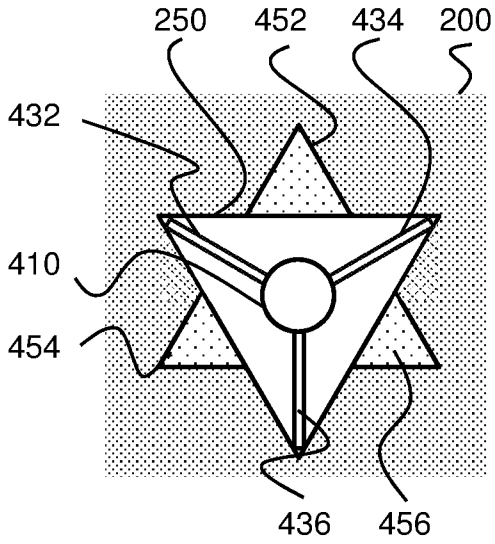

Fig. 4 C

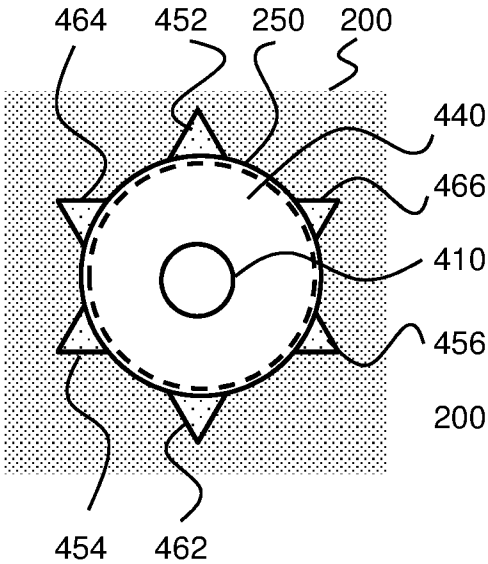

Fig. 4 D

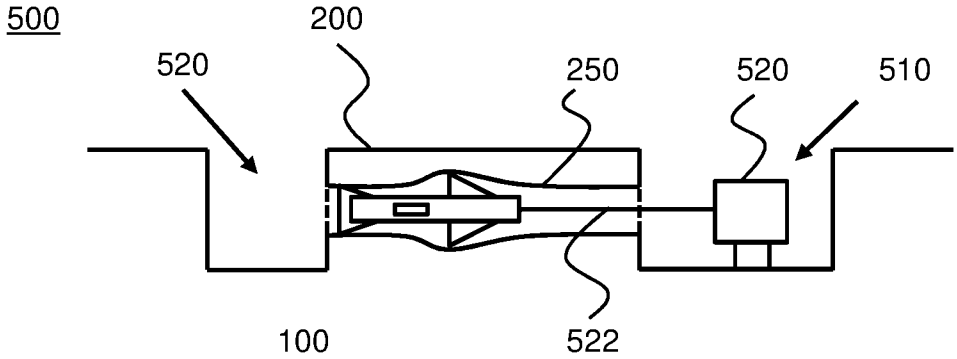

Fig. 5 A

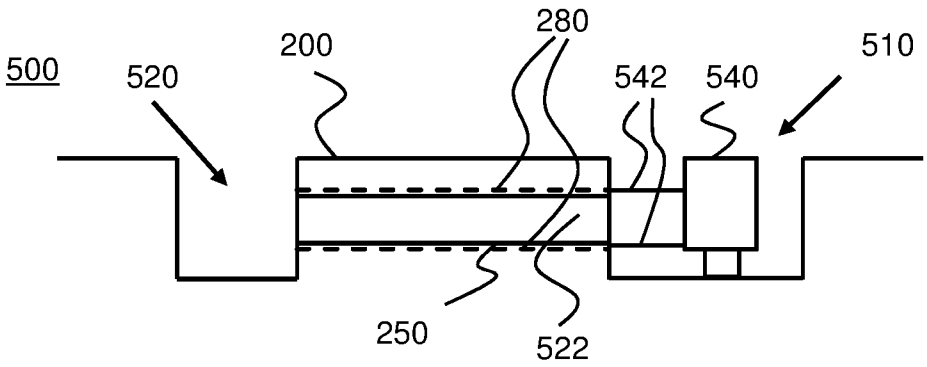

Fig. 5 B

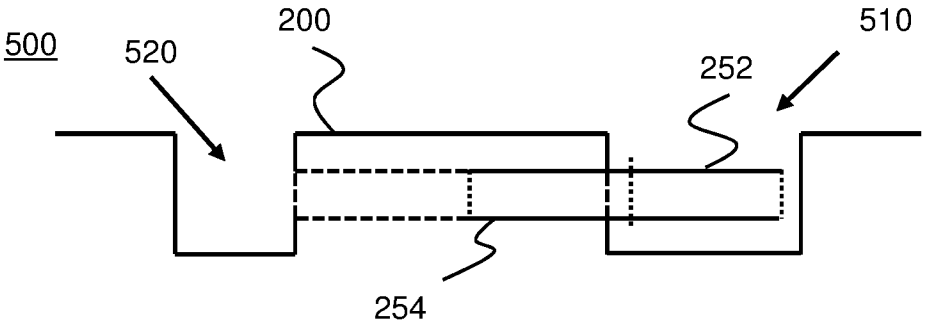

Fig. 5 C

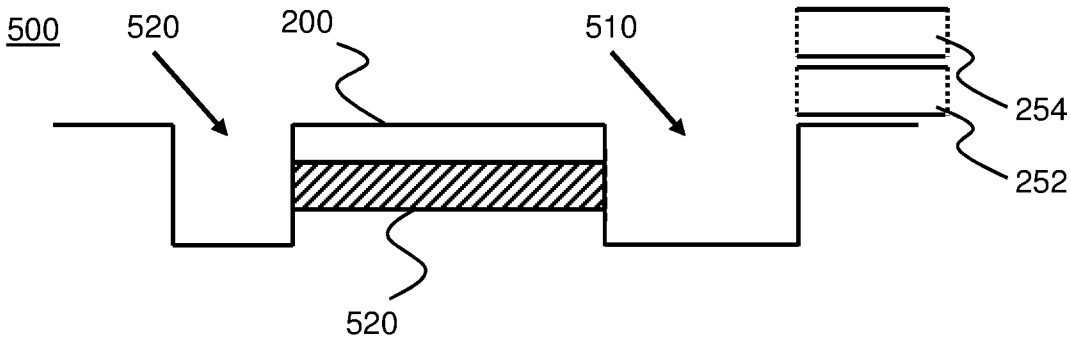

Fig. 5 D

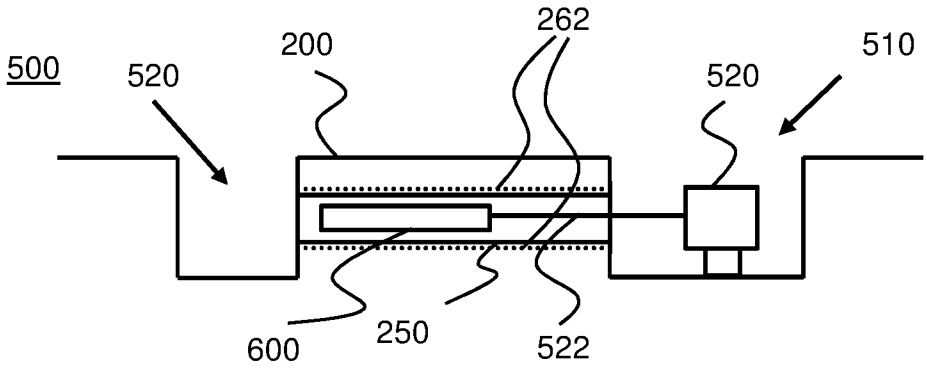

Fig. 6 A

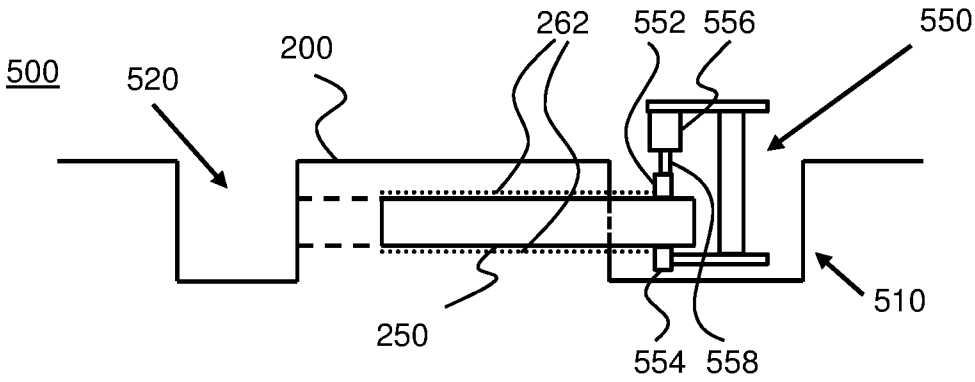

Fig. 6 B

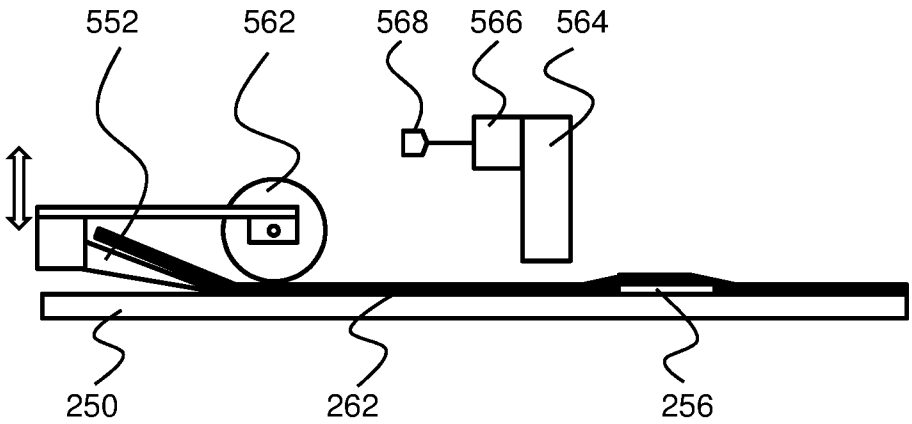

Fig. 7 A

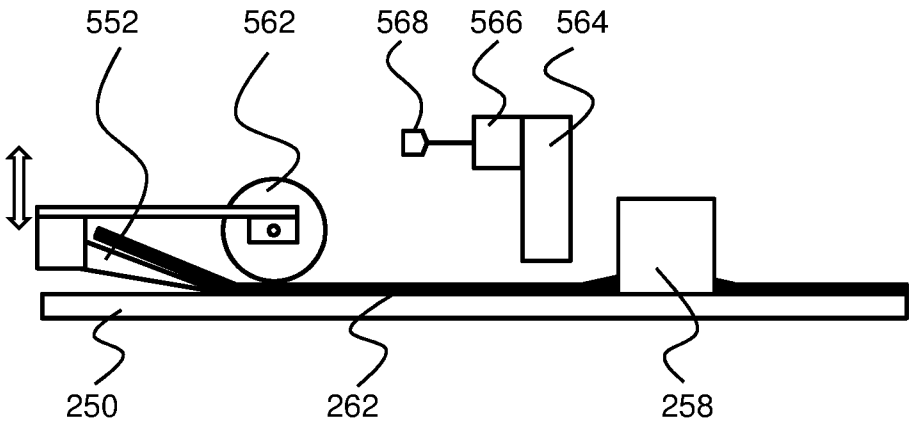

Fig. 7 B