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(54) **Load reduction**

(57) In a fuel injection pump during the pumping stroke of the cycle, the contact load between the surfaces of the tappet (401) and plunger (400) can be very high leading to lubrication breakdown and fretting wear at the contact area surfaces. The present invention reduces wear rates by flushing fresh lubricant in the contact area gap (420) before each load cycle of the pump. Therefore, a resilient disc-like spring seat (403) provides the wanted gap (420) by a concave profile on its underside causing the spring seat to flex against the pumping stroke direction.

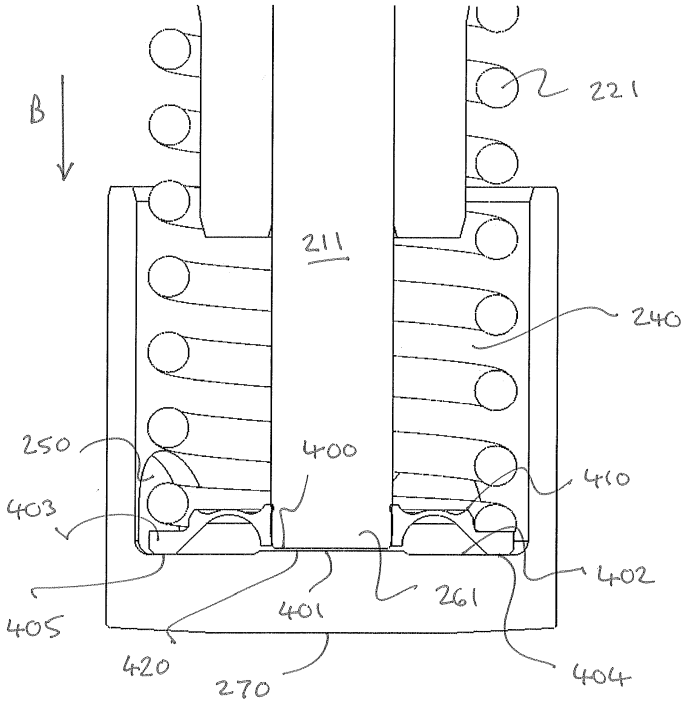

Fig 4.

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Description

[0001] The present invention relates to a method and apparatus for selectively providing a fluid communication path that allows lubricant to flow to a desired location in between two moving parts. In particular, but not exclusively, the present invention relates to a plunger and tappet arrangement. A resilient spring seat is used to separate the plunger and tappet by a short distance at a particular point of a cycle of the plunger movement. The momentary separation allows lubricant to flow from a surrounding region into the space created between the plunger and tappet.

[0002] In known pump assemblies an intermediate element, often referred to as an intermediate drive member, and often in the form of a tappet, transmits drive from a cam mechanism to a pumping plunger. The pumping plunger is used to pressurise fluid in a pumping chamber for delivery to a desired location. For example, the fluid could be engine fuel of a diesel engine fuel injection system.

[0003] Tappets are used to reduce lateral forces applied to a pumping plunger so that in general the pumping plunger is driven in a reciprocal motion by the tappet backwards and forwards along a respective longitudinal axis of motion. Tappets are well known and are generally cup-shaped elements with a cylindrical side wall and solid base. Vents can be provided in the side wall and/or base of the tappet so that a lubricating fluid can flow from around the cam mechanism to regions within the tappet. This helps ensure hydraulic forces do not inhibit free movement of the tappet within a tappet bore in a housing. Thus, pumps which can operate at high pressures, employ a reciprocating plunger to do work on the fluid being pumped. The plunger is moved forward during a pumping stroke by applying a load mechanically to an opposite end of the plunger via a tappet. On a return stroke of the cycle of motion of the plunger, the plunger is held against the tappet by a spring referred to as a return spring.

[0004] During the pumping stroke of the cycle the contact load between tappet and plunger can be very high with small lateral forces leading to lubrication breakdown and fretting wear at the contact zone. The fact that the surfaces of prior art systems are continually held together prevents the flow of lubrication into the contact zone between an end of the plunger and a contact region of the tappet. This allows wear debris to be retained and this can further abrade the juxtaposed surfaces over time.

[0005] It is an aim of the present invention to at least partly mitigate the above-mentioned problems.

[0006] It is an aim of the certain embodiments of the present invention to provide a method and apparatus that from time-to-time provides a fluid communication path, of the type along which lubricant can flow, between a plunger element and a contact region of an intermediate element.

[0007] It is an aim of certain embodiments of the present invention to bias a plunger away from a tappet at least momentarily at a point in time or more than one point in time during a cycle of motion of the plunger.

[0008] It is an aim of certain embodiments of the present invention to provide a pump assembly in which lubricant can selectively flow between a contact region of an intermediate element such as a tappet and an end of a plunger element so that fretting and wear rate can be reduced between juxtaposed surfaces on the component parts.

[0009] It is an aim of certain embodiments of the present invention to reduce fretting and wear rates in a pump assembly by allowing a contact area to be flushed with fresh lubricant before each load cycle.

[0010] It is an aim of certain embodiments of the present invention to selectively cause a small gap to be opened between component parts in a pump assembly when the component parts are unloaded.

[0011] It is an aim of certain embodiments of the present invention to provide a squeeze film between opposed surfaces of a plunger element and intermediate element in a pump assembly.

[0012] It is an aim of certain embodiments of the present invention to provide a method of lubricating between a plunger element of a pump assembly and an intermediate element providing drive to the plunger element.

[0013] According to a first aspect of the present invention there is provided apparatus for selectively providing a fluid communication path between a plunger element and a contact region of an intermediate element that drives the plunger element, comprising:

an elongate plunger element comprising a first end region;
an intermediate element comprising a contact region arranged to selectively abut with and thereby urge a further end region of the plunger element; and
a spring seat member at said further end region that biases the further end region away from the intermediate element during a portion of a cycle of motion of the plunger element to thereby provide a fluid communication path between an abutment surface of said further end region and said contact region.

[0014] Aptly, the intermediate element comprises a tappet received for reciprocating sliding motion in a housing bore of a pump housing of a pump assembly.

[0015] Aptly, the tappet comprises at least one through-hole in a cylindrical side wall and/or base wall thereof, said through-hole providing a fluid path portion connected to said fluid communication path.

[0016] Aptly, the fluid communication path provides lubricating fluid between said abutment surface and said contact region at an end of a return cycle of the plunger element.

[0017] Aptly, the first end region of said plunger element is locatable into a blind end of a pump bore of a pump head of a pump assembly;

and the intermediate element further comprises a drive surface that is driveable by a cam or cam rider element of the pump assembly to thereby urge said contact region against said abutment surface.

[0018] Aptly, the apparatus further comprises a return spring member that urges a surface of the spring seat element away from a pump head of a pump assembly.

[0019] Aptly, the spring seat member and the plunger element are integrally formed or the spring seat member is secured to said plunger element for movement therewith.

[0020] According to a second aspect of the present invention, there is provided a pump assembly comprising:

a pump housing comprising an axially extending opening and at least one housing bore extending generally radially from said opening;
at least one intermediate element each received for reciprocating sliding motion in a respective housing bore and comprising an internal chamber region;
at least one pump head comprising a pump bore having a blind end and secured to said pump housing;
an elongate plunger element in each chamber region driveable in use via a respective intermediate element, and comprising a first end region that pressurises fluid in a pumping chamber provided by a respective pump bore, and a further end region;
a cam and/or cam rider element in said axially extending opening having an inner surface co-operable with a cam driveshaft and an outer surface co-operable with a drive surface of said intermediate member; and
at least one spring seat member each at a further end region of a respective plunger element that biases the further end region away from a contact region of the intermediate element during a portion of a cycle of motion of the plunger element to thereby provide a fluid communication path between an abutment surface of the further end region and said contact region.

[0021] Aptly, the spring seat member and said plunger element are integrally formed or the spring seat member is secured to said plunger element for movement therewith.

[0022] According to a third aspect of the present invention there is provided a method of lubricating between a plunger element of a pump assembly and an intermediate element providing drive to the plunger element, the method comprising the steps of:

driving a first end region of a plunger element in a first reciprocating motion with respect to a blind end of a pump bore of a pump head by selectively urging a contact region of an intermediate element proximate to a further end region of the plunger element in a further reciprocating motion;
via a spring seat member at the further end region of the plunger element, biasing the plunger element away from the intermediate element during a portion of a cycle of motion of the plunger element; and
providing lubricating fluid between an abutment surface of said the further end region and said contact region as the further end region is biased away from the intermediate element.

[0023] Aptly, the method further comprises cooling and removing debris from between the abutment surface and said contact region via the lubricating fluid.

[0024] Aptly, the method further comprises providing a squeeze film layer between the abutment surface and said contact region via the lubricating fluid.

[0025] Aptly, the method further comprises opening and closing a gap between said abutment surface and said contact region each cycle of the plunger element.

[0026] Aptly, the portion of a cycle comprises an end of a return cycle of the plunger element in which the fluid in the pump bore expands and said first reciprocating motion further comprises a pump cycle portion in which fluid in the pump bore is compressed.

[0027] Aptly, the method further comprises biasing the further end region via a spring seat member integrally formed with said plunger element or via a spring seat member secured to said plunger element for movement therewith.

[0028] Certain embodiments of the present invention provide the advantage that a fluid communication path between an end of a plunger and contact region of an intermediate element such as a tappet is provided. This allows lubricant to be drawn into the region between opposed faces and to cool, lubricate and wash away debris. This also provides a squeeze film between the opposed faces as they close back together so that the faces are kept apart for a longer period than would otherwise be allowed with prior known systems. This longer period reduces the wear created by drive motion and/or the inevitable lateral motion induced as part of the reciprocating pumping motion.

[0029] Certain embodiments of the present invention provide a method for reducing fretting and wear and for removing debris in a high pressure head of a pump assembly.

[0030] Embodiments of the present invention will now be described hereinafter, by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates a pump assembly;

Figure 2 illustrates a pump head, return spring and tappet;

Figure 3 illustrates another view of the pump head, return spring and tappet;

Figure 4 illustrates a plunger end in an internal chamber of the tappet; and

Figure 5 illustrates the features shown in Figure 4 and a spring seat member.

[0031] In the drawings like reference numerals refer to like parts.

[0032] Figure 1 illustrates a pump assembly 100. The pump assembly includes a main pump housing 101 provided with an axially extending opening 102. The opening extends in the direction into the page shown in Figure 1. A cam shaft (not shown) having an axis of rotation 103 drives an eccentrically mounted cam 104 mounted in the opening.

[0033] The main pump housing 101 is provided with a first, second and third radially extending opening or through bore 105a, 105b, 105c, each of which communicates at a radially inner end thereof with the axially extending opening 102 which extends through the housing. Other numbers of through bores can of course be utilised according to certain other embodiments of the present invention. A radially outer end of each housing bore 105a, 105b, 105c receives a respective pump head 110a, 110b, 110c. Each pump head is substantially identical and therefore reference will be made hereinafter only to the upper pump head 110a shown in Figure 1 which is described and shown in the further drawings.

[0034] Figure 2 illustrates parts of the pump head 110a in more detail. The pump head includes a head portion 200 which is a substantially rectangular body. A substantially cylindrical central region extends downwardly from an underside region 201 of the pump head. The cylindrical extension 202 encompasses a substantially cylindrical pump bore region 203. The pump bore 203 has a blind end 204 where at least one valve 205 is located. The pump bore 203 also has an open end 206 which thus provides an open mouth of the extension of the pump head. The bore 203 provides a pumping chamber with the space of the pumping chamber being defined by the blind end 204 of the bore and a first end 210 of a plunger 211. The plunger is an elongate shaft-like member which slides backwards and forwards within the cylindrical bore 203 in the pump head. As an upper end surface 212 of the first end 210 of the plunger moves upwardly in the direction shown by arrow A in Figure 2 the volume of the pumping chamber reduces. Equally, as the plunger moves in the direction along the axis of movement opposite to the direction shown by arrow A in Figure 2, the volume of the pumping chamber increases.

[0035] A substantially circular cut out region 215 is provided centrally on the lower surface of the pump head. This is utilised to locate and secure a first end 220 of a return spring 221. The return spring holds the tappet away from the pump head in its relaxed state and is compressed as the tappet is urged towards the pump head during a pump stroke part of a cycle. The space 215 under the pump head also provides clearance for an upper circular surface 230 of a cup-like tappet 231. The blind end of the plunger bore thus defines together with an outer end face of the plunger a pump chamber into which fuel at relatively low pressure may be delivered and within which pressurisation of fuel to a relatively high level suitable for injection takes place as the plunger is driven to perform a pumping stroke upon rotation of the cam or a rider located on the cam.

[0036] The tappet 231 is a substantially hollow body having a cylindrical side wall 232 which extends from the circumferential region of a substantially circular base 233. The base and side wall are integrally formed. The lip of the side wall 232 forms the circular surface which is urged upwards towards the pump head during pumping. The base 233 provides a blind end of an internal chamber 240 defined within the tappet. One or more through holes 250 are formed circumferentially around the side wall of the tappet to enable fluid to flow from an outer region surrounding the tappet body to an inner region within the chamber 240. The through holes may be circular or church window style or the like.

[0037] A spring seat 260 is located at a further end 261 of the plunger 211. The spring seat 260 shown in Figure 2 is secured to the end of the plunger by an interference fit, although it will be appreciated that the spring seat could alternatively be integrally formed with the shaft-like plunger body or could be secured thereto via other ways. The spring seat and plunger move together as one unit. An upper surface 262 of the spring seat seats a further lower end 263 of the return spring.

[0038] As illustrated in Figure 1, the drive shaft co-operates with the cam 104 and as shown in Figure 1 an optional and co-operable generally tubular cam rider which extends coaxially with the cam. On the outer surface the cam rider is provided with a first, second and third flattened surface referred to as flats. Each one of the flats co-operates with the base surface of a tappet 231 for a respective one of the plungers. As a tappet is operably coupled to a plunger, rotation of the shaft causes the cam rider to ride over the surface of the cam thereby imparting drive to both the tappet and the plunger. As the tappet 231 is driven a degree of lateral sliding movement is permitted between the lower surface 270 of the tappet base and the flat of the rider. Optionally, a slipper face may be provided for promoting such sliding movement. A lubricating fluid, such as fuel or the like, is provided in the opening 102 of the housing and bore 105 in which the tappet slides to limit wear due to friction.

[0039] As the cam is driven, the tappet is caused to reciprocate in the opening 105 and the plunger is caused to reciprocate within the plunger bore 203. There is thus a first reciprocating motion of the tappet within the housing bore and a further reciprocating motion of the plunger within the pump bore.

[0040] The tappet and the pumping plunger are thus driven together causing the plunger to perform a pumping cycle including a pumping stroke during which the tappet and the plunger are driven radially outward from the cen-

tral cam shaft (i.e. towards the respective pump head) which reduces the volume within the pump chamber 203. During this pumping stroke the pumping plunger is driven inwardly within its plunger bore and fuel within the pump chamber is pressurised to a high level. During a subsequent plunger return stroke the tappet and plunger are urged in a radially inward direction, i.e. towards the centre of the housing and away from the pump head. This return motion is caused by virtue of the resilient nature of the return spring which thus biases the tappet away from the pump head. During the return stroke of the plunger and its respective tappet the plunger is urged outwardly from the plunger bore and fuel at relatively low pressure may be allowed to fill the associated pump chamber via a valve.

[0041] The provision of the plunger return spring thus serves to urge the plunger to perform its return stroke and additionally ensures contact is maintained between the tappet and the flat of the cam rider during the pumping cycle. The tappet and plunger perform cyclic sinusoidal motion and are driven at a desired frequency. Aptly, the maximum frequency is about around 130Hz. Aptly, the maximum frequency is about around 120Hz. The tappet has a range of travel between bottom-dead-centre and top-dead-centre. Aptly, the range of travel is about around 15mm or less. Aptly, the range of travel is about around 10mm or less. The tappet acts as an intermediate element between the cam and/or cam rider element which provides drive and the plunger which is driven in a reciprocal fashion within the pump bore provided by the pump head.

[0042] Figure 3 illustrates the pump head, tappet and return spring shown in Figure 2 in more detail. In particular, Figure 3 helps clarify how church window style openings 250 are formed at a radially innermost end region of the tappet. Four openings are shown in Figure 3, although it will be appreciated that other shapes and numbers of openings are possible according to certain other embodiments of the present invention. The openings are formed by cut out regions 300 from the cylindrical side wall and base of the tappet. Figure 3 also helps illustrate how the pump head is substantially rectangular in shape, although it will be appreciated that other shapes and configurations are possible according to certain other embodiments of the present invention. The pump head may be secured to the pump housing 101 via bolts or other such securing mechanisms which, in use, extend through the apertures 301 in the pump head. As illustrated in Figure 3, the tappet thus provides an internal chamber which encompasses an end of the return spring. The other end of the return spring is secured at an upper end thereof to the pump head 110.

[0043] Figure 4 illustrates how a plunger extends through the open end 206 of the pump bore into a chamber 240 defined within the tappet. A lower end of the plunger 211 has a generally circular abutment surface end 400. This abuts with a central contact region 401 on an upper facing surface 402 of the base of the tappet. As illustrated in Figure 4 the central contact region 401 may be slightly raised with respect to a surrounding region of the upper surface 402 of the base of the tappet.

[0044] A spring seat 260 is a substantially circular, ring-like body formed of a resilient material. Aptly, the spring seat is formed of hardened steel. The cross-section of the spring seat is formed of a radially outermost (with respect to the axis of the plunger) leg 403 which has a lower annular contact surface 404 which sits on the upper surface 404 of the base of the tappet. The contact point 405 between the spring seat and base of the tappet thus constrains motion of the spring seat in a direction shown by arrow B in Figure 4. The remaining body of the spring seat is generally disc-like with a concave profile on its underside. The concave, partially teardrop shaped recess on the lower side of the spring seat helps allow the spring seat to flex. The upper surface 262 of the spring seat has an upper annular rib 410 extending as a ring shaped protuberance.

[0045] As illustrated in Figure 4, a small gap 420 can be opened between the end surface 400 of the plunger and the contact region 401 of the base of the tappet. This space 420 provides a short separation between component parts. During a pumping process in which a cam rider is urged against the lower surface 270 of the tappet, the tappet is pushed against the end of the plunger and the force overcomes the resilient nature of the spring seat. The plunger and tappet are thus effectively located together for movement as a unitary piece. The pumping stroke follows as the cam rider drives the tappet and plunger in a direction opposite to the arrow B shown in Figure 4 during which the tappet and plunger move as one. At the end of the pumping cycle, the cam rider ceases to urge the tappet (and thus the plunger) in the direction opposite to arrow B. The return spring 221 which acts on the upper surface of the spring seat which is urged against the base of the tappet and which carries the plunger with it, then causes motion of the tappet and plunger in the direction of arrow B. At an end of the return stroke, the resilient nature of the spring seat and the fact that it stands on the base of the tappet causes the plunger end to momentarily be pulled away from the contact region 401 at the base of the tappet. This separating motion creates the gap 420 that provides a fluid communication path between the zone between the component parts. The fluid communication path also communicates with the chamber 240 within the tappet and, via the vents in the tappet 250, the surrounding regions.

[0046] Figure 5 helps illustrate the cylindrical nature of the tappet and circular disc-like nature of the spring seat in more detail. As shown in Figure 5, the tappet 231 is a cup-like element having a cylindrical side wall extending from a substantially circular base. An upper lip 230 of the cylindrical side wall of the tappet provides an open mouth to the tappet and the lip 230 may be urged upwardly towards the pump head into a recess 500 in the central circular inset region 215 on the underside of the pump head body 200. Figure 5 also helps illustrate how a raised

central region of the upper surface of the base of the tappet may be raised to provide an island 501 which includes a contact surface 401 of the tappet at its upper surface.

[0047] The upper surface 262 of the spring seat provides an outermost substantially flat ring surface 505 which then extends upwardly via an upwardly extending region 506 into the upwardly facing rib region 410. This helps locate/seat the end of the return spring. From the rib moving radially inwards towards the plunger, the upper surface of the spring seat then drops into a first concave region 510 separated from an inner concave region 511 by a convex region 512. The radially innermost central region of the spring seat provides a contact region to enable the spring seat to be secured via an interference fit or the like to the end 261 of the plunger. It will be appreciated that the plunger body and spring seat could optionally be integrally formed.

[0048] According to certain embodiments of the present invention, a spring feature is thus added between a plunger and tappet or similar component. This causes a small gap to be opened between the component parts when unloaded. The opening of the small gap operates to draw lubricant into the gap between the faces. This enables the faces to be cooled, lubricated and cleared of debris. The flow of lubricant into the contact region also provides a squeeze film to be provided. This squeeze film helps keep the opposed faces apart for a longer period than would otherwise be possible with prior known systems. This helps reduce the wear created by motion.

[0049] The spring effect may be provided by a resilient spring seat as described hereinabove. Alternatively, the biasing effect which momentarily moves the parts apart may be achieved in a variety of other ways. For example, a solid spring seat could comprise a ring annulus housing a resilient 'o' ring.

[0050] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of them mean "including but not limited to" and they are not intended to (and do not) exclude other moieties, additives, components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0051] Features, integers, characteristics or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of the features and/or steps are mutually exclusive. The invention is not restricted to any details of any foregoing embodiments. The invention extends to any novel one, or novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

[0052] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

Claims

1. Apparatus for selectively providing a fluid communication path between a plunger element and a contact region of an intermediate element that drives the plunger element, comprising:

   an elongate plunger element comprising a first end region;
   an intermediate element comprising a contact region arranged to selectively abut with and thereby urge a further end region of the plunger element; and
   a spring seat member at said further end region that biases the further end region away from the intermediate element during a portion of a cycle of motion of the plunger element to thereby provide a fluid communication path between an abutment surface of said further end region and said contact region.

2. The apparatus as claimed in claim 1, further comprising:

   the intermediate element comprises a tappet received for reciprocating sliding motion in a housing bore of a pump housing of a pump assembly.

3. The apparatus as claimed in claim 2, further comprising:

   the tappet comprises at least one through-hole in a cylindrical side wall and/or base wall thereof, said through-hole providing a fluid path portion connected to said fluid communication path.

4. The apparatus as claimed in any preceding claim, further comprising:

   the fluid communication path provides lubricating fluid between said abutment surface and said contact region at an end of a return cycle of the plunger element.

5. The apparatus as claimed in any preceding claim, further comprising:

the first end region of said plunger element is locatable into a blind end of a pump bore of a pump head of a pump assembly; and
the intermediate element further comprises a drive surface that is driveable by a cam or cam rider element of the pump assembly to thereby urge said contact region against said abutment surface.

6. The apparatus as claimed in any preceding claim, further comprising:

a return spring member that urges a surface of the spring seat element away from a pump head of a pump assembly.

7. The apparatus as claimed in any preceding claim wherein said spring seat member and said plunger element are integrally formed or the spring seat member is secured to said plunger element for movement therewith.

8. A pump assembly comprising:

a pump housing comprising an axially extending opening and at least one housing bore extending generally radially from said opening;
at least one intermediate element each received for reciprocating sliding motion in a respective housing bore and comprising an internal chamber region;
at least one pump head comprising a pump bore having a blind end and secured to said pump housing;
an elongate plunger element in each chamber region driveable in use via a respective intermediate element, and comprising a first end region that pressurises fluid in a pumping chamber provided by a respective pump bore, and a further end region;
a cam and/or cam rider element in said axially extending opening having an inner surface co-operable with a cam driveshaft and an outer surface co-operable with a drive surface of said intermediate member; and
at least one spring seat member each at a further end region of a respective plunger element that biases the further end region away from a contact region of the intermediate element during a portion of a cycle of motion of the plunger element to thereby provide a fluid communication path between an abutment surface of the further end region and said contact region.

9. The pump assembly as claimed in claim 8, wherein said spring seat member and said plunger element are integrally formed or the spring seat member is secured to said plunger element for movement therewith.

10. A method of lubricating between a plunger element of a pump assembly and an intermediate element providing drive to the plunger element, the method comprising the steps of:

driving a first end region of a plunger element in a first reciprocating motion with respect to a blind end of a pump bore of a pump head by selectively urging a contact region of an intermediate element proximate to a further end region of the plunger element in a further reciprocating motion;
via a spring seat member at the further end region of the plunger element, biasing the plunger element away from the intermediate element during a portion of a cycle of motion of the plunger element; and
providing lubricating fluid between an abutment surface of said the further end region and said contact region as the further end region is biased away from the intermediate element.

11. The method as claimed in claim 10, further comprising:

cooling and removing debris from between the abutment surface and said contact region via the lubricating fluid.

12. The method as claimed in claim 10 or claim 11, further comprising:

providing a squeeze film layer between the abutment surface and said contact region via the lubricating fluid.

13. The method as claimed in any one of claims 10 to 12, further comprising:

opening and closing a gap between said abutment surface and said contact region each cycle of the plunger element.

14. The method as claimed in any one of claims 10 to 13, further comprising:

said portion of a cycle comprises an end of a return cycle of the plunger element in which fluid in the pump bore expands and said first reciprocating motion further comprises a pump cycle portion in which fluid in the pump bore is compressed.

15. The method as claimed in any one of claims 10 to 14, further comprising:

biasing the further end region via a spring seat member integrally formed with said plunger element or via a spring seat member secured to said plunger element for movement therewith.

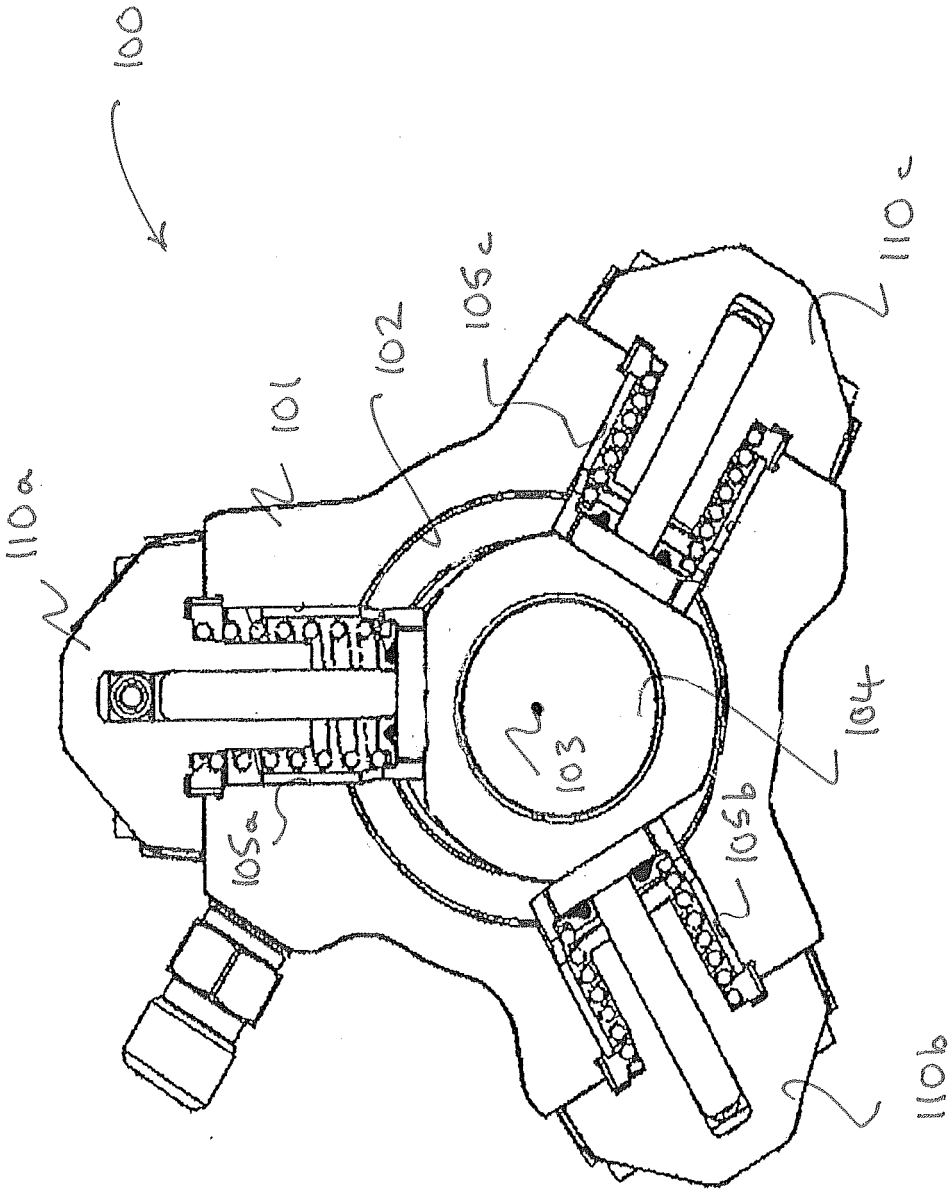

Fig 1.

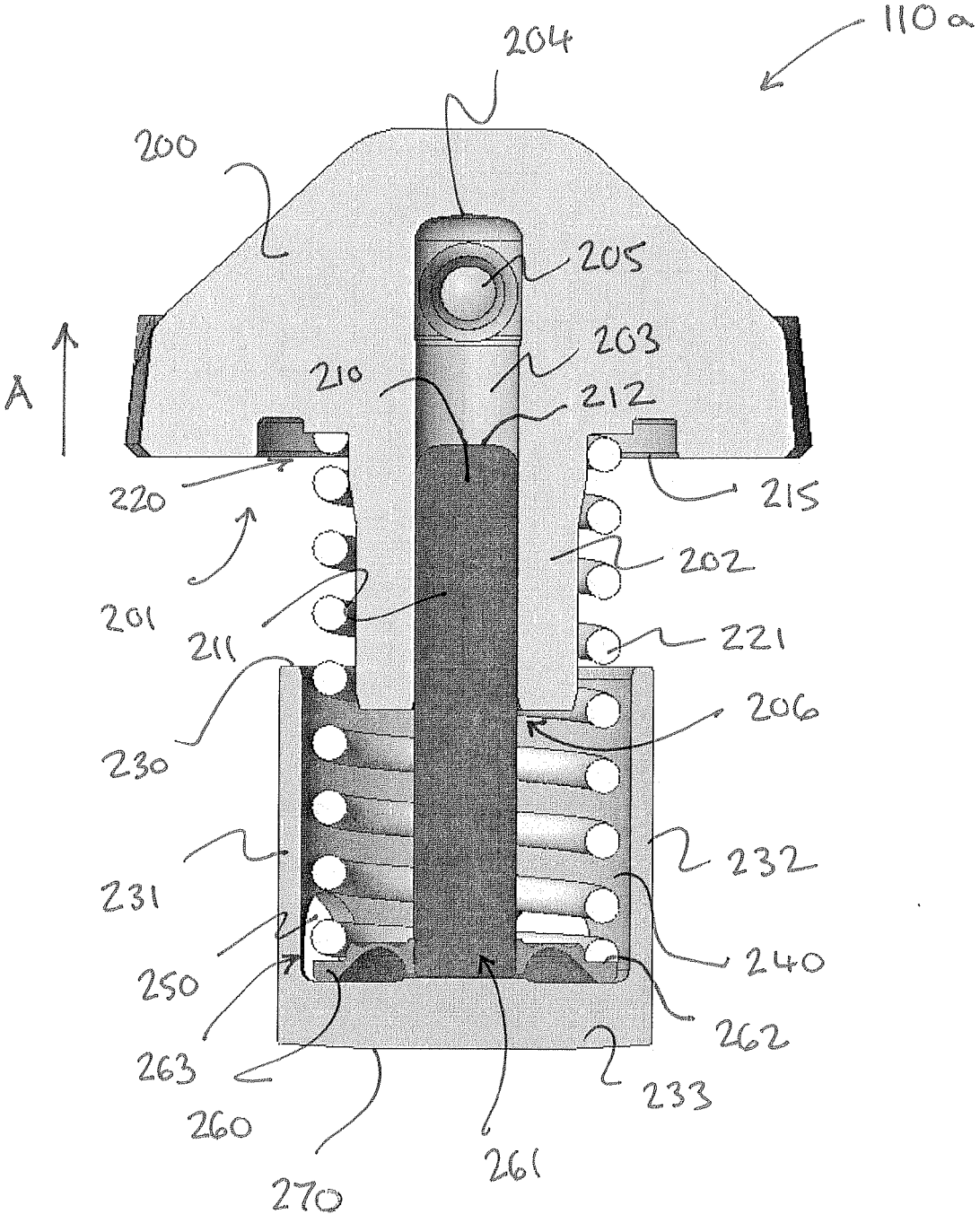
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Fig 2.

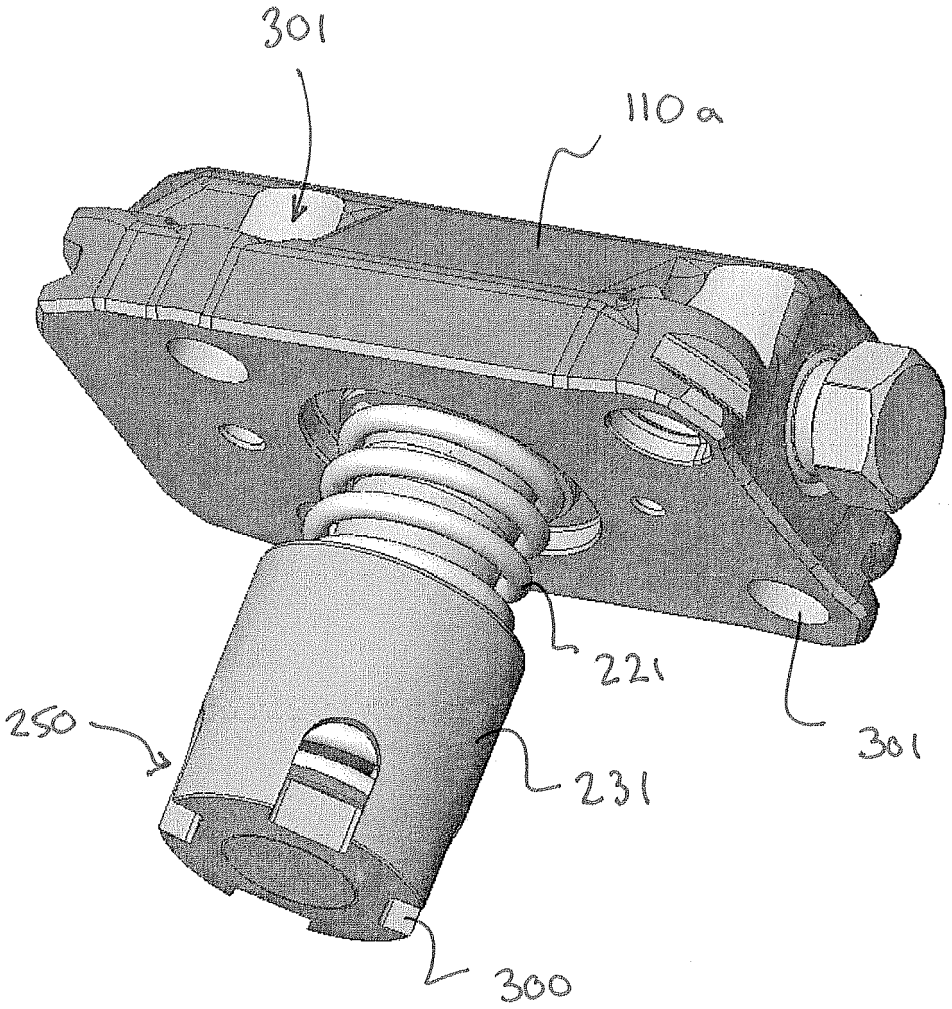

FIG 3.

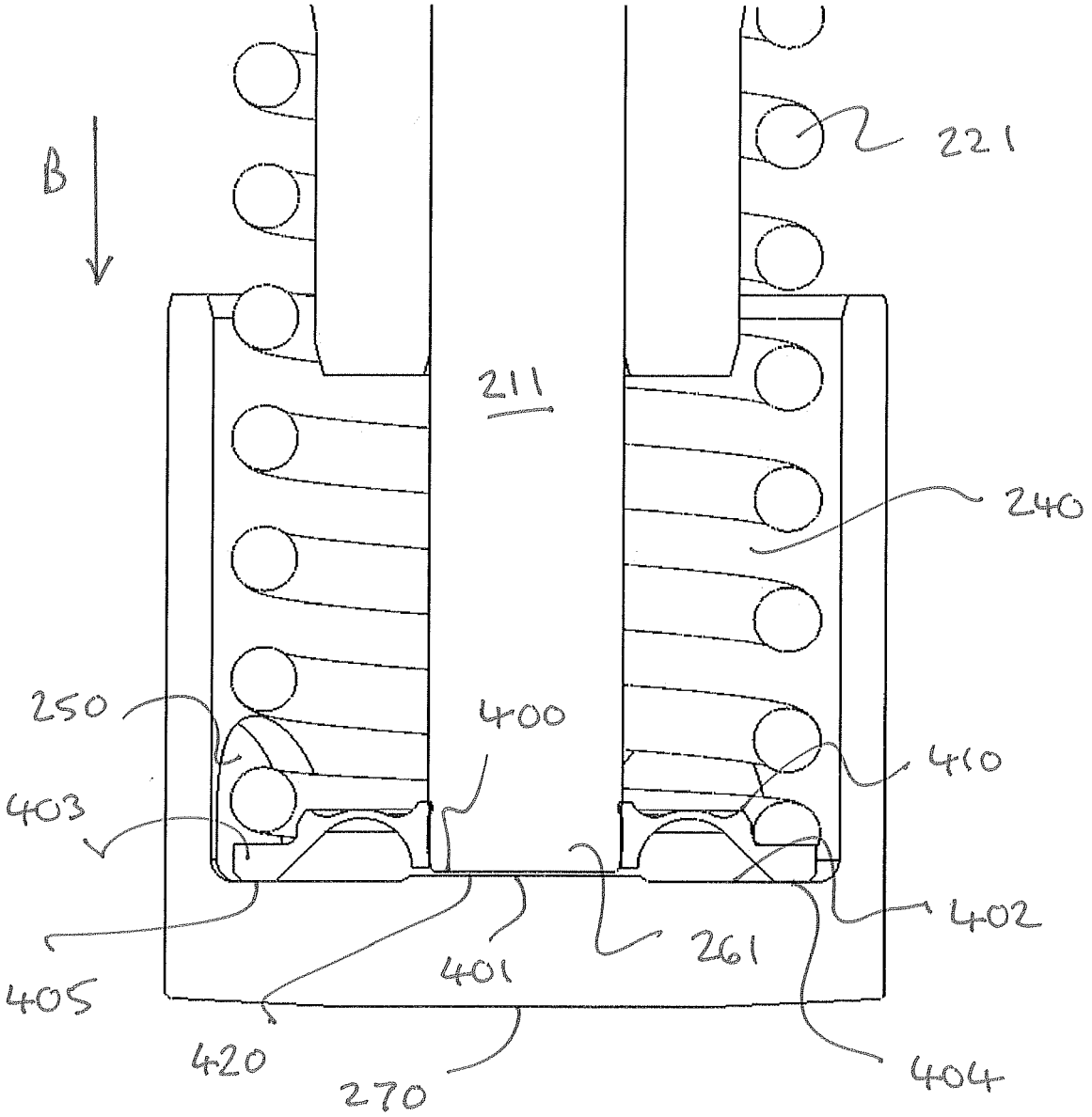

Fig 4.

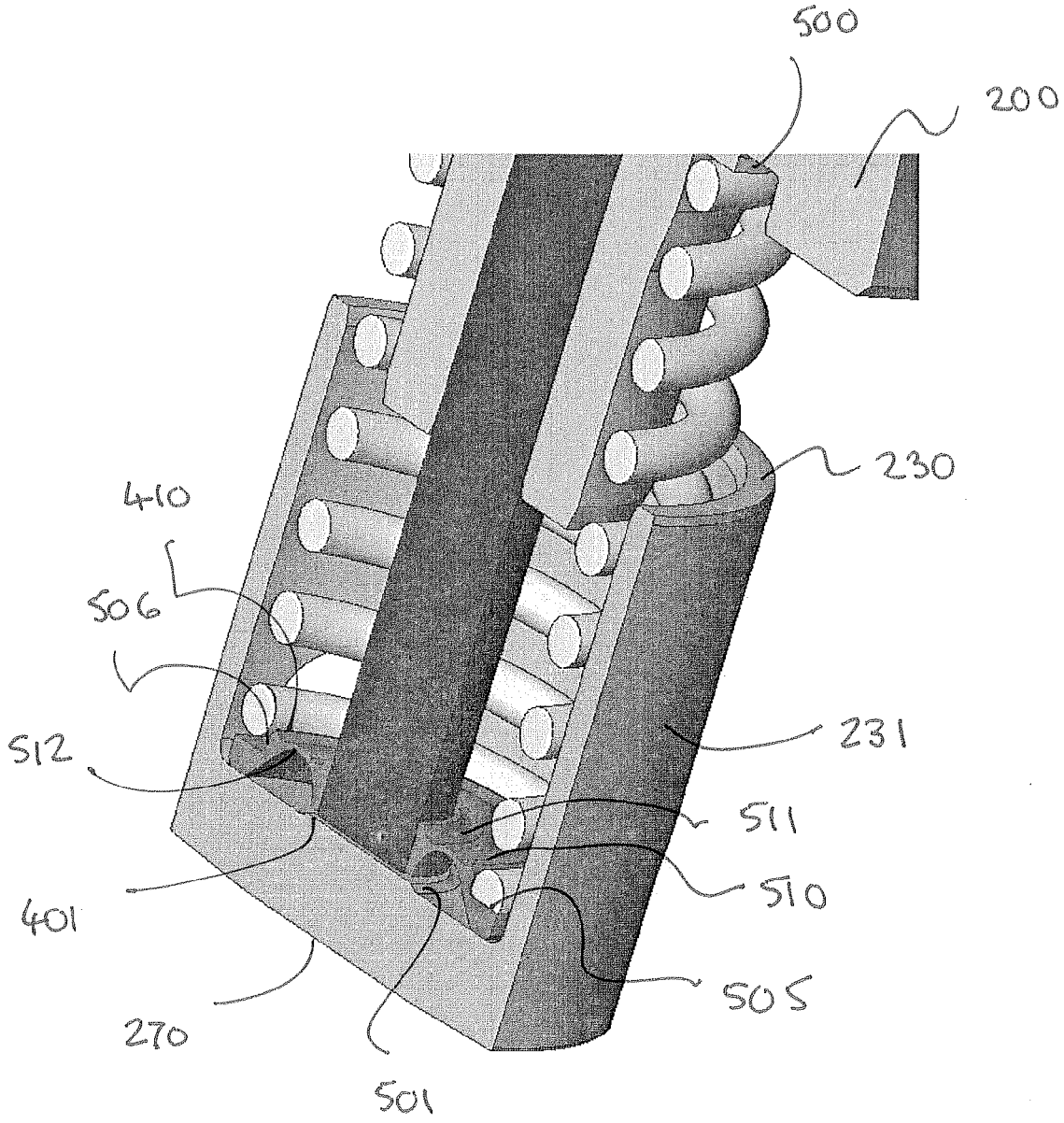

FIG 5.

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Application Number
EP 12 16 6665

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Place of search	Date of completion of the search	Examiner
Munich	11 September 2012	Kolland, Ulrich

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