(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 234 356 B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
05.08.2020 Bulletin 2020/32

(21) Application number: **15784721.1**

(22) Date of filing: **26.10.2015**

(51) Int Cl.:
F04B 1/04 *(2020.01)* ***F02M 59/44*** *(2006.01)*
F04B 53/00 *(2006.01)* ***F04B 53/22*** *(2006.01)*

(86) International application number:
PCT/EP2015/074711

(87) International publication number:
WO 2016/096205 (23.06.2016 Gazette 2016/25)

(54) **FUEL PUMP ASSEMBLY**

BRENNSTOFFPUMPENANORDNUNG

ENSEMBLE POMPE À CARBURANT

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **17.12.2014 GB 201422470**

(43) Date of publication of application:
25.10.2017 Bulletin 2017/43

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(56) References cited:
DE-A1-102012 101 585 **JP-A- 2008 184 953**
US-A1- 2009 120 280

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Description

BACKGROUND

Technical Field

[0001] The present invention relates generally to the field of high pressure fuel pumps. More particularly, but not exclusively, the present invention concerns an improved drive assembly for a high pressure fuel pump.

Description of the Related Art

[0002] There is a continuous demand for high pressure fuel pumps to operate with greater fuel efficiency and yet remain efficient to package within an engine.

[0003] A conventional fuel pump assembly comprises both a low pressure transfer pump and a high pressure pump. The low pressure pump is responsible for transferring fuel from a fuel tank to the fuel pump assembly, whilst the high pressure pump elevates the fuel pressure for distribution to the rail or actuator volume. The rail distributes the fuel under continued high pressure to fuel injectors, which in turn delivers atomised fuel spray to the combustion chamber of the engine as described in JP2008184953 A.

[0004] High pressure fuel pumps are often of a slipper tappet design in which the drive assembly comprises a cam that is driven around an eccentric rotational path by a drive shaft. The cam carries a rider therearound, also driven around the same eccentric rotational path. The rider comprises a flat surface, which cooperates with a corresponding flat surface of a tappet. When the rider is driven around the rotational path, the flat surface remains in the same orientation whilst rising and falling generally following a pumping axis. The movement of the flat surface of the rider along the pumping axis guides the tappet in linear movement along the same pumping axis, such that as the rider flat surface rises in the direction of the tappet it pushes the tappet along the pumping axis, whilst sliding along the tappet flat surface until it reaches its highest point. Continuing along its path, the rider flat surface begins to fall and the tappet follows, until the rider flat surface reaches its lowest point. The cycle is repeated. The rising and falling of the tappet along the pumping axis translates into linear reciprocal movement of a pumping plunger within a pumping head.

[0005] A known dual-head slipper tappet arrangement exists where a drive assembly effects plunger movement of two separate pumping heads. The arrangement is known as a tower block arrangement, which comprises opposing pumping heads stacked at 180° to one another with the drive assembly between. In this case, the rider has a second flat surface opposite the first to cooperate with a second tappet to drive a second pumping plunger within a second pumping head.

[0006] However, the dual-head tower block arrangement is space inefficient and is difficult to package within a fuel pump assembly. This is an increasing problem since engine technology favours more compact engine components.

[0007] Therefore, one significant area for improvement is the packaging efficiency of the dual head fuel pump assembly and in particular the arrangement of the drive assembly and dual pumping heads within a high pressure fuel pump.

[0008] Within the roller-cam pump market, a V-head arrangement has been developed in which the dual pumping heads are organised at 90° to one another. However, this brings with it issues of increased load on the support bearings of the drive shaft and in addressing those issues, problems with the proportions and assembly of both the drive shaft bearings and the rider.

[0009] It is an object of the present invention to address one or more of the problems of known designs, particularly, but not exclusively for dual pumping head high pressure pumps.

[0010] Therefore, it is now desired to provide an improved drive assembly for a high pressure fuel pump that is capable of withstanding higher loads without compromising ease of assembly.

[0011] In particular, it is desired to provide a dual pumping head V-arrangement for slipper tappet pumps, which also provides effective packaging options and is space-efficient.

SUMMARY OF THE INVENTION

[0012] In a first aspect of the present invention there is provided a high pressure fuel pump as claimed in claim 1, comprising at least one pumping head and an improved drive assembly, the drive assembly comprising a drive means and a drive shaft comprising a rider journal adjoined to a rear bearing, the journal and the bearing comprising offset axes relative to one another, a rider fitted on said drive shaft to effect movement of the rider along an eccentric rotational path, the rider comprising a body with an open-ended aperture therethrough, a load section the circumference of the aperture and an idle section disposed around a second portion of the circumference of the aperture, and wherein the load section of the rider comprises at least one outwardly facing flat surface for cooperation with a tappet, wherein the drive shaft comprises an enlarged rear bearing with a reduced-depth section at a bearing-journal junction, and the idle section of the rider comprises a reduced-width portion.

[0013] By 'enlarged rear bearing' what is meant is an increase in the diameter of the rear bearing up to and including the diameter of the rider journal, whilst retaining the offset axes.

[0014] By 'reduced-depth section' what is meant is a reduction in the diameter of the enlarged rear bearing immediately adjacent the bearing-journal junction.

[0015] By 'reduced-width portion' what is meant is a reduction in the width of the body forming part of the idle section relative to the load section.

[0016] With this arrangement, the enlarged rear bearing provides strength and durability to the drive shaft to cope with a higher load capacity, which may be required as a result of, for example, two pumping heads in a V-arrangement, whereas the reduced-depth section of the enlarged rear bearing facilitates the transition of the rider from the rear bearing to the rider journal. In addition, the reduced-width portion of the idle section of the rider minimises the need for an increase in the rear overall shaft length. Accordingly, despite the larger rear bearing, the adaptations to the drive assembly effect easy construction and a more compact arrangement for the optional two pumping heads within the high pressure fuel pump.

[0017] The offset axes and the enlarged rear bearing create a bearing overhang and a journal overhang at the bearing-journal junction. Preferably, the overhangs are arranged at diametrically-opposite sides of a bearing-journal overlapping area. Preferably therefore, a diameter of the aperture of the rider is shorter than a maximum dimension incorporating the overlapping area and the overhangs (between a bottom of the enlarged rear bearing and a top of the rider journal).

[0018] Preferably, each overhang comprises an exposed crescent-shaped face. The overhangs may vary in depth, or may be equal in depth.

[0019] Preferably, each overhang comprises an exposed crescent-shaped face. The overhangs may vary in depth, or may be equal in depth.

[0020] Preferably, the reduced-depth section of the enlarged rear bearing negates (removes) at least a portion of the bearing overhang. Preferably, the reduced-depth section of the enlarged rear bearing negates (removes) substantially all of the bearing overhang.

[0021] Preferably, the reduced-depth section of the enlarged rear bearing comprises a removed segment of the enlarged rear bearing. Most preferably, the reduced-depth section of the enlarged rear bearing comprises a removed crescent-shaped segment of the enlarged rear bearing.

[0022] Preferably therefore, the reduced-depth section comprises an outer edge curvature that matches an outer edge curvature of the rider journal. Preferably therefore, the outer edge curvature of the reduced-depth section continues the adjacent outer edge curvature of the rider journal.

[0023] Preferably, the reduced-depth section is effected by an inward step provided on the bearing overhang. Preferably, the step creates a substantially crescent-shaped face on the enlarged rear bearing.

[0024] Preferably, the bearing overhang is located on an underside of the drive shaft. Preferably, the journal overhang is located on an upper side of the drive shaft. Alternatively, the bearing overhang may be located on a side of the drive shaft, with the journal overhang located on an opposing side of the drive shaft.

[0025] Preferably, the reduced-depth section comprises a short transitional portion wherein the underside thereof is shaped to match and align with the underside profile of the adjacent rider journal, whilst the upperside thereof is a continuation of the profile of the rear bearing.

[0026] The reduced-depth section provides a stepped transition area where the maximum dimension is reduced and can be accommodated by the rider aperture.

[0027] The rear journal, rear bearing and reduced-depth section may be integrally formed as part of the shaft.

[0028] In an alternative arrangement, the rear bearing and the rider journal may be separately formed. The rear bearing and the rider journal may provide cooperating flanges with mating surfaces. The journal may comprise an upwardly facing flange and the rear bearing may comprise a downwardly facing mating surface on the rear bearing. Accordingly, each mating surface may be formed by cutting away a segment of both the journal and the bearing. Preferably, a shallower segment is cut from an underside of the bearing and a deeper segment is cut from an upperside of the journal. The non-mating surfaces of the flanges preferably provide a continuation of the curved outer profile of the respective parent part (rider journal or rear bearing), so as to provide a seamless transition between the rear journal and the reduced-depth section of the rear bearing.

[0029] With the above arrangement, the aperture of the rider can pass over the enlarged rear bearing in an axial direction and upon reaching the reduced-depth can then move passed the step and upwardly to breach the offset between the rear bearing and the rider journal. Accordingly, the reduced-depth provides an opportunity for the aperture to be shifted to accommodate diameter of the rider journal, before the rider continues over the rider journal in an axial direction.

[0030] Preferably, the length of the reduced-depth section is equal to or greater than a width of the rider. Preferably, the length of the reduced-depth is equal to or greater than the width of the idle section. Preferably, the length of the reduced-depth is equal to or greater than the reduced-width portion of the idle section.

[0031] Preferably, the enlarged rear bearing may comprise an increase in length in addition to the increase in diameter. The increase in length may comprise the length of the reduced-depth section.

[0032] Preferably, the reduced-width portion comprises a removed section of the idle section of the rider. Preferably, the reduced-width portion encompasses substantially all of the idle section.

[0033] Preferably, the body of the rider comprises first and second sides. Preferably, the first side comprises a leading side (passes onto the shaft forwardly and first). Preferably, the second side comprises a following side (passes onto the rearwardly and lastly). Preferably, the reduced-width portion is effected by an inward step provided in the first side. Preferably, the step creates an outcrop between the load section and the idle section.

[0034] Preferably, the idle section and the outcrop are located on an underside of the rider. Alternatively, the idle section and the outcrop may be located on a side of the rider.

[0035] The reduced-width portion provides a stepped transition for cooperation with the reduced-depth portion of the bearing.

[0036] Preferably, the reduced-width portion of the idle section comprises approximately 50% of the width of the load section. The idle section may, however, comprise between 30% and 70% of the width of the load section.

[0037] Preferably, the reduced-depth section of the bearing and the reduced-width section of the rider extend over approximately equal circumferential distances, although the reduced-width section of the rider may be extend over a greater circumferential distance than the reduced-depth section of the bearing.

[0038] Preferably, the load section of the rider occupy approximately an upper two thirds of the rider. The idle section may therefore, occupy approximately a lower third of the rider.

[0039] Preferably, therefore, the load section extends around between approximately 50% and approximately 80% of the circumference of the aperture. Accordingly, the idle section may extend around between approximately 20% and approximately 50% of the circumference of the aperture.

[0040] Preferably, the aperture is substantially circular in cross-section to mirror the circular cross-section of the rider journal and preferably, the rear bearing also.

[0041] Preferably, the improved drive assembly is constructed to drive two pumping heads. Preferably therefore, the load section of the rider comprises two outwardly facing flat surfaces disposed at approximately 90° to one another for contact with respective first and second tappets. Preferably, therefore, the pump comprises first and second pumping heads, which are preferably disposed at approximately 90° to one another. With this arrangement, the alternate orientation of the flat surfaces on the rider allows for a cambox of reduced size and a V-arrangement for the two pumping heads, making the whole pump more space efficient and easier to accommodate.

[0042] Preferably, the two outwardly facing flat surfaces comprise substantially all of the load section. Preferably, the two flat surfaces are approximately equal in size. Preferably, the load section adopts an external cross-sectional shape of a triangle. Accordingly, the depth of the body of the load section preferably varies as a result of the circular aperture.

[0043] Preferably, the load section comprises a short substantially flat surface at the junction between the two flat surfaces. Preferably therefore, the load section comprises a blunted apex.

[0044] Preferably, the idle section comprises a substantially arced cross-sectional shape. Preferably, therefore, in cross-section the body of the rider comprises a generally triangular shape with a shallow convex base.

[0045] Preferably, the aperture is disposed centrally through the body on a vertical axis of the body (between the apex of the triangle and the base). Preferably, the aperture is biased towards the convex base of the body. Preferably, therefore, the depth of the body of the idle section gradually narrows towards the middle of the convex base.

[0046] With this arrangement, the load bearing flat surfaces are thicker than the idle (non-load-bearing) surface, which extends the lifetime of the rider.

[0047] The drive shaft preferably comprises first and second ends. The first end preferably comprises the rear bearing and the second end comprises a front journal. The rider journal may be disposed between the rear bearing and the front journal. Preferably, a rider abutment is provided between the rider journal and the front journal. The front journal may be disposed on the same axis as the rear bearing.

[0048] In a second aspect of the present invention there is provided a high pressure fuel pump comprising at least one pumping head and an improved drive assembly, the drive assembly comprising a drive means and a drive shaft comprising a rider journal adjoined to a rear bearing, the journal and the bearing comprising offset axes relative to one another, a rider fitted on said drive shaft to effect movement of the rider along an eccentric rotational path, the rider comprising a body with an open-ended aperture therethrough, a load section disposed around a first portion of the circumference of the aperture and an idle section disposed around a second portion of the circumference of the aperture, and wherein the load section of the rider comprises at least one outwardly facing flat surface, characterised in that the drive shaft comprises an enlarged rear bearing with a reduced-depth section at a bearing-journal junction.

[0049] Preferably, the idle section comprises a reduced-width portion.

[0050] It will be appreciated that the preferred features described in relation to the first aspect of the invention also apply to the second aspect of the invention.

[0051] In a third aspect of the present invention there is provided an improved drive assembly for a high pressure fuel pump comprising at least one pumping head, the improved drive assembly comprising a drive means and a drive shaft comprising a rider journal adjoined to a rear bearing, the journal and the bearing comprising offset axes relative to one another, a rider fitted on said drive shaft to effect movement of the rider along an eccentric rotational path, the rider comprising a body with an open-ended aperture therethrough, a load section disposed around a first portion of the circumference of the aperture and an idle section disposed around a second portion of the circumference of the aperture, and wherein the load section of the rider comprises at least one outwardly facing flat surface for cooperation with a tappet, characterised in that the drive shaft comprises an enlarged rear bearing with a reduced-depth section at a bearing-journal junction.

[0052] Preferably, the idle section comprises a reduced-width portion.

[0053] It will be appreciated that the preferred features described in relation to the first aspect of the invention also apply to the third aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0054] For a better understanding of the invention, and to show how exemplary embodiments may be carried into effect, reference will now be made to the accompanying drawings in which:

Figure 1 is a schematic cross-sectional view of the components of a high pressure fuel pump according to the invention;

Figure 2 is a perspective view of an assembled drive shaft and rider arrangement of an improved drive assembly as used in the invention of Figure 1;

Figure 3 is a perspective view of the rider of Figure 2;

Figure 4 is a cross-sectional side view of the drive shaft of Figure 2;

Figure 5 is a perspective view of the drive shaft of Figure 2;

Figures 6a - e are schematic side views of the assembly of the rider on the drive shaft.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0055] As shown in Figure 1, an embodiment of the invention is shown. A high pressure fuel pump (not shown) comprises at least one pumping head 10, 20 and an improved drive assembly 30, the drive assembly 30 comprising a drive means (not shown), a drive shaft 40 comprising a rider journal 46 adjoined to a rear bearing 42, the journal 46 and the bearing 42 comprising offset axes C-C', D-D' relative to one another, a rider 50 fitted on said drive shaft 40 to effect movement of the rider 50 along an eccentric rotational path, the rider 50 comprising a body 51 with an open-ended aperture 52 therethrough, a load section 55 disposed around a first portion of the circumference of the aperture 52 and an idle section 58 disposed around a second portion of the aperture 52, and wherein the load section 55 of the rider comprises at least one outwardly facing flat surface 56, 57 for co-operation with a tappet, characterised in that the drive shaft 40 comprises an enlarged rear bearing 42 with a reduced-depth section 45 at a bearing-journal junction, and the idle section 58 of the rider comprises a reduced-width portion 59.

[0056] As can be seen in Figures 2 and 5, the drive shaft 40 comprises a substantially elongate cylindrical body 41 with a first end 41a and a second end 41b.

[0057] As can be seen more clearly in Figure 4, the rear bearing 42 is located at the first end 41a of the shaft 40, comprises a diameter X and sits on main axis C-C'. Following the rear bearing 42 is the rider journal 46 comprising a diameter Y, which is parallel with the diameter X. The rider journal 46 sits centrally on alternate axis D-D', which is parallel with the main axis C-C'. In the described embodiment, the axis D-D' of the journal 46 is located directly above axis C-C' of the bearing 42.

[0058] Following the rear journal 46 is an abutment 47 in the form of a disc, which is co-axial with the rear bearing 42 and the axis C-C'. Extending from the abutment 47 to the second end 41b is a front journal 49, which is also co-axial with the rear bearing 42 and the axis C-C'. The front journal 49 comprises a diameter Z approximately equivalent to that of the rear bearing 42 as it extends from the abutment 47, but gradually narrows towards the second end 41b. The second end 41b is attached to a drive means (not shown) via a thread that allows a sprocket to be tightened against the taper and dictates the rotational path of the drive shaft 40 and therefore, the rotational path of the rider 50 fitted thereon.

[0059] The drive shaft 40 generally differs in diameter X, Y, Z along its length, in addition to comprising the at least two longitudinal axes C-C', D-D', which are offset from one another. It is to be appreciated that although the rider journal 46 is shown to be disposed on the alternative axis D-D' located upwardly of the main axis C-C', in an alternative arrangement, it is possible for the alternative axis D-D' to be located sidewardly of the main axis C-C'. It is the rider journal 46 that is offset relative to the coaxial components of the drive shaft 40 (the rear beating 42, front journal 49 and the abutment 47).

[0060] The enlarged rear bearing 42 comprises an increased diameter X when compared with the prior art, up to and including the diameter Y of the rider journal 46. In the described embodiment, the rear bearing diameter X and the front journal diameter Z are both approximately 25 mm, whereas the rider journal diameter Y is approximately 29 mm. However, the diameter X of the rear bearing 42 can be increased up to 29 mm before the rider journal 46 limits further upsize (the diameter X of the rear bearing 42 cannot exceed the diameter Y of the rider journal 46, or retention of the rider 50 on the rider journal 46 would prove difficult).

[0061] The extent of the offset D1 between the axes C-C', D-D' and the diameters X, Y of the rear bearing 42 and the rider journal 46 dictate the maximum distance D2 spanned by the rear bearing 42 and the rider journal 46.

[0062] In the embodiment comprising the above diameters X = 25 mm, Y = 29 mm, the offset D1 between the axes C-C', D-D' shown is approximately 10.5 mm. Accordingly, the maximum distance D2 spanned by the rear bearing 42 and the rider journal 46 comprises 35.5 mm. If a rider 50 is to fit snugly on the rider journal 46, the aperture 52 of the rider 50 should not greatly exceed that of the rider journal 46, except for a clearance tolerance and so, the maximum distance D2 created is not breachable by the rider 50 during assembly.

[0063] Due to the enlarged rear bearing diameter X, the offset D1 creates a journal overhang 43 and a bearing overhang 44. Due to the cylindrical nature of the bearing 42 and the journal 46, each overhang 43, 44 presents a crescent-shaped face. At their widest points, the rear bearing overhang comprises a distance D3 and the rider journal overhang 44 comprises a distance D4. Since the axes C-C', D-D' are only offset in one plane, the overhangs 43, 44 and located on parallel diameter lines.

[0064] Again, in the embodiment comprising the above diameters X = 25 mm, Y = 29 mm, the journal overhang 43 distance D3 = 10.5 mm, whereas the bearing overhang 44 distance D4 = 6.5 mm. Accordingly, a rider 50 with an aperture of approximately 29 mm would need to breach the distance D4 of approximately 6.5 mm in order to be positioned to accommodate the rider journal 46 diameter Y. However, it is to be appreciated, that any bearing overhang 44 would prevent a rider 50 from being assembled on the rider journal 46.

[0065] Accordingly, the reduced-depth section 45 of the enlarged rear bearing 42 removes or substantially negates the overhang 44.

[0066] In order to ensure a smooth transition and retain the cylindrical nature of the shaft 40, the reduced-depth section 45 is achieved by causing the rear bearing 42 to adopt the cylindrical profile (curvature) of the rider journal 46 in the section 45, in the region of the overhang 44.

[0067] In one embodiment of the invention, the shaft 40 is formed as a single part and so, this is accounted for in the machining of the shaft 40, by essentially removing a crescent shaped part (the overhang 43) from the rear bearing 42 in the section 45.

[0068] In an alternative embodiment as shown in Figure 5, the rear bearing 42 may be formed separately from the rider journal 46, in which case each of the rear bearing 42 and the rider journal 46 are provided with cooperating flanges 46a, 42a, by removing a segment of each cylindrical body. The flange 46a of the rider journal 46 provides an upwardly facing mating surface for cooperation with a corresponding downwardly facing mating surface on the flange 42a of the rear bearing 42. On each flange 46a, 42a, the non-mating surfaces retain the cylindrical profile of the respective parent part (rider journal 46 or rear bearing 42). As shown, a larger segment is cut from the journal 46, to leave a relatively shallow flange, whereas a smaller segment is cut from the bearing 42, to leave a relatively deep flange. When the flanges 42a, 46a are brought together, the lower profile of the reduced-depth section 45 is dictated by the non-mating profile of the journal 46, whilst the upper profile is dictated by the non-mating profile of the bearing 42. This provides a seamless transition between the rear journal 46 and the rear bearing 42 in the reduced-depth section 45.

[0069] In order to accommodate the reduced-depth section 45, the enlarged rear bearing 42 comprises an increased length when compared with the prior art. This can introduce a point of weakness into the shaft 40.

[0070] The length of the reduced-depth section 45 is dictated by the width of the part of the rider 50 that cooperates with the reduced-depth section 45. Since the reduced-depth section 45 removes the overhang 44 on the underside of the shaft 40, the relevant part of the rider 50 to accommodate is the idle section 58.

[0071] As shown in Figure 3, the body 51 of the rider 50 comprises a first side 51a and a second side 51b. The aperture 52, is open-ended on both sides 51a, 51b.

[0072] It is to be appreciated that the rider 50 shown in the Figures and described below is adapted specifically to accommodate for a high pressure fuel pump comprising two pumping heads 10, 20 disposed at an angle of, say between 45° and 135° to one another. However, the rider 50 may be provided with a single flat surface on the load section 55 in a single pumping head arrangement.

[0073] The body 51 comprises a generally triangular cross-section with a shallow convex base. The triangular cross-section comprises approximately an upper two thirds of the body 51, whilst the concave base comprises approximately a lower third of the body 51.

[0074] The triangular section provides the two outwardly facing flat surfaces 56, 57 of the load section providing a preferred angle of approximately 90° therebetween. The surfaces 56, 57 are approximately equal in size. Between the two faces 56, 57 there is provided a short substantially flat surface 55a.

[0075] The idle section 58 accommodates the convex base and is approximately half of the width (between sides 51a and 51b) of the load section 55. This is achieved by cutting away an equal width slice from the side 51a of the idle section 58, which leaves behind an inward step 60 on each side of the idle section 58 thereby clearly delineating between the wider load section 55 and the narrower idle section 58. By providing a reduced width in the idle section 58, the length of the corresponding reduced-depth section 45 of the rear bearing 42 need not be so long, thereby minimising any point of weakness and making the shaft 40 more space efficient.

[0076] The open-ended aperture 52 is substantially circular in cross-section and is sized to sit firmly on the rider journal 46. Ideally, the rider 50 is fitted with a low friction bearing. The aperture 52 is disposed centrally through the body 51 on a vertical axis of the body 51, but is biased towards the convex base of the body 51, such that the depth of the base reduces as it reaches a point opposite the apex (or flat surface 55a) of the load section 55. Accordingly, the depth of the body 51 of the idle section 58 significantly narrows towards the middle of the convex base.

[0077] The position of the aperture 52 allows for greater body depth 51 in the load section 55 where it is required and removes body 51 depth in the idle section, where it is less important.

[0078] Accordingly, the reduced-depth section 45 of the rear bearing 42 is approximately as long as (or greater than) the reduced-width portion of the idle section 58.

[0079] As shown in Figure 1, the improved drive assembly 30 can accommodate a high pressure fuel pump comprising a long sought-after slipper tappet design accommodating two pumping heads 10, 20 disposed at 90° to one another, which is more compact, space efficient and easier to accommodate. This V-design is achieved by providing the enlarged rear bearing 42, which imparts increased strength to the drive shaft 40 to cope with the higher load capacity. The inevitable issues of assembly of the rider 50 on the drive shaft 40 are addressed by adapting the rear bearing 42 to provide the reduced-depth section 45. Further potential issues regarding an unwanted increase in length of the drive shaft 40 and/or weakness in the drive shaft 40 are tackled by adapting the cooperating idle section 58 of the rider 50 to comprise a reduced-width portion. In combination, the two sections 45, 58 allow the rider 50 to traverse the increased dimension D1 created by the journal overhang 43 and the bearing overhang 44 - a direct result of the enlarged rear bearing 42 and the offset axes C-C', D-D'.

[0080] As shown in Figures 6A - 6E, the rider 50 is assembled on the shaft 40 by passing the aperture 52 of the rider 50 over the rear bearing 42 (Figure 6B) and into the reduced-depth section 45 (Figure 6C). At this point, the second side 51b of the rider body 51 is abutting the rider journal 46. The reduced- depth portion of the idle section 58 has passed entirely into the reduced-depth section 45, however, a trailing part of the load section 55 is still disposed across the rear bearing 42 beyond the reduced-depth section 45. In this position, since there is no upward barrier to the load section 58, which is resting atop the rear bearing 42, the rider 50 can be moved upwardly on the shaft 40 to breach the distance D3 until the rider aperture 52 is positioned coaxially with the rider journal 46 (Figure 6D). The rider 50 can then be slid transversely onto the rider journal 46.

[0081] In use, the improve drive assembly 30 provides options for a V-slipper tappet fuel assembly for a high pressure fuel pump.

[0082] In the fuel assembly, each pumping head 10, 20 comprises a pumping plunger 11, 21 for reciprocal linear movement along a pumping axis A-A', B-B'. The pumping axes A-A', B-B' are disposed at approximately 90° to one another. The reciprocal movement of each of the pumping heads 11, 12 is driven by its own respective tappet 35, 36, also driven in reciprocal linear movement along the respective axis A-A', B-B' of the appropriate pumping plunger 11, 12. Each tappet 35, 36 has sliding contact with one of the two outwardly facing flat surfaces 56, 57 of the rider 50, such that clockwise rotational movement of the rider 50 on the drive shaft 40 (effected by the drive means), guides the rising of the first tappet 35 along axis A-A', followed by rising of the second tappet 36 along axis B-B' simultaneous with falling of the first tappet 35, followed by falling of the second tappet 36. Accordingly, the rising and falling of the tappets 35, 36 effect rising of the first plunger 11 along axis A-A', followed by rising of the second plunger 12 along axis B-B' simultaneous with falling of the first plunger 11, followed by falling of the second plunger 12. It is to be appreciated that the overlapping of the rising and falling (pumping events) of each pumping head 10, 20, will change if the 90° angle between the pumping heads 10, 20 is altered.

[0083] With this arrangement, the enlarged rear bearing 42 provides strength and durability to the drive shaft 40 to cope with a higher load capacity required as a result of the two pumping heads 10, 20.

[0084] The rider 50 has been adapted for ease of assembly despite the larger rear bearing 42 and to effect a more compact arrangement for the two pumping heads 10, 20 within the high pressure fuel pump. In particular, the alternate orientation of the flat surfaces 56, 57 on the rider 50 allows for a cambox of reduced size and a V-arrangement for the two pumping heads 10, 20, making the whole pump more space efficient and easier to accommodate.

[0085] A rider 50 sized typically for a 14 mm stroke, therefore, weighs approximately 80 g, producing a centrifugal force of approximately 25N at 2000 rpm, 99N at 4000 rpm and 222N at 6000 rpm. Each of these forces are significantly less than the expected 320N produced by a tappet return spring of a single head), providing a good margin of safety with regard to maintaining contact between the rider (50) and the journal (46). The reduced-width portion of the idle section (58) also assists with bearing location and roundness.

[0086] The invention provides lifts restrictions on rear bearing diameter and there is a wide range of possible overhang dimensions available. Since the mass of the rider is reduced, there is greater freedom for cooling fuel flow over rider bearing areas.

[0087] Although a few preferred embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

Claims

1. A high pressure fuel pump comprising at least one pumping head (10, 20) and an improved drive assembly, the drive assembly comprising a drive means and a drive shaft (40) comprising a rider journal (46) adjoined to a rear bearing (42), the journal (46) and the bearing (42) comprising offset axes (C-C', D-D') relative to one another, a rider (50) fitted on said drive shaft (40) to effect movement of the rider (50) along an eccentric rotational path, the rider (50) comprising a body with an open-ended aperture (52) therethrough, a load section (55) disposed around a first portion of the circumference of the aperture (52) and an idle section (58) disposed around a second portion of the circumference of the aperture (52), and wherein the load section (55) of the rider (50) comprises at least one outwardly facing flat surface (56, 57) for cooperation with a tappet (35, 36), **characterised in that** the drive shaft (40) comprises an enlarged rear bearing (42) with a reduced-depth

section (45) at a bearing-journal junction, and the idle section (58) of the rider (50) comprises a reduced-width portion, and wherein the reduced-depth section (45) is achieved by causing the rear bearing (42) to adopt the cylindrical profile of the rider journal (46) in the section (45), in the region of an overhang (44) and, wherein the offset axes (C-C', D-D') and the enlarged rear bearing (42) create the bearing overhang (44) and a journal overhang (43) at the bearing-journal junction.

2. A pump according to claim 1, wherein the overhangs (43, 44) are arranged at diametrically-opposite positions across a bearing-journal overlapping area.

3. A pump according to claims 2 or 1, wherein the reduced-depth section (45) of the enlarged rear bearing (42) negates substantially all of the bearing overhang (44).

4. A pump according to any one of claims 1 to 3, wherein the reduced-depth section (45) comprises an outer edge curvature that matches an outer edge curvature of the rider journal (46) such that the outer edge curvature of the reduced-depth section (45) continues the adjacent outer edge curvature of the rider journal (46).

5. A pump according to any one of claims 1 to 4, wherein the bearing overhang (44) is located on underside side of the drive shaft (40) and the journal overhang (43) is located on an opposite side of the drive shaft (40).

6. A pump according to any one of claims 1 to 5, wherein the reduced-depth section (45) provides a stepped transition area.

7. A pump according to any one of claims 1 to 6, wherein the length of the reduced-depth section (45) is equal to or greater than the reduced-width portion of the idle section (58).

8. A pump according to any one of claims 1 to 4, wherein the enlarged rear bearing (42) may comprise an increase in length equal to the length of the reduced-depth section (45).

9. A pump according to any one of claims 1 to 8, wherein the body (51) of the rider (50) comprises first and second sides (51a, 51b), the first side (51a) comprising a leading side.

10. A pump according to claim 9, wherein the reduced-width portion is effected by an inward step provided in the first side (51a).

11. A pump according to any one of claims 1 to 10, wherein the idle section (58) is located on a underside of the rider (50).

12. A pump according to any one of claims 1 to 11, wherein the reduced-width portion of the idle section (58) comprises approximately 50% of a width of the load section (55).

13. A pump according to any one of claims 1 to 12, wherein the load section (55) of the rider (50) of the improved drive assembly comprises two outwardly facing flat surfaces (56, 57) disposed at approximately 90° to one another for contact with respective first and second tappets (35, 36), which are constructed to drive two pumping heads (10, 20) disposed at approximately 90° to one another.

14. A pump according to any one of claims 1 to 13, wherein the aperture (52) is biased towards the idle section (58).

Patentansprüche

1. Hochdruckkraftstoffpumpe, die zumindest einen Pumpkopf (10, 20) und eine verbesserte Antriebsanordnung aufweist, wobei die Antriebsanordnung eine Antriebseinrichtung und eine Antriebswelle (40) aufweist, die einen an ein hinteres Lager (42) angrenzenden Reiter-Mitnehmer (46) aufweist, wobei der Mitnehmer (46) und das Lager (42) relativ zueinander versetzte Achsen (C-C', D-D') aufweisen, wobei ein Reiter (50) an der Antriebswelle (40) angebracht ist, um eine Bewegung des Reiters (50) entlang eines exzentrischen Rotationspfads zu bewirken, wobei der Reiter (50) einen Körper mit einer durchgehenden Öffnung (52) hindurch, einen Last-Abschnitt (55), der um einen ersten Teil des Umfangs der Öffnung (52) angeordnet ist, und einen Leerlauf-Abschnitt (58) aufweist, der um einen zweiten Teil des Umfangs der Öffnung (52) angeordnet ist, und wobei der Last-Abschnitt (55) des Reiters (50) zumindest eine nach außen gerichtete flache Oberfläche (56, 57) aufweist zur Zusammenarbeit mit einem Stößel (35, 36), **dadurch gekennzeichnet, dass** die Antriebswelle (40) ein vergrößertes hinteres Lager (42) mit einem Abschnitt (45) mit reduzierter Tiefe bei einer Lager-Mitnehmer-Verbindung aufweist, und der Leerlauf-Abschnitt (58) des Reiters (50) einen Teil mit reduzierter Breite aufweist, und wobei der Abschnitt (45) mit reduzierter Tiefe erreicht wird, indem veranlasst wird, dass das hintere Lager (42) das zylindrische Profil des Reiter-Mitnehmers (46) in dem Abschnitt (45) annimmt, in dem Bereich eines Überstands (44), und
wobei die versetzten Achsen (C-C', D-D') und das vergrößerte hintere Lager (42) den Lager-Überstand (44) und einen Mitnehmer-Überstand (43) an der La-

ger-Mitnehmer-Verbindung erzeugen.

2. Pumpe gemäß Anspruch 1, wobei die Überhänge (43, 44) an diametral entgegengesetzten Positionen über einen Lager-Mitnehmer-Überlappungsbereich angeordnet sind.

3. Pumpe gemäß den Ansprüchen 2 oder 1, wobei der Abschnitt (45) mit reduzierter Tiefe des vergrößerten hinteren Lagers (42) im Wesentlichen den gesamten Lager-Überstand (44) negiert.

4. Pumpe gemäß einem der Ansprüche 1 bis 3, wobei der Abschnitt (45) mit reduzierter Tiefe eine Außenkantenkrümmung aufweist, die mit einer Außenkantenkrümmung des Reiter-Mitnehmers (46) übereinstimmt, so dass die Außenkantenkrümmung des Abschnitts (45) mit reduzierter Tiefe die angrenzende Außenkantenkrümmung des Reiter-Mitnehmers (46) fortsetzt.

5. Pumpe gemäß einem der Ansprüche 1 bis 4, wobei sich der Lager-Überstand (44) an einer Unterseite der Antriebswelle (40) befindet und sich der Mitnehmer-Überstand (43) an einer gegenüberliegenden Seite der Antriebswelle (40) befindet.

6. Pumpe gemäß einem der Ansprüche 1 bis 5, wobei der Abschnitt (45) mit reduzierter Tiefe einen abgestuften Übergangsbereich vorsieht.

7. Pumpe gemäß einem der Ansprüche 1 bis 6, wobei die Länge des Abschnitts (45) mit reduzierter Tiefe gleich oder größer als der Teil mit reduzierter Breite des Leerlauf-Abschnitts (58) ist.

8. Pumpe gemäß einem der Ansprüche 1 bis 4, wobei das vergrößerte hintere Lager (42) eine Zunahme der Länge aufweisen kann, die gleich der Länge des Abschnitts (45) mit reduzierter Tiefe ist.

9. Pumpe gemäß einem der Ansprüche 1 bis 8, wobei der Körper (51) des Reiters (50) eine erste und eine zweite Seite (51a, 51b) aufweist, wobei die erste Seite (51a) eine führende Seite aufweist.

10. Pumpe gemäß Anspruch 9, wobei der Teil mit reduzierter Breite durch eine Einwärtsstufe bewirkt wird, die in der ersten Seite (51a) vorgesehen ist.

11. Pumpe gemäß einem der Ansprüche 1 bis 10, wobei sich der Leerlauf-Abschnitt (58) an einer Unterseite des Reiters (50) befindet.

12. Pumpe gemäß einem der Ansprüche 1 bis 11, wobei der Teil mit reduzierter Breite des Leerlauf-Abschnitts (58) ungefähr 50% einer Breite des Last-Abschnitts (55) aufweist.

13. Pumpe gemäß einem der Ansprüche 1 bis 12, wobei der Last-Abschnitt (55) des Reiters (50) der verbesserten Antriebsanordnung zwei nach außen gerichtete flache Oberflächen (56, 57) aufweist, die in ungefähr 90° zueinander angeordnet sind zum Kontakt mit den jeweiligen ersten und zweiten Stößeln (35, 36), die konstruiert sind, um zwei Pumpköpfe (10, 20) anzutreiben, die in ungefähr 90° zueinander angeordnet sind.

14. Pumpe gemäß einem der Ansprüche 1 bis 13, wobei die Öffnung (52) in Richtung des Leerlauf-Abschnitts (58) beeinflusst ist.

Revendications

1. Pompe à carburant à haute pression comprenant au moins une tête de pompage (10, 20) et un assemblage d'entraînement perfectionné, l'assemblage d'entraînement comprenant un moyen d'entraînement et un arbre d'entraînement (40) comprenant un tourillon à cavalier (46) adjacent à un palier arrière (42), le tourillon à cavalier (46) et le palier (42) comprenant des axes (C-C', D-D') décalés l'un par rapport à l'autre, un cavalier (50) monté sur ledit arbre d'entraînement (40) pour effectuer un mouvement du cavalier (50) le long d'un trajet de rotation excentrique, le cavalier (50) comprenant un corps avec une ouverture (52) à extrémité ouverte à travers celui-ci, et une section sous charge (55) disposée autour d'une première portion de la circonférence de l'ouverture (52), et une section folle (58) disposée autour d'une seconde portion de la circonférence de l'ouverture (52), et dans laquelle la section sous charge (55) du cavalier (50) comprend au moins une surface plane tournée vers l'extérieur (56, 57) destinée à coopérer avec un poussoir (35, 36), **caractérisée en ce que** l'arbre d'entraînement (40) comprend un palier arrière élargi (42) avec une section à profondeur réduite (45) au niveau d'une jonction palier-tourillon, et la section folle (58) du cavalier (50) comprend une portion à largeur réduite, et dans laquelle la section à profondeur réduite (45) est réalisée en amenant le palier arrière (42) à adopter le profil cylindrique du tourillon à cavalier (46) dans la section (45), dans la région d'un surplomb (44), et dans laquelle les axes décalés (C-C', D-D') et le palier arrière élargi (42) créent le surplomb de palier (44) et un surplomb de tourillon (43) au niveau de la jonction palier/tourillon.

2. Pompe selon la revendication 1, dans laquelle les surplombs (43, 44) sont agencés au niveau de positions diamétralement opposées à travers une zone de chevauchement palier-tourillon.

3. Pompe selon les revendications 1 ou 2, dans laquelle

la section à profondeur réduite (45) du palier arrière élargi (42) réduit sensiblement à zéro tout le surplomb (44) du palier.

4. Pompe selon l'une quelconque des revendications 1 à 3, dans laquelle la section à profondeur réduite (45) comprend une bordure extérieure avec une courbure qui s'accorde à une courbure d'une bordure extérieure du tourillon à cavalier (46), de telle sorte que la courbure de bordure extérieure de la section à profondeur réduite (45) continue la courbure de la bordure extérieure adjacente du tourillon à cavalier (46).

5. Pompe selon l'une quelconque des revendications 1 à 4, dans laquelle le surplomb de palier (44) est situé sur un côté inférieur de l'arbre d'entraînement (40) et le surplomb de tourillon (43) est situé sur un côté opposé de l'arbre d'entraînement (40).

6. Pompe selon l'une quelconque des revendications 1 à 5, dans laquelle la section à profondeur réduite (45) constitue une zone de transition en gradins.

7. Pompe selon l'une quelconque des revendications 1 à 6, dans laquelle la longueur de la section à profondeur réduite (45) est égale ou supérieure à la portion à largeur réduite de la section folle (58).

8. Pompe selon l'une quelconque des revendications 1 à 4, dans laquelle le palier arrière élargi (42) peut comprendre une augmentation de longueur égale à la longueur de la section à profondeur réduite (45).

9. Pompe selon l'une quelconque des revendications 1 à 8, dans laquelle le corps (51) du cavalier (50) comprend un premier et un second côté (51a, 51b), le premier côté (51a) comprenant un côté d'attaque.

10. Pompe selon la revendication 9, dans laquelle la portion à largeur réduite est réalisée par un gradin rentrant prévu dans le premier côté (51a).

11. Pompe selon l'une quelconque des revendications 1 à 10, dans laquelle la section folle (52) est située sur un côté inférieur du cavalier (50).

12. Pompe selon l'une quelconque des revendications 1 à 11, dans laquelle la portion à largeur réduite de la section folle (58) comprend approximativement 50 % d'une largeur de la section sous charge (55).

13. Pompe selon l'une quelconque des revendications 1 à 12, dans laquelle la section sous charge (55) du cavalier (50) de l'assemblage d'entraînement perfectionné comprend deux surfaces planes tournées vers l'extérieur (56, 57) disposées approximativement à 90° l'une par rapport à l'autre pour venir en contact avec un premier et un second poussoir (35, 36) respectif, qui sont construits pour entraîner deux têtes de pompage (10, 20) disposées approximativement à 90° l'une par rapport à l'autre.

14. Pompe selon l'une quelconque des revendications 1 à 13, dans laquelle l'ouverture (52) est sollicitée en direction de la section folle (58).

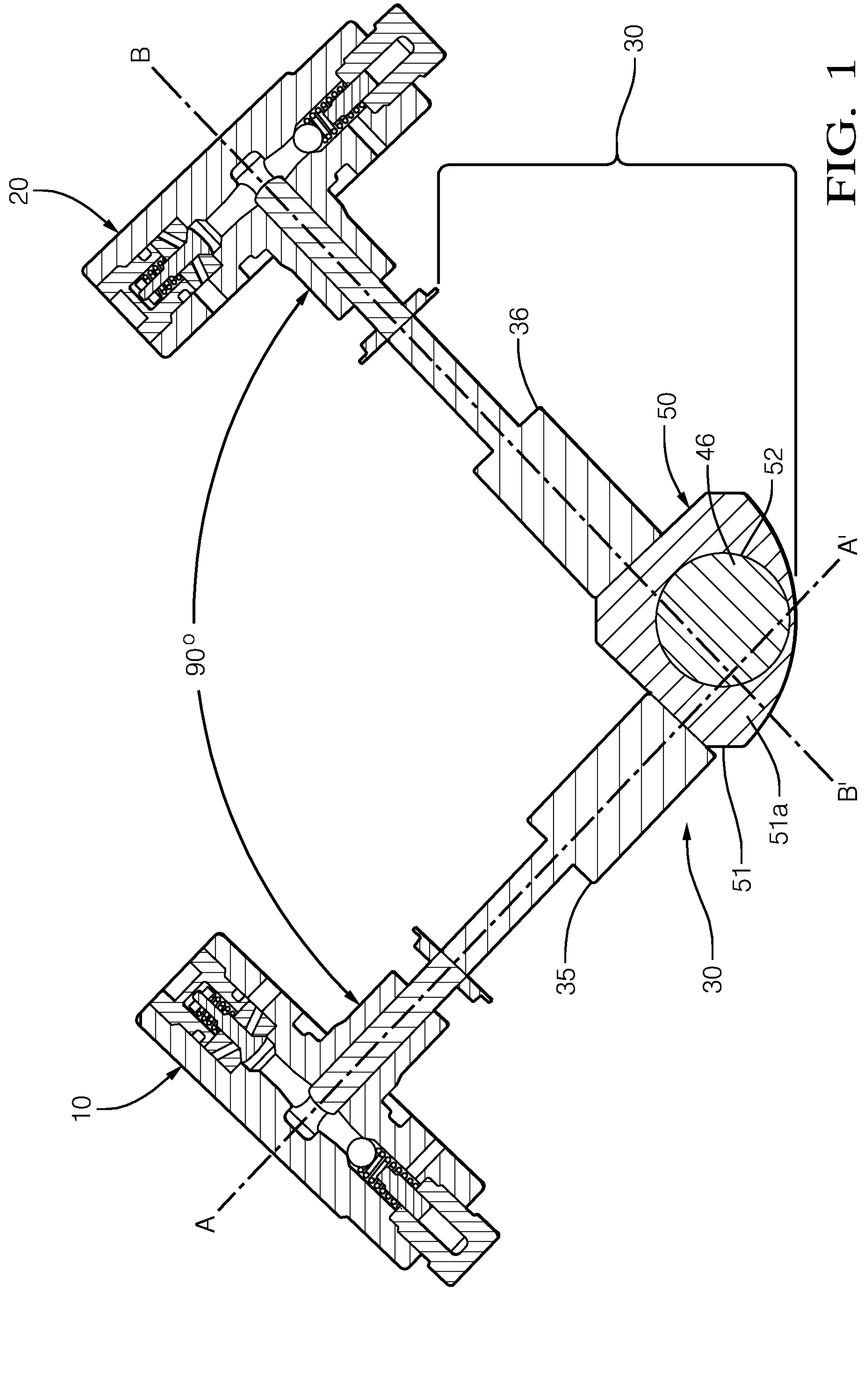
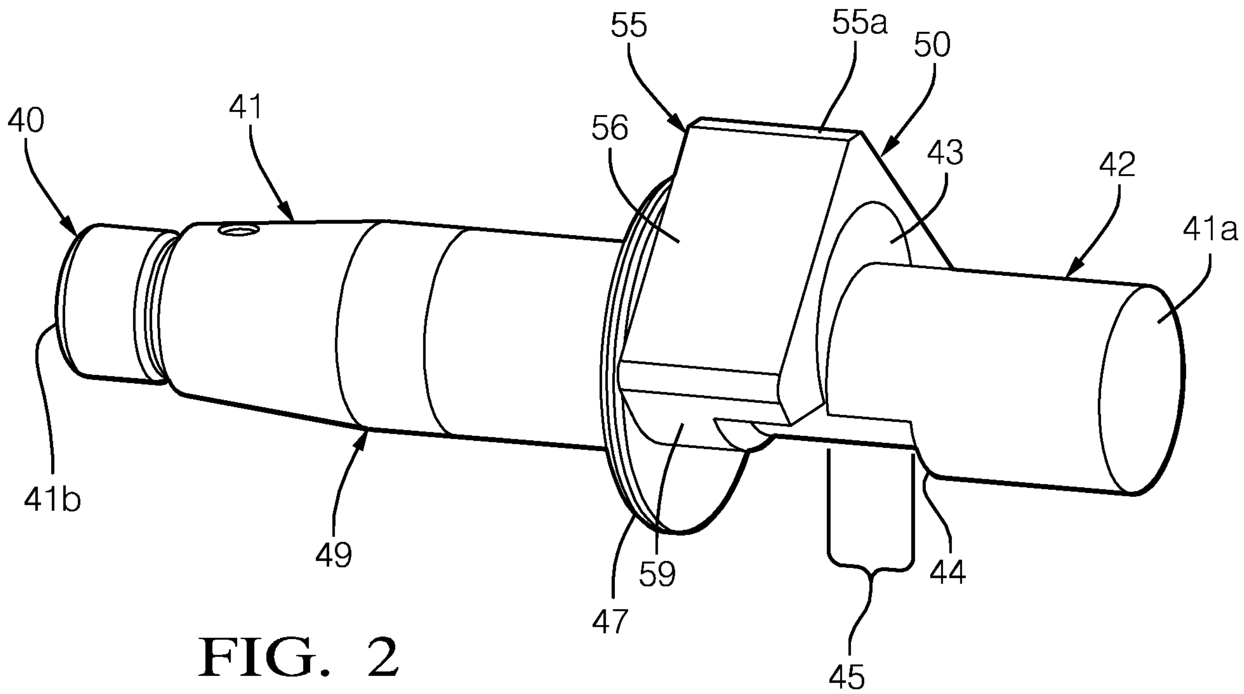


FIG. 1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55a
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56
43
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41a
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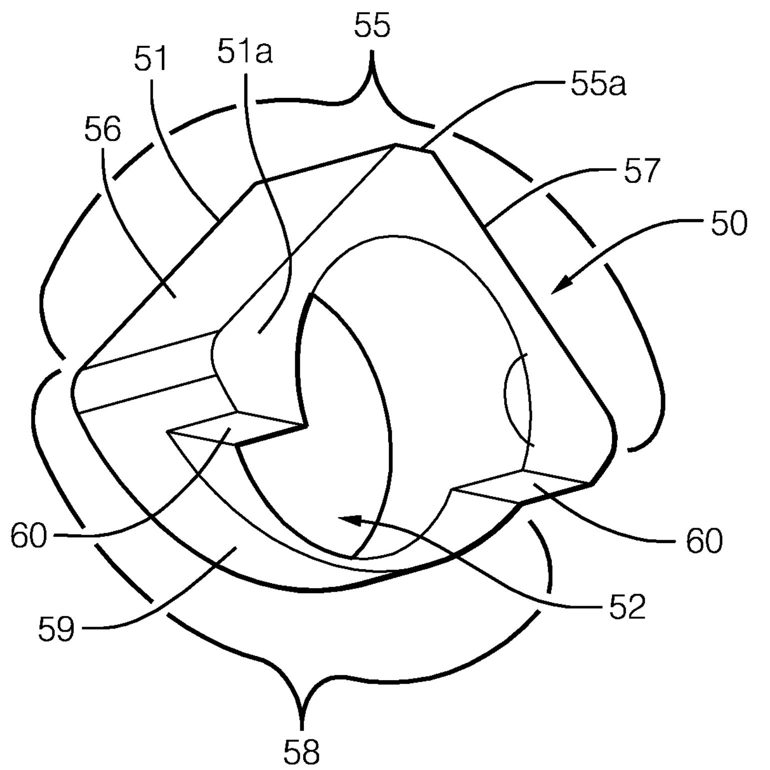
41
41b
49
47
59
44
45

FIG. 2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51a
55a
56
57
50
60
60
52
59
58

FIG. 3

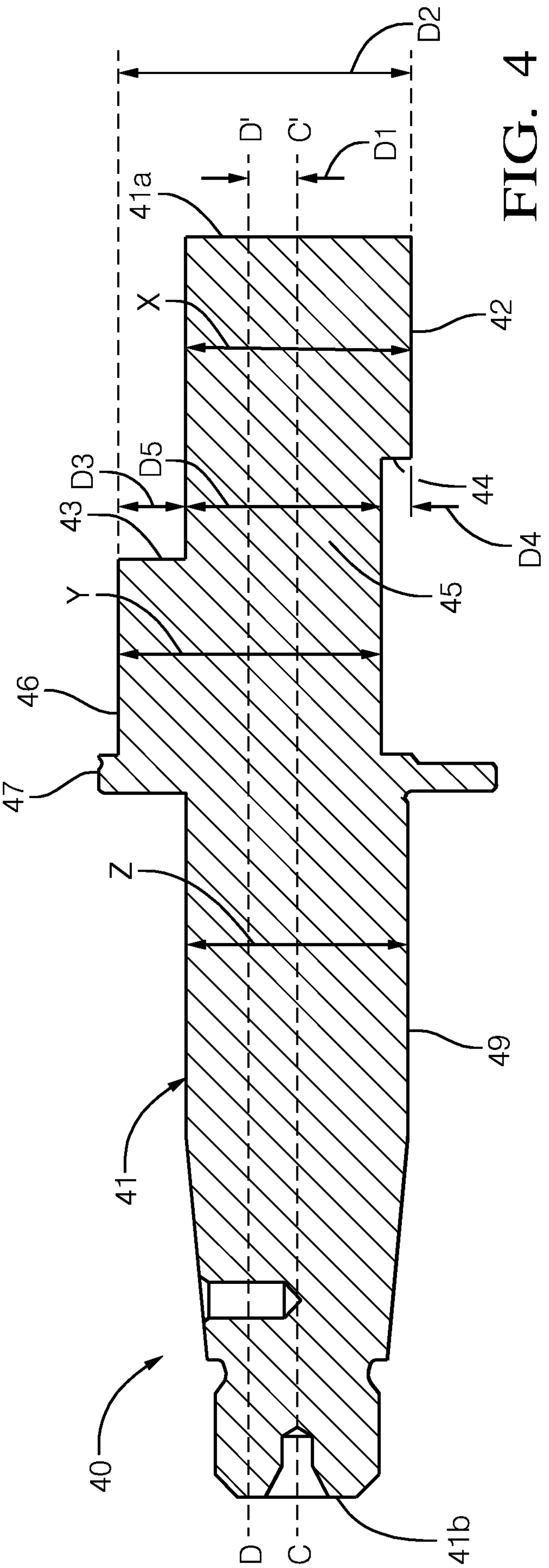
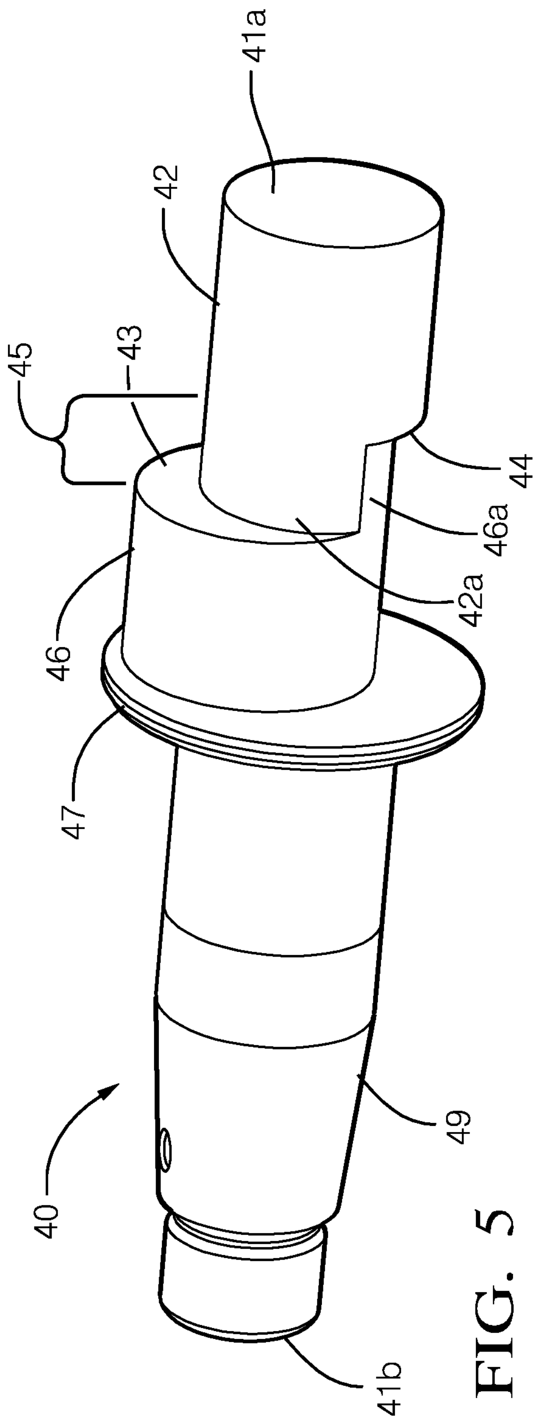

D2
D'
C'
D1
41a
X
42
D3
D5
43
44
D4
45
Y
46
47
Z
49
41
40
D
C
41b

FIG. 4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42
45
43
44
46a
42a
46
47
49
40
41b

FIG. 5

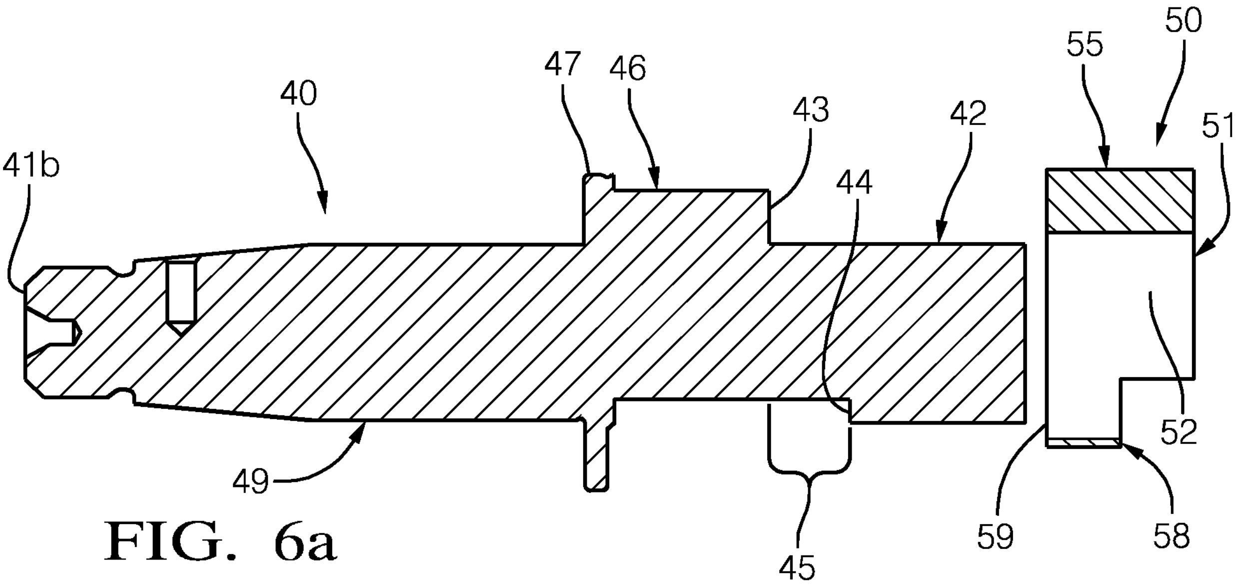


FIG. 6a

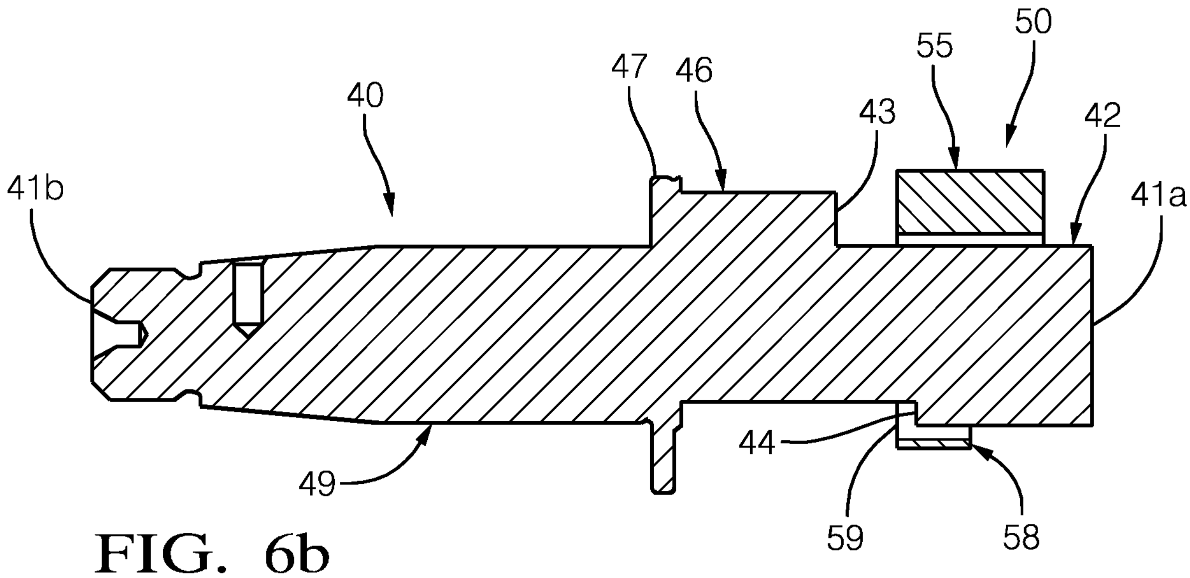


FIG. 6b

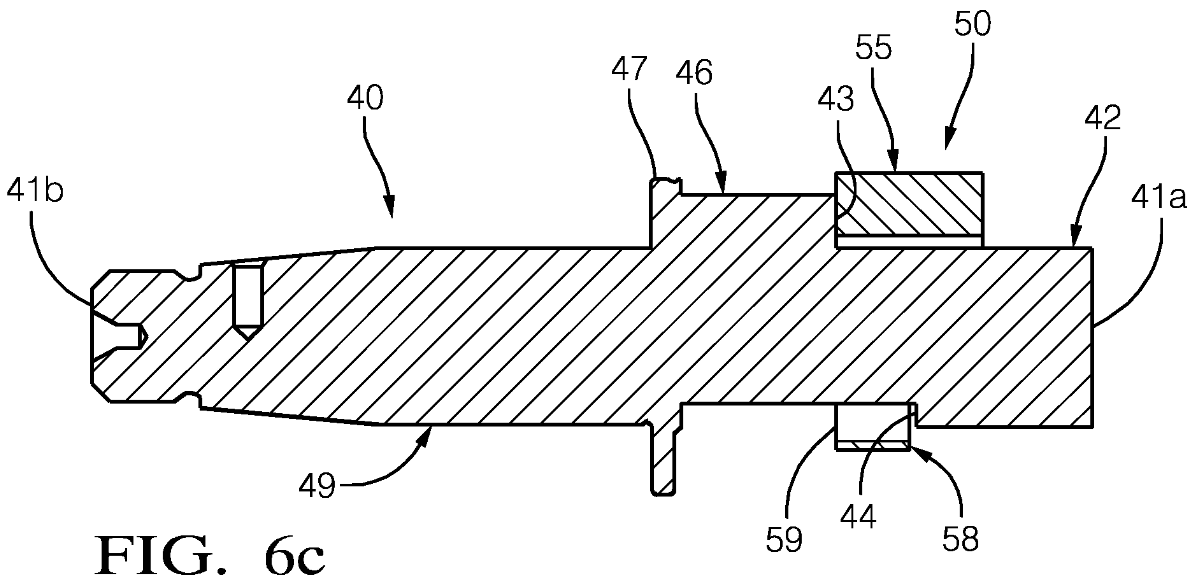
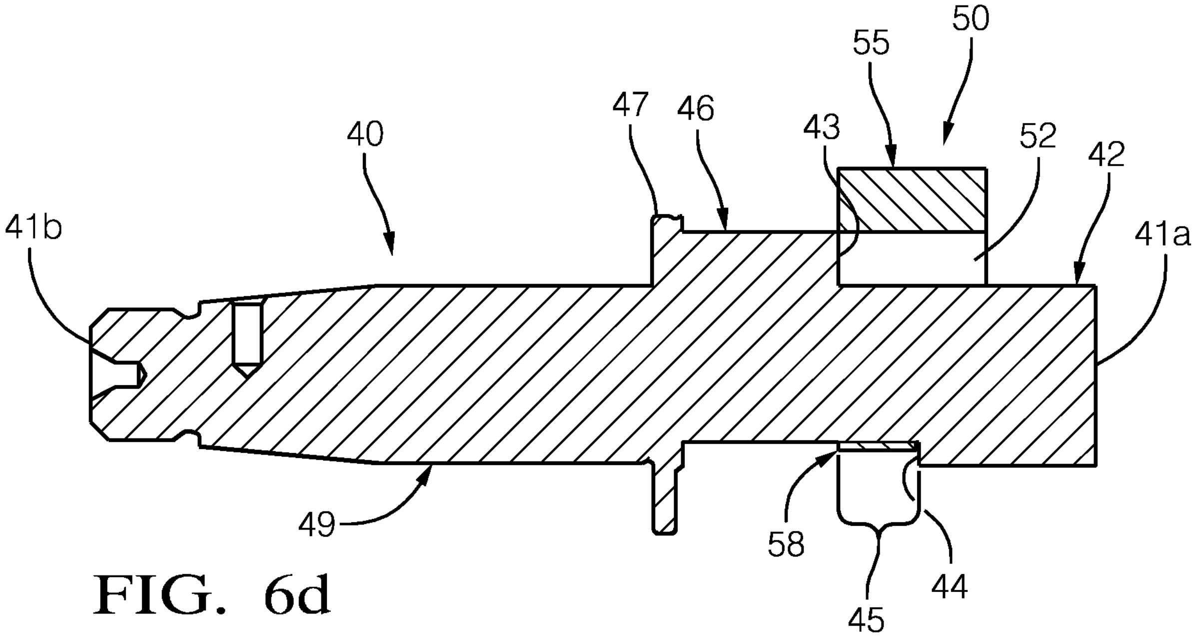


FIG. 6c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46
43
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42
41b
41a
49
58
45
44

FIG. 6d

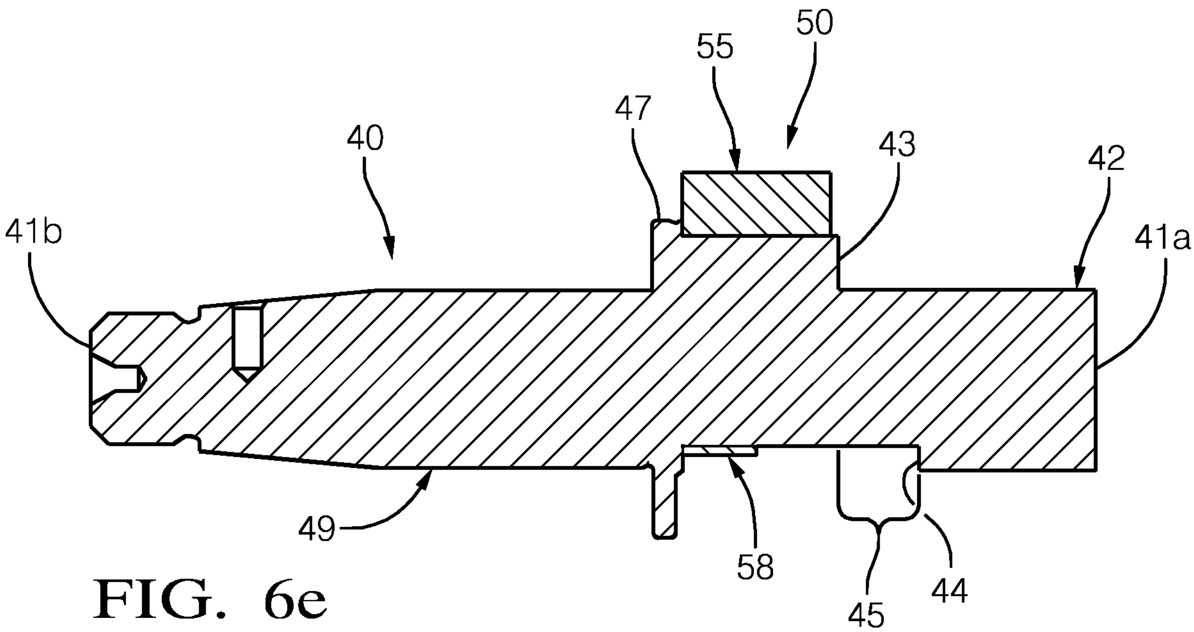
50
55
47
40
43
42
41b
41a
49
58
45
44

FIG. 6e

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008184953 A **[0003]**