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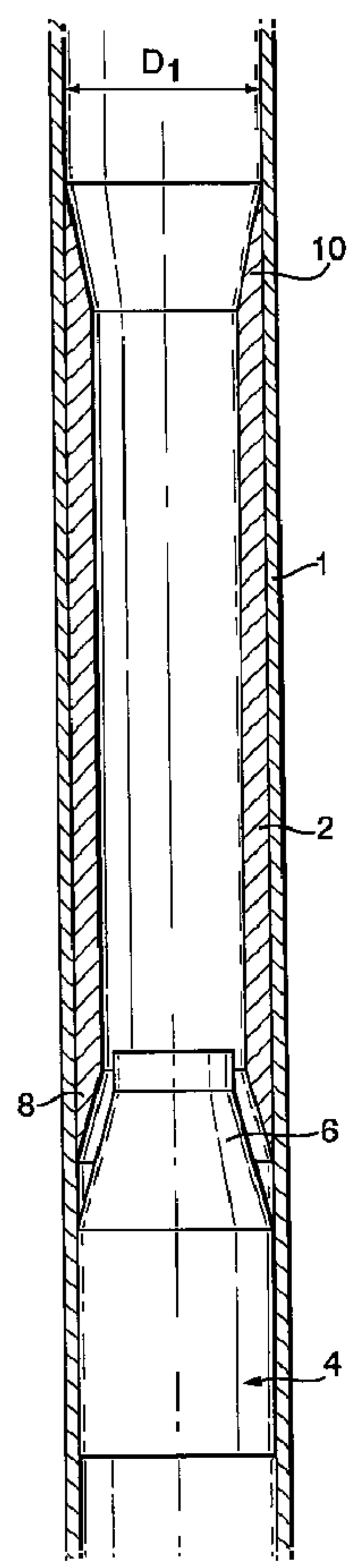
(54) Titre : PROCEDE DE MANDRINAGE D'UN ELEMENT TUBULAIRE
(54) Title: METHOD OF EXPANDING A TUBULAR ELEMENT



(57) Abrégé/Abstract:
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(57) Abrégé(suite)/Abstract(continued):
expander in the tubular element, the expander being suitable to radially expand the sleeve to an outer diameter larger than said first inner diameter by moving the expander in axial direction through the sleeve; and c) moving the expander in axial direction through the sleeve thereby radially expanding the tubular element from the first inner diameter to the second inner diameter.

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(54) Title: METHOD OF EXPANDING A TUBULAR ELEMENT

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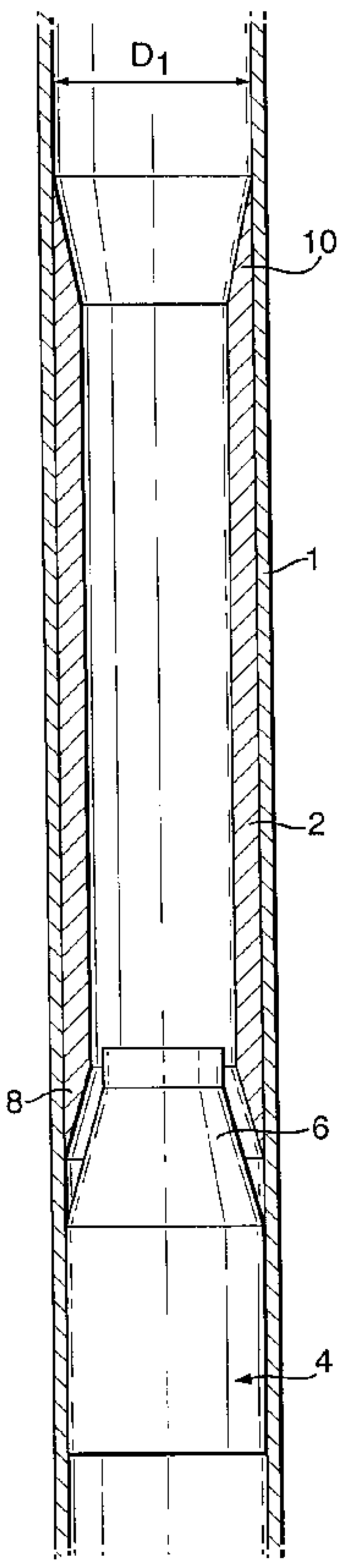

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METHOD OF EXPANDING A TUBULAR ELEMENT

The present invention relates to a method of expanding a tubular element from a first inner diameter to a second inner diameter larger than the first inner diameter.

Expansion of tubular elements finds increased application, for example in the industry of hydrocarbon fluid production from a subterranean formation whereby the produced hydrocarbon fluid flows to surface via one or more production tubings extending into a wellbore. Conventionally, wellbores have been provided with a series of steel tubular casings or liners, for example to stabilise the wellbore wall or to provide zonal isolation between different earth formation layers traversed by the wellbore. Such casings or liners are installed at different depth intervals during drilling of the wellbore, whereby each subsequent casing is lowered through a previously installed casing into the wellbore to a selected depth below the previous casing. Cement is then pumped into the annular space around the casing to seal the annular space and to fix the casing in the wellbore. This procedure implies that the outer diameter of each subsequent casing needs to be smaller than the inner diameter of the previous casing, so that, as a result, the casings are installed in a nested arrangement. An inherent drawback of such nested arrangement relates to the decreasing available diameter with depth, which ultimately may limit the depth to which the wellbore can be drilled.

To relieve this drawback, it has become practice to radially expand casings or liners in the wellbore, for example to form an expanded clad against the borehole wall or a previously installed casing, or to reduce the annular space around the casing or liner. Also, it has been proposed to radially expand each subsequent casing to a diameter substantially equal to the diameter of the previously installed casing so as to create a mono-diameter well or a portion thereof. In this manner it is achieved that the available diameter for drilling and/or for installing completion equipment, remains substantially constant along at least a portion of the depth. The monodiameter concept is particularly of interest for drilling of very deep wellbores, or drilling of extended-reach wellbores with long horizontal or inclined sections.

Expansion of the tubular element is achieved, for example, by moving an expander having a largest diameter about equal to the desired expansion diameter, through the tubular element. This is generally done by pumping, pushing or pulling the expander through the tubular element, sometimes in combination with rotation of the expander.

US-7007760-B2 discloses a method of radially expanding a tubular element using an expander assembled from an inner expander member and an outer expander member extending around the inner expander member. The outer member expands the tubular element to a larger diameter than the inner member. During use, an end portion of the tubular element is first expanded to the larger diameter, whereafter the outer expander member is released from the inner expander member, and the remainder of the tubular element is expanded to the smaller diameter using the inner expander member only.

There remains, however, a need for an alternative method whereby a tubular element, or a portion thereof, is radially expanded, or whereby a portion of the tubular element is expanded to a diameter larger than a remainder portion of the tubular element.

In accordance with the invention there is provided a method of expanding a tubular element from a first inner diameter to a second inner diameter larger than the first inner diameter, the method comprising the steps of:

a) installing a sleeve of flexible material in the tubular element;

b) installing an expander in the tubular element, the expander being suitable to radially expand the sleeve to an outer diameter larger than said first inner diameter by moving the expander in axial direction through the sleeve; and

c) moving the expander in axial direction through the sleeve thereby radially expanding the tubular element from the first inner diameter to the second inner diameter.

The sleeve of flexible material expands to a larger diameter during movement of the expander therethrough, and thereby expands the tubular element without direct contact between the expander and the tubular element. Thus the same expander can be used to expand portions of the tubular element to different diameters by applying sleeves of different wall thickness in such portions. Also, due to its resilience the sleeve can be easily removed from the tubular element after the expansion process.

Furthermore, the method of the invention can be used to expand a portion of the tubular element at a location remote from the ends of the tubular element, for example in order to create a launch section for an expandable expander that is transported to the launch section in unexpanded mode, and then expanded to the expanded mode to start expansion of a remaining portion of the tubular element, or to create a housing for tools such as a separator pump.

If only a portion of the tubular element is to be expanded, the sleeve suitably is installed in said portion, and the expander has a size allowing the expander to be moved substantially unobstructed through a remaining portion of the tubular element. Thus, the expander can be easily removed from the tubular element after expansion is completed.

In order to allow easy removal of the sleeve from the tubular element after the expansion process, said flexible material of the sleeve suitably is a resilient material, for example an elastomer. A preferred elastomer material is polyurethane. Easy removal of the sleeve is enhanced if the sleeve is adapted to elastically deform, after moving the expander through the sleeve, to an outer diameter substantially equal to an outer diameter of the sleeve before moving the expander through the sleeve.

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

Fig. 1 schematically shows a first embodiment of a tubular element before expansion thereof in accordance with the method of the invention;

Fig. 2 schematically shows the tubular element of the first embodiment during expansion in accordance with the method of the invention;

Fig. 3 schematically shows the tubular element of the first embodiment after expansion in accordance with the method of the invention;

Fig. 4 schematically shows a second embodiment of a tubular element before expansion thereof in accordance with the method of the invention;

Fig. 5 schematically shows the tubular element of the second embodiment during expansion in accordance with the method of the invention;

Fig. 6 schematically shows the tubular element of the second embodiment after expansion in accordance with the method of the invention;

Fig. 7 schematically shows an example of an expander and a sleeve for use in the method of the invention; and

Fig. 8 schematically shows an alternative expander for use in the method of the invention.

In the drawings, like reference numerals relate to like components.

Referring to Fig. 1 there is shown a tubular element 1 having a first inner diameter D1 and being expandable to a second inner diameter D2 larger than the first inner diameter. The tubular element is made of any suitable deformable material such as, for example, steel or other metal. Further, the tubular element 1 can find many applications including, for example, as a pipeline for the transportation of fluid at or below the earth surface, or as a casing or a liner extending into a wellbore for the production of hydrocarbon fluid from an earth formation.

The tubular element 1 is internally provided with an elastomer sleeve 2 having an outer diameter substantially equal to the first inner diameter D1 of the tubular element 1. Alternatively the elastomer sleeve 2 may have, before its insertion into the tubular element 1, an outer diameter slightly larger than the inner diameter D1 of the tubular element so that the elastomer sleeve 2 becomes slightly compressed when inserted into the tubular element 1.

Furthermore, the tubular element 1 is internally provided with an expander 4 positioned adjacent the elastomer sleeve 2, the expander 4 having a conical end portion 6 at the side facing the elastomer sleeve 2. The elastomer sleeve 2 has, at the side facing the expander 1, an inwardly tapering end portion 8 of a shape substantially complementary to the shape of the conical end portion 6 of the expander 4. Thus, the conical end portion 6 of the expander 1 snugly fits into the inwardly tapering end portion 8 of the elastomer sleeve 2. The sleeve elastomer 2 has, at its other end, an inwardly tapering end portion 10 similar to the end portion 8. The expander 4 has a largest diameter slightly smaller than the inner diameter D1 of the tubular element 1 so as to allow the expander 4 to be moved substantially unobstructed through the tubular element 1. A preferred half top-angle of the expander is between 5°-10°, most preferably about 7°.

In Fig. 2 is shown the tubular element 1 during movement of the expander 4 through the elastomer sleeve 2 in longitudinal direction thereof. A portion of the elastomer sleeve 2 and a corresponding portion of the tubular element 1 have been radially expanded as a result of movement of the expander 4 through the sleeve 1.

In Fig. 3 is shown the tubular element 1 after the expander 4 has been moved through the elastomer sleeve 2, and after the sleeve 2 has been retrieved from the tubular element 1.

In Figs. 4-6 is shown a system substantially similar to the system of respective Figs. 1-3, however with the difference that the sleeve 2 is at its outer surface provided with a metal sleeve 12 embedded in the elastomer material of the sleeve 2 such that the outer surface of the metal sleeve 12 is substantially flush with portions of the elastomer sleeve axially displaced from the metal sleeve 12. The metal of sleeve 12 is, for example, steel or any other suitable deformable metal. Optionally the metal sleeve 12 is at its outer surface provided with elastomer rings or bands (not shown) surrounding the metal sleeve 12.

In Fig. 7 is shown an assembly 14 of the elastomer sleeve 2 and the expander 4 before installation in the tubular element, and before movement of the expander 4 through the sleeve 2. The expander 4 is suspended on a wireline 16, or tubular string, and the elastomer sleeve 2 rests on the expander 4 whereby the conical end portion 6 of the expander 4 extends into the inwardly tapering end portion 8 of the elastomer sleeve 2.

In Fig. 8 is shown an alternative expander 16 having a first conical end portion 18 and a second conical end portion 20.

During normal operation of the first embodiment (shown in Figs. 1-3), the elastomer sleeve 2 is positioned in the tubular element 1 at a location where the tubular elements is to be radially expanded. Optionally the sleeve 2 can be fixedly connected to the tubular element 1 to keep the sleeve positioned at the desired location. The expander 4 is positioned in the tubular element 1, adjacent the inwardly tapering end portion 8 of the sleeve 2 (Fig. 1). The expander is then moved through the sleeve 2 in longitudinal direction thereof (Fig. 2) by pulling or pushing the expander, by applying fluid pressure to the rear end of the expander 4, or by any other suitable method. Also, the assembly 14 (Fig. 7) can be used whereby the elastomer sleeve 2 and the expander 4 are simultaneously installed in the tubular element 1, for example by lowering the assembly 14 on wireline 16 into the tubular element 1, whereafter the expander 4 is pulled through the sleeve 2 by pulling wireline 16. As a result, the elastomer sleeve 2 is expanded to an inner diameter substantially equal to the outer diameter of the expander 4. The elastomer sleeve 2, in turn, thereby expands a portion of the tubular element 1 to an inner diameter substantially equal to the outer diameter of the expanded elastomer sleeve 2. Thus, if the outer diameter of the expander 4 equals D1, the inner diameter of the expanded portion of the tubular element 1 equals approximately D1 plus twice the wall thickness of the sleeve 2. However, the inner diameter of the expanded portion may be slightly less due to radial compression and/or axial stretching of the elastomer sleeve 2.

The expander 4, after having passed through the full length of the sleeve 2, is then retrieved from the tubular element 1. The elastomer sleeve 2 resumes its original diameter by virtue of its elastic properties. However, if the elastomer sleeve 2 has a tendency to stick to the inner surface of the tubular element 1 after passage of the expander 4, or is bonded to said inner surface, the elastomer sleeve 2 can be removed from the tubular element using a suitable scraping means (not shown) or any other suitable means.

Normal operation of the second embodiment (shown in Figs. 4-6) is substantially similar to normal operation of the first embodiment, however with the difference that the metal sleeve 12 is radially expanded simultaneously with expansion of the elastomer sleeve 2. The metal sleeve 12 thereby becomes firmly pressed against the inner surface of the expanded portion of the tubular element 1.

In an attractive application of the method of the invention, the tubular element 1 forms a casing or a liner in a wellbore for the production of hydrocarbon fluid from an earth formation. In such application, a possible purpose of the expanded metal sleeve 12 is to shut off openings (not shown) in the wall of the tubular element 1. The openings can be perforations that have been shot in the wall to allow flow of hydrocarbon fluid from the earth formation into the tubular element, or holes due to corrosion. The elastomer rings or bands, if present, around the outer surface of the metal sleeve 12 serve to seal the metal sleeve 12 to the inner surface of the tubular element 1.

Normal use of the alternative expander 16 is substantially similar to normal use of the expander 4 described hereinbefore, however with the difference that the expander 16, after having been inserted into the tubular element, can be used to expand the tubular element by moving the expander through the sleeve in either of two axial directions. For example, the expander 16 can be used to expand a first portion of the tubular element by moving the expander in one axial direction through a first sleeve located in the tubular element, and thereafter to expand a second portion of the tubular element by moving the expander in the opposite axial direction through a second sleeve located in the tubular element.

To reduce, or prevent, axial deformation of the sleeve while allowing radial deformation during passage of the expander therethrough, suitably the sleeve is provided with longitudinal reinforcement fibres, such as steel or polymer fibres.

In the above example the sleeve is positioned loosely in the tubular element, whereby the friction forces between the sleeve and the tubular element prevent axial movement of the sleeve during movement of the expander therethrough. However the sleeve alternatively can be bonded to the tubular element, for example by bonding the sleeve to the tubular element during vulcanisation of the elastomer sleeve material, or by gluing the sleeve to the tubular element. Also, the sleeve can be held stationary by means of a shoulder provided at the inner surface of the tubular element.

Alternatively, in order to temporarily anchor the sleeve to the inner surface of the tubular element, the expander is suitable provided with one or more radially extendable anchoring pads arranged to push the sleeve against the inner surface of the tubular element. For example, each pad can include a piston radially movable in a cylinder formed in the expander, whereby the pistons are activated to move radially outward when the nose section of the expander moves into the sleeve, such as by hydraulic activation or by spring force. Once the expander is positioned inside the sleeve, the frictional forces between the sleeve and the tubular element can be sufficient to prevent axial movement of the sleeve, and the pads can then be de-activated.

Further, in order to reduce friction between the sleeve and the expander, a lubricant is suitably applied to the inner surface of the sleeve and/or the outer surface of the expander. A preferred lubricant is soap. The outer surface of the expander and/or the inner surface of the sleeve preferably are provided with grooves extending, for example, in longitudinal direction, to contain the lubricant.

The method of the invention described hereinbefore finds many applications including, for example, creating an enlarged diameter end portion ("bell") of a casing section in a monodiameter well, creating an enlarged diameter casing/liner portion in a section of a well where fluid losses occur during drilling, creating a fishing tool for retrieving a tubular member from a wellbore, creating a tubular connection whereby the expanded portion of the tubular element is pressed against the inner surface of another tubular element, creating a profile in a tubular element, or creating a liner hanger. Also the method of the invention can be used for pipeline repair applications.

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AMENDED CLAIMS

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1. A method of expanding a tubular element from a first inner diameter to a second inner diameter larger than the first inner diameter, the method comprising the steps of:
a) installing a sleeve of flexible material in the tubular element;
b) installing an expander in the tubular element, the expander being suitable to radially expand the sleeve to an outer diameter larger than said first inner diameter by moving the expander in axial direction through the sleeve; and
c) moving the expander in axial direction through the sleeve thereby radially expanding the tubular element from the first inner diameter to the second inner diameter, wherein the sleeve is installed in a portion of the tubular element, and wherein the expander has a size allowing the expander to be moved substantially unobstructed through a remaining portion of the tubular element.

2. The method of claim 1, wherein said flexible material is a resilient material.

3. The method of claim 1 or 2, wherein said flexible material comprises an elastomer.

4. The method of any one of claims 1-3, wherein said flexible material comprises polyurethane.

5. The method of any one claims 1-4, wherein the sleeve is adapted to elastically deform, after moving the expander through the sleeve, to an outer diameter substantially equal to an outer diameter of the sleeve before moving the expander through the sleeve.

6. The method of any one of claims 1-5, wherein the expander and the sleeve are simultaneously installed in the tubular element.

7. The method of claim 6, wherein the expander and the sleeve are coupled to each other during installation of the expander and the sleeve in the tubular element.

8. The method of claim 7, wherein the sleeve rests on the expander during installation of the expander and the sleeve in the tubular element.

9. The method of claim 7 or 8, wherein the expander and the sleeve are inserted into the tubular element using a string extending in longitudinal direction through the tubular element, the string being connected to at least one of the expander and the sleeve.

10. The method of any one of claims 1-9, wherein the sleeve has an outer surface adapted to be bonded to the inner surface of the tubular element.

11. The method of claim 10, wherein the outer surface of the sleeve is fixedly connected to the inner surface of the tubular element.

12. The method of claim 11, wherein the outer surface of the sleeve is bonded to the inner surface of the tubular element as a result of vulcanising the sleeve.

13. The method of any one of claims 1-12, wherein the expander has a conical end portion, and wherein prior to moving the expander through the sleeve, said conical end portion is positioned adjacent an end portion of the sleeve having a shape substantially complementary to said conical end portion of the expander.

14. The method of any one of claims 1-13, wherein the tubular element extends into a borehole formed in an earth formation.

15. The method of claim 14, wherein the tubular element is a wellbore casing or a wellbore liner.

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

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Fig.1.

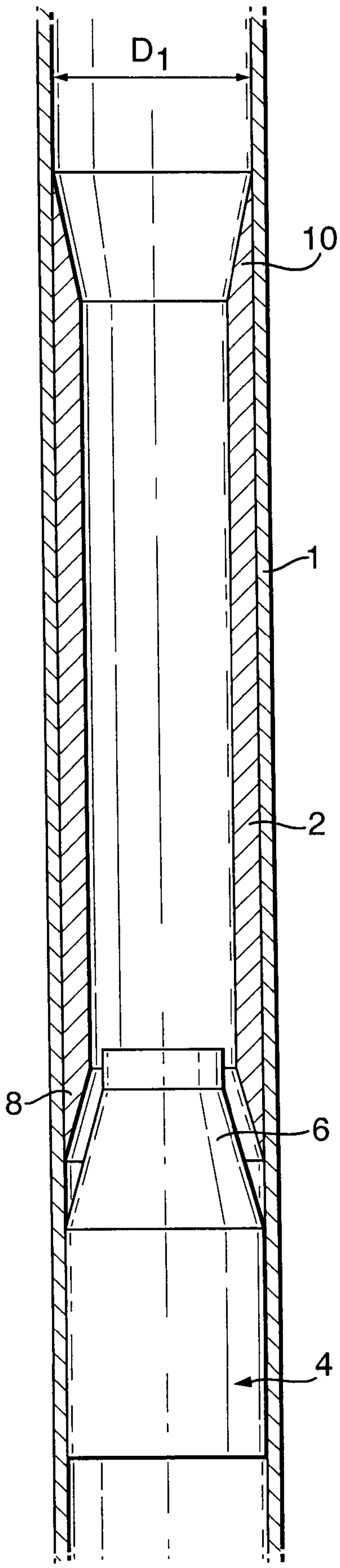


Fig.2.

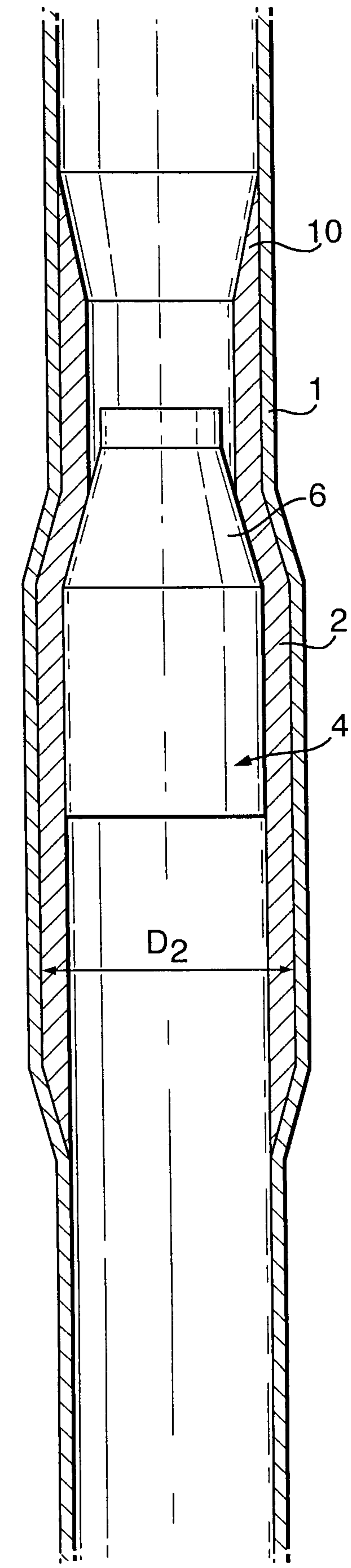


Fig.3.

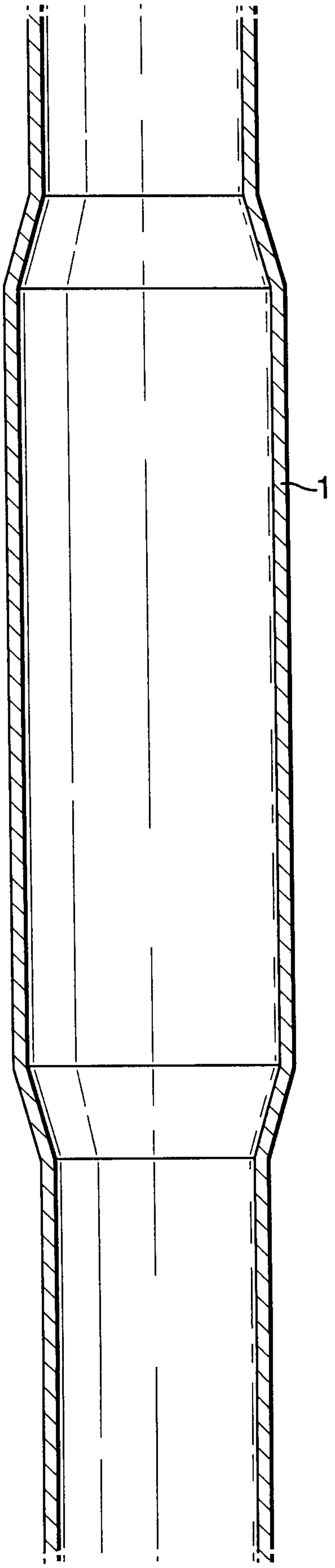


Fig.6.

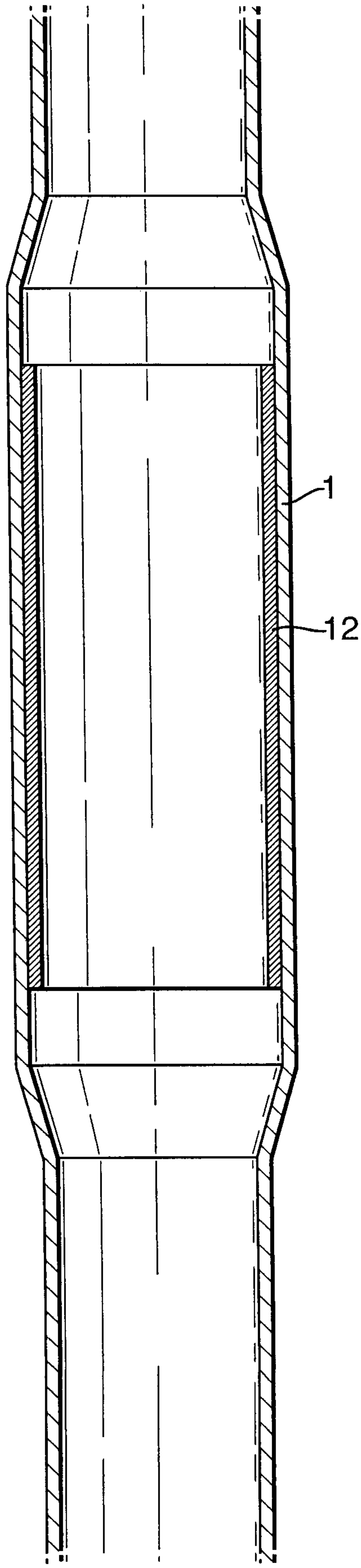


Fig.4.

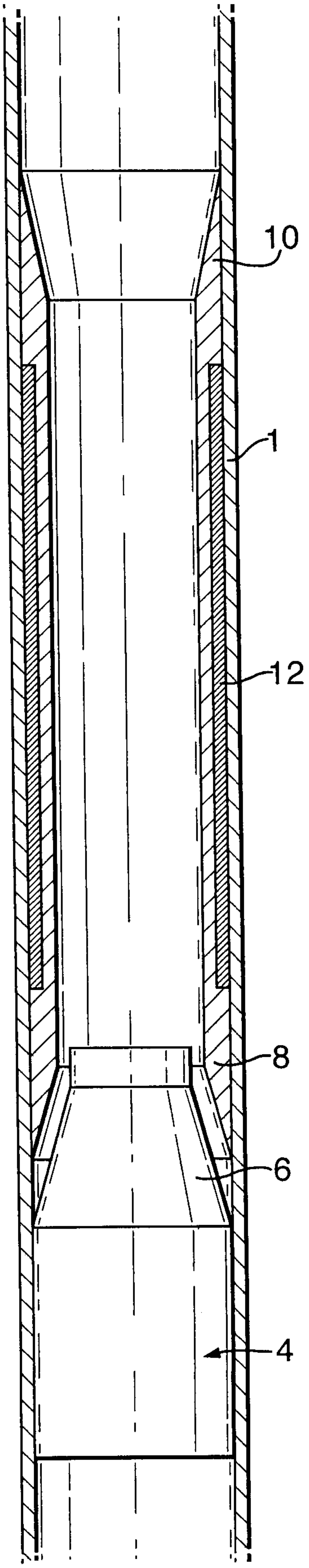


Fig.5.

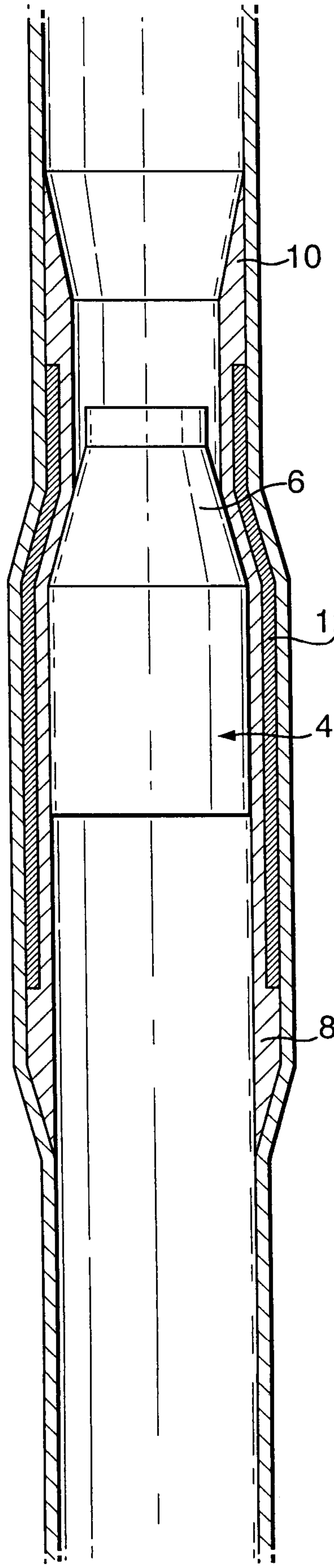


Fig.7.

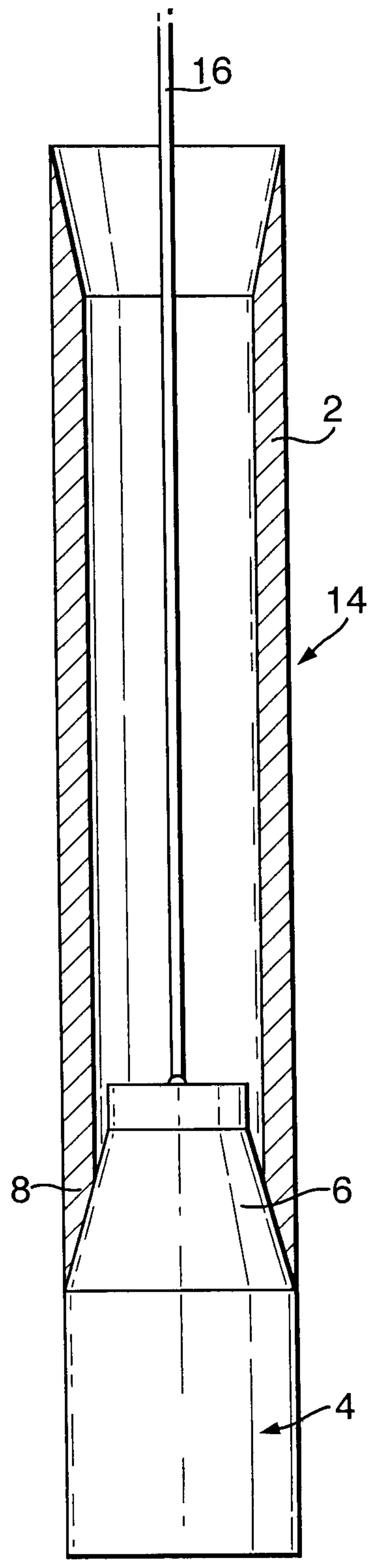
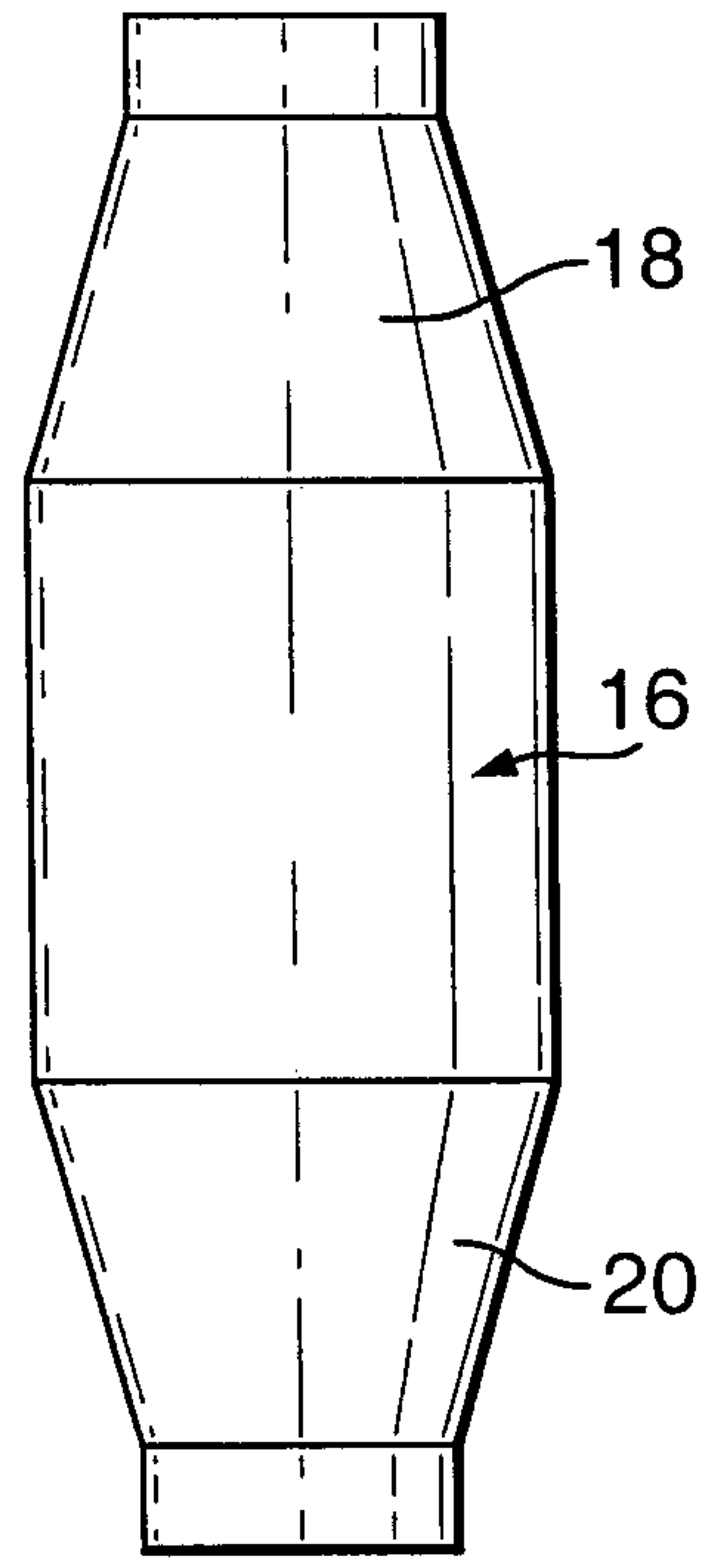


Fig.8.

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