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(54) Method for making lined pipe bends

(57) A method for making lined bends, wherein the smaller thinner pipe (3) is inserted into the larger thicker pipe (2), both extremities of the pipe assembly (1) are sealed by welding and the closed space is filled with nitrogen. The gas is then put under pressure and a portion of the pipe assembly (1) is heated by means of a hot induction device (9) until reaching an appropriate temperature to allow a good deformability of the metal, a bending moment then being applied while maintaining controlled pneumatic internal pressure in the interior of the pipe assembly (1).

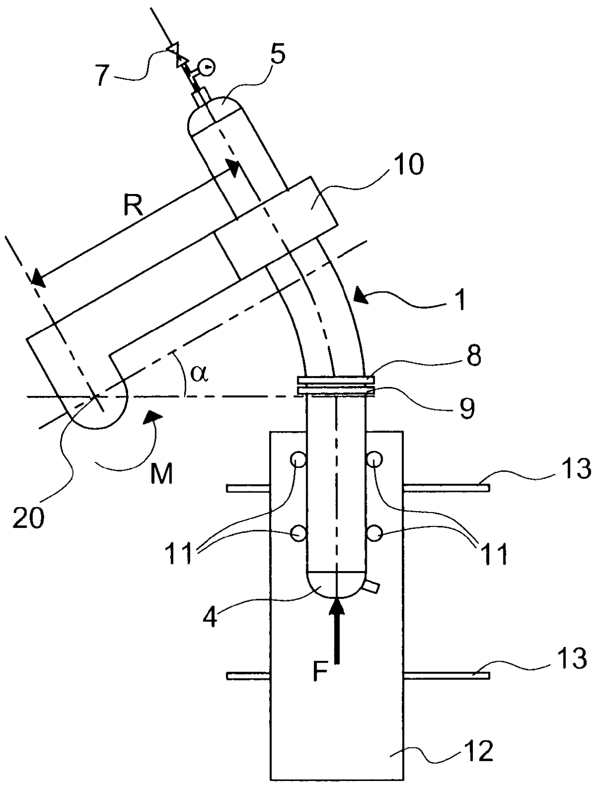

Fig. 3

EP 2 327 486 A1

Description

Field of the invention

[0001] The present invention relates to a method for making lined pipe bends and to the lined pipe bends produced by the method, generally for the lined pipe market and especially for use in the oil and gas industry.

Background of the invention

[0002] Lined pipes are bimetallic products that have been used for years in pipelines construction. The outer pipe is usually made of C-Mn steel and is designed to have high mechanical properties, while the inner pipe is made of Corrosion Resistant Alloy (CRA) and is designed to achieve high resistance against corrosion and has a wall thickness of only few millimetres, in the range from 1 to 5mm. Lined pipes of the state of the art are obtained by methods comprising the expansion of an inner pipe inserted mechanically into an outer pipe, wherein originally the outside nominal diameter of the inner pipe is smaller than the inside nominal diameter of the outer pipe. The lined pipes find an important use in pipeline construction.

[0003] Pipeline projects include not only straight pipes but also a number of accessories, among which bends are frequently present. Non-lined bent pipes are typically obtained by a method based on hot induction bending of straight pipes. This hot induction bending process is however not applicable to obtaining lined bends since the inner pipe with thinner wall does not resist the stress of compression occurring along the intrados line of the bent pipe and separates from the internal surface of the outer pipe. The final shape of the bent pipe would thus include ripples.

[0004] Current trends for complex projects, where reliability is a main concern, indicate the need for producing bends from straight pipes belonging to the same project (bends that are manufactured using the straight pipe as mother pipe), whereby any kind of incoherency (material discontinuity) is avoided along the whole pipeline.

[0005] Some known methods for making lined pipe bends are disclosed in the state of the art.

[0006] Document WO2005/110637 discloses a method for bending pipes wherein the bending is produced by mechanical hot deformation. An internal pressure is applied only to expand the inner pipe until it contacts the outer pipe, not for the bending process. Pipe bending is done by placing the pipe between rollers and applying an external pressure, exerted by the rollers, at points such that the pipe is bent into its final shape. This bending process by means of rollers is applicable only to pipes of smaller size than the ones used in the oil and gas industry, where pipes are bigger, with thicker wall thicknesses and much more resistant. Moreover, as pipes are smaller, inner pipes are easy to deform without the occurrence of internal surface imperfections. This is not the case, however, for pipes used in the oil and gas industry. Heat may also be applied during this bending process. The inner pipe is also bent at certain points in the process while the outer pipe is held loosely in position.

[0007] Next, hydraulic pressure is applied to the inner pipe interior to expand the inner pipe into engagement with the inner wall of the outer pipe. This is done by pressurising to expand the inner pipe beyond its yield point, so generating plastic deformation and causing temporary elastic deformation of the outer pipe. Once the hydraulic pressure is removed, the outer pipe recovers elastically so as to remain in continuos contact with the inner pipe. To prevent kinking, the inner pipe is filled with sand or similar material.

[0008] Document WO99/64180 discloses a method of making lined pipe bends wherein use is made of sand or granular material inserted into the inner pipe to prevent the formation of ripples during the bending process. The use of sand or granular material does not exert any pressure until the bending starts and this is a disadvantage. Only when the tube in which the sand or granular material is contained starts to curve, does the sand or granular material exert significant pressure on the inner tube, helping to avoid ripples.

[0009] Another disadvantage of this method is that the force exerted on the ends of the tube is not adjustable, since it only depends on the change of volume when the pipe passes from a straight shape to a curved shape. Moreover, the physical separation, though of only a few tenths of a millimetre, between the inner tube and outer tube cannot be avoided. In fact, this method also includes the hydraulic expansion of the internal material in the bent shape to recover the physical contact between the inner and outer pipes.

[0010] From the operative benefit viewpoint, the increased weight of the tube filled with sand significantly limits the structure of the bending machine.

Summary of the invention

[0011] It is therefore a main object of the present invention to provide a method for making lined pipe bends or elbows which overcomes the aforementioned drawbacks.

[0012] In particular it is a further object of the present invention to provide lined pipe bends by means of the aforementioned method.

[0013] These above mentioned objects and other objects that will become apparent to a person skilled in the art are achieved in accordance with a first aspect of the invention by means of a method for making lined bends on metal pipes, wherein there is provided

- a first metal pipe and a second metal pipe of straight shape, the outer diameter of the second pipe being smaller than the inner diameter of the first pipe, and the axial length of the second pipe (3) being substantially equal to the axial length of the first pipe;

- a hot induction bending device comprising a hot induction ring;

the method comprising the steps of:

a) inserting the second pipe into the first pipe and expanding the second pipe until the two pipes mechanically engage each other radially, thus forming a lined pipe assembly;
b) sealing both ends of the lined pipe assembly whereby a closed space is obtained separated from the external environment;
c) filling the closed space with an inert gas;
d) bringing the inert gas in the closed space up to a predetermined pressure above atmospheric pressure;
e) heating a portion of the lined pipe assembly by means of the hot induction ring until reaching an appropriate temperature to allow a good deformability of the metal,
f) applying a bending moment on the lined pipe assembly, while maintaining said predetermined pressure in the closed space.

[0014] The method according to the invention uses only internal pneumatic pressure, employing either gaseous nitrogen or any other inert gas, controlled by means of a calibrated valve, to counteract the formation of ripples or buckling during hot induction bending, thus leading to the manufacture of lined bends without any internal surface irregularities.

[0015] The fact that the bending step is performed while maintaining a pneumatic controlled internal pressure in the closed space inside the pipe assembly ensures a perfect contact between inner and outer pipes during bending, thus avoiding the formation of ripples or buckling.

[0016] The controlled internal pressure produces stresses radially pushing the inner pipe towards the outer pipe while simultaneously reducing the compression stresses along the intrados line, given by the bending itself. The stresses added to the pipe walls by the internal pressure counteract the bucking phenomenon, leading to the making of faultless lined bends.

[0017] Moreover as the contact between inner and outer pipes is ensured during the whole deformation process starting from the beginning when the pipe is still straight, no air is retained between pipes, and there is no need to provide the outer pipe with holes to exhaust the retained air as proposed in the prior art.

[0018] With controlled air pressure, the internal pressure is easily adjustable by regulating a control valve therein provided.

[0019] The method of the present invention is applicable to a wide variety of outer diameter and wall thickness measures of the pipes. More preferably, the present invention is applicable to pipes having outer diameters within the range from 76mm (3 inches) to 712mm (28 inches), and wall thicknesses within the range from 6mm (0.24 inches) to 60mm (2.4 inches).

Brief description of the drawings

[0020] The foregoing and other objects of the invention will become more readily apparent by referring to the following detailed description and the appended drawings in which:

Figure 1 shows a section along an axial plane of a lined pipe at an initial stage of the method of manufacture according to the invention, before bending;
Figure 2 shows a view of the lined pipe at said initial stage;
Figure 3 shows a view of the lined pipe at a successive stage of the method of manufacture according to the invention, where the pipe is bent;
Figure 4 shows a lined pipe with cups, valve and pressure gauge ready for the hot induction bending process;
Figure 5 shows an enlarged sectional view of the detail A of Figure 4.

Detailed description of preferred embodiments of the invention

[0021] The method according to the invention provides for preparation of the lined pipes to be bent, comprising the following operations.

[0022] A first pipe 2 of larger diameter and greater wall thickness is provided, made of a steel for example made of C-Mn steel or any other appropriate steel alloy, a second pipe 3 also being provided having a thinner wall thickness and outer diameter slightly smaller than the inner diameter of the first pipe 2.

[0023] In particular, the ratio between outer diameter of the second pipe 3 and outer diameter of the first pipe 2 is within the range 0,5 to 0,97.

[0024] This second pipe 3 is made of a steel more resistant to corrosion, for example AISI 316, 825 steel or other appropriate Corrosion Resistant Alloys. The second pipe 3 has substantially the same length as the first pipe 2.

[0025] A first step of the method according to the invention provides for inserting the second pipe 3 into the first pipe 2 and subsequently expanding the second inner pipe 3 until the two pipes 2, 3 mechanically engage each other radially, i.e. until substantially the entire external surface of the second inner pipe 3 makes contact with the internal surface of the first outer pipe 2, thus forming a lined pipe assembly 1, or simply lined pipe.

[0026] The mechanical contact between inner and outer pipes 2, 3 is obtained only by the expansion of the inner pipe 3. No heat is applied during this expansion.

[0027] An appropriate pressure is applied to the inner pipe interior to expand the inner pipe 3 into engagement with the inner wall of the outer pipe 2. This is done by attaching pressure fittings to each end of the inner pipe 3 and pressurising to expand the inner pipe 3 beyond yield point, so generating plastic deformation and causing temporary elastic deformation of the outer pipe 2. Once the pressure is removed, the outer pipe 2 recovers elastically so as to remain in continual contact with the inner pipe 3.

[0028] A further step of the method provides for sealing both ends of the lined pipe assembly 1 with caps whereby a closed space is obtained separated from the external environment (Figure 4).

[0029] A bevelling operation on both ends of the lined pipe assembly 1 is advantageously carried out to facilitate a subsequent welding operation for sealing said ends and defining said closed space. In particular, a bevel 15 is produced only in the more external zone of the ends of the outer pipe 2, as illustrated in Figure 5.

[0030] A respective closing cap 4, 5 is then placed at each end of the lined pipe assembly 1 so that fluid communication with the external atmosphere is created and the closing caps 4, 5 are welded at both pipe assembly ends, by positioning the couplings so that only the outer pipe 2 of the lined pipe assembly 1 is involved in the welding, whilst the inner pipe 3 is not. The welding zone is indicated by the reference numeral 14 in Figure 5. In this manner both ends of the lined pipe assembly 1 are sealed and a closed space separated from the external environment is obtained (Figure 4).

[0031] A control valve 7 having also a safety function and a pressure gauge 6 are positioned along a duct 16 communicating with an orifice 17, provided preferably on one of the closing caps. In Figure 4 the orifice 17 is provided on the closing cap 5.

[0032] A further step of the method according to the invention provides for filling the closed space with an inert gas, such as Gaseous Nitrogen or Helium.

[0033] The inert gas is introduced into the lined pipe assembly 1 through the control valve 7, and a nominal working pressure for the gas is set.

[0034] The nominal working pressure is comprised in a range from 0.5 MPa (5.0 bar) to 5 MPa (50.0 bar), the choice of said nominal working pressure depending on the outer diameter of the outer pipe 2, on the pipe wall thickness and on their steel composition. The nominal working pressure in the lined pipe assembly 1 is maintained by means of the control valve 7 which releases gas when pressure builds up beyond the preset limit corresponding to the maximum allowable pressure. This maximum allowable pressure is preferably set as 120% of the nominal working pressure.

[0035] The inert gas is then pressurised so as to reach the nominal working pressure while the lined pipe assembly 1 is still in a straight shape. This nominal working pressure is applied in order to maintain contact between the inner pipe 3 and the outer pipe 2, said contact having been already obtained in the first step, and to avoid the formation of irregularities on the internal surface of the lined pipe assembly 1 during the hot induction bending process.

[0036] Subsequently the lined pipe assembly 1, comprising inner 3 and outer 2 pipes mechanically engaged with each other, is positioned in a hot induction bending machine.

[0037] The hot induction bending machine, illustrated in Figures 2 and 3, comprises:

- a platform 12, provided with guiding rollers 11, for supporting and guiding the lined pipe assembly 1 during the bending process;
- a radial bending arm 10 having a first end to be fixed on the lined pipe assembly 1 and a second end fixed at a rotation fulcrum 20;
- rails 13 for possibly moving the platform 12 laterally, to vary the bending radius R;
- pushing means (not illustrated) for pushing the lined pipe assembly 1 along the platform 12;
- an induction coil or heating ring 9 for heating a predetermined portion of the pipe assembly passing through said heating ring;
- and a quenching ring 8 for quenching the steel as the lined bend is formed in the previously heated portion and for precisely delimiting the zone undergoing plastic deformation.

[0038] The lined pipe assembly 1 is preferably positioned with the closing cap 5, provided with the control valve 7, placed at the radial bending arm 10 applied at one end of the lined pipe assembly 1, with respect to the hot induction bending machine (Figure 2).

[0039] Once the lined pipe assembly 1 is in place in the hot induction bending machine, a hot induction bending operation is carried out. This hot deformation process is concentrated only in a specific portion of the pipe assembly 1, conventionally called "Hot Tape" in the following description, whose length, measured along the axial projection of the lined pipe assembly 1, is determined by the distance between the induction coil or heating ring 9 and the quenching ring 8.

[0040] In a preferred embodiment the length of said specific portion or "Hot Tape" follows this equation:

$$HTL \sim= 2\ WTP$$

wherein:

HTL = length of the hot tape;
WTP = Pipe Assembly wall thickness.

[0041] Said specific portion or "hot tape" is heated by means of the heating ring 9 until a preset working temperature is reached, said working temperature being adapted to allow a good deformability of the metal of both pipes 2 and 3.

[0042] During the hot induction bending, there is a continuous displacement of the hot tape, given by the relative movement of the heating ring 9 and the quenching ring 8 with respect to the lined pipe assembly 1, the length of said displacement depending on the desired predetermined bend angle α.

[0043] The length of the displacement of said specific portion or "Hot Tape" can be calculated by the following equation:

$$Ld = 2\pi * Rc * (\alpha/360)$$

wherein

Ld = length of the displacement of the "Hot Tape";
Rc = preset curvature radius of the final lined bend;
α = bend angle.

[0044] The relative movement between the bending lined pipe assembly 1 and the two rings 8 and 9, is normally generated by the pipe assembly 1 which moves by "penetrating" the rings 8 and 9 which are fixed, for example, to the platform 12. To facilitate the bending deformation of the straight lined pipe assembly, also called mother-pipe, the lined pipe assembly 1 is pushed from its rear extremity, provided with the closing cap 4, by said pushing means that exert a pushing force F, whilst the front extremity of the pipe assembly, provided with the closing cap 5, is clamped to the radial bending arm 10 constrained to describe a circular path about the rotation fulcrum 20, as shown in Figure 3, e.g. by means of a torque applied to it.

[0045] This pivoting movement of the arm 10, with respect to the rotation fulcrum 20, produces a bending moment spread along the entire structure comprising the pipe assembly 1 closed with the closing caps 4 and 5 at the ends thereof, but the wall of the lined pipe assembly 1 is plastically deformed only at the "hot tape", where the strength of the steel is significantly lower, while maintaining pneumatic controlled internal pressure in the closed space inside said closed lined pipe assembly 1.

[0046] The plastic deformation takes place in terms of a significant elongation of the inner and outer pipe walls along the extrados line and a significant compression along the intrados line of the inner and outer pipes walls.

[0047] When the predefined maximum design bending radius is reached, the quenching ring 8 is used to cool the "hot tape", bringing the steel to room temperature.

[0048] The quenching ring 8, therefore, has two simultaneous functions: to quench the steel as the lined bend is formed in the previously heated portion of the pipe assembly and to precisely delimit the zone undergoing plastic deformation.

[0049] An optimal dimension of the diameter of both heating and quenching rings is about 20 to 60 mm larger than the outer diameter (OD) of the mother pipe. The bending temperature at both extrados and intrados sides of the lined pipe assembly is continuously measured by pyrometers during all steps of the method. Continuous recording is performed during the bending operation and diagrams are produced.

[0050] The curvature radius of the lined pipe bend can be defined in terms of "times OD" (e.g. 5 OD, 3 OD, etc.) and the development of the bend be defined in degrees (e.g. bend angle equal to 30°, 90°, etc.).

[0051] The controlled nominal working pressure inside the lined pipe assembly, which is much higher than atmospheric pressure, produces stresses radially pushing the inner pipe 3 towards the outer pipe 2 and, simultaneously, reduces the compression stresses at the intrados line (given by the bending itself), this in combination with a steel temperature above the plastic state ensuring a perfectly smooth internal surface of the lined pipe bend or elbow.

Claims

1. A method for making lined bends in metal pipes, wherein there are provided

- a first metal pipe (2) and a second metal pipe (3) of straight shape, the outer diameter of the second pipe (3) being smaller than the inner diameter of the first pipe (2), and the axial length of the second pipe (3) being substantially equal to the axial length of the first pipe (2);
- a hot induction bending device comprising a hot induction ring (9);

the method comprising the steps of:

a) inserting the second pipe (3) into the first pipe (2) and expanding the second pipe (3) until the two pipes (2,3) mechanically engage each other radially, thus forming a lined pipe assembly (1);
b) sealing both ends of the lined pipe assembly (1) whereby a closed space is obtained separated from the external environment;
c) filling the closed space with an inert gas;
d) bringing the inert gas in the closed space up to a predetermined pressure above atmospheric pressure;
e) heating a portion of the lined pipe assembly (1) by means of the hot induction ring (9) until reaching an appropriate temperature to allow a good deformability of the metal,
f) applying a bending moment on the lined pipe assembly (1), while maintaining said predetermined pressure in the closed space.

2. A method according to claim 1, wherein step b) comprises a welding operation in which closing caps (4, 5) are welded to both ends of the lined pipe assembly (1).

3. A method according to any preceding claim, wherein said predetermined pressure is comprised in a range from 0.5 MPa to 5 MPa.

4. A method according to any preceding claim, wherein said inert gas is introduced into the closed space through a control valve (7).

5. A method according to claim 4, wherein said predetermined pressure in the closed space is maintained by means of the control valve (7) which releases gas when pressure inside said closed space builds up beyond a predetermined limit value corresponding to a maximum allowable pressure.

6. A method according to claim 5, wherein said maximum allowable pressure is set at 120% of said predetermined pressure.

7. A method according to any preceding claim, wherein after step d) the lined pipe assembly (1) is positioned in the hot induction bending device, with a first closing cap (5), provided with said control valve (7), positioned at a radial bending arm (10) applied to a first end of the lined pipe assembly (1) and constrained to describe a circular path about a rotation fulcrum (20).

8. A method according to claim 7, wherein the portion of the lined pipe assembly (1) to be heated passes through said hot induction ring (9).

9. A method according to claim 7 or 8, wherein the lined pipe assembly (1) is pushed from a second end thereof, provided with a second closing cap (4), by a pushing means.

10. A method according to any preceding claim, wherein after step f), when the lined bend has been formed, a quenching step for cooling said predetermined portion to room temperature is carried out by means of a quenching ring (8), which is comprised within the hot induction bending device,

11. A method according to any preceding claim, wherein before step b) a bevelling operation is carried out on both ends of the lined pipe assembly (1).

12. A method according to claim 11, wherein a bevel (15) is produced only in a more external zone of the ends of the first pipe (2).

13. Lined bend on a lined pipe assembly (1) obtainable by the method of claim 1, wherein a first metal pipe (2) and a second metal pipe (3) are provided, the outer diameter of the second pipe (3) being smaller than the inner diameter of the first pipe (2), and the axial length of the second pipe (3) being substantially equal to the axial length of the first pipe (2), said first pipe (2) and said second pipe (3) being radially engaged.

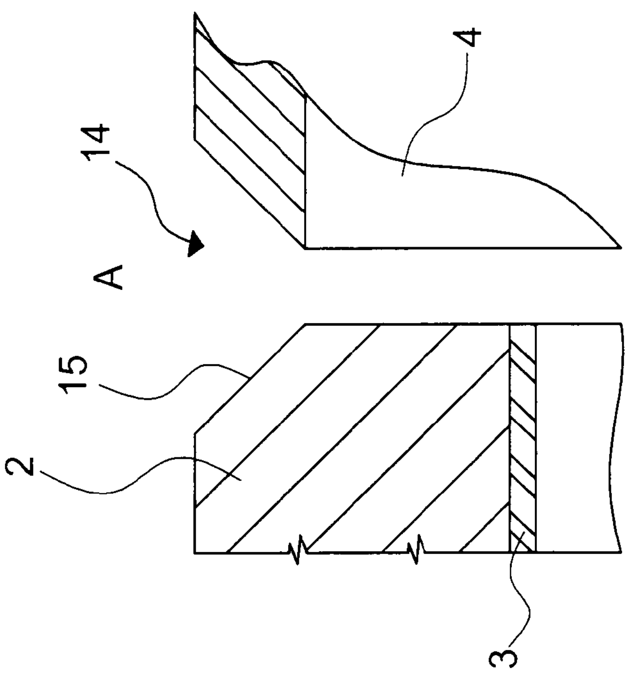

Fig. 5

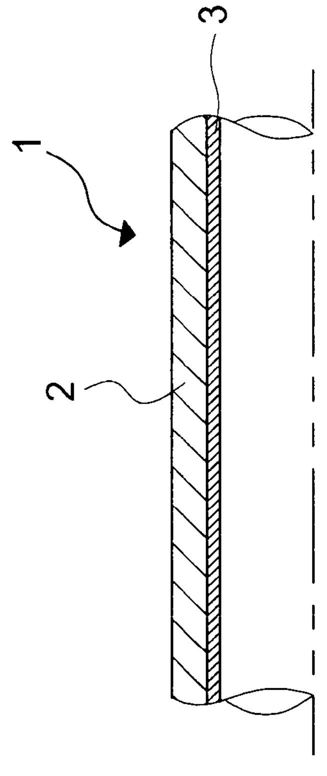

Fig. 1

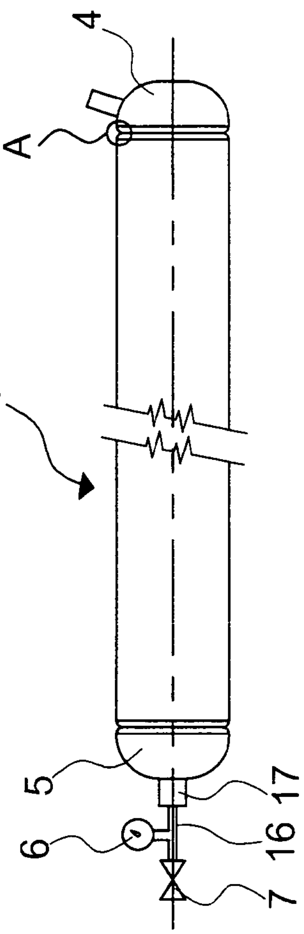

Fig. 4

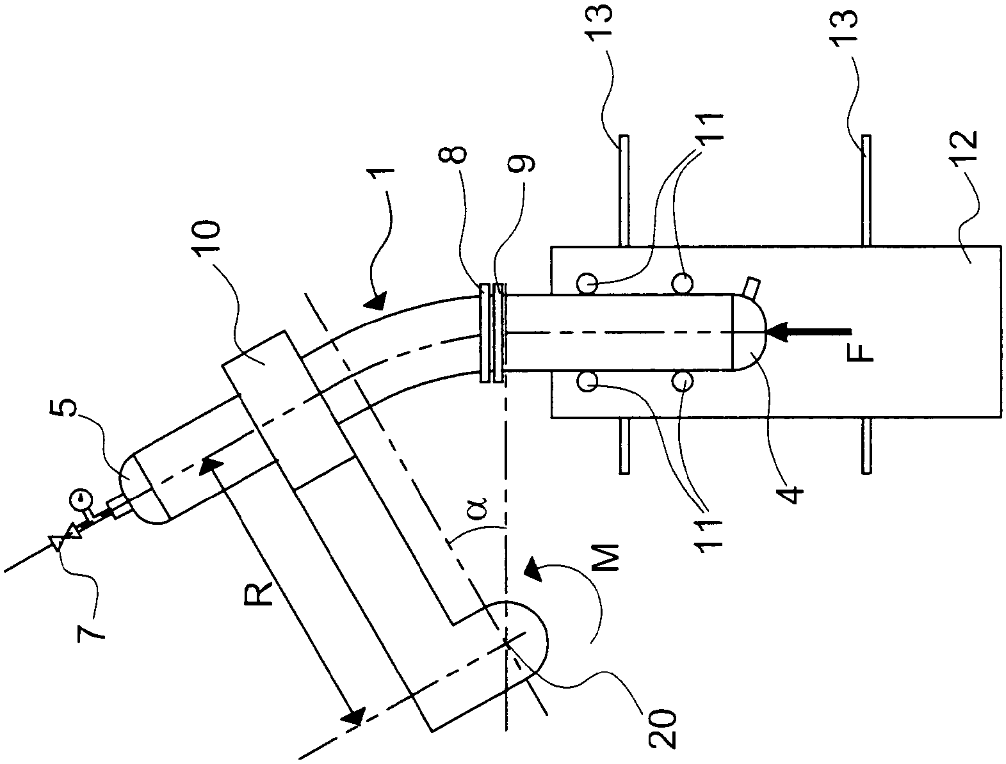

Fig. 3

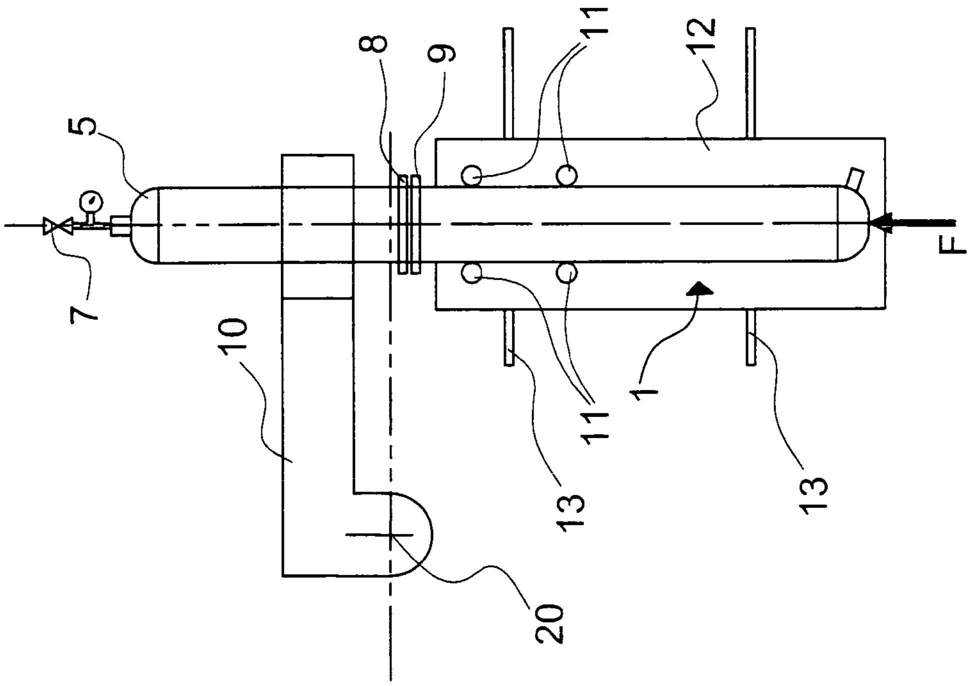

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 09 42 5487

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	25 May 2010	Cano Palmero, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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