



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.03.2017 Bulletin 2017/10

(51) Int Cl.:
F02M 59/10 (2006.01) **F04B 1/04** (2006.01)
F04B 9/04 (2006.01)

(21) Application number: **16185570.5**

(22) Date of filing: **24.08.2016**

(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
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **McHATTIE, James**
Bean, Kent DA2 8AL (GB)
• **EMERY, Charlie**
Gillingham, Kent ME8 0RU (GB)

(74) Representative: **Delphi France SAS**
Patent Department
22, avenue des Nations
CS 65059 Villepinte
95972 Roissy CDG Cedex (FR)

(30) Priority: **01.09.2015 GB 201515435**

(71) Applicant: **Delphi International Operations**
Luxembourg S.à r.l.
4940 Bascharage (LU)

(54) **HIGH PRESSURE FUEL PUMP**

(57) The invention comprises a high pressure fuel pump comprising at least one pumping assembly (10) and a drive assembly (20). The pumping assembly (10) comprises a plunger (12) arranged for reciprocal movement along a pumping axis (A-A'). The drive assembly (20) comprises a drive means and a driveshaft (22) comprising a rider journal (24) and a rear bearing (26), whoses axes (B-B', C-C') are offset relative to each other. A rider (30) is fitted on said rider journal (24) to

effect movement of the rider (30) along an eccentric rotational path. The drive assembly (20) comprises a stroke-increasing arrangement (40) disposed between the rider (30) and the pumping assembly (10). The stroke-increasing arrangement (40) comprises at least two angled, preferably triangular, members configured to translate movement along a first axis (D-D') to along the pumping axis (A-A').

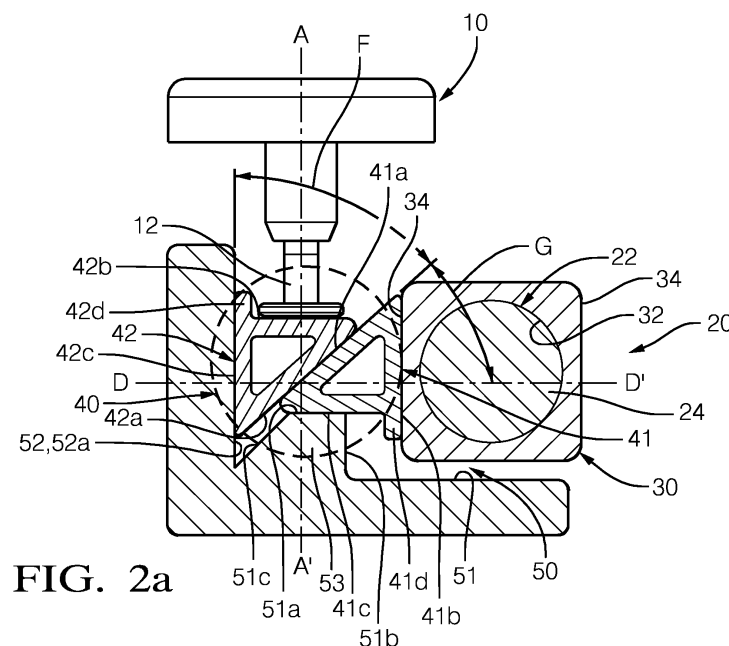


FIG. 2a

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 of slipper-tappet design.

Description of the Related Art

[0002] In high pressure fuel pumps of slipper-tappet design the drive assembly comprises a cam that is driven around an eccentric rotational path by a driveshaft. The cam carries a rider therearound, also driven around the same eccentric rotational path. The rider comprises at least one 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 generally along the pumping axis guides the tappet in linear movement along the same pumping axis, so that as the rider flat surface rises in the direction of the tappet it pushes the tappet along the pumping axis. Simultaneously, the rider flat surface slides 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.

[0003] As shown in Figure 1, a known dual-head slipper tappet arrangement 1 exists where a drive assembly with a driveshaft 8 and rider 5 effects plunger 3 movement of two separate pumping heads 2 (only one is shown). The arrangement 1 is known as a tower block arrangement, which comprises opposing pumping heads 2 stacked at 180° to one another with the drive assembly between. The plunger 3 interacts with a tappet 4. In this case, the rider 5 has first and second flat surfaces 6, 7 opposite one another, with the second surface 7 cooperating with a second tappet (not shown) to drive a second pumping plunger (not shown) within a second pumping head (not shown).

[0004] There is a current trend towards a demand for greater rail pressures. However, this brings with it issues of increased load on the support bearings of the driveshaft and in addressing those issues, problems with the proportions and assembly of both the driveshaft bearings and the rider.

[0005] In order to prevent failure of the driveshaft as a result of the greater load, it is necessary to increase the size of the support bearings (front bearing and rear bear-

ing). This in turn presents issues, since the rider needs to pass over either a front or rear bearing in order to sit on the rider journal.

[0006] One way to allow the bearings to be increased in size without compromising on passage of the rider onto the rider journal is to reduce the rider journal eccentric. However, this significantly decreases the throw or offset of the bearing relative to the rider journal. A reduced throw or offset negatively impacts on the stroke length therefore, decreasing the capacity of the pump. This is a problem since pump capacity is also an important factor.

[0007] Therefore, one significant area for improvement is finding a solution to the increased load issue whilst retaining pump capacity.

[0008] 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.

[0009] 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 pump capacity, or ease of assembly. In particular, it is desired to provide a dual pumping head arrangement for known slipper tappet pumps, which also provides good pump capacity and is capable of higher loads.

SUMMARY OF THE INVENTION

[0010] In a first aspect of the present invention there is provided a high pressure fuel pump comprising at least one pumping assembly and a drive assembly, the or each pumping assembly comprising a plunger arranged for reciprocal movement along a pumping axis, the drive assembly comprising a drive means and a driveshaft comprising a rider journal adjoined to a front bearing and a rear bearing, the rider journal and at least the rear bearing comprising offset axes relative to one another, a rider fitted on said rider journal to effect movement of the rider along an eccentric rotational path, wherein the rider comprises at least one outwardly facing flat surface for cooperation with said pumping assembly, characterised in that the drive assembly comprises a stroke-increasing arrangement disposed between the rider and the pumping assembly.

[0011] By 'stroke-increasing arrangement', what is meant is an assembly that effects an increased plunger lift and drop, thereby adding to the effect of a throw between the rider journal and the bearing that is determined by the offset axes provided between the rider journal and the rear bearing.

[0012] By 'throw' what is meant is a distance between the offset axes of the rider journal and the rear bearing that effects a lifting and dropping action during rotation of the driveshaft.

[0013] With this arrangement, the enlarged rear bearing provides strength and durability to the driveshaft to cope with a higher load capacity, whereas the stroke-increasing arrangement compensates for the decreased

plunger lift and drop (stroke length) caused by the inevitable reduction in a throw defined by the offset axes as a result of said enlarged bearing. Accordingly, despite the larger rear bearing, the adaptations to the drive assembly effect easy construction and a good pump capacity for the optional two pumping heads within the high pressure fuel pump.

[0014] Preferably, the drive assembly comprises an enlarged rear bearing.

[0015] 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.

[0016] Preferably, the stroke-increasing arrangement comprises at least two angled members. Preferably, the angled members are configured to translate movement along a first plane of movement to a second plane of movement. Most preferably, the angled members are configured to translate movement along a first axis to along a second axis.

[0017] Preferably, the first axis is substantially the same as a rider reciprocating axis (axis along which the rider moves). Preferably, the second axis is substantially the same as the pumping axis. Most preferably, the second axis is substantially perpendicular to the first axis.

[0018] Preferably, each angled member comprises at least one contact face for contact with one other angled member. Preferably, the contact faces comprise a substantially planar face.

[0019] Preferably, the plane of the contact face(s) of each angled member is/are configured to be disposed at an angle to both the first axis and the second axis. Preferably, the plane of both contact faces of two contacting angled members are configured to be disposed at the same angle. The angle may be approximately between 30° and approximately 70°. Preferably, the angle is approximately between 35° and approximately 50°. Most preferably, the angle is approximately between 40° and approximately 48°.

[0020] Preferably, two of the angled members comprise an engagement face for engaging a driving component of the drive assembly, or a driven component of the pumping assembly. Preferably, the engagement faces are substantially planar.

[0021] The driving component may be a rider or other such component. The driven component may be a tappet or the plunger as part of the pumping assembly, since the tappet may no longer be required.

[0022] Preferably, the plane of the engagement face of a first angled member is provided in a first orientation and the plane of the engagement face of a second angled member is provided in a second orientation. Preferably, the first orientation is substantially perpendicular to the first/ rider reciprocating axis and the second orientation is substantially perpendicular to the second/ pumping axis. Most preferably, the second orientation is substantially perpendicular to the first orientation. Accordingly, the engagement face of each angled member is preferably pro-

vided at an angle to that of its respective contact face.

[0023] Preferably, the engagement face of each angled member is provided at an angle to that of its respective contact face.

[0024] Preferably, two of the angled members comprise a guided face for guided sliding contact with a guiding face provided by the drive housing. Preferably, the guided face of each angled member is provided at an angle to that of its respective contact face. The guided face of each angled member may be provided at the same angle as that between the engagement face and the contact face. The guided face of each angled member may be provided at a less acute angle as that between the engagement face and the contact face. Preferably, however, the guided face of each angled member is provided at a more acute angle as that between the engagement face and the contact face.

[0025] Preferably, the angled members comprise a substantially triangular cross-section. The angled members preferably comprise a short triangular column, the length of which is long enough to accommodate at least the driven component, e.g. the plunger or a tappet.

[0026] Each angled member may be substantially hollow.

[0027] Preferably, the engagement face of at least the first angled member comprises an upstanding lip along an edge, preferably, the edge adjoining the guided face. Since the angled members are intended to be interchangeable, both angled members may have an upstanding lip.

[0028] Preferably, the drive housing comprises an adapted chamber disposed between the rider and the plunger. Preferably, the chamber comprises at least two guiding faces for contact with said guided faces of the angled members. Preferably, the guiding faces are configured to guide movement of the first angled member in along the first/ reciprocating rider axis and of the second angled member along the second/ pumping axis.

[0029] Preferably, the chamber comprises a first guiding face substantially parallel with the first/ reciprocating rider axis and provided by a protrusion from a first chamber wall. Preferably, the chamber comprises a second guiding face substantially parallel with the second/ pumping axis and provided by a second chamber wall. The second chamber wall may be adjoined to said first chamber wall, either directly or indirectly.

[0030] Preferably, the protrusion comprises an abutment face. The abutment face is preferably configured to abut the lip of the engagement face. This prevents over extension of the first angled member.

[0031] Preferably, the first guiding face is narrower than the guided face in the first direction of travel. Accordingly, the guided face is configured to partially overhang the guiding face.

[0032] Preferably, the protrusion comprises a trailing face shaped to drop away before an end of the first chamber wall and/or before meeting the second chamber wall. The trailing face allows the second angled member to

drop beyond the level of the first guiding face for a greater extent of movement along the second/ pumping axis. The trailing face may be sloped. The trailing face may be provided at an angle of approximately 45° in order to comfortably accommodate a bottom part of a second angled member with varying angles.

[0033] With the above arrangement, the sliding surfaces provided by the angled members provide a larger sliding area. This increases the durability of the members and possibly removes the need for protective coatings on said sliding surfaces.

[0034] Preferably, the angled members are interchangeable with other angled members having a different pitch. This way, the stroke length can be varied by simply swapping out the angled members for alternative members.

[0035] Preferably, the enlarged rear bearing may comprise an increase in length in addition to the increase in diameter.

[0036] Preferably, the drive assembly is constructed to drive two pumping heads and therefore, two stroke-enhancing mechanisms. The pump may comprise first and second pumping heads disposed at approximately 180° to one another with offset pumping axes.

[0037] Preferably, the pump is a diesel pump.

[0038] In a second aspect of the present invention there is provided a drive assembly for a high pressure fuel pump comprising a drive means and a driveshaft, the driveshaft comprising a rider journal adjoined to a front bearing and a rear bearing, the rider journal and at least the rear bearing comprising offset axes relative to one another, a rider fitted on said rider journal to effect movement of the rider along an eccentric rotational path, wherein the rider comprises at least one outwardly facing flat surface for cooperation with a pumping assembly, characterised in that the drive assembly comprises a stroke-increasing arrangement for disposal between the rider and the pumping assembly.

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.

[0039] In a third aspect of the present invention there is provided a stroke-increasing arrangement for a drive assembly of a high pressure fuel pump, characterised in that the stroke-increasing arrangement is adapted for disposal between a rider of the drive assembly and a pumping assembly.

[0040] 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.

[0041] In a fourth aspect of the present invention there is provided a drive housing of a high pressure fuel pump comprising an adapted chamber between a drive assembly and a pumping assembly, characterised in that the chamber comprises guiding means for a stroke-increasing arrangement.

[0042] Preferably, the guiding means comprises guiding surfaces configured for sliding contact with guided

faces of the stroke-increasing arrangement. Preferably, the stroke increasing arrangement comprises at least two angled members.

[0043] It will be appreciated that the preferred features described in relation to the first aspect of the invention also apply to the fourth aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0044] 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 side view of the components of a known high pressure fuel pump showing only one of the two pumping heads;

Figure 2a is a schematic cross-sectional side view of part of a drive assembly and a pumping assembly of a high pressure fuel pump according to an embodiment of the invention in a plunger dropped position;

Figure 2b is a schematic cross-sectional side view of part of a assembly and a pumping assembly of a high pressure fuel pump according to Figure 2a in a plunger lifted position;

Figure 3a is a schematic cross-sectional side view of part of a drive assembly and a pumping assembly of a high pressure fuel pump according to another embodiment of the invention in a plunger dropped position;

Figure 3b is a schematic cross-sectional side view of part of a drive assembly and a pumping assembly of a high pressure fuel pump according to Figure 3a in a plunger lifted position; and

Figure 4 is a schematic side view of a driveshaft the invention of Figures 2a-b and 3a-b.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0045] An embodiment of the invention is shown in Figures 2a 2b, 3a and 3b. A high pressure fuel pump comprises at least one pumping assembly 10 and a drive assembly 20. The or each pumping assembly 10 comprises a plunger 12 arranged for reciprocal movement along a pumping axis A-A'. The drive assembly 20 comprises a drive means (not shown) and a driveshaft 22 comprising a rider journal 24 adjoined to a front bearing 25 and a rear bearing 26. The rider journal 24 and at least the rear bearing 26 comprise offset axes B-B', C-C' relative to one another. A rider 30 is fitted on said rider journal 24 to effect movement of the rider 30 along an

eccentric rotational path, wherein the rider 30 comprises at least one outwardly facing flat surface 34 for cooperation with the pumping assembly 10. The drive assembly 20 comprises a stroke-increasing arrangement 40 disposed between the rider 30 and the pumping assembly 10.

[0046] As can be seen in Figure 4, the driveshaft 22 comprises a substantially elongate cylindrical body with a first end 21a and a second end 21b. The rear bearing 26 is enlarged (comprises an enlarged diameter), sits on axis B-B' and is located at the second end 21b of the shaft 22.

[0047] Following the rear bearing 26 is the rider journal 24 sitting on alternate axis C-C' parallel with the axis B-B'. In the described embodiment, the axis C-C' of the rider journal 24 is located directly above axis B-B' of the bearing 26. The diameter of the rear bearing 26 is just smaller than the rider journal 24 so as to define a throw T between that effects a lifting and dropping action during rotation of the driveshaft 22. Therefore, the enlarged rear bearing 26 comprises an increased diameter when compared with the prior art, almost up to the diameter of the rider journal 24. This allows the driveshaft 22 to endure much higher loads.

[0048] Following the rider journal 24 is an abutment 27 in the form of a disc. Extending from the abutment 27 to the first end 21a is a front journal 49.

[0049] The first end 21a is attached to a drive means (not shown) via a thread that allows a sprocket to be tightened against the end and dictates the rotational path of the driveshaft 22 and therefore, the rotational path of the rider 30 fitted thereon.

[0050] As shown in Figures 2a, 2b, 3a and 3c, the rider 30 comprises a substantially cuboidal body with a cylindrical bore 32 therethrough. The bore 32 is of a diameter suitable for a clearance fit with the rider journal 24 of the driveshaft 22.

[0051] The rider 30 comprises two opposing flat surfaces 34 that are configured to provide load surfaces for the pumping function in opposing directions. The rider 30 reciprocates along an axis E-E' driven by the rotating driveshaft 22. Of course, it is possible that the rider 30 be provided with flat surfaces in a different orientation to one another, such as a V-shaped orientation in order to provide load surfaces for a different arrangement of pumping assemblies.

[0052] The stroke-increasing arrangement 40 comprises a pair of angled members 41, 42. Each angled member 41, 42 comprises a short hollow column with a right-angled triangular cross-section. Accordingly, each angled member 41, 42 has three external planar faces 41a - c and 42a - c respectively, disposed at angles to one another.

[0053] The angled members 41, 42 are configured to translate reciprocating movement along a first/ reciprocating rider axis D-D' to reciprocating movement along a second/ pumping axis A-A'. In the described embodiments, the second/ pumping axis A-A' orientation is sub-

stantially perpendicular to the first/ reciprocating rider axis D-D'.

[0054] Accordingly, each angled member 41, 42 comprises a contact face 41a, 42a, an engagement face 41b, 42b and a guided face 41c, 42c.

[0055] The contact faces 41a, 42a are configured for contact with the other angled member 41, 42 and as such, in order to translate the orientation of movement, the plane of the contact face 41a, 42a of each angled member 41, 42 is disposed at an angle F to the second/ pumping axis A-A' and at an angle G to the first/ reciprocating rider axis D-D'. Accordingly, the contact faces 41a, 42a form the hypotenuse of the right-angled column.

[0056] The angle F at which the contact faces 41a, 42a are disposed has an impact on the extent of lift and drop of the plunger 12. In Figures 2a- 2b, the angle F is set at 48° which has been shown to be capable of achieving a range of movement of 7.18 mm. In contrast, in Figures 3a-3b, the angle F is set at 40° which has been shown to be capable of achieving a range of movement of 9.53 mm. Although not shown specifically, a 45° angle F provides an 8 mm lift and drop and a 43° angle F provides 8.53 mm lift and drop. Therefore, the angled members 41, 42 are adapted to be interchangeable with other pairs of angled members having a different angle F and a different lift and drop (which will likely be dictated by the height of the pumping head). Therefore, the stroke length can be varied easily by simply swapping out the angled members 41, 42 for alternative angled members with a different angle F.

[0057] Each engagement face 41b, 42b is configured to engage a driving component of the drive assembly, e.g. a load face 34 of the rider 30, or a driven component of the pumping assembly, e.g. a tappet or alternatively, a driven end 12a of a plunger 12. The engagement faces 41b, 42b comprise one of the pair of catheti faces formed by the right-angled column.

[0058] The guided faces 41c, 42c are configured for guided sliding contact with a guiding face 51a, 52a provided by the chamber 50 of the drive housing. The guided faces 41c, 42c comprise the other of the pair of catheti faces formed by the right-angled column and as such, is disposed at a right-angle to the respective engagement face 41b, 42b. Each guided face 41c, 42c is provided at angle F to that of its respective contact face 41a, 42a.

[0059] In the embodiment shown by Figures 2a and 2b, the engagement face 41b of at least the first angled member 41 comprises an upstanding lip 41d along an edge adjoining the guided face 41c/ the right-angled edge. Since the angled members 41, 42 are intended to be interchangeable as far as possible, both angled members 41, 42 may have an upstanding lip 41d, 42d. However, the lip 41d, 42d may be omitted (as in Figures 3a and 3b) in order to achieve a greater extent of movement and to accommodate the narrower engagement face 41b, 42b as a result of a more acute angle F.

[0060] In order to provide both guiding faces 51a, 52a, the drive housing comprises an adapted chamber 50 dis-

posed between the rider 30 and the plunger 12.

[0061] The chamber 50 comprises a first chamber wall 51 substantially parallel with the first/ reciprocating rider axis D-D' and a second chamber wall 52 substantially parallel with the second/ pumping axis A-A'. Accordingly, in the shown embodiments, the two walls 51, 52 meet in a substantially right-angled corner, which is dictated by the perpendicular relationship between the first/ reciprocating rider axis D-D' and the second/ pumping axis A-A'. However, should the relationship between the first/ reciprocating rider axis D-D' and the second/ pumping axis A-A' be different, the relative orientation of the between the two walls 51, 52 would potentially mirror that relationship.

[0062] The second chamber wall 52 functions as the second guiding face 52a for the guided face 42c of the second angled member 42. The first chamber wall 51 comprises a protrusion 53 comprising a leading face 51b, the first guiding face 51a and a trailing face 51c. The leading face 51b is substantially perpendicular to the chamber wall 51. The guiding face 51a is substantially parallel with the chamber wall 51 and linked with the leading face 51b. The trailing face 51c slopes away from the guiding face 51a back towards the chamber wall 51. In the embodiment shown, the trailing face 51b meets the first chamber wall 51 at the junction with the second chamber wall 52. In a preferred embodiment, the trailing face 51c comprises an angle of approximately 45° to the guiding face 51a, although it could be disposed at a more or less acute angle, or a 90° angle (mirroring the leading face 51b).

[0063] The first guiding face 51a is narrower than the span of the guided face 41c between the leading and trailing faces 51b, 51c and so, the guided face 41c of the angled member 41 is configured to partially overhang the guiding face 51a. The narrower guiding face 51a also facilitates the existence and slope of the trailing face 51c in order that the second angled member 42 is able to drop below the level of the first guiding face 51a for a greater range of movement along the second/ pumping axis A-A'.

[0064] During assembly of the stroke-increasing arrangement 40, the second angled member 42 is disposed with the engagement face 42b facing the end 12a of the plunger 12 and the guided face 42c against the guiding face 52a of the second chamber wall 52. For ease, the second angled member 42 may be in a dropped position and may be substantially resting in the space between the trailing face 51c and the second chamber wall 52. In this position, the contact face 42a is in a generally downwardly disposed orientation (angled).

[0065] The first angled member 41 is slid in 'under' the second angled member 42, with the guided face 41c disposed downwardly and resting against the first guiding face 51a, which places the contact face 41a in an generally upwardly disposed orientation (angled) to meet the second contact face 42a. The first engagement face 41b is in an orientation to interface with the load face 34 of

the rider 30.

[0066] In a first position, as shown in Figures 2a and 3a, the plunger 12 is in a 'dropped' state sitting against the engagement face 42b of the 'dropped' second angled member 42, part of which nestles in the space between the trailing face 51c of the protrusion 53 and the second chamber wall 52. An upper portion of the second contact face 42a is resting against a lower portion of the first contact face 41a of the first angled member 41, thereby maintaining the angle F and the orientation of the contact face 42a relative to the pumping axis A-A'. The first angled member 41 overhangs the guiding face 51a on protrusion 53 by partially extending over the leading face 51b. Accordingly, the first angled member 41 is trapped between the contact face 42a of the second angled member 42, the first guiding face 51a and the load face 34 of the rider 30 to retain its orientation.

[0067] In use, as the driveshaft 22 is rotated, the load face 34 of the rider 30 moves along the axis D-D' towards the second chamber wall 52 pushing the engagement face 41b of the first angled member 41 along the first/ reciprocating rider axis D'→D. The guided face 41c of the first angled member 41 slides along the guiding face 51a of the protrusion 53 in the first chamber wall 51 until the lip 41d meets the leading face 51b of the protrusion 53 (where a lip is present) as shown in Figures 2b and 3b. The lip 41d prevents over extension of the first angled member 41 which may otherwise hit the second chamber wall 52 during operation. This movement, translates the contact face 41a into a sloped location substantially under the end 12a of the plunger 12 (as shown in Figures 2b and 3c). Simultaneous with the translation of the first contact face 41a, the second contact face 42a is forced to slide upwardly on the first contact face 41a, causing the second angled member 42 to move upwardly along the second/ pumping axis A'→A supported by the interaction of the guided face 42c with the guiding face 52a. The resultant rising engagement face 42b lifts the plunger 12. The lip 42d of the second angled member 42 may help to retain the plunger 12 in position, although the presence of the lip 42d of the second angled member 42 is primarily to enable the members 41, 42 to be easily interchangeable if required making assembly simple.

[0068] In this lifted position, the second contact face 42a substantially overlies the first contact face 41a to be fully supported between the first angled member 41 and the second guiding face 52a of the chamber 50.

[0069] As the rider 30 recedes on completion of one rotation of the driveshaft 22, the force of a return spring (not shown) located around the plunger 12, causes the engagement face 42b to be driven downwardly and the second angled member 42 to drop whilst supported by the guiding face 52a. This downward movement of the second angled member 42 forces the first angled member back along the first axis D-D' due to the sliding interaction of the two contact faces 41a, 42a. The first angled member 41 follows the receding face 34 of the rider 30 until it returns fully to the dropped position.

[0070] The drive assembly is constructed to drive two pumping assemblies 10 and therefore, two stroke-enhancing mechanisms 40. The pump may comprise first and second pumping assemblies 10 disposed at approximately 180° to one another with offset pumping axes. The opposite faces 34 of the rider 30 are able to accommodate such an arrangement, wherein as the rider 30 'drops' relative to a first pumping assembly 10, the rider 30 is 'lifted' in relation to the second pumping assembly 10 and *vice versa*.

[0071] Although the above embodiments are shown and have been described in relation to a pumping assembly without a tappet, it is possible to extend the invention to a tappet installation. In this case, each flat surface 34 of the rider 30 would contact a tappet which in turn would contact the bottom end 12a of the plunger 12 (in much the same arrangement as shown in Figure 1).

[0072] The choice of angle F has a significant impact of the range of movement of the plunger 12. In particular, a shallower angle F appears to increase the range of movement, which in turn increases the pump capacity. The examples discussed above are based upon a rider journal 24/ rear bearing 26 throw T of 8 mm due to the enlarged rear bearing 26 and the stroke-increasing arrangement 40 aims to compensate for the loss of plunger lift. However, it has been shown that a greater throw T of 10.5 mm, e.g. little or no enlargement of the rear bearing 26, greater pump capacities could be achieved. As the throw T increases, the pump capacity increases exponentially with an increase in angle F.

[0073] With the above arrangement, it is possible to increase pump capacity only with the replacement of two angled members 41, 42, which allows the rear bearing 26 of the driveshaft 22 to be upsized where necessary. The tappet and associated sleeve may also be removed, which improves on the packaging efficiency of the pump. Since there is also a large increase in the area of sliding surfaces 41a-c and 42a-c, the durability of those surfaces is significantly increased, which may allow removal of any durable coatings which add to the cost of manufacturing of sliding parts. Furthermore, since driving movement is translated to be along the pumping axis A-A' before it reaches the plunger 12, plunger side-load is removed and as such, a narrower plunger with high lift could be used to deliver a higher volumetric efficiency.

The arrangement will also support a second pumping assembly 10 incorporated on an opposing side of the rider 30 to double the capacity of the pump. This can either be located so as to be side-by-side with the first pumping assembly, or opposite the first pumping assembly, or even at a different angled orientation (in the latter case with an adapted rider 30). In a side-by-side arrangement, it could be possible to fit one long high pressure dual-head with one high pressure outlet.

[0074] 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

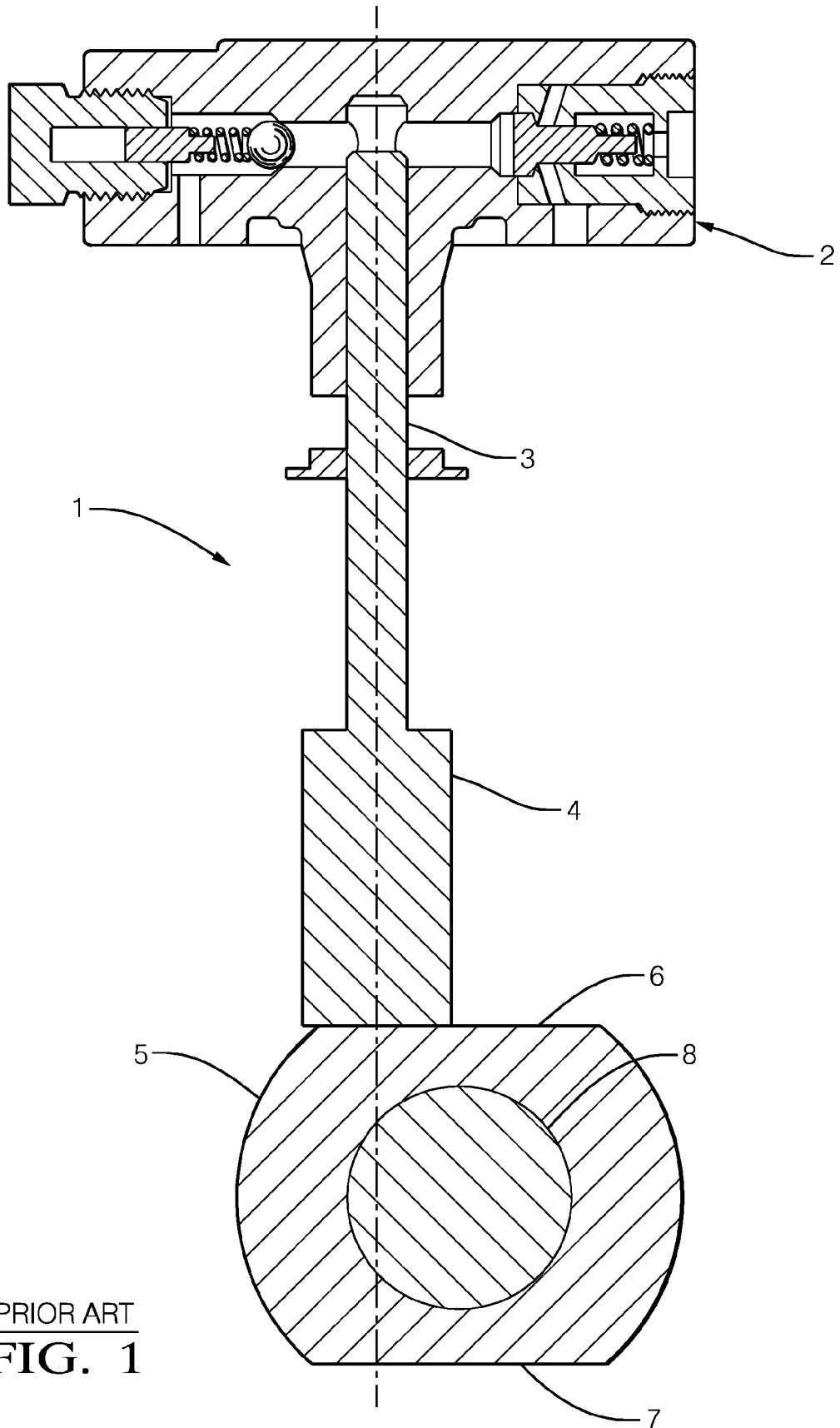
1. A high pressure fuel pump comprising at least one pumping assembly (10) and a drive assembly (20), the or each pumping assembly (10) comprising a plunger (12) arranged for reciprocal movement along a pumping axis (A-A'), the drive assembly (20) comprising a drive means and a driveshaft (22) comprising a rider journal (24) adjoined to a front bearing (25) and a rear bearing (26), the rider journal (24) and at least the rear bearing (26) comprising offset axes (B-B', C-C') relative to one another, a rider (30) fitted on said rider journal (24) to effect movement of the rider (30) along an eccentric rotational path, wherein the rider (30) comprises at least one outwardly facing flat surface (34) for cooperation with said pumping assembly (10), **characterised in that** the drive assembly (20) comprises a stroke-increasing arrangement (40) disposed between the rider (30) and the pumping assembly (10).
2. The pump according to claim 1, wherein the drive assembly (20) comprises an enlarged rear bearing (26).
3. The pump according to any one of claims 1 or 2, wherein the stroke-increasing arrangement (40) comprises at least two angled members (41, 42) configured to translate movement along a first axis (D-D') to along a second axis (A-A').
4. The pump according to claim 3, wherein the first axis (D-D') is substantially the same as a rider (30) reciprocating axis (D-D') and the second axis (A-A') is substantially the same as the pumping axis (A-A').
5. The pump according to any one of claims 3 or 4, wherein each angled member (41, 42) comprises at least one substantially planar contact face (41a, 42a) for contact with one other angled member (41, 42) and configured to be disposed at an angle (F) to both the first axis (D-D') and the second axis (A-A').
6. The pump according to claim 5, wherein the angle (F) is approximately between 30° and approximately 70°.
7. The pump according to any one of claims 1 to 6, wherein two of the angled members (41, 42) comprise a substantially planar engagement face (41b, 42b) for engaging a driving component (30) of the drive assembly (20), or a driven component (12) of the pumping assembly (10).
8. The pump according to claim 7, wherein the plane

of the engagement face (41b) of a first angled member (41) is provided in a first orientation substantially perpendicular to the first/ rider reciprocating axis (D-D') and the plane of the engagement face (41b) of a second angled member (42) is provided in a second orientation substantially perpendicular to the second/ pumping axis (A-A').

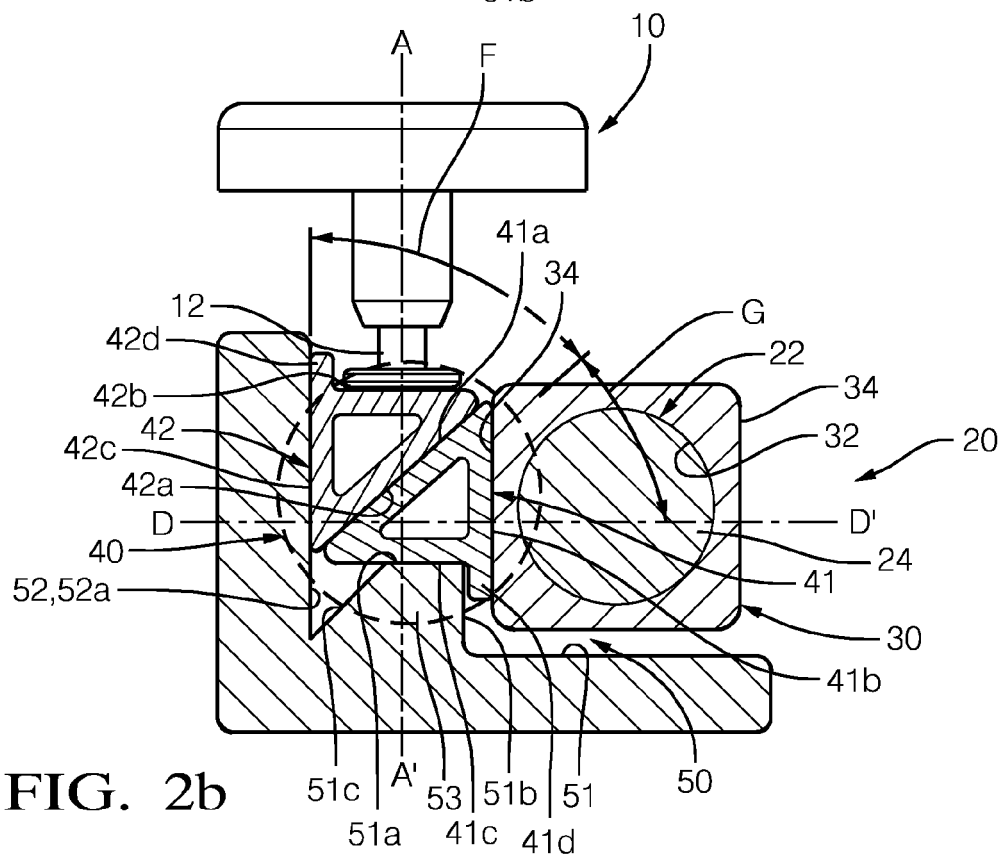
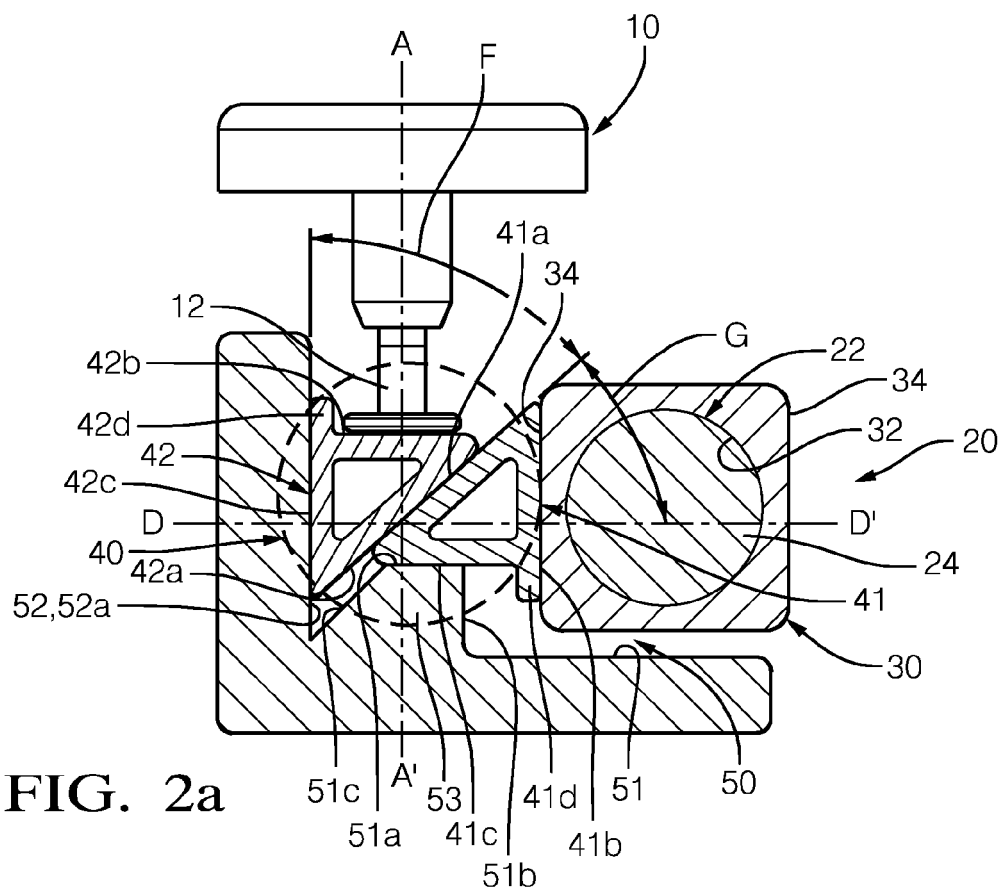
9. The pump according to any one of claims 1 to 8, wherein two of the angled members (41, 42) comprise a guided face (41c, 42c) provided at angle (F) to that of its respective contact face (41a, 42a) for guided sliding contact with a guiding face (41c, 42c) provided by the drive housing.
10. The pump according to any one of claims 1 to 9, wherein the angled members (41, 42) comprise a substantially triangular cross-section.
11. The pump according to any one of claims 9 or 10, wherein the drive housing comprises an adapted chamber (50) disposed between the rider (30) and the plunger (12) comprising at least two guiding faces (51a, 52a) for contact with said guided faces (41c, 42c) of the angled members (41, 42).
12. The pump according to claim 11, wherein the chamber (50) comprises a first guiding face (51a) substantially parallel with the first/ reciprocating rider axis (D-D') provided by a protrusion (53) from a first chamber (50) wall and a second guiding face (52a) substantially parallel with the second/ pumping axis (A-A') and provided by a second chamber wall (52).
13. The pump according to claim 12, wherein the first guided face (41c) is configured to partially overhang the first guiding face (51a).
14. The pump according to claim 13, wherein the protrusion (53) comprises a sloped trailing face (51c) shaped to drop away before an end of the first chamber wall (51) and/or before meeting the second chamber wall (52).
15. The pump according to any one of claims 5 to 14, wherein the angled members (41, 42) are interchangeable with other angled members comprising a different angle (F).

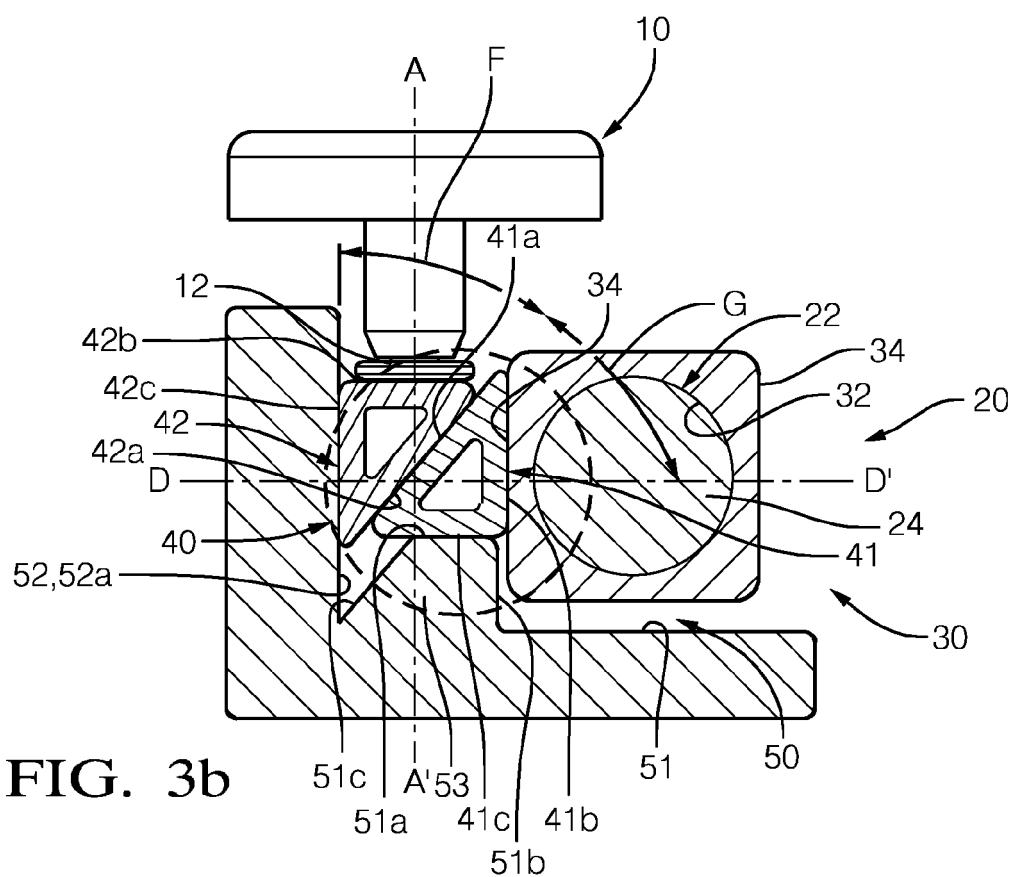
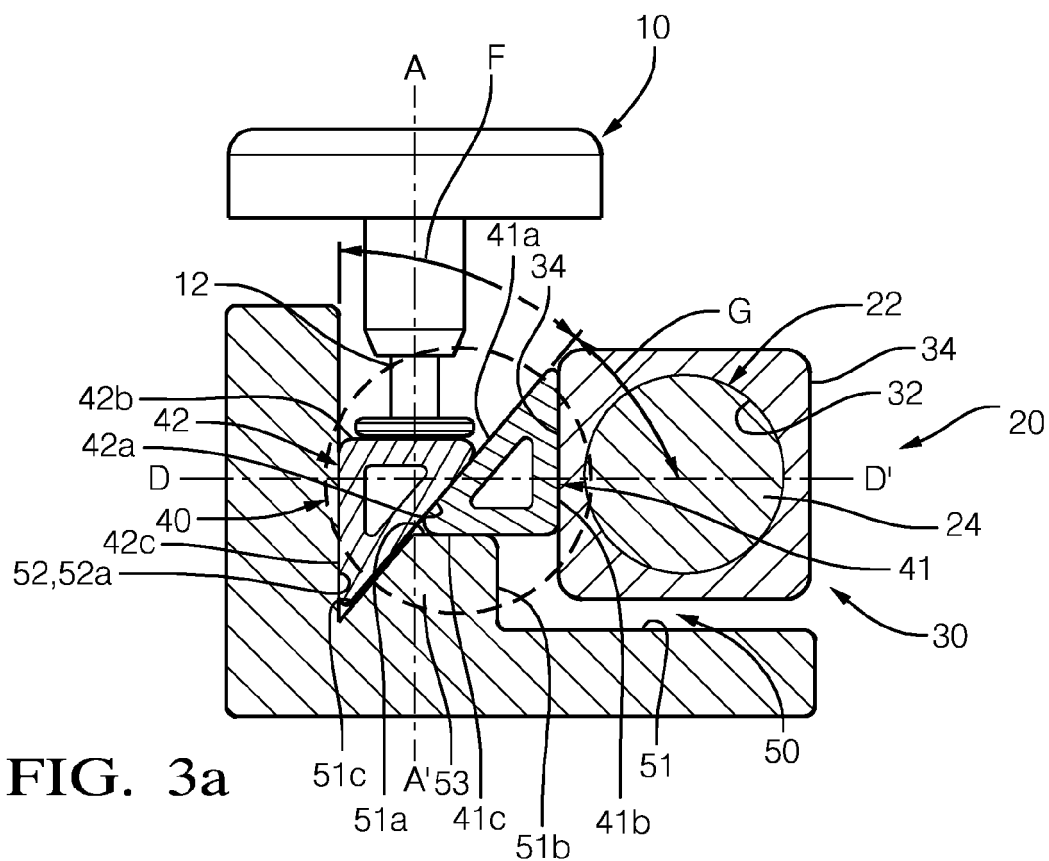
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PRIOR ART
FIG. 1





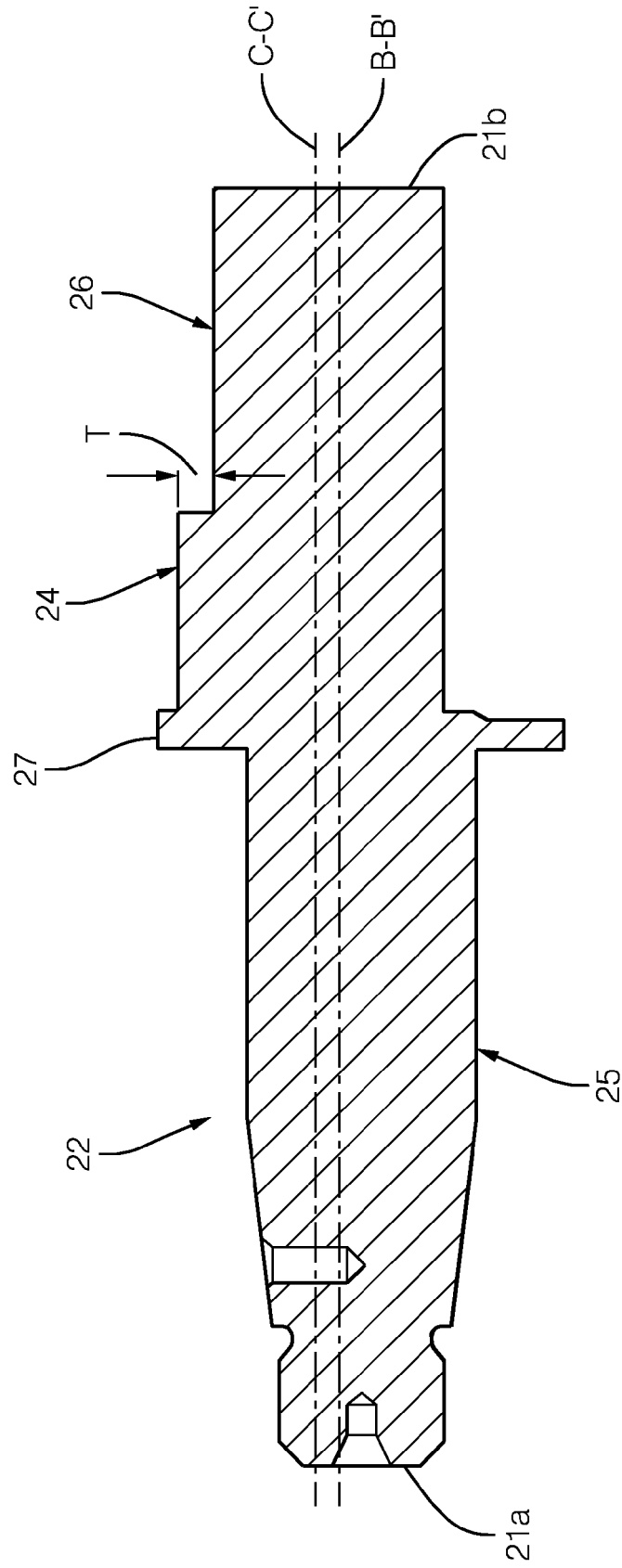


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
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A	* column 1, line 5 - line 17 * * column 4, line 10 - line 44 * * column 5, line 13 - line 36 * * claim 1; figures 1-5 *	3-15	
X,P	WO 2016/096205 A1 (DELPHI INTERNAT OPERATIONS LUXEMBOURG S À R L [LU]) 23 June 2016 (2016-06-23) * page 1, line 4 - line 6 * * page 2, line 19 - line 22 * * page 10, line 1 - page 11, line 6 * * claim 1; figures 1-2,4 *	1,2	
X	EP 1 767 771 A1 (DENSO CORP [JP]) 28 March 2007 (2007-03-28)	1,2	
A	* paragraph [0001] * * paragraphs [0010] - [0013] * * claim 1; figures 2-3 *	3-15	TECHNICAL FIELDS SEARCHED (IPC)
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Place of search Munich		Date of completion of the search 10 January 2017	Examiner Nicolai, Sébastien
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