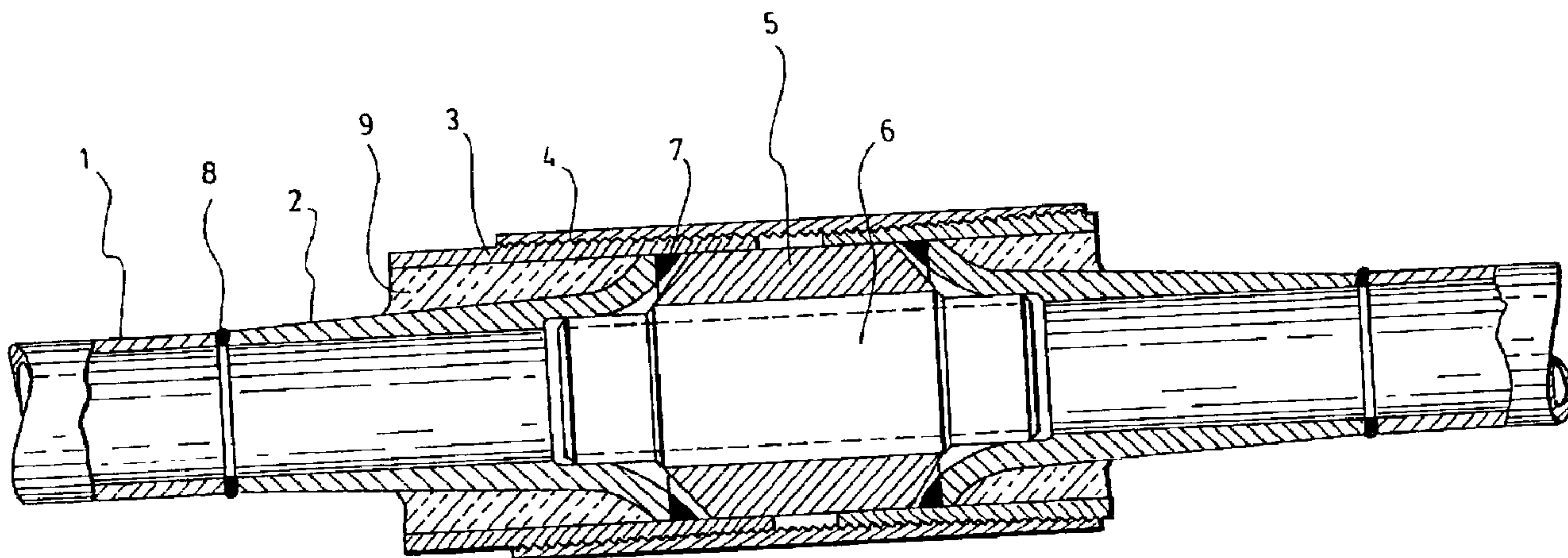




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(54) Titre : PROCÉDE DE FABRICATION D'UNE UNITÉ TUBULAIRE EN DEHORS DE L'AIRE DE TRAVAIL POUR LE RACCORD DE TUBES A DOUBLE PAROI ET UNITÉ TUBULAIRE AINSI OBTENUE  
 (54) Title: PROCESS FOR MANUFACTURING A TUBULAR UNIT OFFSITE FOR COUPLING DOUBLE-WALLED TUBES AND A TUBULAR UNIT OBTAINED THEREFROM



(57) **Abrégé/Abstract:**

Process for the offsite manufacturing of a tubular unit coupling, for coupling double-walled tubes which comprise an outer tube or jacket and an inner tube or conductor, by means of a bell-shaped piece. The piece is manufactured from tubular sections of certain length. One of the inner tube ends is heated to be formed and subsequently machined. The coupling is subject to a thermal treatment as required for the desired grade. In order to control thermal insulation, the piece is covered with thin aluminum foils and then with ceramic fiber material in a helicoidal fashion. Subsequent steps involve covering the ceramic layer with a fiber-glass fabric thus generating an assembly which enables smooth sliding through the outer tube without breakage or displacement of the insulating layer. The insulated unit is introduced into outer tube and ends are alternately welded. The tubular unit coupling obtained by such process is also disclosed.

## ABSTRACT

Process for the offsite manufacturing of a tubular unit coupling, for coupling double-walled tubes which comprise an outer tube or jacket and an inner tube or conductor, by means of a bell-shaped piece. The piece is manufactured from tubular sections of certain length. One of the inner tube ends is heated to be formed and subsequently machined. The coupling is subject to a thermal treatment as required for the desired grade. In order to control thermal insulation, the piece is covered with thin aluminum foils and then with ceramic fiber material in a helicoidal fashion. Subsequent steps involve covering the ceramic layer with a fiber-glass fabric thus generating an assembly which enables smooth sliding through the outer tube without breakage or displacement of the insulating layer. The insulated unit is introduced into outer tube and ends are alternately welded. The tubular unit coupling obtained by such process is also disclosed.

**PROCESS FOR MANUFACTURING A TUBULAR UNIT OFFSITE FOR  
COUPLING DOUBLE-WALLED TUBES AND A TUBULAR UNIT OBTAINED  
THEREFROM**

5 The present invention relates to a process for the offsite manufacturing of a  
tubular unit coupling in order to couple double-walled tubes and the tubular unit  
coupling obtained therefrom. More specifically, the manufacturing process of  
such tubular unit couplings applies to the field of petroleum, which requires high  
temperature fluid transmission through double-walled tubes, while avoiding  
10 thermal losses and fluid-dynamic distortions.

Known processes for the manufacturing of these kind of connections of insulated  
double-walled tubes are carried out in large industrial plants. Tubes to be coupled  
have significative lengths ranging from 10 to 12 meters, and therefore the task of  
15 carrying out these kind of coupling processes on site is not practical. Precision  
obtained with these kind of processes for the manufacturing of couplings is  
relatively low, as is productivity, as a large quantity of man-hours are required in  
order to accomplish the different steps thereof.

20 Further, during coupling and handling of the tubes, tears are generated that affect  
the thermal insulation of the assembly, as the ceramic layer meant to ensure  
thermal insulation has reduced mechanical strength.

Accordingly, it was necessary to develop a process able to avoid all of these  
25 drawbacks during double-walled tube coupling, and thus the Applicant has  
invented an offsite manufacturing process for producing a coupling unit, wherein  
the resulting product serves as an insulated unit for joining double-wall tubes.  
This unit, also with its double-walls and smaller metallic section, avoids  
distortions during fluid movement, its construction is simple and it represents an  
30 improvement in terms of costs and productivity.

The object of this invention solves said difficulties through an offsite manufacturing process of a bell-shaped coupling tubular unit between double-walled tubes.

5 It is thus an object of the present invention to obtain a coupled tubular insulated unit for the coupling of insulated double-walled tubes.

According to the present invention, there is provided a process for an offsite manufacturing of a tubular unit coupling, for coupling at least two double-walled  
10 tubes, each of the double-walled tubes comprising an inner tube and an outer tube, the inner tube comprising a coupling end, the process comprising the following steps:

- heating of the inner tube coupling ends;
- forging, forming and machining the inner tube coupling ends into bell-  
15 shaped pieces;
- assembling centralizers in said inner tubes;
- joining of bell-shaped pieces by means of a nipple;
- covering of said bell-shaped pieces and the nipple with an insulating material, thus generating an insulated coupling unit;
- 20 - welding the insulated coupling unit to the outer tubes; and
- surrounding of the outer tubes with a coupling enclosure.

Yet another object of the invention is to improve productivity related to the coupling of double-walled tubes, for tubes having lengths that are considerably  
25 long and that are difficult to handle, and the reducing of costs and time required in the coupling thereof.

Yet another object of the invention is to provide an improved insulating layer against tears, which is positioned between the inner and outer tubes, thus  
30 maintaining an improved thermal insulation of the coupled tubular unit during fluid displacement.

Yet another object of the invention is to provide a nipple with improved constructive features able to ensure thermal insulation and fluid-dynamic continuity within the coupling space within both bell-shaped pieces of both double-walled tubes.

5

Yet another object of the invention is to attain an easy and quick assembly, welding and inspection of the end of the coupling tubular unit.

This invention will be better understood when reference is made to the drawings, in this case Figure 1, which shows a sectional view of a coupling for double-walled tubes with bell-shaped pieces.

10

#### DESCRIPTION OF PREFERRED EMBODIMENTS

15 This invention refers to a manufacturing process of an insulated double-walled tubular coupling unit for double-walled tubes, which tubes are used for high temperature fluid transmission, e.g. those used in the petroleum field. Each unit comprises an outer tube 3 or jacket and an inner tube 1 or conductor, joined together by weld 7, through a bell-shaped piece 2, machined and thermally  
20 treated if so required, and featuring insulating materials and/or a void 5 in its annular space, as well as a ceramic fabric as finishing insulating layer 9.

The conductor inner tube 1 comprises an assembly formed by the tube itself and pieces forged, machined and welded at both ends of said tube. These pieces are  
25 eventually thermally-treated.

Tubular sections of certain length are used in order to manufacture the forged bell-shaped piece 2. One of the ends thereof is heated at approximately 850-950°C as a function of the chemical compositions used, which include, for  
30 example, carbon steel, micro-alloy steels or low-alloy steels, which specifically depend on the carbon contents and alloys used. Then, said end is formed and machined. Eventually, it is subject to a thermal treatment as required by the

desired mechanical strength level and chemical composition, according to standards API 5CT, ASTM A106 and API. Lastly, it is welded to the outer tube 3 by means of various welding points 7.

5 In order to control thermal insulation, the bell is covered with thin aluminum foils and then, over all of its length, with helicoidally arranged ceramic fiber material. Next stage consists of covering said ceramic fiber layer with a fiber-glass fabric, thus generating an assembly, which enables a smooth sliding through outer tube 3, without breaking or displacing said insulating layer 9, whereby a thermally  
10 insulated unit is produced.

The insulating material 5 is wrapped with a tension of about 5 to 15 kgf in order to avoid compacting thereof when tubes are vertically positioned in an injection well.

15 Insulated unit is introduced into outer tube 3 and its ends are alternately welded through welding points 7.

Welding at a first end is free, whereas a closing welding of the other end is made after a thermal expansion of the inner tube 1, so that when temperatures match,  
20 outer tube 3 will be in compression and the inner tube 1, in tension.

Coupling of inner tube 1 or conductor to outer tube 3 is accomplished by means of a semi-automatic welding process with tubular wire (GMAW). First, both ends are heated to a temperature of approximately 150-250°C, which varies according  
25 to the steel grade employed, and then 2 to 5 bead passes are carried out depending of the thickness of components to be welded.

Before welding the remaining end, it is necessary to make a 4 mm hole and a 120° taper on the tube at 200 mm from the end to be welded (not shown). The  
30 purpose of this hole is to enable exhaust of gases during heating of inner tube 1, and during said closing bead passes. Before pre-heating the end to be closed, it is necessary to expand inner tube 1 in a small length increment of approximately

10-25 mm, in order to generate residual stresses in the outer tube 3 and the inner tube 1.

The outer tube 3 is then subject to compression stresses of 10-30 kg/mm<sup>2</sup> and the inner tube 1 to tensile stresses of 20-40 kg/mm<sup>2</sup>, whereby upon high temperature vapor circulation and due to the weight of the column when positioned vertically, stresses are inverted, the outer tube 3 being subject to tensile stresses and inner tube 1 subject to compression stresses. This is essentially due to a temperature gradient, which varies with well depth, between the outer tube 3 and the inner tube 1, which amounts to a change of about 300°C. Consequently, the insulating assembly is then strapped with a tension such as to avoid compacting thereof when tubes are vertically positioned in the injection well. The insulated unit is introduced into the outer tube and the ends are alternately welded.

15

Lastly, a nipple 6 is placed in order to join both bell-shaped pieces 2, over which a nipple insulating material 5 is placed. Said nipple 6 enables continuity not only with respect to fluid-dynamics but also with respect to insulating capacity. Consequently, the cylindrical nipple 6 inner diameter matches the internal section of the inner tube 1 or conductor. Over this nipple 6, two perforated washers (not shown) are assembled which follow the bell-shaped ends of the double-walled tubes. Said ceramic or insulating material 5 is annularly placed around said nipple 6 in order to provide thermal insulation of equal magnitude compared to the rest of the tube. Construction of this piece is very simple and adjustment thereof is very precise, thus ensuring thermal insulation continuity and avoiding the turbulence which the presence of obstacles in the inner conductor tube 1 would otherwise generate.

25

All of the insulated unit is surrounded by a coupling enclosure 4 which encloses the unit.

30

A welding 8 joins the bell-shaped piece 2 to tubes which are joined to said tubular unit. To produce welding 8, it is necessary to place a centralizer (not shown), to pre-heat to a temperature of approximately 150-200°C, and to determine at least two fixing points. A first pass is done with TIG ("Tungsten Inert Gas", a kind of  
5 welding process which uses tungsten electrode and inert gas protection), it is then completed with passes of low hydrogen basic electrodes of the Exx15 type as per the AWS/ASTM designation. Caloric contribution is controlled according to the thickness of assembly components, to ensure an adequate penetration and prevent the generation of an excessive area affected by heat, which would impair  
10 the integrity of the assembly.

Insulating spacers are installed which, in addition to enabling centering of tubes, also constrain bending lengths.

15 Also as an object of the invention, the present disclosure includes a tubular unit coupling which comprises a bell-shaped piece 2 which is joined by welding points 8 and 7 to an inner conductor tube 1 and an outer tube 3 respectively. Said bell-shaped piece is surrounded around its annular region by a combination of thin aluminum foils, an insulating ceramic layer and a fiber-glass fabric which form the  
20 insulating layer 9, which allows sliding of outer tube 3 without wear. At their central coupling interface, both confronted bell-shaped pieces 2 are joined by a nipple having a diameter equivalent to that of inner tube 1, in order to enable fluid-dynamic continuity. The tube is also surrounded by an insulating material 5 (sleeve), which enables thermal insulation continuity. All of the assembly is  
25 externally surrounded (and contacting outer tube 3) by a coupling enclosure 4. This tubular unit coupling manufactured offsite away from the area of industrial activity, e.g. an oil well, operates as a hermetic seal and thermal insulation unit used to join ends of considerably long tubes. This type of coupling was until this  
30 day manufactured onsite at the industrial area and during the exploration process. According to the present invention, there is now provided a unit pre-manufactured outside said areas, whereby the use of double-walled tube couplings is optimized, and productivity, costs and quality thereof are improved.

The following are examples of double-walled tubes with different inner and outer tubes diameters:

- 5 a) Outer tube diameter 3 1/2" or 88.9 mm  
Inner tube diameter 2 3/8" or 60.3 mm
- b) Outer tube diameter 4 1/2" or 114.3 mm  
Inner tube diameter 2 3/8" or 60.3 mm
- c) Outer tube diameter 4 1/2" or 114.3 mm  
Inner tube diameter 2 7/8" or 73 mm
- 10 d) Outer tube diameter 5" or 127 mm  
Inner tube diameter 3 1/2" or 88.9 mm

15 Thicknesses range is from 3 to 15 mm depending on the minimum fluence required, as well as respecting API 5CT grades J55, M65 and N80, as well as grades B of ASTM A106 and B, X42, X52 of API 5L.

Hereinbelow are a series of tests which are typically used in order to assess quality of the product obtained by the process according to the invention:

#### 20 Welded assembly tests

1. Stress test on the weld between the bell-shaped piece and inner tube at full scale, to observe breakage of the inner tube body.
2. Metallographic analysis of welded ends, heat-affected areas, penetration area  
25 and weld material area.
3. Hardness profiles including those of base material, weld material and affected areas.

Vapor Injection Test:

One of the tubes, consisting of the tubular unit coupling plus the double-walled tubes to be coupled, was prepared with extensometric bands in order to measure  
5 longitudinal and circumferential stresses induced during manufacturing after the tube is hermetically closed and the assembly is cooled until temperatures become uniform.

Once the tube is hermetic, in its insulated chamber and while maintaining  
10 assembly of manufacturing load cells, a test uses a passage of overheated vapor at 483°C which is injected into an end, the opposed end remaining free.

By means of this test, it was possible to verify the stress state inversion between the outer and inner tubes and the capacity of thermal insulation of elements  
15 placed at the gap.

This is a higher stress than the actual one, as vapor enters wells at 350°C and during the test it was injected at 483°C. As a result, a temperature reduction of about 50°C was observed.

CLAIMS

1. Process for an offsite manufacturing of a tubular unit coupling, for coupling at least two double-walled tubes, each of said double-walled tubes comprising an inner tube and an outer tube, said inner tube comprising a coupling end, said process comprising the following steps:
- heating of the inner tube coupling ends;
  - forging, forming and machining the inner tube coupling ends into bell-shaped pieces;
  - assembling centralizers in said inner tubes;
  - joining of bell-shaped pieces by means of a nipple;
  - covering of said bell-shaped pieces and said nipple with an insulating material, thus generating an insulated coupling unit;
  - welding said insulated coupling unit to said outer tubes; and
  - surrounding of said outer tubes with a coupling enclosure.
2. Process according to claim 1, characterized in that heating of said inner tube ends is carried out at a temperature of approximately 850 to 950°C.
3. Process according to claim 1, characterized in that said covering of said bell-shaped pieces is accomplished by means of thin aluminum foils, said aluminum foils being covered with a ceramic fiber material which is arranged in an helicoidal fashion, said ceramic fiber material being covered by a fiber-glass fabric.
4. Process according to claim 1, characterized in that said welding to said outer tubes of said insulated coupling unit is accomplished stepwise, first to a free end and then, after subjecting the inner tube to thermal expansion, to a second end.
5. Process according to claim 4, characterized in that said welding is carried out by a semiautomatic process with tubular wire after heating of both ends to a temperature of approximately 150 to 250°C, and then 2 to 5 bead passes are carried out.

6. Process according to claim 4 or 5, characterized in that each of the outer tubes comprises a 4 mm hole and a 120° cone at 200 mm of said second end to be welded.

5

7. Process according to claim 6, characterized in that before welding of said second end, the inner tube is expanded in a length increment of approximately 10-25 mm.

10

8. Process according to claim 1, characterized in that said inner and outer tubes, once formed, are subject to compression stresses of from about 10 to about 30 kg/mm<sup>2</sup> and tensile stresses of from about 20 to about 40 kg/mm<sup>2</sup> respectively with the tubes positioned horizontally, which are then reversed with the tubes positioned vertically once in use, due to a temperature gradient between said tubes.

15

9. Process according to claim 8, characterized in that said temperature gradient is of a change in temperature of approximately 300°C.

20

10. Process according to claim 1, characterized in that said nipple has a diameter similar to that of the inner tube.

25

11. Process according to claim 1, characterized in that two perforated washers are assembled over said nipple which follow a shape of the bell-shaped pieces and further, said nipple is covered with an insulating ceramic material sleeve, in order to provide thermal insulation continuity.

30

12. Process according to claim 1, characterized in that said double-walled tubular unit coupling is joined to said double-walled tubes by means of providing said centralizers, preheating said inner tubes to a temperature of approximately 150 to 200°C and establishing at least two attachment points.

13. Process according to claim 12, characterized in that said centralizers are insulating spacers which also limit bending length.

14. Process according to claim 1, characterized in that said insulating material is wrapped with a tension of approximately 3 to 15 kgf in order to avoid its compacting.

15. A tubular unit coupling obtained by means of the process of any one of claims 1 to 14, characterized in that confronted ends of said inner tubes are shaped as bell-shaped pieces and joined by means of first welding points to said outer tubes, an opposing end of said inner tubes being in turn joined by second welding points, said bell-shaped pieces being in turn enclosed by an insulating compound which allows sliding of outer tubes without wear, and said confronted ends being joined together by a nipple in order to enable fluid-dynamic continuity, said nipple being surrounded by an insulating material, thus forming an insulated tubular coupling unit surrounded by a coupling enclosure.

16. Tubular unit coupling according to claim 15, characterized in that said insulating compound is a combination of aluminum foils, ceramic fiber material and fiber-glass fabric.

17. Tubular unit coupling according to claim 15, characterized in that said nipple possesses an inner diameter which coincides with that of the internal section of the inner tube, on which there are assembled two perforated washers which follow said bell shape of the confronted ends.

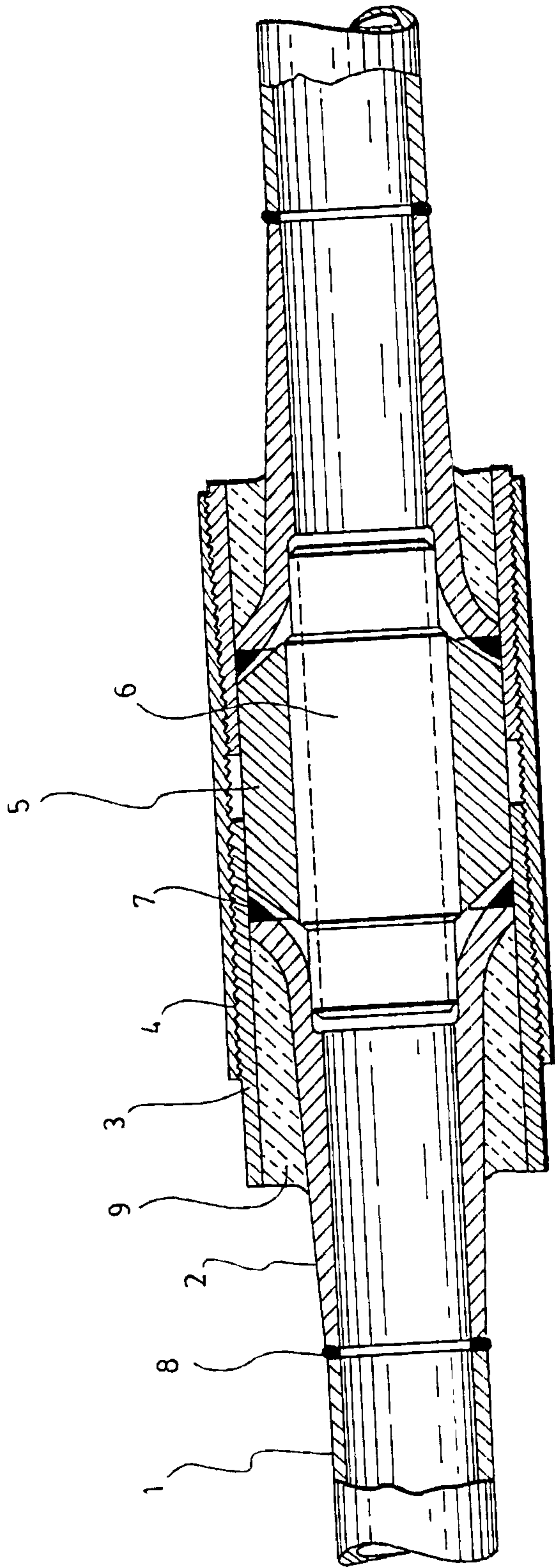


FIG. 1

