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(54) EXTERNALLY SPRUNG TAPPET WITH HEAD TURRET GUIDE FOR A FUEL PUMP

(57) In known fuel pump assemblies, a single tappet return spring inside the tappet urges a pumping plunger away from a pump head and ensures contact between the tappet and a drive arrangement. The spring rests on a spring seat fixed to the plunger. This design requires the tappet return spring to fit within the tappet, thereby limiting the spring's diameter. The present invention provides a tappet return spring (58) that wraps around the outside of the tappet (40) to urge only the tappet away from the pump head (22a, 22b, 22c). A second plunger return spring (56) working in tandem with the tappet return spring (58) is located within the tappet (40) and urges the plunger (30) away from the pump head (22a, 22b, 22c) and further urges the plunger (30) to maintain contact with the tappet (40).

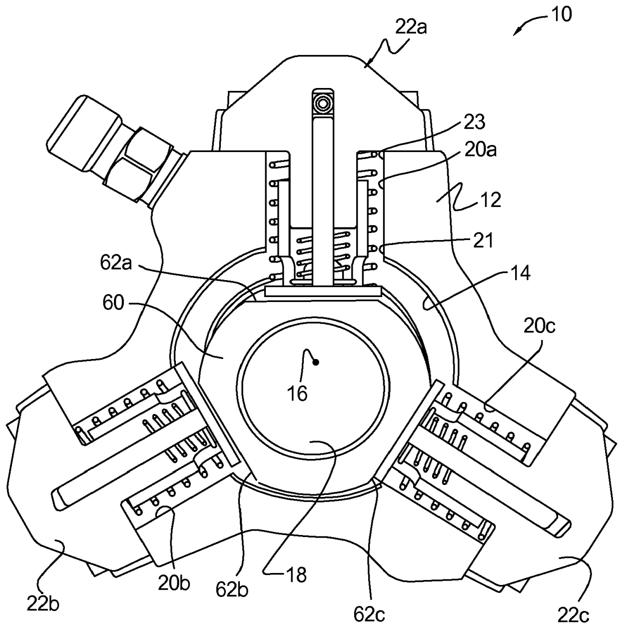

FIG. 1.

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Description

FIELD OF THE INVENTION

[0001] This invention relates to an intermediate drive assembly for a fuel pump. In particular, the invention relates to a spring actuated tappet and more specifically to a spring actuated tappet having an internal plunger spring and an externally mounted tappet spring seated on a tappet flange.

BACKGROUND OF THE INVENTION

[0002] In a known common rail fuel pump, for example as described in European Patent No. EP 1184568, three pumping plungers are arranged at equi-angularly spaced locations around an engine driven cam. The cam carries a cam ring (or cam rider), which travels over the surface of the cam as it is driven by the engine. Each plunger is mounted within a respective plunger bore provided in a pump housing and, as the cam is driven, each of the plungers is caused to reciprocate within its bore. As the plungers reciprocate, each causes pressurisation of fuel within an associated pumping chamber. The delivery of fuel from the pumping chambers to a common high pressure supply passage is controlled by means of respective delivery valves associated with each of the pumps. The high pressure supply passage supplies fuel to a common rail, or other accumulator volume, for delivery to the downstream injectors of the injection system.

[0003] In this arrangement it is typical for an intermediate drive member in the form of a tappet to be provided to transmit drive from the cam/cam rider arrangement to each of the plungers. As stated above, 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. Each tappet is located within a tappet bore provided in the pump housing and is arranged so that, as the cam is driven, each tappet is caused to reciprocate within its respective bore, resulting in reciprocating motion to the plungers. As the tappet is driven radially outward from the shaft by the cam rider, its respective plunger is driven to reduce the volume of the pumping chamber. This part of the pumping cycle is referred to as the pumping stroke of the plunger, during which fuel within the associated pumping chamber is pressurised to a relatively high level. During a return stroke of the plunger, the plunger is urged in a radially inward direction under the influence of a plunger return spring.

[0004] A secondary function of the tappet is to reduce lateral forces applied to the plunger by transmitting transverse loads to the tappet bore so that generally the plunger is driven in a reciprocal motion by the tappet along a respective longitudinal axis of motion. A known tappet, which is slidably received in a tappet bore in the pump housing, is generally cup-shaped and has a cylindrical side wall portion to cooperate with the wall of the tappet bore, and a base end portion opposing the cam rider, which together define an internal chamber. Vents or windows may be provided in the base portion and/or side wall portion of the tappet to allow a lubricating fluid to flow from a region around the cam mechanism to a region within the tappet so that hydraulic forces do not inhibit sliding movement of the tappet within the tappet bore.

[0005] A spring seat or plate is mounted to or otherwise engaged with the lower end of the plunger and is received in the internal chamber of the tappet. A plunger return spring abuts the radially outer face of the spring seat and is compressed during a pumping stroke of the plunger, so that a return biasing force is applied to the plunger, via the spring seat, to help drive the plunger return stroke. In PCT Publication No. WO 2004/104409 for example, a coupling mechanism in the form of a circlip may be used to couple the bucket tappet to the lower portion of the pumping plunger, so that axial motion of one (e.g., the tappet) results in axial motion of the other (e.g., the plunger).

[0006] The internal spring employed within current systems limits the size of the spring that can be used within the pump. A larger size spring would require a larger tappet to encircle such a spring. However, this larger tappet would have an increased mass which in turn would require an even larger spring to produce the necessary biasing force during operation. A further drawback due to the limited size of the spring used within the pump is that it limits the size of the pumping chamber and thus establishes a maximum pressure ceiling for the pump.

[0007] Accordingly, the present invention seeks to address at least one of the aforementioned problems in the art.

SUMMARY OF THE INVENTION

[0008] In general, the invention provides an intermediate drive assembly for a fuel pump having improved tappet performance and reduced manufacturing costs. In particular, rider/tappet type fuel pumps use a guided tappet to protect the pumping plunger (pumping element) from the side-load of the orbiting cam rider of a drive arrangement. The side-loading of the tappet occurs due to friction between the cam rider and tappet. Traditional designs utilise a spring inside the tappet which ensures contact between the tappet and cam rider during the pumping operation. The spring rests on a spring seat which is press-fit onto the plunger such that the spring also maintains the contact between the plunger and tappet. This arrangement requires the tappet return spring to fit within the tappet, and as a result, is limited in the diameter that can be used. For instance, a larger spring would require a larger tappet (which would have more mass), which would in turn require a still larger spring to provide sufficient restorative force to the higher mass tappet.

[0009] The invention therefore provides an intermediate drive assembly having an externally sprung tappet.

The tappet is flanged at a cambox end to provide a spring seat for a larger-diameter tappet return spring. This spring wraps around the outside of the tappet and can be of a much larger diameter than the tappet, if required. A second, plunger return spring is fitted between a head turret and the plunger spring seat in order to maintain contact between the plunger and the tappet. The plunger return spring is sized only to act against the lighter weight plunger and not the heavier tappet. By moving the tappet return spring from within the tappet to around the tappet, the diameter of the tappet may be reduced. A tappet guide may then be machined on the outer diameter of the head turret, thereby removing the need for a honing operation or sleeving to form the tappet guide in the pump housing. Further, since the plunger is not directly connected to the tappet, the allowable coaxial tolerance between plunger bore and machined outer diameter of the head turret may be increased. The resulting improvements include a greater range of spring design options, the possibility for increasing the size of the head turret (for higher pressure operation) and eliminating the need for sleeving or machining of the pump housing to form the tappet guide.

[0010] Thus, in accordance with an aspect of the invention, there is provided an intermediate drive assembly for a fuel pump assembly, the fuel pump assembly including a pump housing provided with a bore for receiving the intermediate drive assembly. The fuel pump assembly further includes a pumping plunger and a pump head. The pump head includes a pump head portion and a head turret extending into the bore. A plunger bore is defined in the pump head and extends within the head turret. The pumping plunger is driven in a reciprocal manner within the plunger bore by a drive arrangement to pressurise fuel disposed within a pumping chamber defined by the pump head and the pumping plunger. The intermediate drive assembly is operably disposed between the drive arrangement and the pumping plunger and comprises: a tappet including a base portion and a side wall portion. The base portion includes a perimeter, and the side wall portion is connected with the base portion so as to be upstanding an intermediated distance from the perimeter of the base portion to define a tappet flange. The side wall portion is slidably disposed around the head turret. The side wall portion and base portion define an internal chamber. The base portion is configured for cooperating with the drive arrangement for driving the pumping plunger in the reciprocal manner. A plunger spring seat is coupled to the pumping plunger and positioned within the internal chamber. The invention in this is aspect is characterised in that a plunger return spring is positioned within the internal chamber and disposed between the plunger spring seat and the head turret for biasing the pumping plunger away from the pump head. A tappet return spring is positioned around the side wall portion and disposed between the tappet flange and the pump head portion for biasing the tappet away from the pump head.

[0011] The intermediate drive assembly of the invention may also include a pumping plunger, wherein the plunger spring seat is provided with an aperture for receiving the pumping plunger. The aperture in the plunger spring seat may be coupled with a lower end of the pumping plunger using a press fit or friction fit.

[0012] The intermediate drive assembly may also include a plurality of vents defined in at least one of the base portion or the side wall portion of the tappet for allowing the passage of fluid.

[0013] Furthermore, the intermediate drive assembly may further include at least one valve in fluid communication with the plunger chamber.

[0014] The pump housing of the intermediate drive assembly may be provided with a plurality of bores, wherein a corresponding number of intermediate drive assemblies are disposed in the respective bores.

[0015] Furthermore, the intermediate drive assembly may have a side wall portion that is generally cylindrical-shaped.

[0016] The plunger spring seat of the intermediate drive assembly may be integrally formed with the pumping plunger.

[0017] The invention further provides a method for maintaining a pumping plunger in operational engagement with a drive arrangement in a fuel pump assembly. The fuel pump assembly includes a pump housing provided with a bore. The fuel pump assembly includes the pumping plunger and a pump head. The pump head includes a pump head portion and a head turret extending into the bore. A plunger bore is defined in the pump head and extends within the head turret. The pumping plunger is configured for being driven in a reciprocal manner within the plunger bore by the drive arrangement to pressurise fuel disposed within a pumping chamber defined by the pump head and the pumping plunger. The method comprises: providing a tappet including a base portion and a side wall portion. The base portion includes a perimeter, and the side wall portion is connected with the base portion so as to be upstanding an intermediated distance from the perimeter of the base portion to define a tappet flange. The side wall portion is configured for being slidably disposed around the head turret, the side wall portion and the base portion defining an internal chamber. The method further comprises providing a plunger spring seat that is coupled to the pumping plunger wherein the plunger spring seat is positioned within the internal chamber. The method is characterised by positioning a plunger return spring within the internal chamber and disposing the plunger return spring between the plunger spring seat and the head turret; positioning a tappet return spring around the side wall portion and disposing the tappet return spring between the tappet flange and the pump head portion; urging the pumping plunger against base portion using the plunger return spring; and urging the base portion against the drive engagement using the tappet return spring thereby transmitting movement of the drive engagement to reciprocate the pumping plunger.

[0018] The method may also include selecting a ratio of spring strengths of the tappet return spring and the plunger return spring such that a first biasing force exerted by the tappet return spring on the tappet flange and a second biasing force exerted by the plunger return spring on the pumping plunger maintains the plunger in contact with the base portion during reciprocating movement.

[0019] It will be appreciated by the skilled person how any embodiment or feature of one aspect of the invention may optionally be combined with any embodiment or feature of any other aspect of the invention and *vice versa.* It is particularly beneficial that the intermediate drive assembly comprises a tappet having an external flange configured to mount a tappet return spring wherein the tappet also defines an internal chamber configured to house a plunger return spring. Together these springs provide an improved intermediate drive assembly or pump assembly that offers a large range of tappet spring ratios while maintaining plunger isolation from side-load. Additionally, since the head turret provides the tappet guide surface, there is no longer a need to provide sleeving of the pump housing and/or a honing operation to provide for a means for guiding of the tappet. Furthermore, the intermediate drive assembly allows for less precise machining due to larger plunger bore/turret outer diameter coaxial tolerances. The intermediate drive assembly may also accommodate enlargement of the head turret diameter for higher pressure applications while requiring no changes to the pump housing.

[0020] These and other aspects, objects and benefits of this invention will become clear and apparent on studying the details of this invention and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The invention will further be described, by way of example, with reference to the accompanying drawings:

Figure 1 is a sectional view of a fuel pump assembly including an intermediate drive assembly in accordance with one aspect of the invention;

Figure 2 is a side view showing the intermediate drive assembly shown in Figure 1;

Figure 3 is a sectional view of the intermediate drive assembly shown in Figure 2 including an externally sprung tappet with a head turret guide in accordance with an aspect of the invention; and

Figure 4 is a partial perspective of the intermediate drive assembly shown in Figures 2 and 3.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Referring to the drawings in detail, and specifically to Figure 1, fuel pump assembly 10 is shown. The fuel pump assembly 10 includes a pump housing 12 provided with an axially extending opening 14. The opening extends in the direction into the page shown in Figure 1. A cam shaft (not shown) having an axis of rotation 16 drives a drive arrangement 18, such as, for example, an eccentrically mounted cam mounted in opening 14.

[0023] Pump housing 12 is provided with a first, second and third radially extending openings or through bores 20a, 20b, 20c, each of which communicates at a radially inner end thereof with axially extending opening 14 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 20a, 20b, 20c receives a respective pump head 22a, 22b, 22c. Each pump head 22a, 22b, 22c may be substantially identical and therefore for illustrative purposes, reference will be made hereinafter only to pump head 22a shown in Figure 1, which is described and shown in the further drawings.

[0024] Turning now to Figures 2-4, pump head 22a includes a head portion 24 and a radially inwardly extending head turret 26 which projects into outer end 23 of opening 14 in pump housing 12. Head turret 26 is provided with a plunger bore 28 that is configured for slidably receiving a pumping plunger 30. A blind end 32 of plunger bore 28 is located within head portion 24 of pump head 22a where at least one valve 33 is located to allow fluid communication into and out of pumping chamber 34. Blind end 32 of plunger bore 28 defines, together with a radially outer end face 36 of plunger 30, the pumping chamber 34. Plunger 30 is an elongate shaft-like member that slides within plunger bore 28 inward toward and outward away from pumping chamber 34 (the "pumping cycle"). As outer end face 36 of plunger 30 moves toward pumping chamber 34 in the direction shown by arrow A in Figure 3 (the "pumping stroke"), the volume of the pumping chamber 34 reduces. As plunger 30 moves away from the pumping chamber 34 in the direction along the axis of movement opposite to the direction shown by arrow A in Figure 3 (the "return stroke"), the volume of the pumping chamber 34 increases. Thus, fuel at relatively low pressure is delivered during a return stroke of the plunger 30, and pressurisation of fuel to a relatively high level suitable for injection takes place as plunger 30 is driven to perform a pumping stroke upon rotation of the cam shaft. Head turret 26 of pump head 22a provides an increased sealing length for plunger bore 28, which tends to reduce high pressure fuel leakage from pumping chamber 34 along a path between plunger 30 and plunger bore 28.

[0025] Radially inner end 21 of axially extending opening 14 receives an intermediate drive assembly 38 for plunger 30 in the form of a tappet 40, a plunger return spring 56, and a tappet return spring 58. Tappet 40 is a substantially hollow body including a side wall portion 42 and a base portion 44. Side wall portion 42 is generally cylindrical and extends upstandingly from base portion

44 at an intermediated distance from a perimeter 45 of base portion 44 so as to define a generally circular or disc-shaped radially extended tappet flange 46. Base portion 44 and side wall portion 42 may be separately or integrally formed. An upper lip 48 of side wall portion 42 forms the circular surface which is urged upwards towards head portion 24 during the pumping stroke. An internal chamber 50 within tappet 40 is defined by side wall portion 42 and base portion 44. Base portion 44 provides a blind end of internal chamber 50. Tappet 40 locates within radially inner end 21 of opening 14 (see Figure 1) so that an internal surface 51 of side wall portion 42 is in sliding contact with an external surface 53 of turret 26 and serves to guide longitudinal movement and constrain lateral movement of tappet 40 during the pumping and return strokes. One or more vents or through holes 52 are formed circumferentially around side wall portion 42 and/or base portion 44 of tappet 40 to enable fluid, such as engine fuel, to flow from an outer region surrounding tappet 40 to an inner region within internal chamber 50. Vents 52 reduce the pressure differential between internal chamber 50 and opening 14 and therefore prevent excessive hydraulic force on tappet 40 during reciprocating motion. As tappet 40 and plunger 30 are driven through the pumping and return strokes, fuel is dispelled from internal chamber 50 through vents 52. As tappet 40 and plunger 30 perform the return stroke, fuel is drawn into and out of internal chamber 50 through vents 52. The flow of fuel into and out of internal chamber 50 serves to lubricate and cool the mating surfaces between plunger 30 and base portion 44 and between base portion 44 and flats 62a, 62b, 62c of a cam rider 60. Vents 50 may be, for example, circular or church window style or the like. Additionally, while four vents are shown in the Figures, it will be appreciated that other shapes and numbers of openings are possible according to certain other embodiments of the present invention.

[0026] Tappet 40 is coupled to plunger 30 by multiple springs so that plunger 30 is urged to remain in contact with tappet 40 during the pumping cycle. Accordingly, a plunger spring seat 54 in the form of a plate is received in internal chamber 50 of tappet 40 and defines a central aperture 55 for receiving a lower end of plunger 30 in a press or friction interference fit. While plunger spring seat 54 is described as being secured to the end of plunger 30 by an interference fit, it will be appreciated that spring seat 54 could alternatively be integrally formed with the shaft-like plunger 30 or could be secured thereto via other ways. Plunger spring seat 54 and plunger 30 move together as one unit. Plunger spring seat 54 locates one end of a plunger return spring 56 with the other end of plunger return spring 56 abutting a radially inner surface 57 of head turret 26 of pump head 22a, so that plunger return spring 56 serves to apply a return biasing force to plunger spring seat 54 and plunger 30 to drive a plunger return stroke. A second tappet return spring 58 has one end located on a top surface 59 of tappet flange 46 with the second end abutting against a radially inner surface 61 of head portion 24 of pump head 22a. Tappet return spring 58 may be concentrically disposed within plunger return spring 56. Tappet return spring 58 serves to apply a return biasing force to tappet flange 46 (and therefore tappet 38) during a plunger (and therefore tappet) return stroke. The tappet return spring 58 biases tappet 38 away from pump head 22a during the return stroke while plunger return spring 56 urges plunger 30 against tappet 40 so that plunger 30 is urged to be in contact with tappet 40 and a full plunger stroke is travelled upon rotation of cam 18 or rider 60 located on cam 18.

[0027] As illustrated in Figure 1, the cam shaft co-operates with the eccentrically mounted cam 18 and, as shown in Figure 1, the co-operable generally tubular cam rider 60 which extends coaxially with cam 18. On the outer surface cam rider 60 is provided with first 62a, second 62b and third 62c flattened surfaces referred to as flats. Each one of flats 62a, 62b, 62c co-operates with base portion 44 of tappet 40 for a respective one of plungers 30. As respective tappets 40 are operably coupled to respective plungers 30, rotation of the shaft causes cam rider 60 to ride over the surface of eccentrically mounted cam 18 thereby imparting drive to both each respective tappet 40 and plunger 30 combination. As tappet 40 is driven a degree of lateral sliding movement is permitted between the lower surface of base portion 44 and the flat (e.g., 62a) of the cam rider 60. Optionally, a smooth slipper face may be provided for promoting such sliding movement. A lubricating fluid, such as fuel or the like, is provided in opening 14 of the housing and bore 20 in which tappet 40 slides to reduce wear due to friction.

[0028] As cam 18 is driven, tappet 40 is caused to reciprocate in its respective bore (e.g., 20a as described above) and plunger 30 is caused to reciprocate within plunger bore 28. There is thus a first reciprocating motion of tappet 40 within the housing bore and a further reciprocating motion of plunger 30 within plunger bore 28.

[0029] Tappet 40 and plunger 30 are thus driven together causing plunger 30 to perform a pumping cycle including a pumping stroke during which tappet 40 and plunger 30 are driven radially outward from the central cam shaft (i.e., in the direction shown by Arrow A in Figure 3; towards the respective pump head) which reduces the volume within pumping chamber 34. During this pumping stroke plunger 30 is driven toward head portion 24 of pump head 22a within its plunger bore 28 and fuel within pumping chamber 34 is pressurised to a high level.

[0030] During a subsequent plunger return stroke tappet 40 and plunger 30 are urged in a radially inward direction, i.e. towards the centre of housing 12 and away from head portion 24 (i.e., in the direction opposite Arrow A). This return motion is caused by virtue of the resilient nature of tappet return spring 58 which thus biases tappet 40 away from head portion 24. Concurrently with the tappet return, plunger return spring 56 biases plunger 30 away from valve 33. In this manner, during the return stroke of plunger 30 and its respective tappet 40, plunger 30 is urged outwardly from plunger bore 28 and held in contact with tappet 40, and fuel at relatively low pressure may be allowed to fill the associated pumping chamber 34 via valve 33. In accordance with an aspect of the present invention, the ratio of spring strengths of tappet return spring 58 and plunger return spring 56 is selected such that the biasing forces exerted by tappet return spring 58 on tappet 40 and plunger return spring 56 on plunger 30 are closely matched so that plunger 30 return is generally synchronous with tappet 40 return. In a further aspect of the present invention, plunger return spring 56 may be selected to store a slightly larger biasing force than tappet return spring 58. In this manner, when plunger 30 is urged by plunger return spring 56 to perform its return stroke, this addition biasing force ensures that plunger 30 travels with tappet 40 and that contact is maintained between tappet 40 and the flat of cam rider 60 and that plunger 30 fully return travels during the pumping cycle.

[0031] Although particular embodiments of the invention have been disclosed herein in detail, this has been done by way of example and for the purposes of illustration only. The aforementioned embodiments are not intended to be limiting, and it should be appreciated that various modifications may be made to the embodiments described above without departing from the scope of the invention as defined by the appended claims.

[0032] For example, although the invention has been described with reference to a pump 10 having three bores 20a, 20b, 20c, it should be appreciated that this need not be the case and the invention is applicable to pumps having one, or more than one, pumping chamber with an associated pumping plunger.

[0033] As a further example, although the invention has been described with reference to a single plunger return spring 56 for biasing plunger 30 away from pump head 22a, 22b, 22c and a single tappet return spring 58 for biasing tappet 40 away from pump head 22a, 22b, 22c, it should be appreciated that more than one spring can be used in place of either or both of the singular return springs to achieve the purpose of this invention.

[0034] 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.

[0035] 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.

[0036] Various aspects of the invention may be illustrated by describing components that are coupled together. As used herein, term "coupled" is used to indicate either a direct connection between two components or, where appropriate, an indirect connection to one another through intervening or intermediate components. In contrast, if a component is referred to as being "directly coupled" to another component, there are no intervening elements present.

Claims

1. An intermediate drive assembly (38) for a fuel pump assembly (10), the fuel pump assembly (10) including a pump housing (12) provided with a bore (20a, 20b, 20c) for receiving the intermediate drive assembly (38), the fuel pump assembly (10) further including a pumping plunger (30) and a pump head (22a, 22b, 22c), the pump head (22a, 22b, 22c) including a pump head portion (24) and a head turret (26) extending into the bore (22a, 22b, 22c), the pumping plunger (30) is driven in a reciprocal manner within a plunger bore (28) by a drive arrangement (18) to pressurise fuel disposed within a pumping chamber (34) defined by the pump head (22a, 22b, 22c) and the pumping plunger (30), the intermediate drive assembly (38) is operably disposed between the drive arrangement (18) and the pumping plunger (30), the intermediate drive assembly (38) comprising:

   a tappet (40) including a base portion (44) and a side wall portion (42), the base portion (44) including a perimeter (45), the side wall portion (42) connected with the base portion (44) so as to be upstanding an intermediated distance from the perimeter (45) of the base portion (44) to define a tappet flange (46), the side wall portion (42) is slidably disposed around the head turret (26), the side wall portion (42) and the base portion (44) defining an internal chamber (50), the base portion (44) configured for cooperating with the drive arrangement (18) for driving the pumping plunger (30) in the reciprocal manner;
   a plunger spring seat (54) coupled to the pumping plunger (30) and positioned within the internal chamber (50);
   characterised by a plunger return spring (56)

positioned within the internal chamber (50) and disposed between the plunger spring seat (54) and the head turret (26) for biasing the pumping plunger (30) away from the pump head (22a, 22b, 22c); and
a tappet return spring (58) positioned around the side wall portion (42) and disposed between the tappet flange (46) and the pump head portion (24) for biasing the tappet (40) away from the pump head (22a, 22b, 22c).

2. The intermediate drive assembly (38) of Claim 1, wherein the plunger spring seat (54) is provided with an aperture (55) for receiving the pumping plunger (30).

3. The intermediate drive assembly (38) of Claim 2, wherein the aperture (55) in plunger spring seat (54) is coupled with a lower end of the pumping plunger (30) using a press fit or friction fit.

4. The intermediate drive assembly (38) of any preceding Claim, wherein at least one of the base portion (44) or the side wall portion (42) are provided with a plurality of vents (52) for allowing the passage of fluid.

5. The intermediate drive assembly (38) of any preceding Claim, further comprising at least one valve (33) in fluid communication with the pumping chamber (34).

6. The intermediate drive assembly (38) of any preceding Claim, wherein the pump housing (12) is provided with a plurality of bores (20a, 20b, 20c), and wherein a corresponding number of intermediate drive assemblies (38) are disposed in the respective bores (20a, 20b, 20c).

7. The intermediate drive assembly (38) of any preceding Claim, wherein the side wall portion (42) is generally cylindrical-shaped.

8. The intermediate drive assembly (38) of Claim 1, wherein the plunger spring seat (54) is integrally formed with the pumping plunger (30).

9. A method for maintaining a pumping plunger (30) in operational engagement with a drive arrangement (18) in a fuel pump assembly (10), the fuel pump assembly (10) including a pump housing (12) provided with a bore (20a, 20b, 20c), the fuel pump assembly (10) including the pumping plunger (30) and a pump head (22a, 22b, 22c), the pump head (22a, 22b, 22c) including a pump head portion (24) and a head turret (26) extending into the bore (22a, 22b, 22c), the pumping plunger (30) configured for being driven in a reciprocal manner within a plunger bore (28) by the drive arrangement (18) to pressurise fuel disposed within a pumping chamber (34) defined by the pump head (22a, 22b, 22c) and the pumping plunger (30), the method comprising:

providing a tappet (40) including a base portion (44) and a side wall portion (42), the base portion (44) including a perimeter (45), the side wall portion (42) connected with the base portion (44) so as to be upstanding an intermediated distance from the perimeter (45) of the base portion (44) to define a tappet flange (46), the side wall portion (42) configured for being slidably disposed around the head turret (26), the side wall portion (42) and the base portion (44) defining an internal chamber (50);
providing a plunger spring seat (54) that is coupled to the pumping plunger (30), the plunger spring seat (54) positioned within the internal chamber (50);
the method **characterised by** positioning a plunger return spring (56) within the internal chamber (50) and disposing the plunger return spring (56) between the plunger spring seat (54) and the head turret (26);
positioning a tappet return spring (58) around the side wall portion (42) and disposing the tappet return spring (58) between the tappet flange (46) and the pump head portion (24);
urging the pumping plunger (30) against base portion (44) using the plunger return spring (56); and
urging the base portion (44) against the drive engagement (18) using the tappet return spring (58) thereby transmitting movement of the drive engagement (18) to reciprocate the pumping plunger (30).

10. The method of Claim 9, further comprising:

selecting a ratio of spring strengths of the tappet return spring (58) and the plunger return spring (56) such that a first biasing force exerted by the tappet return spring (58) on the tappet flange (46) and a second biasing force exerted by the plunger return spring (56) on the pumping plunger (30) maintain the pumping plunger (30) in contact with the base portion (44) during reciprocating movement.

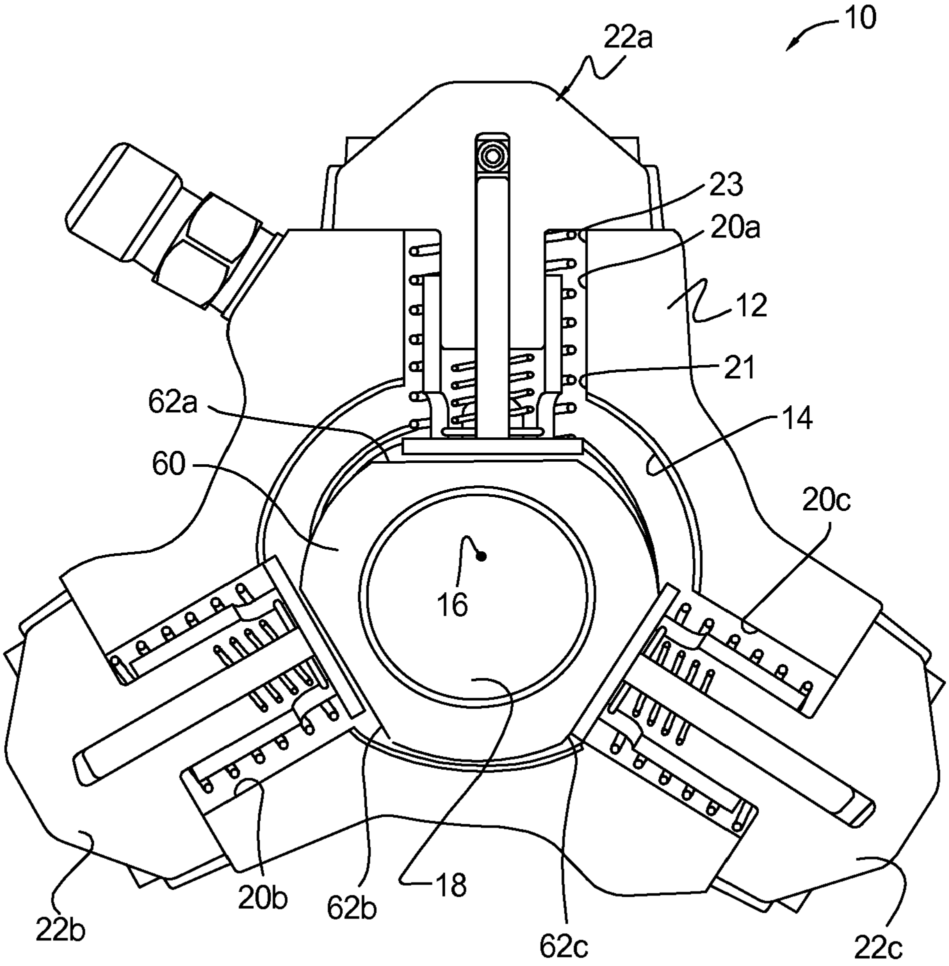

FIG. 1.

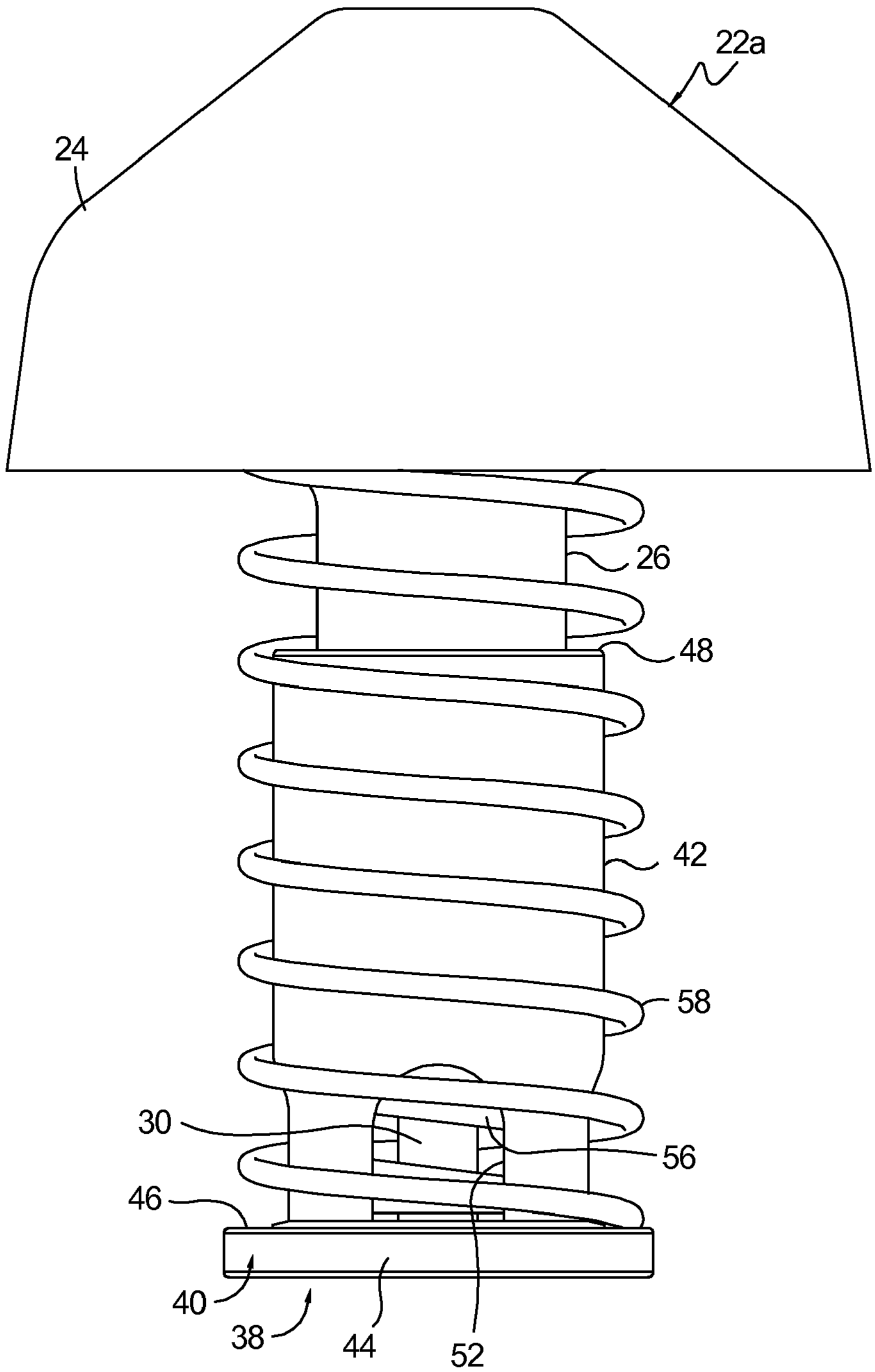

FIG. 2.

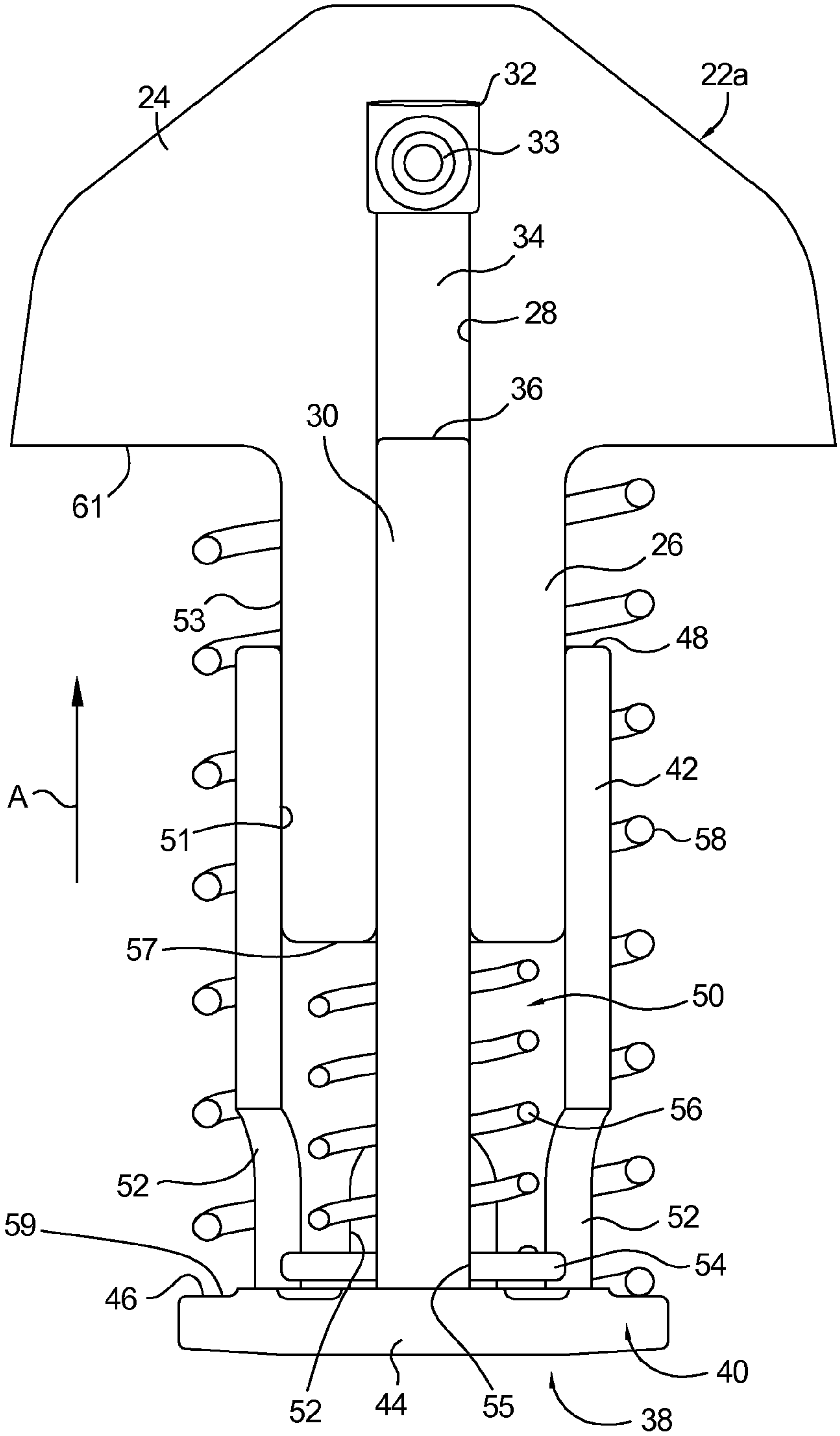
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FIG. 3.

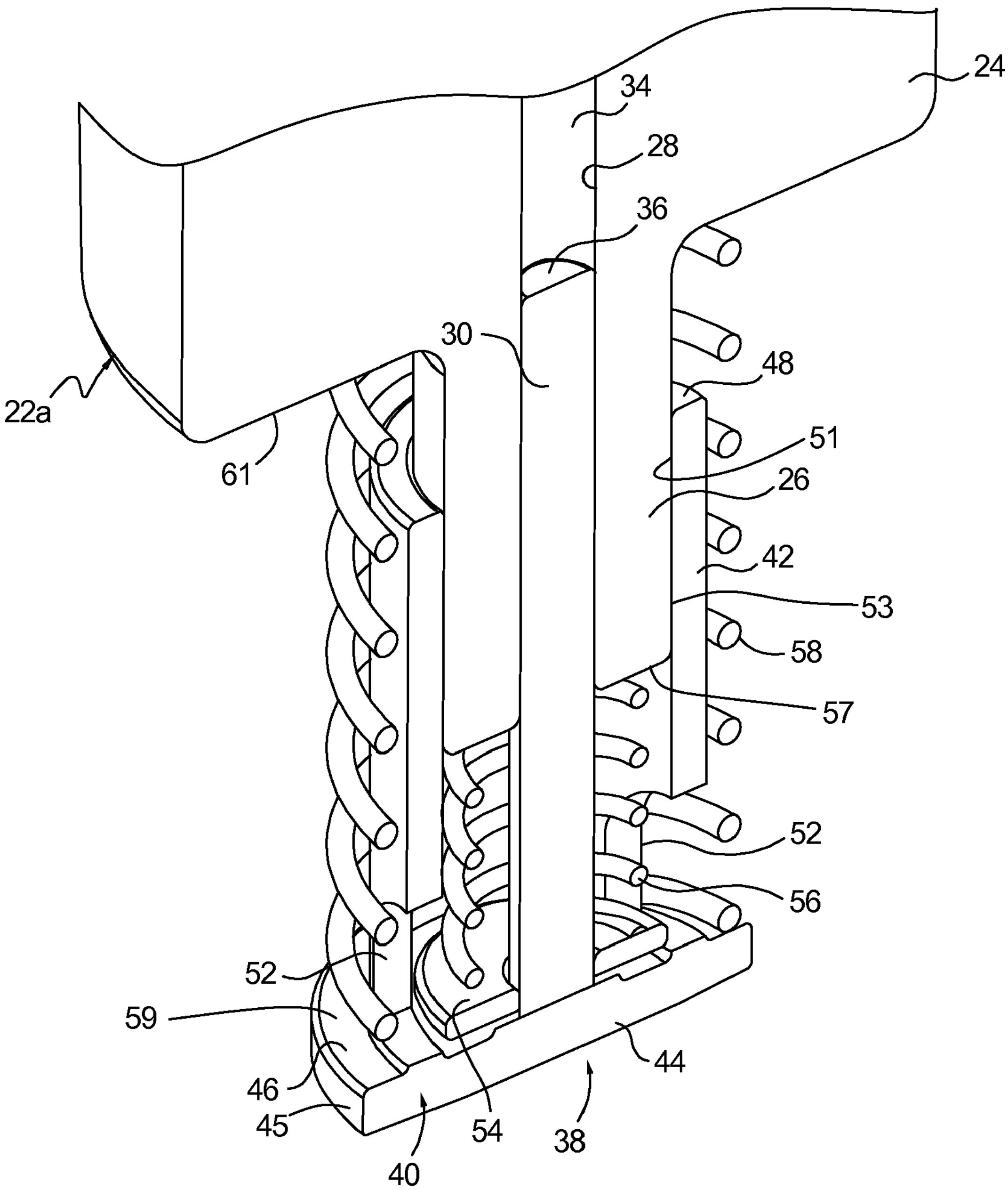

FIG. 4.

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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 3743

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			F02M F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	28 June 2016	Morales Gonzalez, M

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