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(71) Applicant: **DELPHI INTERNATIONAL OPERATIONS LUXEMBOURG S.À R.L.** [LU/LU]; Avenue de Luxembourg, 4940 Bascharage (LU).

(72) Inventors: **EMERY, Charlie**; c/o Delphi Diesel Systems, Courteney Road, Hoath Way, Gillingham KENT ME8 0RU (GB). **MCHATTIE, James**; 20 School Lane, Bean Kent DA2 8AL (GB).

(74) Agent: **DELPHI FRANCE SAS**; Bâtiment le Raspail - ZAC Paris Nord 2, 22 avenue des Nations, CS65059 Villepinte, 95972 Roissy CDG Cedex (FR).

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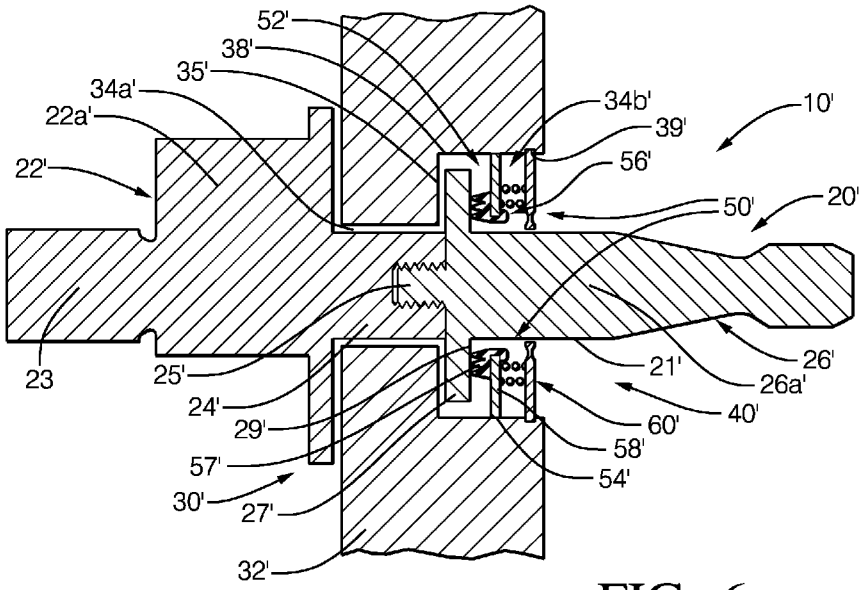


FIG. 6

(57) **Abstract**: The invention relates to a high pressure diesel fuel pump comprising a drivetrain assembly having a driveshaft, a drive chamber isolated from external chamber surroundings by a chamber wall having a bearing, and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft. The seal arrangement comprises a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face. The seal arrangement further comprises a pressure member adapted to force the sealing member against the axial face. The invention also extends to a drivetrain assembly, a sealing arrangement and an adapted driveshaft.

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HIGH PRESSURE FUEL PUMPS

BACKGROUND

Technical Field

The present invention relates generally to the field of high pressure fuel pumps. More particularly, but not exclusively, the present invention concerns driveshaft seals for high pressure diesel fuel pumps.

Description of the Related Art

In a high pressure fuel pump, the rotation of a driveshaft is translated into reciprocal movement of one or more plungers along a pumping axis by a cam arrangement on the driveshaft. The driveshaft comprises a front end and a rear end. The rear end of the driveshaft generally comprises a rear journal for the cam arrangement and is housed within a drive chamber, whilst the front end of the driveshaft is located externally of the drive chamber. The drive chamber is isolated from the external surroundings by a front chamber wall with a bearing therein, through which the driveshaft passes. The bearing provides a clearance fit with the driveshaft to minimise fluid communication between the drive chamber and the external surroundings.

Whilst the clearance between the driveshaft and the front chamber wall bearing is minimal, a driveshaft seal is required to prevent fuel from leaking from the drive chamber to the external surroundings of a fuel pump. Where fuel is permitted to leak to the external surroundings of a pump, it is considered to be a serious incident. As such, a driveshaft seal typically extends between the driveshaft and the bearing in the front chamber wall to close the gap and prevent fuel leakage.

Known existing seals are generally flexible radial seals, which engage with a radial face of the driveshaft and a radial face of the front chamber wall bearing to close the gap between the front chamber wall bearing and the circumference of the driveshaft.

However, as engine power ratings increase, there is a greater demand for high chain/belt tensions. As shown in Figure 1, these increased tensions increase the

side load 2 on the driveshaft 1, causing the driveshaft 1 to be pulled to one side and in turn bear strongly against one side 3a of a radial seal 3. This impact on one side 3a of a seal 3 causes the seal 3 to stretch and deform into an elliptical shape, which eventually leads to breaking of the seal 3 on the impacted side 3a. On the opposite side of the driveshaft 1, the seal 3 fails to function as it leaves a gap 4.

One improvement in the area of driveshaft seals is to provide an axial seal, where instead of the seal engaging with radial faces of the driveshaft and the bearing, the seal engages with an axial face of the front chamber wall bearing. However, such known seals are thought to be insufficient at maintaining the sealing interface with the axial face.

One such example of an axial seal is a V-ring seal available from SKF, for multiple sealing purposes, but not specifically adapted for diesel engines. As seen in Figure 2, the v-ring 6 forms a radial interference fit with a circumferential entity 7 and a contact sealing interface with an axial face 8a of a surrounding wall 8 providing a bearing 9 around the circumferential entity 7. The SKF V-ring 6 relies on the stiffness of the seal material to continue to apply sealing pressure to the axial face 8a. However, if the circumferential entity 7 skews, such a seal 6 is found to be insufficient to maintain the sealing interface with the axial face 8a and the seal 6 may fail.

Accordingly, the aim is to provide an axial-acting seal whose sealing ability is not compromised by the effects of a high side load applied to the driveshaft.

Therefore, it is now desired to provide an improved arrangement for high pressure diesel fuel pump to minimise the effects of a high side load on a driveshaft seal.

SUMMARY OF THE INVENTION

In a first aspect of the present invention there is provided a high pressure diesel fuel pump comprising a drivetrain assembly having a driveshaft, a drive chamber isolated from external chamber surroundings by a chamber wall having a bearing, and a seal arrangement adapted to provide a sealing interface between the bearing

and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the sealing member comprises a plurality of circumferential sealing ridges.

With this arrangement, the combination of the action of the pressure member and the sealing ridges ensures that even when the driveshaft skews in the bearing due to application of a high side load, the sealing member can remain in sealing contact with the axial face as opposed to drifting away and compromising the seal.

Preferably, the sealing ridges comprise a suitable sealing material. The sealing material preferably comprises a synthetic rubber, e.g. Viton® or PTFE.

Preferably, the seal (at least the retaining member) comprises an integrally-formed member. Preferably, the integrally-formed member comprises a metallic ring.

Preferably, the sealing member comprises a back support for the sealing ridges. Preferably, the back support comprises part of the integrally-formed metallic ring. Preferably, the suitable sealing material of the sealing ridges is bonded to the metallic ring.

Preferably, the pressure member comprises a resiliently flexible annular part.

The pressure member may comprise part of the integrally-formed member. Accordingly, the pressure member may comprise part of the integrally-formed metallic ring and may connect the retaining member with the sealing member. Therefore, the pressure member may be sprung to provide an axial distance between the retaining member and the sealing member, so as to naturally force the sealing member axially away from the retaining member (and therefore, against the axial face). The flexible member may therefore, comprise a sprung material, e.g. spring steel. The sprung material may be sufficiently thin to be flexible over a small diameter.

Where the sealing arrangement comprises an integrated pressure member, e.g. the pressure member formed as part of the seal described above, the axial face may comprise a part of the chamber wall and the radial face may comprise a circumferential wall of the driveshaft. Alternatively, the axial face may comprise an axial wall provided by an adapted driveshaft and the radial face may comprise a part of the chamber wall, e.g. a radial part.

However, preferably, the pressure member comprises an additional separate component to the seal. Preferably, the separate pressure member comprises a sprung component adapted for disposal behind the seal, e.g. on the opposite side of the seal to the axial face with which the sealing member forms the sealing interface. Preferably, the sprung component comprises a resiliently flexible annular member. Preferably, the sprung component comprises a metallic ring.

Preferably, the sprung component comprises an anchoring means adapted to anchor the sprung component to the chamber wall or the driveshaft.

Preferably therefore, the anchoring means comprises an anchor fitted to a radial face of either the chamber wall or the driveshaft, most preferably, the chamber wall. The anchor may comprise a circumferential press-fitted part into a radial face. Preferably, the anchoring means comprises a circlip arrangement with the radial face. Therefore, the anchoring means preferably comprises a circumferential groove in said radial face. Preferably, the anchor comprises a lip adapted to be retained in a circumferential groove of the radial face. Preferably, the lip and the groove have a rotating relationship, such that the lip slides circumferentially within the groove.

Preferably, the sprung component of the pressure member comprises a free inner circumference, e.g. not anchored, but floating around the driveshaft.

Preferably, the sprung component comprises a spring means. Preferably, the spring means is provided on said annular member so as to be disposed behind the sealing member of the seal. Preferably, the spring means is located inwardly of the free inner circumference. Preferably, the spring means comprises a plurality of springs. Preferably, the springs are disposed substantially equally around the

circumference of the sprung component. Preferably, the spring means are adapted to locate in locating means in the back support of the sealing member. The locating means may comprise one or more spring pockets or hollows each locating a single spring. Alternatively, the locating means may comprise one or more channels each locating a plurality of springs, e.g. in groups, or the full set.

Preferably, the driveshaft comprises a rear end housed within the drive chamber, an intermediate portion located within the bearing and a front end located in the external surroundings.

Where the sealing arrangement comprises a separate pressure member, the seal may be retained in the chamber wall and the axial face may comprise a radially projecting flange provided on the front end of the driveshaft adjacent the intermediate portion and the radial face comprises a part of the chamber wall. Accordingly, the chamber wall preferably provides a stepped bearing, e.g. having different first and second diameters, with an internal axial face and first and second radial faces depending from first and second ends of the axial face. In this case, the second radial face forms the second diameter of the bearing and comprises the face for cooperation with an anchor of the sprung member. However, an arrangement without the flange is also anticipated, wherein the seal may be retained on the driveshaft and the axial face may comprise a part of the chamber wall.

With the features described in the above alternatives, the sealing ridges interface with the axial face of the driveshaft flange or the chamber wall to create a floating seal, as the sealing member is capable of moving/ flexing relative to the axis of the driveshaft (assisted by the resiliently flexible pressure member, either integrated or separate) and around the axial face whilst maintaining contact, even in the event of the driveshaft being pulled to one side.

Preferably, the driveshaft flange comprises at least a coating of suitable sealing material, e.g. a synthetic rubber, such as Viton® or PTFE. Preferably, in order to aid assembly of the adapted driveshaft in the drive chamber/ chamber wall bearing, the driveshaft comprises two parts. Preferably, the front end of the

driveshaft having the flange comprises a first part and is screwed, or otherwise attached to the thread to the intermediate portion and rear end (second part).

Preferably, to aid fluid flow evacuation, the driveshaft comprises a central axial drilling therethrough. Alternatively, the chamber wall may comprise a drilling therethrough.

In a second aspect of the present invention there is provided a high pressure diesel fuel pump comprising a drivetrain assembly having a driveshaft, a drive chamber isolated from external chamber surroundings by a chamber wall having a bearing, and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, characterised in that the seal further comprises an integrally-formed pressure member with said retaining member and said sealing member, adapted to force the sealing member against the axial face.

By 'integrally-formed' what is meant is formed together or bonded together, e.g. not separate parts assembled together.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the second aspect of the invention.

In a third aspect of the present invention there is provided a high pressure diesel fuel pump comprising a drivetrain assembly having a driveshaft, a drive chamber isolated from external chamber surroundings by a chamber wall having a bearing, and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the pressure member comprises a separate sprung component adapted for assembly behind the seal.

Preferably, the sprung component is adapted for only a single point of contact with the seal. Preferably, the sprung component is adapted for contact with a rear face of the sealing member.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the third aspect of the invention.

In a fourth aspect of the present invention there is provided a drivetrain assembly for a high pressure diesel fuel pump comprising: a driveshaft for assembly within a bearing of a chamber wall between a drive chamber and external chamber surroundings; and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the sealing member comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the fourth aspect of the invention.

In a fifth aspect of the present invention there is provided a drivetrain assembly for a high pressure diesel fuel pump comprising: a driveshaft for assembly within a bearing of a chamber wall between a drive chamber and external chamber surroundings; and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, characterised in that the seal further comprises an integrally-formed pressure member with said retaining member and said sealing member adapted to force the sealing member against the axial face.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the fifth aspect of the invention.

In a sixth aspect of the present invention there is provided a drivetrain assembly for a high pressure diesel fuel pump comprising: a driveshaft for assembly within a bearing of a chamber wall between a drive chamber and external chamber surroundings; and a seal arrangement adapted to provide a sealing interface between the bearing and the driveshaft, the seal arrangement comprising a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the pressure member comprises a separate sprung component adapted for assembly behind the seal.

Preferably, the sprung component is adapted for only a single point of contact with the seal. Preferably, the sprung component is adapted for contact with a rear face of the sealing member.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the sixth aspect of the invention.

In a seventh aspect of the present invention there is provided a seal arrangement for a drivetrain assembly of a high pressure diesel fuel pump, the seal arrangement being adapted to provide a sealing interface between a bearing in a chamber wall and a driveshaft, the arrangement comprising: a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the sealing member comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the seventh aspect of the invention.

In an eighth aspect of the present invention there is provided a seal arrangement for a drivetrain assembly of a high pressure diesel fuel pump, the seal arrangement being adapted to provide a sealing interface between a bearing in a chamber wall and a driveshaft, the arrangement comprising: a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the seal further comprises an integrally-formed pressure member with said retaining member and said sealing member, adapted to force the sealing member against the axial face.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the eighth aspect of the invention.

In a ninth aspect of the present invention there is provided a seal arrangement for a drivetrain assembly of a high pressure diesel fuel pump, the seal arrangement being adapted to provide a sealing interface between a bearing in a chamber wall and a driveshaft, the arrangement comprising: a seal having a retaining member adapted to fit with a radial face and a sealing member adapted to provide the sealing interface with an axial face, the seal arrangement further comprising a pressure member adapted to force the sealing member against the axial face, characterised in that the pressure member comprises a separate sprung component adapted for assembly behind the seal.

Preferably, the sprung component is adapted for only a single point of contact with the seal. Preferably, the sprung component is adapted for contact with a rear face of the sealing member.

Preferably, the sealing means comprises a plurality of circumferential sealing ridges.

It will be appreciated that the relevant preferred features described in relation to the first aspect of the invention apply to the ninth aspect of the invention.

In a tenth aspect of the present invention there is provided a driveshaft for a drivetrain assembly of a high pressure diesel fuel pump, the driveshaft comprising a rear end adapted to be housed within a drive chamber, an intermediate portion adapted to be located within a bearing in a chamber wall and a front end adapted to be located externally of the drive chamber, characterised in that the front end of the driveshaft comprises a radially projecting flange adjacent the intermediate portion.

Preferably, the driveshaft is formed in two parts adapted to be removably attached to one another.

It will be appreciated that the relevant preferred features described in relation to all of the previous aspects of the invention apply to the tenth aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

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 cross-sectional view of a driveshaft and with a **prior art** radial seal during high side loads;

Figure 2 is a cross-sectional side view of a **prior art** axial seal 6 in use;

Figure 3 is a cross-sectional partial side view of a first embodiment of a drivetrain assembly of a high pressure fuel diesel pump according to the invention;

Figure 4 is a schematic front view of the seal arrangement of the drivetrain assembly of Figure 3;

Figure 5 is a schematic rear view of the seal arrangement of the drivetrain assembly of Figure 3;

Figure 6 is a cross-sectional partial side view of a second embodiment of a drivetrain assembly of a high pressure fuel diesel pump according to the invention;

Figure 7 is a close-up cross-sectional partial side view of the seal arrangement of Figure 6 *in situ*;

Figure 8 is a schematic front view of the seal of the seal arrangement of the drivetrain assembly of Figure 6; and

Figure 9 is a schematic front view of a sprung component of the seal arrangement of Figure 7.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

Figures 3 to 9 show embodiments of the present invention in which a high pressure diesel fuel pump (not shown) comprises a drivetrain assembly 10, 10' having a driveshaft 20, 20', a drive chamber 30, 30' isolated from external chamber surroundings 40, 40' by a chamber wall 32, 32' having a bearing 34, 34' therethrough, and a seal arrangement 50, 50' adapted to provide a sealing interface between the bearing 34, 34' and the driveshaft 20, 20', the seal arrangement 50, 50' comprising a seal 52, 52' having a retaining member 54, 54' adapted to fit with a radial face 28, 38' and a sealing member 56, 56' adapted to provide a sealing interface with an axial face 29, 35', characterised in that the seal arrangement 50, 50' further comprises a pressure member 60, 60' adapted to force the sealing member 56, 56' against the axial face 29, 35'.

The drive chamber 30, 30' typically provides a substantially upright front chamber wall 32, 32' to divide the chamber 30, 30' from the external surroundings of the pump. A typical chamber wall 32, 32' comprises a stepped

bearing 34, 34' therethrough between the drive chamber 30, 30' and the external surroundings 40, 40' having a series of two bores 34a/34a', 34b/34b' with different concentric diameters. In other words, the diameter of the bearing 34, 34' is smaller adjacent the drive chamber 30, 30' (a first part 34a, 34a') and wider adjacent the external surroundings 40, 40' (a second part 34b, 34b'). A substantially upright axial face 35, 35' provides an immediate transition between the two diameters of the bearing 34, 34'.

In both embodiments, the driveshaft 20, 20' comprises a rear end 22, 22' housed within the drive chamber (30, 30'), an intermediate portion (24, 24') located within the bearing (34, 34') and a front end (26, 26') located in the external surroundings (40, 40'). The driveshaft 20, 20' comprises a typical construction having a rear journal 22a, 22a' at the rear end 22, 22' for accommodating a cam arrangement (not shown) for providing the pumping motion along a pumping axis (not shown). Following the rear journal 22a, 22a' is an intermediate portion 24, 24', which is axially offset to, and usually of smaller diameter than that of the rear journal 22a, 22a'. The intermediate portion 24, 24' typically forms part of the front end 26, 26' of the driveshaft 20, 20', but for the purposes of the present invention, is identified separately. The intermediate portion 24, 24' is axially concentric with, and usually of similar/ same diameter to that of a front journal 26a, 26a' of the front end 26, 26'. The front end 26, 26' is attached to a drive mechanism (not shown) for rotation of the driveshaft 20, 20'.

During assembly of the driveshaft 20, 20' in the drive chamber 30, 30', the front end 26, 26' of the driveshaft 20, 20' is typically passed through the bearing 34, 34' from the drive chamber 20, 20' until the rear journal 22a, 22a' abuts the (internal) chamber wall 32, 32'. As such, the rear journal 22a, 22a' is located inside the drive chamber 30, 30' and the front end 26, 26' of the driveshaft 20, 20' with the majority of the front journal 26a, 26a' is located in the external surroundings 40, 40' (outside the drive chamber 30, 30'). The narrower intermediate portion 24, 24' is located within the first part of the bearing 34a, 34a' and an immediately adjacent portion of the front journal 26a, 26a' is located within the second part of the bearing 34b, 34b'.

As shown in Figures 3 to 5, this typical driveshaft 20 arrangement is adopted with the addition of a drilling 23 disposed centrally through the rear end 22 and the intermediate portion 24 of the driveshaft 20 and extending radially outwardly therefrom to open to the second part of the bearing 34b adjacent the axial face 35 of the chamber wall 32. This drilling 23 provides a means for evacuation of fluid leaking through the bearing 34a back to the drive chamber 30.

However, in a preferred alternative embodiment shown in Figures 6 to 9, the driveshaft 20' is formed in two separate parts: a first part comprises the rear end 22' and the intermediate portion 24'; and a second part comprises the front journal 26a' of the front end 26'. The two parts are connected together by a projecting screw and cooperating threaded aperture 25' disposed on a common axis shared by the front journal 26a' and the intermediate portion 24'. The second part of the driveshaft 20' comprises a projecting annular flange 27' disposed between the screw and the front journal 26a' of wider diameter that that of the intermediate portion 24' and the first part of the bearing 34a'. As such, the flange 27' cannot pass through or beyond the first part of the bearing 34a'. The intermediate portion 24' is therefore sized appropriately such that the flange 27' sits close to the axial face 35' of the chamber wall 32' and within the second part of the bearing 34b' along with a portion of the front bearing 26a'. Accordingly, any axial movement of the driveshaft 20' within the bearing 34' is limited.

Returning to the first embodiment as shown in Figures 3 to 5, the seal 52 comprises an integrally-formed, substantially disc-shaped part comprising the retaining member 54, the pressure member 60 and the sealing member 56. The retaining member 54 comprises a short tubular portion located centrally of the part that is adapted and sized to provide an interference fit with the radial face 28 of the driveshaft 20. An annular disc 58 projects outwardly of the tubular retaining member 54 at a front end thereof to form the pressure member 60. At an outer end of the pressure member 60, the sealing member 56 is provided, comprising a plurality of forwardly projecting sealing ridges 57.

The integrally-formed seal 52 comprises a sprung material and most specifically a spring steel. The pressure member 60 comprises a sufficiently thin spring steel in order to be flexible over a relatively small diameter. The pressure member 60 is

naturally biased to extend with a forward lean, e.g. to present the sealing member 56 forwardly of the front end of the retaining member 54. The ridges 57 of the sealing member 56 are formed from a suitable sealing material, such as a synthetic rubber material and specifically, either Viton ® or PTFE.

The diameter of the seal 52 is sufficiently large so as to cover at least approximately 70% of the diameter of the second part of the bearing 34b.

In use, the interference fit of the tubular retaining member 54 around the front journal 26a of the driveshaft 20 ensures that the position of the seal arrangement 50 relative to a longitudinal axis of the driveshaft 20 is substantially fixed. Since the seal arrangement 50 is only fixed relative to the driveshaft 20, the seal arrangement 50 'floats' in respect of the axial face 35. Accordingly, even in the event that the driveshaft 20 skews or shifts axially in the bearing 34, the forwardly biased pressure member 60 naturally forces the sealing member 56 forwardly (accommodated by the flexibility of the connecting member 58), such that when the retaining member 54 is located close to the axial face 35 of the chamber wall 32, the sealing ridges 57 are pressed against the face 35 to create and retain the reliable sealing interface therewith. The large diameter of the seal 52 provides a significant cavity within the second part of the bearing 34b between the seal 52 and the axial face 35 to allow fluid to access the drilling 23 and be directed back to the drive chamber 30. Alternatively, fluid evacuation may be effected by a drilling in the chamber wall 32.

Turning to the second embodiment as shown in Figures 6 to 8, the seal arrangement 50' comprises two parts: the seal 52' and a separate pressure member 60'.

The pressure member 60' (Figure 9) comprises an integrally-formed, substantially annular-shaped body 61'. The member 60' comprises an anchor 62' forming a circlip arrangement in the form of a lip on the outer periphery of the body 61' for disposal within a groove 39' (Figures 6 and 7) in the radial face 38' of the chamber wall 32'. Alternatively, the anchor 62' can form a circumferential ring disposed on an outer periphery of the body 61' and adapted to be press-fitted into the radial face 38' chamber wall 32'.

The member 60' further comprises a an inner boundary 64' of the body 61' adapted to 'float' around the front journal 26a' of the driveshaft 20'. In other words, the inner boundary 64' of the body 61' does not make contact with the driveshaft 20'. An annular connecting portion 68' extends between the anchor 62' and the inner boundary 64'. Inwardly of, and adjacent to the inner boundary 64', there are a plurality of forwardly protruding springs 66' seated concentrically and substantially equally around the body 61'.

It is to be appreciated that the mechanisms of the anchor and the floating boundary 64' of the pressure member 60' could potentially be provided the other way around.

The body 61' of the pressure member 60' comprises a sprung material and most specifically a spring steel.

The seal 52' (Figure 8) comprises an integrally-formed, substantially disc-shaped body 53'; comprising the retaining member 54', the sealing member 56' and a connecting member 58' therebetween. The retaining member 54' comprises a short annular portion located outwardly of the body 53', and adapted and sized to be press-fitted into the radial face 38' of the second part of the bearing 34b'. The connecting member 58' comprises an annular disc projecting inwardly of the retaining member 54' at a front end thereof. At an inwardly disposed end of the connecting member 58', the sealing member 56' is provided, comprising a plurality of forwardly projecting sealing ridges 57'. Behind the sealing member 56' there is provided a seat or back support member 55' in the form of a back plate for receiving the plurality of springs 66' of the pressure member 60' (shown in Figure 7). The seat member 55' comprises one or more receiving hollows (not shown) to retain the radial position of the springs and prevent slippage of the springs 66' outwardly or inwardly of the seat member 55'.

The integrally-formed seal 52' comprises a sprung material and most specifically a spring steel. The connecting member 58' comprises a sufficiently thin spring steel in order to be flexible over a relatively small diameter. The ridges 57' of the sealing member 56' are formed from a sealing material, such as a synthetic rubber material and specifically, either Viton ® or PTFE.

In use, the pressure member 60' is firmly positioned between the driveshaft 20' and the second part of the bearing 34b' via the anchor 62'. The seal 52' is positioned in front of the pressure member 60' with the retaining member 54' press-fitted into the second bearing 34b'. The location of the seal 52' relative to the flange 27' of the driveshaft 20' is carefully chosen such that when the flange 27' is pressed firmly against the axial face 35' of the chamber wall 32' the sealing ridges 57' provide an effective sealing interface. The location of the pressure member 60' relative to the seal 52' is chosen such that the springs 66' are firmly seated behind the sealing ridges 57' of the sealing member 56' in the seat member 55' in compressed condition.

As the driveshaft 20' moves within the bearing 34' the pressure member 60' floats around the driveshaft 20', but is retained in axial position relatively thereto, by the anchor 62'. Since the seal 52' is only fixed relative to the bearing 34b', the seal 52' 'floats' in respect of the axial face 29' of the driveshaft 20' flange 27'. Accordingly, even in the event that the driveshaft 20 skews or shifts axially in the bearing 34', the springs 66' of the pressure member 60' naturally forces the sealing member 56' of the seal 52' forwardly (accommodated by the flexibility of the connecting member 58'), such that the sealing ridges 57' are always pressed against the face axial 35' to create and retain the reliable sealing interface.

A drilling (not shown) in the chamber wall 32' allows fluid to be evacuated back to the drive chamber 30'.

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 diesel fuel pump comprising a drivetrain assembly having a driveshaft (20, 20'), a drive chamber (30, 30') isolated from external chamber surroundings (40, 40') by a chamber wall (32, 32') having a bearing (34, 34'), and a seal arrangement (50, 50') adapted to provide a sealing interface between the bearing (34, 34') and the driveshaft (20, 20'), the seal arrangement (50, 50') comprising a seal (52, 52') having a retaining member (54, 54') adapted to fit with a radial face (28, 38') and a sealing member (56, 56') adapted to provide the sealing interface with an axial face (35, 29'), the seal arrangement (50, 50') further comprising a pressure member (60, 60') adapted to force the sealing member (56, 56') against the axial face (35, 29'), characterised in that the sealing member (56, 56') comprises a plurality of circumferential sealing ridges (57, 57'),

   wherein the sealing ridges (57, 57') comprise a synthetic rubber,

   wherein the seal (52, 52') comprises an integrally-formed metallic ring,

   wherein the sealing member (56, 56') comprises a back support (55, 55') for the sealing ridges (57, 57'), which comprises part of the integrally-formed metallic ring.

2. The pump according to any one of claims 1, characterised in that the pressure member (60, 60') comprises a resiliently flexible annular part.

3. The pump according to claim 2, characterised in that the pressure member (60, 60') comprises part of the integrally-formed metallic ring.

4. The pump according to any one of claims 2 to 3, characterised in that the pressure member (60, 60') is sprung to provide an axial distance between the retaining member (54, 54') and the sealing member (56, 56'), so as to naturally force the sealing member (56, 56') axially away from the retaining member (54, 54') (and therefore, against the axial face (35, 29')).

5. The pump according to any one of claims 3 to 4, characterised in that where the sealing arrangement comprises an integrated pressure member (60, 60'), the axial face (35, 29') comprises a part of the chamber wall (32, 32') and the radial face (28, 38') comprises a circumferential wall of the driveshaft (20, 20').

6. The pump according to any one of claims 1, characterised in that the pressure member (60, 60') comprises an additional separate component to the seal (52, 52') adapted for disposal behind the seal (52, 52').

7. The pump according to claim 6, characterised in that the pressure member comprises a sprung component comprising an anchoring means adapted to anchor the sprung component to the chamber wall (32, 32') or the driveshaft (20, 20').

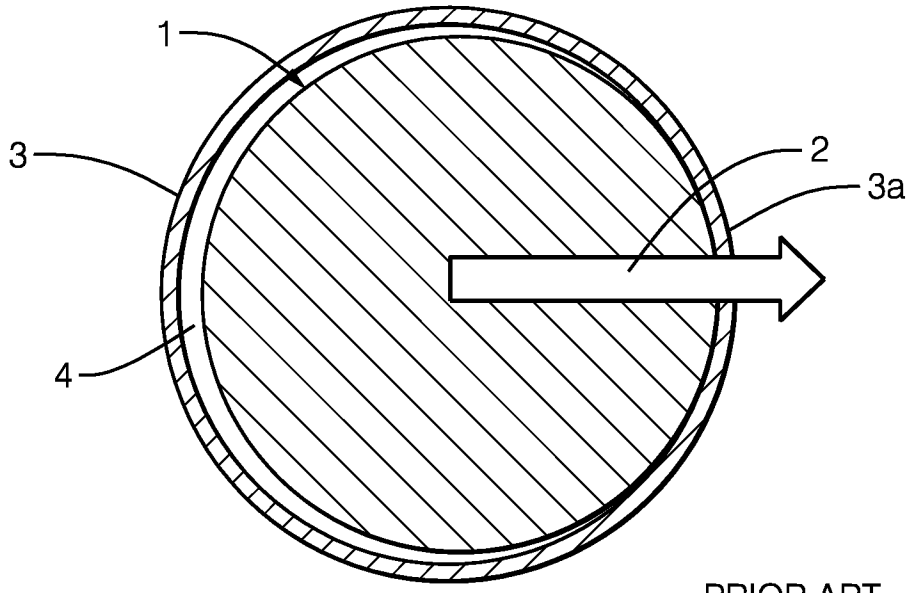
8. The pump according to claim 7, characterised in that the anchoring means comprises an anchor (62, 62') fitted to a radial face (28, 38') of the chamber wall (32, 32').

9. The pump according to any one of claims 7 to 8, characterised in that the sprung component of the pressure member (60, 60') comprises a free inner circumference (64'), e.g. not anchored, but floating around the driveshaft (20').

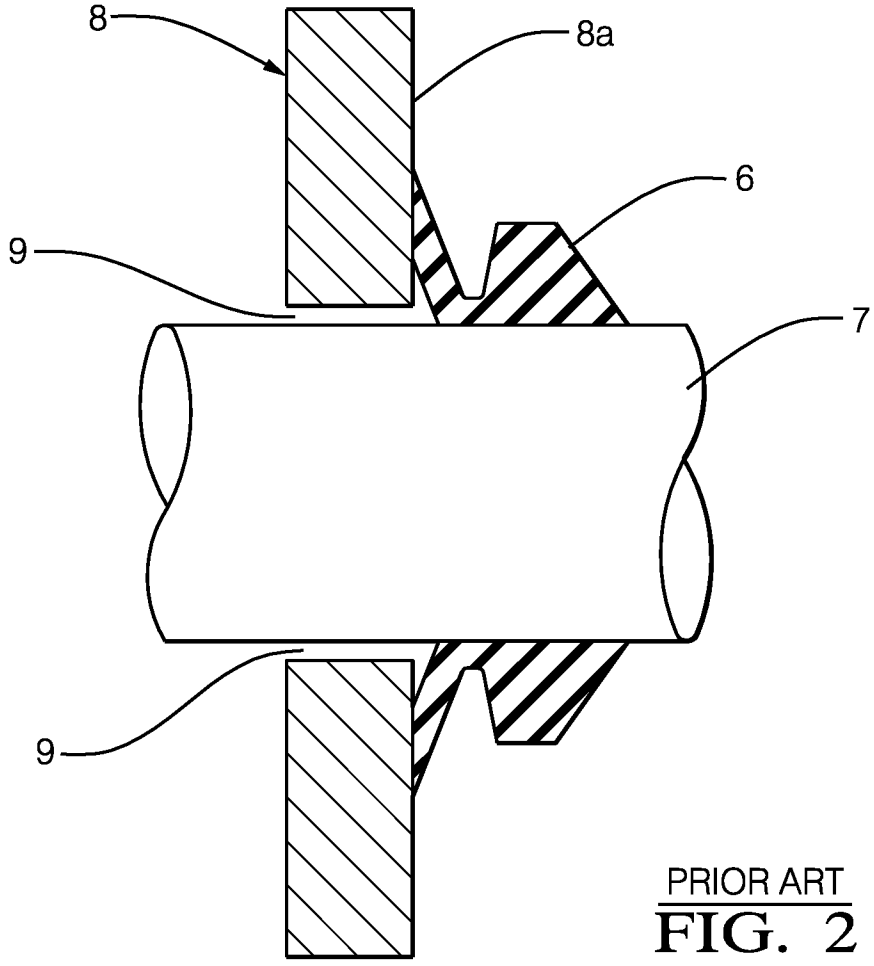
10. The pump according to any one of claims 7 to 9, characterised in that the sprung component comprises a spring means (66, 66') provided on said annular member so as to be disposed behind the sealing member (56, 56') of the seal (52, 52').

11. The pump according to claim 10, characterised in that the spring means are adapted to locate in locating means in the back support (55, 55') of the sealing member (56, 56').

12. The pump according to any one of claims 6 to 11, characterised in that where the sealing arrangement comprises a separate pressure member (60, 60'), the seal (52, 52') is retained in the chamber wall (32, 32') and the axial face (35, 29') comprises a radially projecting flange (27, 27') provided on a front end (26, 26') of the driveshaft (20, 20') adjacent an intermediate portion (24, 24').



PRIOR ART
FIG. 1



PRIOR ART
FIG. 2

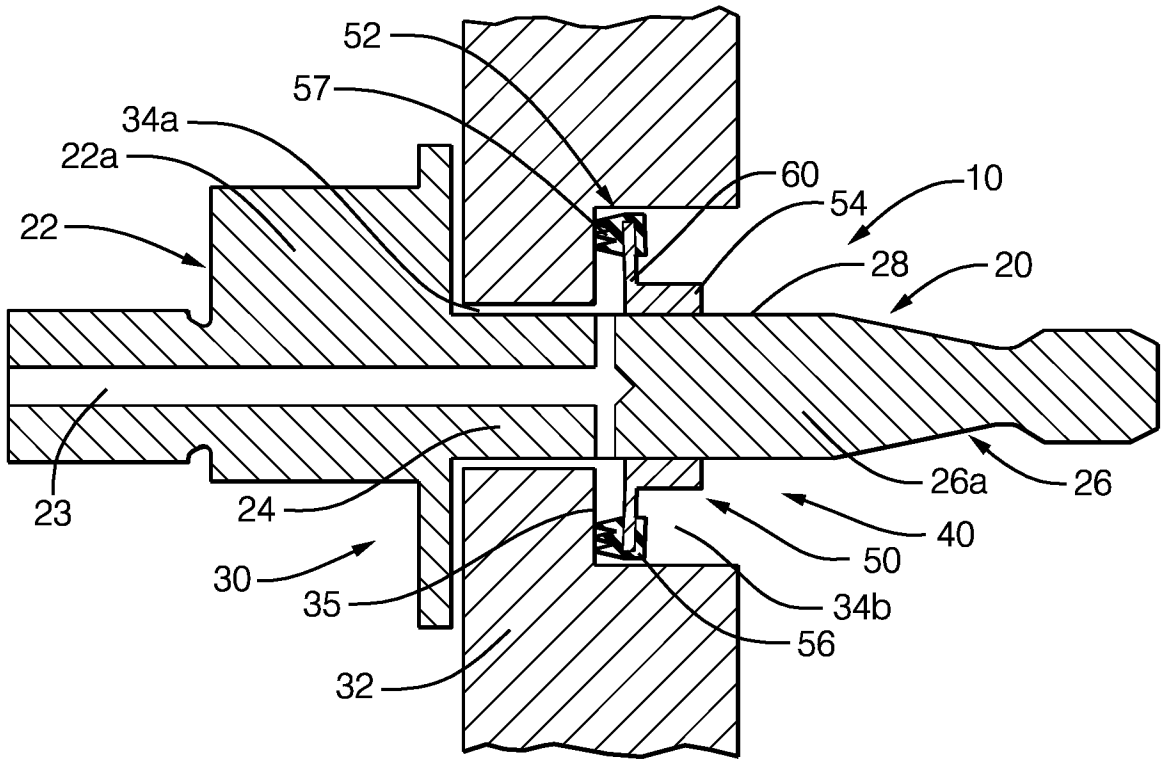


FIG. 3

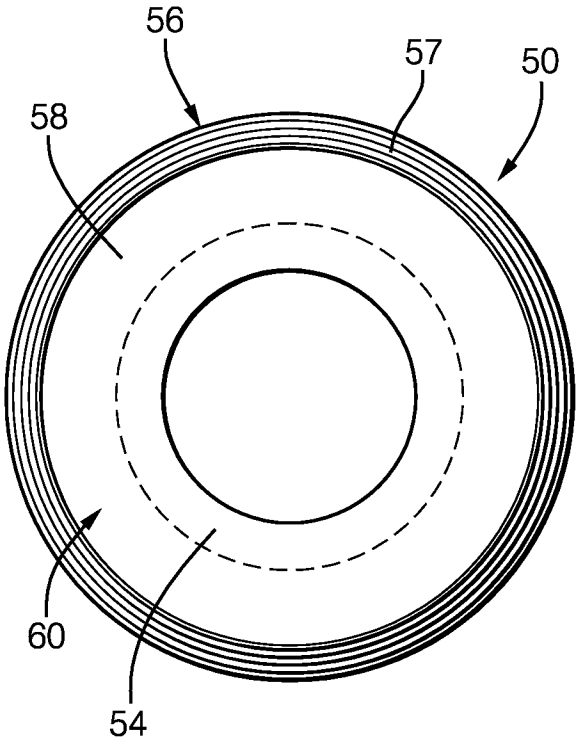


FIG. 4

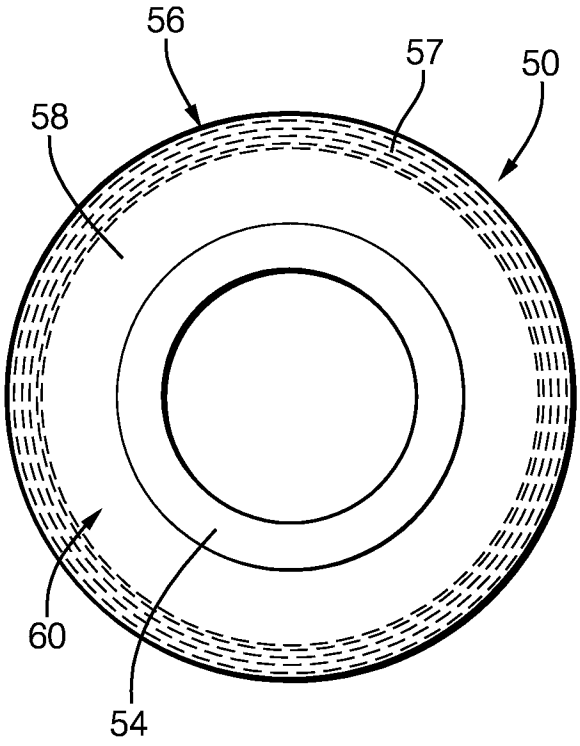


FIG. 5

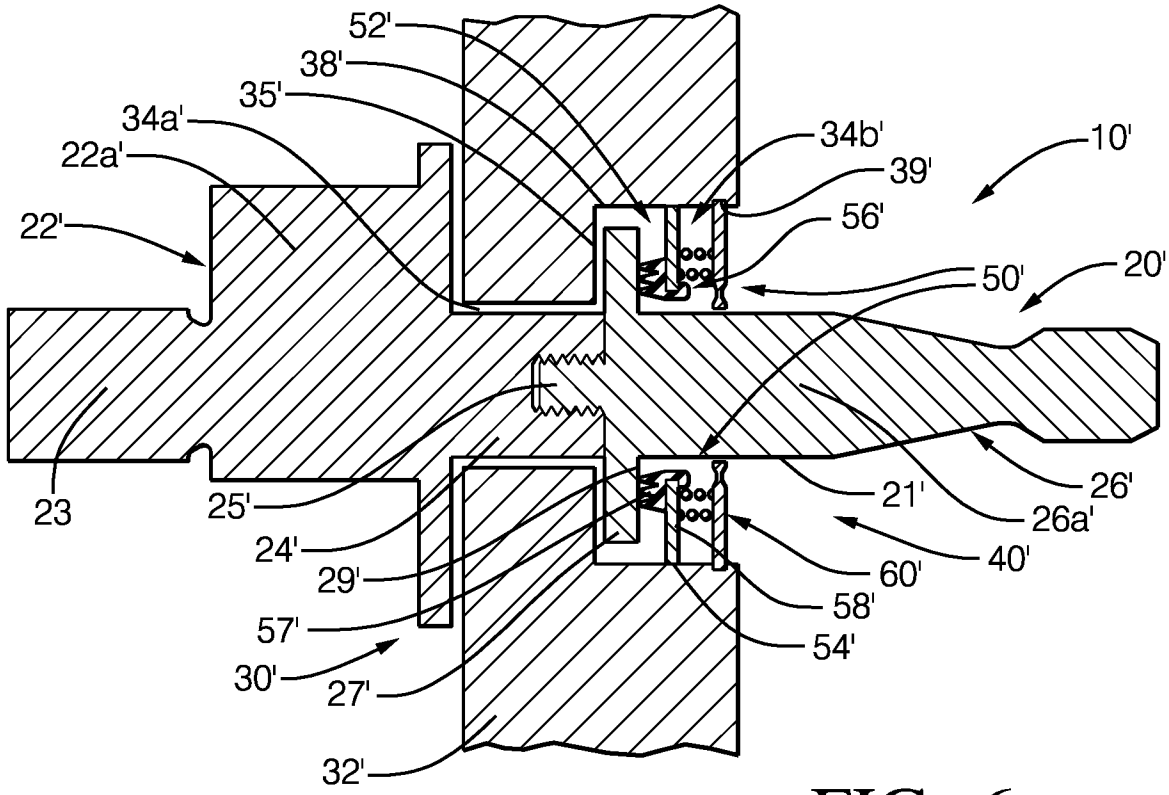

52'
38'
35'
34a'
22a'
22'
34b'
39'
10'
56'
50'
20'
23
25'
24'
29'
57'
30'
27'
32'
21'
26'
26a'
40'
60'
58'
54'

FIG. 6

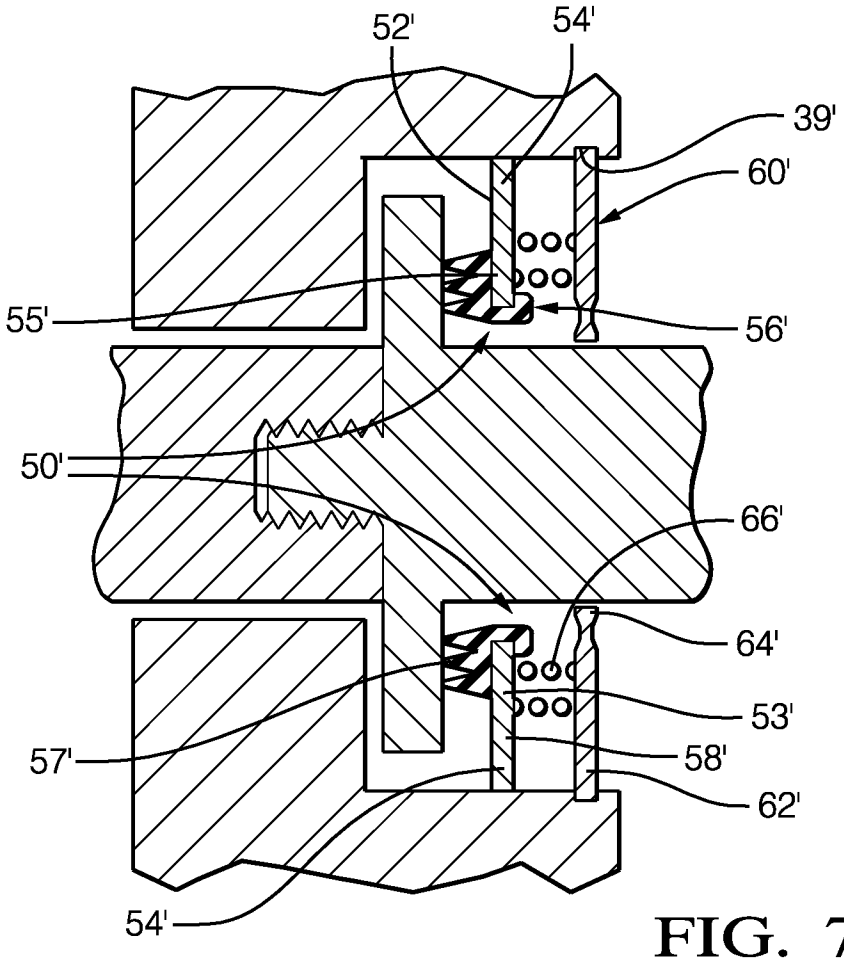

52'
54'
39'
60'
55'
56'
50'
66'
64'
53'
57'
58'
62'
54'

FIG. 7

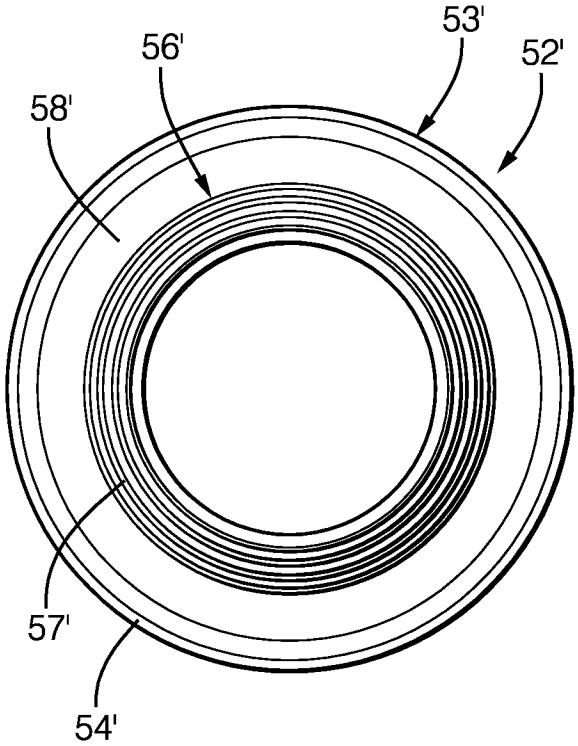


FIG. 8

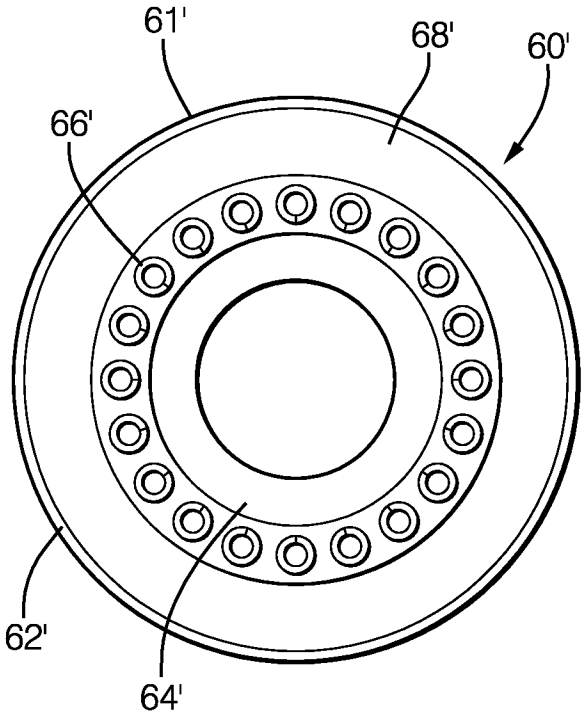


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/065324

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B1/04 F02M59/10 F16J15/34 F16J15/54 F16J15/16 F16J15/3204
ADD. F04C15/00
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)
F04B F02M F16J F04C

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

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 32 43 633 A1 (GOETZE AG [DE]) 30 May 1984 (1984-05-30) abstract; figures 1,2 claims 1,2,3,4,5,6,7 page 4, line 1 - line 9 page 5, line 29 - page 6, line 7 page 6, line 20 - line 24 page 9, line 5 - line 17 -----	1
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 September 2016	12/09/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barunovic, Robert

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/065324

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP S62 28968 U (EAGLE INDUSTRIAL CO., LTD.) 21 February 1987 (1987-02-21) abstract; figures 2,3	11
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A	US 2 250 348 A (BEIER KURT A) 22 July 1941 (1941-07-22) abstract; figures 1,2,3,4	1-12

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International application No
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