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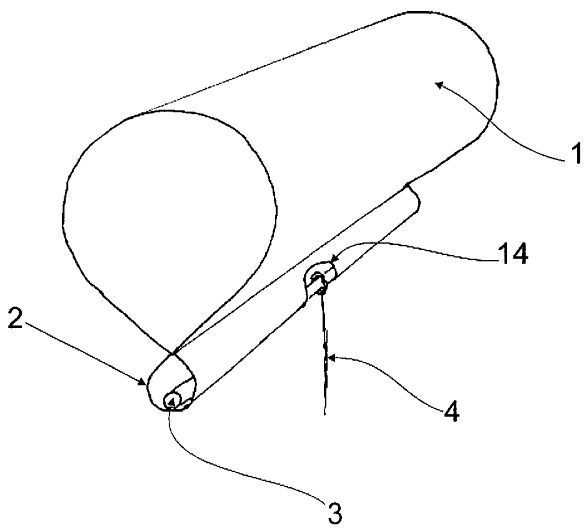
(54) Title: A FLEXIBLE DUCT FOR TRANSPORTING FLUIDS, AND USE OF A FLEXIBLE DUCT FOR TRANSPORTATING FLUIDS



(57) Abstract: One describes a flexible duct for transporting fluids (40) comprising a main flexible pipe (1), at least one fixing and anchoring pipe (2, 2', 2'') associated on the outside and parallel to the main pipe (1) and at least one ballast (5, 27, 37) associated to at least one fixing and anchoring pipe (2, 2', 2''), the main pipe (1) is capable of being used submerged in an aqueous medium so as to comprise a relative pressure between the internal pressure of the main pipe (1) and a substantially null external pressure from the aqueous medium, and further is capable of being subjected to a compensation of loss of charge. One further describes the use of a flexible duct for transporting fluids (40) as defined in claims 1-15, the flexible duct (40) comprising a main pipe (1) arranged submerged in an aqueous medium so as to comprise a relative pressure between the internal pressure of the main pipe (1) and a substantially null external pressure from the aqueous medium, and further being subjected to a compensation of loss of charge.

WO 03/081105 A1

Title: "A FLEXIBLE DUCT FOR TRANSPORTING FLUIDS, AND USE OF A FLEXIBLE DUCT FOR TRANSPORTING FLUIDS"

The present invention relates to a flexible duct for use in transporting fluids, for example, drinkable water, in large volumes and over long distances across the sea, in order to supply desert coastal areas or areas having a reduced supply of drinkable water for human consumption or industrial and irrigation use, such as: the Persian Gulf, Caribbean Islands, California coast (USA) and Canary Islands.

Description of the Prior art

At present, for coastal areas, insular regions and desert coastal areas that suffer from shortage of water, the only economic choice to supply drinkable water in large volumes has been the desalinization of seawater, since there is an effective shortage of rainfall throughout these regions.

The process of desalinization of sea water involves various methods, the most usual and economic on a large scale being the reversed osmose and the vapor-compression process. In reversed osmose seawater is pressurized against a semipermeable membrane, which only allows water to go through and retains the ions. The vapor-compression process consists in the latest evolution of the distillation method, wherein vaporization takes place at relatively low temperatures, since the process occurs under partial vacuum conditions. These processes depend upon a high energy consumption, high production cost, low productivity of drinkable water, and the equipment is expensive. The option for transporting water through land and/or air water-mains is limited to short distances due to geographic conditions, and the unfavorable conditions often render the construction impossible.

Moreover, the large land water-mains have the following drawbacks: (i) the penstocks of the water-mains that have large diameters require a great structural effort to resist the deformation caused by the action of the gravity force on the internal water mass of the pipes and on the structure of the pipes; (ii) large free conduits such as channels have topographic limitation, high material and construction costs and take time to carry out.

The option for reducing the costs by using penstocks of smaller diameter, in turn, has the drawback of limiting the flow and raising the recharge, since the internal friction on the duct increases in exponential ratio in function of the decrease in diameter of the duct.

Objectives of the Invention

The invention has the objective of providing a flexible duct having large diameter and thin wall, capable of transporting a large volume of fluids to long distances and with a low loss of charge, without a deformation occurring in the diameter of the duct, with a low manufacture and installation costs and that requires a low consumption of energy for pumping the water to be conveyed.

Brief Description of the Invention

An objective of the invention is to provide a flexible duct for transporting fluids, comprising a main flexible pipe, at least one fixing and anchoring pipe associated externally and parallel to the main pipe and at least one ballast associated to at least one fixing and anchoring pipe, the main pipe having the capability of being used submerged in an aqueous medium, so as to comprise a relative pressure between the pressure inside the main pipe and a substantially null external pressure from the aqueous medium, and further the capability of being subjected to a compensation of loss of charge.

Another objective of this invention is to use a flexible pipe for transporting fluids, the flexible pipe comprising a main pipe arranged submerged in an aqueous medium, so as to comprise a relative pressure between the pressure inside the main pipe and a substantially null external pressure from the aqueous medium, and further being subjected to a compensation of loss of charge.

Brief Description of the Drawings

The present invention will now be described in greater detail with reference to an embodiment represented in the drawings. The figures show:

- Figure 1 is a schematic cross-section view of a first embodiment of the flexible duct for transporting fluids of the present invention;

- Figure 2 is a perspective view of the flexible duct illustrated in figure 1;

- Figure 3 is a side view of the flexible duct illustrated in figure 2 and of its anchoring system;

- Figure 4 is a perspective view of a second embodiment of the flexible duct for transporting fluids of the present invention;

- Figure 5 is a schematic side view of the flexible duct illustrated in figure 4;

- Figure 6 is a perspective view of a third embodiment of the flexible pipe for transporting fluids of the present invention;

- Figure 7 is a schematic view of the flexible duct illustrated in figure 6; and

- Figure 8 is a schematic view of the seabed relief containing the flexible pipe for transporting fluids of the present invention.

Detailed Description of the Figures

According to a first preferred embodiment illustrated in figures 1, 2 and 3, the flexible duct for transporting fluids 40 of the present invention comprises a main flexible pipe 1 having thin wall and being impermeable, made of vinylic fabric, of high-density polyethylene film or another compatible material having flexibility, impermeability and strength.

This main pipe 1 is provided with a first variable diameter, which may range from less than 2m to more than 10m, the purpose of the large diameter being to allow a large volume of fluid to displace at a relatively low speed, resulting in a small loss of charge due to friction and providing a lower cost of energy. The pipe 1 is also designed for working under a low pressure with respect to the external medium, which enables one to use thin-wall vinylic fabric and to reduce the cost of material.

The economic feasibility is achieved by using a flexible, impermeable and resistant material such as vinylic fabric or high-density polyethylene films. The solution found to use thin-wall vinylic fabric in constructing the flexible duct 40 consists in positioning the duct 40 submerged in the aqueous medium, preferably the marine medium or seawater, which may also be a fluvial medium.

The main purpose of positioning the pipe 40 submerged is to annul the deformation caused by the gravity force on this pipe 40 and, secondly, to enable one to reduce the initial apparent discharge pressure, when there is a difference in density between the liquid conveyed within the main pipe 1 and the external aqueous medium. For instance, if one foresees a pressure of 3 mca for a tubing, which is a very high absolute pressure for the material, positioning the beginning of the pipe in the depth equivalent to the discharge pressure divided by the difference in density of the external aqueous medium (3 mca/0.027 = 111 m of depth in the sea) allows the relative pressure of the external medium at this point to be close to zero, although the absolute pressure is high, which makes it possible to use relatively weak materials.

Thus, the main pipe 1 is arranged submerged in the aqueous medium, and the pressure inside the pipe 1 with respect to the external pressure of this aqueous medium ranges from 0.01 to 0.50 mca (meters of water column). As already mentioned, this low pressure of the fluid conveyed with respect to the fluid outside the main pipe 1 is obtained by compensating the internal pressure of the main pipe 1 by the weight of the fluid of the external aqueous medium, that is to say, the seawater.

Due to this pressure-compensation mechanism, the operation pressure becomes sufficiently low to permit reduction of the costs of pipe material, since the thickness of the wall of the main pipe 1 may be on the order of millimeter, depending on the maximum pressure calculated for the cross-section.

With regard to the loss of charge due to the flow friction of the conveyed fluid inside the main pipe 1, this loss is compensated by decreasing the external pressure. For this purpose, the main pipe 1 will have a rising inclination between an inlet end 12 and an outlet end 13, following the seabed relief, so that the weight caused by the seawater, which is equivalent to the pressure of 0.027 mca for each meter of depth, progressively decreases as the seawater blade on the main pipe 1 decreases. In this case, the progressive decrease of the external pressure compensates the charge loss inside the main pipe 1 and keeps it open, that is, not collapsed.

The main pipe 1 is fed by a reinforced pipe 7, the function of which is to link the catchment 6 to the inlet end 12 of the main pipe 1. In this way, the water flows through the main pipe 1 as far as the outlet 13, where it passes through the outflow pipe 8 as far as the surface, and then it is deposited in a reservoir 9 and becomes available for consumption and distribution.

In this case, the flexible duct 40 does not need any discharge substations in addition to the pumping that will feed the main pipe 1. The water will flow from the lower inlet end 12 as far as the upper outlet end 13, only by the initial charge as far as the distance limit in which the main pipe 1 gets close to the surface. The diameter of the main pipe 1 and its inclination will be determined by the desired flow rate and by the distance to be traveled.

As illustrated in figure 2, the main pipe 1 is continuously connected to at least one fixing and anchoring pipe 2 having a second diameter smaller than the first diameter of the main pipe 1. In this way, the flexible pipe for transporting liquids 40 is formed by joining the main pipe 1, which is used for fluid outflow, to at least one fixing and anchoring pipe 2, the function of which is to be associated to a ballast capable of fixing the main pipe 1, so that it will adapt itself to the conditions of topography and submarine stream.

Thus, at least one rigid bar 3 is arranged inside the fixing and anchoring pipe 2, which serves for concentrating the thrust force of the main pipe 1 on an anchoring cable 4, thus preventing the main pipe 1 from deforming.

The rigid bar 3 is also segmented, and the center of each segment is aligned with the openings 14, arranged in the fixing and anchoring pipe 2, where the anchoring cable 4 is fixed to this rigid bar 3.

As can be seen in figure 3, the anchoring cable 4 is connected to at least one ballast or anchor 5, which is a body having sufficient weight to stand the thrust of the main pipe 1.

The flexible duct for transporting fluids 40 remains suspended under the seawater or river water, but fixed to the ballast bodies 5, thus making use of them to overcome accentuated differences elevation of the seabed or riverbed relief 11. In this regard, the anchoring cable 4 may be simple for shallow places or arched for deeper places in the sea, as shown in figure 1.

In a second preferred embodiment of the flexible duct for transporting fluids 40, illustrated in figures 4 and 5, the main pipe 1 is continuously connected to the fixing and anchoring pipe 2' by means of a continuous joining 24.

As illustrated in figure 5, the fixing and anchoring pipe 2' comprises pleats 23 in orthogonal arrangement with respect to the fixing and anchoring pipe 2' and so as to render this fixing and anchoring pipe 2' segmented in compartments 26, isolated from each other, measuring 2 – 3 m.

Each compartment 26 has a filling opening 25 at the upper side portion, a determined amount of granulated ballast 27 being placed inside these compartments 26, which is capable of maintaining the flexible duct attached to the seabed relief 11' (figure 4).

The purpose of compartmentalizing the fixing and anchoring pipe 2' is to prevent the ballast charge 27 from sliding longitudinally and prevent the formation of accumulation points if the main pipe 1 remains inclined, which would cause the fixing and anchoring pipe 2' to break at this accumulation point.

This way of fixing the flexible duct for transporting fluids is used in stretches where it is possible to take advantage of the favorable conditions of the plane or slightly undulated seabed or riverbed relief. In this way, unlike the manner of fixing the flexible duct described in the first embodiment of this invention, this fixing way maintains the flexible duct 40 in contact with the seabed relive 11'; hence the non-existence of the anchoring cable 4 and the presence of the granulated-ballast charge 27.

A third main embodiment of the flexible duct for transporting fluids 40, illustrated in figures 6 and 7, aims at enabling one to use the object of this invention under conditions of strong ocean currents, such as in straits and channels that separate islands, where the speed of the water may reach values of up to 5 m/s.

According to figure 6, the main pipe 1 is continuously joined to one or preferably two fixing and anchoring pipes 2" having a smaller diameter, by means of two continuous joinings 34, which are lateral and parallelly opposed. The fixing and anchoring pipes 2" are substantially identical to each other and positioned on the outside and are parallelly associated to the opposed sides of the main pipe 1.

As illustrated in figure 7, the fixing and anchoring pipes 2" comprise pleats 33 in orthogonal arrangement with respect to the fixing and anchoring pipes 2", so as to make them segments in compartments 36, isolated from each other and measuring about 2 – 3 m.

Each compartment 36 has a filling opening 35 at the upper side portion, the function of which is to enable one to fill the compartments 36 with a determined amount of granulated ballast 37, for example sand, capable of maintaining the flexible duct 40 secured to the seabed relief 11' (figure 6).

The purpose of compartmentalizing the fixing and anchoring pipe 2" is to prevent the ballast charge 37 from sliding longitudinally and prevent the formation of accumulation points if the main pipe 1 remains inclined, which would cause the fixing and anchoring pipe 2" to break at this accumulation points.

Thus, as in the second preferred embodiment of this invention, in this third embodiment the flexible duct for transporting fluids is kept in contact with the seabed relief 11', being used in stretches where the ocean currents are strong, but the relief conditions are favorable, that is, it has plane or slightly undulate stretches.

According to figure 8, the seabed or riverbed relief has a varied topography, where plane and slightly undulate stretches may be followed by quite uneven stretches, with accentuated peaks and valleys. For this reason and considering that the objective of the present invention is to transport fluids over long distances, one foresees the combination of different forms of carrying out this invention. Thus, one may, for instance, use the first embodiment of the flexible duct, which is suitable for overcoming accentuated differences in level in the stretch A, combining the second and the third embodiments in the stretches B and C, respectively, where the relief is less accentuated and allows the flexible duct to contact the ground 11'.

Independently of the way of carrying out the present invention, the technique that renders feasible the way of making the main pipe 1 with thin and flexible walls corresponds, as already mentioned, to the fact that this main pipe works with low pressure with respect to the external medium. For this purpose, when it is submerged in seawater, one makes use of the difference in density between the seawater and the fresh water being transported, which is of about 0.027 mca (meters of water column) for each meter of depth, in order to effect the compensation of internal pressure in the main pipe 1.

Also as mentioned, the inclination of the main pipe 1 serves to use the same effect of the difference in density for compensating the loss of charge, thus reducing the internal pressure along the main pipe 1, so as to keep it open and non-collapsed, which allows the flow of fluid to be continuous.

If the flexible duct 40 transports fresh water at the bottom of a river, the effect of difference in density will not occur, because both the liquid being transported and the external medium will have the same density. In this case, the relative pressure of the aqueous medium is also close to zero, which enables one to use a main pipe 1 having thin walls.

However, the main pipe 1 should be pressurized at its inlet with a recharge equivalent to the loss of charge expected for the distance to be traveled. Further, the vinylic fabric should contain some reinforcements calculated for standing the designed pressure. Thus, in this case a rising inclination between the inlet end 12 and the outlet end 13 is not necessary for decreasing the losses of charge.

With regard to the system of anchoring the main pipe 1, that is to say, the ways in which the fixing and anchoring pipe 2, 2', 2" keeps the main pipe 1 fixed to the seabed relief, this system is related to the thrust generated by the seawater on the fresh water that flows in the main pipe 1, which is calculated by the difference between the density between these two fluids and the displaced volume.

The thrust increases at the square ratio of the diameter of the main pipe 1, that is to say, at the direct ratio of the fluid being displaced.

The anchoring system should be sufficiently heavy to annul this thrust and stabilize the structure of the flexible duct 40 close to the seabed relief. So, the ballast 5, 27 and 37 should have a weight factor twice or more as high as the thrust value. The component of the thrust of the submerged fresh water is determined by the volume of the main pipe 1, at the ratio of 27Kg to each m^3 contained in each linear meter of the section.

The tension on the vinylic fabric is formed by two components: (i) the thrust of the fresh water submerged in the seawater, which, however small for small pipes (with less than 2 m in diameter), is relevant for pipes having a larger diameter, and (ii) the internal pressure applied onto the walls of the main pipe 1.

When the main pipe 1 goes on to the pressurized condition (turgid), the component of internal pressure applied onto the walls of the pipe 1 generates a tension on the vinylic fabric that is adds to the thrust tension. What limits the size of the main pipe 1 most is the pressure tension, since for large pipes 1 small pressures generate large tensions.

There is a range of depth where the lower limit is the point where the internal pressure of the main pipe 1 is equal to the external pressure. If the flexible duct 40 is positioned below this lower limit, it will collapse under the weight of the seawater.

The upper limit is determined by the maximum tension which the wall of the main pipe 1 can stand. The tension that breaks the vinylic fabric that forms the flexible duct 40 is achieved in function of the internal pressure of the main pipe 1 and also of the diameter of this pipe 1. So, the larger the pipe the greater the tension, since the latter is also related to the perimeter of the pipe 1.

Thus, in order to find the maximum or upper-limit height of positioning the flexible pipe 40 with respect to the lower-limit level, one should consider that, with every 37 m of depth which one rises with the flexible pipe 40, the internal pressure in the main pipe 1 with respect to the external pressure increases by 1 mca. If the flexible duct is positioned above the maximum limit, it will break. In this way, the larger the diameter of the main pipe 1, the narrower the operation range.

In case the flexible pipe 40 object of the present invention is positioned exactly in the depth that compensates the internal pressure, that is to say, in the depth that corresponds to the compensation of the piezometric line, along the main pipe 1, there will be no increase in the internal pressure of the pipe 1 and the latter will not collapse. In this case, the size of the diameter of the flexible duct 40 will be limited solely and exclusively by the tension generated by the thrust of the fresh water.

Examples of preferred embodiments having been described, one should understand that the scope of the present invention embraces other possible variations, being limited only by the contents of the accompanying claims, which include the possible equivalents.

CLAIMS

1. A flexible duct for transporting fluids (40), characterized by comprising a main flexible pipe (1), at least one fixing and anchoring pipe (2, 2', 2") associated on the outside and parallel to the main pipe (1) and at least one ballast (5, 27, 37) associated to at least one fixing and anchoring pipe (2, 2', 2"), the main pipe (1) is capable of being used submerged in an aqueous medium so as to comprise a relative pressure between the internal pressure of the main pipe (1) and a substantially null external pressure from the aqueous medium, and further is capable of being subjected to a compensation of loss of charge.

2. A flexible duct according to claim 1, characterized in that the compensation of the loss of charge consists in positioning the main pipe (1) submerged in the aqueous medium so as to comprise a rising inclination between an inlet end (12) and an outlet end (13).

3. A flexible duct according to claim 1, characterized in that the compensation of loss of charge consists in pressurizing the main pipe (1).

4. A flexible duct according to claim 2 or 3, characterized in that the inlet end (12) is associated to a reinforced pipe (7) and the outlet end (13) is axially opposed to the inlet end (12) and associated to an outflow pipe (8).

5. A flexible duct according to claim 4, characterized in that the reinforced pipe (7) interconnects the catchment (6) to the inlet end (12).

6. A flexible duct according to claim 5, characterized in that the outflow pipe (8) interconnects the outlet end (13) to a reservoir (9).

7. A flexible duct according to claim 1, characterized in that the aqueous medium corresponds to a sea environment having a seabed relief (11, 11').

8. A flexible duct according to claim 1, characterized that that the aqueous medium corresponds to a river environment having a river relief (11, 11').

9. A flexible duct according to claim 1, characterized in that at least one fixing and anchoring pipe (2, 2', 2") comprises a rigid bar (3), which is segmented and axially arranged inside the fixing and anchoring pipe (2),

the rigid bar (3) being associated to a plurality of anchoring cables (4) through a plurality of openings (14) arranged in the fixing and anchoring pipe (2).

10. A flexible duct according to claim 9, characterized in that the anchoring cables (4) have different sizes and are associated to at least one ballast (5) arranged in contact with the relief (11).

11. A flexible duct according to claim 1, characterized in that the fixing and anchoring pipe (2', 2") comprises a plurality of pleats (23, 33) ,arranged parallel to the fixing and anchoring pipe (2', 2"), forming a plurality of compartments (26, 36) isolated from each other.

12. A flexible duct according to claim 11, characterized in that the compartments (26, 36) are filled by granulated ballasts (27, 37) through filling openings (25, 35).

13. A flexible duct according to any one of claims 1 – 12, characterized in that the main pipe (1) is thin, has a thin wall, is made from a polymeric material and has a first diameter.

14. A flexible duct according to any one of claims 1 – 12, characterized in that at least one fixing and anchoring pipe (2, 2', 2") is thin and constituted by a flexible polymeric material and comprises a second diameter.

15. A flexible duct according to claim 14, characterized in that the first diameter of the main pipe (1) is larger than the second diameter of at least one fixing and anchoring pipe (2, 2', 2").

16. Use of a flexible duct for transporting fluids (40) as defined in claims 1 – 15, characterized in that the flexible duct (40) comprises a main pipe (1) arranged submerged in an aqueous medium so as to comprise a relative pressure between the internal pressure of the main pipe (1) and a substantially null external pressure from the aqueous medium, and is subjected to a compensation of loss of charge.

17. Use of a flexible duct according to claim 16, characterized in that the compensation of loss of charge consists in positioning the main pipe (1) submerged in the aqueous medium so as to comprise a rising inclination

between an inlet end (12) and an outlet end (13).

18. Use of a flexible duct according to claim 16, characterized in that the compensation of loss of charge consists in pressurizing the main pipe (1).

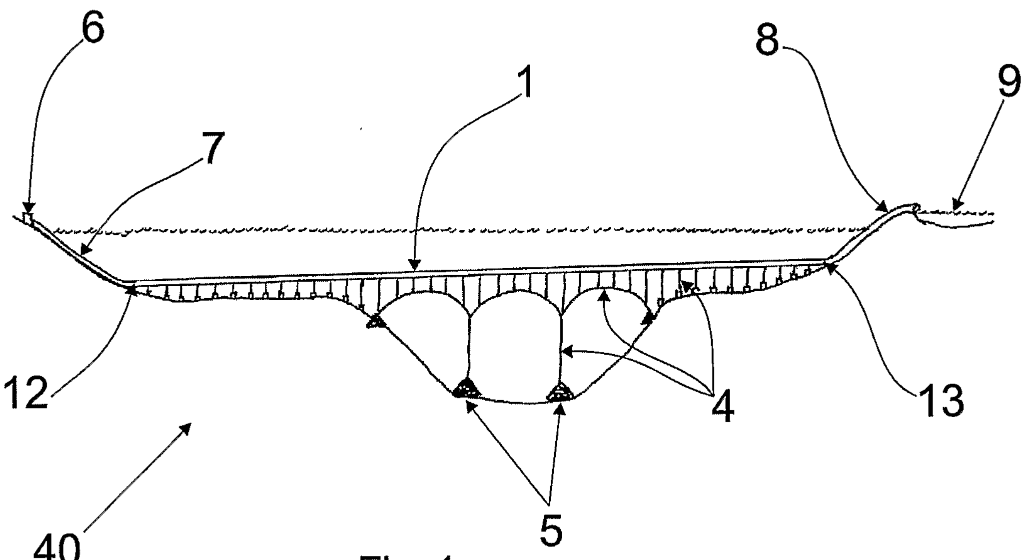


Fig. 1

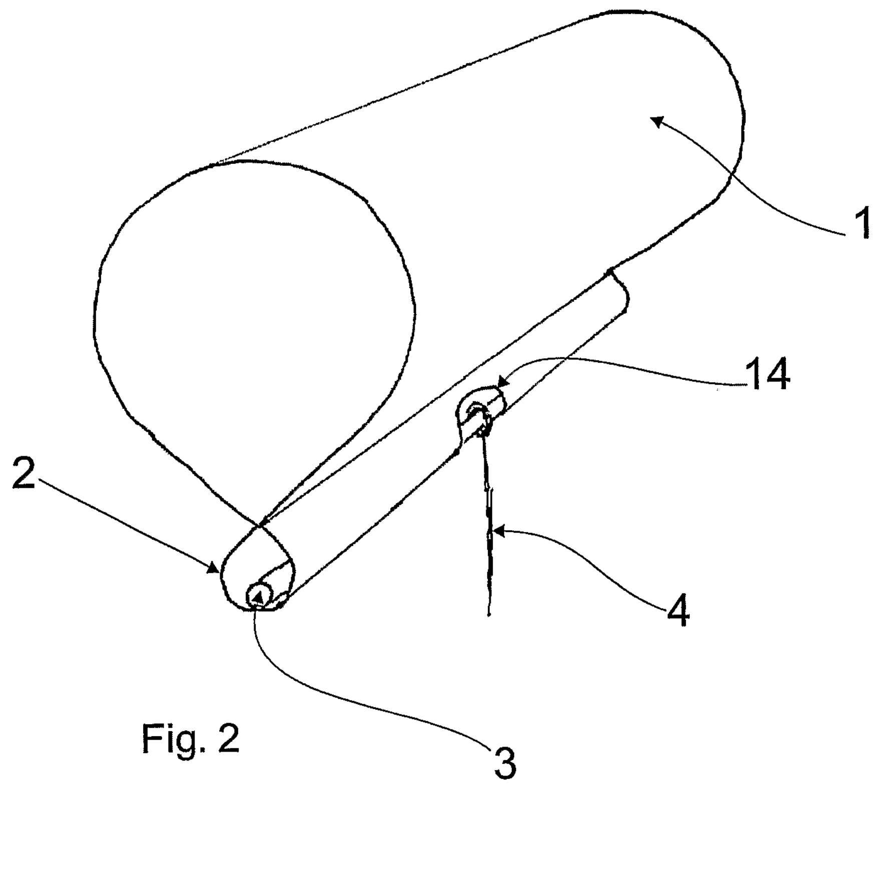


Fig. 2

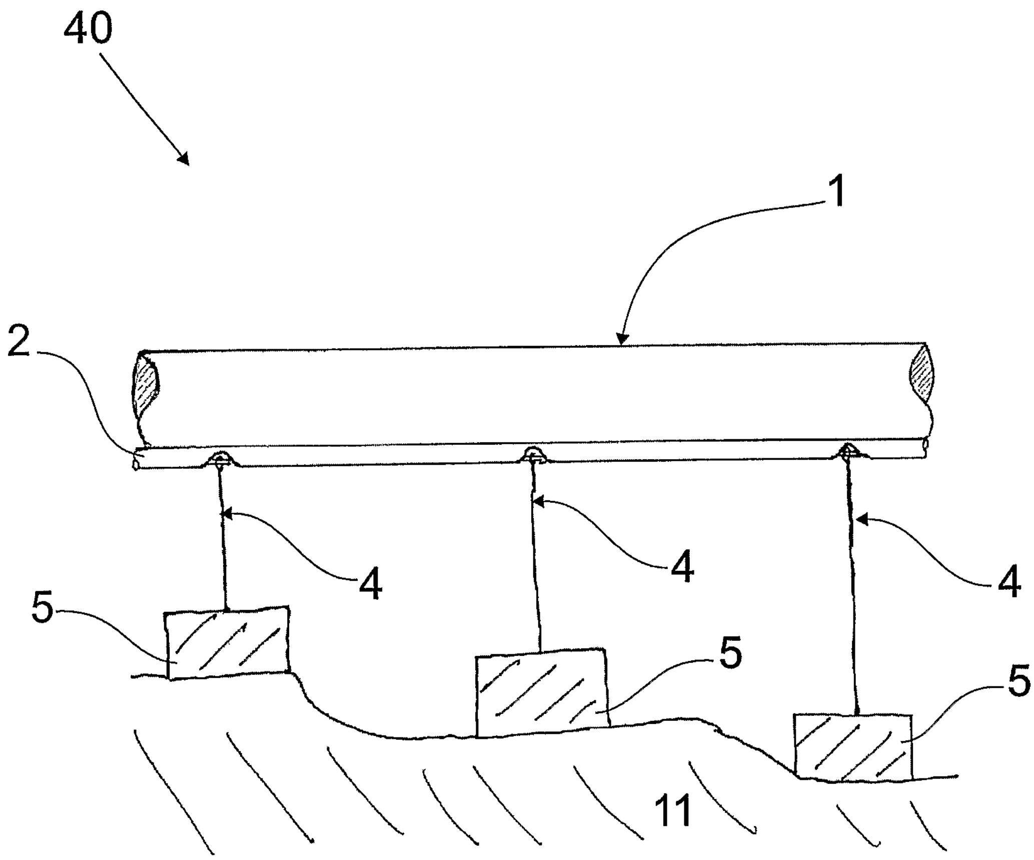


Fig. 3

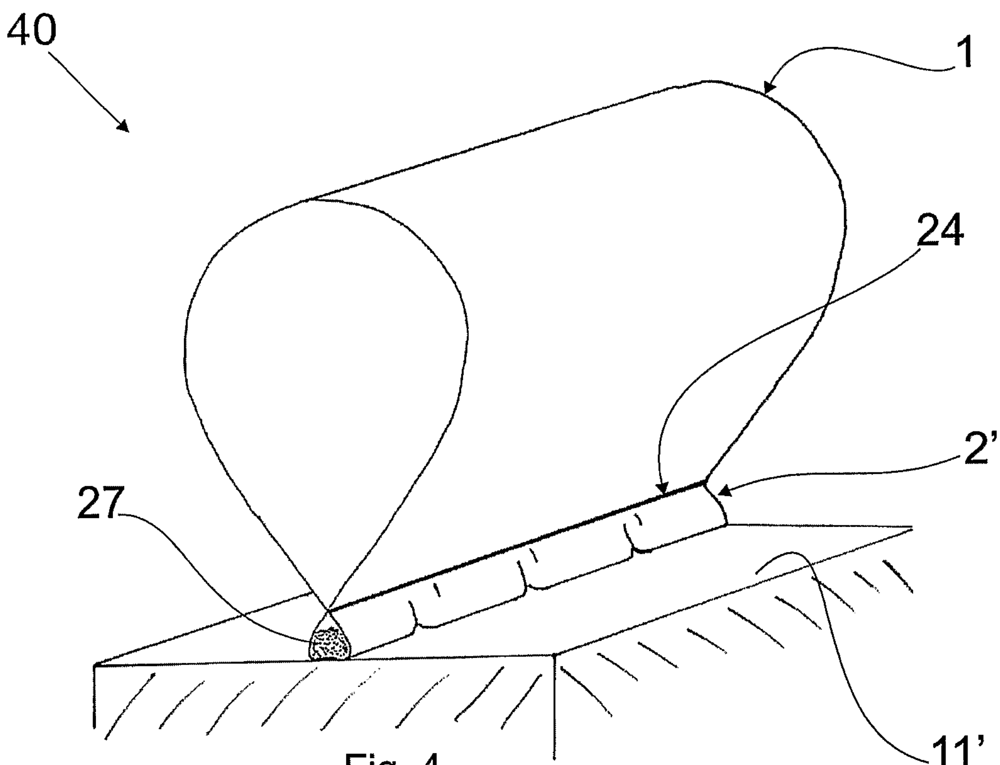


Fig. 4

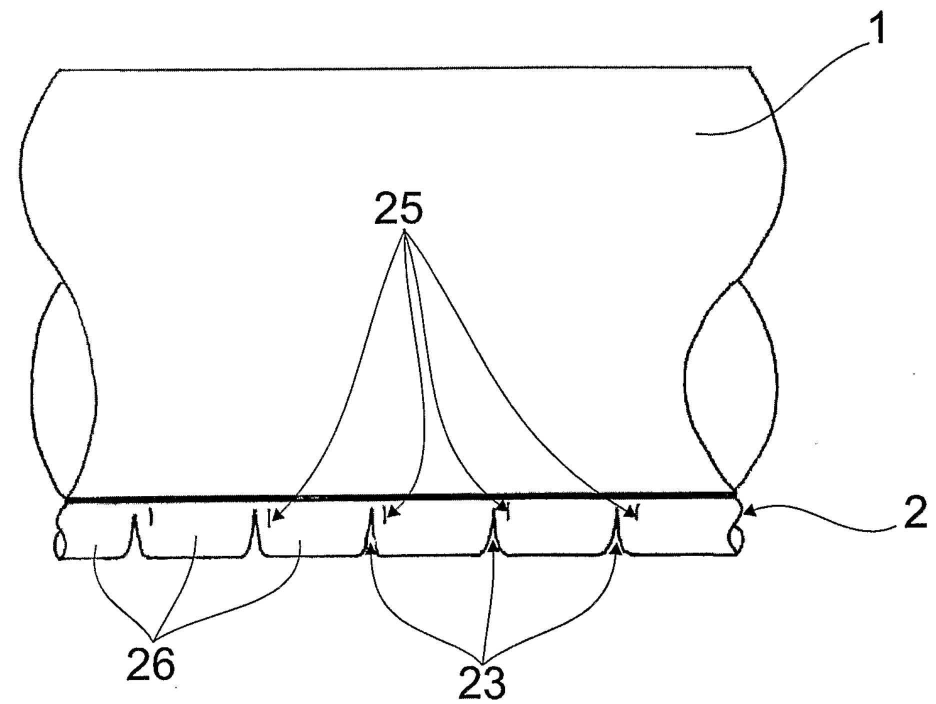


Fig. 5

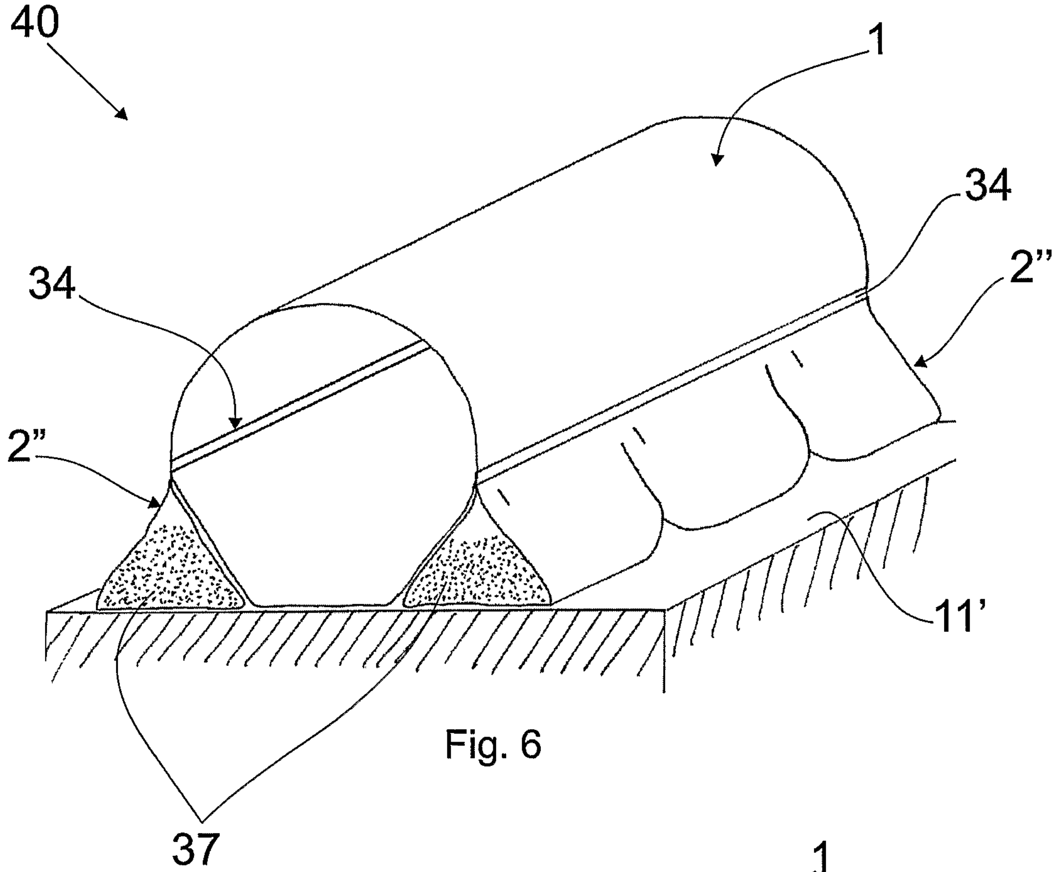


Fig. 6

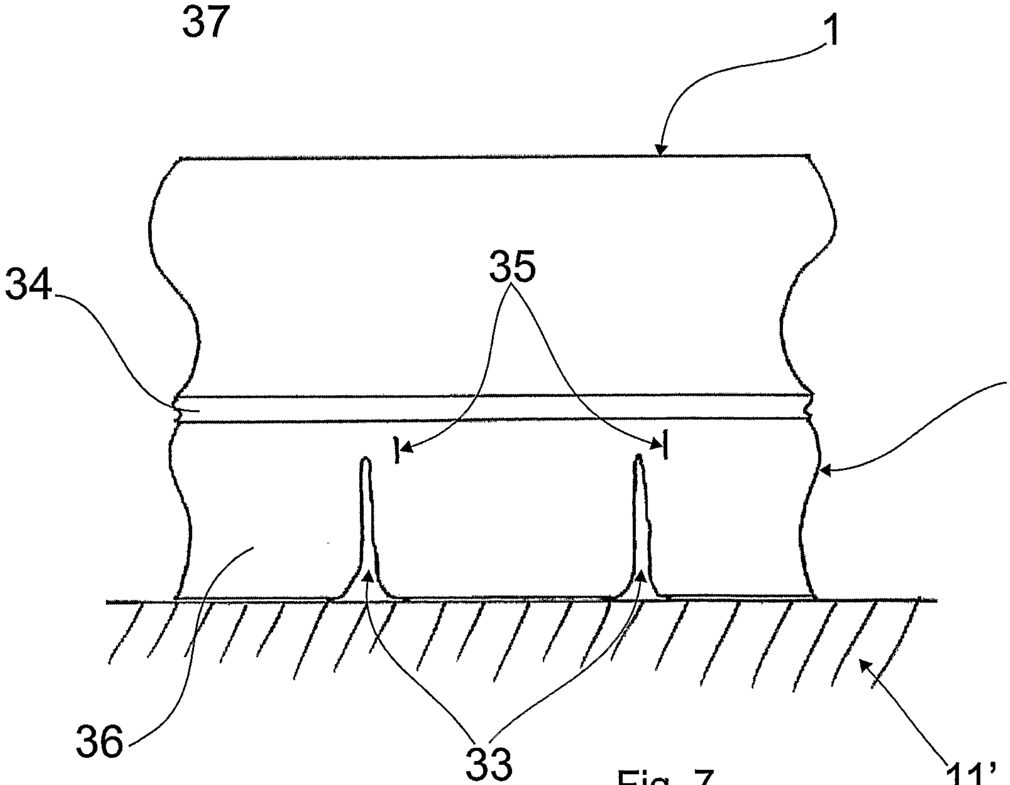


Fig. 7

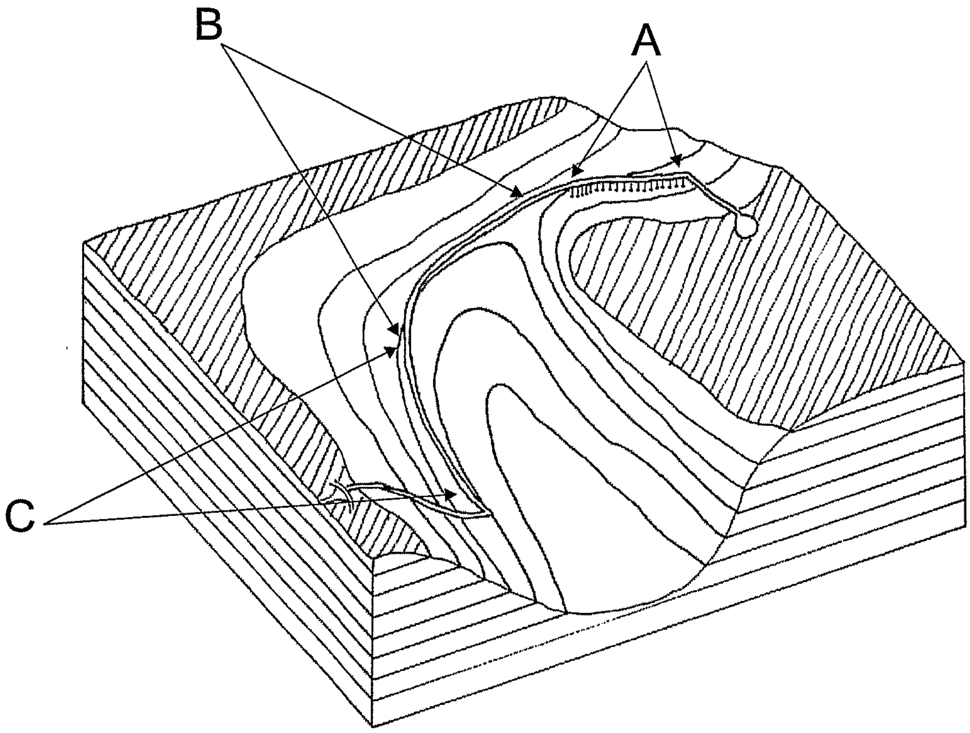


Fig. 8

INTERNATIONAL SEARCH REPORT

International Application No
PCT/BR 03/00044

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16L1/20 F16L1/16

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 F16L

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.
A	ROBERTSON R ET AL: "SCREW ANCHORS ECONOMICALLY CONTROL PIPELINE BUOYANCY IN MUSKEG" OIL AND GAS JOURNAL, PENNWELL PUBLISHING CO. TULSA, US, vol. 93, no. 17, 24 April 1995 (1995-04-24), pages 49-52,54, XP000501969 ISSN: 0030-1388 page 51, figure 4 ---	1
X	US 6 357 966 B1 (THOMPSON ALLISTER WADE) 19 March 2002 (2002-03-19) abstract figures 2,13 claim 1	1,16
A	---	3-6,9
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] 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

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Date of the actual completion of the international search	Date of mailing of the international search report
13 May 2003	22/05/2003

Name and mailing address of the ISA	Authorized officer
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	Schaeffler, C

Form PCT/ISA/210 (second sheet) (July 1992)

International Application No
PCT/BR 03/00044

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 467 013 A (CONNER JACK S) 16 September 1969 (1969-09-16) claims 1,2	1
A	figure 6	7-10, 16-18
A	US 4 120 168 A (LAMY JACQUES EDOUARD) 17 October 1978 (1978-10-17) abstract figure 1	1,16

INTERNATIONAL SEARCH REPORT

Inf   :ion on patent family members

International Application No
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