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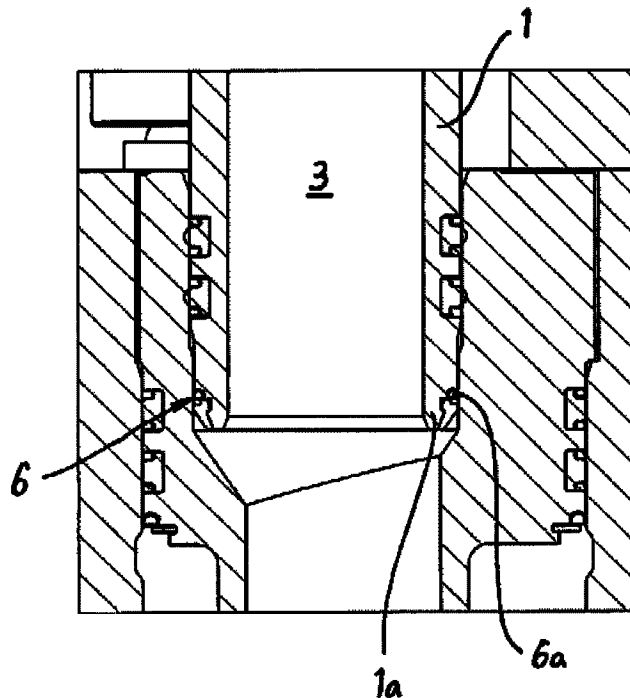
(54) Title **Oilfield tubular with metal c-ring seal**

(56) References  
Cited:

US 4832381 A  
US 5015016 A  
GB 2214543 A  
WO 2007/050618 A1

(57) Abstract

An oilfield tubular, such as a stinger (1), designed to be installed in a tubing hanger (2) in an XMT (Christmas tree) located on the seabed, is presented. The oilfield tubular (1) is exposed to the production bore (4) pressure, and includes axial sealing means (6) located on an end (1a) of the tubular (1). The axial sealing means (6) includes a metal c-ring seal (6a), which metal c-ring seal (6a) is smaller in cross section than the thickness (t1) of the oilfield tubular wall (1c). The opening (6b) of the metal c-ring seal (6a) is facing the high pressure side of the production bore (4). This pressure tend to expand the c-profile to firm engagement with contacting surfaces.



## **Oilfield tubular with metal c-ring seal**

The present invention is to be used in the oil and gas industries, and relates to  
5 an axial sealing means located on an end surface of a tubular or similar, such  
as a stinger, designed to be installed in a tubing hanger in an XMT (Christmas  
tree) located on the sea bed, which oilfield tubular is exposed to the production  
bore pressure. The oilfield tubular includes axial sealing means provided at an  
end of the oilfield tubular, which axial sealing means includes a metal c-ring  
10 seal and an external ledge or shoulder at said end, which shoulder supports  
said metal c-ring seal.

Known prior art technology within this technical field, are US 4832381, US  
5015016, GB 2214543 and WO 2007/050618.

15 In an oil or gas well, a stinger assembly may be attached to the lower end of an  
upper section of tubing to provide a releasable sealed connection with a well  
tool such as a tubing hanger or packer or the like which supports a lower  
section of tubing in the well. When installing the well tool in the well, it is  
20 desirable that the stinger be locked against separation from the well tool but,  
once the well tool is anchored in its desired position in the well, it may become  
necessary to disconnect the stinger from the well tool to allow the upper section  
of tubing to be pulled from the well for servicing. Apparatus connected to the  
tubing at the wellhead may make it desirable to be able to disconnect the  
25 stinger from the well tool without having to rotate the tubing or slide the upper  
section of tubing downwardly within the well.

### **Background of the invention**

When installing a stinger assembly into a bore in a tubing hanger (TH), there  
30 are some compromises to consider which is discussed below. Increasing  
production bore size reduces space through the tubing hanger for the annulus  
bore; this reduces available annulus flow area. In order to achieve an

acceptable flow area in a reduced bore annulus stinger, it is typical to split the annulus bore into two separate smaller stingers. This is unfavorable from a reliability perspective amongst others.

- 5 The ideal solution is to reduce the cross-section of the stinger wall in order to obtain the desired flow area within the available space, but conventionally used metal lip seals do not allow a sufficiently thin cross-section. Stinger integral metal bump seals, which allow a thin cross-section, do not flex sufficiently to make reliable seals and replacement of such a seal on a completed XT  
10 assembly at typical small diameters, is a costly task as the whole stinger must be removed.

According to the present invention an oilfield tubular of the introductory said kind is provided, which is distinguished in that said metal c-ring seal is smaller  
15 in cross section than a thickness ( $t_1$ ) of an oilfield tubular wall and the opening of said metal c-ring seal is facing the high pressure side of the production bore, which pressure tends to expand a c-profile of said metal c-ring seal to firm engagement with contacting surfaces, wherein said shoulder includes a V or U shaped seat, said seat being designed to receive and support said metal c-ring  
20 seal.

Hence, the invention relates to the use of an axial sealing means, i.e. an axial sealing between two parallel bores. To provide such sealing, the proposed metal c-ring seal is used on the stinger, as opposed to a metal lip-seal. These  
25 seals can be made in extremely small cross-sections and thus enable a very thin section stinger.

Preferably, the opening of the metal c-ring seal is facing in the axial direction of the oilfield tubular and away from said oilfield tubular.

30

Preferably, the metal c-ring seal makes sealing contact with a bore wall in the tubing hanger, which is adapted to receive the oilfield tubular, in addition to

make sealing contact with an external surface of the oilfield tubular, which external surface is part of the shoulder and is opposing the bore wall.

Normally, the metal c-ring seal is less than 1-5mm in cross section.

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When using these seals at small cross-sections (e.g. 1-3mm or even 5mm) the c-ring gets extremely stiff if the body of the seal is designed to resist normal pressures used for XT systems. A stiff seal is typically not a reliable seal unless seal bore tolerances are reduced to uneconomic levels.

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Therefore, a design is proposed where the c-ring is made thinner than it typically needs to be to handle the pressure rating, thus allowing it to be more resilient to tolerance variations. This is combined with the V or U shaped seat provided in the stinger which supports the thin seal and allows it to handle a

15 higher pressure rating.

A similar c-ring seal is used with electrical and hydraulic connectors through the TH. To our knowledge, metal c-rings have never been used in this application and this is attributed to the excessive tight tolerances required, or the inability for typical flat seated c-rings to handle the pressure – a problem that this design solves.

20

Using the c-ring on the annulus (or production) stinger and adding a U or V shaped seat will improve pressure rating and reduce tolerance sensitivity.

25

The c-ring operates like a normal lip seal and that is how it is used in most applications. Specifically for this application, it works because of (a) small size to achieve the required stinger envelope (b) thin section material to make the seal flexible allowing manufacturing tolerances that can be reliably machined (c) u shaped seat that supports the c-ring against pressure.

30

With a normal flat seat behind the c-ring pressure tries to make the c-ring go a square shape. The effect of this is that after pressure application the seal is

permanently deformed and loses contact preload between the surfaces being sealed unless the material thickness is sufficient to avoid plastic damage.

5 The U shaped seat supports the seal and means that it cannot be forced by pressure into a square shape. Therefore a thinner than usual seal can be used thus obtaining the benefit (b) given above.

10 Any typical corrosion resistant alloy can be used here. The seal is very slightly deformed if installed at tolerance extremes and some further small deformation does occur with initial pressure application but after this the c-ring operates in an elastic regime. The seal can be re-used in theory since these deformations are extremely small when compared to the seal interference with its sealing surfaces.

15 Thus, the metal c-ring seal may preferably be made of a corrosion resistant alloy, such as Inconel.

On one embodiment, the metal c-ring seal has a wall thickness in the range of 0.01 to 0.25mm.

20

On one embodiment, the shoulder is an angular notch, preferably a 90 degree notch. This shoulder may be defined by one transversally extending surface and one axially extending surface, both surfaces supporting the metal c-ring seal.

## 25 **Example of embodiment**

While the various aspects of the present invention has been described in general terms above, a more detailed and non-limiting example of an embodiment will be described in the following with reference to the drawings, in which:

30

Fig. 1 is a sectional view of a typical tubing hanger and a stinger installed into it in an arrangement involving the present invention,

5

Fig. 2 is an enlarged view of the lower end of the stinger, which includes the c-ring seal on its end surface,

Fig. 3 is a still more enlarged view of the lower end of the stinger shown in fig. 2, and

5 Fig. 4A-4D show seated and unseated c-ring deformations.

Reference is first made to fig. 1 showing in general a tubing hanger 2 installed in a wellhead 5 located in a Christmas tree (XMT) on the seabed. These components are well known per se and will not be described in further detail. A  
 10 stinger 1 is installed in the tubing hanger 2 and provides an independent flow path 3 external to the main flow bore 4 through the wellhead 5. The flow path 3 of the stinger 1 may be used, as an example, to supply fluid or gas from the surface to the well flow to provide gas lift to the produced flow.

15 Reference is now made to fig 2, which is an enlarged view of the lower end area of the stinger 1 in fig. 1. This is indicated by the arrow A between the two figures 1 and 2. The stinger 1 includes axial sealing means 6 located at the lower end 1a of the stinger 1. This axial sealing means 6 includes a metal c-ring seal 6a. Further, the axial sealing means 6 at the lower end 1a of the stinger 1 includes  
 20 an external ledge 1b, or shoulder, which is more clearly shown in fig. 3. The shoulder 1b supports the metal c-ring seal 6a.

As shown in fig. 3 and still more detailed in fig. 4A to 4D, the shoulder 1b is defined by one transversally extending surface 1b' and one axially extending  
 25 surface 1b''. Both surfaces 1b' and 1b'' support the metal c-ring seal 6a. In addition, the metal c-ring seal 6a makes contact with the bore wall 2a in the tubing hanger 2. The shoulder surfaces 1b' and 1b'' is typically like an angular notch, normally a 90 degree angle between the surfaces 1b' and 1b''.

30 The opening 6b of the metal c-ring seal 6a is installed in such a way that the opening 6b is exposed to the high pressure side of the production bore 4. When the metal c-ring seal 6a is exposed to such high pressure at the opening 6b, the

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high pressure tend to expand the c-profile to firm engagement with contacting surfaces, i.e. the supporting shoulder surfaces 1b' and 1b'' and the bore wall 2a.

5 Normally, this means that the opening 6b of the metal c-ring seal 6a is facing in the axial direction of the stinger 1 and away from the stinger 1. This also means that the sealing means 6 is smaller in cross section than the thickness  $t_1$  of the stinger wall 1c.

10 The shoulder 1b, or ledge, of the stinger 1 will normally include either a V or a U shaped seat s. The seat s is designed to receive and support the metal c-ring seal 6a. Normally, such seat s will be provided in the transversally extending shoulder surface 1b'. However, it would be possible also to provide such seat in the axially extending shoulder surface 1b'', and even the bore wall 2a.

15 The theory behind this design and function is further detailed below with reference to fig. 4A to 4D.

Typically, the metal c-ring seal 6a is less than 1-5mm in cross section. A typical diameter of the metal c-ring seal for use on a stinger 1 can have a diameter of 20 38mm and a cross section "diameter" of about 1,6mm, without such dimensions being any limitation, only mentioned as an example for the proposed stinger 1. The metal c-ring seal 6a is typically made of a corrosion resistant alloy, such as Inconel. Inconel 625 and Inconel 718 are examples of suitable grades. The metal c-ring seal 6a may have very thin walls and may typically have a wall 25 thickness  $t_2$  in the range of .01 to .25mm.

With reference again to fig. 4A to 4D, fig. 4A shows the metal c-ring seal 6a supported in the shoulder seat s in the transversally extending support surface 1b', which provides a safe and controllable support for the metal c-ring seal 6a. 30 The arrows indicate that the U-seat with short unsupported length is stable over pressure cycling.

Fig. 4B shows the metal c-ring seal 6a supported only along a line in the transversally extending support surface 1b', which provides an unstable and poorly controllable support for the metal c-ring seal 6a. The arrows indicate that the ring thickness now is insufficient to withstand pressure over unsupported length.

Fig. 4C shows the metal c-ring seal 6a supported in the transversally extending support surface 1b'. The arrows indicate that the pressure plastically deforms the metal c-ring seal 6a.

Fig. 4D shows the metal c-ring seal 6a supported in the transversally extending support surface 1b'. The arrows indicate loss of sealing after pressure removal.

Hence, we may say that the metal c-ring seal 6a operates like a normal lip seal and that is how it is used in most applications. We repeat that specifically for this application it works because of:

- (a) small size to achieve the required stinger envelope
- (b) thin section material to make the seal flexible allowing manufacturing tolerances that can be reliably machined
- (c) u shaped seat that supports the c-ring against pressure.

As mentioned, with a normal flat seat behind the metal C-ring, the pressure tries to make the c-ring go a square shape. The effect of this is that after pressure application, the metal c-ring seal is permanently deformed and loses contact preload between the surfaces being sealed unless the material thickness is sufficient to avoid plastic deformation and damage.

The U or V shaped seat will support the metal c-ring seal and provides for that the seal cannot be forced by pressure into a square shape. Therefore a thinner than usual metal c-ring seal 6a can be used and thus obtaining the benefit (b) given above.

As mentioned, the metal c-ring seal 6a is very slightly deformed if installed at



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tolerance extremes. Some further small deformation does occur with initial pressure application, but after this the metal c-ring seal 6a operates in an elastic regime. The metal c-ring seal 6a can be re-used in theory since these deformations are extremely small when compared to the seal interference with its sealing surfaces.

5

Thus, it is to be understood that without support from the U or V shaped seat s, the thin section c-ring is deformed by pressure and loses ability to seal after one cycle.

10

This would require a thicker ring, which cannot be made so small and is more sensitive to tolerances, making a less robust seal that is more expensive due to much reduced tolerances on mating parts.

15

P a t e n t   c l a i m s

1.

An oilfield tubular designed to be installed in a tubing hanger (2) in an XMT  
(Christmas tree) located on the sea bed, which oilfield tubular (1) is exposed to  
the production bore (4) pressure, said oilfield tubular (1) includes axial sealing  
means (6) provided at an end (1a) of said oilfield tubular (1), which axial sealing  
means (6) includes a metal c-ring seal (6a) and an external ledge or shoulder  
(1b) at said end (1a), which shoulder (1b) supports said metal c-ring seal (6a),  
**characterized in that** said metal c-ring seal (6a) is smaller in cross section than  
a thickness ( $t_1$ ) of an oilfield tubular wall (1c) and the opening (6b) of said metal  
c-ring seal (6a) is facing the high pressure side of the production bore (4), which  
pressure tends to expand a c-profile of said metal c-ring seal to firm  
engagement with contacting surfaces, wherein said shoulder (1b) includes a V  
or U shaped seat (s), said seat (s) being designed to receive and support said  
metal c-ring seal (6a).

2.

The oilfield tubular according to claim 1, **characterized in that** said opening  
(6b) of said metal c-ring seal (6a) is facing in the axial direction of said oilfield  
tubular (1) and away from said oilfield tubular.

3.

The oilfield tubular according to claim 1 or 2, **characterized in that** said metal  
c-ring seal (6a) makes sealing contact with a bore wall (2a) in said tubing  
hanger (2) adapted to receive said oilfield tubular (1), in addition to sealing  
contact with an external surface (1b'') of said oilfield tubular (1), which external  
surface (1b'') is part of said shoulder (1b) and is opposing said bore wall (2a).

4.

The oilfield tubular according to any of the claims 1-3, **characterized in that**  
said metal c-ring seal (6a) is less than 1-5mm in cross section.

10

5.

The oilfield tubular according to any of the claims 1-4, **characterized in that** said metal c-ring seal (6a) is made of a corrosion resistant alloy.

5 6.

The oilfield tubular according to any of the claims 1-5, **characterized in that** said metal c-ring seal (6a) has a wall thickness ( $t_2$ ) in the range of 0.01 to 0.25mm.

10 7.

The oilfield tubular according to any of the claims 1-6, **characterized in that** said shoulder (1b) is an angular notch.

8.

15 The oilfield tubular according to any of the claims 1-7, **characterized in that** said shoulder (1b) is defined by one transversally extending surface (1b') and one axially extending surface (1b''), both surfaces (1b', 1b'') supporting said metal c-ring seal (6a).

20 9.

The oilfield tubular according to any of the claims 7-8, **characterized in that** said shoulder (1b) is a 90 degree notch.

## Patentkrav

1.

- 5 Rørvare for oljeindustrien konstruert for å bli installert et røroppheng (2) i et ventiltre plassert på sjøbunnen, hvilken rørvare (1) er eksponert for trykket i en produksjonsboring (4), der rørvaren (1) innbefatter en aksial tetningsinnretning (6) anordnet i en ende (1a) av rørvaren (1), hvilken aksiale tetningsinnretning (6) innbefatter en metallisk c-ring tetning (6a) og en utvendig avsats eller
- 10 skulder (1b) i nevnte ende (1a), hvilken skulder (1b) understøtter den metalliske c-ring tetning (6a), **karakterisert ved at** den metalliske c-ring tetning (6a) er mindre i tverrsnitt enn en tykkelse ( $t_1$ ) av en rørvarevegg (1c) og den metalliske c-ring tetnings (6a) åpning (6b) vender mot høytrykkssiden av produksjonsboringen (4), hvilket trykk tenderer til å ekspandere et c-profil av
- 15 den metalliske c-ring tetning til fast anlegg mot kontaktende flater, idet skulderen (1b) innbefatter et V- eller U-formet sete (s), hvilket sete (s) er utformet til å motta og støtte den metalliske c-ring tetning (6a).

2.

- 20 Rørvare for oljeindustrien som angitt i krav 1, **karakterisert ved at** åpningen (6b) til den metalliske c-ring tetning (6a) vender i den aksiale retning av rørvaren (1) og bort fra rørvaren.

3.

- 25 Rørvare for oljeindustrien som angitt i krav 1 eller 2, **karakterisert ved at** den metalliske c-ring tetning (6a) foretar tettende kontakt med en boringsvegg (2a) i røroppphenget (2) tilpasset til å motta rørvaren (1), i tillegg til tettende kontakt med en utvendig overflate (1b'') av rørvaren (1), hvilken utvendige overflate (1b'') er del av skulderen (1b) og er motstående boringsveggen (2a).

30

4.

Rørvare for oljeindustrien som angitt i ett av kravene 1-3, **karakterisert ved at** den metalliske c-ring tetning (6a) er mindre enn 1-5mm i tverrsnitt.

5.

Rørvare for oljeindustrien som angitt i ett av kravene 1-4, **karakterisert ved at** den metalliske c-ring tetning (6a) er tilvirket av en korrosjonsmotstandig

5 legering.

6.

Rørvare for oljeindustrien som angitt i ett av kravene 1-5, **karakterisert ved at** den metalliske c-ring tetning (6a) har en veggtykkelse ( $t_2$ ) i størrelsesområde

10 0,01 til 0,25mm.

7.

Rørvare for oljeindustrien som angitt i ett av kravene 1-6, **karakterisert ved at** skulderen (1b) er en vinklet fordypning.

15

8.

Rørvare for oljeindustrien som angitt i ett av kravene 1-7, **karakterisert ved at** skulderen (1b) er avgrenset av en tversgående overflate (1b') og en aksialt forløpende overflate (1b''), idet begge overflater (1b', 1b'') understøtter den

20

metalliske c-ring tetning (6a).

9.

Rørvare for oljeindustrien som angitt i ett av kravene 7-8, **karakterisert ved at** skulderen (1b) er en 90 graders fordypning.

25

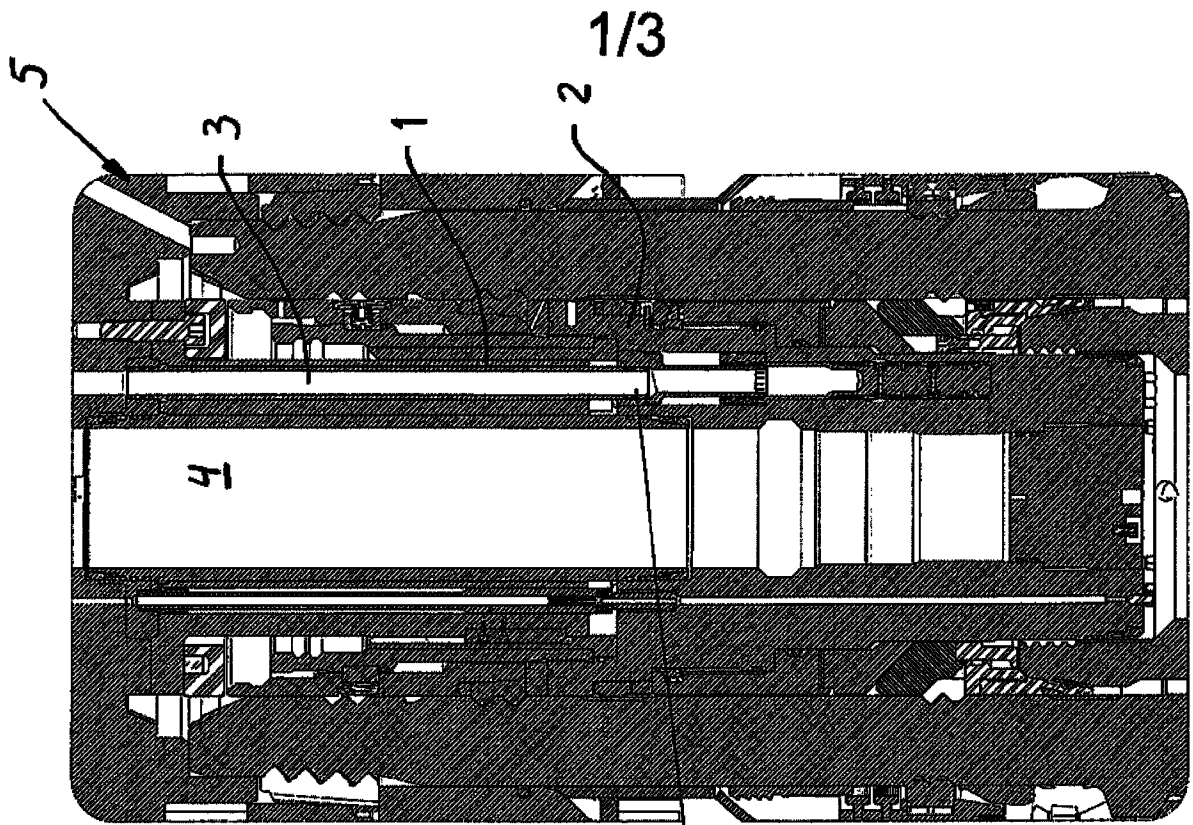


Fig. 1.

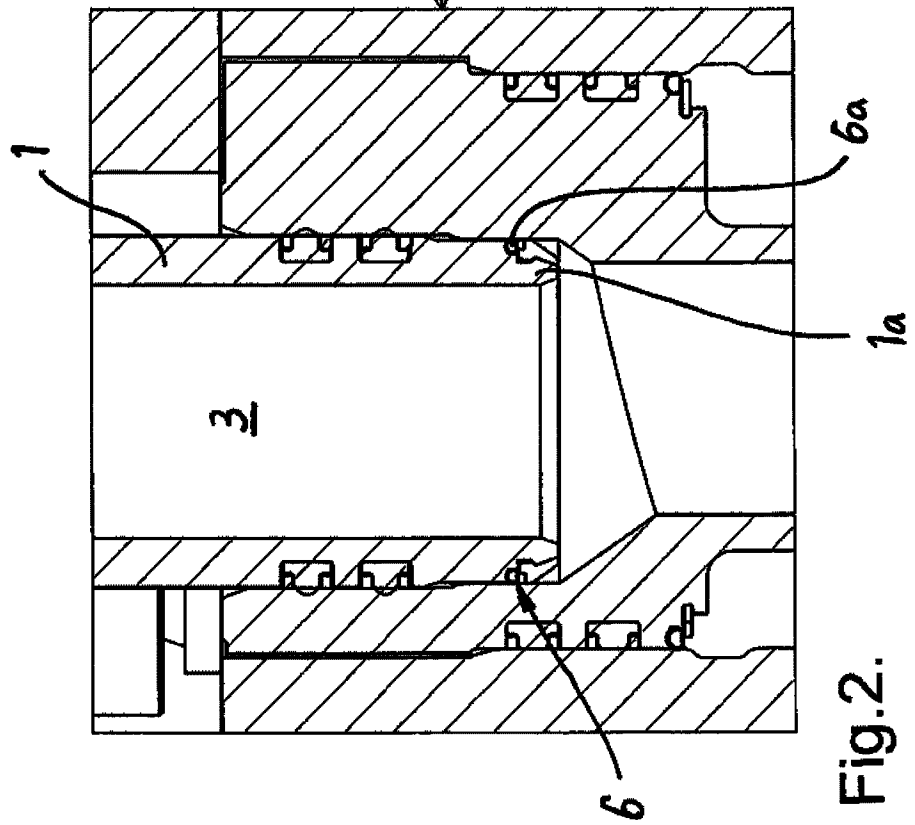


Fig. 2.



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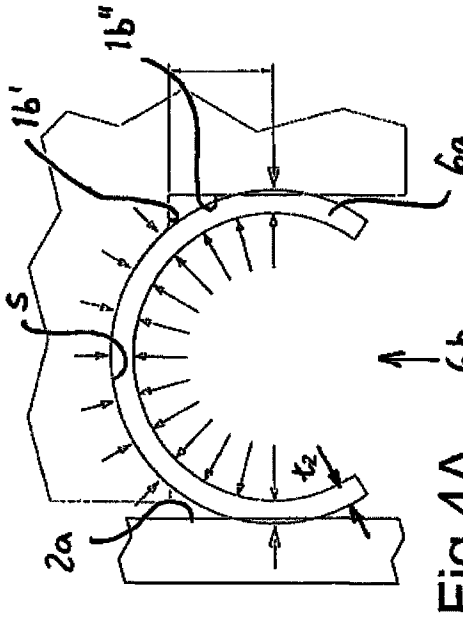


Fig. 4A.

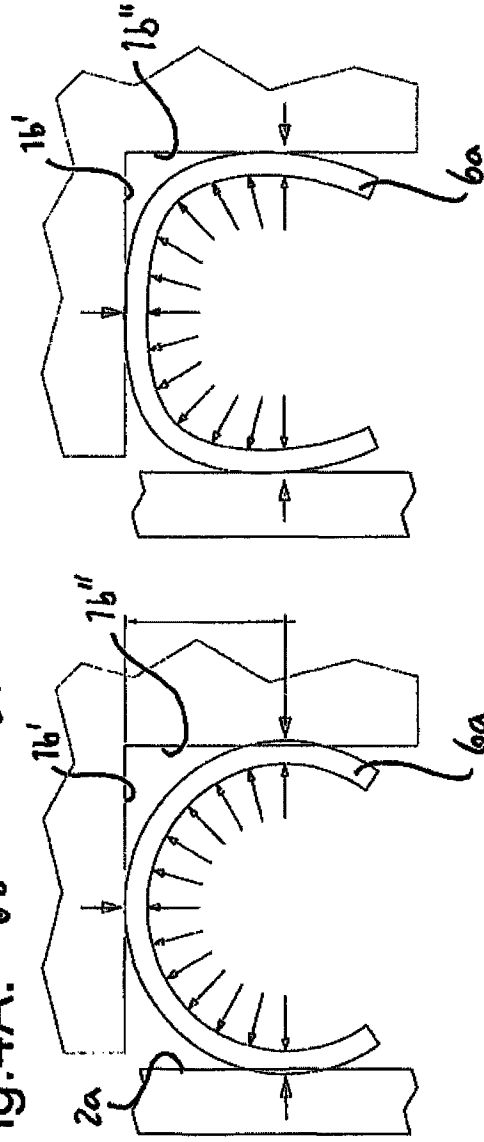


Fig. 4B.

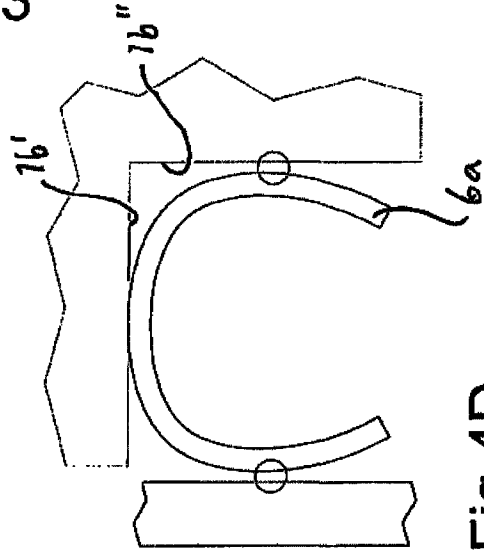


Fig. 4C.

Fig. 4D.