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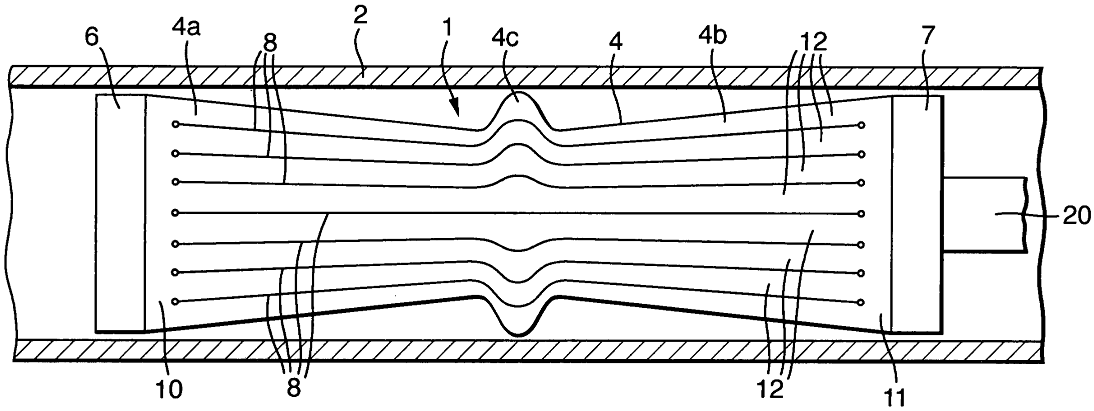
(54) **Method of forming a corrugation in a tubular element**

(57) A method of creating a corrugation in a tubular element (2), the method comprising inserting an expansion mandrel (1) having an annular rim (4c) into the tubular element, the mandrel being radially expandable between a retracted mode in which the annular rim has an outer diameter equal or smaller than the inner diameter of the tubular element, and an expanded mode in which the annular rim has an outer diameter larger than said inner diameter of the tubular element, whereby the mandrel is in the retracted mode during insertion into the tubular element, transporting the mandrel through the tubular element to the location where the corrugation is to be created, and inducing the mandrel to move from the radially retracted mode to the radially expanded mode thereby creating said corrugation in the tubular element.

Fig.1.



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Description

[0001] The present invention relates to a method of creating a corrugation in a tubular element. It is known to provide a tubular element with one or more corrugations, such as for the purpose of accommodating thermal expansion or contraction of the tubular element. If, for example, fluid of varying temperature is transported through the tubular element, one or more corrugations in the tubular element may serve to alleviate compressive forces due to thermal expansion by controlled deformation of the corrugations. Also, corrugations can be created in casings or liners extending into wellbores for the production of hydrocarbon fluid to accommodate compaction of the surrounding earth formation or to accommodate thermal expansion during start-up of the wellbore. Furthermore, corrugations generally also increase the collapse resistance of the tubular element.

[0002] WO 2004/005669 discloses a method and a tool for creating a corrugation in a tubular element. The tool comprises a hollow body having three radially extending apertures which each accommodate a piston, with a roller being mounted on each piston. Each roller has a raised rib that is pressed against the inner surface of the tubular element when the pistons are activated to move radially outward. A corrugation is created in the tubular element by simultaneously activating the pistons and rotating the tool in the tubular element. During rotation of the tool in, the rollers move along the inner surface of the tubular element with a high compressive force between each roller and the tubular element.

[0003] It is a drawback of the known tool that an irregularly shape corrugation is created since, at each moment in time, the rollers press against the inner surface of the tubular element at three circumferential locations only. Moreover, the wall of the tubular element can be subjected to fatigue by virtue of the varying loads exerted by the moving rollers to the wall.

[0004] Accordingly it is an object of the invention to provide an improved method of creating a corrugation in a tubular element, which overcomes the drawbacks of the

prior art.

[0005] In accordance with the invention there is provided a method of creating a corrugation in a tubular element, the method comprising inserting an expansion mandrel having an annular rim into the tubular element, the mandrel being radially expandable between a retracted mode in which the annular rim has an outer diameter equal or smaller than the inner diameter of the tubular element, and an expanded mode in which the annular rim has an outer diameter larger than said inner diameter of the tubular element, whereby the mandrel is in the retracted mode during insertion into the tubular element, transporting the mandrel through the tubular element to the location where the corrugation is to be created, and inducing the mandrel to move from the radially retracted mode to the radially expanded mode thereby creating said corrugation in the tubular element.

[0006] With the method of the invention it is achieved that the corrugation is formed by virtue of a substantially uniform pressure exerted by the annular rim to the inner surface of the tubular element. This allows the corrugation to be created in a single stroke of the mandrel from the retracted mode to the expanded mode, thus ensuring that the corrugation has a regular shape and that fatigue of the wall of the tubular element is avoided.

[0007] Suitably the mandrel comprises a tubular body formed of a plurality of segments spaced along the circumference of the tubular body and separated from each other by respective longitudinal slits.

[0008] In a preferred embodiment, each segment has a rim portion, and the rim portions of the respective segments form the annular rim.

[0009] The invention will be described hereinafter in more detail by way of example with reference to the accompanying drawings in which:

Fig. 1 schematically shows a longitudinal section of a tubular element in which a corrugation is to be created using an embodiment of a mandrel used in the method of the invention;
Fig. 2 schematically shows the wellbore casing of Fig. 1 after the corrugation has been created;
Fig. 3 schematically shows a longitudinal section of the mandrel of Fig. 1;
Fig. 4 schematically shows cross-section 4-4 of Fig. 3;
Fig. 5 schematically shows a detail of the cross-section of Fig. 4;
Fig. 6 schematically shows the corrugation created with the mandrel of Fig. 1; and
Fig. 7 schematically shows the corrugation after being axially collapsed.

[0010] In the Figures like reference numerals relate to like components.

[0011] Referring to Figs. 1 and 2 there is shown an expansion mandrel 1 located in a tubular element 2, the mandrel 1 being movable between a radially retracted mode (Fig. 1) and a radially expanded mode (Fig. 2). The mandrel 1 comprises a steel tubular body 4 including a first body portion 4a, a second body portion 4b, and an expander portion 4c located centrally between the first and second body portions 4a, 4b. The ends of the expander body 4 are closed by respective circular end plates 6, 7 of a diameter slightly smaller than the inner diameter of the tubular body 4. The first body portion 4a tapers radially inward in the direction from end plate 6 towards the expander portion 4c, and the second body portion 4a tapers radially inward from end plate 7 towards the expander portion 4c. The expander portion 4c forms an annular rim 4c protruding radially outward from the first and second body portions 2a, 2b. When the mandrel 1 is in the radially retracted mode (Fig. 1), the annular rim 4c has an outer diameter slightly smaller than the inner diameter of the tubular element 2. When the mandrel 1 is in the radially expanded mode (Fig. 2), the annular rim 4c has an outer diameter significantly larger than the inner diameter of the tubular element 2.

[0012] The tubular body 4 is provided with a plurality of narrow longitudinal slots 8 regularly.spaced along the circumference of the tubular body 4. The slots 8 do not extend the full length of the tubular body 4, with short unslotted sections 10, 11 of the tubular body 4 at both ends thereof. Further, the slots 8 pass through the wall of the tubular body 4, thus defining a plurality of separate longitudinal body segments 12 spaced along the circumference of the tubular body 4. By virtue of their elongate shape and elastic properties, the body segments 12 are capable of elastic bending radially outward upon application of a suitable internal pressure applied to the tubular body 4. Thus, the body segments 12 are in rest position when the mandrel 1 is in the radially retracted mode (Fig. 1), whereas the body segments 12 are bent radially outward by internal pressure when the mandrel 1 is in the radially expanded mode (Fig. 2).

[0013] Referring further to Figs. 3 and 4, the tubular body 4 is internally provided with an inflatable bladder 14 of elastomeric material, whereby the shape of the bladder 14 substantially corresponds to the shape of the space defined by the inner surface of the tubular body 4 and the end plates 6, 7. The internal space of the bladder 14 forms a fluid chamber 18 that is fluidly connected to a fluid control system (not shown) via a fluid conduit 20 extending through the tubular element 2.

[0014] Referring further to Fig. 5 there is shown a detail of the cross-section of the mandrel 1, indicating a tubular layer of relatively stiff elastomer 22 and a plurality of thin (about 0.5 mm thick) steel plates 24 located between the bladder 14 and the body segments 12. The steel plates 24 extend in longitudinal direction of the mandrel 1, with a small longitudinal space inbetween each pair of adjacent plates 24. The plates 24 are twice as wide as the body segments 12. Each plate 24 is fixedly connected to the inner surface of a body segment 12a, for example by means of glue, and extends along the inner surfaces of the two adjacent body segments 12b, 12c in a free sliding manner.

[0015] During normal operation the mandrel 1 is inserted into the tubular element 2 in its radially retracted mode, and moved to a location where a corrugation is to be formed in the tubular element 2. Fluid is then pumped from the fluid control system, via the tubular string 20, into the inflatable bladder 14 so as to increase the fluid pressure in the fluid chamber 18. As a result the body segments 12 move radially outward, with the effect that the annular rim 4c radially expands against the wall of the tubular element 2 at high force. A short section of the tubular element 2 thereby becomes plastically deformed to form a corrugation 26 (Fig. 2) of a shape corresponding to the shape of the annular rim 4c. It will be understood that the slots 8 become wider as the mandrel 1 moves to the radially expanded mode. The elastomer layer 22 and the plates 24 serve to prevent the wall of the bladder 14 becoming pressed into the widened slots 8. After the corrugation has been made, the fluid control system is operated to release the fluid pressure in the bladder 14 so as to allow the body segments 4 to elastically move back to their respective rest positions. If necessary, the mandrel 1 is then moved to another location in the tubular element 2 to create another corrugation in a similar manner. The corrugations 26 made in this manner have several possible purposes.

[0016] Referring further to Figs. 6 and 7, one possible purpose is to reduce the axial stiffness of the tubular element 2. Namely, when the tubular element becomes loaded with an axial compressive load, the corrugation 26 collapses (Fig. 7) if the compressive load exceeds a selected threshold magnitude. It is thereby achieved that the corrugation 26 functions as a mechanical 'fuse' by preventing the tubular element being overloaded. Such axial compressive load is, for example, caused by thermal expansion of the tubular element 2. Also, in case the tubular element 2 is a casing or a liner extending into a well for the production of oil or gas, the axial compressive force can be due to vertical compaction of the surrounding earth formation. Thus, the 'fuse' functionality of the corrugation 26 prevents damage to other portions of the tubular element 2 due to overloading.

Claims

1. A method of creating a corrugation in a tubular element, the method comprising:

   - inserting an expansion mandrel having an annular rim into the tubular element, the mandrel being radially expandable between a retracted mode in which the annular rim has an outer diameter equal or smaller than the inner diameter of the tubular element, and an expanded mode in which the annular rim has an outer diameter larger than said inner diameter of the tubular element, whereby the mandrel is in the retracted mode during insertion into the tubular element;
   - transporting the mandrel through the tubular element to the location where the corrugation is to be created; and
   - inducing the mandrel to move from the radially retracted mode to the radially expanded mode thereby creating said corrugation in the tubular element.

2. The method of claim 1, wherein the mandrel comprises a tubular body formed of a plurality of segments spaced along the circumference of the tubular body and separated from each other by respective longitudinal slits.

3. The method of claim 2, wherein each segment has a rim portion, and wherein the rim portions of the respective segments form the annular rim.

4. The method of claim 2, wherein the annular rim protrudes radially outward from a remainder portion of the tubular body.

5. The method of claim 3 or 4, wherein said annular rim of the tubular body is located between first and second end portions of the tubular body, wherein the first end portion tapers radially inward from one end of the tubular body towards the expander portion, and wherein the second end portion tapers radially inward from the other end of the tubular body towards the expander portion.

6. The method of any one of claims 1-5, wherein the mandrel comprises a fluid chamber containing a body of fluid, and wherein the mandrel is induced to radially expand by increasing the fluid pressure in said fluid chamber.

7. The method of claim 6, wherein the fluid chamber has a wall of flexible material.

8. The method of claim 7, wherein said wall comprises an elastomeric material.

9. The method of any one of claims 1-8, wherein the tubular element is a wellbore casing, a wellbore liner, a pipeline for the transportation of fluid at elevated temperature, or a pipe section of a chemical or petrochemical plant.

10. The method substantially as described hereinbefore with reference to the accompanying drawings.

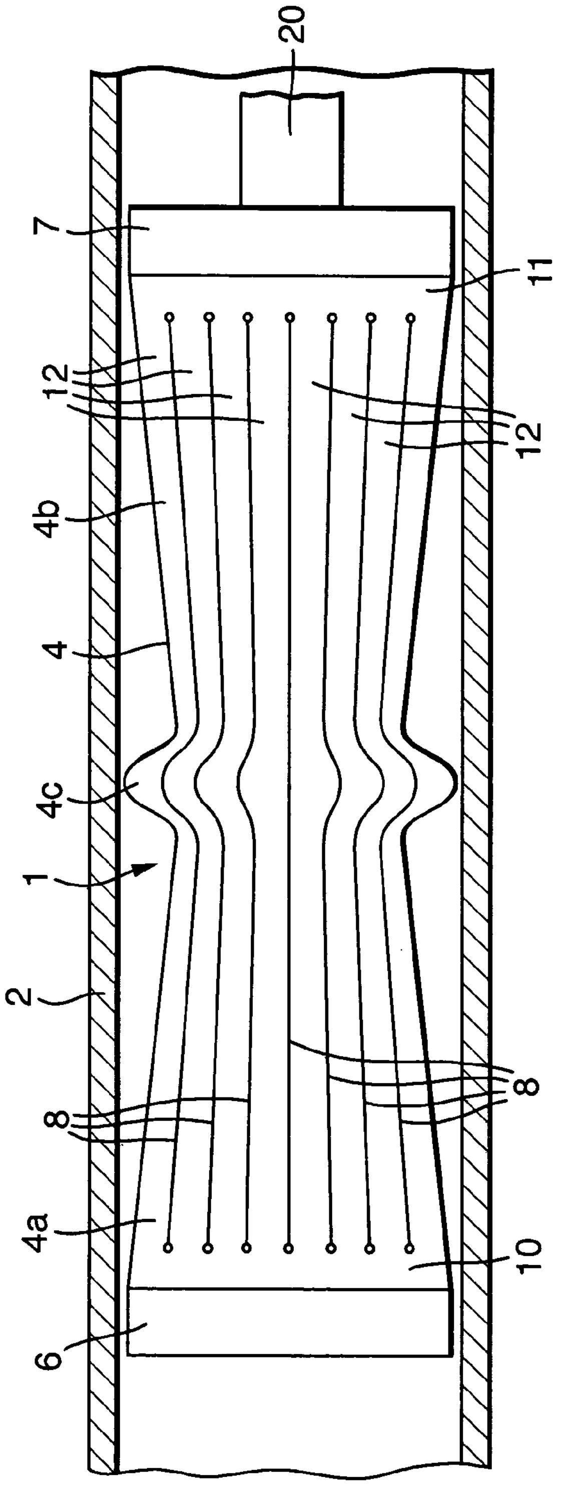


Fig.1.

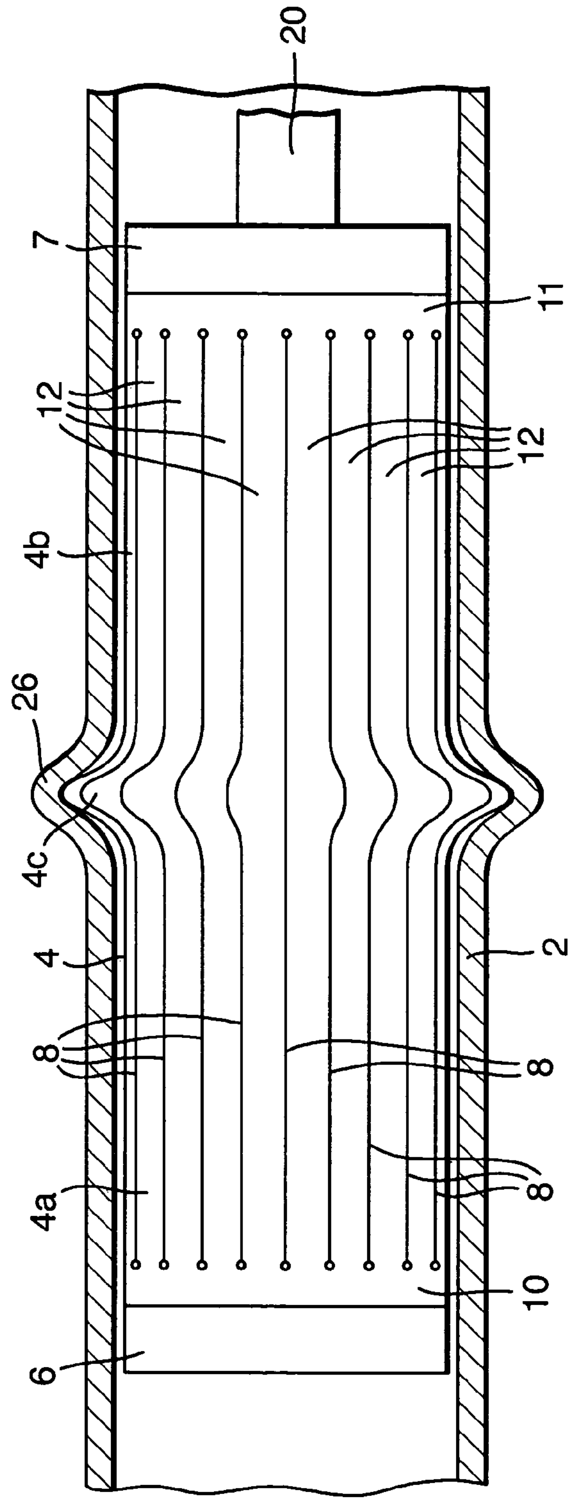


Fig.2.

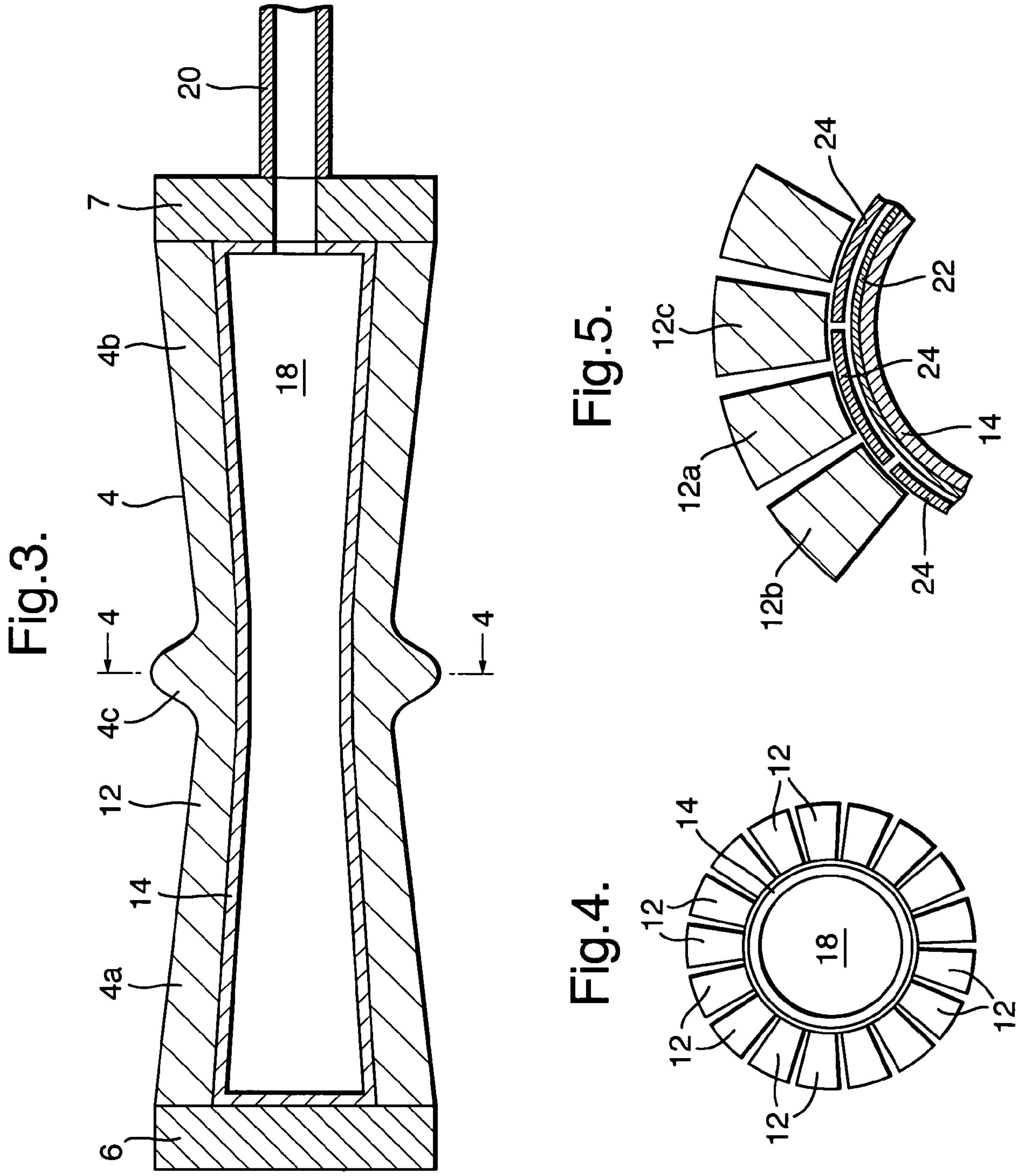


Fig.3.

Fig.4.

Fig.5.

Fig.6.

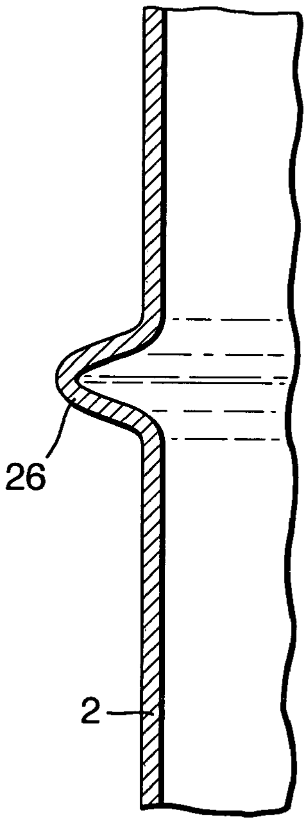
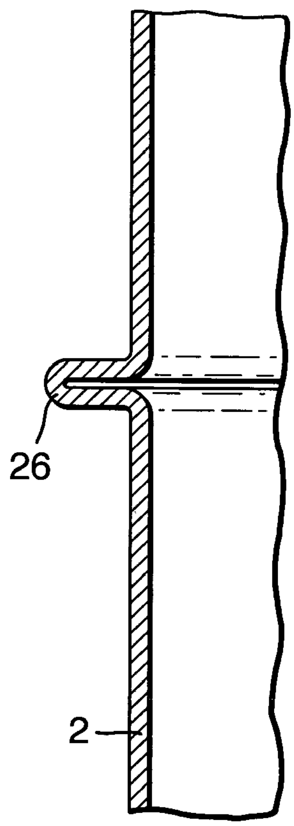


Fig.7.



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EUROPEAN SEARCH REPORT

Application Number
EP 05 25 6528

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 779 445 A (RABE ET AL) 25 October 1988 (1988-10-25) * column 3, line 29 - line 57 * -----	1-4,6,9	E21B43/10 B21D39/20
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A	WO 2004/097170 A (SHELL INTERNATIONAL RESEARCH MAATSCHAPPIJ B.V; SHELL CANADA LTD; LOHBE) 11 November 2004 (2004-11-11) * page 6, line 3 - page 7, line 20 * * page 10, line 8 - line 11 * -----	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B B21D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 March 2006	Ott, S

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03-03-2006

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