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(54) **Fuel pumping mechanism**

(57) Internal combustion engine fuel pumping mechanism (200), comprising a pumping element (214) such as a plunger, moveable within first location bore, an intermediate member such as a tappet, movable within a second location bore, and a driving mechanism such as a cam, wherein during a pumping stroke, cam load is transferred to the plunger via contact surfaces plunger and tappet contact surfaces, the plunger contact surface being radiused, and the tappet contact surface being angled at a selected angle with respect to an axial axis of

the tappet, such that when the tappet tilts within the second location bore on application of cam load, the tappet contact surface becomes orthogonal with a longitudinal axis of the second bore and the plunger, ensuring a substantially central contact point between the contact surfaces. The inventive concept also extends to an intermediate member comprising a contact surface which is angled with respect to an axial axis of the intermediate member.

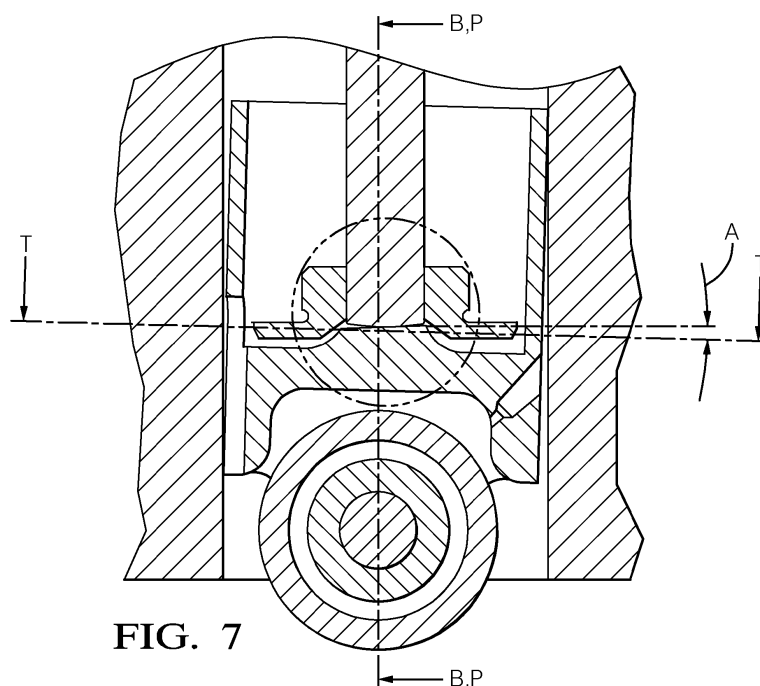


FIG. 7

Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel pump for use in an internal combustion engine, and more particularly to an improved pumping mechanism for a fuel pump having at least one pumping element which is driven by an engine-driven cam or other appropriate drive arrangement.

BACKGROUND OF THE INVENTION

[0002] Figure 1 is a cross-sectional partial view of a pumping mechanism in accordance with the prior art. As illustrated in this figure, a common pumping mechanism 100 for a fuel pump for an internal combustion engine comprises a pump housing 102, containing a pumping element location bore 120 in which a pumping element such as a plunger 114 is moveable. A first end (not shown) of the plunger 114 extends into a pumping chamber (not shown) defined at one end of the pumping element location bore 120. The pumping mechanism 100 further comprises a driving mechanism such as a cam roller 110, and an intermediate member such as a follower or tappet 112, which is moveable within an intermediate member location bore 122.

[0003] During a pumping stroke, the plunger 114 is urged further into the pumping element location bore 120, by a driving force applied by the cam roller 110. On rotation of the cam roller 110, load is transferred from the cam roller 110 to the plunger 114 via a contact surface 116 provided on the tappet 112, and a contact surface 118 provided at a second end 128 of the plunger 114. The plunger 114 is urged into the pumping chamber by the cam load, thereby reducing the volume of the pumping chamber, causing fuel in the pumping chamber to become pressurised.

[0004] It is important that the very high forces which are transferred via the contact surfaces 116, 118 are distributed over as large an area as possible, to reduce contact (Hertzian) stresses, which may result in wear or failure of the components.

[0005] Ideally, the contact surface 116 of the tappet 112 would make a flat, even contact with a flat contact surface 118 of the plunger 114. In practice, however, the axes of the plunger 114 and tappet 112 within their respective location bores are usually misaligned, due to geometry errors and clearances. For example, on application of cam load, the tappet will usually be caused to tilt within the tappet location bore 122 at an angle relative to the cam load. Therefore if the contact surfaces 116, 118 of the plunger 114 and tappet 112 were both flat, the misalignment of the axes of the plunger 114 and the tilted tappet 112 would result in substantially all cam load being transferred to an edge of the plunger contact surface 118, resulting in high point stresses at this edge. Accordingly, it is common for a radius to be provided on the end of

the plunger 112, i.e. for the contact surface 118 of the plunger 112 to be arcuate.

[0006] The radius provided on the plunger 112 must be selected in accordance with the anticipated misalignment of the axis of the tappet 114 from the axis of the tappet location bore 122. It is preferable for the radius provided on the plunger 112 to be large, thereby ensuring that contact (Hertzian) stresses are maintained within the capability of the materials. However, if the radius is too large, edge contact will occur when the tappet 112 is tilted within the tappet location bore 122. Accordingly, selection of a sufficiently large radius for the end of the pumping element is constrained by the requirement to avoid edge contact and resulting high point stresses.

[0007] Figures 2 and 3 are enlarged cross-sectional partial views of the prior art pumping mechanism of Figure 1. The tappet contact surface 116 contacts the plunger contact surface 118 during the pumping stroke at a contact point, indicated generally at 130. As illustrated, even with a radiused end of plunger 112, the contact point 130 occurs towards to a side portion of the contact surfaces 116, 118.

SUMMARY OF THE INVENTION

[0008] It is an object of the present invention to at least mitigate the above problems and provide an improved pumping mechanism for an internal combustion engine.

[0009] Accordingly the present invention provides, in a first aspect, a pumping mechanism for a fuel pump according to claim 1.

[0010] The intermediate member is usually caused to tilt to a known angle. Preferably, the intermediate member contact surface is angled with respect to the axial axis of the intermediate member to this known angle, such that during the pumping stroke, the intermediate member contact surface is orthogonal with the longitudinal axis of the intermediate member location bore.

[0011] Selecting the angle A of the tappet contact surface in accordance with the predictable tilt of the tappet within the tappet bore during the pumping stroke ensures that the nominal contact between the contact surfaces occurs substantially at the centre of each contact surface, thereby avoiding edge contact. The present invention allows a larger degree of tilt of the tappet within the tappet location bore, or allows a larger radius to be provided on the plunger. Contact stresses are thereby maintained within the capabilities of the materials providing greater durability, or the possibility of higher pressure running, than prior art embodiments.

[0012] The second end of the pumping element is preferably radiused, thereby providing an arcuate pumping element contact surface.

[0013] The present invention also provides, in a further aspect, a tappet for use in a pumping mechanism of a fuel pump, according to claim 4, and a fuel pump according to claim 5.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 4 is a cross-sectional view of a pumping mechanism in accordance with the present invention taken along a longitudinal axis of the cam,
 Figure 5 is a cross-sectional view of a tappet of Figure 4 taken along an axial axis of the cam;
 and
 Figures 6, 7 and 8 are partial cross-sectional views of the pumping mechanism of Figure 3 taken along an axial axis of the cam.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Referring to Figure 4, the present invention comprises a pumping mechanism 200 comprising a pump housing 202. The pump housing 202 comprises a plunger location bore 220 for locating a pumping element in the form of a plunger 214, a driving mechanism comprising a cam roller 210, and an intermediate member comprising a tappet 212 located in a tappet location bore 222.

[0016] The plunger location bore 220 defines a pumping chamber 224 at one end, into which a first end 226 of the plunger 214 extends.

[0017] As indicated in Figures 6 and 8, the tappet 212 is provided with a tappet contact surface 216, for contacting with a plunger contact surface 218 (Figure 6) provided at a second end 228 of the plunger 214 remote from the first end 226. The figures represent a pumping stroke, wherein the tappet contact surface 216 is in contact with the plunger contact surface 218, i.e. load from the cam roller 210 is being imparted to contact surface 218 of the plunger 214 via the contact surface 216 of the tappet 212. Consequently, the plunger 214 is being urged further into the plunger location bore 220 by the cam load, thereby causing fuel in the pumping chamber 224 to become pressurised.

[0018] As indicated in Figures 4 and 7, the tappet location bore 220 has a longitudinal axis B, and the plunger 214 has a longitudinal axis P. Although minor tolerance errors may occur in the machining of the plunger location bore 220, the clearance between the plunger 214 and the plunger location bore 220 is minimal, therefore any tilting of the plunger P within the plunger location bore 220 is negligible. Therefore, the longitudinal axis B of the tappet location bore 222 is substantially coincident with the longitudinal axis P of the plunger 214.

[0019] The second end 228 of the plunger 214 is radiused, such that the plunger contact surface 218 is arcuate. The tappet contact surface 216 is substantially flat, and is angled at an angle A with respect to an axial axis T of the tappet (wherein axis T is perpendicular to an external wall 232 of the tappet 212, as indicated in Figure

5).

[0020] Before application of force from the cam roller 210 to the tappet 212, the axial axis T of the tappet is orthogonal to the axis B of the tappet location bore 222 and the axis P of the plunger. As shown in Figures 6 and 7, on application of the cam load, i.e. during the pumping stroke, the tappet 212 is caused to tilt within the tappet location bore 222, to an angle A. At this tilted position, the axial axis T of the tappet is no longer orthogonal with the axis B of the tappet location bore 222.

[0021] The direction and degree A of tilt of the tappet 212 within the tappet location bore 222 is consistent in each pumping stroke for a nominal clearance, i.e. the direction and angle of tilt A can be predicted for a given fuel pump for a nominal clearance. The direction of tilt, and the angle of the tappet contact surface 216 (with respect to the axial axis T of the tappet), is selected in accordance with the predicable tilt of the tappet 212 during the pumping stroke, i.e. the tappet contact surface 216 is angled at angle A to the axial axis T of the tappet 212, such that when the tappet 212 is in the tilted position, the angled tappet contact surface 216 is orthogonal with the axis B of the tappet location bore 222. As a result, when the tappet 212 is tilted, a nominal contact point, (most clearly indicated in Figure 8, at approximately point 230), between the tappet contact surface 216 and the plunger contact surface 218 occurs substantially at the centre of the plunger contact surface 216, thereby avoiding high point stresses which would result from edge contact. Allowing a larger radius to be provided on the plunger 214 ensures that contact stresses are maintained within the capabilities of the materials, or allows the pumping mechanism to be run at higher pressures.

References

[0022]

100, 200	pumping mechanism
102, 202	pump housing
110, 210	driving mechanism (cam)
112, 212	intermediate member (tappet)
114, 214	pumping element (plunger)
116, 216	intermediate member (tappet) contact surface
118, 218	pumping element (plunger) contact surface
120, 220	pumping element (plunger) location bore
122, 222	intermediate member (tappet) location bore
224	pumping chamber

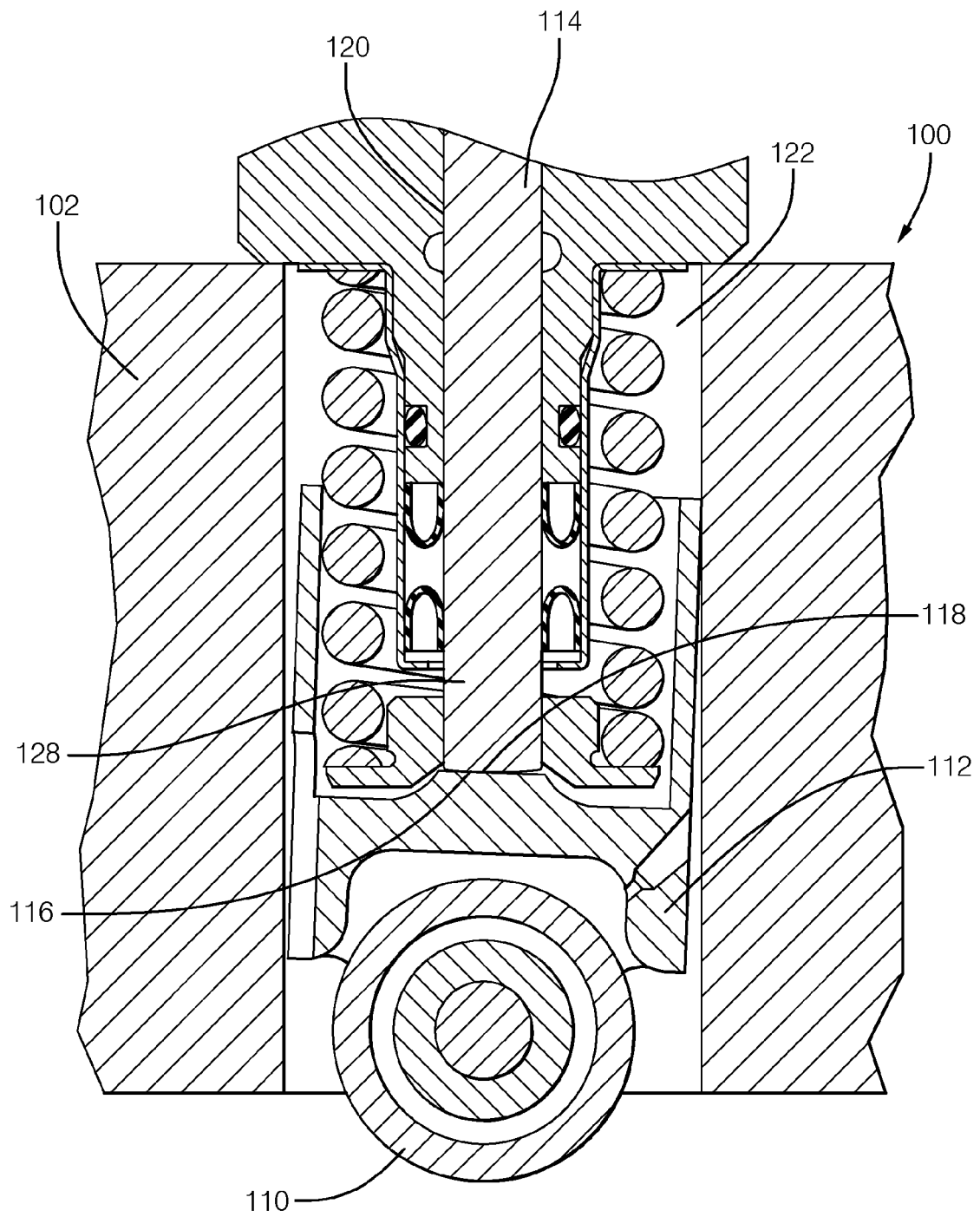
226	plunger first end	
128, 228	plunger second end	
130, 230	contact point	5
232	tappet external wall	
Angle A	tappet surface angle	10
Axis B	tappet location bore longitudinal axis	
Axis P	plunger longitudinal axis	
Axis T	tappet axial axis	15

Claims

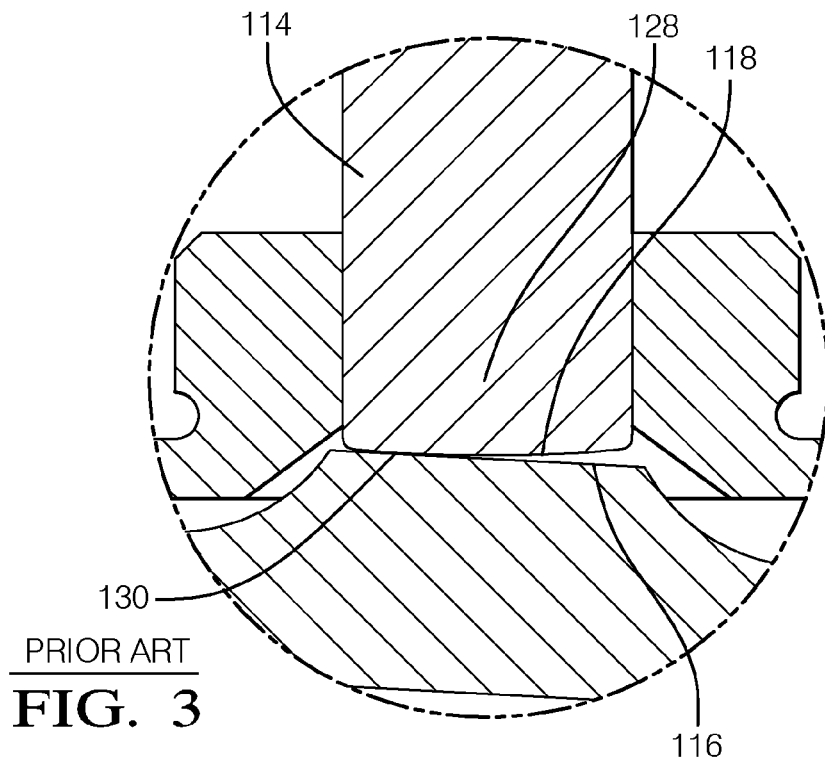
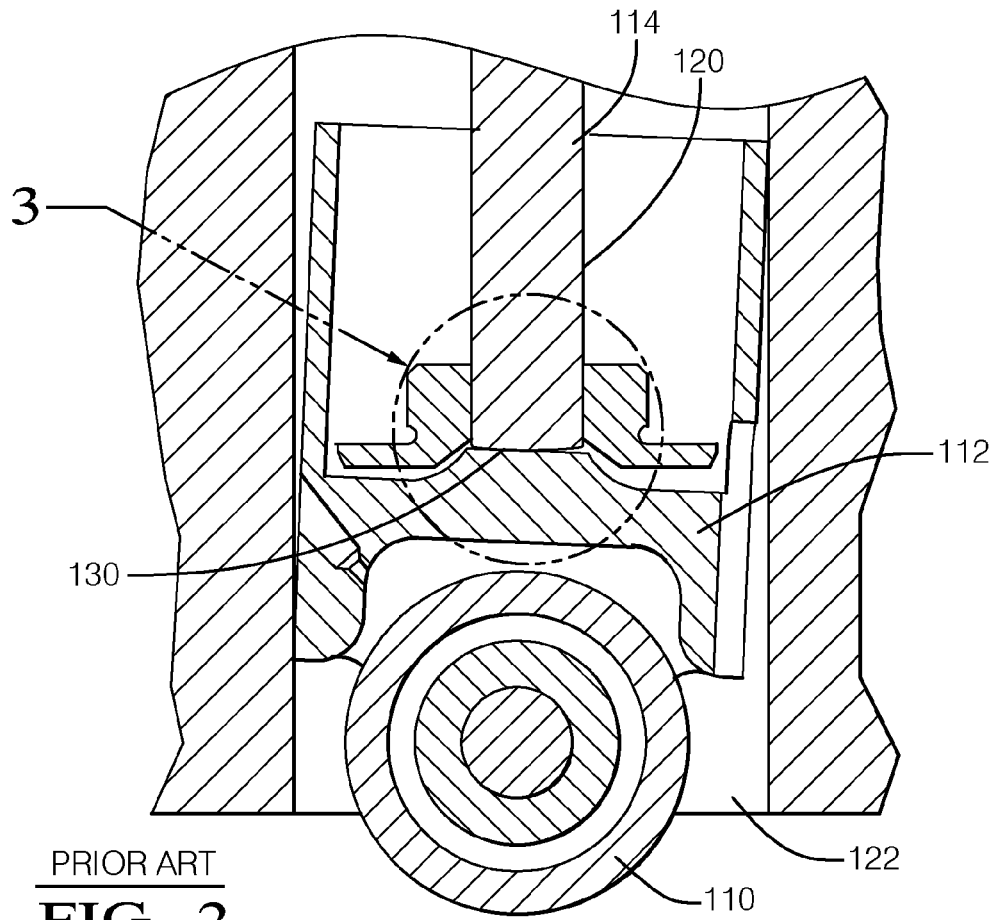
1. A pumping mechanism (200) for a fuel pump for use in an internal combustion engine, the pumping mechanism (200) comprising:
 - a pumping element location bore (220) for locating a pumping element (214), an intermediate member location bore (222) for locating an intermediate member (212),
 - wherein the intermediate member (212) is co-operable with a driving mechanism (210), wherein the pumping element (214) is moveable within and along a longitudinal axis (B) of the pumping element location bore (220), to pressurise fuel within a pumping chamber (224) adjacent a first end (226) of the pumping element (214) during a pumping stroke; the intermediate member (212) being movable within the intermediate member location bore (222);
 - wherein the intermediate member (212) comprises an intermediate member contact surface (216), for contacting a pumping element contact surface (218) located at a second end (228) of the pumping element (214) remote from the first end (226), thereby to transfer load from the driving mechanism (210) to the pumping element (214) during the pumping stroke;
 - characterised in that** the intermediate member contact surface (216) is angled with respect to an axial axis (T) of the intermediate member (212).
2. A pumping mechanism (200) as claimed in claim 1 wherein, during the pumping stroke, the intermediate member (212) is caused to tilt within the intermediate member location bore (222) to a known angle (A), and wherein the intermediate member contact surface (216) is angled with respect to the axial axis (T) of the intermediate member (212) to the known angle

(A), such that during the pumping stroke, the intermediate member contact surface (216) is orthogonal with the longitudinal axis (B) of the intermediate member location bore (222).

3. A pumping mechanism (200) as claimed in any one of the preceding claims wherein the second end (228) of the pumping element (214) is radiused thereby providing an arcuate pumping element contact surface (218).
4. An intermediate member (212) for a pumping mechanism (200) of a fuel pump for an internal combustion engine;
 - the intermediate member (212) having an intermediate member contact surface (216) for imparting drive from a driving mechanism (210) to a pumping element contact surface (218) provided on a pumping element (214), thereby to urge the pumping element (214) into a pumping chamber (224) to pressurise fuel contained in the pumping chamber (224), wherein the intermediate member contact surface (216) is angled with respect to an axial axis (T) of the intermediate member (212) perpendicular to an external wall (232) of the intermediate member (212).
5. A fuel pump for an internal combustion engine comprising at least one pumping mechanism (200), the at least one pumping mechanism (200) comprising a pumping element location bore (220) for locating a pumping element (214), an intermediate member location bore (222) for locating an intermediate member (212),
 - wherein the intermediate member (212) is co-operable with a driving mechanism (210), wherein the pumping element (214) is moveable within and along a longitudinal axis (B) of the pumping element location bore (220), to pressurise fuel within a pumping chamber (224) adjacent a first end (226) of the pumping element (214) during a pumping stroke;
 - the intermediate member (212) being movable within the intermediate member location bore (222);
 - wherein the intermediate member (212) comprises an intermediate member contact surface (216), for contacting a pumping element contact surface (218) located at a second end (228) of the pumping element (214) remote from the first end (226), thereby to transfer load from the driving mechanism (210) to the pumping element (214) during the pumping stroke;
 - characterised in that** the intermediate member contact surface (216) is angled with respect to an axial axis (T) of the intermediate member (212).



PRIOR ART
FIG. 1



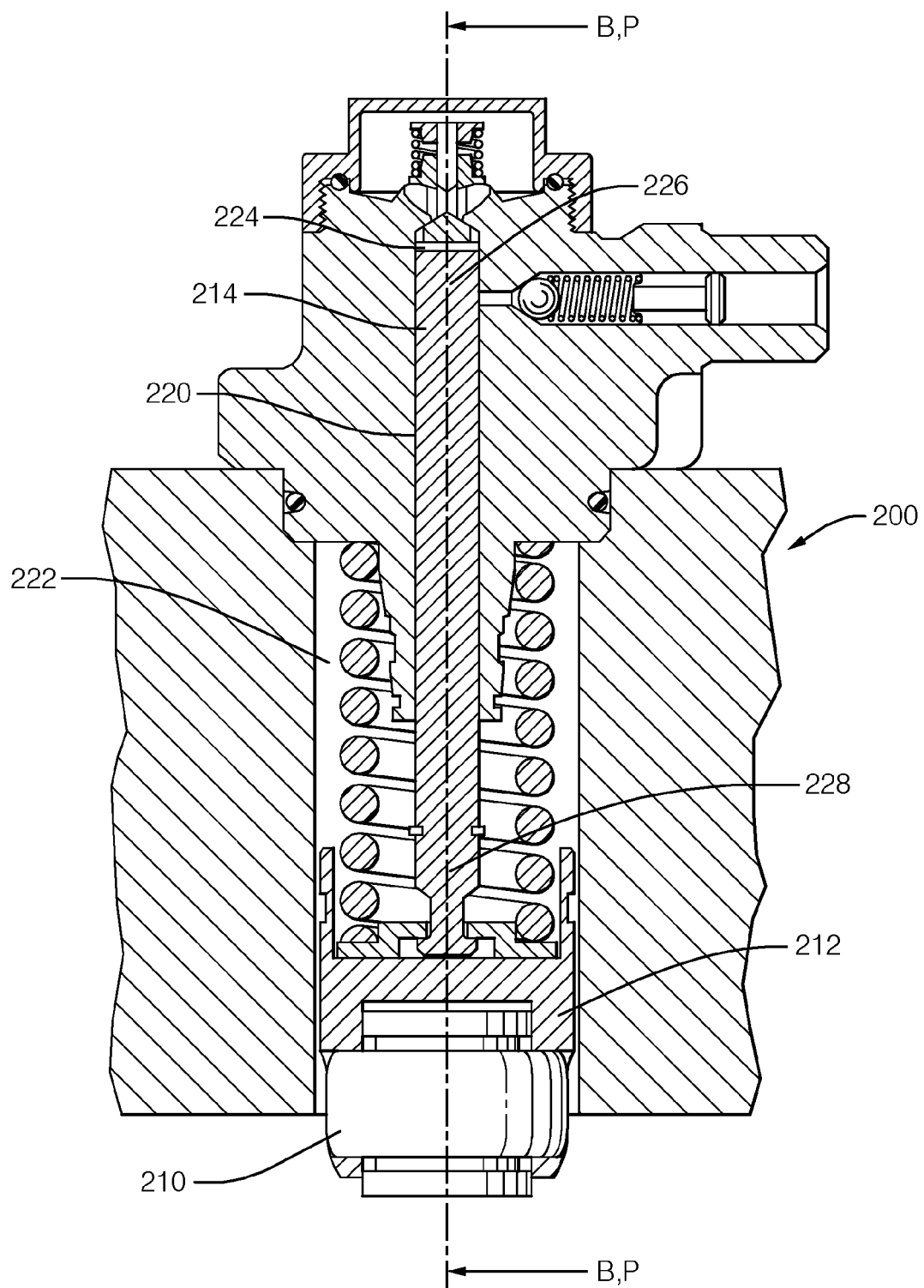
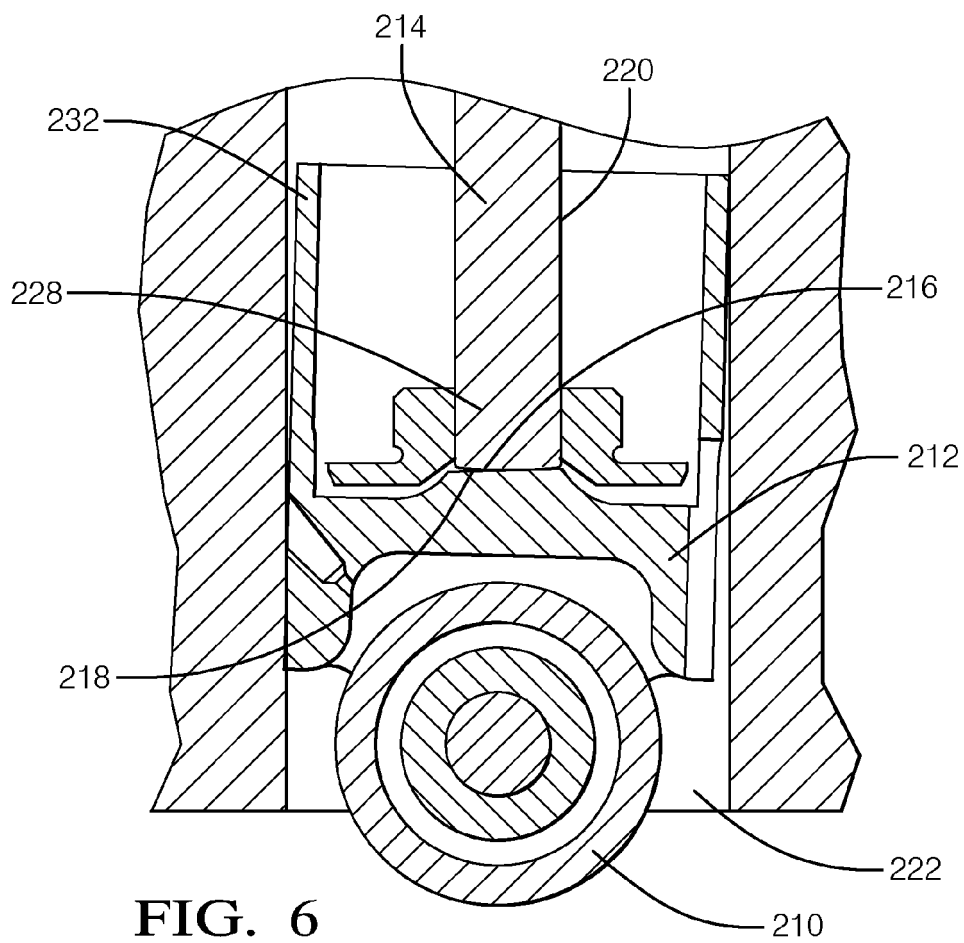
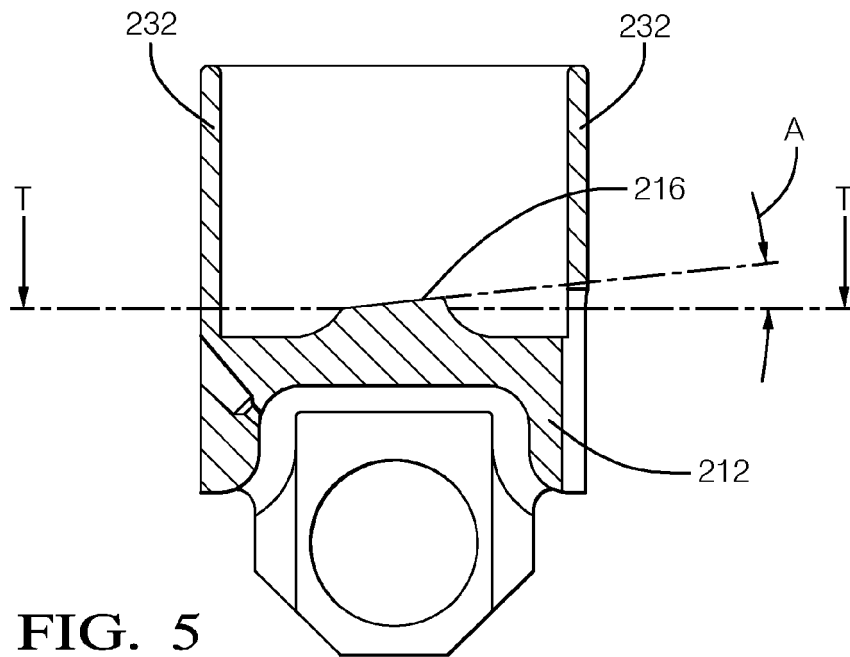


FIG. 4



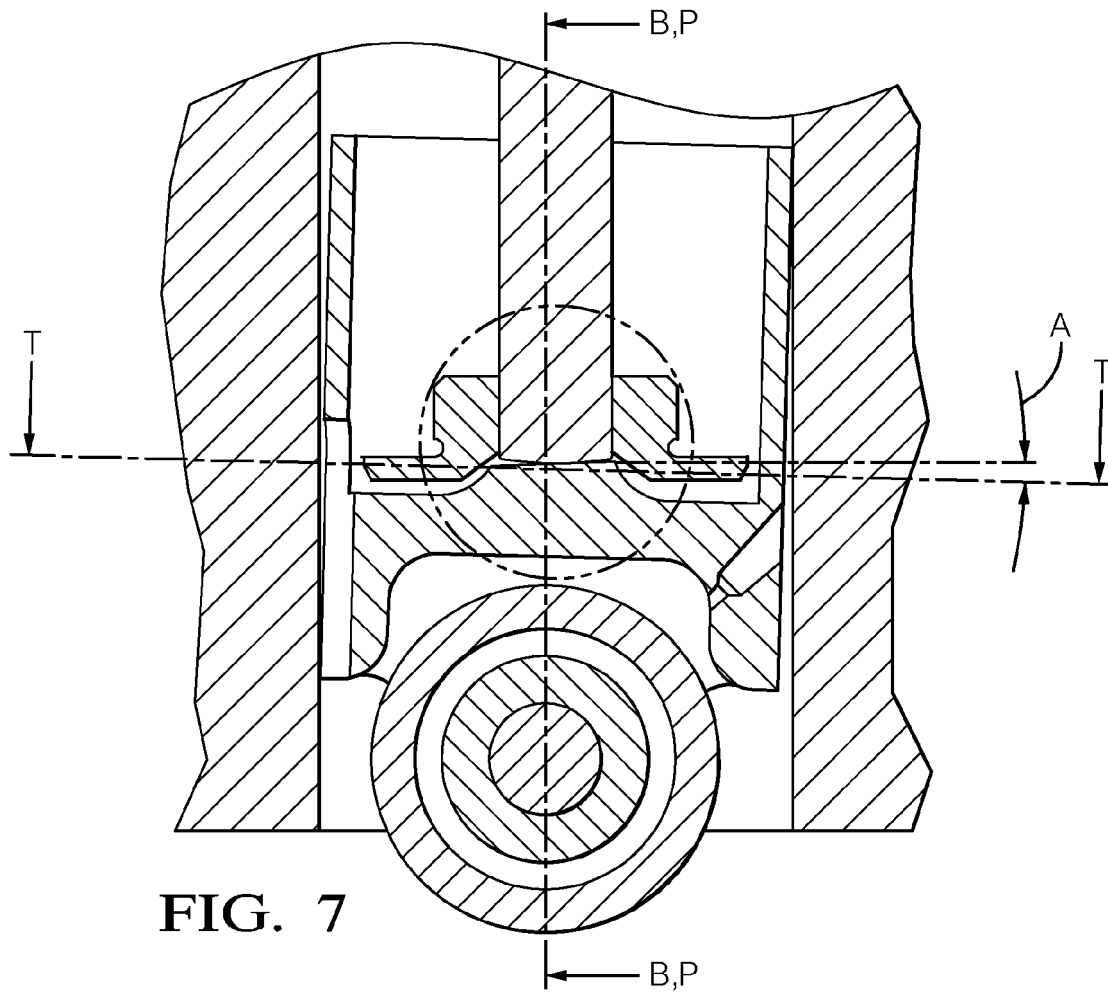


FIG. 7

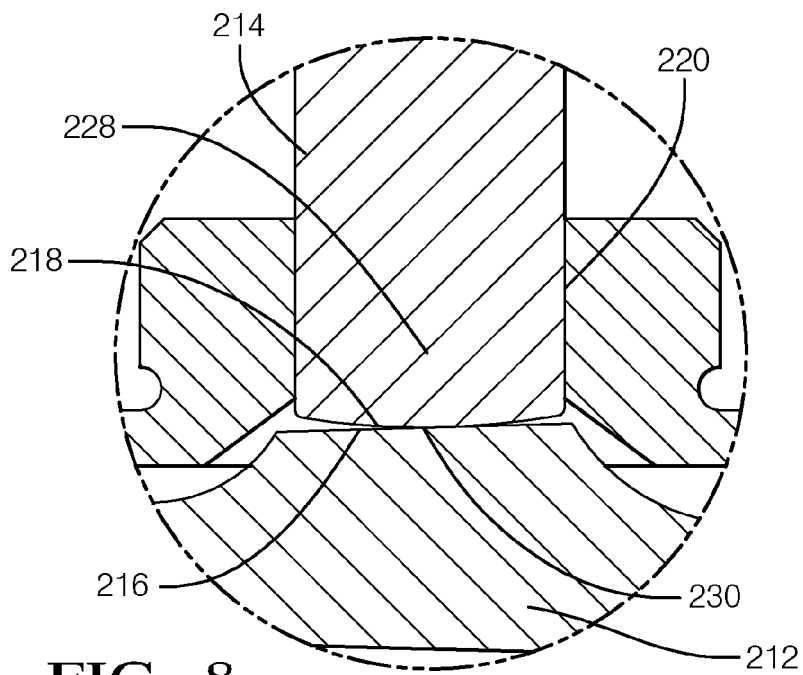


FIG. 8



EUROPEAN SEARCH REPORT

 Application Number
EP 14 15 6469

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2006 045933 A1 (BOSCH GMBH ROBERT [DE]) 3 April 2008 (2008-04-03)	1,5	INV. F02M59/10
Y	* figure 7 *	2-4	
Y	EP 1 347 172 A2 (DAIMLER CHRYSLER AG [DE]) 24 September 2003 (2003-09-24) * figures 1-11 *	2,4	
Y	DE 10 2007 022220 A1 (BOSCH GMBH ROBERT [DE]) 13 November 2008 (2008-11-13) * figures 1-5 *	3	
X	WO 2013/117485 A1 (DELPHI TECH HOLDING SARL [LU]) 15 August 2013 (2013-08-15) * line 11 - page 8, line 20; figure 2 *	1,5	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F02M
Place of search		Date of completion of the search	Examiner
The Hague		16 June 2014	Morales Gonzalez, M
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 15 6469

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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16-06-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006045933 A1	03-04-2008	AT 483907 T	15-10-2010
		BR PI0716260 A2	06-08-2013
		CN 101523044 A	02-09-2009
		DE 102006045933 A1	03-04-2008
		EP 2076669 A1	08-07-2009
		JP 2010505058 A	18-02-2010
		US 2010037865 A1	18-02-2010
		WO 2008037524 A1	03-04-2008

EP 1347172 A2	24-09-2003	DE 10212492 A1	02-10-2003
		EP 1347172 A2	24-09-2003
		US 2003180159 A1	25-09-2003

DE 102007022220 A1	13-11-2008	NONE	

WO 2013117485 A1	15-08-2013	NONE	
