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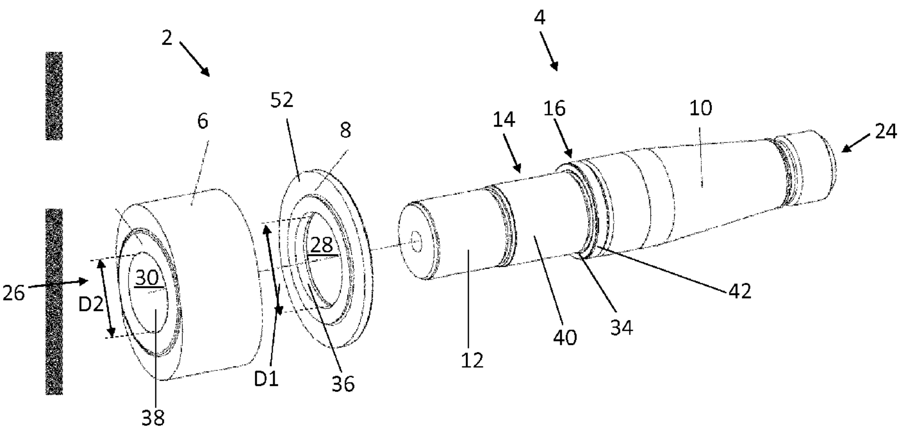
(54) **Title**: DRIVESHAFT

Figure 4



(57) **Abstract**: A three-part driveshaft assembly for a high pressure fuel pump, comprising a shaft, at least one cam lobe located in an interference fit on a first mid-portion of the shaft, and a thrust washer located in an interference fit on a second mid- portion of the shaft; and a method of assembling the driveshaft assembly, for example using heating and cooling steps.

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Driveshaft

TECHNICAL FIELD

The present invention relates to a driveshaft assembly, and in particular a driveshaft assembly for transmitting drive in a pump suitable for high pressure fuel supply in a fuel injection system such as a diesel injection system.

BACKGROUND OF THE INVENTION

Known driveshaft assemblies for high pressure fuel pumps comprise an elongate shaft element, and an integrally formed cam lobe. To enable the assembly to withstand high cam loads and stresses, it must be formed of a sufficiently hard material, such as a high grade steel, therefore presenting high manufacturing costs.

As pumps are required to work at increasing pressures, the hardness requirement of single-piece camshaft assemblies is further increasing manufacturing costs.

Known high pressure fuel pumps may further comprise a thrust washer, to counteract axial loading during use of the pump. Thrust washers with free rotating movement are used in the automotive industry for rotary applications in general. Thrust washers free of rotating movement are also known, however in a high pressure fuel pump, such washers could be disadvantageous in terms of noise, cleanliness, and generation of debris which can affect the performance of the pump and or/injector, for example by causing an injector blockage.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved driveshaft assembly which at least mitigates above problems.

Accordingly the present invention provides, in a first aspect, a driveshaft assembly according to claim 1.

The or each cam lobe is an interference fit on the first mid-portion of the shaft and the thrust washer an interference fit on the second mid-portion of the shaft.

A thrust face of the thrust washer, remote from the or each cam lobe, may be coated.

The thrust washer and the cam lobe may be bonded to each other.

In a further aspect, the present invention comprises a pump for a high pressure fuel system comprising a driveshaft assembly as described above, the pump comprising a housing and a front plate wherein the driveshaft assembly is rotatable along a longitudinal axis of the driveshaft assembly within a bore provided in the housing and the front plate.

In a further aspect, the present invention comprises a method of assembling a driveshaft assembly comprising steps of assembling the thrust washer onto the second mid-portion of the shaft and assembling the cam lobe onto the first mid-portion of the shaft.

The thrust washer and the cam lobe may be assembled onto the shaft by at least one of press or force-fitting, laser welding, cold welding and drive dog application.

The method of assembling a driveshaft assembly may comprise a first set of method steps of:

heating the thrust washer to expand a diameter of a bore of the thrust washer;

assembling the thrust washer onto the shaft and locating the thrust washer over the second mid-portion of the shaft;

and

allowing the thrust washer to cool whereby the diameter of the bore of the thrust washer reduces during cooling and whereby when cooled to a temperature of the shaft, the thrust washer is an interference fit on the second mid-portion of the shaft;

and a second set of method steps of:

heating the or each cam lobe to expand a diameter of a bore of the or each cam lobe;

assembling the cam lobe onto the shaft and locating the cam lobe over the second mid-portion of the shaft;

and

allowing the cam lobe to cool to a temperature of the shaft whereby the diameter of bore of the or each cam lobe reduces during cooling and whereby when cooled to a temperature of the shaft, the cam lobe is an interference fit on the first mid-portion of the shaft.

In an alternative method in accordance with the present invention, the second set of method steps described above is undertaken prior to the first set of method steps.

The method may further comprise a step of coating a thrust surface of the thrust washer.

The method may further comprise a step of applying an adhesive to a contact surface of the cam lobe which contacts a contact surface of the thrust washer after assembly of the driveshaft assembly, and/or applying an adhesive to the contact surface of the thrust washer.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view of a pump for a high pressure fuel system including the driveshaft assembly according to the present invention.

Figures 2 and 3 are isometric, partially cut out view of a driveshaft assembly in accordance with the present invention;

and

Figures 4 and 5 are exploded isometric views of the driveshaft assembly of Figures 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 illustrates a high pressure fuel pump 100 comprising a housing 102 and a front plate 112. A driveshaft assembly 2 is arranged for rotation within a bore provided in the housing 102 and front plate 112.

The driveshaft assembly 2 comprises a shaft 4, a cam lobe 6 and a thrust washer 8. During a pumping cycle, the driveshaft assembly 2 is caused, by a driving mechanism (not shown), to rotate relative to the housing 102 and front plate 112, around a longitudinal axis A, and in a direction indicated by arrow X in Figure 1. Rotation of the driveshaft assembly 2 causes a reciprocating force to be imparted to a plunger 106, via a roller 108, thereby causing fuel within a pumping chamber 110 to become pressurised.

Figures 2 to 5 illustrate the driveshaft assembly 2 in isolation. The shaft 4 comprises, towards a first end 24, a front journal portion 10, and towards a second end 26, a rear journal portion 12. Between the front journal portion 10 and the rear journal portion 12 is provided a first mid-portion 14, and a second mid-portion 16, which is of a greater cross-sectional diameter than the first mid-portion

14 (the boundaries of the first mid-portion 14 and second mid-portion 16 are indicated by dashed lines on Figure 2). The cam lobe 6 is fitted onto the first mid-portion 14 of the shaft 4, and the thrust washer 8 is fitted onto the second mid-portion 16 of the shaft 4, as described in greater detail below.

The cam lobe 6 is formed of a high grade, relatively hard material, such as a steel, or steel alloy such as M50 (EN ISO 4957 HSP-4-1). The shaft 4 and the thrust washer 8 are formed of materials having a relatively reduced hardness, which are of a lower cost than the cam lobe 6. An example material for the shaft 4 and thrust washer 8 could be 16MnCrS5 or a mild steel such as EN 10277-3 46S2.

The thrust washer 8 is provided with a through bore 28 of diameter D1. Similarly, the cam lobe 6 is provided with a through bore 30 of diameter D2. (Bores 28 and 30, and diameters D1 and D2 are indicated on Figures 4 and 5).

During rotation of the driveshaft assembly 2 within the bore of the pump 100, the thrust washer 8 allows axial loading by the front plate 112, via a thrust surface 20 of the thrust washer 8. Axial loading may be due to either internal forces encountered within the high pressure fuel pump 100, or external forces due to the drive mechanism.

Assembly of the driveshaft assembly 2 by a method comprising temperature controlled processes will be described below.

In a first set of method steps, the thrust washer 8 is located in a fixture (not shown) and heated, thereby causing the diameter of the through bore 28 of the thrust washer 8 to be increased to a value greater than D1.

The heated thrust washer 8 is then fitted onto the shaft 4, from either the first end 24 or the second end 26 of the shaft 4, to be located over the second mid-portion 16 of the shaft 4.

Fitting of the thrust washer 8 onto the second mid-portion 16 of the shaft 4 is enabled by the increased diameter of the through bore 28 of the thrust washer 8 in the heated condition.

The temperature of the thrust washer 8 is subsequently allowed to decrease, until it equalises with the temperature of the shaft 4. As the temperature of the thrust washer 8 decreases, the diameter of the thrust washer bore 28 decreases, to D1.

An external diameter of the second mid-portion 16 of the shaft 4 is selected such that the thrust washer 8, once fitted and cooled to the temperature of the shaft 4, is located by an interference fit on the shaft 4, i.e. an internal surface 36 defining the bore 28 of the thrust washer 8 is an interference fit on an outer surface 42 of the second mid-portion 16 of the shaft 4 (surfaces 36 and 42 are indicated on Figures 4 and 5). Relative movement of the thrust washer 8 on the shaft 4 during use of the pump 100 is thereby prevented by the interference fit between the surfaces 36, 42.

After the thrust washer 8 has been assembled onto the shaft 4, and in a second set of method steps, the cam lobe 6 is heated, thereby causing the diameter of the through bore 30 of the cam lobe 6 to be increased to a value greater than D2. The heated cam lobe 6 is then inserted into the shaft via the second end 26 of the shaft 4, over the rear journal portion 12, until it is located over the first mid-portion 16. A shoulder 34 formed by the junction of the first mid-portion 14 and the second mid-portion 16 acts as a stop for the cam lobe 6 thereby aiding assembly of the cam lobe 6 onto the shaft 4.

Fitting of the cam lobe 6 onto the first mid-portion 14 of the shaft 4 is enabled by the increased diameter of the through bore 30 of the cam lobe 6 in the heated condition.

The cam lobe 6 is subsequently allowed to decrease in temperature, until it equalises with that of the shaft 4. As the temperature of the cam lobe 6 decreases, the diameter of the through bore 30 decreases, to D2.

An external diameter of the first mid-portion 14 of the shaft 4 is selected such that the cam lobe 6, once fitted and cooled to the temperature of the shaft 4, is located by an interference fit on the first mid-portion 14 of the shaft 4, i.e. an internal surface 38 defining the bore 30 of the cam lobe 6 is an interference fit on an outer surface 40 of the first mid-portion 14 of the shaft 4 (surfaces 38, 40 are indicated on Figures 4 and 5). Relative movement of the cam lobe 6 on the shaft 4 during use of the pump 100 is thereby prevented by the interference fit.

Due to the interference fits between cam lobe 6 and the thrust washer 8 on the shaft 4, the cam lobe 6 and thrust washer 4 also cannot move relative to one another during use of the pump 100.

After assembly of the driveshaft assembly 2, a contact face 50 (indicated on Figure 5) of the cam lobe 6 is in contact with a contact portion comprising part of surface 52 (indicated on Figure 4) of the thrust washer 8.

During assembly, an adhesive may be applied to the contact face 50 of the cam lobe 6 and/or contact portion of surface 52 of the thrust washer 8, thereby to bond the cam lobe 6 and the thrust washer 8 to one another, thereby further ensuring that the cam lobe 6 and the thrust washer 8 cannot move relative to one another during use of the pump 100.

In an alternative method in accordance with the present invention, instead of or in addition to the heating of the thrust washer 8 and the cam lobe 6 to enable assembly onto the shaft 4, the thrust washer 8 and/or the cam lobe 6 may be assembled onto the shaft 4 by press or force-fitting, laser welding, cold welding or “drive dog” application By “drive dog” is meant a device used in a lathe (also referred to as a lathe carrier), which clamps the workpiece and allows rotary motion of the spindle of the machine to be transmitted to the workpiece.

A pin or extrusion could be provided on the thrust washer 8, which fits into a bore provided on the face 50 of the cam lobe 6, or vice versa. Relative movement between the thrust washer 8 and the cam lobe 6 is thereby prevented.

The thrust washer 8 of the present invention may be coated, for example on the thrust surface 20.

Although the rotational movement of the driveshaft assembly 2 in the Figures is indicated by arrow X to be in a clockwise direction, the present invention allows interchangeability between clockwise and counter-clockwise rotation, thereby providing flexibility in production.

In an alternative method in accordance with the present invention, the cam lobe 6 is heated and assembled onto the shaft 4 before the thrust washer 8 is heated and assembled onto the shaft 4.

Although the embodiment described above includes a single cam lobe 6, in alternative embodiments more than one cam lobe may be provided, each being assembled onto the shaft 4 by the method outlined above.

The present invention enables a more cost effective driveshaft assembly than prior art embodiments, by allowing a different materials to be used for each of the components. The cam lobe 6 can be produced from a high grade material, which has sufficient hardness and strength to be able to withstand high forces and stresses, whilst the shaft 4 and thrust washer 8, which are not subject to forces and stresses of the same magnitude as the cam lobe 6, can be formed of less expensive materials having a relatively lower hardness.

The manufacturing cost of a driveshaft assembly 2 in accordance with the present invention can therefore be significantly lower than prior art embodiments.

REFERENCES

driveshaft assembly 2

shaft 4

cam lobe 6

thrust washer 8

front journal portion 10

rear journal portion 12

shaft first mid-portion 14

shaft second mid-portion 16

thrust washer thrust surface 20

shaft first end 24

shaft second end 26

thrust washer through bore 28

cam lobe through bore 30

(junction) shoulder 34

thrust washer bore internal surface 36

cam lobe bore internal surface 38

first mid-portion outer surface 40

second mid-portion outer surface 42

cam lobe contact surface 50

thrust washer surface 52

pump 100

pump housing 102

plunger 106

roller 108

pumping chamber 110

pump front plate 112

longitudinal axis A

rotation direction X

thrust washer through bore diameter D1

cam lobe through bore diameter D2

CLAIMS

1. A driveshaft assembly (2) for a high pressure fuel pump (100), the driveshaft assembly (2) comprising a shaft (4), at least one cam lobe (6) located on a first mid-portion (14) of the shaft (4), and a thrust washer (8) located on a second mid-portion (16) of the shaft (4);

wherein the shaft (4), the or each cam lobe (6), and the thrust washer (8) are separate components;

characterised in that the or each cam lobe (6) is an interference fit on the first mid-portion (14) of the shaft (4) and wherein the thrust washer (8) is an interference fit on the second mid-portion (16) of the shaft (4).

2. A driveshaft assembly (2) as claimed in claim 1 wherein a thrust face (20) of the thrust washer (8), remote from the or each cam lobe (6), is coated.

3. A driveshaft assembly (2) as claimed in any one of the preceding claims wherein the thrust washer (8) and the cam lobe (6) are bonded to each other.

4. A pump (100) for a high pressure fuel system comprising a driveshaft assembly (2) as claimed in any of the preceding claims, the pump (100) comprising a housing (102) and a front plate (112) wherein the driveshaft assembly (2) is rotatable along a longitudinal axis (A) of the driveshaft assembly (2) within a bore provided in the housing (102) and the front plate (112).

5. A pump (100) according to claim 4 wherein the driveshaft assembly (2) is rotatable along the longitudinal axis (A) of the driveshaft assembly (2) within the bore provided in the housing (102) and the front plate (112), in a clockwise direction.

6. A pump (100) according to claim 4 wherein the driveshaft assembly (2) is rotatable along the longitudinal axis (A) of the driveshaft assembly (2) within the bore provided in the housing (102) and the front plate (112), in a counter-clockwise direction.

7. A method of assembling a driveshaft assembly (2) as claimed in any one of claims 1 to 4, the method comprising steps of assembling the thrust washer (8) onto the second mid-portion (16) of the shaft (4) and assembling the cam lobe (6) onto the first mid-portion (14) of the shaft (4).

8. A method as claimed in claim 7 wherein the thrust washer (8) and the cam lobe (6) are assembled onto the shaft (4) by at least one of press or force-fitting, laser welding, cold welding and drive dog application.

9. A method claimed in claim 7 comprising a first set of method steps of:

heating the thrust washer (8) to expand a diameter (D1) of a through bore (28) of the thrust washer (8);

assembling the thrust washer (8) onto the shaft (4) and locating the thrust washer (8) over the second mid-portion (16) of the shaft (4);

and

allowing the thrust washer (8) to cool whereby the diameter (D1) of the through bore (28) of the thrust washer (8) reduces during cooling and whereby when cooled to a temperature of the shaft (4), the thrust washer (8) is an interference fit on the second mid-portion (16) of the shaft (4);

and a second set of method steps of:

heating the or each cam lobe (6) to expand a diameter (D2) of a through bore (30) of the or each cam lobe (6);

assembling the cam lobe (6) onto the shaft (4) and locating the cam lobe (6) over the first mid-portion (14) of the shaft (4);

and

allowing the cam lobe (6) to cool to a temperature of the shaft (4) whereby the diameter of through bore (30) of the or each cam lobe (6) reduces during cooling and whereby when cooled to a temperature of the shaft (4), the or each cam lobe (6) is an interference fit on the first mid-portion (14) of the shaft (4).

10. A method as claimed in claim 7 wherein the second set of method steps is undertaken prior to the first set of method steps.

11. A method as claimed in any one of claims 7 to 10 further comprising a step of coating a thrust surface (20) of the thrust washer (8).

13. A method as claimed in any one of claims 7 to 11 further comprising a step of applying an adhesive to a contact surface (50) of the cam lobe (6) which contacts a contact surface (52) of the thrust washer (8) after assembly of the driveshaft assembly (2), and/or applying an adhesive to the contact surface (52) of the thrust washer (8).

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Figure 1

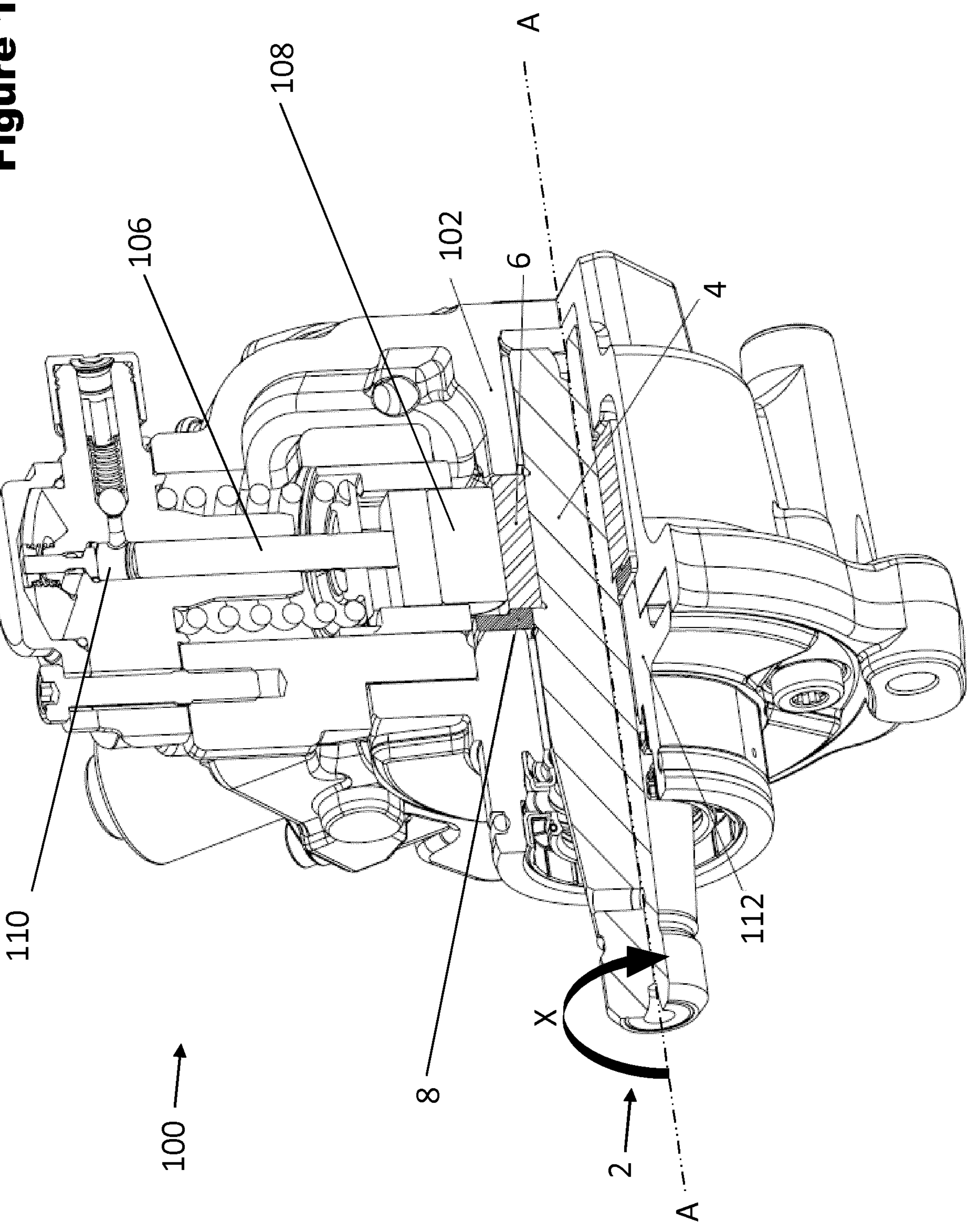


Figure 2

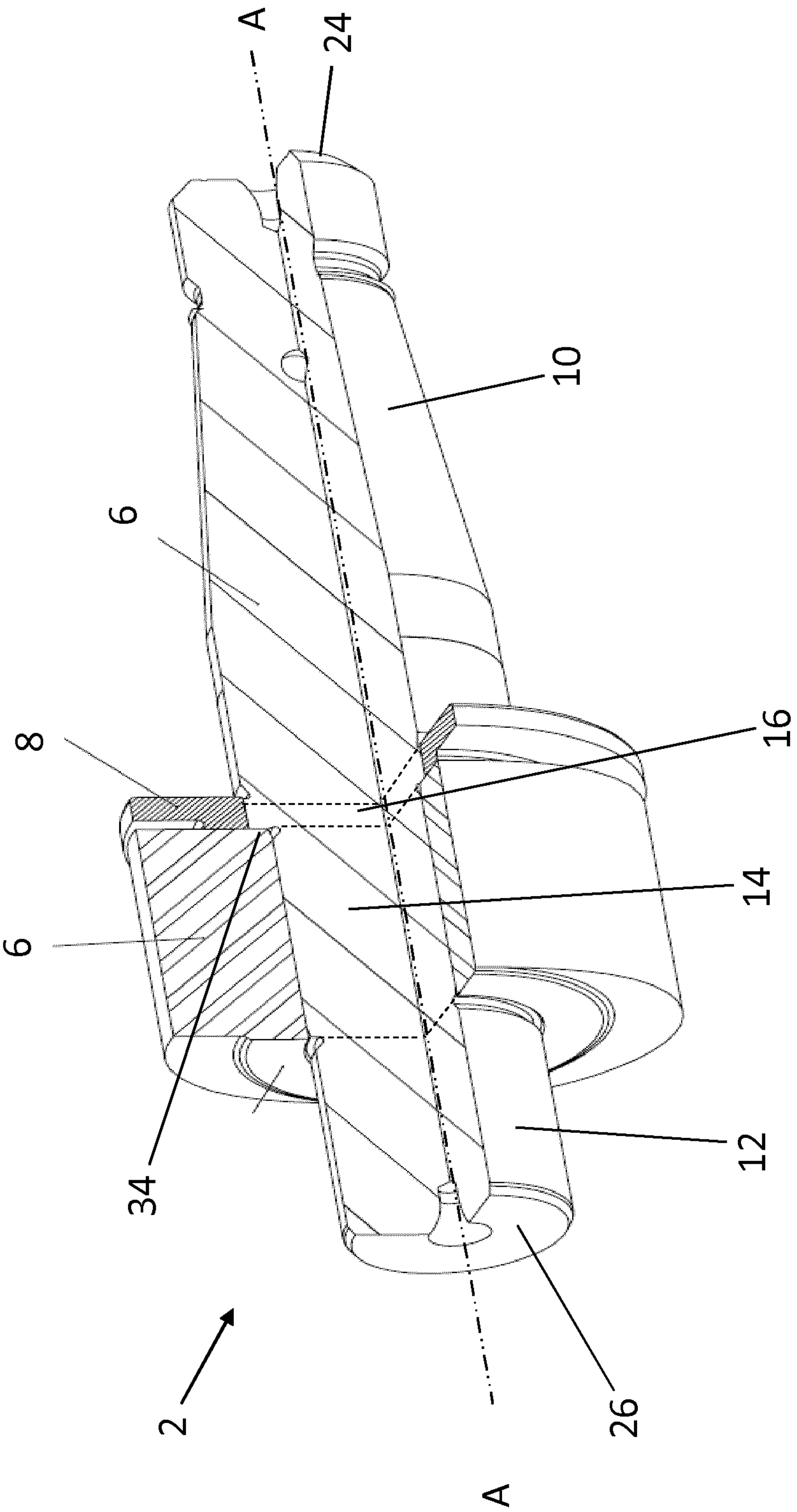


Figure 3

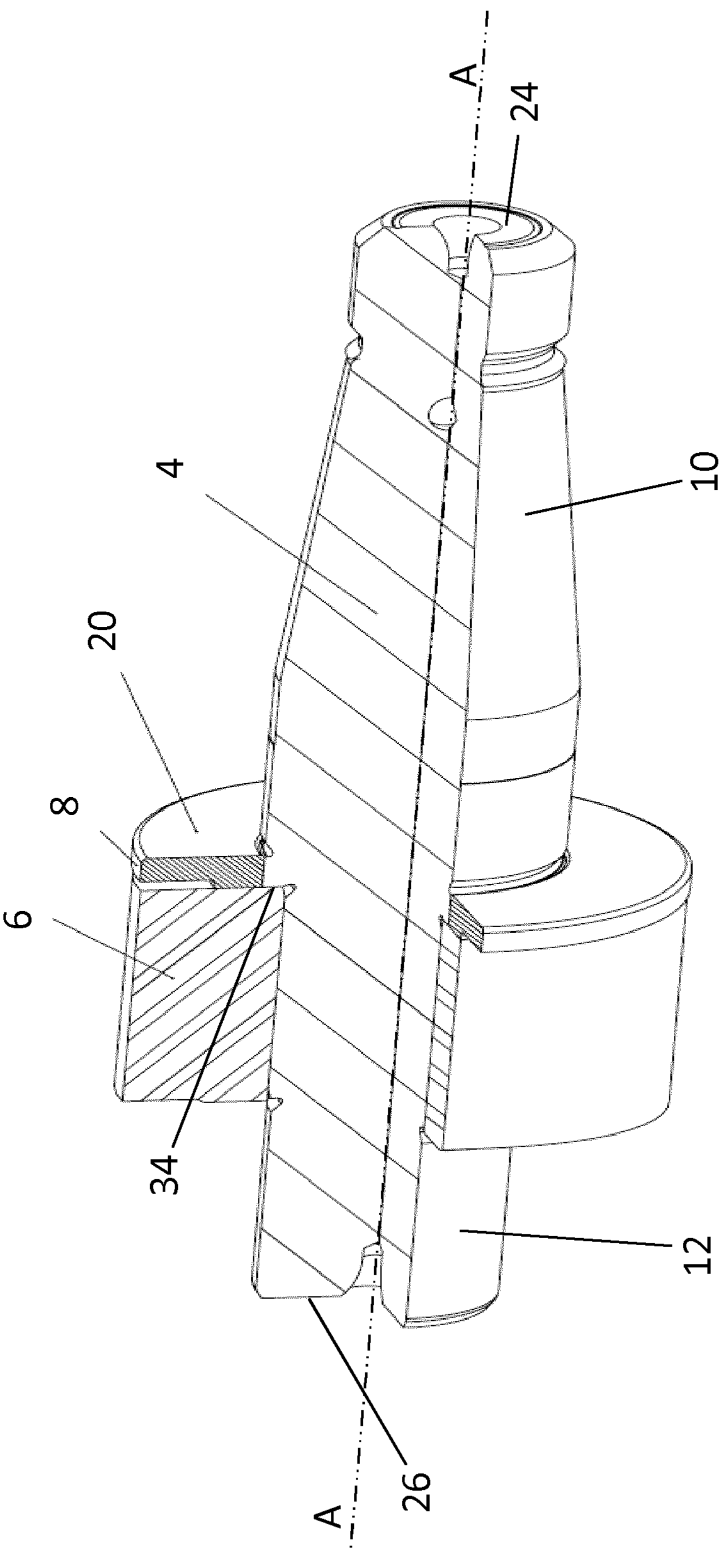


Figure 4

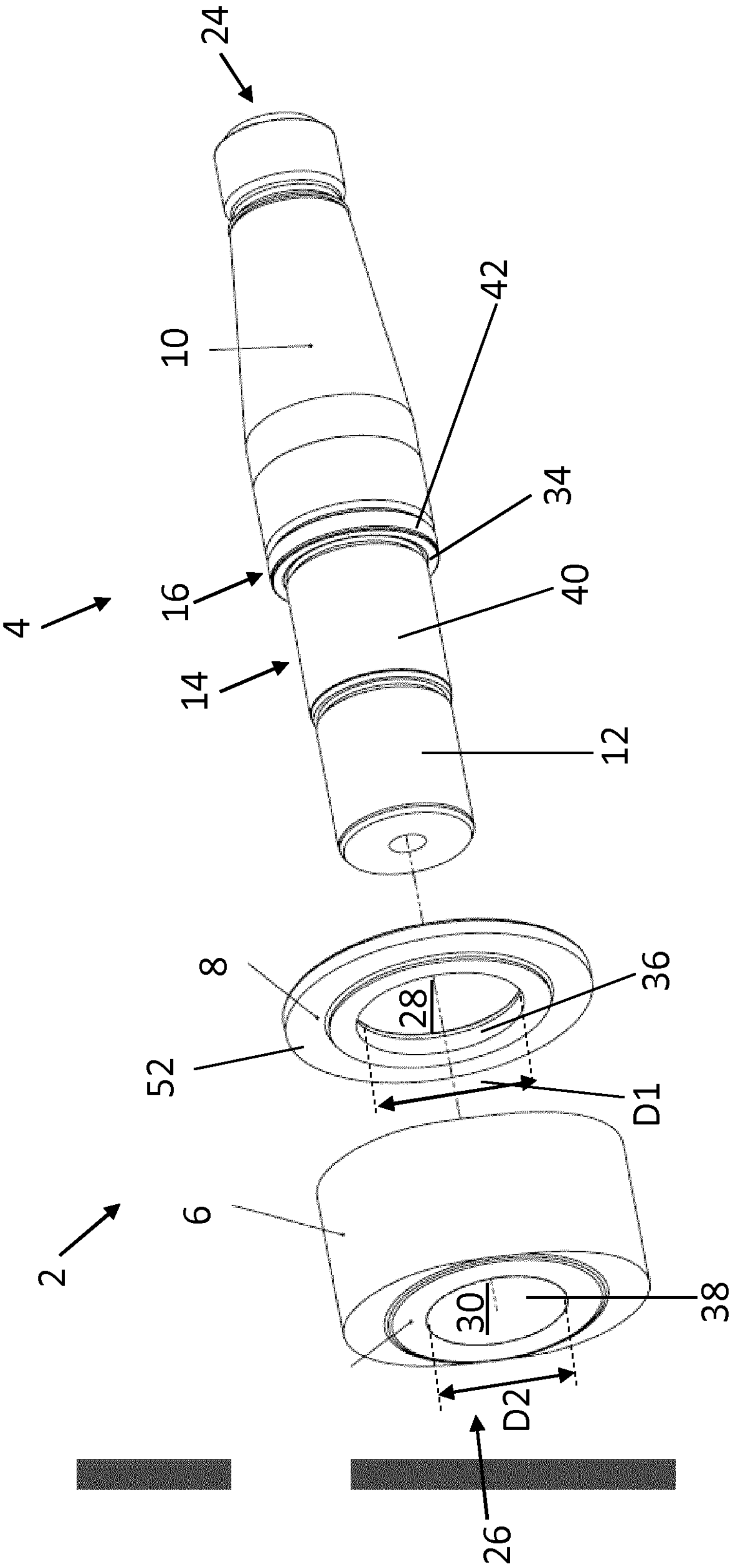
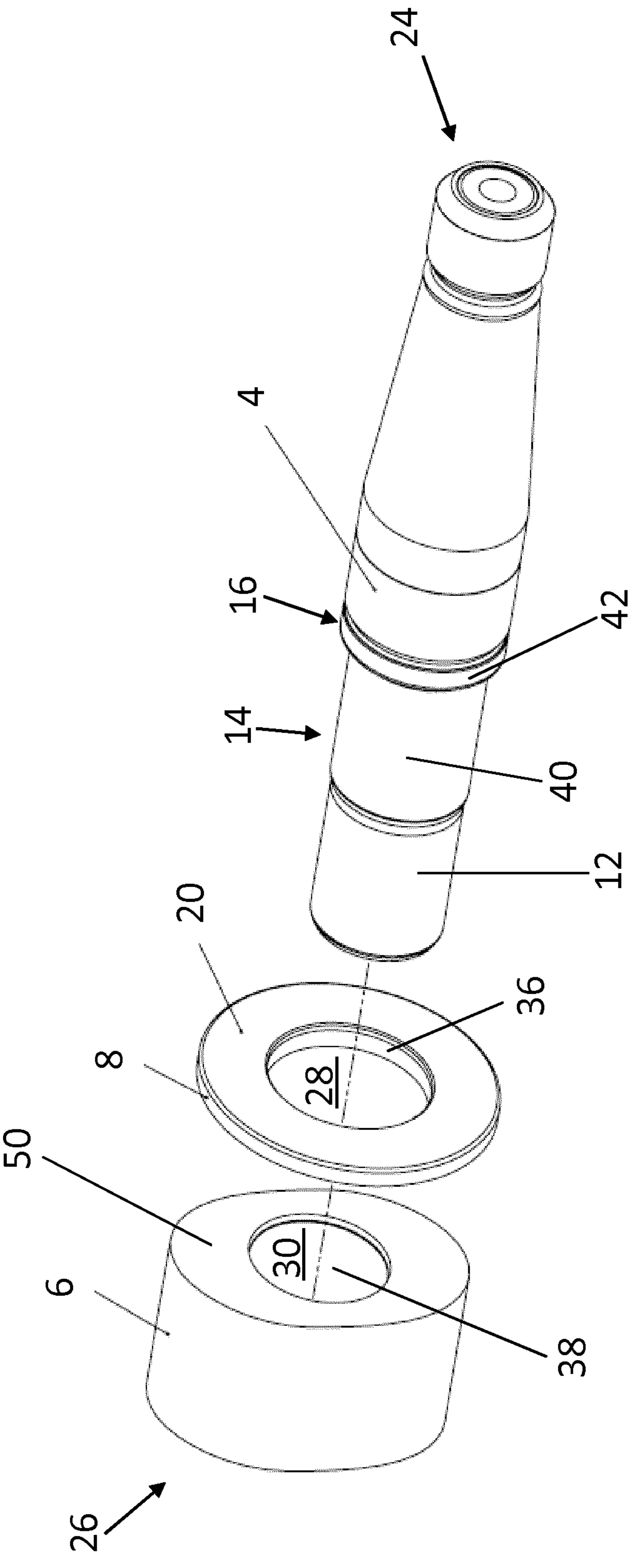


Figure 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/074713

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M59/10 F04B1/04 F02M59/44 F02M59/48 F04B9/04
F01L1/047
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)
F02M F04B F01L

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)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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International application No
PCT/EP2015/074713

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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