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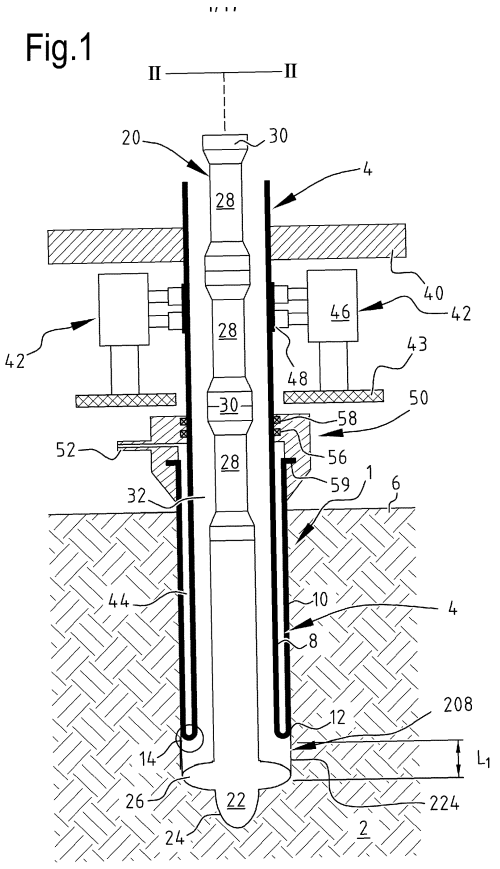
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(54) SYSTEM AND METHOD FOR EXPANDING A TUBULAR ELEMENT WITH SWELLABLE COATING

(57) The invention provides a method and a system for expanding a tubular element. The tubular element comprises a wall which is bent radially outward and in axially reverse direction defining an expanded tubular section extending around an unexpanded tubular section. An inner surface of the unexpanded section is provided with a coating for zonal isolation. The coating may comprise multiple layers. The coating comprises a swellable layer, which is able to swell when contacted by a predetermined activation fluid. The activation fluid is selected from water, oil, or gas comprising water vapour. The swellable layer may comprise swellable elastomer.

Fig.1



EP 3 034 777 A1

Description

[0001] The present invention relates to a system and a method for expanding a tubular element. The system and method can be used to expand the tubular element, for instance for lining a borehole or for making a pipeline. The borehole may for instance be a wellbore for the exploration or production of hydrocarbons. Alternatively, the borehole may be a tunnel, for instance for transferring cables and wires, or fluids and/or gases, effectively providing an underground pipeline. The tunnel may allow passage under rivers, buildings, or nature reserves.

[0002] The technology of radially expanding tubular elements finds increasing application in the industry of oil and gas production from subterranean formations. Wellbores are generally provided with one or more casings or liners to provide stability to the wellbore wall, and/or to provide zonal isolation between different earth formation layers. The terms "casing" and "liner" refer to tubular elements for supporting and stabilising the wellbore wall. Typically, a casing extends from surface into the wellbore and a liner extends from a certain depth further into the wellbore. However, in the present context, the terms "casing" and "liner" are used interchangeably and without such intended distinction.

[0003] In conventional wellbore construction, several casings are set at different depth intervals, and in a nested arrangement. Herein, each subsequent casing is lowered through the previous casing and therefore has a smaller diameter than the previous casing. As a result, the cross-sectional area of the wellbore that is available for oil and gas production decreases with depth.

[0004] To alleviate this drawback, it is possible to radially expand one or more tubular elements at a desired depth in the wellbore, for example to form an expanded casing, expanded liner, or a clad against an existing casing or liner. Also, it has been proposed to radially expand each subsequent casing to substantially the same diameter as the previous casing to form a monodiameter wellbore. It is thus achieved that the available diameter of the wellbore remains substantially constant along (a section of) its depth as opposed to the conventional nested arrangement.

[0005] WO-2008/006841 discloses a wellbore system for radially expanding a tubular element in a wellbore. The wall of the tubular element is induced to bend radially outward and in axially reverse direction so as to form an expanded section extending around an unexpanded section of the tubular element. The length of the expanded tubular section is increased by moving, for instance by forcing or pushing, the unexpanded section into the expanded section. Herein the expanded section retains the expanded tubular shape. At its top end at surface, the unexpanded section can, for instance, be extended by adding pipe sections or by unreeling, folding and welding a sheet of material into a tubular shape.

[0006] WO-2009/074643 discloses a system for expanding a tubular element, similar to the system disclosed in WO-2008/006841. Herein, a conduit extends into a blind annulus between the expanded section and the unexpanded section of the tubular element. The conduit enables to replace a fluid arranged in the blind annulus with a replacement fluid.

[0007] The pipe expansion systems as disclosed in WO-2008/006841 or WO-2009/074643 can provide a borehole lined with an expanded tubular element, wherein an annulus between the expanded tubular section and the borehole wall is relatively small. The small annulus is typically too small to allow pumping of cement slurry. For instance WO-2013/167520 and WO-2013/167521 disclose solutions for zonal isolation in this respect.

[0008] The present invention aims to provide an alternative system and method for expanding a tubular element.

[0009] The present invention provides a system for expanding a tubular element, the tubular element comprising a wall which is bent radially outward and in axially reverse direction defining an expanded tubular section extending around an unexpanded tubular section,

- an inner surface of the unexpanded section being provided with a coating for zonal isolation.

[0010] The inner surface of the unexpanded section is provided with a coating for zonal isolation. The coating may include one or more layers. The coating may include a layer of swellable elastomer material. The swellable elastomer coating layer may swell when contacted with a predetermined fluid, such as water, gas or oil. The elastomer typically is a rubber coating applied on the wall of the tubular element. After inversion, the zonal isolation coating is located on the outer surface of the expanded section, and in the annulus between the expanded section and the wellbore wall. When the predetermined fluid moves in the annulus and contacts the swellable layer, the swellable elastomer will swell and provide zonal isolation in the annulus enclosing the expanded tubular element.

[0011] The coating may also include a wear resistance coating layer covering and protecting the swellable elastomer layer.

[0012] The bended section and the flexible trajectory, which may be adjusted as required and to comply with available space, provides a flexible set-up for fabricating an expandable tubular element. The flexibility of the set-up allows a significant reduction in footprint and space required for the system, typically a drilling system for drilling a wellbore.

[0013] The wall of the tubular element may comprise a metal such as steel or any other ductile material capable of being plastically deformed by eversion of the tubular element. The expanded tubular section preferably has adequate collapse resistance to support or stabilize the wellbore wall. Depending on the respective formation, the collapse resistance of the expanded tubular section may exceed, for example, 100 bar to 150 bar. The col-

lapse resistance may be in the range of for instance 200 bar to about 1600 bar or more, for instance about 400 bar to 800 bar or more.

[0014] In an embodiment, the blind annulus, i.e. the annulus between the expanded section and the unexpanded section, is provided with a fluidic material. The fluidic material may for instance include a hardenable material. The latter may reinforce the collapse pressure rating of the inverted tubular element, increasing the collapse rating by filling the blind annulus. Herein, the material may comprise cement, and the fluidic material may be cement slurry which hardens to become cement after a predetermined setting time. The material may comprise other materials that will add to the strength of the expanded section. In another embodiment, the material comprises a lubricant. Herein, the blind annulus is used to convey lubricants. The lubricant may be selected from: oil or hydrocarbon based lubricant, bearing balls for instance made of steel, an ionic liquid, and other types of friction reducing mechanisms.

[0015] According to another aspect, the invention provides a method for expanding a tubular element, comprising the steps of:

- providing a strip of sheet material;
- receiving the strip and guiding the strip along a predetermined trajectory;
- folding the strip in a tubular shape to form and extend an unexpanded section of the tubular element;
- bending the unexpanded section radially outward and in axially reverse direction for defining an expanded tubular section extending around the unexpanded tubular section; and
- pushing the unexpanded section into the expanded section to expand the tubular element;
- the method comprising the further step of providing an inner surface of the unexpanded section with a coating for zonal isolation.

[0016] The invention will be described hereinafter in more detail and by way of example with reference to the accompanying drawings in which:

Fig. 1 shows a vertical cross section of a system for radially expanding a tubular element;
Fig. 2 shows a vertical cross section of an example of an upper portion of the system of Figure 1;
Fig. 3 shows a vertical cross section of another example of an upper portion of the system of Figure 1;
Fig. 4A shows a top view of an embodiment of a system for expanding a tubular element according to the invention;
Fig. 4B shows a top view of a detail of the embodiment of Fig. 4A;
Fig. 5 shows a side view of another embodiment of a system for expanding a tubular element according to the invention;
Fig. 6 shows a side view of yet another embodiment of a system for expanding a tubular element according to the invention;
Fig. 7 shows a top view of an example of a drilling pattern, using the system for expanding a tubular element according to the invention;
Figs. 8 to 10 show side views of respective embodiments of a system of the invention;
Fig. 11 shows a top view of yet another embodiment of a system of the invention;
Fig. 12 shows a side view of the embodiment of Fig. 11;
Figs. 13 and 14 show a top view of the system of the invention, depicting exemplary steps in a method of expanding a tubular element of the invention;
Figs. 15 to 18 show a perspective view of a detail of the system of Fig. 13, depicting exemplary steps of the method of the invention; and
Fig. 19 shows a cross section of a coil for forming a tubular element, the strip of the coil being provided with one or more coating layers.

[0017] In the drawings and the description, like reference numerals relate to like components.

[0018] Figure 1 shows a borehole 1 formed in an earth formation 2. A radially expandable tubular element 4, for instance an expandable steel liner, extends from surface 6 into the wellbore 1. The tubular element 4 comprises an unexpanded tubular section 8 and a radially expanded tubular section 10. The unexpanded section 8 extends within the expanded section 10. Preferably, an outer diameter of the expanded tubular section 10 is substantially equal to the diameter of the borehole 1.

[0019] Although the borehole shown in Figure 1 extends vertically into the formation 2, the present invention is equally suitable for any other borehole. For instance, the borehole 1 may extend at least partially in horizontal direction. Herein, upper end of the borehole refers to the end at surface 6, and lower end refers to the end down hole.

[0020] At its lower end, the wall of the unexpanded section 8 bends radially outward and in axially reverse (in Fig. 1 the upward) direction so as to form a curved downhole section 12, defining a bending zone 14 of the tubular element 4. The curved section 12 is U-shaped in cross-section and interconnects the unexpanded section 8 and the expanded section 10.

[0021] A drill string 20 may extend from surface through the unexpanded liner section 8 to the lower end of the borehole 1. The downhole end of the drill string 20 is provided with a drill bit 22. The drill bit comprises, for instance, a pilot bit 24 having an outer diameter which is slightly smaller than the internal diameter of the unexpanded liner section 8, and a reamer section 26 having an outer diameter adapted to drill the borehole 1 to its nominal diameter. The reamer section 26 may be radially retractable to a smaller outer diameter, allowing it to pass through the unexpanded liner section 8, so that the drill bit 22 can be retrieved through the unexpanded liner sec-

tion 8 to surface. The drill string 20 may comprise multiple drill pipe sections 28. The pipe sections 28 may be mutually connected at respective ends by male and female threaded connections 30. An annular space 32 between the drill string 20 and the unexpanded tubular section 8 is referred to as the drilling annulus 32.

[0022] The connections 30 are not shown in detail, but comprise for instance threaded, pin and box type connections. The connections 30 may comprise joints fabricated with male threads on each end, wherein short-length coupling members (not shown) with female threads are used to join the individual joints of drill string together, or joints with male threads on one end and female threads on the other. Said threaded connections may comprise connections which are standardized by the American Petroleum Institute (API).

[0023] Figure 1 also shows a rig floor 40, which is elevated with respect to the surface 6 and encloses an upper end of the drill string 20 and of the unexpanded tubular section 8. The rig floor 40 is part of a drilling rig, which is however not shown in its entirety. A pipe pusher 42, which is for instance arranged below the rig floor, encloses the unexpanded section 8. The pipe pusher is for instance supported by base frame 43. The base frame 43 provides stability, and may for instance be connected to the drilling rig or be supported at surface 6. The pipe pusher may comprise one or more motors 46, which are arranged on the base frame, and one or more conveyer belts 48 which can be driven by the respective motors. Each conveyer belt 48 engages the outside of the unexpanded section 8. The conveyer belts 48 can exert force to said unexpanded section 8 to force the unexpanded section to move into the expanded section 10. Other embodiments of the pipe pusher 42 are conceivable, which will be able to exert downward or upward force to the unexpanded section.

[0024] A sealing device 50 can be connected to the upper end of the expanded liner section 10 to seal the unexpanded liner section 8 relative to the expanded liner section 10. Herein, the sealing device 50 enables the unexpanded liner section 8 to slide in axial direction relative to the sealing device 50. The sealing device comprises a conduit 52 which is connected to a pump (not shown) for pumping fluid into or out of a blind annulus 44, i.e. the annular space between the unexpanded liner section 8 and the expanded liner section 10. The annular space 44 is referred to as blind annulus as it is closed at the downhole end by the bending zone 14. The sealing device includes one, two or more annular seals 56, 58. The seals 56, 58 engage the outside of the unexpanded section 8 and prevent said fluid to exit the blind annulus. Preferably, the sealing device 50 comprises at least two seals 56, 58 to provide at least one additional seal to improve safety and reliability in case the first seal may fail.

[0025] The sealing device 50 can be regarded as a blind annulus blow out preventer (BABOP). Therefore, the seals 56, 58, the connection of the device 50 to the upper end of expanded section 10, and one or more valves (not shown) for closing conduit 52 will all be designed to at least withstand fluid pressures that may arise in a well control situation. Depending on specifics of the formation, the sealing device 50 is for instance designed to withstand pressures that may be expected in case of a blowout, for instance in the range of 200 bar to 1600 bar, for instance about 400 bar to 800 bar or more. Such pressures may for instance arise in the blind annulus 44 in case of a failure, for instance due to rupture, of the expandable tubular 4 in combination with a well control situation.

[0026] The expanded liner section 10 is axially fixed, by any suitable fixation means, to prevent axial movement. The expanded liner section 10 may be fixated at its upper end at surface. For instance, said upper end of the expanded section may be connected to a ring or flange 59, for instance by welding and/or screwing. Said ring can be attached to or incorporated in any suitable structure at surface, such as the sealing device 50. The inner diameter of said ring may be larger than the outer diameter of the expanded section. Optionally, the expanded section 10 may be fixed to the wellbore wall 224, for instance by virtue of frictional forces between the expanded liner section 10 and the wellbore wall 224 as a result of the expansion process. Alternatively, or in addition, the expanded liner section 10 can be anchored, for instance to the wellbore wall, by any suitable anchoring means.

[0027] At the interface indicated by the line II-II, the lower portion of the system shown in Fig. 1 can be connected to an upper portion as for instance shown in Figures 2 and 3.

[0028] Figure 2 shows a top drive 60 connected to an upper end connection part 62, which is rotatable with respect to the top drive. Preferably, the upper end connection part comprises a flush pipe, having a smooth outer surface. A connection part end 64, which is remote from the top drive, is provided with a threaded connection 30 as described above. The threaded end 64 is connected to an additional drill string section 66. Typically, the additional drill string section 66 will be substantially equal to the drill string sections 28, shown in Fig. 1. At the interface indicated by line I-I, the additional drill pipe section 66 can be connected to the upper end of the drill string 20 shown in Fig. 1.

[0029] A drilling annulus sealing device 70 may cover the top end of the drilling annulus 32. The sealing device 70 comprises a housing 72, which encloses the connection part 62 and provides an internal space 74. At the top end, near the top drive 60, the housing may comprise one, two or more seals 76, 78, which engage the outside of the pipe 62. Preferably, the seals 76, 78 enable the housing to slide along the pipe 62. At the opposite end, the housing may comprise one, two or more seals 80, 82 which engage the outside of an additional expandable pipe section 84. In addition to the seals, the housing may comprise grippers 106, which may engage the outside and/or the inside of the pipe section 84. An activation line

88 is connected to the housing for activating or releasing the seals 80, 82 and/or the grippers 106. A fluid conduit 90 is connected to the internal space 74 for supply or drainage of (drilling) fluid to or from the annular space 32.

[0030] The sealing device 70 may comprise an extending part or stinger 100. The stinger extends into the inside of the additional expandable pipe section 84. The stinger may comprise seals 102, 104 and/or grippers 106 to engage the upper end of the pipe section 84. The stinger may also comprise seals 108 to engage a lower end of the pipe section 84, and seals 110 to engage the inside of the upper end of the unexpanded tubular section 8 (shown in Fig. 1). A backing gas tool 198 may be integrated in the stinger between the seals 108, 110. The backing gas tool covers the inner interface between the additional expandable pipe section 84 and the unexpanded tubular section 8.

[0031] The stinger may be at least slightly longer than the pipe section 84 so that the stinger may extend into the unexpanded section 8, which will enable the stinger to function as an alignment tool for aligning the pipe section 84 and the unexpanded section 8.

[0032] In practice, the length of the pipe section 84 may be in the range of about 5-20 metres, for instance about 10 metres. The stinger will for instance be about 2% to 10% longer, for instance 5% longer than the pipe section 84. An annular space 112 is provided between the stinger and the pipe 62 to provide a fluid connection from the annulus 32 to the space 74 and the conduit 90.

[0033] The sealing device 70 may be referred to as drilling annulus blow out preventer (DABOP) 70. The seals 76-82, the grippers 106, and one or more valves (not shown) for closing conduits 88 and 90 will all be designed to at least withstand fluid pressures that may arise in a well control situation. Depending on specifics of the formation and the expected maximum pore pressures, the DABOP 70 is for instance designed to withstand pressures in the range of about 200 bar to 800 bar or more, for instance about 400 bar.

[0034] The DABOP may comprise any number of seals. The DABOP 70 may comprise one seal 76 and one seal 80, or a plurality of seals. In a practical embodiment, two seals 76, 78 to seal with respect to the pipe 62 and two seals to seal with respect to the tubular section 84 will provide a balance between for instance fail-safety and reliability on one hand and costs on the other hand. For instance, the double barrier provided by the inner seals 102, 104, engaging the inside of the expandable pipe 84, and the outer seals 80, 82, engaging the outside of the expandable pipe 84, improves the reliability and leaktightness of the sealing device 70.

[0035] Figure 3 shows an upper portion of the system of Fig. 1. The unexpanded liner section 8 is at its upper end formed from a (metal) sheet 130 wound on a reel 132. The metal sheet 130 has opposite edges 133, 134. After unreeling from the reel 132, the metal sheet 130 is bent into a tubular shape and the edges 133, 134 are interconnected, for instance by welding, to form the unexpanded tubular section 8. Consequently, the expandable tubular element 4 may comprise a longitudinal weld 135.

[0036] A fluid conduit 136 extends from the interior of the unexpanded tubular section 8, to above the upper end of the unexpanded tubular section 8. The fluid conduit 136 may at its lower end be connected to, or integrally formed with, a tube 138 located in the unexpanded tubular section 8. A first annular seal 140 seals the tube 138 relative to the unexpanded liner section 8, and a second annular seal 142 seals the tube 138 relative to the drill string 20. The fluid conduit 136 is in fluid communication with the interior space of the tube 138 via an opening 144 provided in the wall of the tube 138. Furthermore the tube 138 is provided with gripper means 146 allowing upward sliding, and preventing downward sliding, of the tube 138 relative to the unexpanded liner section 8. The first annular seal 140 allows upward sliding of the tube 138 relative to the unexpanded liner section 8.

[0037] The upper portion shown in Figure 3 can be combined with a lower portion shown in Figure 1, wherein the unexpanded tubular section 8 is however continuously formed around the drill string 20. Herein, some of the features shown in Figure 1 are omitted in Figure 3 to improve the clarity of the latter figure, such as the sealing device 50, the pipe pusher 42 and drilling floor 40.

[0038] Exemplary embodiments of a system and method of expanding the tubular element 4 according to the present invention are described herein below.

[0039] Figure 4A shows a system 200 according to the invention. The system 200 is suitable for expanding a tubular element 4. The tubular element may for instance be formed according to the embodiment shown in Figure 3.

[0040] In the embodiment shown in Fig. 4A, the system 200 comprises a drilling rig 210 which is positioned substantially horizontally. To enable drilling, the drill string 20 is connected to a drive unit (not shown) of the drilling rig 210 and may extend from the drilling rig 200 towards a selected well head 212. The selected well head 212 herein may be selected from a multitude of well heads 214. Multitude herein can indicate any predetermined number, meaning basically two or more. In practice, the number of wellheads that can be reached from the same well pad, i.e. substantially without having to move the drilling rig 210, may be in the order of one to 40.

[0041] A distance L2 between the nearest wellhead 214 and the drilling rig herein may be selected to allow the drill string 20 to bend within a predetermined range, enabling the drilling rig 210 to drill consecutive boreholes, each extending from another well head 214. The predetermined range may be +/- α, wherein α is an angle in the horizontal plane. The angle α herein may be in the order of 1 to 30 degrees.

[0042] The section of the system 200 between the pipe pusher 42 and the wellhead 212 may be referred to as a goose neck structure. The goose neck guides the inverted pipe 10 into the wellhead at a predetermined angle.

The angle of the well head can vary anywhere between 0 and 90 degrees with respect to the horizontal plane. The support structure 280 herein may form an important part of the goose neck, and may include a steel frame. The steel frame may support a PE pipe 270 on top. The inverted SOCCS tube is guided through this PE pipe. If a non-retractable BHA is selected, it can be assembled and made up at the Gooseneck. Instead of the pipe 270, clamps may provide sufficient guidance and anti-buckling support.

[0043] The goose neck structure provides anti-buckling support and guides the tubular element 4. The goose neck enables the system 200 to drill and line multiple boreholes, indicated by their wellheads 241 in Fig. 4A, by simply moving the support structure 280 and guiding the pipe 4 to the selected wellhead. This enables pad drilling of a relatively large number of boreholes. This may provide a significant benefit when multiple wellbores are required at close distances to produce a hydrocarbon reservoir efficiently, for instance for unconventional resources, such as tight gas or coal bed methane reservoirs. See also Figures 13 to 18 in this respect.

[0044] The drive system (not shown) of drilling rig 210 may be set up for rotating the drill string 20 and the drill bit 22 at the downhole end thereof (see Fig. 1). Alternatively, or in addition, the drill string may be provided with a mud motor at the downhole end for driving the drill bit. In another embodiment, the drill string may be coiled tubing, provided with a mud motor and drill bit at the downhole end thereof. In yet another embodiment, the drill string and drill bit may constitute a Rotary Steerable System (RSS). The RSS system enables steerable drilling using modulated fluid jets, as described for instance in US-4637479, US-5265682, and WO-2014/177505.

[0045] The system 200 may comprise a strip supply unit 220 for supplying the strip 130 (compare to Fig. 3). The strip supply unit is also positioned substantially horizontally. The horizontal position enables the unit 220 to take in the coil 132 at one end 222, unreel the sheet material for making the tubular element 4, and outputting the sheet 130 at the opposite end 224.

[0046] The strip supply unit may comprise various other machining parts, such as a flattening tool 226 for flattening the strip 130. Flattening herein means removing any unwanted bumps, folds etc. from the unreeled sheet material. The flattening tool may comprise two sets of opposing rollers 228. The sheet 130 may be guided between the rollers 228 to flatten the sheet and make it more even and flat. The flattening tool and/or the unreeling equipment may also function as a loop control, i.e. for controlling the tension on the coil to prevent uncontrolled unreeling.

[0047] The strip supply unit 220 may also comprise an end cutter 230 for cutting off a front end and aft end of the unreeled sheet material 130. The front end and aft end may be relatively uneven, and by removing these ends along a predetermined length, the overall evenness of the tubular element 4 may be improved. The predetermined length may be in the order of 0.1 to 1 meter.

[0048] The tubular element 4 may be used to line a borehole having a length of several kilometres, requiring multiple subsequent rolls 132 of material connected end to end to make up the tubular element, for instance by welding. The latter may introduce circumferential welds at set intervals, which will be inverted when they reach the bending zone 14. Cutting blades 232 of the cutter may be arranged at an angle β with respect to the direction of movement of the sheet 130, to cut the front and aft ends at the angle β with respect to the longitudinal axis of the sheet 130. The angle β may be between 20 to 70 degrees, for instance in the order of 45 degrees.

[0049] A welding unit 236 may be provided to connect the aft end of one strip 130 to the front end of a subsequent strip. Given the angle β, the welding unit will create a weld at the same angle with respect to the longitudinal axis. Thus, after folding of the sheet 130, the tubular element 4 will comprise circumferential welds which are angled at about the angle β with respect to the longitudinal axis. Upon eversion in the bending zone 14 (Fig. 1), the circumferential weld will not be everted at once, but only gradually. The latter will limit stress levels in the pipe material at and near the circumferential weld during eversion and consequently make the eversion process more reliable.

[0050] When all the material of a first coil 132 has been formed into pipe 4, a new, second coil is inserted in the strip supply unit 220. The strip-end-welder 230 welds the start of the new strip to the end of the previous strip. At this time, both the drilling and the pipe forming will be paused.

[0051] If the weld is not up to specifications, it can be cut out, and the strips will be welded again. The main functions of the strip-end-welder are to guide the strip ends for a proper line up; shear the strip ends at the selected angle β; and weld the strip ends at the angle β. For the optimal quality of inversion, the strip is cut and welded at an angle β of about 45 degrees. The guiding, shear cutting and welding is done at the middle of the strip supply unit 220. When performing a strip end weld, the front end of the new strip and the aft end of the previous strip are clamped at the entry and exit points. Furthermore, a pinch roll section at the exit side 224 can feed the material to the next section. The welding may be done by automated TIG welding. Movements of the components of the welding station 236 may be hydraulically or pneumatically actuated.

[0052] The strip 130 is subsequently transported via bended section 240 to a pipe mill 250. The bended section may be provided with guide means, such as sets of rollers 242, 244, to direct the strip 130 according to a predetermined trajectory.

[0053] In addition, the bended section 240 may be provided with one or more sensors 246. The sensors 246 may include for instance a distance sensor, to measure the distance L3 between the respective sensor and the strip 130 at the location of the sensor. A difference ΔL

between the distance L3 and a reference distance Lref may provide an indication of the amount of strip material which is available to the pipe mill 250. Herein, the reference distance is for instance the distance between the sensor and the strip 130 when the strip 130 engages the rollers 242. Due to differences in speed of transport of the strip 130 between the strip supply unit 220 on one hand and the pipe mill 250 on the other, the strip 130 may be lifted from the rollers 242. Thus, the bended section 240 may function, for instance, as a buffer for material for the pipe mill 250, allowing the pipe mill to maintain a controlled speed even when the speed of the strip supply unit 220 changes, for instance near the beginning or end of a strip section.

[0054] The bended section 240 may turn the strip of material 130 along any selected angle, for instance over an angle of about 180 degrees as depicted in Figure 4A. The flexibility provided by the bended section 240 allows to adapt the system 200 to the available space. The bend of about 180 degrees, shown in Fig. 4A, allows a particular compact setup of the system 200. A conventional drilling rig will require more space. Typically, the system 200 of the invention allows a reduction of the area of the patch of land required for the drilling rig with, for instance, a factor two to five, when compared to a conventional drilling rig. The area reduction is for instance possible because no space is required to store casing or liner pipe sections. Also, a single liner size may be sufficient to line the entire borehole, thus limiting the amount of liner material and obviating corresponding storage capacity and space.

[0055] The strip guide 240 allows the strip 130 to make a preselected turn, such as a 180 degree turn, between the strip supply unit 220 and the pipe mill 250. The turn limits the length required for the system 200, may save space or allows for optimal use of the space available. Secondly, the strip guide rollers 242, 244 may be moveable with respect to the strip supply unit 220, as indicated by arrow 248. Thus, part of the strip material in the turn 240 can be fed back into the strip-end-welder 236. For instance when a strip end weld may not meet a quality criteria threshold, the original weld can be cut out and the weld can be redone. The loop function 240 may contain a predetermined amount of strip material, functioning as an adjustable buffer for strip material. The loop 240 may have a size allowing a predetermined number of cuts and re-welds. Also, the buffer function provided by the adjustable loop 240 may compensate a potential speed difference between the strip supply unit 220 and the pipe mill 250. Herein, the throughput speed of the pipe mill 250 is preferably relatively constant, to provide an optimal weld quality. The buffer 240 thus relaxes the speed tolerance of the strip supply unit 220, allowing to reduce complexity and costs.

[0056] The loop 240 can be designed in any fashion and can make any angle or turn and at any radius. This provides significant design flexibility to adapt or limit the footprint of the system 200. In addition, the loop 240 provides extra length of material, allowing rectifying and repairing damage or failures in the strip 130 or the weld.

[0057] The pipe mill 250 comprises bending means to bend the strip 130 around the drill string 20. The bending means comprise for instance a number of consecutive roller pairs 252, each having a predetermined shape to bend the strip 130 in a predetermined form. The consecutive roller pairs 252 are formed such, that their shape first slightly bends the strip, and eventually creates a round liner pipe enclosing the drill string. The pipe mill comprises a welding station 254 for welding the opposite edges 133, 134 to create the longitudinal weld 135 and form the tubular element 4 (see also Fig. 3). The welding station is arranged downstream of the roller pairs 252.

[0058] The welding station 254 may be a laser welding station. In addition to the welding station, the pipe mill 250 may comprise a weld repair station. In the pipe forming machine 250, strip material 130 is bent continuously to form a pipe 4 as the material moves through the rollers 252 or roll forming stands. The pipe mill comprises a sequence of roller pairs 252, for instance located on the top and bottom of the machine. The bending of the strip to a pipe may be done at room temperature, providing a cold forming process.

[0059] When the strip is formed to a pipe and fixed between the last roller pair, a focused laser beam may weld the sides together into a seam weld 135. The high power density of the laser beam causes the material to melt. The material cools down and solidifies to a narrow welding seam. Helium or Argon or any other inert gas maybe used as shielding gas, to minimize oxidation on the weld surface. A suction unit at the weld spot may extract spatters and fumes produced during welding. The actual laser generator may be arranged near the pipe mill in a separate container. A welding optic head of the welding cabinet 254 on the pipe mill can be connected to this laser generator by a flexible laser light cable. Optics in the welding head focus the laser light onto the pipe surface to weld the edges 133, 134 together.

[0060] The pipe mill 250 of the system 200 of the invention can be made for every size of pipe, ranging from large scale operations such as pipelines to small scale applications, ultra slim hole applications, and exploration purposes. This ranges for instance from 30 inch or more down to 2 inch or less (75 to 5 cm).

[0061] The pipe mill 250 may comprise a welding mechanism as well as a weld repair mechanism. The weld repair mechanism may follow the welding station 254. The weld repair may include any type of welding system. In a preferred embodiment, the weld repair includes a laser, TIG, or MIG welding station. The weld repair station may be preceded by a weld damage detection mechanism, such as non-destructive testing (NDT). NDT herein may refer to analysis techniques to evaluate the properties of a material, component or system without causing damage and without permanently altering the inspected weld. The NDT method may include ultrasonic, magnetic-particle, liquid penetrant, ra-

diographic, remote visual inspection (RVI), eddy-current testing, and low coherence interferometry.

[0062] If the quality of the weld line 135 is below a threshold quality, for instance not fully penetrated weld, the line is stopped. The parameters of the welding station can be adjusted or the problem may be solved otherwise. Since the formed and welded pipe cannot be deformed and then re-welded, the section containing the inadequate seam weld may be repaired. This can be done by re-melting the weld 135 along a certain length by TIG (Tungsten Inert Gas Welding) in the repair station 256. The TIG welding may use a welding head which can move on a rail and is grounded by clamps (not shown).

[0063] The system comprises pipe pusher 42 which receives the drill string and enclosing tubular element 4 from the pipe mill 250. The pipe pusher may comprise a number of push roller pairs 260. Each push roller pair comprises rollers having a predetermined semi-circular shape substantially matching the outside diameter of the tubular element 4, and adapted to engage the outer surface of the unexpanded section 8 of the tubular element. The semi-circular shaped surfaces of the rollers may also be provided with a layer of friction material to improve grip on the outside of the tubular element. The number of push roller pairs 260 is selected such that the available power to push the tubular element forward is sufficient to evert the tubular element and expand it along the entire length of the planned borehole trajectory.

[0064] A front section of the unexpanded section 8 may be everted and made into, or connected to, the flange 59. The flange 59 can be appropriately fixated at or near an aft section of the pipe pusher 42. The flange 59 may for instance be created by initially pushing the unexpanded section onto a flaring tool (not shown). Basically, the flaring tool may comprise a cylindrical part having an outer diameter substantially corresponding to an inner diameter of the unexpanded section 8. The cylindrical part may be provided with a foot section having a gradually increasing diameter. By pushing the unexpanded section onto the cylinder and further onto the foot section, the expanded section with flare outward onto the foot section and provide the flange 59.

[0065] A flexible guide conduit 270 may be provided to receive and guide the tubular element. The guide conduit may for instance be connected to, or arranged near an end of, the pipe pusher 42. The flexible guide conduit is sufficiently flexible to allow bending within the angles +/- α. On the other hand, the conduit 270 is sufficiently strong to withstand and guide the expanded tubular section 10 towards the selected wellhead 212. The conduit 270 may for instance comprise a polymer material, such as polypropylene or polyethylene.

[0066] At least part of the guide conduit 270 may be supported by a guide structure 280. The guide structure may be moveable to direct an end 282 of the guide conduit towards one of the available wellheads 214. The structure 280 may for instance be moveable in lateral direction, as indicated by arrows 284, 286. In addition or alternatively, the structure 280 may be moveable in longitudinal direction, as indicated by arrow 288 (see also Fig. 4B).

[0067] Fig. 5 shows an embodiment wherein the support structure 280 can be adapted to achieve a predetermined entry angle γ. Herein, entry angle γ may be defined as the angle γ between the uphole end of the borehole 1 and the normal vector 290. The normal vector, or normal, indicates a line that is perpendicular to the surface 6, i.e. perpendicular to the tangent plane at the point of entry 292. In a practical embodiment, the angle γ may be selected in the range of 0 to about 80 degrees, dependent on the specific circumstances, the selected drilling system and/or the purpose of the borehole. Figs. 8 to 10 show exemplary angles γ of about 80, 60 and 20 degrees respectively.

[0068] The unexpanded section 8 of the tubular element 4 extends onto the support structure 280. The structure 280 defines a suitable curvature 294 to allow the tubular element 4 to enter the borehole at the angle γ. The pipe pusher 42 may be arranged downstream of the structure 280. Arranging the pipe pusher 42 downstream of the support structure 280 may obviate the guide conduit 270. The uphole end of the borehole 1 may be provided with a guide conduit (not shown), comparable to conduit 270, to guide the initial phase of the eversion process in the selected direction.

[0069] Fig. 6 shows an embodiment, wherein the guide conduit 270 is arranged below the drill floor 40 of a vertical drilling rig 300. The tubular element 4 and the expansion by eversion thereof may be initiated as depicted in Figure 1. The flexible conduit 270 is arranged below the drill floor, and guides the tubular element 4 and drill string 20 towards the selected wellhead 212.

[0070] The wellhead can be selected with a circle of maximum reach 302 (Fig. 7). The radius of circle 302 depends on the flexibility of the tubular element 4 and the drill string 20 on one hand, and the distance L3 between the drill floor 40 and the surface 6 on the other. The radius of the circle 302 can be adjusted, for instance, by adjusting one or more of these parameters.

[0071] In another embodiment, the height position of the system 200 may be adjusted, or of parts thereof including the drilling rig, the pipe mill 250, and/or the strip supply unit 220. In the drawing, only the pipe mill 250 is indicated, as it usually precedes the support structure 280. The description is however equally applicable to other parts of the system 200, or to a drilling rig platform whereon the system 200 is arranged. Pipe mill 250 herein below therefore may refer both to the pipe mill for folding the pipe, as described with respect to Figure 4A, or to equipment to connect subsequent pipe sections, as shown in Figure 2.

[0072] The pipe mill may for instance be arranged on supports 310, such as columns, blocks, and a framework (Fig. 8).

[0073] Alternatively, the pipe mill may be supported by adjustable supports 320, such as hydraulic jacks (Fig.

9). The adjustable supports may be adjustable independently, to allow the pipe mill to be arranged at a selected angle δ with respect to the surface 6. The angle δ may be any angle to, in combination with the support structure 280, allow the appropriate angle γ of the top end of the borehole.

[0074] The system 200 of the invention has a relatively small footprint or required surface area, compared to a conventional drilling rig. The relatively small footprint allows to arrange one or more systems 200 on a vessel 330. See Figures 11 and 12 in this respect. The water level 332 is indicated in Fig. 12. The vessel may be provided with a guide conduit 270 and/or a support structure 280, which may at least partially extend from the vessel. The guide conduit and/or support structure may thus provide a predetermined direction and curvature for the tubular element.

[0075] As described with respect to Figures 8 to 10, the entry angle γ can be adjusted, simply by elevating and/or tilting the drilling platform itself. Offshore or onshore, this can be possible by using a jack-up with a platform, wherein the platform holds (parts of) the system 200. As indicated in Fig. 10, the elevation can also be made at an angle with surface and not necessarily horizontal.

[0076] The system of the invention may use a tubular element folded from reeled material, which obviates the need for relatively extensive pipe racks and related storage and pipe handling facilities. Consequently, multiple systems 200 may be arranged on a single vessel 330, to allow drilling and lining multiple boreholes in different directions. The respective boreholes may be drilled simultaneously.

[0077] Fig. 13 shows an exemplary step in a process of expanding the tubular element 4. In addition to the elements already described above with respect to Fig. 4A, the system 200 may comprise one or more of a drilling fluid supply system 340, and container rack 350 for additional rolls 132 of sheet material for the tubular element. The drilling fluid supply system 340 may comprise fluid supply lines 342, 344 for supply and discharge of drilling fluid, as well as pump systems 346. Semi-circular strips 360, 362 may be provided on the surface 6 to provide a pathway for the support structure 280. The support structure 280 may be provided with wheels 364, 366 to allow easy movement of the structure from a first position (Fig. 13) to a second position (Fig. 14).

[0078] The guide conduit 270 may be arranged on the support structure 280, on the wellhead, and/or extend at least partly from the structure 280 to the pipe pusher 42. The guide conduit may be arranged to guide the tubular element in the right direction, and to prevent uncontrolled bending or buckling thereof. The latter may depend on, for instance, the angle α, the strength of the tubular element 4, the diameter of the unexpanded section 8, and the force which is required to evert the tubular element.

[0079] Alternatively, instead of the guide conduit, the support structure may be provided with guide means, such as one or more clamps 370, to guide the tubular element along the support structure 280 and towards a selected wellhead 212.

[0080] The wellhead may comprise a conductor conduit 372, which may be provided with a connection part 374 at its uphole end. The conductor conduit 372 may be a relatively strong and stiff tube, which is inserted in the ground to provide the predetermined angle γ of entry of the borehole. The conductor may be made of steel or a relatively hard polymer. The conductor may be made of high-density polyethylene (HDPE), having a density of greater than about 0.940 g/cm3. The conductor may have a length in the range of, for instance, 2 to 50 meters.

[0081] In a first step (Fig. 15), the support structure 280 is moved to align the bending zone 14 with the selected wellhead 212. The system shown in Fig. 15 lacks a drill string and drill bit, which would be suitable for lining an existing borehole or for creating a pipeline by everting the tubular element. However, the system is equally suitable for use with a drill string and drill bit, enabling the system of the invention to drill and line the borehole in a single trip.

[0082] The tubular element is subsequently pushed forward and everted by the pipe pusher 42, into the conductor pipe 372 (Fig. 16). As described above, the drilling system 210 may simultaneously drill the borehole. The system allows directional drilling.

[0083] After reaching the target, such as target depth of a wellbore or the other side of a river or similar obstacle, the borehole is completed. The tubular element is cut off near the end of the borehole. The conductor tube may be provided with appropriate valves. Fig. 17 shows a Christmas tree 380 connected to flanges 376 of the connection part 374, to allow production of hydrocarbons.

[0084] In a next step, the support structure may be moved towards a subsequent wellhead 214. Once the bending zone 14 is aligned with the subsequent wellhead, the steps as described above may be repeated.

[0085] A sequence of drilling boreholes may be selected such that the boreholes farthest removed from the drill rig will be drilled first, followed by the mid-line and then the nearest boreholes (compare to Fig. 4A). This sequence minimizes the intervention with already drilled boreholes.

[0086] Also, the system of the present invention allows simultaneous drilling and completion of boreholes. While drilling one borehole, for instance on the right of the system 200, another already drilled borehole, for instance on the left, can be completed using an alternate rig and/or completion set-up installation in the same area (compare to Fig. 4A).

[0087] In a practical embodiment, the diameter and/or wall thickness of the liner 4 can be selected such that the expanded liner section 10 is pressed against the borehole wall 224 during the expansion process. The expanded liner 10 may thus seal against the borehole wall and/or stabilize the borehole wall.

[0088] The wall thickness of the liner 4 may be equal

to or thicker than about 2 mm (0.08 inch). The wall of the liner 4 may be for instance more than 2.5 mm thick, for instance about 3 to 30 mm thick or about 3.2 to 10 mm. The outer diameter of the unexpanded section may be about 50 mm (2 inch) or more, for instance in the range of about 50 to 400 mm (16 inch). The expanded section may have any outer diameter suitable for or commonly used for hydrocarbon wellbores. The wall of the liner may comprise a relatively strong material, such as a metal or preferably steel, or may be made of solid metal or solid steel. Thus, the liner 4 can be designed to have adequate collapse strength to support a borehole wall and/or to withstand internal or external pressures encountered when drilling for hydrocarbon reservoirs.

[0089] The length and hence the weight of the unexpanded liner section 8 will gradually increase during extension of the wellbore. Hence, the downward force exerted by the pushing device 42 can be gradually decreased in correspondence with the increasing weight of unexpanded liner section 8. As said weight increases, the downward force eventually may need to be replaced by an upward force to maintain the total force within a predetermined range. This may prevent buckling of liner section 8.

[0090] During drilling, the unexpanded liner section 8 proceeds into the borehole while the drill string 20 also gradually proceeds into the borehole 1. The unexpanded liner section 8 may be pushed into the borehole at about twice the speed as the drill string 20, so that the bending zone 14 remains at a relatively short distance above the drill bit 22. Herein, said short distance indicates the length L1 of the open hole section 208 (see Figs. 1 and 4), i.e. the unlined section, of the borehole 1. The method of the present invention enables an open hole section having a length L1 smaller than, for instance, about 100 or smaller than 50 metres at all times while drilling the wellbore.

[0091] The unexpanded liner section 8 may be supported by the drill string 20, for example by means of a bearing device (not shown) connected to the drill string, which supports the bending zone 14. In that case the upward force is suitably applied to the drill string 20, and then transmitted to the unexpanded liner section 8 through the bearing device. Furthermore, the weight of the unexpanded liner section 8 then can be transferred to the drill string and utilised to provide a thrust force to the drill bit 22.

[0092] Drilling fluid containing drill cuttings is discharged from the wellbore 1 via outlet conduit 90. Alternatively, drilling fluid may be circulated in reverse circulation mode wherein the drilling fluid is pumped into the wellbore via the conduit 90 and discharged from the wellbore via the drill string 20.

[0093] When it is required to retrieve the drill string 20 to surface, for example when the drill bit 22 is to be replaced or when drilling of the wellbore 1 is complete, the reamer section 26 can be collapsed to its radially retracted mode, wherein the radial diameter is smaller than the internal diameter of the unexpanded liner section 8. Subsequently, the drill string 20 can be retrieved through the unexpanded liner section 8 to surface.

[0094] With the wellbore system of the invention, it is achieved that the borehole is progressively lined with the everted liner directly above the drill bit, during the drilling process. As a result, there is only a relatively short open-hole section 208 during the drilling process at all times. Short herein may indicate a length L1 of the open hole section of less than 1 km, for instance in the range of about 10 to 300 meter. Advantages of a short open hole section include limited possibility of influx into the borehole, which will minimize the resulting pressure increase and simplify well control. The advantages of such short open-hole section will be most pronounced during drilling into a hydrocarbon fluid containing layer of the earth formation. In view thereof, for many applications it will be sufficient if the process of liner eversion during drilling is applied only during drilling into the hydrocarbon fluid reservoir, while other sections of the wellbore are lined or cased in conventional manner. Alternatively, the process of liner eversion during drilling may be commenced at surface or at a selected downhole location, depending on circumstances.

[0095] In view of the short open hole section during drilling with the technology of the present invention, the risk of exposing wellbore fluids, such as drilling fluid, to two widely different formations is significantly reduced. This means that at any given point in time, the wellbore fluid is exposed to only one type of formation and hence properties might be sufficient to be both lower than the fracture gradient of the formation as well as be higher than the pore pressure gradient. Thus, the technology eliminates the need for setting up new casing strings as in conventional drilling to overcome problems related to widely varying formation properties.

[0096] Another advantage of the short open hole section is that losses of wellbore fluids can be minimized. The reduction in loss of wellbore fluid when compared to conventional drilling with nested casing sections is significant. Also, considerably longer intervals can be drilled at a single nominal diameter than in a conventional drilling practice wherein casings of stepwise decreasing diameter must be set at selected intervals.

[0097] Also, if the borehole is drilled through a shale layer, such short open-hole section eliminates possible problems due to a heaving tendency of the shale.

[0098] After the borehole has been drilled to the desired depth and the drill string has been removed from the wellbore, the length of unexpanded liner section that is still present in the wellbore can be left in the borehole or it can be cut-off from the expanded liner section and retrieved to surface.

[0099] In case the length of unexpanded liner section is left in the borehole, there are several options for completing the wellbore. These are, for example, as outlined below.

A) A fluid, for example brine, is pumped into the blind

annulus 44 between the unexpanded and expanded liner sections so as to pressurise the annulus and increase the collapse resistance of the expanded liner section 10. Optionally one or more holes are provided in the bending zone 14 to allow the pumped fluid to be circulated.

B) Cement is pumped into the blind annulus 44 in order to create, after hardening of the cement, a solid body between the unexpanded liner section 8 and the expanded liner section 10. The cement may expand upon hardening.

C) The unexpanded liner section is radially expanded (i.e. clad) against the expanded liner section, for example by pumping, pushing or pulling an expander through the unexpanded liner section.

[0100] In the above examples, expansion of the liner is started at surface or at a downhole location. In case of an offshore wellbore wherein an offshore platform is positioned above the wellbore, it may be advantageous to start the expansion process at the offshore platform, at or above the water surface. Herein, the bending zone moves from the offshore platform to the seabed and subsequently into the borehole. Thus, the resulting expanded tubular element not only forms a liner in the borehole, but also a riser extending from the offshore platform to the seabed. The need for a separate riser is thereby obviated.

[0101] Furthermore, conduits such as electric wires or optical fibres for communication with downhole equipment can be extended in the annulus between the expanded and unexpanded sections. Such conduits can be attached to the outer surface of the tubular element before expansion thereof. Also, the expanded and unexpanded liner sections can be used as electricity conductors to transfer data and/or power downhole.

[0102] Since any length of unexpanded liner section that is still present in the borehole after completion of the eversion process, will be subjected to less stringent loading conditions than the expanded liner section, such length of unexpanded liner section may have a smaller wall thickness, or may be of lower quality or steel grade, than the expanded liner section. For example, it may be made of pipe having a relatively low yield strength or relatively low collapse rating.

[0103] Instead of leaving a length of unexpanded liner section in the borehole after the expansion process, the entire liner can be expanded with the method described above so that no unexpanded liner section remains in the wellbore. In such case, an elongate member, for example a pipe string, can be used to exert the necessary downward force to the unexpanded liner section during the last phase of the expansion process.

[0104] In an embodiment, the inner surface of the unexpanded section may be provided with a coating for zonal isolation. The coating may include one or more layers 400, 402 (Fig. 19). The coating may comprise two or three layers, depending on the application and the wellbore conditions. A first, optional, coating layer 400 may comprise an adhesive material, for gluing a subsequent layer to the pipe or sheet material. A second layer 402 may comprise a swelling material. An optional wear resist coating layer (not shown) may cover and protect the swellable elastomer layer 402. In an alternative embodiment, the swellable coating layer may not require a separate adhesive. In the latter case, the embodiment in Fig. 19 may show the layer 400 being a swellable layer and layer 402 being the protective layer.

[0105] The wear resistant and/or abrasion resistant coating layer may be the outer layer, which protects the underlying layers from wear when exposed to drilling environments (mud circulation with cuttings inside the drilling annulus, etc.). The wear resistant layer may also prevent premature reaction of the underlying layer or layers, for instance to delay swelling thereof or of any other chemical nature.

[0106] The wear resistant layer may comprise hard or soft abrasion resistant coating materials, such as silicon carbide, tungsten carbide, and/or sacrificial rubbers or polymers.

[0107] As shown in Fig. 19, the zonal isolation coating may have been applied on the sheet material 130 before coiling thereof. Alternatively, the coating may be applied at a suitable location in the pipe forming line 200 (Fig. 4), for instance after de-coiling (in the strip supply unit 220), at or near the loop 240, or at or near the entrance to the pipe mill 250. In yet another embodiment, the coating layer may be applied on the inside surface of a pipe section, in case the system uses subsequent pipe section to create the tubular element 4 (see for instance WO-2008/006841).

[0108] The swellable elastomer coating layer may swell when contacted with a predetermined fluid, such as water, gas or oil. The elastomer typically is a rubber coating applied on the wall of the tubular element. Suitable application methods and compositions of the swellable coating are for instance described in WO-2014/154577. The coating may for instance be applied using spray coating, dip coating, chemical plating, or plasma depositing.

[0109] In a practical embodiment, the swellable coating 400 may have a thickness in the range of about 1 to 5 millimetres, for instance about 2 to 3 millimetres. The amount of swelling can be tuned to a predetermined swelling ratio of thickness after swelling : thickness before swelling. The swelling ratio may vary from 10% to 200% or even more, depending on the mechanism and material used. The coating may be able to swell about 50% to 100% in thickness when contacted with the selected fluid. The selected fluid may be water of hydrocarbons, or gas such as natural gas containing water vapour. The swellable coating layer may comprise a swellable material, such as some types of rubbers, epoxies, resins, clays, encapsulated clays, or any other materials which can swell and thereby provide a seal between the inverted pipe 10 and the formation. The swelling action can be

a result of any mechanism, for instance due to osmosis, due to super absorbent polymers, or via a chemical reaction.

[0110] The coating may be applied on a side of the coil 130 that ends up to form the inside surface of the unexpanded section 8. After inversion in the bending zone 14, the coating layers 400, 402 will be located on the outer surface of the expanded section 10. Thus, the coating will be arranged in the (relatively small) annulus between the expanded section 10 and the wellbore wall.

[0111] When the predetermined fluid in the annulus contacts the swellable layer 400, the swellable elastomer will swell until it engages the wellbore wall. By closing the already relatively small annular gap, the coating 400 provides zonal isolation in the annulus enclosing the expanded tubular element 10. After swelling, the coating 400 fills up the annular space, thereby creating a seal and accomplishing zonal isolation. This zonal isolation will also function while drilling.

[0112] In order to reduce friction forces between the unexpanded and expanded liner sections during the expansion process, a friction reducing layer, such as a Teflon layer, may be applied between the unexpanded and expanded liner sections. For example, a friction reducing coating can be applied to the outer surface of the unexpanded section 8. In Fig. 19, the friction reducing layer will be applied to the side of the sheet material 130 opposite to layers 400, 402. The friction reducing layer reduces the force which is required to evert the liner and to push the unexpanded section into the wellbore. Thus said force is kept further below a so-called critical buckling load, which is the force at which the unexpanded liner will buckle or otherwise fail. Instead of, or in addition to, the friction reducing layer, centralizing pads and/or rollers can be applied in the blind annulus between the unexpanded and expanded sections to reduce the friction and the annular clearance.

[0113] Instead of expanding the expanded liner section against the borehole wall (as described), the expanded liner section can be expanded against the inner surface of another tubular element, e.g. casing or a liner, already present in the borehole.

[0114] Although the embodiments of the invention have been described including a top drive, the present invention is likewise suitable for use with alternative drilling systems. The latter may include for instance a downhole motor instead of a top drive. Said downhole motor is a drilling tool comprised in the drill string directly above the bit. Activated by pressurized drilling fluid, it causes the bit to turn while the drill string does not rotate. Examples of the downhole motor include a positive-displacement motor and a downhole turbine motor. Also, any other drilling tool may be deployed to drill the borehole. Such drilling tool may include, for instance, an abrasive jetting device suspended at the end of a pipe string.

[0115] The present invention is likewise suitable for directional drilling, i.e. drilling wherein the drilling direction can be adjusted. For instance, a downhole motor may be used as a deflection tool in directional drilling, where it is made up between the bit and a bent sub, or the housing of the motor itself may be bent.

[0116] Above, the system of the invention has been described in a U-shape. Another setup may however be possible, such as all equipment (strip supply 220, pipe mill 250, pusher 42 and rig 210) arranged in a straight line, or equipment may be arranged in layers on top of each other (for instance the rig 210 below and the strip supply unit 220 arranged on top of the rig unit 210).

[0117] Also, the system can operate from or on any medium - on land or on a truck, or on an offshore platform or from a dedicated supply vessel (shown in Figure 12). The system can be used to drill and/or line any type of hydrocarbon wellbore.

[0118] For off-shore applications, heave compensation can be achieved via many possible mechanisms, including heave compensation coupled to the gooseneck, e.g. the assembly of guide conduit and support structure, or by compensating and adjusting a floor of the vessel 330 for heave.

[0119] The BHA can be made up either before the pipe mill 250 (in case of a retractable system) or can be made up after the drill pipe 20 extends from the bending zone 14 just before entering the borehole (in case of a non-retrievable bit). Mud pits for supply and discharge of drilling fluid can be positioned right below the flow return system.

[0120] The present invention is not limited to the above-described embodiments thereof, wherein various modifications are conceivable within the scope of the appended claims. For instance, features of respective embodiments may be combined.

Claims

1. A system for expanding a tubular element, the tubular element (4) comprising a wall which is bent radially outward and in axially reverse direction defining an expanded tubular section (10) extending around an unexpanded tubular section (8),

   - an inner surface of the unexpanded section (8) being provided with a coating (400, 402) for zonal isolation.

2. The system of claim 1, the coating comprising multiple layers (400, 402).

3. The system of claim 1 or 2, the coating comprising a swellable layer (402), which is able to swell when contacted by a predetermined activation fluid.

4. The system of claim 3, the activation fluid being selected from water, oil, or gas comprising water vapour.

5. The system of claim 3 or 4, the swellable layer comprising swellable elastomer.

6. The system of claim 3, the swellable layer having a thickness in the order of 1 to 5 mm.

7. The system of claim 2, comprising a first adhesive layer (400) for bonding a second layer (402) to the inner surface of the unexpanded section.

8. The system of claim 3, comprising a wear resistant layer covering and protecting the swellable layer (402).

9. The system of claim 1, an outer surface of the unexpanded section (8) being provided with a lubricating coating.

10. The system of claim 1, the system (200) further comprising:

- a strip supply unit (220) for providing a strip (130) of sheet material;
- pipe production means (250) for folding the strip (130) in a tubular shape to form and extend the unexpanded section (8) of the tubular element (4); and
- a pipe pusher (42) for pushing the unexpanded section into the expanded section to expand the tubular element,
- the coating being provided on the strip (130) of sheet material.

11. The system of claim 1, the system (200) comprising:

- a strip supply unit (220) for providing a strip (130) of sheet material;
- pipe production means (250) for folding the strip (130) in a tubular shape to form and extend the unexpanded section (8) of the tubular element (4);
- a pipe pusher (42) for pushing the unexpanded section into the expanded section to expand the tubular element; and
- coating means, arranged between the strip supply unit and the pipe production means, for applying the coating on the strip (130) of sheet material.

12. The system of claim 11, the coating means comprising application means selected from spray nozzles, a brush, and a roller.

13. Method for expanding a tubular element, comprising the steps of:

- providing a strip (130) of sheet material;
- receiving the strip (130) and guiding the strip along a predetermined trajectory;
- folding the strip (130) in a tubular shape to form and extend an unexpanded section (8) of the tubular element (4);
- bending the unexpanded section (8) radially outward and in axially reverse direction for defining an expanded tubular section (10) extending around the unexpanded tubular section (8); and
- pushing the unexpanded section (8) into the expanded section (10) to expand the tubular element;
- the method comprising the further step of providing an inner surface of the unexpanded section (8) with a coating (400, 402) for zonal isolation.

Fig.1

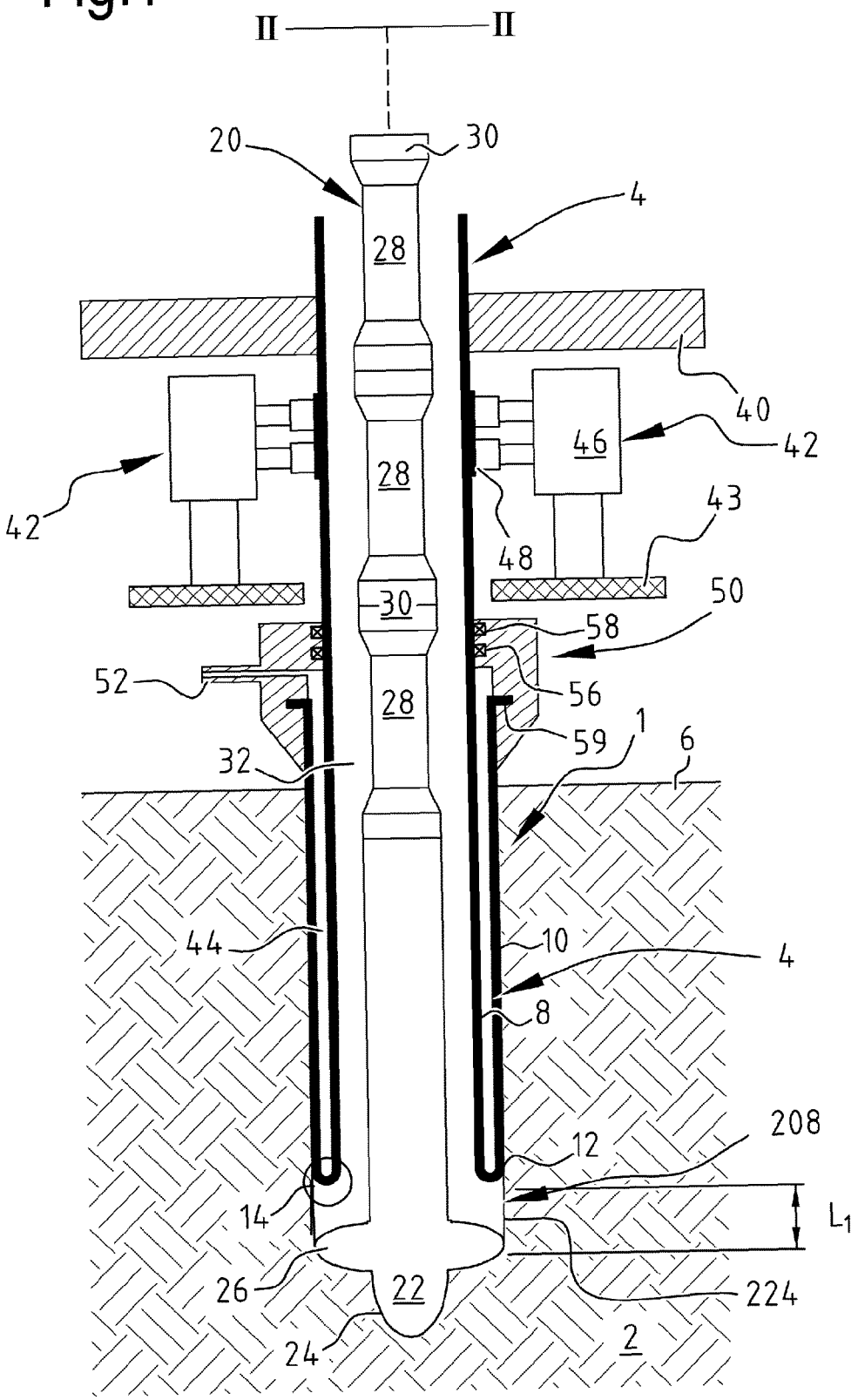

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Fig.2

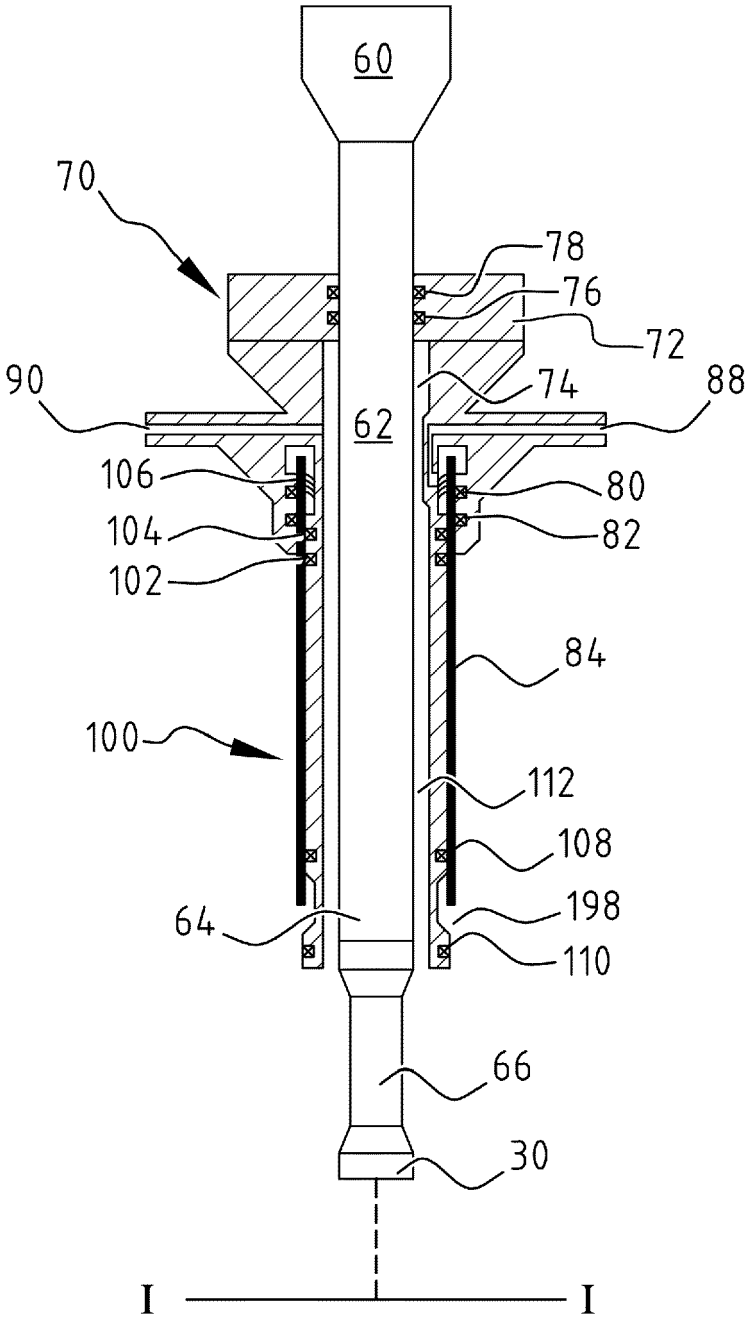
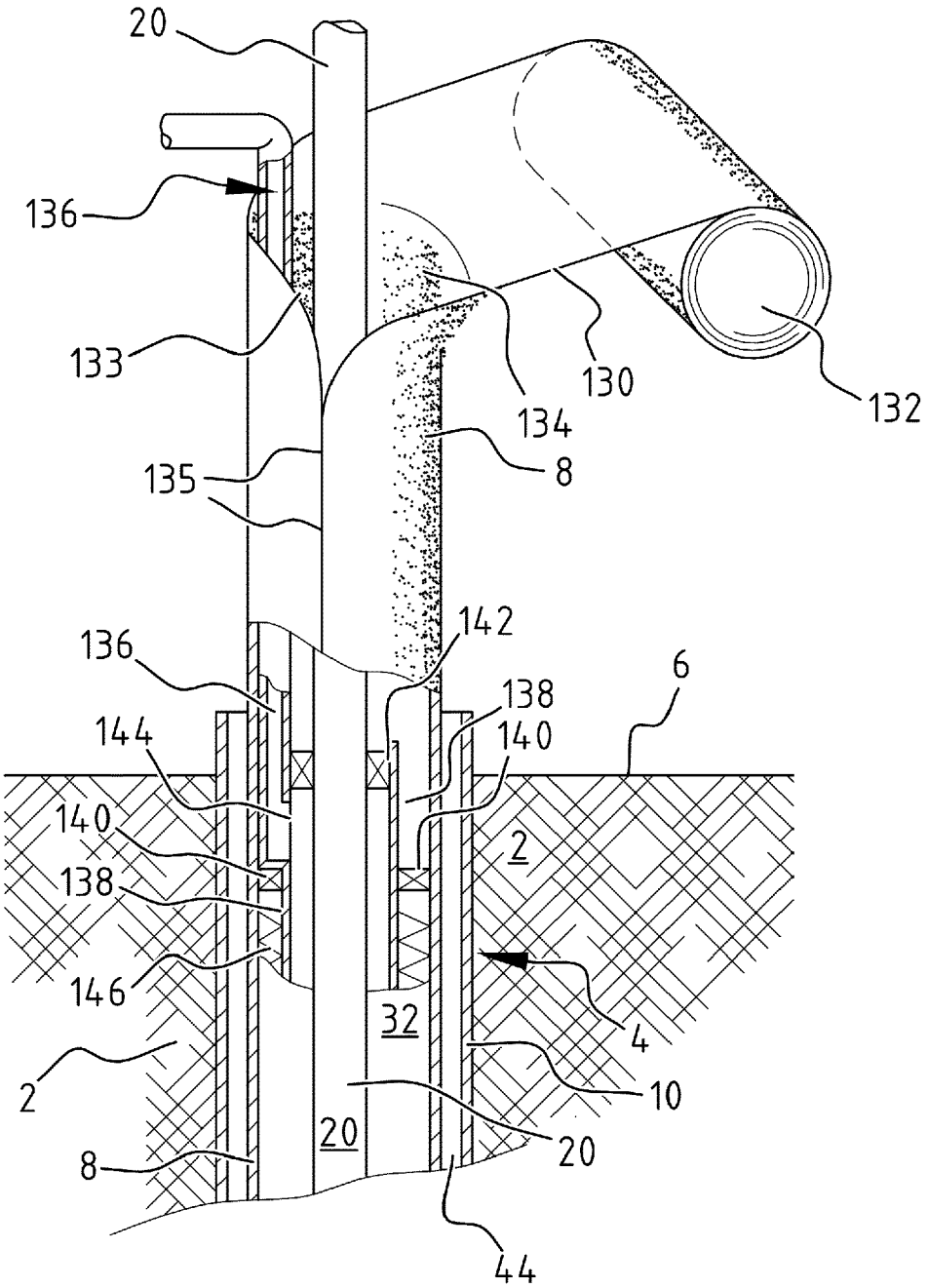

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Fig.3


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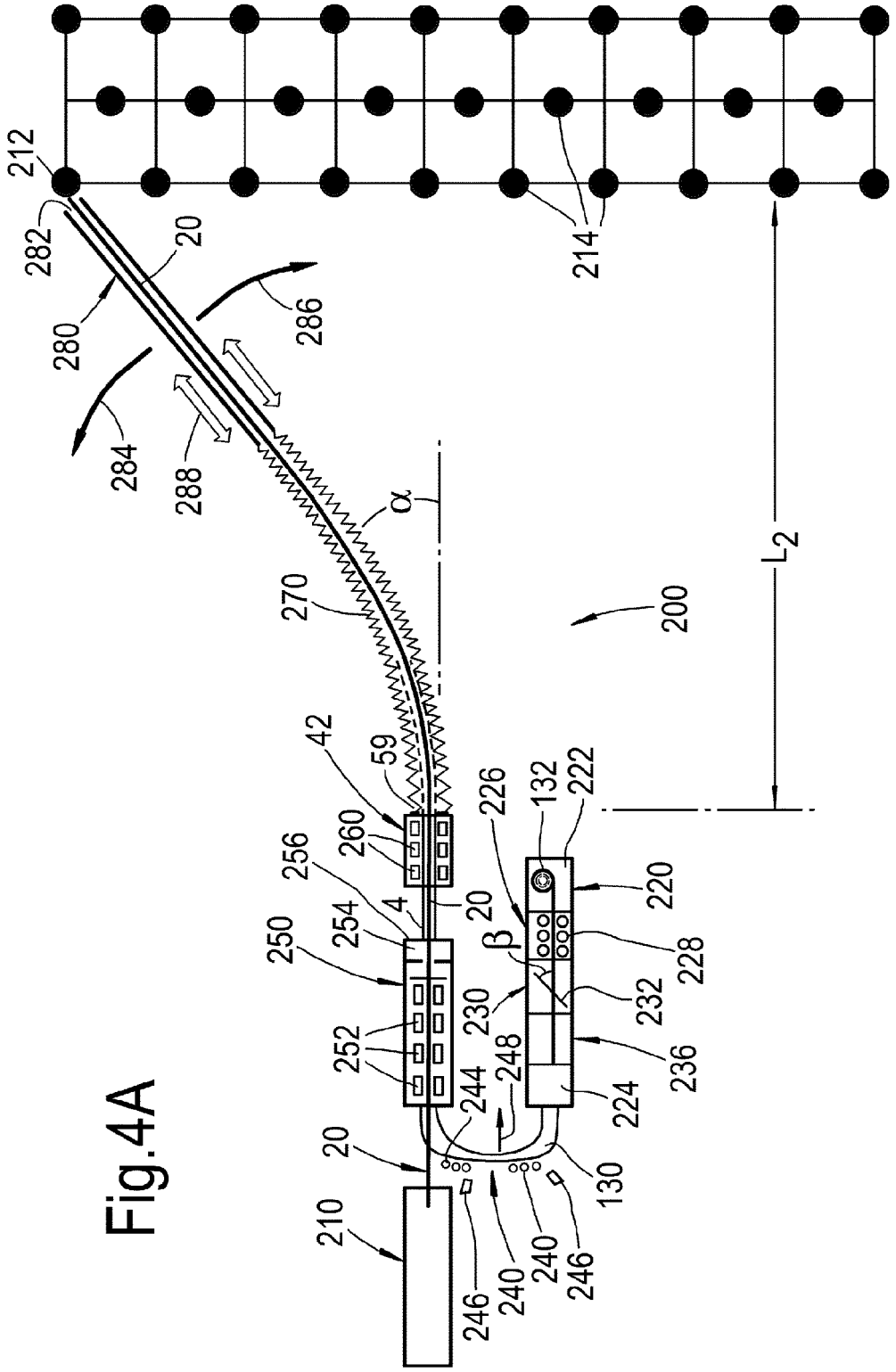

212
282
20
280
286
214
284
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α
270
200
L2
42
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246

Fig.4A

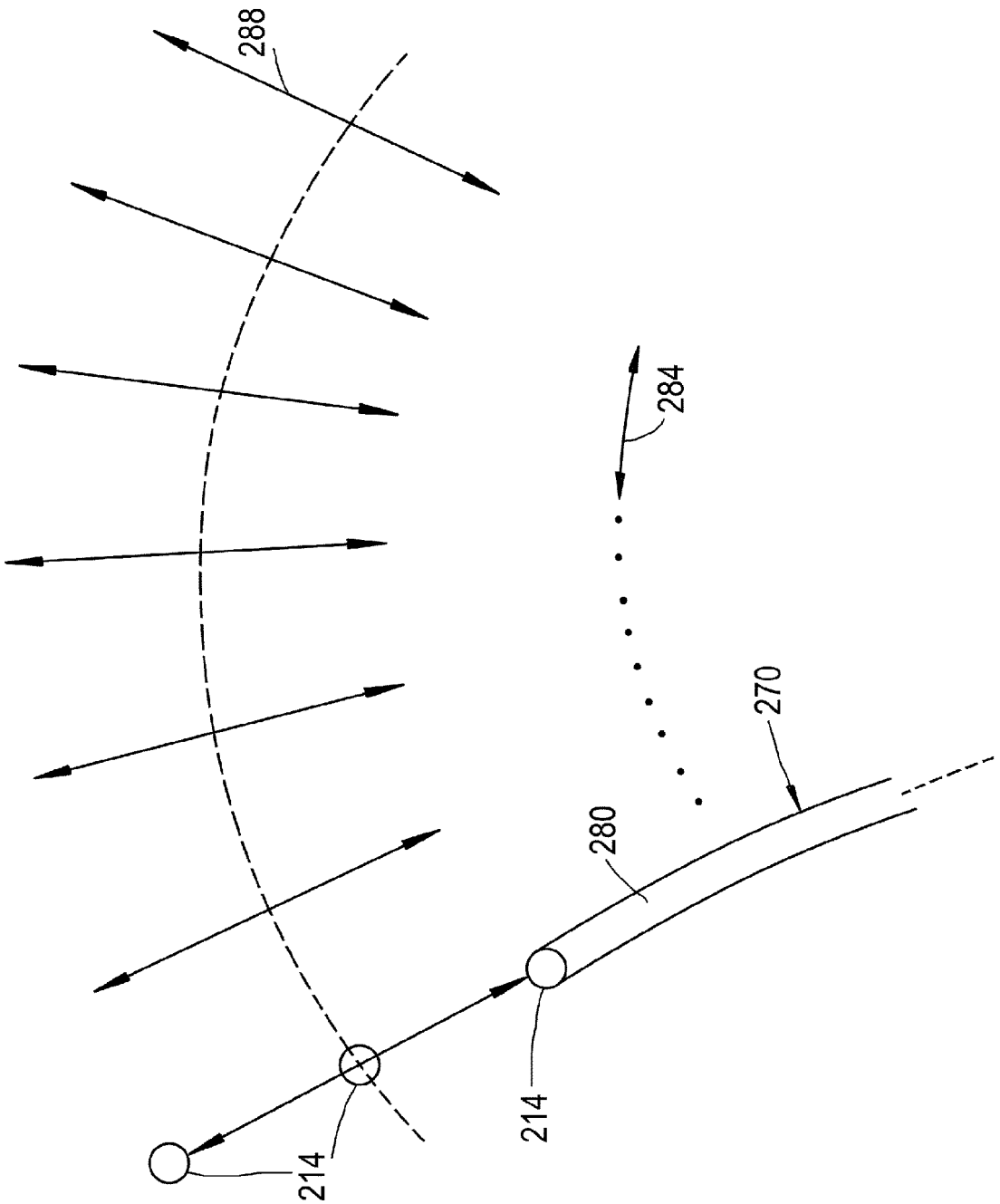


Fig.4B

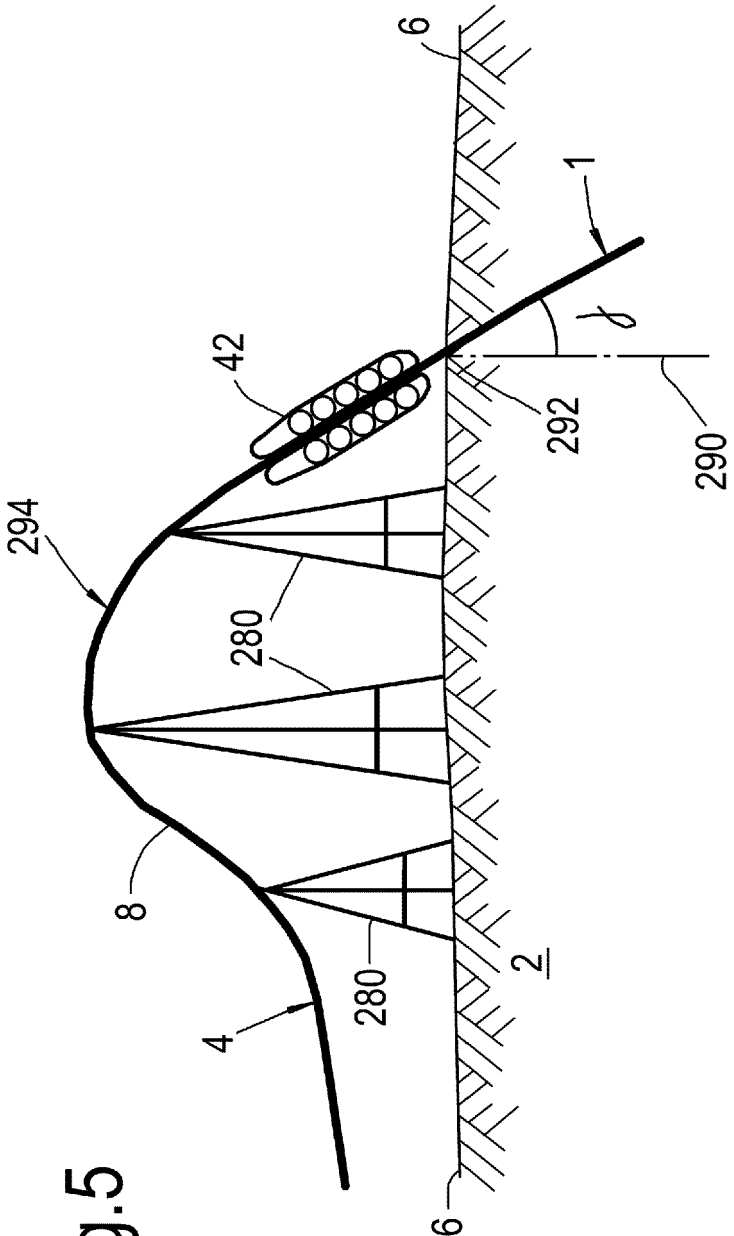


Fig.5

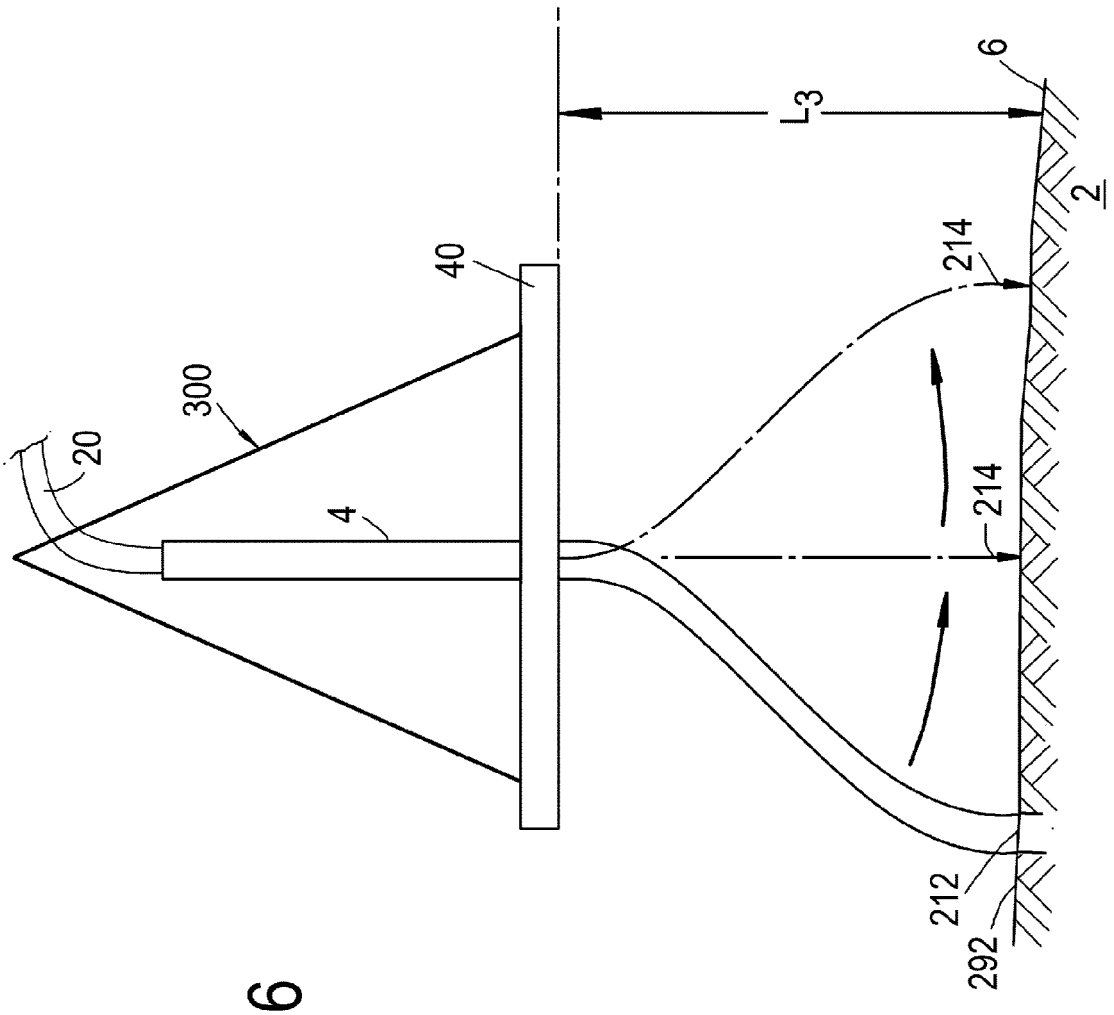
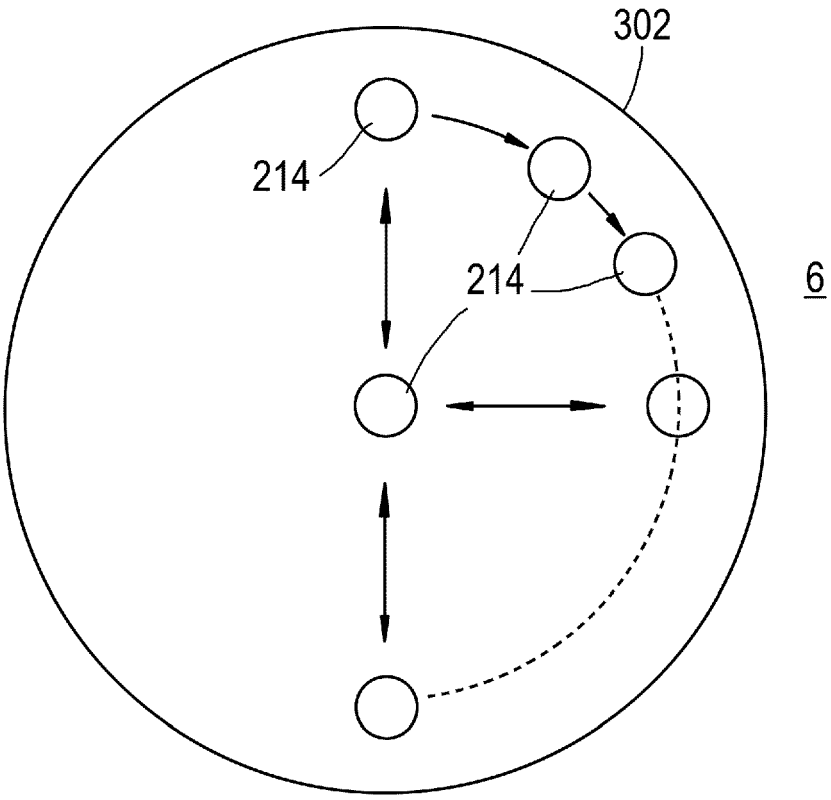


Fig.6

Fig.7



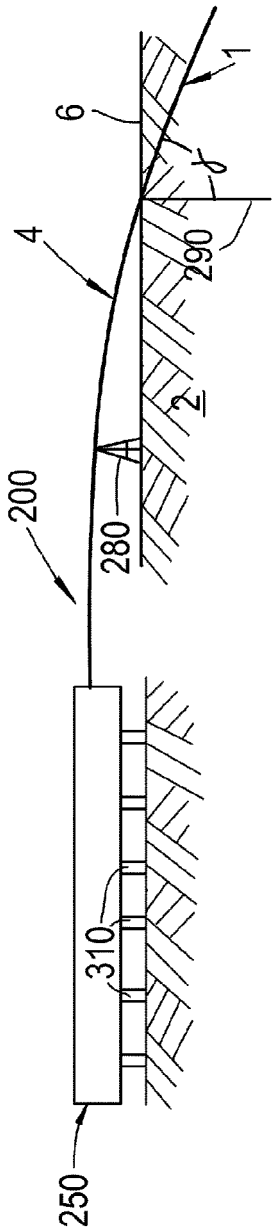


Fig.8

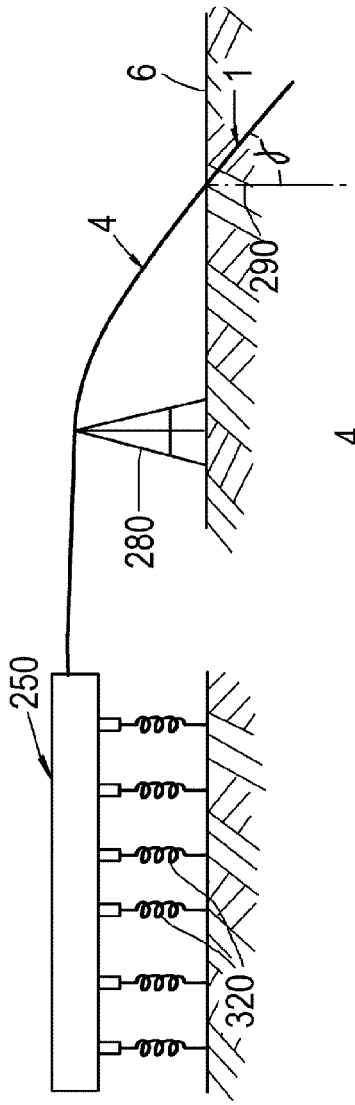


Fig.9

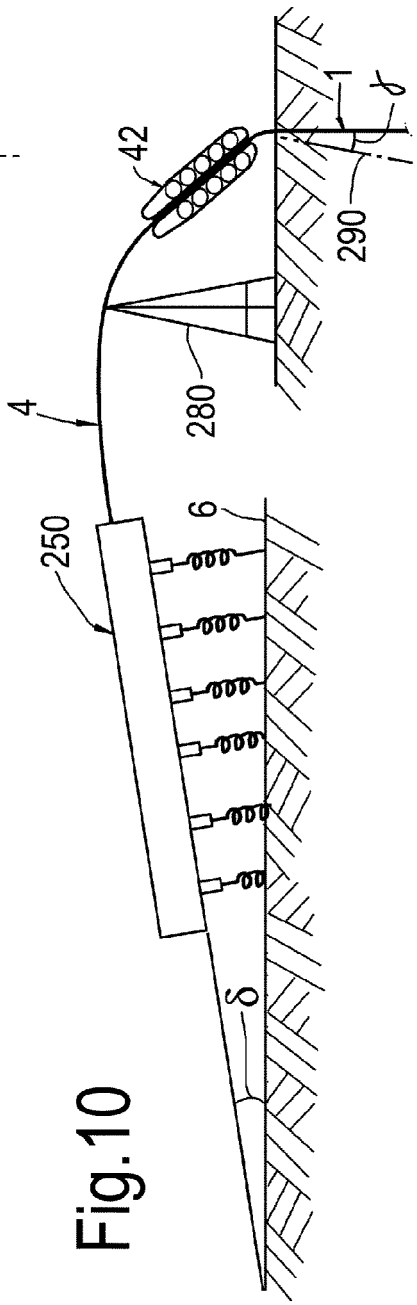


Fig.10

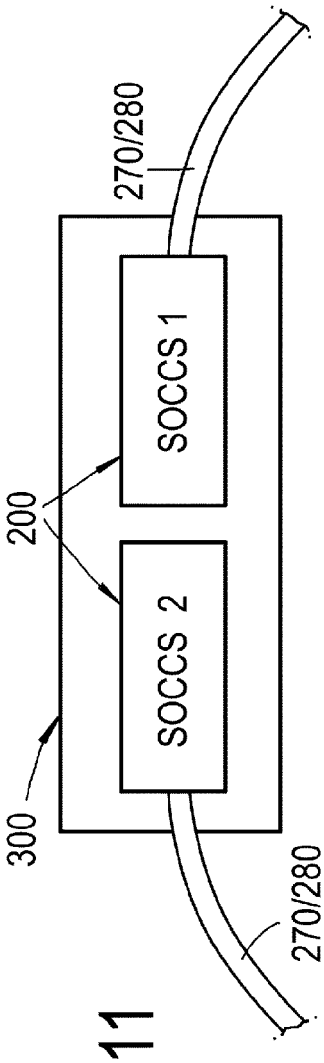

270/280
SOCCS 1
200
SOCCS 2
300
270/280

Fig.11

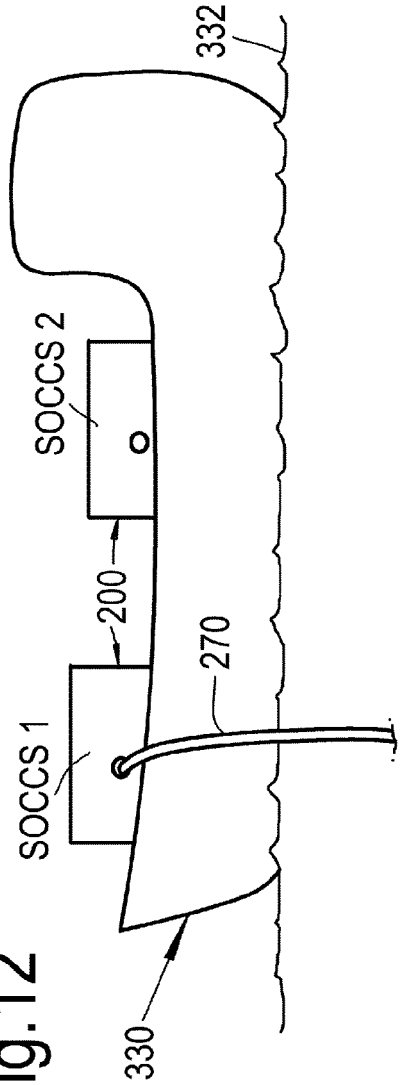

332
SOCCS 2
200
270
SOCCS 1
330

Fig.12

Fig.13

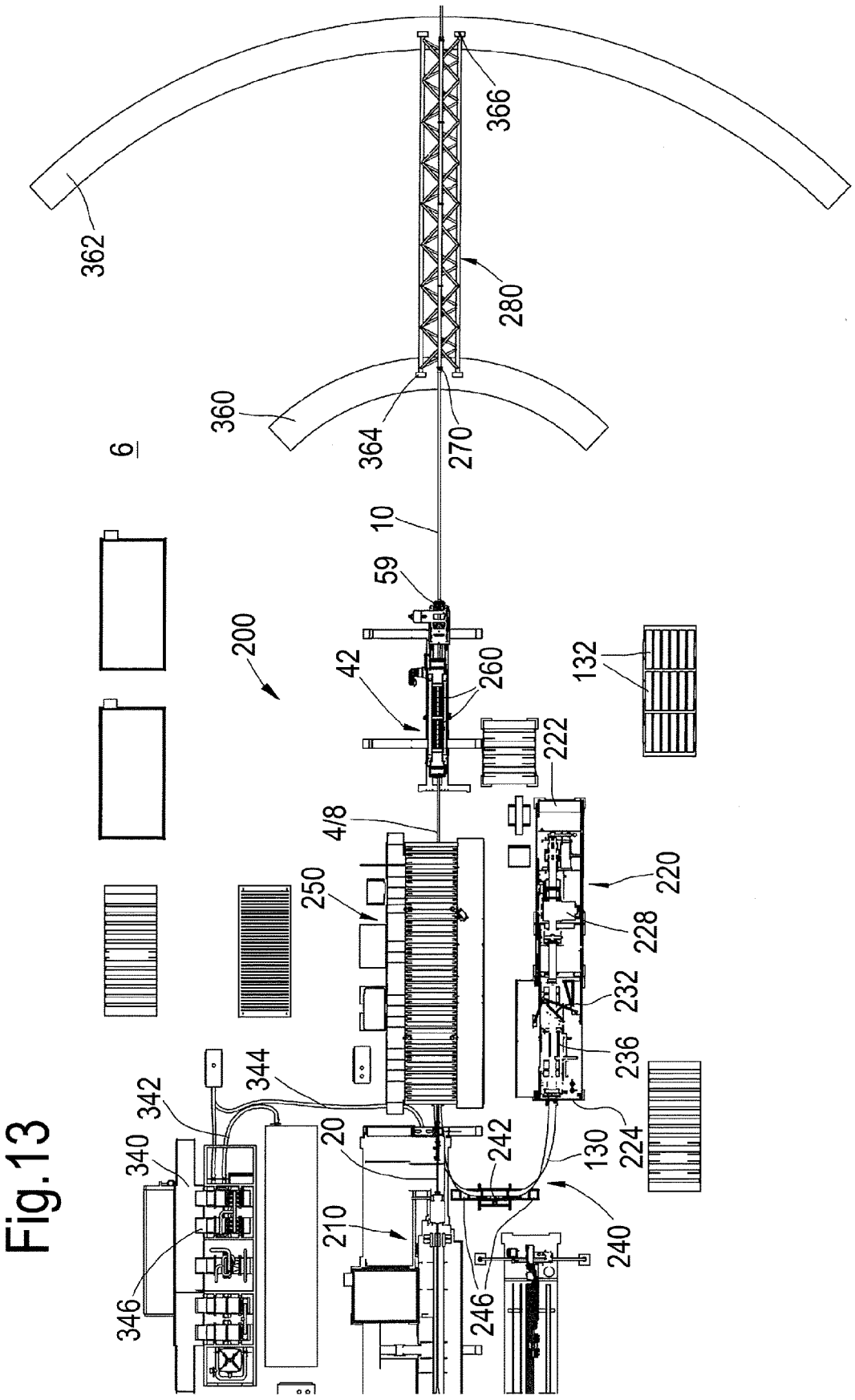

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Fig.14

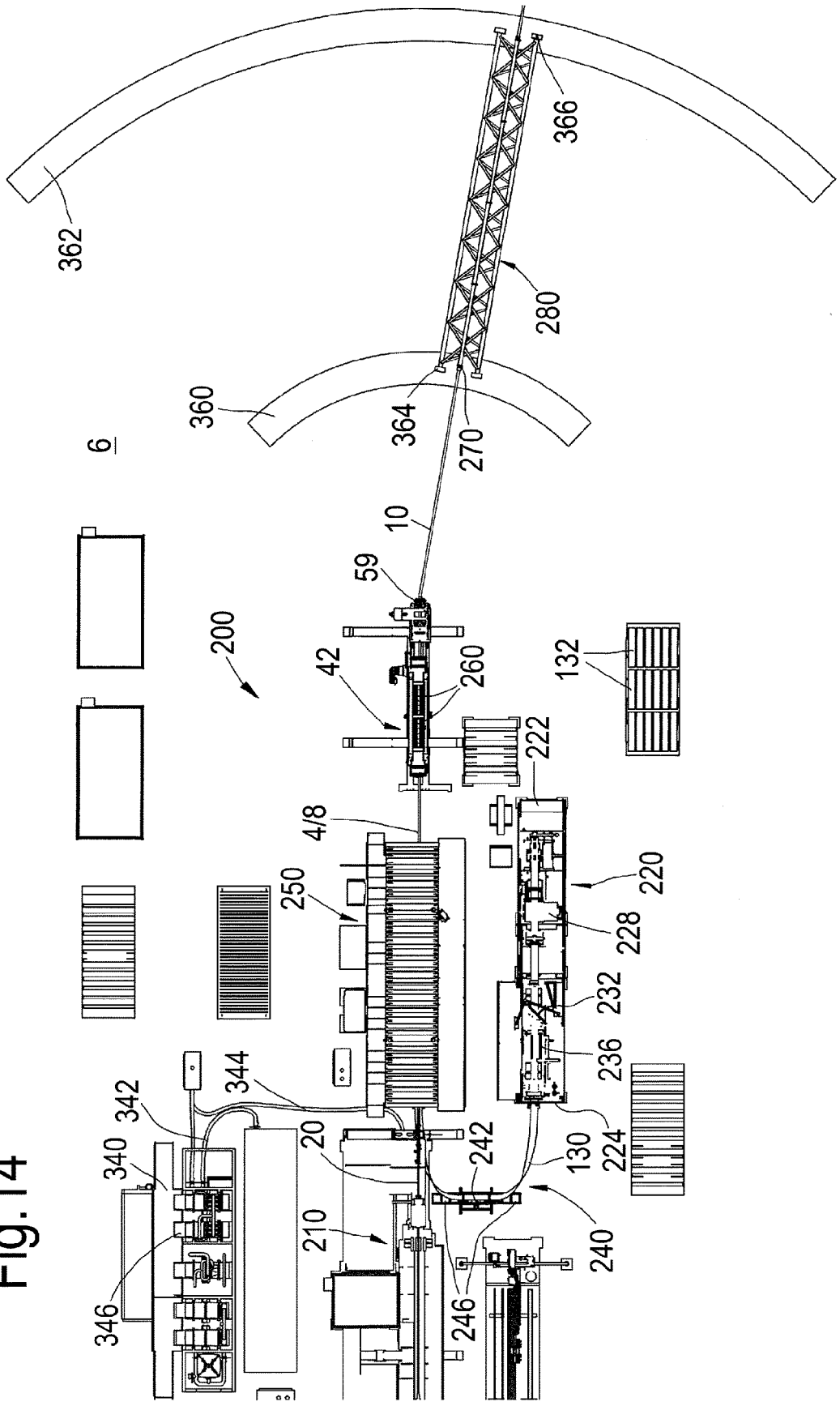

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Fig.15

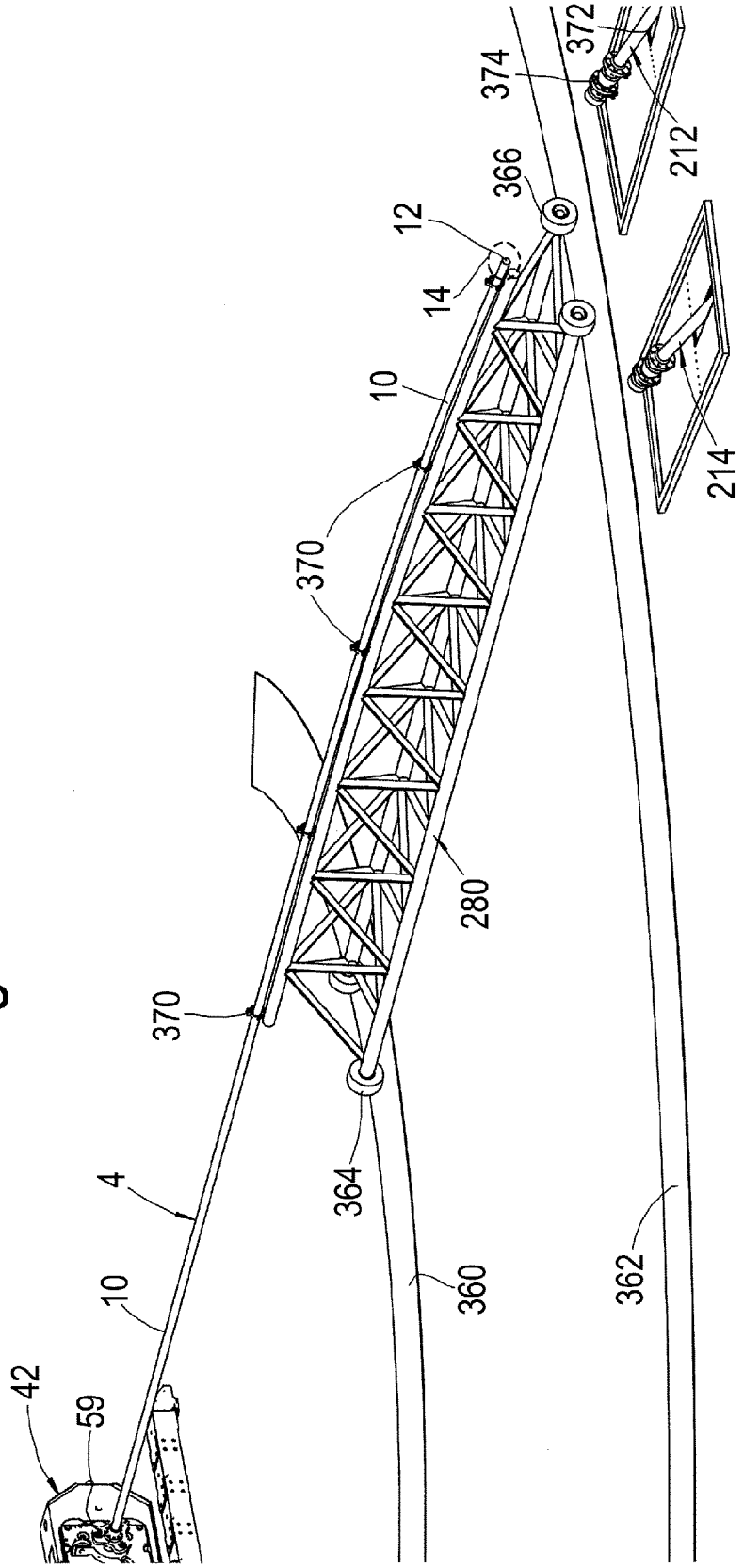


Fig.16

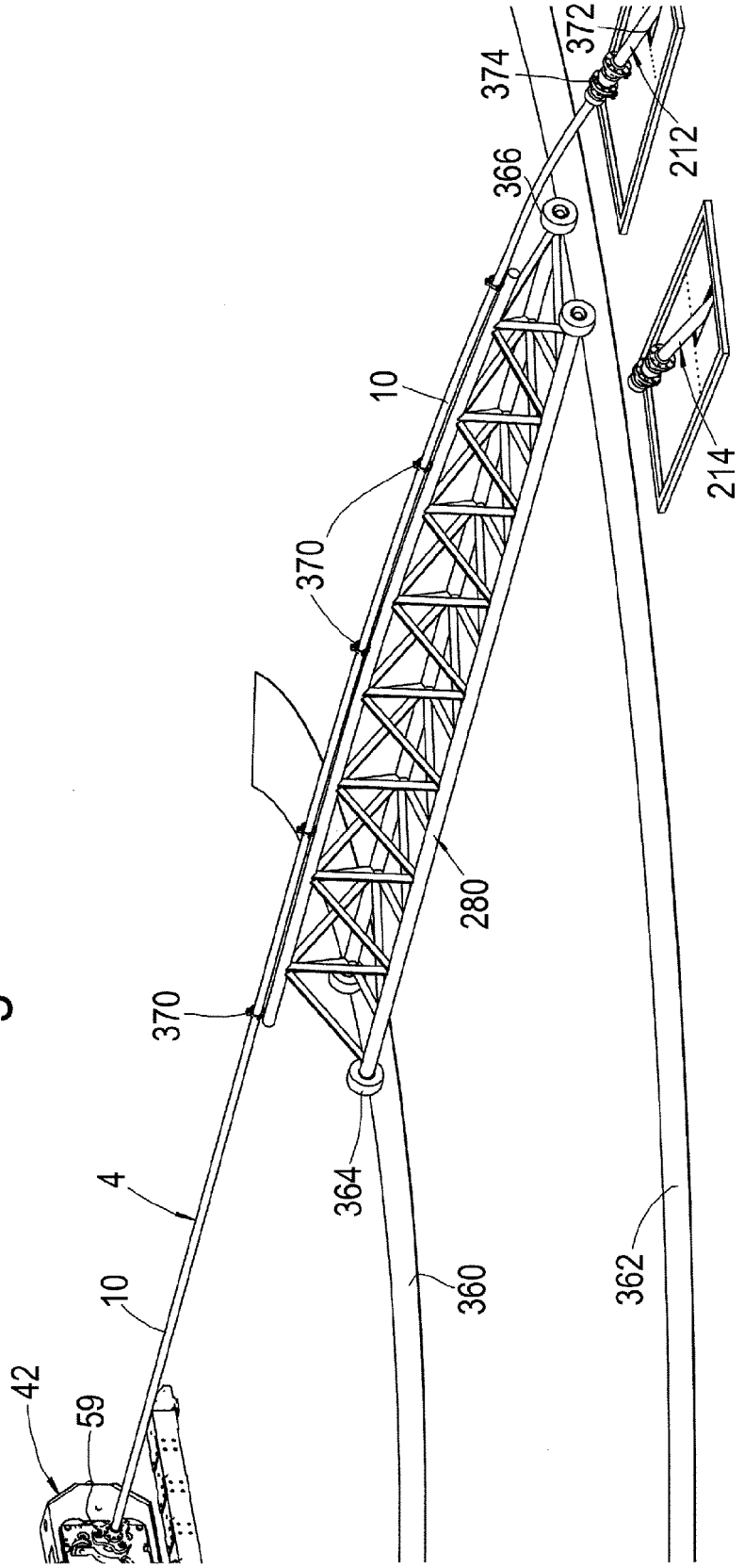


Fig.17

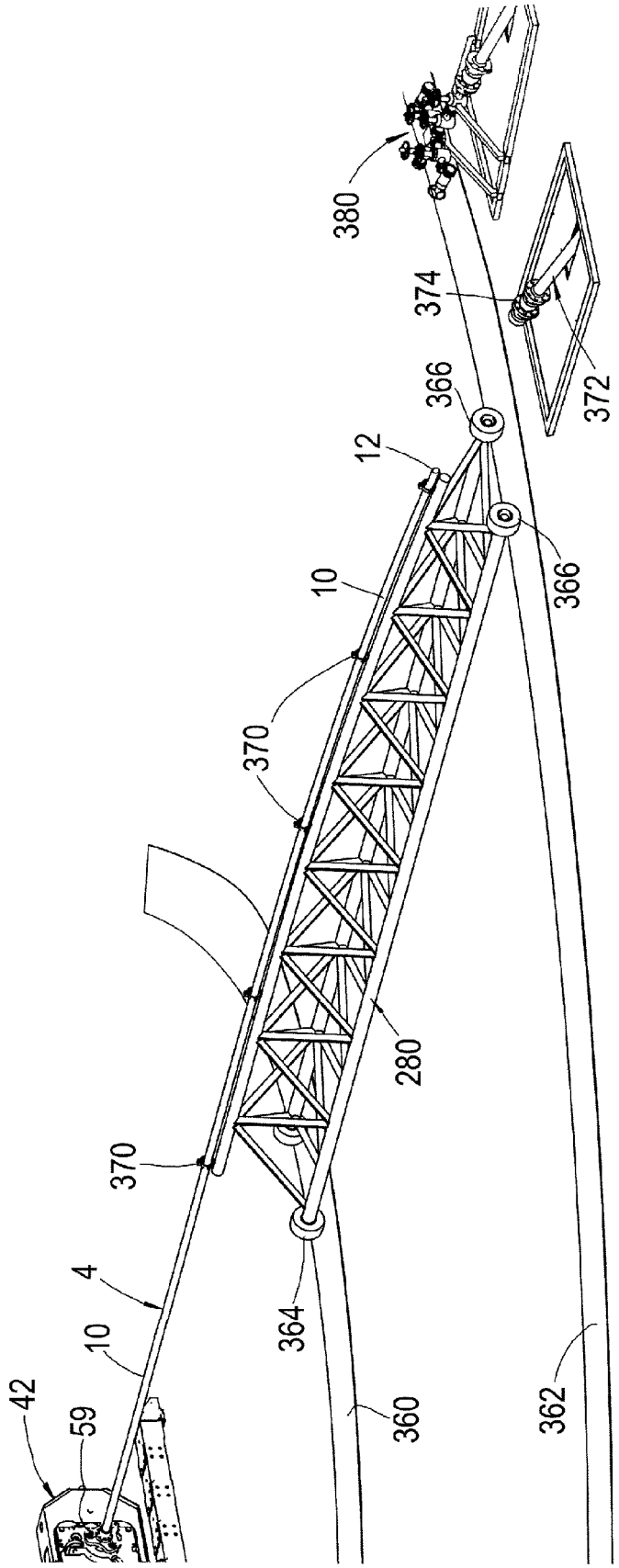


Fig.18

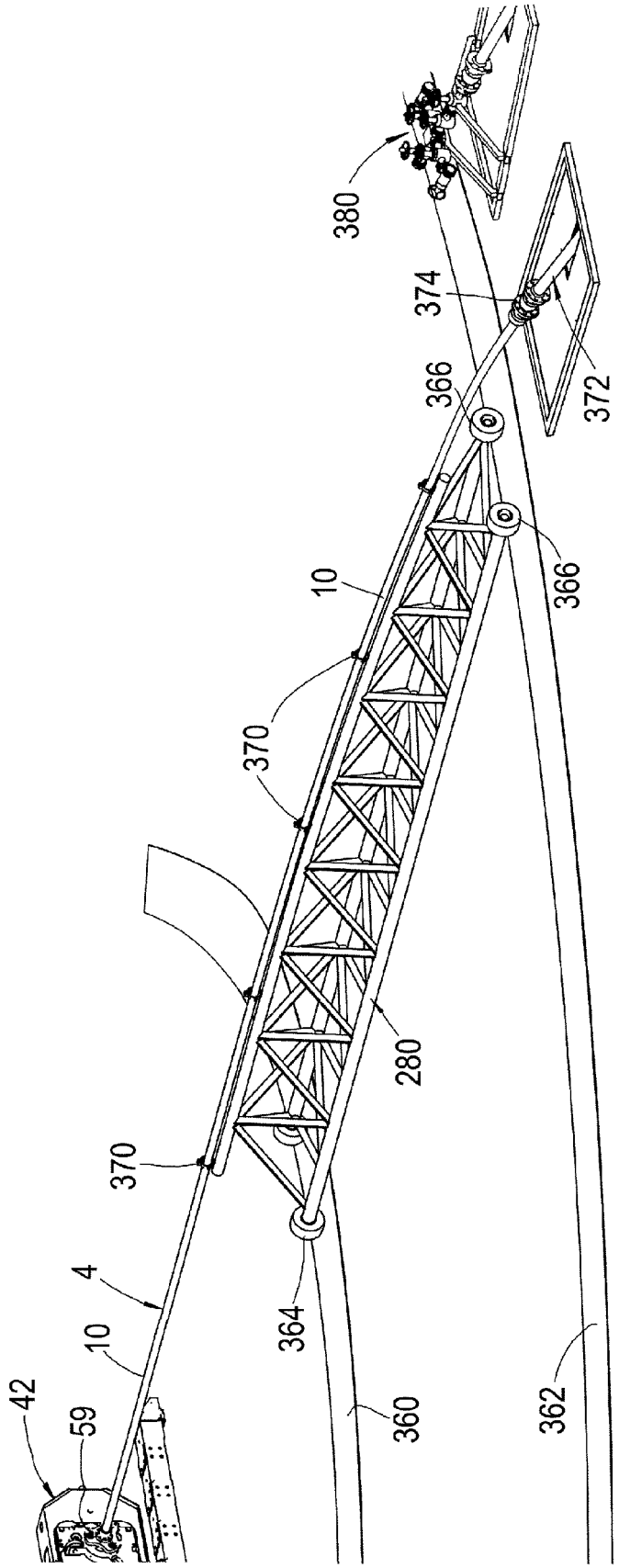
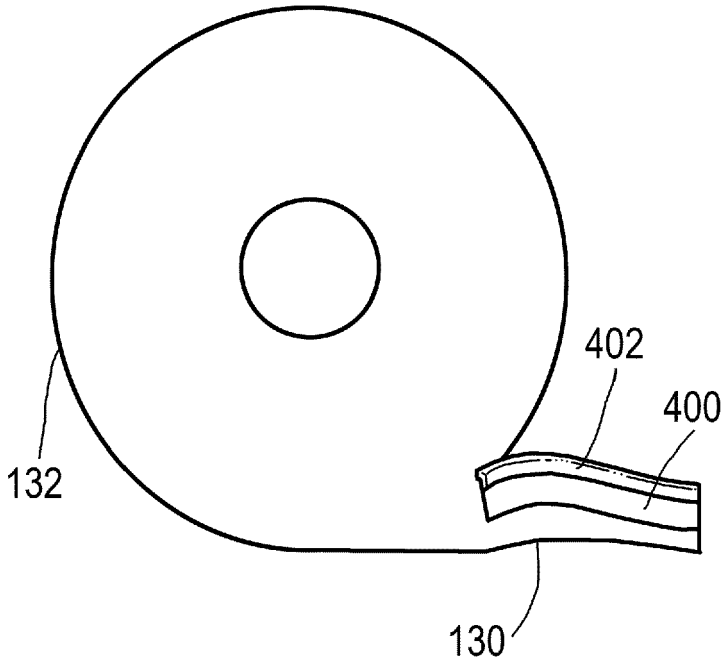


Fig.19



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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 9064

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2012/138314 A1 (KRIESELS PETRUS CORNELIS [NL]) 7 June 2012 (2012-06-07) * paragraphs [0003], [0069] - [0099]; figures 1,4-6 * * the whole document * * a friction reducing coating can be applied to the outer surface of the tubular element before expansion; paragraph [0100] *	1,2,7,9, 10,13 3-6,8	INV. E21B43/10 F16L55/165
Y	WO 2009/087068 A2 (SHELL INT RESEARCH [NL]; VAN NIEUWKOOP PIETER [NL]) 16 July 2009 (2009-07-16) * page 4, lines 4-7; claim 4 * * the whole document *	3-6,8	
X A	GB 2 302 153 A (WRC PLC [GB]) 8 January 1997 (1997-01-08) * cementitious coating; figures 1-3 * * the whole document *	1 3-6	
X A	WO 93/08367 A1 (INSITUFORM GROUP LTD [GB]) 29 April 1993 (1993-04-29) * page 3, lines 10-23; claim 6 * * page 6, lines 10-28 *	1 3-6	TECHNICAL FIELDS SEARCHED (IPC) E21B F16L
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~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
The Hague	17 August 2015	van Berlo, André

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 9064

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
The Hague	17 August 2015	van Berlo, André

CATEGORY OF CITED DOCUMENTS

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A : technological background
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Application Number
EP 14 19 9064

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-10, 13

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 14 19 9064

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-10, 13

   Expanding a tubular element

   ---

2. claims: 11, 12

   Coating means

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 19 9064

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17-08-2015

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