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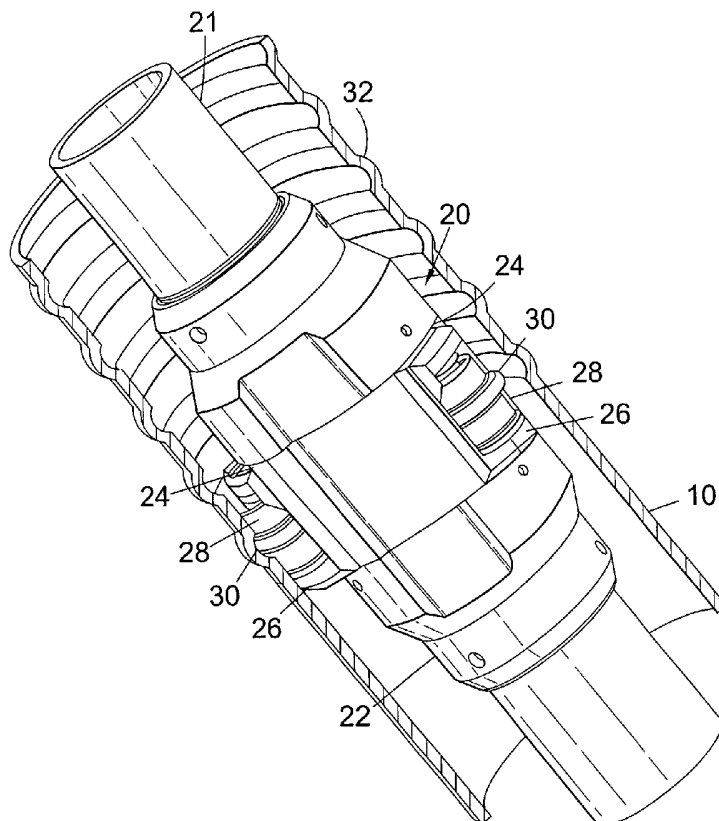
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(54) Title: CORRUGATED DOWNHOLE TUBULARS



(57) Abstract: A method of lining a drilled bore comprises running a tubular (40) into a drilled bore (42) and then corrugating the tubular in the bore. The tubular may also be expanded in the bore. In other aspects of the invention the tubular is corrugated prior to running into the bore and may be rotated as it is run into the bore.

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CORRUGATED DOWNHOLE TUBULARS

FIELD OF THE INVENTION

This invention relates to tubulars, and in particular to downhole tubulars, which may take the form of bore-lining casing or liner, production tubing, work strings or the like. In particular, the present invention relates to
5 formed tubulars which have a corrugated wall over at least a portion of their length, and also to methods of forming corrugations in tubulars, methods of utilising such tubulars, and tools and devices adapted for use in conjunction with such tubulars.

10 BACKGROUND OF THE INVENTION

Where deep bores are drilled to gain access to subsurface formations, for example as in the oil and gas exploration and production industry, it is conventional to line the drilled bores with metallic tubulars. Typically,
15 the tubulars take the form of thick-walled cylindrical tubulars sections which are coupled together and run into the drilled holes as strings. Methods of producing, handling and running in of such tubulars are well established, however problems remain, particularly in
20 running tubular strings into bores; and these problems

become more acute as attempts are made to access hydrocarbon deposits in more challenging locations, and the drilled bores become longer and more highly deviated.

It is among the objectives of at least one embodiment of an aspect of the present invention to provide downhole tubulars which obviate or mitigate some of the problems associated with existing tubular forms.

SUMMARY OF THE INVENTION

According to the present invention there is provided a method of lining a drilled bore, the method comprising:
running a tubular into a drilled bore; and
corrugating the tubular in the bore, to increase the collapse resistance of the tubular.

Testing has shown that corrugating a conventional cylindrical-walled tubular tends to increase the collapse resistance of the tubular, typically by a factor of two. Thus, the present invention allows an operator to line a bore with tubulars which, before corrugation, have perhaps only half of the collapse resistance of conventional tubulars which would otherwise be utilised. This allows use of lighter tubulars, with corresponding savings in material and transport costs, and facilitates handling of the tubulars. In addition, or alternatively, the operator may choose to use lighter tubulars of higher quality material, for example with a higher chromium content.

The invention may also be usefully employed when, for example, a drilling operation encounters a formation or section such as clay, shale or salt, which has a tendency to swell or flow causing the bore to close in prematurely, or even to crush casing which may already have been set across the section. Where surveys have identified that such formations are likely to be encountered, heavy wall casing capable of withstanding the collapse pressures will be on hand and available to run across the problem area. However, in many cases these problem formations are not anticipated beforehand and when encountered an intermediate casing has to be run into the bore and which casing must then be subsequently reinforced by a further casing, substantially reducing the available bore diameter of the well. However, by virtue of the present invention, if a problem formation is encountered, a standard casing may be run across the problem area and then corrugated, the corrugated casing possessing the collapse resistance necessary to prevent the bore from closing. The entire length of the casing may be corrugated, or only the portion that intersects the problem formation. Furthermore, as will be described below, the casing may also be diametrically expanded, such that the intermediate casing will not restrict the bore diameter.

Preferably, the tubular is a thin-walled tubular. In the context of bore-lining tubulars, conventional tubulars

typically have a wall thickness in excess of 6 mm, however, as noted above, the present invention facilitates use of thinner walled tubulars, without loss of collapse resistance. Most preferably, the tubular has a wall thickness of less than 6 mm, and typically around 3 to 4 mm. Alternatively, the tubular may be a conventional tubular, having a wall thickness in excess of 6 mm.

Preferably, the corrugation of the tubular also diametrically expands the tubular. Depending on the degree of expansion, this may permit the tubular to be run in through existing bore-lining tubing having an internal first diameter and the tubular then expanded to an internal diameter at least as large as the first diameter. Alternatively, the tubular may be diametrically expanded in a separate step from the corrugation step, either before or after corrugation. The diametric expansion following corrugation may create a cylindrical wall form. In one embodiment of the invention, a thin wall tubular having an external diameter of 7 5/8" (19.4 cm) is run in through existing 9 5/8" (24.4 cm) casing (having an internal diameter of 8 1/2" (21.6 cm)). The tubular is then corrugated and expanded, such that the minimum internal diameter, at the peaks of the corrugations, is 8 1/2" (21.6 cm). The corrugated tubular may thus serve to support the bore wall, but allows the subsequent 7 5/8" (19.4 cm) casing to be run in and cemented below the 9 5/8" (24.4 cm)

casing.

The tubular may be corrugated from the top down, or from the bottom up. The tubular may be expanded from the top down, or from the bottom up.

5 The method may comprise the further step of cementing the tubular in the bore, to seal and secure the tubular relative to the bore wall. In other embodiments, the tubular may carry a deformable or swelling material on an external surface of the tubular, or may be provided in
10 combination with a sleeve of deformable material.

Some or all of the tubular may be corrugated; it may be desired to retain a section of cylindrical-walled tubular, for coupling to or for receiving conventional connectors, seals, tools or devices.

15 The corrugations may extend solely circumferentially, but are preferably helical.

At least one further tubular may be located internally of the corrugated tubular, which further tubular may have a cylindrical wall, and which tubular may subsequently be
20 diametrically expanded.

Tools or devices may be located within the corrugated tubular, and other aspects of the invention relate to tools and devices adapted to engage the corrugated tubular. For example, rather than providing conventional slips or a
25 portion adapted to engage a particular nipple profile, a device may include radially extendable portions profiled to

correspond to the corrugated wall. Thus, a device may be securely located at any desired location within a tubular. In a similar fashion, a packer may be provided with packer elements shaped to engage and conform to the corrugated tubular wall form. These packer elements will not form notches in the casing wall, as occurs with slips, and which notches act as a starting point for corrosion. The tool may take the form of a well control dart, which is dropped into the bore and travels down through the bore until flow of fluid up through the bore reaches a level where the dart is moved upwardly. When this occurs, the dart is arranged to engage the surrounding wall of the corrugated tubular, and close the bore. Such tools and devices are of course less likely to be displaced by axial forces, and corrugated or wave-form sealing members are less likely to be extruded out than conventional elastomer sleeves or seals. Other aspects of the invention relate to tractors and the like which are adapted to utilise the corrugations to facilitate travel through the tubular.

Preferably, the corrugations are formed by a rotary expander, that is an expander featuring at least one bearing member which applies a radial force to an inner wall of the tubular and which is rotated within the tubular, typically while being advanced axially through the tubular. The axial advancement may be achieved by any appropriate means, such as application of force achieved

by, for example, application of weight from surface, use of a tractor, or application of fluid pressure. Alternatively, the rotary expander may feature skewed rollers, such that rotation of the expander in the tubular creates an axial force on the expander. Preferably, the expander features a plurality of bearing members, typically three, and most preferably the bearing members include rolling elements, which may be in the form of balls or rollers, to provide a rolling contact with the tubular wall. The rotary expander may describe a single, fixed diameter, but is preferably configurable in a smaller diameter configuration and a larger diameter expansion configuration. The bearing member may be movable between the configurations by any appropriate means, for example by application of mechanical force and co-operation of cam faces, but is most preferably fluid actuated. The expander may take the form of one of the expanders described in applicant's WO 00/37766, the disclosure of which is incorporated herein by reference. The rotary expander may be configured to create a single circumferential or helical corrugation, or may be configured to create a plurality of corrugations, for example a triple helical corrugation.

Other aspects of the invention relate to corrugated tubulars which are run into a bore in the corrugated form. The tubulars may be corrugated on surface utilising a

rotary expansion tool as described above, which tool may be rotated relative to a cylindrical tubular to achieve the desired degree of corrugation. Alternatively, a tool may be provided for engaging the outer wall of a cylindrical tubular, to achieve the desired degree of corrugation. For heavier tubing, or to obtain tighter corrugations, it may be preferable or necessary to provide a tool which engages both the inner and outer walls of the tubular. In other embodiments of the invention the corrugations may be provided by other methods. As noted above, the presence of corrugations tends to provide a collapse resistance which is high relative to the tubular wall thickness. Thus, the invention has particular application to thin-walled tubulars, which are relatively easily corrugated, and once corrugated provide a level of collapse resistance corresponding to significantly thicker parallel-walled tubulars.

The tubulars may be annealed or otherwise treated following corrugation, to reduce or minimise any work-hardening effects and to reduce internal stresses which might lead to an increased susceptibility to corrosion. Such tubulars may also be subsequently expanded or otherwise deformed more readily.

Aspects of the invention relate to particular uses and applications of such tubulars, some of which are described below.

The presence of a corrugation in the tubular wall provides protective recesses, both internally and externally, in which elongate members or elements such as conduits, signal carriers, power carriers, electrical
5 conductors, heating elements, sensors and the like may be located, and aspects of the invention relate to corrugated tubulars provided in combination with such members and elements. In one embodiment, optical fibres having both sensing and data transmission capabilities are provided.
10 Of course it is not only elongate elements which may be located in the corrugations, and discrete or individual objects may be positioned within the troughs.

Alternatively, or in addition, the presence of corrugations provides protective recesses in which to
15 locate a sealing or filling material, or which may be utilised to carry a material into a bore. For example, external corrugations may be at least partially filled with a flowable, settable or swelling material, the peaks of the corrugations protecting the material as the tubular is run
20 into the bore. Once in the bore, the corrugated tubular may be diametrically expanded, such that at least some of the material is pushed out of the troughs of the corrugations to fill and seal the annulus between the tubular and the bore wall. A degree of corrugation may be
25 retained, or the expansion may be such that the expanded tubing is parallel-walled. This obviates the requirement

to cement the tubular in the bore, and it is not necessary to size the bore (or reduce the tubular diameter) to provide an annulus which is sufficiently large to accommodate cement circulation. Where a swelling material is provided, it may not be necessary to expand the tubular to achieve sealing, and the swelling material may be activated by exposure to well fluid or by circulating an appropriate activating material.

The different aspects of the invention also have utility in subsea or surface applications, for example as risers or forming parts of risers, flowlines or pipelines. The corrugations provide flexibility which is useful when the tubular is likely to experience movement, bending or axial extension or contraction. In such embodiments, a corrugated metallic tubular may be embedded within a flexible polymeric or elastomeric material, or may have an internal or external coating.

Aspects of the invention relate to running corrugated tubulars into a bore, which provides numerous advantages, as described below.

The corrugated tubulars will be less prone to differential sticking than conventional cylindrical-walled tubulars, and accordingly may be selected for bores where it is anticipated that differential sticking may be a problem. Differential sticking may occur where a bore intersects a relatively low pressure formation, such that

a tubular in contact with the bore wall may be pushed into contact with the wall by the pressure of the fluid in the bore. With the corrugated tubulars, only the peaks of the corrugations will contact the wall, such that potential for differential sticking is significantly reduced. The presence of the corrugations may also assist when the tubular is cemented in the bore. These advantages may be achieved using helical corrugations having a relatively large pitch, for example 4 to 10 feet (1.2 to 3m).

The applicant has also recognised that many of the advantages gained by use of corrugated tubulars will be available from running conventional parallel walled tubulars in corrugated bores, and other aspects of the invention relate to the provision of such corrugated bores.

The corrugated tubular has greater flexibility than a conventional cylindrical-walled tubular providing corresponding collapse resistance. Furthermore, the corrugated tubular will be significantly lighter. Thus, handling of the tubular is facilitated, as is the ability of the tubular to accommodate bends, dog legs or steps in the bore, which may occur during drilling of the bore or following drilling of the bore; corrugated tubulars may be selected for use in bores where such conditions are likely to be encountered. Embodiments of the invention therefore include corrugated casing and liner. Helical corrugations may also be used to advantage when running corrugated

tubulars: if a difficulty is encountered on running a tubular into a bore, if the tubular is rotated the corrugations in contact with the bore wall will act in a similar manner to a screw-thread, and will tend to create an axial force between the tubular and the bore wall, which may serve to advance or retract the tubular, and may facilitate overcoming a restriction or tight spot in the bore. Furthermore, the corrugations may be employed in a similar fashion to dislodge or disturb drill cuttings and the like which have gathered on the low side of an inclined bore, and which may create difficulties when attempting to run a tubular into a bore. The presence of corrugations in large diameter tubular strings which are rotated on a bore also reduces the likelihood of connector failure as the additional flexibility provided by the corrugations serves to reduce the cyclic bending loads experienced by the relatively stiff connectors between the individual tubulars.

Aspects of the invention also relate to drilling using corrugated tubulars as a drill bit support, and in particular drilling with corrugated casing. As identified above, such casing will be less likely to experience differential sticking and connector failure. The casing may subsequently be diametrically expanded, either retaining a degree of corrugation or being expanded to a parallel-walled form.

Rotation of a corrugated tubular is also useful during a cementing or bore-cleaning operation, as the corrugations will tend to disturb any drill cuttings lying in the bore, and will enhance even cement distribution around a tubular.

5 Some of these effects will of course also be available from solely axial movement of the tubular in the bore.

The enhanced flexibility provided by the corrugated wall may also be utilised to advantage in providing tubulars for passing through lateral junctions into lateral wells. Due to the enhanced flexibility of the corrugated tubing, it is possible to pass relatively large diameter tubulars through the junctions, which may involve deviations of the order of 20 to 40 degrees per 100 feet (30m).

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The flexibility of the corrugated tubing may also be utilised to advantage to allow provision of reelable tubing, which may be of relatively large diameter, and which may provide relatively high levels of collapse resistance for a given wall thickness.

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The presence of corrugations may also be utilised for coupling adjacent corrugated or part-corrugated tubular sections. By providing corresponding helical corrugations it is possible to thread adjacent tubular sections together by relative rotation, or it may simply be enough to push the sections together, or to corrugate an inner tubular in a corresponding manner to a surrounding outer tubular. The

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thread provided by the corrugations may be parallel or tapered, and in other embodiments the corrugations may be circumferential. To facilitate provision of a seal at such a coupling, deformable material may be provided on one or both of the tubular sections. This aspect of the invention may be utilised in a wide variety of applications, but is particularly useful in achieving a coupling at a lateral junction, where difficulties are often experienced when using conventional coupling-forming methods. For use in coupling sections of casing and liner, this feature obviates the need to provide separate connectors, and thus also avoids the upsets that are created by such connectors. The couplings formed will also be better able to withstand torques applied to the tubulars.

If desired, only a portion of a tubular may be corrugated. The corrugated portion may be provided, as mentioned above, to facilitate coupling. For example, an upper portion of a liner may be corrugated to facilitate coupling with a liner hanger, or to engage a corrugated lower portion of existing casing, thus obviating the requirement to provide a separate liner hanger. Alternatively, a selected portion of the tubular may be corrugated, such that the tubular will preferentially flex at the corrugated location, or if it is desired that a portion of the tubular have greater flexibility. This may be useful when the tubular is utilised in, for example, an

earthquake zone, and earth movements are likely, or if it is desired to provide a tubular with a relatively flexible end portion to facilitate entry to a lateral bore.

The corrugated tubing of embodiments of the invention
5 may also be usefully employed in the creation of liner hangers and the like where it is desired to provide hanging support for a tubular within an existing tubular or hanger while providing a fluid flow path to allow displacement of fluid from an annulus to facilitate cementing of the
10 tubular. The flow path through the troughs of the corrugations may subsequently be closed by energising or activating seals above or below the corrugated portion, by subsequently expanding and flattening the corrugated portion, or simply by passing cement slurry into the
15 corrugations, which cement then sets or cures within the corrugations.

A temporary or permanent liner hanger may also be created by forcing a corrugated section of tubular into a bore section having an internal diameter less than the
20 diameter described by the peaks of the tubular, such that the corrugated section experiences a degree of elastic deformation, and the resulting restoring force produced by the deformation provides for sufficient frictional contact between the tubular and the bore wall to retain the tubular
25 in the bore. Alternatively, or in addition, a corrugated section of tubular may be placed in tension, such that the

diameter described by the tubular decreases. The tubular is then located in a bore section, and the tension then reduced, such that the tubular experiences an increase in diameter and engages the wall of the bore section.

5 The provision of circumferential or helical corrugations will tend to decrease the axial stiffness of a tubular and thus enhances the ability of the tubular to accommodate axial compression or expansion. Thus, completion tubing featuring a corrugated section may
10 accommodate the axial forces that result from the temperature variations experienced by the tubing, for example between the tubing being run into the bore and sealed and located in the bore, and the tubing subsequently carrying relatively high temperature production fluid.
15 Such temperature variations, and the resulting length changes in the tubing, are conventionally accommodated by means of seal bands engaging a polished bore receptacle (PBR), which permits a degree of movement of the lower end of the tubing, without loss of seal integrity. However,
20 the seals and the PBR are vulnerable to damage. Embodiments of the present invention allow completion or production tubing to be locked into a seal. Corrugated tubing sections may be provided at any appropriate location in the tubing, and indeed a similar advantage may be
25 achieved by providing a bore-mounted seal which incorporates a corrugated bellows section between the seal

and the mounting to the bore wall.

As noted above, corrugated tubulars in accordance with aspects of the invention may be subject to diametric expansion. On experiencing such expansion, corrugated tubulars tend to axially expand. This contrasts with swage expansion of parallel walled cylindrical tubulars, which tends to result in axial contraction of the tubular. This contraction may present significant problems, particularly in bottom-up swage expansion; a string of tubulars may contract by approximately 5%, and if the string is differentially stuck in the bore above the expansion location, the tubing will tend to stretch and the tubulars may part, particularly at weak points such as tubular connections. If desired, these effects may be combined, by providing a corrugated section or section in a tubular to be swage expanded, such that, following expansion, there is no net change in the overall length of the tubular. Furthermore, even if a degree of axial expansion or contraction is present, the presence of the corrugations will readily accommodate a degree of contraction, and the presence of the corrugations makes the occurrence of differential sticking far less likely. Alternatively, it is possible to select a degree of corrugation that when expanded and flattened neither axially expands nor contracts.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present will now be described, by way of example, with reference to the accompanying drawings, in which:

5 Figure 1 illustrates a tubular being corrugated in accordance with an embodiment of a first aspect of the present invention;

 Figures 2 and 3 illustrate steps in the corrugation of a downhole tubular in accordance with an embodiment of
10 another aspect of the present invention.

 Figures 4 and 5, and Figures 6 and 7 illustrate steps in the expansion of corrugated tubulars in accordance with embodiments of further aspects of the present invention;
and

15 Figure 8 is a schematic illustration of a lateral junction featuring tubing in accordance with an embodiment of a yet further aspect of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

 Reference is first made to Figure 1 of the drawings,
20 which illustrates a tubular 10 being corrugated in accordance with an embodiment of a first aspect of the present invention. Located within the tubular is a corrugation tool 20, mounted on a pipe 21, the tool 20 being of a similar form to the expansion tools as described
25 and illustrated in applicant's WO 00/37766. The tool 20

comprises a hollow body 22 having three radially extending apertures 24 (only two shown) which each accommodate a piston 26, with a roller 28 being mounted on each piston. The rollers 28 are each arranged to rotate around a
5 respective axis which is slightly skewed relative to the tool body axis. Each roller features a raised rib 30, the relative axial locations of the ribs 30 being such that rotation of the fluid-pressure energised tool 20 causes the roller ribs 30 to create a single helical corrugation 32 in
10 the wall of the tubular 10, and also pulls the tool 20 through the tubular 10. Corrugation of the tubular 10 increases the collapse resistance of the tubular 10.

Reference is now made to Figures 2 and 3 of the drawings, which illustrates, somewhat schematically, a
15 downhole tubular 40 being corrugated and expanded in accordance with an embodiment of another aspect of the present invention. As illustrated in Figure 2, the tubular 40 is first run into the lower open section of a drilled bore 42, through existing casing 44.

20 An appropriate corrugation tool, such as illustrated in Figure 1, is then run into the tubular 40, mounted on the lower end of a pipe string 21. The tool 20 is rotated and advanced through the tubular 40 to create a single helical corrugation 52 in the wall of the tubing 40, as
25 shown in Figure 3. Furthermore, the tool 20 diametrically expands the tubular 40 to a minimum internal diameter

corresponding to the internal diameter of the casing 44.

The expanded and corrugated tubular 40 may serve as an intermediate casing, allowing further, conventional casing 54 (shown in chain-dotted outline in Figure 3) to be subsequently run in and located in the bore without any additional loss of diameter.

Reference is now made to Figures 4 and 5 of the drawings, which illustrate a corrugated tubular 60 being run into a bore 62 and expanded to a parallel-walled form (Figure 5) within the bore 62.

The tubular 60 may form part of a casing string to be run into and set in the bore 62. The tubular 60 is initially corrugated, and this offers a number of advantages when running in. Only the peaks of the corrugations contact the bore wall, such that differential sticking is unlikely to occur. Furthermore, if the tubular 60 is rotated in the bore 62, the helical corrugations will tend to act in a similar manner to a screw thread, and pull the tubular through the bore; this may be useful in negotiating tight spots, ledges and the like. In certain situations it may also be advantageous to rotate the tubular 60 in the opposite direction, to allow the tubular to be retracted. The corrugations will also assist in dislodging and agitating cuttings which may have settled on the low side of the bore. The flexibility provided by the corrugations will also facilitate bending of the string, to

facilitate negotiation of bends or curves in the bore 62. The presence of the corrugations also reduces the cyclic stresses experienced by the relatively stiff casing connectors 63 if the string is being rotated.

5 On reaching the desired location, the tubular is diametrically expanded, using a rotary expander as described with reference to Figure 1, which expansion also creates an expanded tubular 60 with substantially parallel walls.

10 Figures 6 and 7 illustrate a corrugated tubular 64 being run into a bore 66 (Figure 6), which tubular 64 is then expanded to a larger diameter, while retaining a corrugated wall (Figure 7).

15 It will be noted that the external troughs formed by the corrugations are filled with a deformable material 67 which may serve a number of purposes, as described above, and also accommodate a member 68, which may be a conduit, signal carrier or the like. The tubular 64 may subsequently receive a further tubular 65 or a device 69
20 adapted to engage with the corrugated tubular wall.

Reference is now made to Figure 8 of the drawings, which is a schematic illustration of a lateral junction 70 featuring tubing in accordance with an embodiment of a second aspect of the present invention.

25 The junction 70 is between a primary bore 72 and a lateral bore 74, and the junction 70 features a pre-

corrugated casing 76, the corrugations facilitating accommodation of the deviation between the bores 72, 74. Furthermore, to place the casing 76 in the bore 74, the casing 76 may have been rotated such that the helical corrugations act as screw threads, to assist in negotiating tight spots in the bores 72, 74, and in particular the window into the lateral bore 74.

Following the casing 76 being secured at the junction 70, and the lateral bore 74 being drilled beyond the section of the bore lined by the casing 76, a parallel-walled liner 78 is run into the bore 74, at least the upper end of the liner 78 overlapping the lower end of the casing 76. At least the overlapping portion of the liner 78 is then expanded and corrugated, in a similar manner to that described above with reference to Figure 1, to correspond to the surrounding corrugated casing 76. The liner 78 will thus be locked and sealed relative to the casing 76.

In other embodiments, the liner may have been corrugated on surface, and once in overlapping relationship with the casing the liner may be expanded while retaining the corrugations.

Those of skill in the art will recognise that these embodiments are merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the invention. For example, the invention has utility in subsea

applications, for example in pipelines, where the flexibility of the corrugated pipes and the ability to accommodate axial extension and contraction facilitate maintaining pipeline integrity when the pipeline experiences temperature variations or movements in the supporting seabed.

CLAIMS

1. A method of lining a drilled bore, the method comprising:

running a tubular into a drilled bore; and

5 corrugating the tubular in the bore.

2. The method of claim 1, wherein the corrugation of the tubular increases the collapse resistance of the tubular.

3. The method of claim 1 or 2, wherein the tubular is a thin-walled tubular.

10 4. The method of claim 3, wherein the tubular has a wall thickness of less than 6 mm.

5. The method of claim 4, wherein the tubular has a wall thickness of around 3 to 4 mm.

15 6. The method of claim 1 or 2, wherein the tubular has a wall thickness of at least 6 mm.

7. The method of any of the preceding claims, wherein the step of corrugating the tubular also diametrically expands

the tubular.

8. The method of any of the preceding claims, wherein the tubular is run in through existing bore-lining tubing having an internal first diameter and the tubular is then expanded to an internal diameter at least as large as the first diameter.

9. The method of any of the preceding claims, wherein the tubular is diametrically expanded in a separate step from the corrugation step.

10. The method of claim 9, wherein the tubular is diametrically expanded before corrugation.

11. The method of claim 9, wherein the tubular is diametrically expanded after corrugation.

12. The method of claim 11, wherein the diametric expansion creates a cylindrical wall form.

13. The method of any of the preceding claims, wherein the tubular is corrugated from the top down.

14. The method of any of claims 1 to 12, wherein the tubular is corrugated from the bottom up.

15. The method of any of the preceding claims, wherein the tubular is expanded from the top down.

16. The method of any of claims 1 to 14, wherein the tubular is expanded from the bottom up.

5 17. The method of any of the preceding claims, further comprising the step of cementing the tubular in the bore.

18. The method of any of the preceding claims, wherein the tubular carries a deformable material on an external surface thereof.

10 19. The method of any of the preceding claims, wherein the tubular is provided in combination with a sleeve of deformable material.

15 20. The method of any of the preceding claims, wherein only a portion of the tubular is corrugated, to retain a section of cylindrical-walled tubular.

21. The method of any of claims 1 to 19, wherein all of the tubular is corrugated.

22. The method of any of the preceding claims, wherein the corrugations extend solely circumferentially.

23. The method of any of claims 1 to 21, wherein the corrugations extend helically.

24. The method of any of the preceding claims, further comprising locating at least one further tubular internally
5 of the corrugated tubular.

25. The method of claim 24, wherein the at least one further tubular has a cylindrical wall.

26. The method of claim 24 or 25, wherein the at least one further tubular is subsequently diametrically expanded.

10 27. The method of any of the preceding claims, further comprising locating a tool or device within the corrugated tubular.

15 28. The method of any of the preceding claims, wherein the corrugations are formed by a rotary expander featuring at least one bearing member which applies a radial force to an inner wall of the tubular and which expander is rotated within the tubular, and is advanced axially through the tubular.

20 29. The method of claim 28, wherein the rotary expander is configured to create a single-start helical corrugation.

30. The method of claim 28, wherein the rotary expander is configured to create a multiple-start plurality of helical corrugations.

5 31. The method of any of the preceding claims, wherein the tubular is located to intersect a problem formation.

32. A method of lining a drilled bore, the method comprising:

10 running a tubular into a drilled bore to intersect a problem formation; and

corrugating the tubular in the bore at least where the tubular intersects the problem formation.

33. The method of claim 32, further comprising expanding the tubular.

15

34. A method of forming a downhole tubular, comprising corrugating a cylindrical tubular by rotating a rotary expansion tool relative to the tubular.

20 35. The method of claim 34, wherein the tool is advanced axially relative to the tubing to create at least one helical corrugation.

36. A thin-walled downhole tubular having a corrugated wall.

37. A downhole tubular having a corrugated wall, the tubular having been annealed following corrugation.

5 38. A downhole tubular having a wall defining helical corrugations and an elongate element located in the troughs of the corrugations.

39. The tubular of claim 39, wherein a signal carrier is located in the troughs of the corrugations.

10 40. The tubular of claim 38 or 39, wherein a conduit is located in the troughs of the corrugations.

41. The tubular of claim 38, 39 or 40, wherein a power carrier is located in the troughs of the corrugations.

15 42. The tubular of claim 38, 39, 40 or 41, wherein a sensing element is located in the troughs of the corrugations.

20 43. The tubular of claim 38, 39, 40, 41 or 42, wherein an optical fibre is located in the troughs of the corrugations.

44. A downhole tubular having a corrugated wall and at least one object located in a trough in the wall.

45. A downhole tubular having a corrugated wall and material located in troughs of the wall.

5 46. The tubular of claim 45, wherein the troughs contain at least one of a sealing, filling and swelling material.

47. A method of sealing a tubular in a bore, the method comprising:

10 providing a downhole tubular having a corrugated wall and a sealing material located in troughs of the wall; and running the tubular into a bore.

48. The method of claim 47, wherein the material fills and seals an annulus between the tubular and the bore wall.

15 49. A method of sealing a tubular in a bore, the method comprising:

providing a downhole tubular having a corrugated wall and a material located in troughs of the wall;
running the tubular into a bore;
diametrically expanding the tubular.

50. The method of claim 49, wherein expanding the tubular pushes the material out of the troughs.

51. The method of claim 50, wherein the material fills and seals an annulus between the tubular and the bore wall.

52. The method of claim 51, wherein the bore is defined by an existing tubular.

53. The method of claim 51, wherein the bore is defined by a well bore wall.

54. A method of running tubing into a bore to minimise differential sticking, the method comprising:

providing corrugated tubing; and
running the tubing into the bore.

55. A method of running tubing into a bore to minimise differential sticking, the method comprising:

identifying whether elongate members located in a selected bore are likely to encounter differential sticking;

providing corrugated tubing; and
running the tubing into the bore.

56. A method of running tubing into a bore, the method

comprising:

running a corrugated-walled tubular into the bore; and
rotating the tubular in the bore.

57. The method of claim 56, wherein the tubular is a
5 tubing string comprising a plurality of tubing sections
joined by relatively rigid connectors.

58. A method of running tubing into a bore, the method
comprising:

10 running a tubular defining a helical configuration
into the bore; and
rotating the tubular in the bore.

59. The method of claim 58, comprising rotating the tubing
to advance the tubular axially in the bore.

60. The method of claim 59, comprising rotating the
15 tubular a predetermined number of times to advance the
tubular a predetermined axial distance in the bore, related
to the pitch of the corrugations.

61. The method of claim 58, 59 or 60, comprising rotating
the tubing to negotiate a tight spot in the bore.

20 62. The method of any of claims 56 to 61, comprising

rotating the tubing to dislodge sediment in the bore.

63. The method of any of claims 56 to 62, comprising rotating the tubing during a cementing operation.

5 64. The method of any of claims 56 to 63, comprising rotating the tubing during a bore-cleaning operation.

65. A downhole tubular for location in a lateral bore, the tubular having a corrugated wall.

10 66. A reelable downhole tubular, the tubular having a corrugated wall.

67. Downhole tubulars, each tubular comprising at least one corrugated end portion, whereby the tubulars are adapted to be coupled to one another by locating the corrugated end portion of one tubular within the corrugated end portion of another tubular.

15

68. The tubulars of claim 67, wherein the corrugations are helical.

69. The tubulars of claim 67, wherein the corrugations are circumferential.

70. The tubulars of claim 67, 68 or 69, wherein the corrugated end portions are parallel.

71. The tubulars of claim 67, 68 or 69, wherein the corrugated end portions are tapered.

5 72. The tubulars of any of claims 67 to 71, wherein deformable sealing material is provided on the corrugated end portion of at least one of the tubulars.

73. A downhole tubular having a corrugated upper portion adapted for engaging a tubing hanger.

10 74. A method of forming a tubing coupling between a first tubular and a second tubular in a bore, the method comprising:

providing at least one of the first tubular and the second tubular with a corrugated portion; and

15 running the first tubular into the second tubular such that the first tubular and the second tubular engage at the corrugated portion.

75. The method of claim 74, wherein the first tubular is hung from the second tubular.

20 76. The method of claims 74 or 75, wherein at least one of

a lower end of the first tubing and an upper end of the second tubular is corrugated.

5 77. The method of any of claims 74 to 76, wherein a fluid flow path is provided between the first tubular and the second tubular.

78. The method of claim 77, comprising subsequently closing the flow path.

.10 79. The method of any of claims 74 to 78, comprising subsequently expanding and flattening the corrugated portion.

80. A method of forming a coupling between first and second tubulars in a bore, the method comprising:

providing at least one of the first tubular and the second tubular with a corrugated portion; and

15 running the first tubular into second tubular such that at least one of the first tubular and the second tubular is elastically deformed to provide for positive engagement therebetween.

20 81. A method of locating a tubular within a larger diameter bore, the method comprising:

providing a corrugated tubular;

locating the tubular in a larger diameter bore; and
reducing the degree of tension applied to the tubular
such that the tubular axially contracts and diametrically
expands.

5 82. The method of claim 81, wherein the tubular is
initially under tension.

83. The method of claim 81 or 82, wherein the degree of
tension applied to the tubular is reduced by placing the
tubular in compression.

10 84. The method of claim 81, 82 or 83, wherein the degree
of diametric expansion of the tubular is such that the
tubular engages the surrounding bore wall.

15 85. Completion tubing having at least a portion of
corrugated wall to accommodate a degree of at least one of
axial compression and expansion.

86. The tubing of claim 86, in combination with a seal for
locking a lower end of the tubing relative to surrounding
bore-lining tubing.

20 87. A method of lining a bore, the method comprising:
diametrically expanding a corrugated tubular in a

bore.

88. The method of claim 87, further comprising selecting at least one of the degree of expansion, the expansion method, and the degree of corrugation of the tubular such that the unexpanded tubular and the expanded tubular are substantially the same length.

89. A downhole device comprising portions adapted for engaging corrugations of a corrugated downhole tubular.

90. The downhole device of claim 89, wherein the device is a tractor.

91. The downhole device of claim 89, wherein the device is provided in combination with a sliding sleeve.

92. A subsea tubular comprising a wall element and at least a portion of the wall element being corrugated.

93. A method of drilling a bore, comprising using a corrugated tubular as a drill bit support.

94. The method of claim 93, wherein the tubular is corrugated casing.

95. The method of claim 93 or 94, wherein the tubular is subsequently diametrically expanded.

96. The method of claim 93, 94 or 95, wherein the tubular is subsequently expanded to a parallel-walled form.

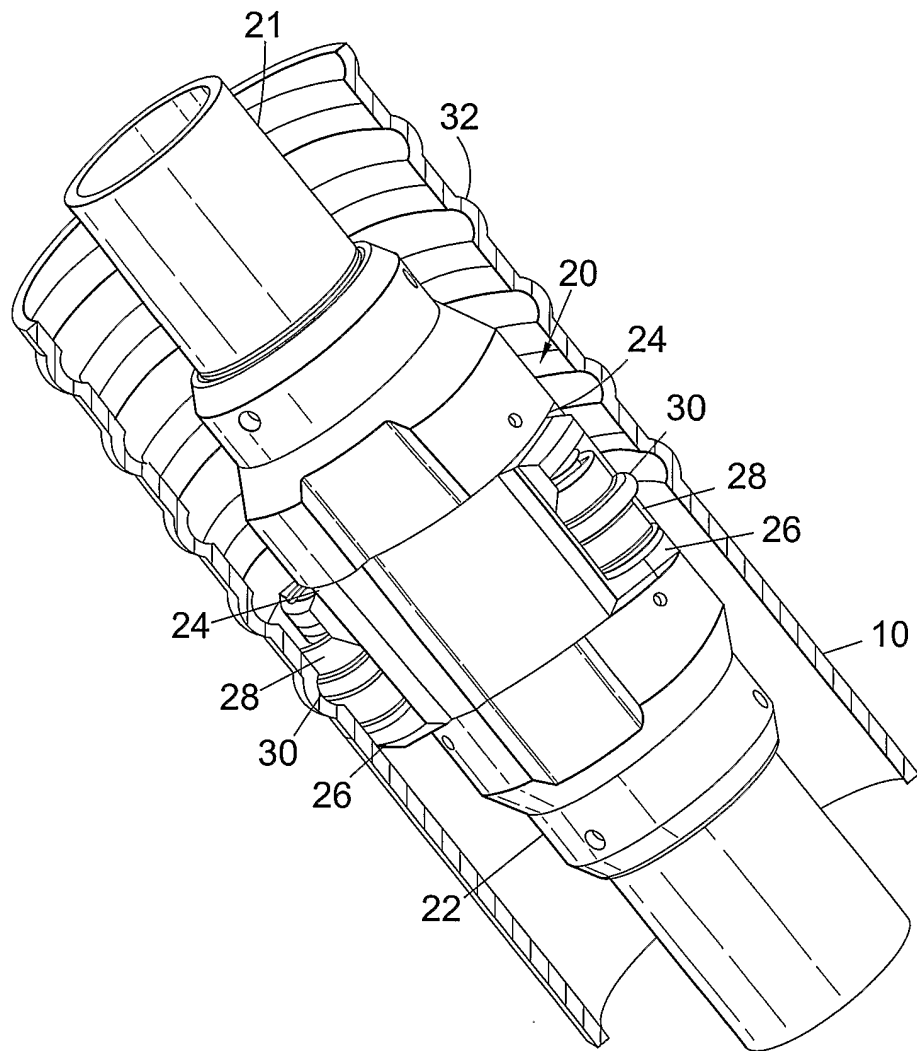


Fig. 1

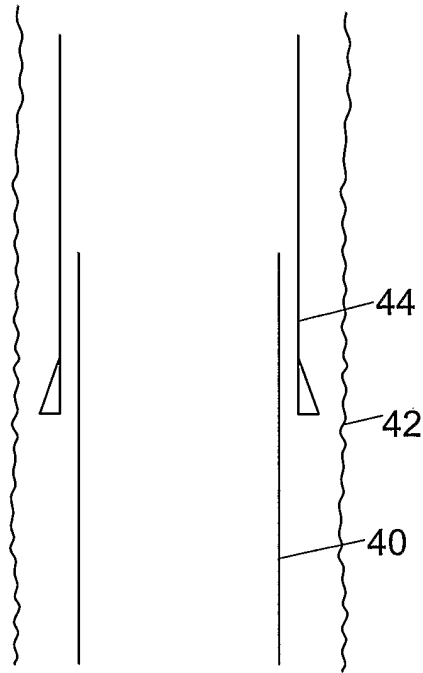


Fig. 2

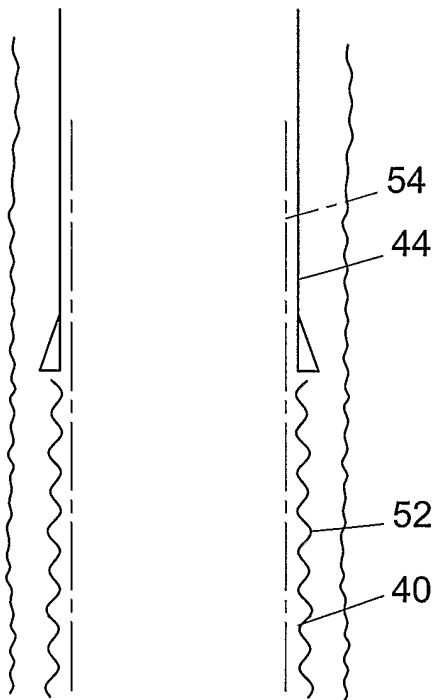


Fig. 3

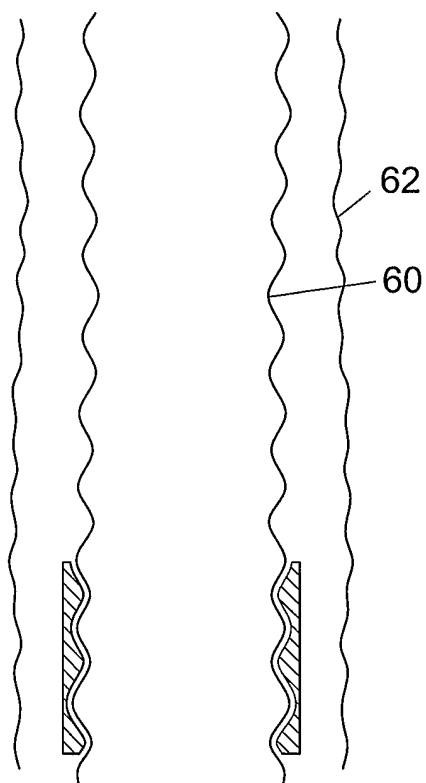


Fig. 4

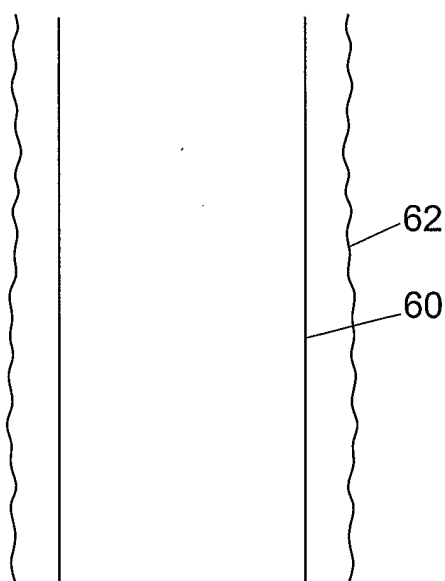


Fig. 5

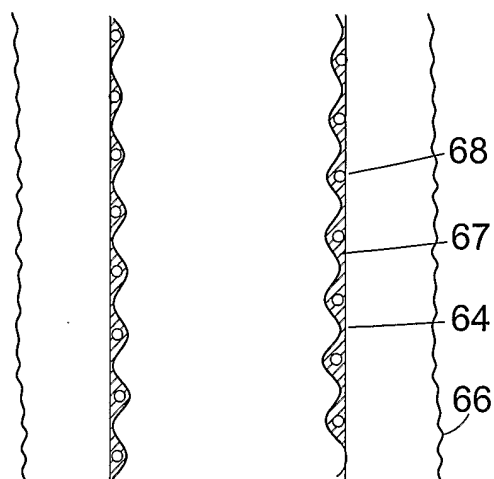


Fig. 6

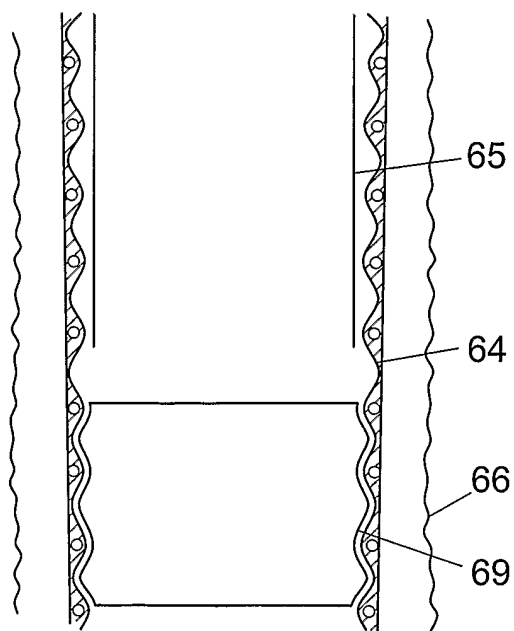


Fig. 7

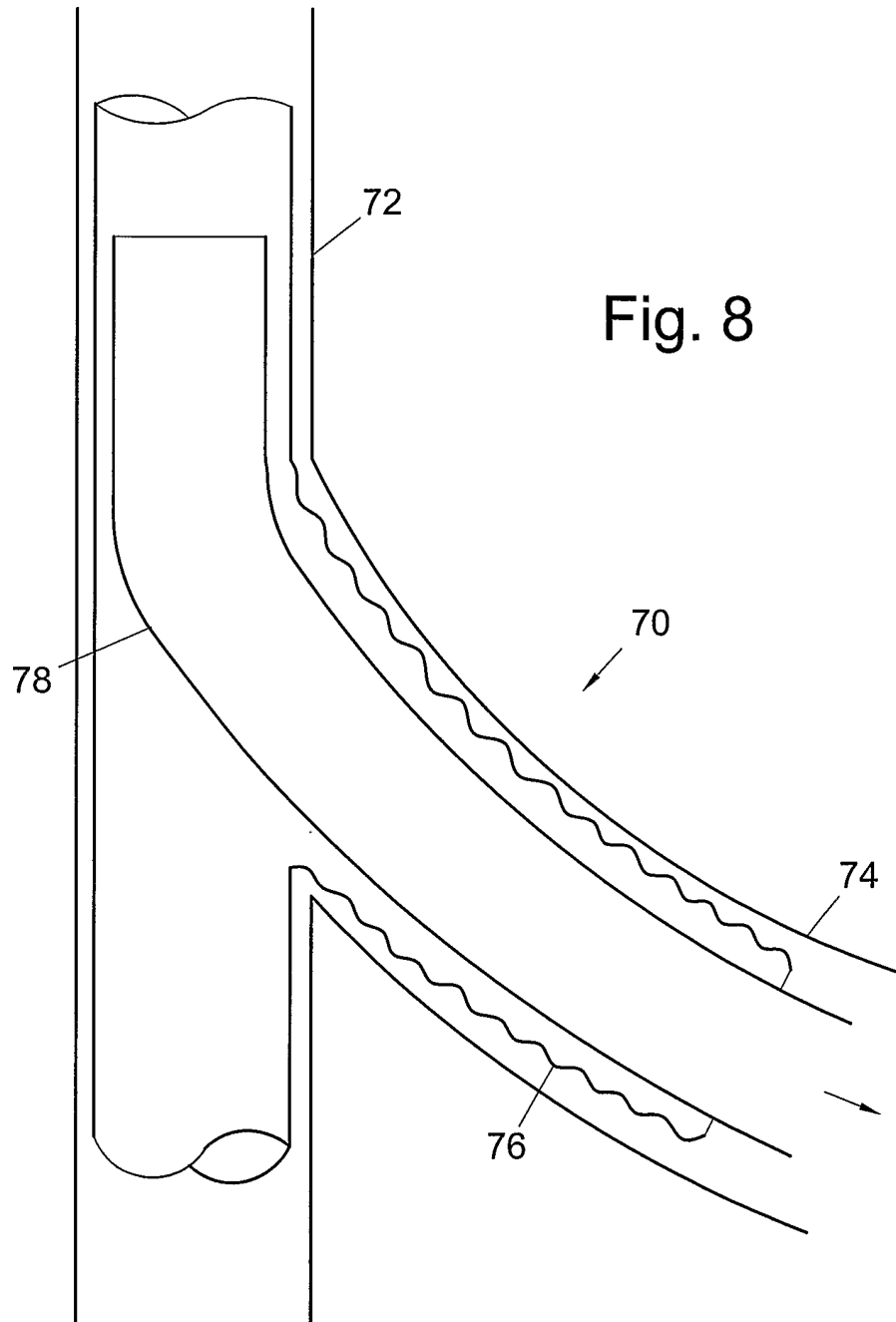


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB 03/02880

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 E21B43/10		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 E21B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 46551 A (HARDING RICHARD PATRICK ;WEATHERFORD LAMB (US)) 28 June 2001 (2001-06-28) page 1, line 3-5; figures 10,11 page 4, line 32,33 -page 5, line 1,2 page 9, line 24-26 page 9, line 22	1-8, 13-17, 20, 22-25, 27-35
X	US 6 253 850 B1 (COON ROBERT JOE ET AL) 3 July 2001 (2001-07-03) column 1, line 15,16,54-58; figures 1-4 --- -/--	1-7, 13-16, 21,22, 24-26, 31-33
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C.		
<input checked="" type="checkbox"/> Patent family members are listed in annex.		
° Special categories of cited documents :		
A document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family		
Date of the actual completion of the international search 3 November 2003		Date of mailing of the international search report 20/11/2003
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Georgescu, M

INTERNATIONAL SEARCH REPORT

Internatic	Application No
PCT/GB	03/02880

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>GB 2 350 137 A (BAKER HUGHES INC) 22 November 2000 (2000-11-22)</p> <p>page 9, line 10,17,18; figures 27-30 page 3, line 1,2 page 5, line 3-6 page 4, line 9,10 further tubular 14 located internally of corrugated tubular 108</p>	<p>1-7,9, 11-20, 24,25, 27,31-33</p>
A	<p>US 4 482 086 A (BEARL LESLIE K ET AL) 13 November 1984 (1984-11-13) figures 3,4</p>	<p>3,4, 18-20,22</p>
A	<p>US 6 409 226 B1 (KAISER TRENT MICHAEL VICTOR ET AL) 25 June 2002 (2002-06-25) the whole document</p>	
A	<p>US 5 040 620 A (NUNLEY DWIGHT S) 20 August 1991 (1991-08-20) the whole document</p>	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 03/02880

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 36-96
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 36-96

In view of the large number and also the wording of the claims presently on file, which render it difficult, if not impossible, to determine the matter for which protection is sought, the present application fails to comply with the clarity and conciseness requirements of Article 6 PCT (see also Rule 6.1(a) PCT) to such an extent that a meaningful search is impossible. Consequently, the search has been carried out for those parts of the application which do appear to be clear (and concise), namely on the matter related to running a tubular into a drilled bore which, subsequently, is corrugated in the bore.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Internat	pplication No
PCT/GB	03/02880

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