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(54) **METHOD FOR DRILLING OIL AND GAS WELLS**

VERFAHREN ZUM BOHREN VON ÖL UND GASBOHRLÖCHERN

PROCEDE DE FORAGE DE PUITS DE PETROLE ET DE GAZ

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Description

[0001] The present invention relates to a method and apparatus for drilling oil and gas wells. In particular, the invention relates to a method and apparatus for opening a window in a well bore to initiate a lateral well bore and for drilling a well bore through such a window.

[0002] When drilling or completing an oil or gas well, it is often desirable to drill a borehole at an angle to the initial, substantially vertical, borehole. For example, it may be necessary to establish a new drilling course for directional or horizontal drilling, or it may be necessary to sidetrack the original borehole to avoid a section of damaged bore, junk in the hole, or other negative well conditions.

[0003] In order to initiate or "kick-off" a deviated well, it is necessary to deflect the drilling tool through the wall of the initial well bore. A deflecting tool known as a "whipstock" has been known and used for many years to achieve the deflection of the drilling tool. Whipstocks can be used in both cased and open hole. Where the initial well bore is cased, a window is first milled in the casing and then the drilling tool is deflected through the window to drill the lateral well. Although other methods, such as the use of bent subs and mud motors have been developed, whipstocks are still widely used to deflect the milling and drilling tools to kick-off lateral wells. Some whipstock designs are intended to be left downhole, whereas others are designed to be retrieved.

[0004] The standard whipstock is generally an elongate tool, typically about 3m to 6m long, which has the general cross-sectional shape of a right triangle. The short base of the right triangle is the bottom of the whipstock in the well bore. An upstanding back surface intersects the base at essentially a right angle. The hypotenuse is the gently sloping guide surface of the whipstock which is designed to direct the well tools into a direction which is at an angle to the longitudinal axis of the initial well bore.

[0005] To be effective, the whipstock must be positioned and secured in the well bore at the required location and orientation. A whipstock can be set on the bottom of the initial well bore, or on top of a suitable anchor or cement plug. Some designs of whipstock may be used in the open hole. The upstanding back surface of the whipstock may rest on the wall of the well bore or the casing lining the well bore. When secured in this manner the whipstock provides a stable platform for guiding the mill or drilling tool.

[0006] A common problem with known whipstocks is that the starter mill or drill can damage the whipstock, adversely affecting the drilling of the lateral. In some cases the attempt to drill the lateral may have to be abandoned and begun again at a different, usually higher, location in the initial well bore. This will entail significant cost and loss of time.

[0007] Sometimes the interior of the initial well bore has one or more restrictions along its length that reduce the cross-sectional area of the wellbore. For example, the well bore may have a string of production tubing that is carried concentrically within the main wellbore and that is of a smaller internal diameter than the wellbore or any casing lining the wellbore. Typically, the wellbore has an internal diameter of about 5 inches (12.7 cm) to about 10 inches (25.4 cm), for example 7 inches (17.8 cm) and the production tubing has an internal diameter of about 2.5 inches (6.4 cm) to about 6 inches (15.2 cm), for example 4.5 inches (11.4 cm). This means that any tool that is passed down the interior of that well bore, including a whipstock, has to be small enough in cross-section to pass through the restriction in order to reach lower levels in the wellbore. This is called through-tubing operations in that any well operations that are to be carried out in the well bore below the end of the production tubing require the equipment to be passed through the interior of the production tubing before it can reach the area where the well operation is to be carried out. The alternative would be to remove the production tubing in its entirety from the well bore, which is an expensive and time consuming process. Thus, it is very desirable to be able to pass well tools that are to be used in well operations through the interior of the smaller diameter production tubing down below the end of that tubing into the larger diameter wellbore and then carrying out well operations with those tools in that larger area of the wellbore.

[0008] Unfortunately, some tools that are made small enough to pass through restrictions such as production tubing do not operate as well in the larger diameter well bore area below the end of the production tubing and this includes whipstocks. This is because the small tools do not adequately take up the space afforded by the larger well bore area. In particular, the upstanding back surface of the whipstock may not be adequately supported. Some through-tubing whipstocks are set diagonally across the larger diameter bore hole and so only the top section rather than substantially the full length of the back surface is in contact with the wall or casing opposite the wall in which the window is to be milled and the bottom of the guide surface of the whipstock is positioned against the wall into which the window is to be milled. In this position, the whipstock may flex or bend when contacted by the milling or drilling tools, which can result in the mill or drill jumping off the guide surface of a whipstock. Some designs of whipstock have hinged sections that can be opened after the whipstock has been passed through the restriction to provide improved support for the whipstock. However, these more complex devices may still provide insufficient guidance to the milling and drilling tools. Sometimes the through-tubing whipstock can slip within the hole and as a result may provide inadequate guidance to the milling and drilling tools.

[0009] The present invention relates to an alternative method of initiating or drilling a lateral well and more specifically to a method that can be used in the larger diameter area of a well bore below the end of a restriction through which the tools must pass.

[0010] The term "side track well" is sometimes used to describe a branch from an existing wellbore where the existing wellbore no longer produces hydrocarbon fluid and the term "lateral well" is sometimes used to describe a branch from an existing wellbore where the existing wellbore continues to produce hydrocarbon fluid. The present invention can be used in any wellbore from which a second, branched, wellbore is to be drilled. References herein to lateral wells or bores should be understood to include any such wells, whether or not the existing well continues to produce. Indeed, should the need arise; the invention could be used to drill a lateral well in an injection well.

[0011] Thus, according to the present invention, a process for deflecting a well tool towards the wall of a well bore comprises positioning within the well bore a radially expandable pipe, which has over at least part of its length an asymmetrical wall thickness, designed to curve longitudinally when its diameter is expanded, expanding the diameter of the radially expandable pipe thereby causing the pipe to curve, due to the asymmetric wall thickness, and passing the well tool through the curved pipe.

[0012] The present invention is particularly suitable for through-tubing operations and includes a process for initiating a lateral bore from a production well having within the well a smaller diameter production tubing comprising (i) passing through the production tube a radially expandable pipe, which has over at least part of its length an asymmetrical wall thickness, designed to curve longitudinally as its diameter is expanded, into a section of well bore having a diameter greater than the diameter of the production tubing (ii) expanding the diameter of the radially expandable pipe thereby causing the pipe to curve, due to the asymmetric wall thickness, (iii) passing through the curved pipe a milling device or drill bit and (iv) milling the casing or drilling into the well bore wall.

[0013] The milling device or drill bit may be attached to the lower end of a drill string or may be used at the end of a wireline. The present invention can be used with remotely controlled drilling devices. Such devices are known. For example, US Patent 6,305,469 and PCT Patent Application WO 2004/011766 disclose methods for drilling a wellbore using a remotely controlled drilling device. By controlling stabilisers for the remotely controlled drilling device, the drill bit can be tilted in the wellbore to start drilling a curved wellbore section. The drilling device may be provided with a remotely operable steering means, for example, a steerable joint, which can be used to adjust the trajectory of the new wellbore section as it is drilled.

[0014] The present invention includes a radially expandable pipe for use in the process, which has over at least part of its length an asymmetrical wall thickness. It is known from DE8626975 to cold-form bends in hollow sections of non-ferrous metals and their alloys wherein the wall thickness of the hollow section that will form the outer part of the bend is greater than the wall thickness of the hollow section that will form the inner part of the bend.

[0015] The asymmetrical wall thickness can be provided by any known method. For example, the pipe may be manufactured by rolling or extrusion such that the wall thickness is not symmetrical over at least a portion of the pipe. The asymmetry may be provided by machining the internal or external surfaces of a pipe that initially has a substantially uniform wall thickness. Suitable material may also be fixed to the external surface of the pipe to provide a thicker wall.

[0016] The radially expandable pipe is generally made of steel and any material fixed to the outer surface is also preferably steel. Suitably, the pipe comprises a steel pipe of substantially uniform wall thickness and at least one length of steel is securely attached to the outer surface of the steel pipe. Conveniently, the length of steel may be attached to the pipe by welding around all or part of its periphery. The length of steel may be of any shape but preferably comprises a cylindrical section having an internal surface which is an arc of a circle having a central angle of from about 2 to about 160 degrees, typically from about 2 to about 20 degrees or 5 to about 20 degrees, and a radius which is substantially the same as, or slightly larger than, the external radius of the pipe. The length of steel attached to the pipe may be of substantially uniform thickness. In this case, there will be a step change in the wall thickness. It is preferable that the wall thickness gradually increases and decreases around the pipe. The length of steel welded to the pipe may therefore preferably be crescent shaped in cross-section.

[0017] The asymmetric wall thickness may extend along the whole length of the pipe or only a part of the length.

[0018] The relative thicknesses of the wall of the pipe and the length of the asymmetry are selected to achieve the desired curvature in the pipe as it is expanded. Since the pipe is to be curved down the well bore, it must be designed such that expanding the pipe to the desired internal diameter results in the desired curvature without exerting unacceptable stresses on the well bore. For example, in an uncased wellbore, it may be undesirable if the expansion would result in a greater curvature of the pipe, but for the limitations of space in the well bore, resulting in the walls of the well bore being put under compressive stress, as this could result in damage to the formation.

[0019] The person skilled in the art could readily determine the design of the pipe that will provide the appropriate curvature on expansion of the pipe. This may require some trials with pipe of the size and material to be used. When drilling a deviated well, the amount of deviation from the vertical may typically be of the order of 1 or 2 inches (2.54 to 5.08 cm) per 10 feet (3m) of depth, i.e. the angle of deviation of the lateral bore may be of the order of about 0.4 to about 1.0 degree although greater or smaller deviations may be used in some applications.

[0020] Expandable pipe for use in oil and gas wells is known. For example, it is known to position pipe downhole and then expand it. This technology is used, for example, in producing monobore casing or production tubing where a tubing string of smaller diameter is lowered through wider diameter tubing and then expanded to substantially the same diameter as the wider diameter tubing. The use of expandable pipe to create zonal isolation is disclosed, for example, in US6070671 which specifically describes creating zonal isolation in an existing well casing, including creating a mono-diameter well. Also disclosed is the insertion of an expandable tubular into an existing lateral borehole.

[0021] Any of the known methods for expanding pipe may be used in the present invention such as by urging a mandrel or conical expander through the pipe or using a system of rolling the pipe using balls or rollers, which are urged outwardly against and rotated around the inner surface of the pipe. An example of the latter type of expanding apparatus is disclosed in US Patent Application Publication US 2001/0045284. When a pipe is expanded using a mandrel forced through the pipe, the diameter of the pipe may be typically increased by about 10 to 20 % and the overall length reduces by about 5%. Whereas, when the expansion is achieved using rotating balls or rollers, an expansion of about 10 to 20% in diameter is accompanied by an increase in the overall length of the pipe of about 5%.

[0022] Due to the asymmetric wall thickness of the expandable pipe the pipe expands preferentially where it is less thick. This causes the pipe to become curved.

[0023] The expandable pipe may be oriented before or after expansion, but is preferably oriented before expansion. Known techniques can be used to orient the pipe within the well bore so that after expansion the curved pipe will direct the well tools in the desired direction.

[0024] Preferably spacers are used to support the curved pipe in the well bore. Spacers are therefore preferably positioned around the circumference and along the length of the curved pipe. Suitable spacers are known and include, for example, bow spring centralizers.

[0025] The upper end of the curved pipe is preferably centralised and held securely within the well bore. Suitable spacers to achieve this would be substantially cylindrical and expand substantially symmetrically around the circumference of the pipe. However, in order to support the curved pipe in the substantially straight hole, the supports along the length of the curved pipe will have to bridge a wider gap at one side of the curved pipe than at the other. Thus, the radially expandable pipe preferably has spacers that are designed to expand asymmetrically about the centre of the pipe. This could be for example, a substantially cylindrical spacer having elements that are designed to expand asymmetrically about the centre of the pipe. The invention includes a radially expandable pipe having a plurality of spacers positioned along the length and around the circumference of the radially expandable pipe such that when the pipe is expanded the spacers expand to different radial lengths to hold the curved pipe in place within the well bore.

[0026] The invention includes a radially expandable pipe having at least one spacer positioned along its length the spacer comprising a deformable elongate member having a first end and a second end, each of said ends being attached to the radially expandable pipe such that as the pipe is expanded the change in the length of the pipe deforms the elongate member so that it projects radially from the centre of the pipe. The amount of radial expansion required for the spacer will depend on the location in which it is to be used. An expansion of up to and in some cases exceeding 80% of the initial radial length may be desired for the spacer. For example, in order to be capable of passing through a 4.5 inch (11.4 cm) internal diameter production tubing, the radial length of the radially expandable pipe and spacer would be about 2 inches (5 cm) and in order to support the pipe in a 7 inch (17.8 cm) internal diameter casing, the expanded radial length would be about 3.5 inches (8.9 cm); an expansion of about 75% of the original radial length.

[0027] The outer surface of the spacer may be provided with means to improve the grip with the casing or wellbore wall after expansion. For example, the outer surface may be shaped, coated or treated to provide a rough surface. A suitable surface can be provided by thermally spraying the surface with a metal carbide.

[0028] The deformable elongate member can be a bow spring attached at each end such that a reduction in the length of the pipe, such as occurs when the pipe is expanded using a mandrel, forces the ends towards each other and the bow spring bows outwardly. The bow spring can initially lie substantially flat against the surface of the pipe. This facilitates movement of the expandable pipe down the well and into position. Expansion of the pipe causes the bow spring to expand and engage the wall of the well bore or the casing of the well.

[0029] Preferably, the spacer comprises a plurality of bow springs arranged around the circumference of the radially expandable pipe. The bow springs can be attached together at the ends to form a substantially cylindrical cage structure. By selecting.different shapes, lengths, thicknesses and/or materials, the bow springs can be made to bow more or less for the same reduction in length of the expandable pipe. The bow spring must be made of material and designed to provide sufficient stiffness to provide support for the expanded pipe.

[0030] In another embodiment, the deformable elongate member can be an articulated element, each end of which is attached to the expandable pipe such that an increase in the length of the pipe, such as occurs when the pipe is expanded using a rolling ball or roller expander, causes the ends of the deformable elongate member to move away from each other and the articulated member moves from a first position close to the surface of the expandable pipe to a second position which is radially extended from the centre of the pipe. For example, the articulated element may be a folded element that is a single piece of material folded to form the folded element. Another embodiment of the articulated element comprises two or more pieces of material fixed together to form the articulated element. The articulated element may have a joint towards one or both ends and/or along its length. An example of a suitable articulated element comprises a length of material folded into two unequal legs and attached by the end of each leg to the expandable pipe such that in cross-section, the external wall of the pipe and the two legs of the deformable elongate member have the form of an obtuse triangle. The obtuse angle is preferably greater than 120 degrees in order that in the first position, the articulated element lies close to the wall of the pipe. A similar articulated element comprises two lengths of material fixed together at one end and the other ends are attached to the pipe.

[0031] A person skilled in the art will readily be able to select or design one or more spacers that will support the curved pipe in the well bore.

[0032] The process according to the present invention is particularly suitable where it is necessary to pass the well tools required to initiate and drill a lateral well through the interior of a smaller diameter production tubing down below the end of that tubing into the larger diameter well bore and then carrying out the initiation or drilling of the lateral well with those tools in that larger area of the well bore. The radially expandable pipe is lowered down the well bore, through the smaller diameter production tubing and down into a cased or open hole of greater diameter. The radially expandable pipe can be centralised within the larger diameter well bore, using suitable centralising equipment. Means for expanding the radially expandable pipe are introduced into the interior of the pipe and the pipe expanded. The pipe can conveniently be expanded to substantially the same as the internal diameter of the last section of the production tubing. As it expands, the asymmetric wall thickness causes the pipe to curve. Spacers can be provided to support the pipe within the well bore. These can be of the type described above that arc fixed to the pipe and are deployed as the pipe is expanded. Optionally, the spacers initially support the pipe centrally, but are distorted as the pipe expands and curves.

[0033] In an embodiment of the invention, a window is first milled in the casing and then the radially expandable pipe is lowered into position adjacent the window and then expanded and curved such that the window provides more space to accommodate the curved pipe. A suitable method for forming a window in the production tube or casing is disclosed in PCT Patent Application WO 2004/046499. The disclosed method of cutting a window in a tubular, in particular a casing, comprises using a remotely controlled electrically powered cutting tool that has a pivotally mounted cutting head that can be pivoted towards the wall of the tubular.

[0034] The invention will now be described with reference to the accompanying drawings in which:

Fig 1 is an isometric drawing of part of a radially expandable pipe suitable for use in the present invention.

Fig 2 is a cross-sectional drawing of the expandable pipe of Fig taken through A-A.

Fig 3 is a cross-sectional drawing of another embodiment of a radially expandable pipe suitable for use in the present invention.

Fig 4 is a schematic sectional drawing of the radially expandable pipe being expanded and curved by an expanding device.

Fig 5 is a schematic sectional drawing of a bow spring spacer before expansion of the radially expandable pipe.

Fig 6 is a schematic sectional drawing of the bow spring spacer of Fig 5 after expansion of the radially expandable pipe.

Fig 7 is a schematic sectional drawing of a folded spacer before expansion of the radially expandable pipe.

Fig 8 is a schematic sectional drawing of the folded spacer of Fig 7 after expansion of the radially expandable pipe.

Fig 9 is a schematic sectional drawing of an alternative articulated spacer before expansion of the radially expandable pipe.

Fig 10 is a schematic sectional drawing of the alternative articulated spacer of Fig 9 after expansion of the radially expandable pipe. Figure 10a illustrates an expanded cross-section of the spacer showing a profile of the legs 9 and 10.

Figure 11 is an illustration of an expanded pipe in place in the well bore.

[0035] Figures 1 and 2 illustrate part of a radially expandable pipe 1 which has, over at least part of its length, an asymmetrical wall thickness. The asymmetrical wall thickness is provided by securely fixing to the outside surface 4 of the pipe a length of steel 2. The length of steel 2 comprises a cylindrical section having an internal surface that is an arc of a circle having a central angle θ of about 90° and a radius which is substantially the same as the external radius of the pipe. The length of steel 2 is fixed to the pipe by welding along the outer edges 3, that are transverse to the longitudinal axis of the expandable pipe 4. Thus the length of steel 2 is not welded along the longitudinal edges 5.

[0036] Figure 3 is a cross section of an alternative radially expandable pipe in which the asymmetrical wall thickness is provided by the inner surface 6 and outer surface 4 being eccentric.

[0037] Figure 4 is a.schematic drawing of an expandable pipe 1 in which, as for Fig 1, the asymmetrical wall thickness is provided by a length of steel 2 securely fixed to the outer surface 4 of the pipe by welding along the outer edges 3. The pipe has been expanded and curved by the action of an expanding device 16. The expanding device can be any suitable expanding device such as a mandrel expander or a ball or roller type expander as shown, for example, in US Patent Application Publication US 2001/0045284.

[0038] Figures 5 to 10 are schematic sectional drawings illustrating spacers that could be used in the present invention.

[0039] Figures 5 and 6 show a spacer 7 comprising a length of material fixed at each end to the radially expandable pipe 4. The spacer is designed to act like a bow spring. In the first position shown in Figure 5, the spacer lies alongside the outer surface 4 of the expandable pipe. As the radially expandable pipe 4 is expanded, for example by pulling a mandrel through the pipe, the axial length of the pipe decreases; the fixed ends of the bow spring 7 move towards each other causing the spring to bow and extend radially from the pipe surface as shown in Figure 6.

[0040] Figures 7 and 8 show a folded spacer 8 fixed to the outer surface 4 of a radially expandable pipe. The folded spacer is folded at each end and, as shown in Figure 7, initially lies in a first position alongside the outer surface 4 of the expandable pipe. Expansion of the radially expandable pipe 4, for example by using a rolling ball or roller expander, causes the fixed ends of the folded spacer 8 to move away from each other and the spacer is unfolded such that it extends radially from the surface of the expandable pipe, as shown in Figure 8.

[0041] Figures 9 and 10 show another embodiment of an articulated spacer, which comprises two legs 9 and 10. The two legs are of unequal length and could have been formed by folding a single piece of material, but as shown more clearly in Figure 10 the spacer comprises two, initially separate, pieces of material joined, e.g. by welding at one end 11. The other ends of the legs are fixed to the surface of the radially expandable pipe 4. As shown in Figure 9, the spacer comprising the two legs 9 and 10 initially lies in a first position alongside the outer surface 4 of the expandable pipe. Expansion of the radially expandable pipe 4 causes the fixed ends of the spacer to move away from each other and the spacer unfolds such that it extends radially from the surface of the expandable pipe, as shown in Figure 10. Figure 10a shows the profile of the legs 9 and 10 taken along B-B of Figure 10. Such a profile can provide additional stiffness to the spacers as compared with flat substantially rectangular sections. When the spacer is lying adjacent the surface of the radially expandable pipe 4 as shown in Figure 9, the two legs 9 and 10 and the surface of the pipe form an obtuse triangle with the obtuse angle being about 170 degrees. When the spacer is extended, the triangle is still obtuse, but the obtuse angle is shown as about 100 degrees.

[0042] It will be appreciated that if identical spacers are placed around the circumference of the pipe at about the same axial position and are subjected to the same change in the length of the expandable pipe 4, then the spacers will be displaced from the surface 4 of the expandable pipe by substantially the same amount and the arrangement will tend to centralise the expandable pipe. By using different spacers, e.g. spacers of different lengths then they will be deflected from the surface 4 of the expandable pipe by different amounts and the spacers will provide asymmetric support.

[0043] Figure 11 illustrates a curved expanded pipe I in the cased well bore 12. As the curved expanded pipe 1 is wider than the cased well bore 12, it is apparent that the window 13 was milled through the casing 12 and into the formation before the radially expandable pipe 1 was expanded and curved. This could be achieved, for example, by using the apparatus and method disclosed in PCT Patent Application WO 2004/046499. After milling the window 13, the radially expandable pipe 1 was passed down the well bore and through the production tube 14. It was centralised in the well bore using centraliser 15. The radially expandable pipe was then expanded to substantially the same internal diameter of the production tube 14. Due to the asymmetric wall thickness of the radially expandable pipe in the region 17, expansion of the pipe caused it to bend at 18. The lower end of the pipe passed through the window 13. As the pipe expanded, the spacers 19 fixed to the surface of the pipe extended to support the curved pipe in the well bore.

Claims

1. A process for deflecting a well tool towards the wall of a well bore comprising positioning within the well bore a radially expandable pipe, which has over at least part of its length an asymmetrical wall thickness, designed to curve longitudinally when its diameter is expanded, expanding the diameter of the radially expandable pipe thereby causing the pipe to curve, due to the asymmetric wall thickness, and passing the well tool through the curved pipe

2. A process as claimed in claim 1 in which a lateral well bore is initiated from a production well having within the well bore a smaller diameter production tubing comprising (i) passing through the production tube a radially expandable pipe, which has over at least part of its length an asymmetrical wall thickness, designed to curve longitudinally as its diameter is expanded, into a section of well bore having a diameter greater than the diameter of the production tubing, (ii) expanding the diameter of the radially expandable pipe thereby causing the pipe to curve, due to the asymmetric wall thickness, (iii) passing through the curved pipe a milling device or drill bit and (iv) milling the casing or drilling into the well bore wall.

3. A process as claimed in claim 2 in which a lateral well bore is initiated from a cased production well having within the well bore a smaller diameter production tubing comprising (i) milling a window in the

casing of the well bore, (ii) passing through the production tube a radially expandable pipe, which has over at least part of its length an asymmetrical wall thickness, designed to curve longitudinally as its diameter is expanded, into a section of well bore having a diameter greater than the diameter of the production tubing, (iii) orienting the radially expandable pipe within the well bore, (iv) expanding the diameter of the radially expandable pipe thereby causing the pipe to curve into the milled window, due to the asymmetric wall thickness, (v) passing through the curved pipe a drill bit and (vi) drilling into the well bore wall.

4. A process as claimed in any one of claims 1 to 3 in which the radially expandable pipe is oriented within the well bore prior to expansion.

5. A process as claimed in any one of claims 1 to 4 in which at least one spacer is used to support the curved tube within the well bore.

6. A process as claimed in any one of claims 2 to 5 in which the angle of deviation of the lateral bore is from about 0.4 to about 1.0 degree.

7. A radially expandable pipe for use in the process as claimed in any one of claims 1 to 6 which has over at least part of its length an asymmetrical wall thickness provided by securely fixing a length of steel longitudinally on the outer surface of a cylindrical pipe.

8. A radially expandable pipe as claimed in claim 7 in which the length of steel comprises a cylindrical section having an internal surface which is an arc of a circle having a central angle of from 2 to 20 degrees and a radius which is the same as or slightly larger than the external radius of the pipe.

9. A radially expandable pipe as claimed in claim 7 orclaim 8 having at least one spacer fixed to the outer surface, the spacer comprising an elongate element having a first and second end each of which is securely fixed to the pipe such that the change in length as the pipe is expanded deforms the elongate element, increasing its maximum radial distance from the centre of the pipe.

10. A radially expandable pipe as claimed in claim 9 in which the spacer is substantially cylindrical and expands substantially symmetrically.

11. A radially expandable pipe as claimed in claim 9 in which the spacer is substantially cylindrical and has elements that are designed to expand asymmetrically about the centre of the pipe.

12. A radially expandable pipe as claimed in claim 9 having a plurality of spacers positioned along the length and/or around the circumference of the radially expandable pipe such that when the pipe is expanded they expand to different radial lengths to hold the curved pipe in place within the well bore.

Patentansprüche

1. Verfahren zum Auslenken eines Bohrwerkzeuges in Richtung der Wandung eines Bohrloches, umfassend das Positionieren eines in radialer Richtung dehnbaren Rohres im Bohrloch, wobei das Rohr zumindest über einen Teil seiner Länge eine asymmetrische Wanddicke aufweist und derart konstruiert ist, dass es sich in Längsrichtung krümmt, wenn sein Durchmesser gedehnt wird, das Dehnen des Durchmessers des in radialer Richtung dehnbaren Rohres, wodurch das Rohr veranlasst wird, sich infolge der asymmetrischen Wanddicke zu krümmen und das Hindurchführen des Bohrwerkzeuges durch das gekrümmte Rohr.

2. Verfahren nach Anspruch 1, bei welchem von einem Produktionsbohrloch mit einem Produktionssteigrohr kleineren Durchmessers in demselben ein seitliches Bohrloch beginnt, umfassend (i) das Hindurchführen eines in radialer Richtung dehnbaren Rohres durch das Produktionsrohr, wobei das in radialer Richtung dehnbare Rohr zumindest über einen Teil seiner Länge eine asymmetrische Wanddicke aufweist und derart konstruiert ist, dass es sich in Längsrichtung krümmt, wenn sein Durchmesser gedehnt wird, in einen Abschnitt des Bohrloches, dessen Durchmesser größer ist als der Durchmesser des Produktionssteigrohres, (ii) das Dehnen des Durchmessers des in radialer Richtung dehnbaren Rohres, wodurch das Rohr veranlasst wird, sich infolge der asymmetrischen Wanddicke zu krümmen, (iii) das Hindurchführen einer Fräsvorrichtung oder eines Bohrkopfes durch das gekrümmte Rohr und (iv) das Fräsen der Auskleidung oder das Bohren in die Bohrlochwandung.

3. Verfahren nach Anspruch 2, bei welchem von einem ausgekleideten Produktionsbohrloch mit einem Produktionssteigrohr kleineren Durchmessers in demselben ein seitliches Bohrloch beginnt, umfassend (i) das Fräsen eines Fensters in die Auskleidung des Bohrloches, (ii) das Hindurchführen eines in radialer Richtung dehnbaren Rohres durch das Produktionsrohr, wobei das in radialer Richtung dehnbare Rohr zumindest über einen Teil seiner Länge eine asymmetrische Wanddicke aufweist und derart konstruiert ist, dass es sich in Längsrichtung in einen Abschnitt des Bohrloches hinein krümmt, dessen Durchmesser größer ist als der Durchmesser des Produktionssteigrohres, wenn sein Durchmesser gedehnt wird, (iii) das Ausrichten des in radialer Richtung dehnbaren Rohres im Bohrloch, (iv) das Dehnen des Durchmessers des in radialer Richtung dehnbaren Rohres, wodurch das Rohr veranlasst wird, sich infolge der asymmetrischen Wanddicke in das gefräste Fenster hinein zu krümmen, (v) das Hindurchführen eines Bohrkopfes durch das gekrümmte Rohr und (vi) das Bohren in die Bohrlochwandung hinein.

4. Verfahren nach einem der Ansprüche 1 bis 3, bei welchem das in radialer Richtung dehnbare Rohr im Bohrloch vor dem Dehnen ausgerichtet wird.

5. Verfahren nach einem der Ansprüche 1 bis 4, bei welchem mindestens ein Abstandshalter verwendet wird, um das gekrümmte Rohr im Bohrloch abzustützen.

6. Verfahren nach einem der Ansprüche 2 bis 5, bei welchem der Abweichungswinkel des seitlichen Bohrloches von etwa 0,4 Grad bis etwa 1,0 Grad beträgt.

7. In radialer Richtung dehnbares Rohr zur Anwendung bei dem Verfahren nach einem der Ansprüche 1 bis 6, welches zumindest über einen Teil seiner Länge eine asymmetrische Wanddicke aufweist, was durch die Befestigung eines Stahlstückes in Längsrichtung auf der Außenseite eines zylindrischen Rohres realisiert ist.

8. In radialer Richtung dehnbares Rohr nach Anspruch 7, bei welchem das Stahlstück einen zylindrischen Abschnitt umfasst, dessen Innenfläche von einem Kreisbogen mit einem Zentriwinkel von 2 Grad bis 20 Grad und mit einem Radius gebildet wird, welcher gleich dem Außenradius des Rohres oder ein wenig größer als dieser ist.

9. In radialer Richtung dehnbares Rohr nach Anspruch 7 oder 8 mit mindestens einem auf der Außenfläche befestigten Abstandshalter, wobei der Abstandshalter aus einem lang gestreckten Element mit einem ersten und einem zweiten Ende, die beide am Rohr befestigt sind, so dass, wenn das Rohr gedehnt wird, das lang gestreckte Element bei einer Längenänderung verformt und sein maximaler radialer Abstand von der Mitte des Rohres vergrößert wird.

10. In radialer Richtung dehnbares Rohr nach Anspruch 9, bei welchem der Abstandshalter im Wesentlichen zylindrisch ist und sich im Wesentlichen symmetrisch ausdehnt.

11. In radialer Richtung dehnbares Rohr nach Anspruch 9, bei welchem der Abstandshalter im Wesentlichen zylindrisch ist und Elemente aufweist, welche derart konstruiert sind, dass sie sich asymmetrisch um die Mitte des Rohres ausdehnen.

12. In radialer Richtung dehnbares Rohr nach Anspruch 9 mit einer Vielzahl von Abstandshaltern, die entlang der Länge und/oder rund um den Außenumfang des in radialer Richtung dehnbaren Rohres positioniert sind, so dass sie sich, wenn das Rohr gedehnt wird, auf unterschiedliche radiale Abmessungen ausdehnen, um das gekrümmte Rohr an Ort und Stelle im Bohrloch zu halten.

Revendications

1. Processus pour dévier un outil de puits vers la paroi d'un forage, consistant à positionner à l'intérieur du forage un tuyau radialement extensible, qui a sur au moins une partie de sa longueur une épaisseur de paroi asymétrique, conçu pour se courber longitudinalement lorsque son diamètre est étendu, étendre le diamètre du tuyau radialement extensible faisant ainsi se courber le tuyau, en raison de l'épaisseur de paroi asymétrique, et passer l'outil de puits à travers le tuyau courbé.

2. Processus selon la revendication 1, dans lequel un forage latéral est amorcé à partir d'un puits de production ayant à l'intérieur du forage un tube de production de plus petit diamètre, comprenant (i) passer à travers le tube de production un tuyau radialement extensible, qui a sur au moins une partie de sa longueur une épaisseur de paroi asymétrique, conçu pour se courber longitudinalement lorsque que son diamètre est étendu, dans une section de forage ayant un diamètre supérieur au diamètre du tube de production, (ii) étendre le diamètre du tuyau radialement extensible faisant ainsi se courber le tuyau, en raison de l'épaisseur de paroi asymétrique, (iii) passer à travers le tuyau courbé un dispositif de fraisage ou un trépan et (iv) fraiser le tubage ou forer dans la paroi du forage.

3. Processus selon la revendication 2, dans lequel un forage latéral est amorcé à partir d'un puits de production tubé ayant à l'intérieur du forage un tube de production de plus petit diamètre, comprenant (i) fraiser une fenêtre dans le tubage du forage, (ii) passer à travers le tube de production un tuyau radialement extensible, qui a sur au moins une partie de sa longueur une épaisseur de paroi asymétrique, conçu pour se courber longitudinalement lorsque que son diamètre est étendu, dans une section du forage ayant un diamètre supérieur au diamètre du tube de production, (iii) orienter le tuyau radialement extensible à l'intérieur du forage, (iv) étendre le diamètre du tuyau radialement extensible faisant ainsi se courber le tuyau dans la fenêtre fraisée, en raison de l'épaisseur de paroi asymétrique, (v) passer à travers le tuyau courbé un trépan et (vi) fraiser dans la paroi du forage.

4. Processus selon l'une quelconque des revendications 1 à 3, dans lequel le tuyau radialement extensible est orienté à l'intérieur du forage avant l'extension.

5. Processus selon l'une quelconque des revendications 1 à 4, dans lequel au moins une entretoise est utilisée pour supporter le tube courbé à l'intérieur du forage.

6. Processus selon l'une quelconque des revendications 2 à 5, dans lequel l'angle de déviation du forage latéral est d'environ 0,4 à environ 1,0 degré.

7. Tuyau radialement extensible destiné à être utilisé dans le processus selon l'une quelconque des revendications 1 à 6, qui a sur au moins une partie de sa longueur une épaisseur de paroi asymétrique fournie en fixant solidement une longueur d'acier longitudinalement sur la surface extérieure d'un tuyau cylindrique.

8. Tuyau radialement extensible selon la revendication 7, dans lequel la longueur d'acier comprend une section cylindrique ayant une surface intérieure qui est un arc de cercle ayant un angle central allant de 2 à 20 degrés et un rayon qui est le même ou légèrement plus grand que le rayon extérieur du tuyau.

9. Tuyau radialement extensible selon la revendication 7 ou la revendication 8, ayant au moins une entretoise fixée sur la surface extérieure, l'entretoise comprenant un élément allongé ayant une première et une seconde extrémité qui sont chacune solidement fixées sur le tuyau de sorte que le changement de longueur lorsque le tuyau est étendu déforme l'élément allongé, augmentant sa distance radiale maximale par rapport au centre du tuyau.

10. Tuyau radialement extensible selon la revendication 9, dans lequel l'entretoise est sensiblement cylindrique et s'étend sensiblement symétriquement.

11. Tuyau radialement extensible selon la revendication 9, dans lequel l'entretoise est sensiblement cylindrique et a des éléments qui sont conçus pour s'étendre asymétriquement autour du centre du tuyau.

12. Tuyau radialement extensible selon la revendication 9, ayant une pluralité d'entretoises positionnées le long de la longueur et/ou sur la circonférence du tuyau radialement extensible de sorte que lorsque le tuyau est étendu, elles s'étendent à différentes longueurs radiales pour maintenir le tuyau courbé en place à l'intérieur du forage.

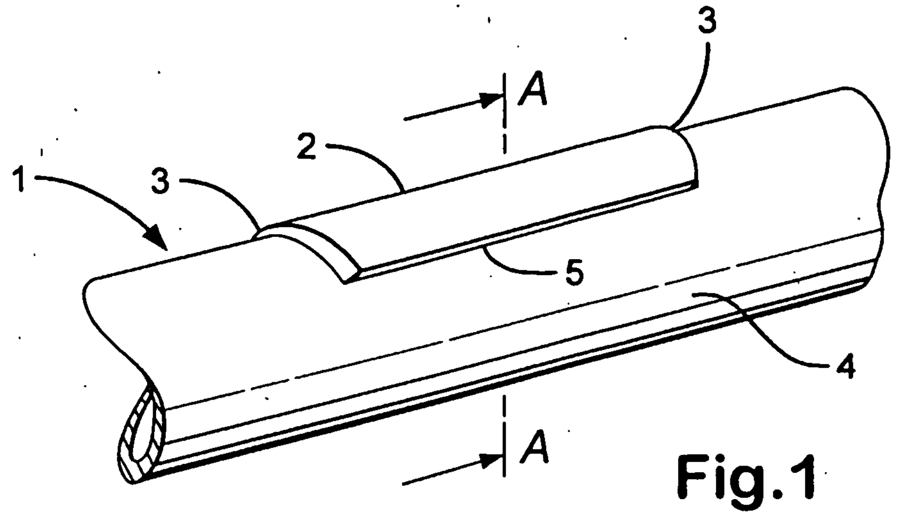

Fig.1

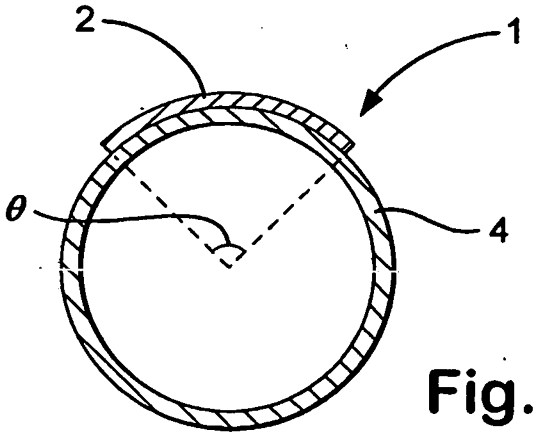

Fig.2

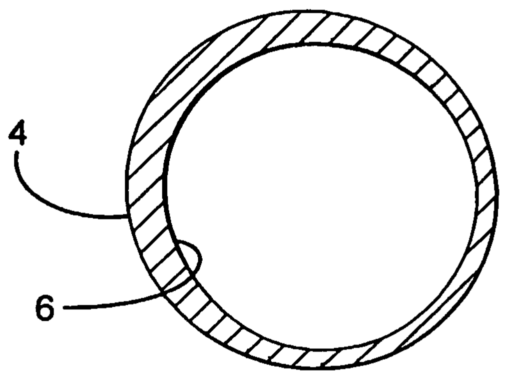

Fig.3

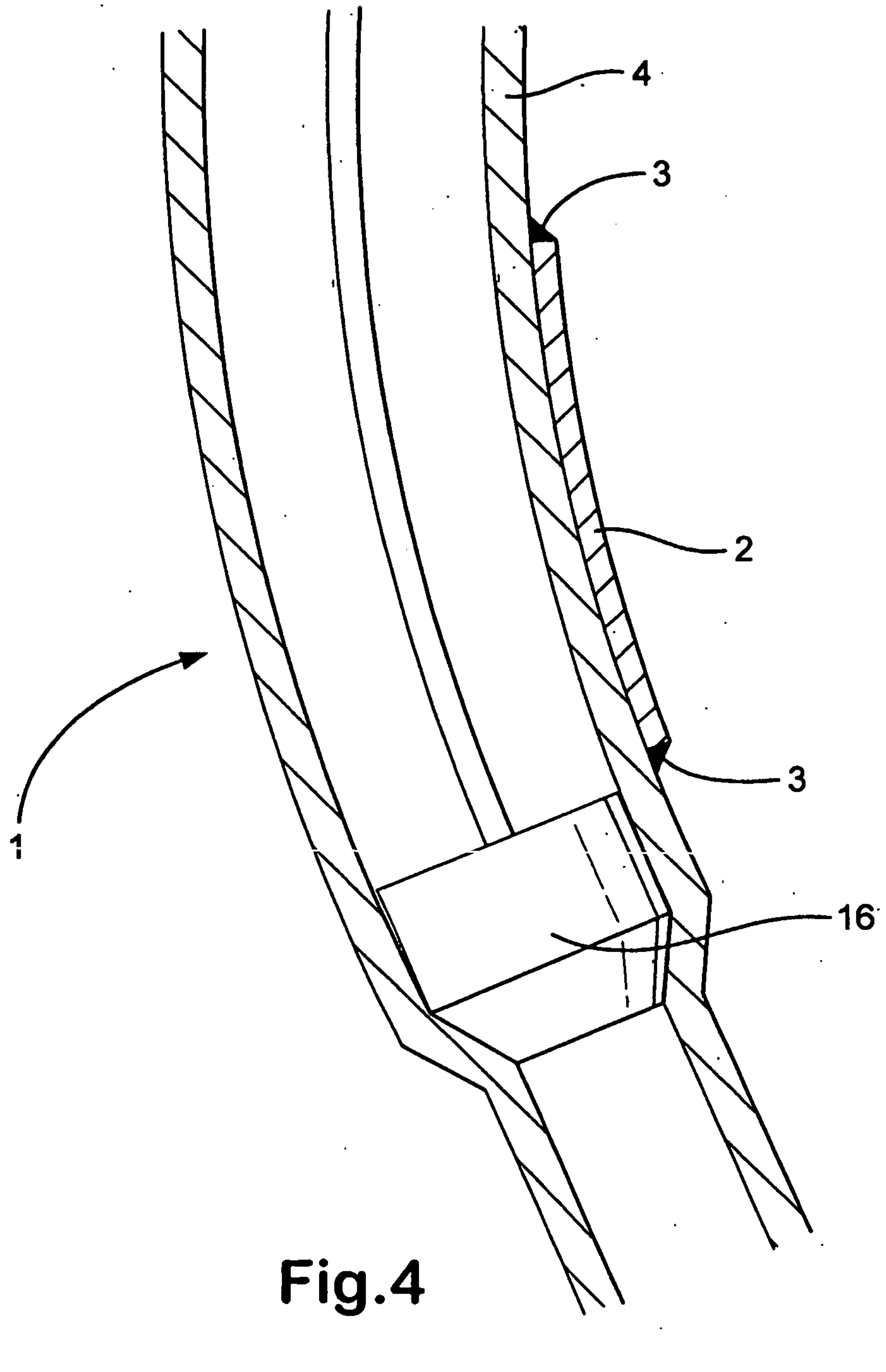

Fig.4

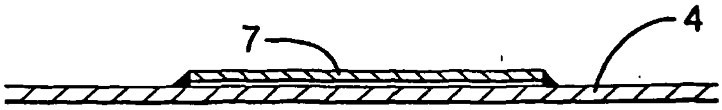

Fig.5

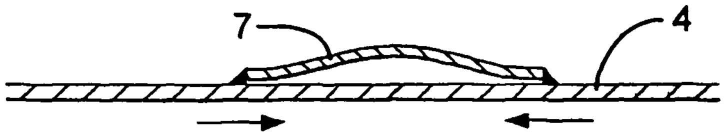

Fig.6

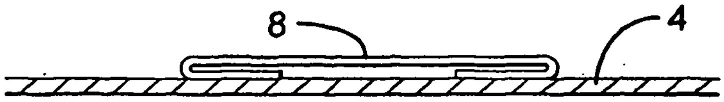

Fig.7

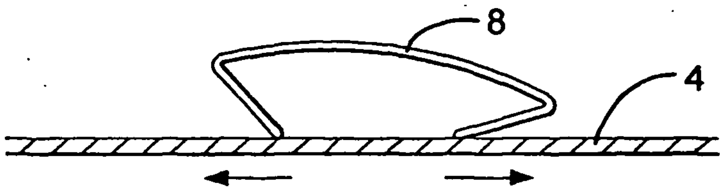

Fig.8

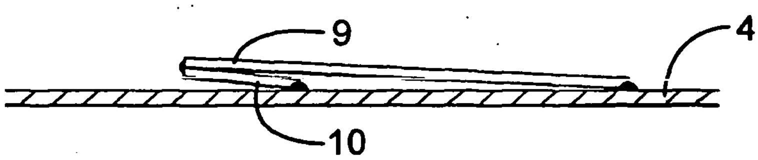

Fig.9

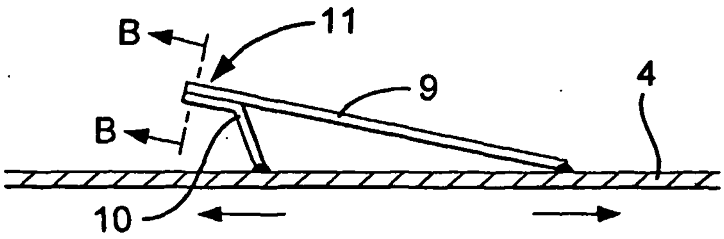

Fig.10

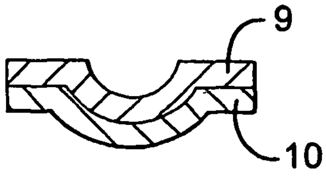

Fig.10a

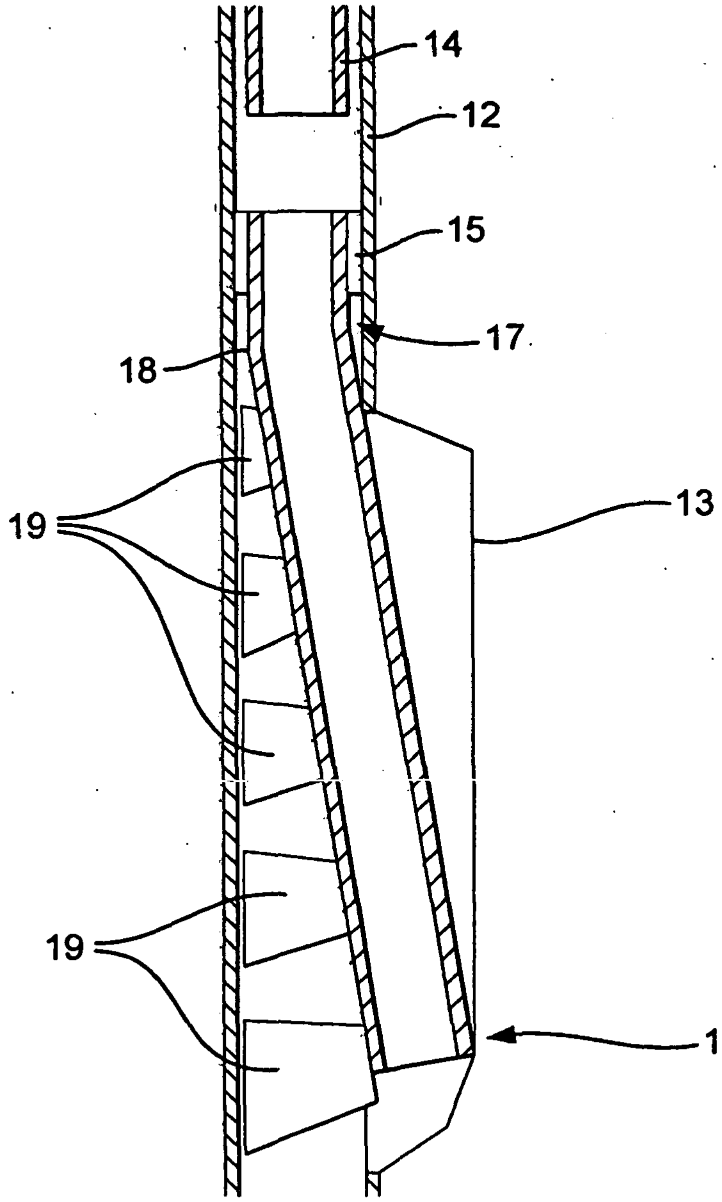

Fig.11

REFERENCES CITED IN THE DESCRIPTION

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