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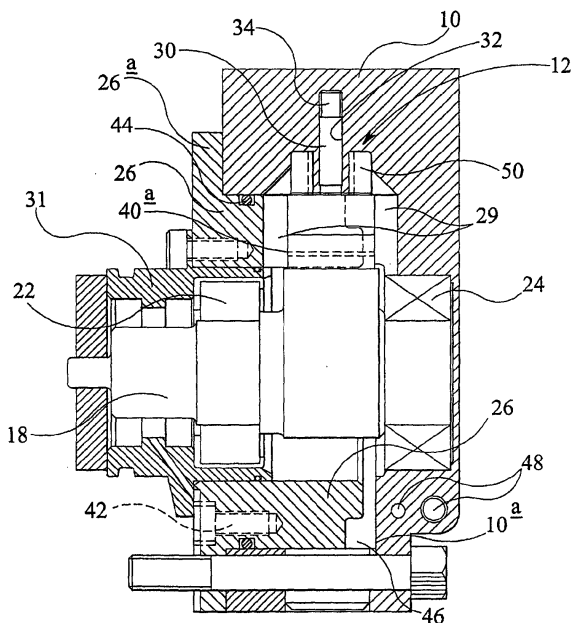
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(54) **Fuel pump**

(57) A fuel pump for use in an engine comprises a pump housing (10) and a plunger member (30) which is reciprocable within a plunger bore (32) provided in the pump housing (10) under the influence of a cam drive arrangement (20, 36, 38) so as to cause pressurisation of fuel within a pumping chamber (34). The cam drive arrangement includes a reciprocable shoe (36) and a roller member (38) and is driven, in use, by means of an associated drive shaft (18). The roller member (38) is

located radially inward of the shoe (36) and is cooperable with a cam surface (20a) of the cam drive arrangement so as to impart reciprocable movement to the shoe (36) upon rotation of the drive shaft (18). The pump also includes a tubular member (26) which is secured to the pump housing (10) and arranged such that it is substantially coaxial with the drive shaft (18), the tubular member (26) being further arranged such that it guides reciprocal movement of the shoe (36), in use.

FIG 1



Description

[0001] The invention relates to a fuel pump for use in supplying high pressure fuel to the fuel injection system of a compression ignition internal combustion engine.

[0002] In a known fuel pump for use in a compression ignition internal combustion engine, a plurality of plungers are reciprocable within respective plunger bores so as to pressurise fuel within respective pumping chambers for delivery to the fuel injection system associated with the engine. It is common to provide three plungers which are equi-angularly spaced around a drive shaft, the plungers being moveable under the influence of a cam drive arrangement. The cam drive arrangement includes a common eccentric cam surface, cooperable with all three of the plungers, to cause reciprocal movement of the plungers within the bores.

[0003] In an alternative known arrangement, each of the plungers is in connection with an associated tappet member which serves to drive movement of the plunger within its bore. The tappet members are slidable within tappet bores under the influence of respective roller members driven by means of an eccentric cam surface. The eccentricity of the cam surface causes the tappet members, and hence the plungers, to be driven inwardly within the bores, the plungers thereby performing a forward stroke in which fuel within the respective pumping chamber is pressurised. The tappet members are urged outwardly from the tappet bores by means of fluid pressure within a working chamber, thereby urging the plunger in an outward direction to perform the return stroke. Pump arrangements of this type can, however, be difficult to assemble. Furthermore, the tappet members require a relatively large accommodation space and are relatively expensive components. Parasitic pumping power losses are also an inherent feature of hydraulic tappet operation.

[0004] In known fuel pumps in which a tappet assembly is employed, it is also necessary to secure the tappet member to the plunger member so as to ensure the tappet member does not separate from the plunger when the pump operates under partial load conditions. For example, the plunger member may be secured to the tappet member by means of a suitable circlip and washer arrangement. It is also known to provide the tappet member with means for preventing relative angular movement about the tappet body's axis between the roller member and the cam surface. A roller member mounting pin is also provided to secure the roller to the tappet member. In such arrangements, the accommodation space available for the roller is limited, such that the roller member associated with the tappet member has a relatively short axial length compared to the diameter of the tappet member. A highly localised load is therefore applied to the cam surface by the roller member. Compressive stresses are therefore induced in regions of the cam surface which can ultimately cause the cam surface to fail.

[0005] In an alternative, known arrangement, pads are attached to the plungers. The pads are slidable on flats machined on a tube member which is carried by the eccentric cam surface so as to drive the plungers within their respective bores. However, this arrangement can only be operated with a cam surface having a single lobe, so that no multiplication of the pump's displacement is possible.

[0006] It is an object of the present invention to provide a fuel pump which removes or alleviates at least one of the aforementioned problems.

[0007] According to the present invention, there is provided a fuel pump for use in an engine, the fuel pump comprising a plunger member which is reciprocable within a plunger bore provided in a pump housing under the influence of a cam drive arrangement so as to cause pressurisation of fuel within a pumping chamber, the cam drive arrangement including a reciprocable shoe and roller member, and being driven, in use, by means of an associated drive shaft, the roller member being cooperable with a cam surface of the cam drive arrangement so as to impart reciprocal movement to the shoe upon rotation of the drive shaft, the pump further comprising a tubular member arranged such that it is substantially coaxial with the drive shaft and such that it guides reciprocal movement of the shoe, in use.

[0008] The tubular member is secured to the pump housing such that the tubular member remains static during pump operation. The roller member is arranged radially inward of the shoe such that it cooperates with a central, radially outward acting cam surface.

[0009] The invention provides the advantage that the need for a relatively expensive tappet assembly, to impart drive to the plunger member, can be avoided. As shoes are relatively small components, the invention provides the further advantage that the pump requires a smaller accommodation space than known fuel pump designs.

[0010] Additionally, although the shoe is a relatively small component compared with a tappet member such that the roller member may be of reduced diameter, the roller member may have an increased axial length. The load bearing capability of the cam member is therefore improved and compressive stresses within the cam member are reduced.

[0011] Preferably, the tubular member is provided with an aperture within which the shoe is received, the aperture being arranged to guide reciprocal movement of the shoe, in use.

[0012] Preferably, the shoe and the plunger member are arranged such that, in use, the plunger member is able to move axially relative to the shoe (i.e. along the axis of the plunger member) under partial load conditions. As the shoe is not in connection with the plunger, installation and assembly of the pump can be achieved relatively easily.

[0013] Inward movement of the plunger member within the plunger bore causes the plunger member to per-

form a forward stroke, in which pressurisation of fuel within the pumping chamber occurs.

[0014] The shoe may also be provided with a return spring which acts on the shoe so as to ensure the roller member remains in engagement with the cam surface during a return stroke of the plunger member.

[0015] The shoe may be arranged such that a surface thereof is exposed to fuel pressure within a volume defined within the pump housing, the pump further comprising vent means to permit the volume to be vented, in use, so as to substantially prevent reciprocal movement of the shoe and the plunger member from being impeded.

[0016] Preferably, the vent means may include one or more passage defined, at least in part, in any one or more of the tubular member, the shoe and the pump housing. The or each passage may conveniently be defined by a groove, recess, flat or drilling provided in any one or more of the shoe, the tubular member and the pump housing.

[0017] The roller member may take the form of a cylindrical roller.

[0018] The fuel pump may include a second tubular member, which is substantially coaxial with, and is arranged to extend at least partially within, the pump housing. The second tubular member is conveniently provided with a flange which extends into the pump housing and which enables the second tubular member to be secured to the pump housing.

[0019] If the second tubular member is provided, the second tubular member may be arranged to support a bearing for supporting the drive shaft within the pump housing. Alternatively, the bearing may be supported by the pump housing itself.

[0020] In a preferred embodiment of the invention, the fuel pump comprises a plurality of pump assemblies, each pump assembly comprising a plunger member slidable within a respective plunger bore so as to cause pressurisation of fuel within a respective pumping chamber, each of the pump assemblies having an associated shoe and roller member for imparting reciprocal movement to the respective plunger member, in use, wherein the tubular member is provided with a plurality of apertures, reciprocal movement of the shoes being guided within a respective one of the apertures, in use. Thus, each pump assembly has a different pumping chamber within which fuel pressurisation occurs upon reciprocating movement of a respective pumping plunger.

[0021] Conveniently, the tubular member may be provided with a plurality of diametrically opposed aperture pairs. If the pump comprises an even number of plunger members, a corresponding number of apertures are preferably provided. If the pump comprises an odd number of plunger members, a corresponding number of aperture pairs are provided, one of the apertures in each pair being arranged to receive a shoe so as to guide movement thereof, the other aperture in each pair being provided to facilitate manufacture of the side walls

of the aperture, for example by grinding with a large diameter wheel.

[0022] It will be appreciated that the fuel pump of the present invention may, but need not, be manufactured to include the drive shaft.

[0023] According to a second aspect of the present invention, there is provided a method of assembling a fuel pump on a drive shaft, the fuel pump comprising a cam drive arrangement including a reciprocable shoe and roller arrangement comprising a shoe and a roller member, for imparting movement to a plunger member, the shoe and roller arrangement being provided with return spring means which serve to maintain contact between the roller member and a cam surface of the cam drive arrangement, in use, the method of assembly comprising the steps of:

inserting a first tubular member provided with an opening into an additional tubular member provided with an aperture such that the opening is aligned with the aperture provided in the additional tubular member;

inserting the shoe and roller arrangement through the opening such that the shoe is received within the aperture, and moving the first tubular member angularly relative to the additional tubular member so as to misalign the opening and the aperture, the first tubular member thereby serving to compress the return spring means to permit insertion of the drive shaft into the first tubular member; and

removing the first tubular member from the fuel pump when assembly is complete.

[0024] The additional tubular member may be provided with a plurality of apertures, each for receiving a shoe associated with a respective one of a plurality of plunger members. In this case, the method includes the further step of moving the first tubular member relative to the additional tubular member so as to align each one of the apertures with the opening in turn and, when each one of the apertures is aligned with the opening, inserting the respective shoe and roller arrangement through the opening, such that the shoe is received within the aperture.

[0025] The invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a sectional view of a fuel pump in accordance with a first embodiment of the present invention;

Figure 2 is a cross-sectional view of the embodiment shown in Figure 1;

Figure 3 is a schematic diagram of an assembly ring

for use in assembling the fuel pump in Figures 1 and 2;

Figure 4 is a sectional view of an alternative embodiment of the fuel pump to that shown in Figures 1 and 2; and

Figure 5 is a cross sectional view of the fuel pump in Figure 4.

[0026] Referring to Figures 1 and 2, there is shown a high pressure fuel pump suitable for use in the fuel injection system of a compression ignition internal combustion engine. In particular, the fuel pump is suitable for use in delivering high pressure fuel to the common rail of a common rail fuel injection system.

[0027] As can be seen most clearly in Figure 2, the pump comprises a main pump housing 10 within which three pump assemblies, referred to generally as 12, 14 and 16, are housed. The pump assemblies are radially spaced around a central drive shaft 18 and are located at approximately equi-angularly spaced locations. The drive shaft carries a single, central cam member 20 having a cam surface 20a, the cam member 20 being arranged to drive the pump assemblies to deliver high pressure fuel through associated outlets (not shown) to the common rail fuel injection system. The drive shaft 18 is supported within the pump housing 10 by means of front bearings 22 and rear bearings 24, the drive shaft 18 being driven, in use, by an appropriate rotary drive from the engine. The front bearings 22 are supported by means of a carrier member 31 in connection with a tubular member 26 housed within the main pump housing 10. The tubular member 26 is fixedly secured to the main pump housing 10 and is arranged such that it is substantially coaxial with the drive shaft 18. The rear bearings 24 are supported by the main pump housing 10.

[0028] The tubular member 26 includes a flanged region 26a for securing the tubular member 26 to the pump housing 10 by means of appropriate bolts 42. The tubular member 26 may be shaped to accommodate an annular seal 44, if desired.

[0029] The pump assemblies 12, 14, 16 are substantially identical to one another and, in the following description, only the pump assembly 12 (as can be seen in Figure 1), will be described in detail. The pump assembly 12 comprises a plunger member 30, having a plunger axis (not identified), which is slidable within a bore 32 provided in the main pump housing 10. The bore 32 defines, together with an end surface of a plunger member 30, a pumping chamber 34 for receiving fuel, reciprocal movement of the plunger member 30 within the bore 32, in use, causing fuel within the pumping chamber 34 to be pressurised. Fuel is delivered to the pumping chamber 34 through an appropriate inlet valve arrangement (not shown) and pressurised fuel is delivered from the pumping chamber 34 through an appropriate outlet valve arrangement (not shown) in a con-

ventional manner.

[0030] As can be seen most clearly in Figure 2, the plunger member 30 is arranged to co-operate with a shoe 36 located radially outward of an associated roller member 38, preferably of cylindrical form, which is co-operable with the cam surface 20a of the cam member 20. In use, upon rotation of the drive shaft 18, the roller member 38 rides over the cam surface 20a, thereby imparting movement to the shoe 36 and, hence, to the plunger member 30. The shoe 36 and the associated roller member 38 are received within an aperture 40 provided in the tubular member 26, the aperture 40 being shaped to guide reciprocal movement of the shoe 36 as the roller member 38 rides over the cam surface 20a. The aperture 40 is further shaped such that an inner surface 40a thereof serves to limit the extent of movement of the shoe 36 and the roller member 38 in a first direction (out of the page in the illustration shown in Figure 2), movement of the shoe 36 and the roller member 38 in a second, perpendicular direction being limited by an end face 10a of the housing 10.

[0031] The housing 10 is shaped to accommodate drillings 48 which communicate with the pumping chambers to permit fuel flow to and from the pumping chambers in a conventional manner. The pump housing 10 is also shaped to define, together with the tubular member 26, a chamber 46 of relatively large volume for receiving fuel at relatively low pressure. Other parts of the pump housing are also flooded with fuel at relatively low pressure, typically referred to as "housing pressure". The shoe 36 may be arranged such that, throughout at least part of its range of movement, a part thereof extends into or is exposed to fuel within a volume, radially inward of the shoe 36, defined within the pump housing 10 and filled with fuel at housing pressure. Fuel pressure within this volume applies a force to the shoe 36, and hence to the plunger member 30, which serves to oppose outward movement of the plunger member 30 from the plunger bore 32. As the shoe 36 reciprocates within the aperture 40, it is important that fuel within the volume radially inward of the shoe 36 can escape relatively easily as, if this volume is not vented, fuel pressure within the volume will tend to increase upon radially inward movement of the shoe 36.

[0032] In order to aid venting of the volume around the shoe 36, the tubular member 26 may be shaped to define, at least in part, one or more passages 29 providing communication between the volume radially inward of the shoe 36 and a low pressure reservoir arranged radially outward of the shoe 36, thereby preventing reciprocal movement of the shoe 36 and the plunger member 30 from being impeded.

[0033] In addition, or as an alternative, to the provision of the passages 29 in the tubular member 26, the shoe itself may be provided with at least one further passage or recess to permit venting of the volume radially inward of the shoe 36. Additionally, or alternatively, the pump housing 10 may be provided with one or more

venting passages. It will be appreciated that the or each venting passage may be defined by a drilling, recess, groove or flat provided in or on any one or more of the tubular member 26, the shoe 36 and the pump housing 10. The provision of the venting passage(s) prevents the formation of cavities within the volumes radially inward and outward of the shoe 36 by minimising the pressure difference required to displace fuel between these volumes as the shoe 36 reciprocates.

[0034] The pump assembly 12 may be provided with a return spring 50, or other resilient bias means, which serves to urge the shoe 36 and the roller member 38 in a radially inward direction such that the roller member 38 maintains contact with the cam surface 20a throughout a complete rotation of the drive shaft 18. The force due to the return spring 50 is aided by the force due to fluid pressure within the pumping chamber 34 acting on the plunger member 30 in providing a return force which urges the plunger member 30 outwardly from the bore 32 to perform a return stroke. It will be appreciated that this only occurs if the pump is operating at its maximum displacement and, hence, at maximum filling. Alternatively, the resilient bias means may be omitted, in which case movement of the plunger member 30, shoe 36 and roller member 38 outwardly from the pumping chamber depends solely on the pressure therein.

[0035] In use, fuel at relatively low pressure is supplied to the pumping chamber 34 in a conventional manner, for example through one of the drillings 48 provided in the pump housing 10 and through the associated inlet valve arrangement. As the drive shaft 18 rotates, the roller member 38 is caused to move in a radially outward direction, thereby imparting movement to the shoe 36 within the aperture 40 and causing inward movement of the plunger member 30 within the bore 32. Continued rotation of the drive shaft 18 results in continued reciprocal movement of the plunger member 30 within the bore 32, thereby causing fuel within the pumping chamber 34 to be pressurised. When fuel pressure within the pumping chamber 34 exceeds an amount sufficient to open the associated outlet valve arrangement, fuel under high pressure is delivered to the common rail fuel injection system.

[0036] When the plunger member 30 has completed its forward stroke, such that the volume of the pumping chamber 34 is minimised, the pressure of fuel within the pumping chamber 34 acting on the plunger member 30 and the force due to the spring 50 serve to urge the plunger member 30 in an outward direction, to perform its return stroke, the force due to fuel pressure within the pumping chamber 34 and the force due to the spring 50 also serving to maintain contact between the roller member 38 and the cam surface 20a.

[0037] It is preferable to ensure that a positive housing pressure is maintained within the chambers and volumes throughout the pump housing, applying a force to the plunger member 30 to urge the plunger member 30 against incoming filling fuel. In this way, the formation of

cavities within the pumping chamber 34 during reciprocal movement of the shoe 36 and the plunger member 30 is substantially prevented. This provides a particular advantage when the pump is operating under partial load conditions as control is improved.

[0038] In order to assemble the fuel pump, the tubular member 26 is inserted within, and is secured to, the pump housing 10. A temporary tubular restraining member 54, having a cross section of C-shaped form, is inserted into the tubular member 26. The tubular restraining member 54 is provided with an aperture or opening 54a and is inserted into the tubular member 26 such that the opening 54a aligns with a first one of the apertures 40 in the tubular member 26. One of the pre-assembled pump assemblies 12, 14, 16 is then inserted radially through the opening 54a in the restraining member 54 and the aperture 40 in the tubular member 26 such that the associated shoe is received within the aperture 40. As the roller member 38 is inserted into the respective aperture 40, the spring 50 is compressed such that the restraining member 54 can be moved angularly to align the opening 54a with another one of the apertures 40. The associated pump assembly is then inserted into the respective aperture 40, as described previously, and the process is repeated until all pump assemblies are installed. When all of the pump assemblies have been installed, the shaft 18 and the cam member 20 are inserted into the tubular member 26. The use of the restraining member 54 ensures the springs 50 associated with each of the pump assemblies, 12, 14, 16 are compressed whilst the drive shaft 18 is then inserted into the tubular member 26.

[0039] The restraining member 54 is shaped to ensure that, during assembly, the springs 50 are not compressed to less than their minimum length during operation of the pump. Once installation is complete, the restraining member 54 is removed. The restraining member 54 has an axial length which is greater than that of the tubular member 26, the restraining member 54 preferably being provided with apertures, lugs or a flange which extend beyond the end of the tubular member 26 when the pump is assembled so as to permit easy extraction of the restraining member 54.

[0040] The outer surface of the tubular restraining member 54 is provided with at least one feature which co-operates with the roller member 38 in such a way that angular movement of the roller members 38 is resisted. This ensures the roller members do not ride over the surface of the restraining member 54 unintentionally during assembly of the pump. For example, the feature may be a longitudinal groove or detent provided on the surface of the restraining member 54, the groove or detent being shaped to receive a roller member. Alternatively, as can be seen in Figure 3, the tubular restraining member 54 may be provided with regions 54b of increased thickness.

[0041] The fuel pump of the present invention may be provided with any convenient number of pump assem-

blies. With reference to Figures 4 and 5, there is shown an alternative embodiment of the invention in which eight pump assemblies, 60a-60h, are employed, each one of the pump assemblies 60a-60h being substantially the same as the pump assembly 12 described previously. Similar parts to those shown in Figures 1 and 2 are denoted with like reference numerals and only the differences between the two embodiments will be described in further detail hereinafter. The inlet and outlet valve arrangements, 63, 62 respectively, associated with each pump assembly can be seen in Figure 5. Passages 64 are provided in the pump housing 10 to permit communication between the pump assemblies in a conventional manner.

[0042] As can be seen in Figure 4, the tubular member 26 is integrally formed with the carrier member 31, the tubular member 26 and the carrier member 31 providing support for the front bearings 22. Additionally, a second tubular member 28 is provided, thereby reducing the size of the pump housing 10. The second tubular member 28 extends coaxially with the drive shaft 18 and the tubular member 26 and at least a portion of the second tubular member 28 extends within the housing 10, said portion having a diameter substantially equal to the diameter of the tubular member 26. The second tubular member 28 includes a flange 28a to enable the member 28 to be secured to the pump housing 10. In this embodiment of the invention, the second member 28 provides a support for the rear bearings 24, rather than the pump housing 10.

[0043] The springs 50 associated with each of the pump assemblies 60a-60h are removed such that the roller member 38 is maintained in contact with the cam surface 20a only by means of the force due to fuel pressure within the pumping chamber 34.

[0044] In order to manufacture the fuel pump of the present invention when an even number of pump assemblies are to be employed, the apertures 40 provided in the tubular member 26 may be machined as diametrical pairs. Even if an odd number of pump assemblies is to be provided, operationally redundant apertures may also be machined opposite the required apertures for ease of manufacture, for example to facilitate manufacture of the required apertures by grinding with a large diameter grinding wheel. When one or more redundant apertures is provided, the tubular member 26 retains stiffness as it has a relatively large diameter.

[0045] The present invention provides a cost advantage over existing fuel pumps which include tappet assemblies to impart reciprocal movement to the plunger members. Additionally, the circular cross-section of a tappet member results in a high proportion of unused material, and hence a higher reciprocating mass. As shoes are of reduced mass, the inertial forces are reduced and it is possible to employ smaller return springs 50 requiring a reduced accommodation space, if desired.

[0046] In fuel pumps in which tappet members are

employed, it is also necessary to provide a means for preventing angular movement of the tappet, for example in the form of a pin carried by the pump housing which rides within a slot formed in the tappet member. By employing a shoe to impart movement to the plunger member, no additional means for preventing unwanted angular movement is required. Additionally, the full width of the shoe can be used to support the roller member and, hence, the load-bearing capability of the cam member is improved. Compressive stresses induced in the cam surface are therefore reduced. Furthermore, as the volumes radially inward and outward of the shoe 36 are vented by means of the passages provided in, or otherwise defined by, the shoe and/or the tubular member, the formation of cavities during reciprocal movement of the shoe 36 and the plunger member 30 is substantially prevented.

[0047] It will be appreciated that, as the shoe 36 is not constrained to move with the plunger member 30, relative movement between the shoe 36 and the plunger member 30 along the plunger axis may occur under partial load conditions. If only a relatively low volume of fuel is delivered to the pumping chamber 34 to be pressurised, movement of the plunger member 30 and the shoe 36 will be decoupled. As there is no need to couple movement of the plunger member 30 to movement of the shoe 36, assembly of the pump is simplified. In conventional pumps in which a tappet assembly is employed it is necessary to attach the tappet member to the plunger member and it is therefore relatively difficult to assemble the pump.

[0048] The present invention also permits a cam surface to be employed with two or more cam lobes, thereby permitting multiplication of the pump's displacement without an increase in size.

Claims

1. A fuel pump for use in an engine, the fuel pump comprising a plunger member (30) which is reciprocable within a plunger bore (32) provided in a pump housing (10) under the influence of a cam drive arrangement (20, 36, 38) so as to cause pressurisation of fuel within a pumping chamber (34), the cam drive arrangement including a reciprocable shoe (36) and a roller member (38) and being driven, in use, by means of an associated drive shaft (18), wherein the roller member (38) is arranged radially inward of the shoe (36) and is cooperable with a cam surface (20a) of the cam drive arrangement so as to impart reciprocable movement to the shoe (36) upon rotation of the drive shaft (18), the pump further comprising a tubular member (26) which is secured to the pump housing (10) and arranged such that it is substantially coaxial with the drive shaft (18), the tubular member (26) being further arranged such that it guides reciprocal movement of

the shoe (36), in use.

2. A fuel pump as claimed in Claim 1, wherein the tubular member (26) is provided with an aperture (40) within which the shoe (36) is received, the aperture (40) being shaped to guide movement of the shoe (36), in use. 5
3. A fuel pump as claimed in Claim 1 or Claim 2, wherein the shoe (36) is provided with a return spring (50) which acts on the shoe (36) and the roller member (38) to ensure the roller member (38) remains in engagement with the cam surface (20a), in use. 10
4. A fuel pump as claimed in any of Claims 1 and 3, wherein the shoe (36) and the plunger member (30) are arranged such that the plunger member (30) is able to move axially relative to the shoe (36), in use. 15
5. A fuel pump as claimed in any of Claims 1 to 4, further comprising a second tubular member (28) which is substantially coaxial with the tubular member (26) and is arranged to extend, at least in part, into the pump housing (10). 20
6. A fuel pump as claimed in Claim 5, including a bearing (24) for supporting the drive shaft (12) within the pump housing (10), wherein the bearing (24) is supported by the second tubular member (28). 25
7. A fuel pump as claimed in any of Claims 1 to 4, including a bearing (24) for supporting the drive shaft (12) within the pump housing (10), wherein the bearing (24) is supported by the pump housing (10). 30
8. A fuel pump as claimed in any of Claims 1 to 7, wherein the shoe (36) is arranged such that a surface thereof is exposed to fuel pressure within a volume defined within the pump housing (10), the pump further comprising vent means (29) to permit the volume to be vented, in use, so as to substantially prevent reciprocal movement of the shoe (36) and the plunger member (30) from being impeded. 35
9. A fuel pump as claimed in Claim 8, wherein the vent means include one or more passage (29) provided in any one or more of the tubular member (26), the shoe (36) or the pump housing (10), the or each passage (29) providing communication between the volume and a low pressure fuel reservoir. 40
10. A fuel pump as claimed in any of Claims 1 to 9, comprising a plurality of pump assemblies (12, 14, 16), each pump assembly comprising a plunger member (30) slidable within a respective plunger bore (32) so as to cause pressurisation of fuel within a respective pumping chamber (34), each of the pump as- 45

semblies (12, 14, 16) having an associated shoe (36) and roller member (38) for imparting reciprocal movement to the respective plunger member (32), wherein the tubular member (26) is provided with a plurality of apertures (40), reciprocal movement of the shoes (36) being guided within a respective one of the apertures (40), in use.

11. A fuel pump as claimed in Claim 10, wherein the tubular member (26) is provided with a plurality of diametrically opposed aperture pairs. 50
12. A fuel pump as claimed in Claim 11, wherein the pump comprises an odd number of plunger members (30) and wherein the tubular member (26) is provided with a corresponding number of aperture pairs, one of the apertures (40) in each pair being arranged to receive a shoe (36) associated with one of the plunger members (30) so as to guide movement thereof, the other aperture in each pair being operationally redundant. 55
13. A method of assembling a fuel pump on a drive shaft (12), the fuel pump comprising a cam drive arrangement including a reciprocable shoe and roller arrangement (36, 38), comprising a shoe (36), a roller member (38) and return spring means (50) which serve to maintain contact between the roller member (38) and a cam surface (20a) of the cam drive arrangement when the pump is in use, the method of assembly comprising the steps of:

inserting a first tubular member (54) provided with an opening (54a) into an additional tubular member (26) provided with an aperture (40) such that the opening (54a) is aligned with the aperture (40) provided in the additional tubular member (26);

inserting the shoe and roller arrangement (36, 38) through the opening (54a) such that the shoe (36) is received within the aperture (40), and moving the first tubular member (54) angularly relative to the additional tubular member (26) so as to misalign the opening (54a) and the aperture (40), the first tubular member (54) thereby serving to compress the return spring means (50) to permit insertion of the drive shaft (12) into the first tubular member (54); and

removing the first tubular member (54) from the fuel pump when assembly of the pump is complete.

FIG 1

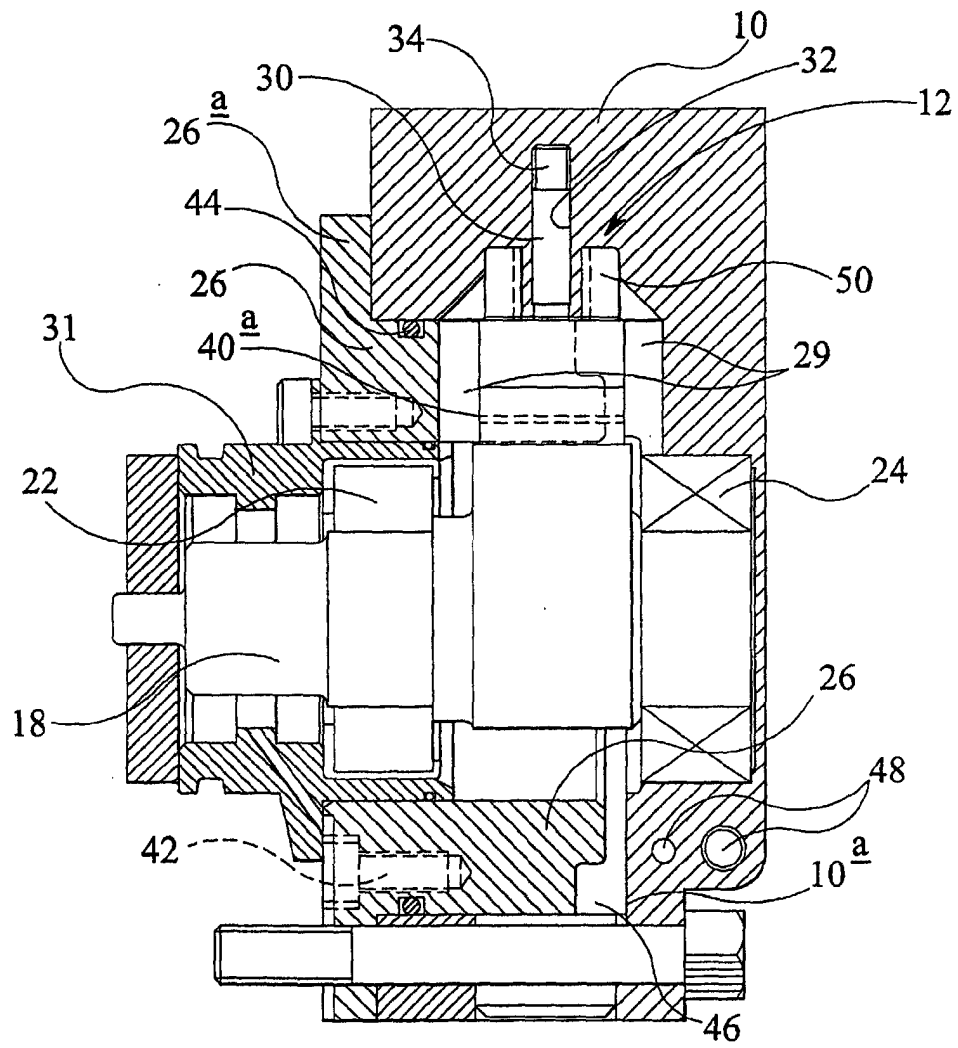


FIG 2

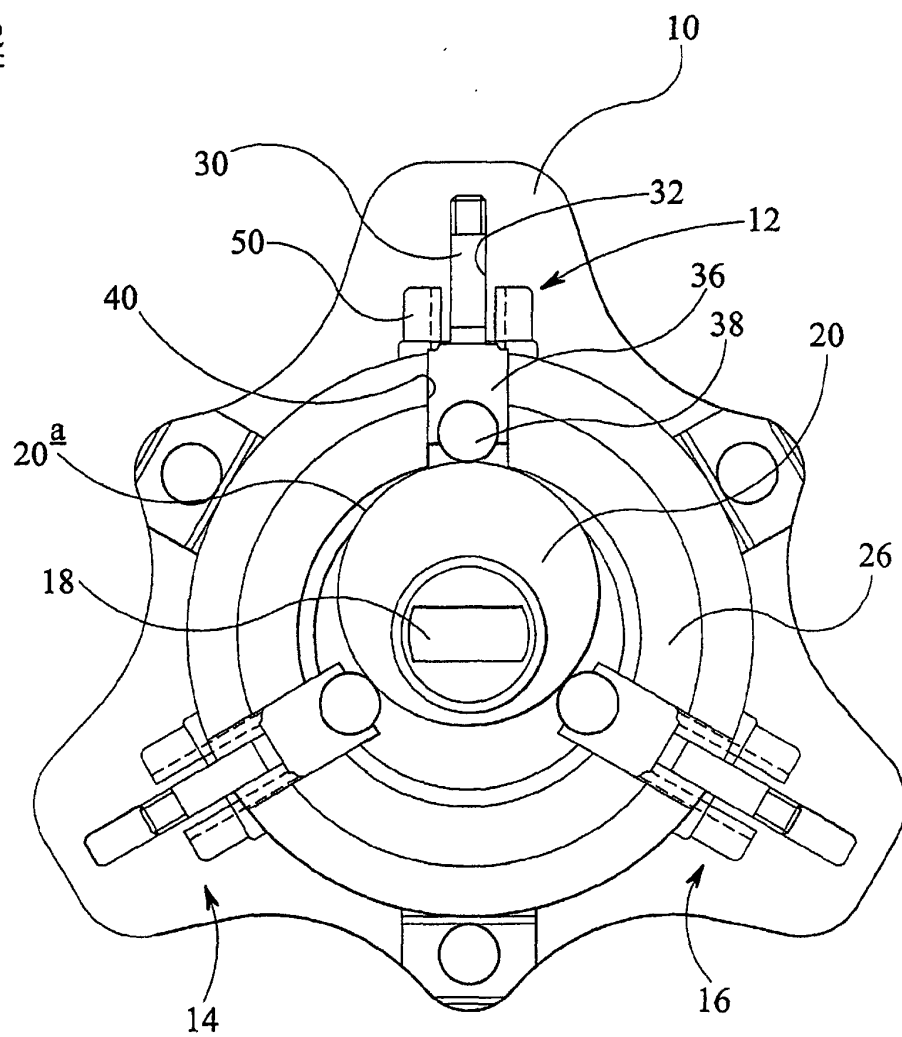
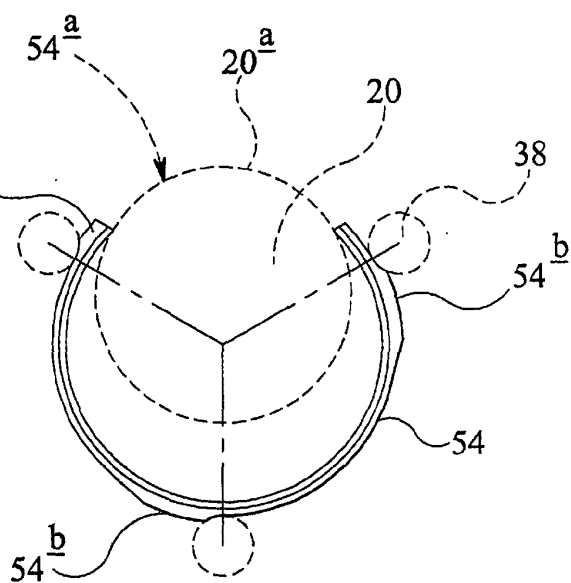


FIG 3



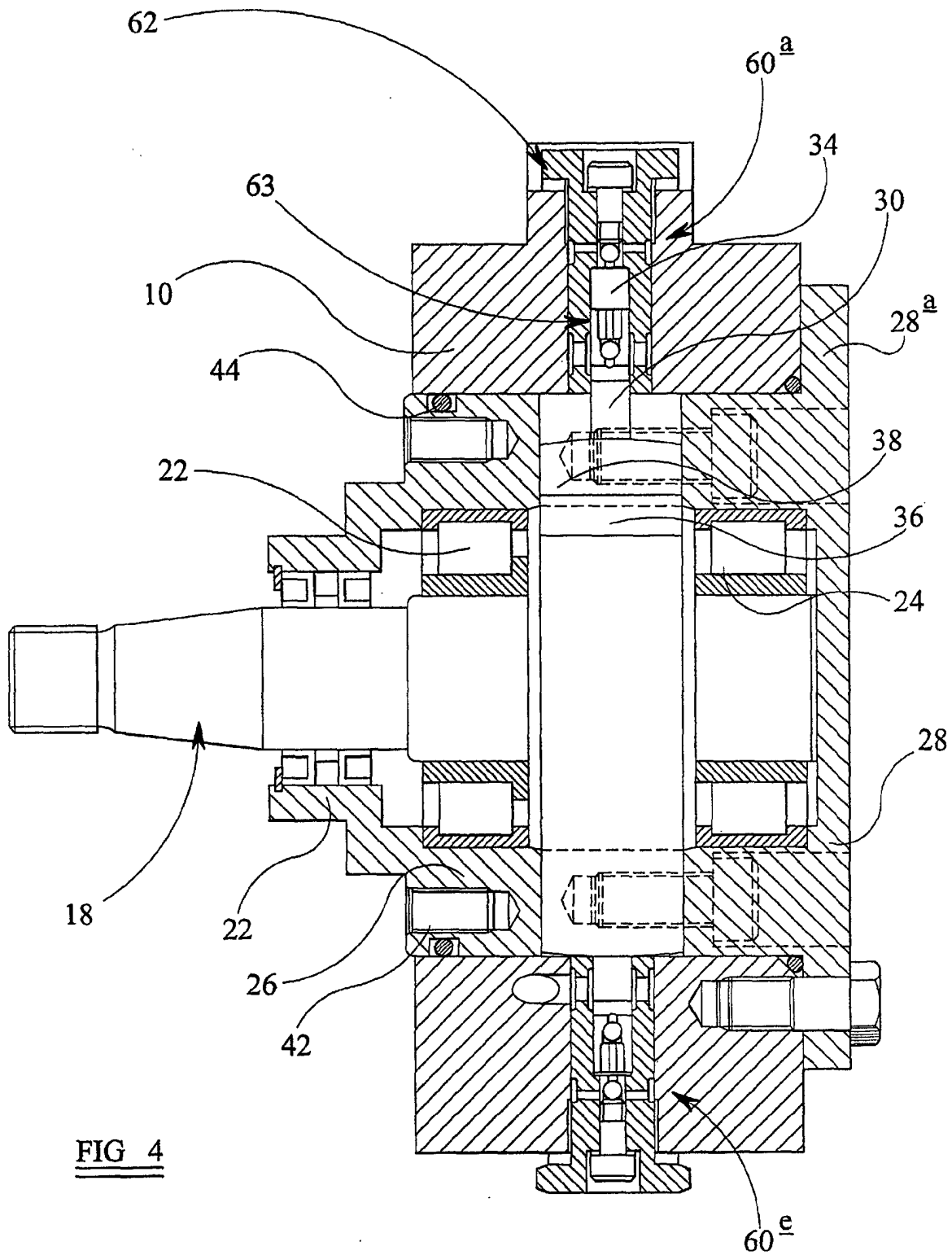


FIG 4

FIG 5

