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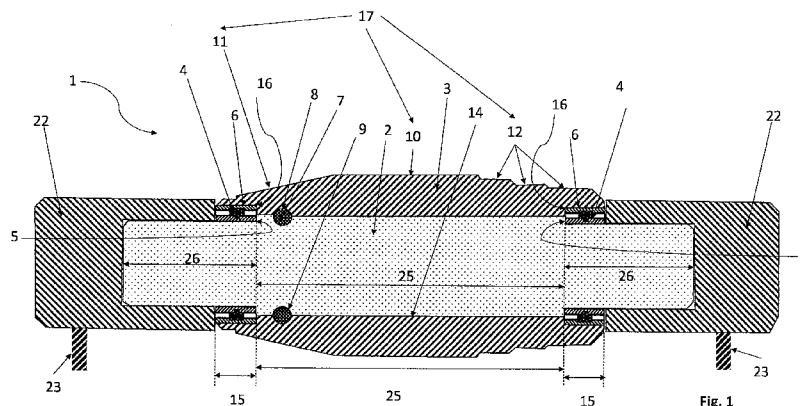


Fig. 1

- (57) Abstract: A cartridge assembly includes a roller arranged about a shaft and secured in an axial position relative to the shaft, characterized in that at least the radial load on the roller is carried by a polycrystalline diamond bearing arranged between the shaft and a bore surface.

**CARTRIDGE ASSEMBLY AND DOWNHOLE TOOL COMPRISING SAID
CARTRIDGE ASSEMBLY**

Technical field

The present invention is related to a cartridge assembly comprising a roller arranged about a shaft and secured in an axial position relative to the shaft, characterized in that a PDC bearing is arranged between the said shaft and a bore surface. The present invention is also related to a downhole tool comprising the cartridge assembly.

State of the art

Roller reamers are generally inserted in a drill string for reaming the wall of a drilled wellbore. Various kind of roller reamer are already known in the art. A roller reamer generally comprises a cylindrical tool body provided with connecting ends and comprising a pocket in which is inserted a cartridge assembly comprising a roller arranged about the shaft, wherein the roller generally comprises reaming inserts as for example tungsten carbide dome shaped insert, or tungsten carbide flat dome shaped inserts. The shaft is generally connected to a pair of blocs comprising fastening means for attaching the cartridge assembly to the tool body.

Seals are generally arranged between the shaft and the roller to prevent entrance of particles, for example abrasive or hard particles, between the shaft and the roller, that can accelerate the wear or even cause the failure of the cartridge. To increase the performance of the roller reamer, the applicant has introduced a pressure lubrication system between the shaft and the roller as presented in the document EP1818500. Such a system adds complexity to the cartridge, and the O-rings of the system have to be changed periodically. During the maintenance of the cartridge, lubricant has to be evacuated and then after the change of the seals or of the roller, new lubricant has to be introduced.

Generally, the cartridge assembly has to be replaced periodically after one or a few runs in a wellbore.

There is a need to increase the lifetime of a cartridge assembly of a roller reamer.

There is also a need for a cartridge assembly simpler to assemble and disassemble.

Summary of the present invention

The present invention is related to a cartridge assembly comprising a roller arranged about a shaft and secured in an axial position relative to the shaft, characterized in that the at

least the radial load on the roller is carried by a PDC bearing arranged between the said shaft and a bore surface.

Preferably, the said roller comprises a longitudinal bore 14, characterized in that the said bore surface 6 is a portion of the said longitudinal bore 14 of the said roller 3.

5 Preferably, the said PDC bearing 4 comprises:

- an outer ring 4a provided with a plurality of PDC surfaces 21 protruding from the inner surface 19b of the outer ring 4a and;
- an inner ring 4b provided with a plurality of PDC surfaces 20 protruding from the outer surface 18a of the inner ring 4b.

10 Preferably, the said shaft 2 comprises a main portion 25 having a first diameter and an end portion 26 having a diameter inferior to the first diameter of the main portion 25 and forming a first shoulder 5 against which bears an inner ring 4b of the said PDC bearing 4.

Preferably, the said longitudinal bore 14 of the roller 3 comprises

- a main portion 27 having a first inner diameter and;
- 15 - an end portion 15 having an inner diameter larger than the said main portion of the roller 3 forming a shoulder 16 against which bears an outer ring 4a of the said PDC bearing 4.

Preferably, the said shoulder 5 of the shaft 2 is in contact with the inner ring 4b of the PDC bearing but not with the outer ring 4a of the PDC bearing, and in that the shoulder 16 of the roller 3 is in contact with the outer ring 4a of the PDC bearing, but not with the inner ring 4b of the PDC bearing.

Preferably, the said outer ring 4a is arranged into the said roller 3 by interference fit, and the said inner ring 4a is arranged on the said shaft 2 by interference fit.

Preferably, the said roller 3 comprises an inner bearing race 8, the said shaft 2 comprises 25 an outer bearing race 9 aligned with the said inner bearing race 8 and balls 7 are arranged into the said inner bearing race 8 and the said outer bearing race 9.

Preferably, the cartridge assembly further comprises a positioning member 22 adapted for positioning and fastening the said cartridge into a pocket of a tool.

Preferably, the cartridge assembly comprises a positioning member 22 on both sides of 30 the said roller 3.

Preferably, there is a clearance C between the said positioning member 22 and:

- the said roller 3 and;
- the said PDC bearing 4.

5 Preferably, the said roller 3 comprises an intermediate portion 28 between the said main portion 27 and the said end portion 15, said intermediate portion 28 having an inner diameter comprised between the inner diameter of the main portion 27 and the inner diameter of the end portion 15.

10 Preferably, an inner zone 19b of the outer ring 4a of the PDC bearing adjacent to the shoulder 16 of the roller 3, and an outer zone 18a of the inner ring 4b of the PDC bearing adjacent to the shoulder 5 of the shaft 2 both comprises a notch 24 for facilitating the removal of the PDC bearing.

Preferably, the said roller comprises tungsten carbide inserts 13 arranged on its outer surface 17.

15 In a second aspect, the present invention is related to a downhole tool 100 comprising a body 101 provided with a pocket 102, characterized in that said pocket 102 comprises a cartridge assembly 1 as described herein.

Brief description of the drawings

Figure 1 shows a longitudinal cross sectional view of first embodiment of a cartridge assembly according to the present invention.

20 Figure 2 shows an exploded view of a radial PDC bearing comprising an inner ring and an outer ring for a cartridge assembly according to an embodiment of the present invention.

Figure 3 shows an exploded view of a radial PDC bearing comprising an inner ring and an outer ring according to another embodiment of the present invention.

25 Figure 4 shows a longitudinal cross sectional view of a second embodiment of a cartridge assembly according to the present invention.

Figure 5 shows an enlarged view of a portion of the cartridge assembly according to the embodiment of figure 4.

30 Figure 6 shows a schematic cross sectional view of a downhole tool according to the present invention.

Detailed description of the present invention.

The present invention is related to a cartridge assembly 1 comprising a roller 3 arranged about a shaft 2 and secured in an axial position relative to the shaft 2, characterized in that a PDC bearing is arranged between the said shaft 2 and a bore surface 6. In a preferred embodiment of the present invention, the bore surface is a portion of the longitudinal bore 14 of the roller 3. Alternatively, the bore surface 6 can be also a portion of a bore made in another member than the roller, such as a bore made in a positioning member or in the body of a downhole tool. The PDC bearing can be selected among a radial PDC bearing, a taper (conical) PDC bearing or a thrust PDC bearing. Preferably, the PDC bearing is a radial PDC bearing.

The roller 3 of the cartridge assembly preferably comprises an outer surface 17 defining a reaming surface. In an embodiment, the roller 3 comprise a first portion 12 forming a stepped surface, a second portion 10 of substantially constant diameter and a third portion 11 tapering from the second portion 10 towards an end portion 15 of the roller having a smaller diameter than the first portion 10. The outer surface 17 of the roller 3 may be machined with hardfaced teeth or provided with tungsten carbide inserts 13.

The figure 2 presents an embodiment of a radial PDC bearing 4. The radial PDC bearing comprises an outer ring 4a provided with a plurality of PDC (polycrystalline diamond compact) surfaces 21 protruding from the inner surface 19b. The radial PDC bearing further comprises an inner ring 4b provided with a plurality of PDC surfaces 20 protruding from the outer surface 18a. The outer ring 4a and the inner ring 4b are sized such as the PDC surfaces of the outer ring 4a and the PDC surfaces of the inner ring are into contact with each other and such as the outer ring 4a is adapted to rotate relative to the inner ring 4b. Advantageously, the PDC surfaces 20, 21 are spaced from the edges of their respective rings 4a, 4b.

The figure 3 presents an alternative embodiment of a radial PDC bearing 4 wherein both of the outer ring 4a and the inner ring 4b comprise a notch 24 for facilitating their removal from the cartridge assembly.

The PDC bearings provides a longer lifetime of the cartridge assembly that are used for example in roller reamers. The use of PDC bearings in the cartridge assembly eliminate the need of sealing, lubrication and pressure compensation between the shaft and the roller. The use of PDC bearings allows the drilling fluid to pass through the shaft and the roller as it

lubricates the PDC bearings and as the PDC surfaces rotating against each other can grinds the small particles that can enter in the clearance between the roller and the shaft. The use of PDC bearings in a cartridge assembly may also eliminate the need of surface treatment by a nitriding process. The use of PDC bearings also allows to reduce the manufacturing tolerances and finishes for the shaft and the roller.

Besides the advantages of the use of PDC bearings in cartridge assemblies, it is believed that the man skilled in the art would have never considered to introduce them in a cartridge assembly because of the elevated cost of PDC bearings relative to conventional cartridge assemblies. However, the tendency of drilling wells deeper than deeper renders the use of those PDC bearings advantageous because of the reduced risk of failure and of wear of such a cartridge assembly. A cartridge assembly according to the present invention can be run in a well for a long distance exceeding a few kilometres. Therefore despite the elevated cost of the cartridge assembly including PDC bearings, such a cartridge assembly is profitable for runs over a long distance such as in ERD wells (extended reach drilling wells).

The figure 1 presents an embodiment of a cartridge assembly according to the present invention. In that embodiment, the cartridge assembly comprises a roller 3 arranged about a shaft 2 and secured in an axial position about the shaft 2. The shaft 2 has a main portion 25 having a first diameter substantially constant over a longitudinal axis. The shaft comprises two end portions 26 having a diameter inferior to the first diameter of the main portion 25. Each of the end portions 26 of the shaft forms a shoulder 5 with its main portion 25. An inner ring 4b of a radial PDC bearing is arranged about each of the end portions 26 preferably by interference fit and abuts the shoulder 5.

The roller 3 has a longitudinal bore 14 comprising a main portion 27 having a first inner diameter and two end portions 15 having an inner diameter larger than the said main portion 27 of the roller 3. Each of the end portions 15 of the roller forms a shoulder 16 with its main portion. An inner ring 4a of a radial PDC bearing is arranged into the end portion 15 of the roller 3 by interference fit.

To avoid problems of friction, the shoulder 5 of the shaft in contact with the inner ring 4b of the radial PDC bearing is preferably not in contact with the outer ring 4a of the radial PDC bearing 4 and the shoulder 16 of the roller 3 in contact with the outer ring 4a of the radial PDC bearing 4 is preferably not in contact with the inner ring 4a of the radial PDC bearing 4.

As presented in the embodiment of figure 1, the height of the shoulder 5 of the shaft is superior to the thickness of the inner ring 4b, and the height of the shoulder 16 of the roller is superior to the thickness of the outer ring 4a.

The cartridge assembly further comprises bearings for maintaining the roller 3 in an axial position relative to the shaft. In an embodiment of the invention, the roller 3 comprises an inner bearing race 8 and the shaft comprises an outer bearing race 9 facing the inner bearing race 8 of the roller 3, and balls 7 are arranged into both bearing races. The axial load is therefore taken by ball bearings. The figure 1 shows an embodiment of a cartridge assembly wherein the roller and the shaft comprise one bearing race facing each other and in which are arranged balls 7 at one location close to one end portion 15 of the shaft, but other locations are possible and the roller and the shaft may comprise more than one bearing races and balls.

The cartridge assembly is assembled by providing the roller around the shaft with their respective bearing races 8, 9 aligned with each other and by inserting balls 7 through a hole made in the roller and connected to the bearing races 8, 9 and by pugging the hole, for example by welding or preferably by plugging the hole with a tungsten carbide insert 13 inserted by interference fit.

In an alternative to ball bearings and bearing races, the axial load may be carried by a thrust PDC bearing or partially carried by a taper (conical) PDC bearing.

In the embodiment of the figure 1, the cartridge assembly further comprises a pair of positioning members 22 arranged on both sides of the shaft 2 and the roller 3. In that embodiment, each of the positioning members 22 comprise a recess 32 in which is inserted an end portion 26 of the shaft 2 by interference fit. The recess 32 of the positioning member is dimensioned relative to the end portion 26 of the shaft 2 such as there is a clearance C between the positioning member 22 and :

- the roller 3 and;
- the radial PDC bearing 4.

The positioning members 22 comprise a fastening means 23 for fastening the cartridge assembly into a pocket made in a body of a downhole tool.

In another embodiment, as presented in figure 4, the positioning member 22 may comprise a hole 30 opening into the recess 32 of the positioning member, and the shaft 2 further comprises a recess 31 aligned with the hole 30, and a locking pin 29 is inserted into

the hole 30 of the positioning member 22 and the recess 31 of the shaft 2 such that the shaft is prevented to move radially relative to the positioning members 22. The hole 30 of the positioning member 22, the recess 31 made in the shaft 2 and the locking pin 29 may be oriented perpendicularly relative to the axis of the shaft 2 or alternatively parallel to the axis of the shaft 2.

The figure 5 presents an enlarged view of the cartridge assembly according to the embodiment presented in figure 4, showing an end portion 15 of the roller 3 about an end portion 26 of the shaft 2. In that embodiment, the shaft 2 comprises a main portion 25 having a first diameter and two end portions 26 having a diameter inferior to the diameter of the main portion 25, forming a shoulder 5 on which bears an inner ring 4b of a radial PDC bearing 4. In that embodiment, the height of the shoulder 5 is inferior to the thickness of the inner ring 4b. The roller 3 has a longitudinal bore 14 that comprises:

- a main portion 27 having a first inner diameter;
- an end portion 15 having an inner diameter larger than the said main portion 27 of the roller and;
- an intermediate portion 28 between the main portion 27 and the end portion 15, the said intermediate portion 28 having an intermediate diameter comprised between the inner diameter of the main portion 27 and the inner diameter of the end portion 15.

The outer ring 4a of the radial PDC bearing bears against the shoulder 16 formed between the end portion 15 and the intermediate portion 28. The height of the shoulder 16 is inferior to the thickness of the outer ring 4a of the radial PDC bearing 4 and there is a gap between the intermediate portion of the roller and the main portion 25 of the shaft 2.

With this arrangement, the radial load is only carried by the radial PDC bearings.

This arrangement also provides an easy removal of rings of the radial PDC bearing. For example, when the positioning members 22 and the balls 7 are removed from the cartridge assembly, the roller can be moved axially relative to the shaft such as to uncover one of the inner ring 4a on the shaft. A bearing puller can be used to remove this uncovered inner ring 4a, then the roller 3 is removed from the shaft 2, and the opposite inner ring can be further removed by using the same bearing puller. Then another bearing puller can be easily inserted into the roller to remove both of the outer rings 4b from the roller 3.

The figure 6 presents a schematic cross sectional view of a downhole tool 100 according to a second aspect of the present invention, wherein the downhole tool 100 comprises a tool body 101 provided with a pocket 102 in which is fastened a cartridge assembly as presented herein above. The downhole tool may obviously be provided by a plurality of pockets including a cartridge assembly as presented herein.

5

CLAIMS

What is claimed is:

1. Cartridge assembly 1 comprising a roller 3 arranged about a shaft 2 and secured in an axial position relative to the shaft 2, characterized in that at least the radial load on the roller is carried by a PDC (polycrystalline diamond compact) bearing 4 arranged between the said shaft 2 and a bore surface 6.
2. Cartridge assembly according to claim 1 wherein the said roller comprises a longitudinal bore 14, characterized in that the said bore surface 6 is a portion of the said longitudinal bore 14 of the said roller 3.
3. Cartridge assembly according to claims 1 or 2 characterized in that the said PDC bearing 4 comprises:
 - an outer ring 4a provided with a plurality of PDC surfaces 21 protruding from the inner surface 19b of the outer ring 4a and;
 - an inner ring 4b provided with a plurality of PDC surfaces 20 protruding from the outer surface 18a of the inner ring 4b.
4. Cartridge assembly according to any one of the preceding claims characterized in that the said shaft 2 comprises a main portion 25 having a first diameter and an end portion 26 having a diameter inferior to the diameter of the main portion 25, the main portion 25 and the end portion 26 forming a shoulder 5 against which bears an inner ring 4b of the said PDC bearing 4.
5. Cartridge assembly according to any one of the preceding claims characterized in that the said longitudinal bore 14 of the roller 3 comprises
 - a main portion 27 having a first inner diameter and;
 - an end portion 15 having an inner diameter larger than the said main portion of the roller 3 forming a shoulder 16 against which bears an outer ring 4a of the said PDC bearing 4.
6. Cartridge assembly according to any one of the preceding claims characterized in that the said shoulder 5 of the shaft 2 is in contact with the inner ring 4b of the PDC bearing but not with the outer ring 4a of the PDC bearing, and in that the shoulder 16

of the roller 3 is in contact with the outer ring 4a of the PDC bearing, but not with the inner ring 4b of the PDC bearing.

7. Cartridge assembly according to any one of the preceding claims wherein the said outer ring 4a is arranged into the said roller 3 by interference fit, and the said inner ring 4a is arranged on the said shaft 2 by interference fit.
8. Cartridge assembly according to any one of the preceding claims characterized in that the said roller 3 comprises an inner bearing race 8, the said shaft 2 comprises an outer bearing race 9 aligned with the said inner bearing race 8 and balls 7 are arranged into the said inner bearing race 8 and the said outer bearing race 9.
9. Cartridge assembly according to any one of the preceding claims characterized in that it further comprises a positioning member 22 adapted for positioning and fastening the said cartridge into a pocket of a tool.
10. Cartridge assembly according to any one of the preceding claims characterized in that it comprises a positioning member 22 on both sides of the said roller 3.
11. Cartridge assembly according to any one of the preceding claims characterized in that there is a clearance C between the said positioning member 22 and :
 - the said roller 3 and;
 - the said PDC bearing 4.
12. Cartridge assembly according to any one of the preceding claims characterized in that the said roller 3 comprises an intermediate portion 28 between the said main portion 27 and the said end portion 15, said intermediate portion 28 having an inner diameter comprised between the inner diameter of the main portion 27 and the inner diameter of the end portion 15.
13. Cartridge assembly according to any one of the preceding claims characterized in that an inner zone 19b of the outer ring 4a of the PDC bearing adjacent to the shoulder 16 of the roller 3, and an outer zone 18a of the inner ring 4b of the PDC bearing adjacent to the shoulder 5 of the shaft 2 both comprises a notch 24 for facilitating the removal of the PDC bearing.
14. Cartridge assembly according to any one of the preceding claims characterized in that the said roller comprises tungsten carbide inserts 13 arranged on its outer surface 17.

15. Downhole tool 100 comprising a body 101 provided with a pocket 102, characterized in that said pocket 102 comprises a cartridge assembly 1 according to any one of the claims 1 to 14.

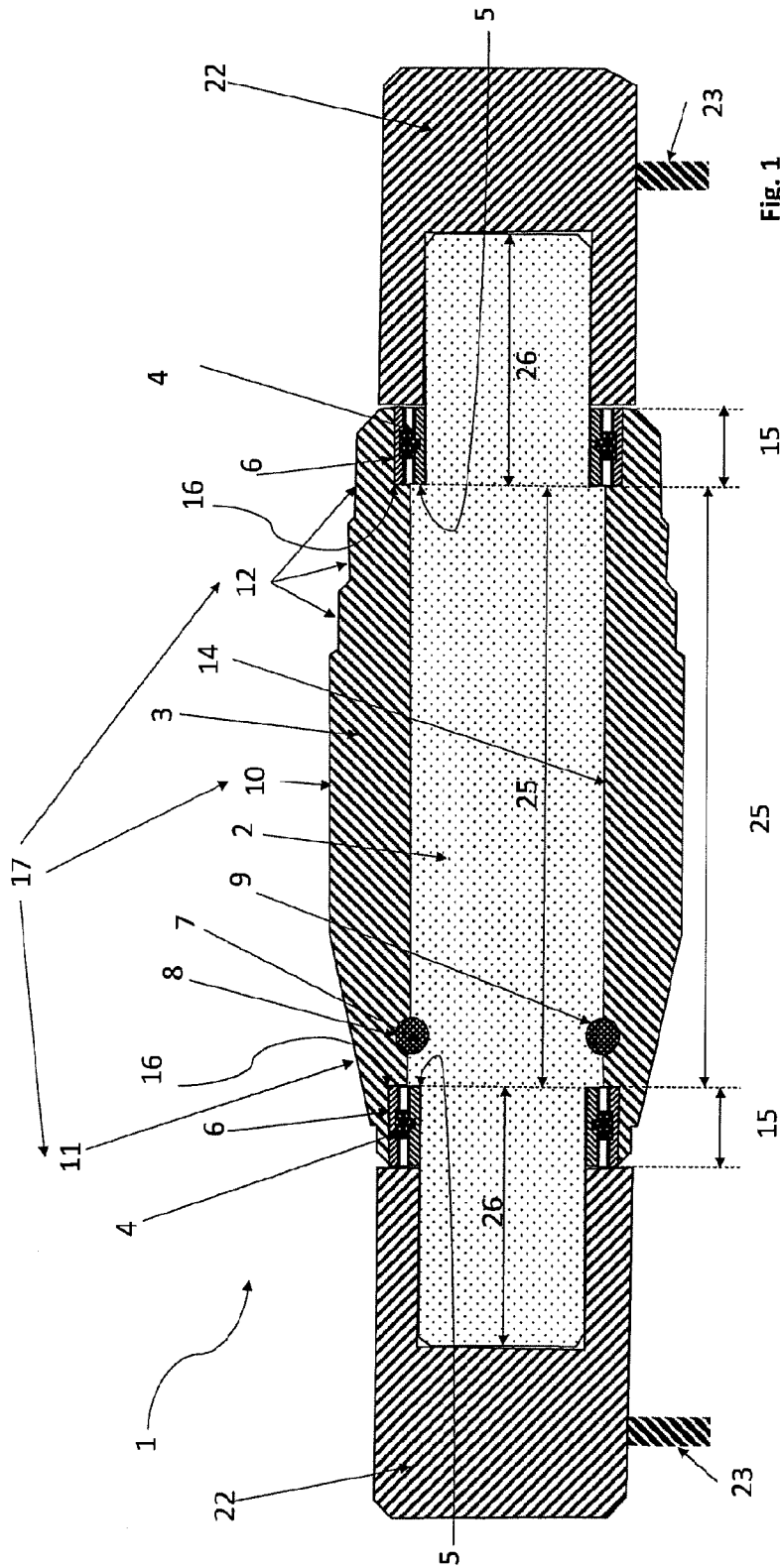


Fig. 1

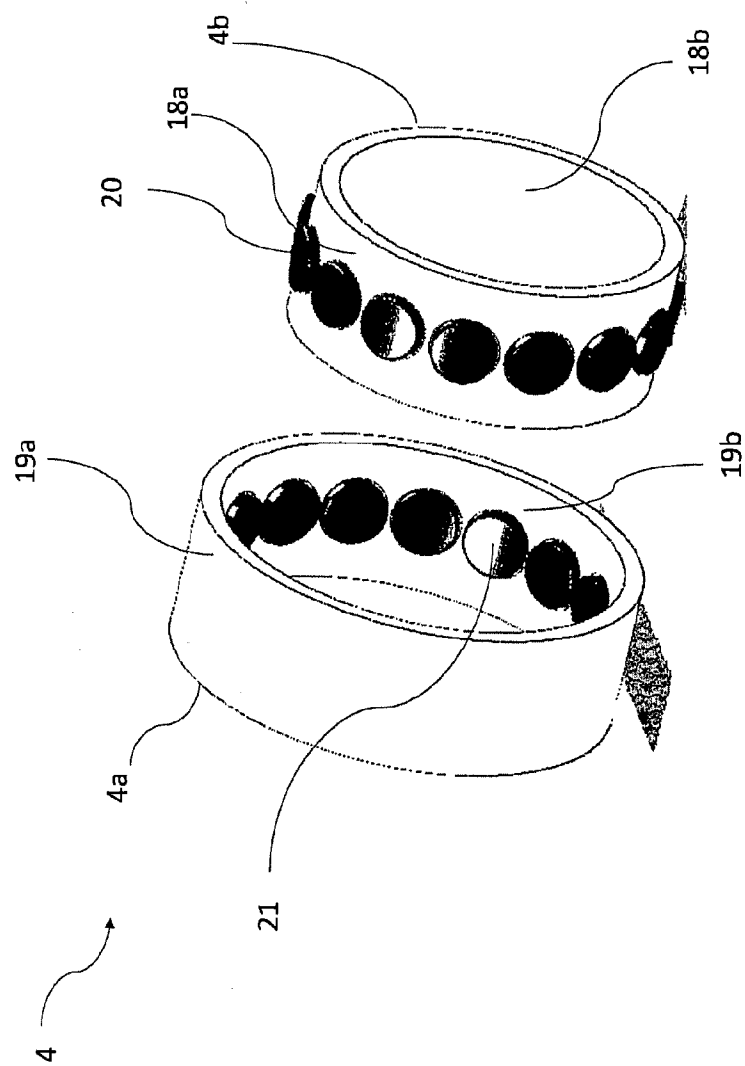


FIG. 2

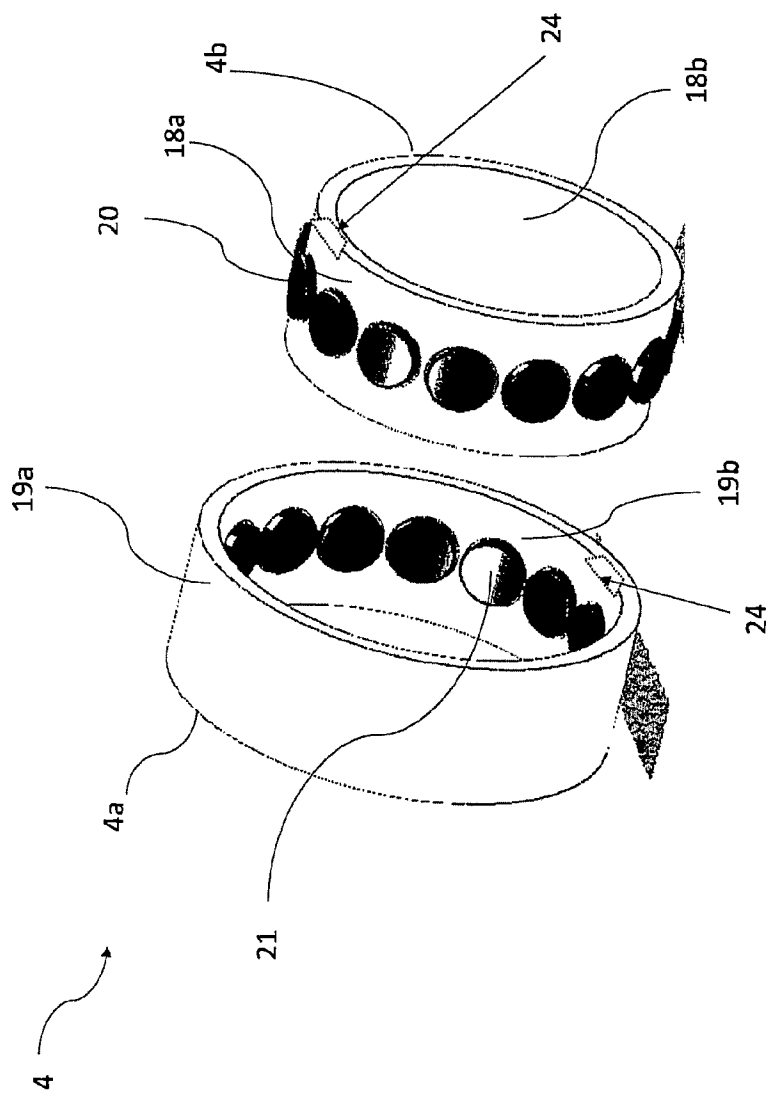


Fig. 3

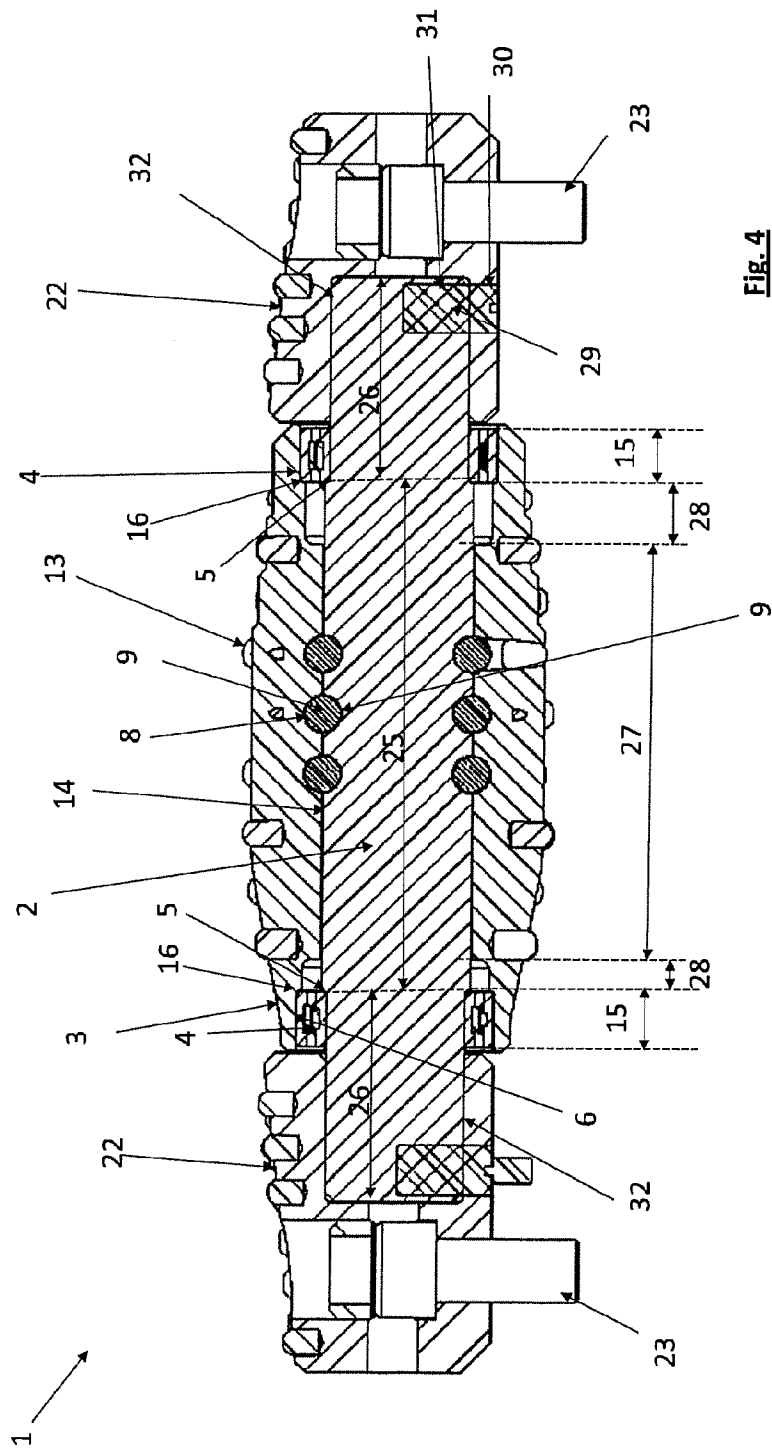


Fig. 4

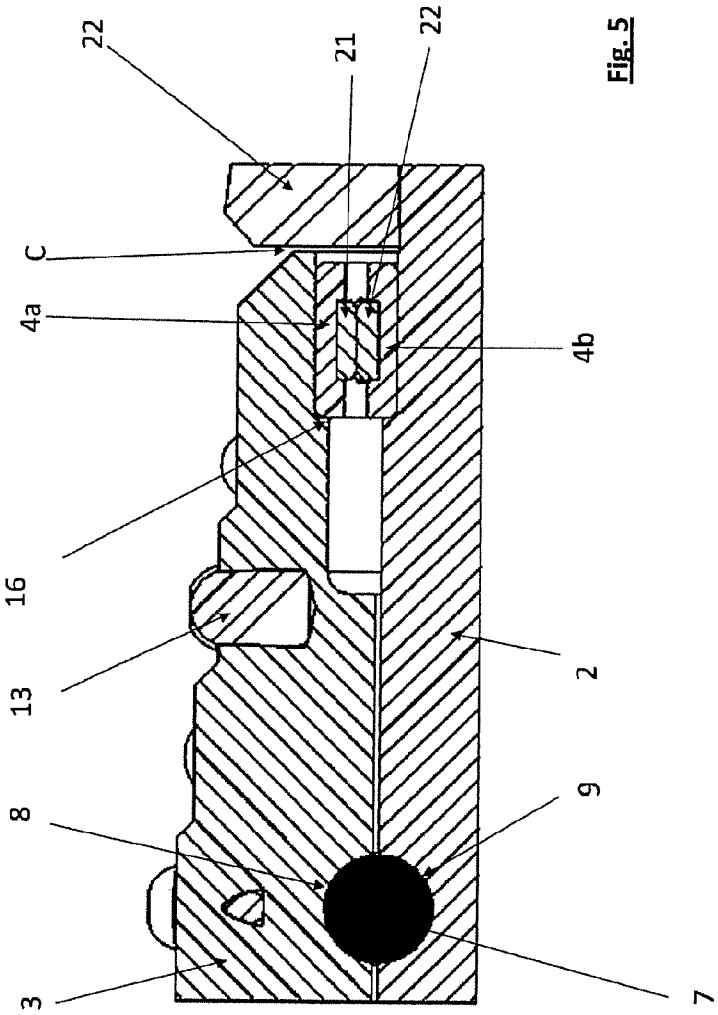


Fig. 5

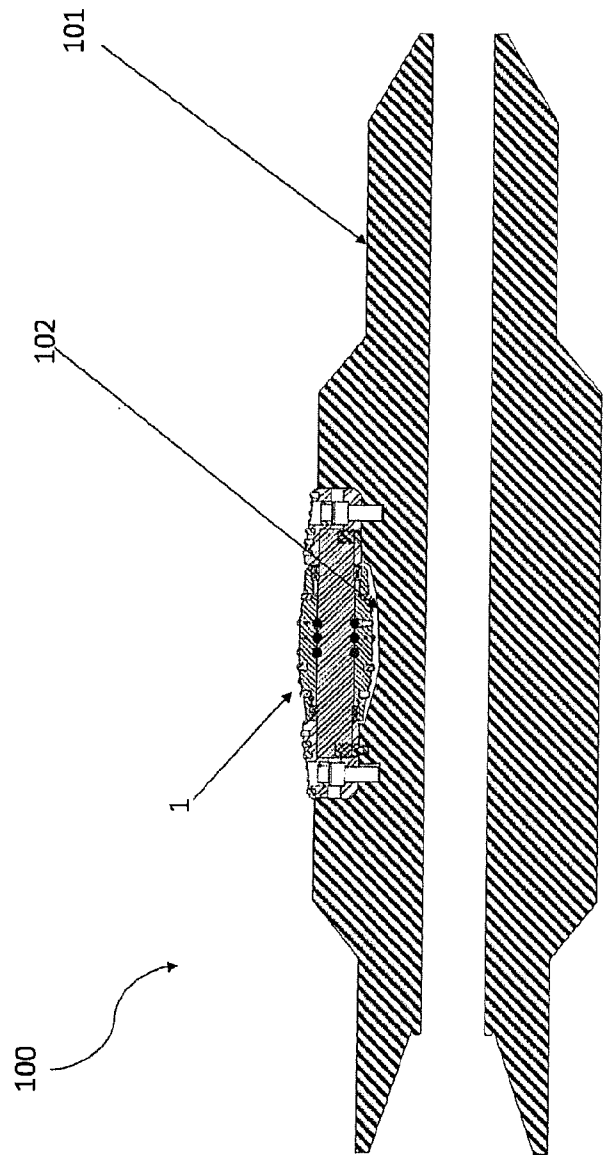


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/000495

A. CLASSIFICATION OF SUBJECT MATTER

INV. E21B10/30 E21B10/22
ADD.

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)

E21B

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 practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/120775 A1 (KRUEGER SVEN [DE] ET AL) 26 May 2011 (2011-05-26) paragraph [0026] - paragraph [0027]; figure 2	1,2
Y	US 2 026 323 A (REED CLARENCE E) 31 December 1935 (1935-12-31) the whole document	1-15
Y	US 6 488 103 B1 (DENNIS MAHLON D [US] ET AL) 3 December 2002 (2002-12-03) column 4, line 36 - column 5, line 24; figures 3-6	1-15
Y	US 4 561 508 A (GARRETT WILLIAM R [US]) 31 December 1985 (1985-12-31) column 7, line 46 - line 58; figure 1	4-6
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

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08/08/2016

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2012/321232 A1 (COOLEY CRAIG H [US] ET AL) 20 December 2012 (2012-12-20) paragraph [0032] - paragraph [0036] paragraph [0055] - paragraph [0056] figures 14-18 -----	1-15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/000495

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