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(54) **PUMP ASSEMBLY**

(57) A high pressure pump, comprising a lubrication and cooling circuit for driveshaft bearings (140-142), wherein low temperature, filtered fuel from the fuel tank (150) is supplied to a chamber (158) at the rear of the driveshaft (106), wherein the chamber (158) communicates directly with the rear bearing clearances, and with the front bearing clearances and cambox (108) via axial (134) and radial (136,138) driveshaft drillings, wherein the system is sealed at backleak pressure, and optionally a channel (160,172) is provided directly from the chamber to the cambox volume thereby to cool a tappet/cam rider interface.

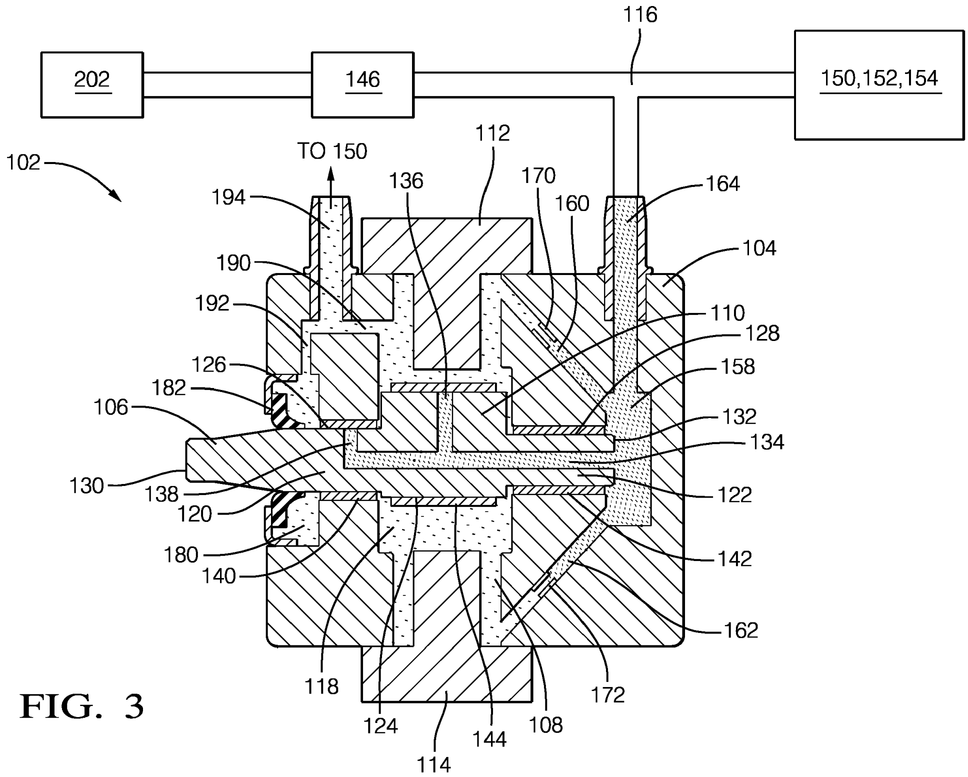

FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to a pump assembly for use in an internal combustion engine, and particularly to lubrication and cooling in a high pressure pump.

BACKGROUND OF THE INVENTION

[0002] A known embodiment of high pressure pump assembly is partially illustrated in Figure 1, and schematically illustrated in Figure 2. The pump assembly 2 comprises pump housing 4 (Figure 2), and a driveshaft 6 which is rotatable within the pump housing 4. The driveshaft 6 comprises a cam portion 10, located in a cambox 8 of the pump housing 4, a front journal portion 20 and a rear journal portion 22. Rotation of the driveshaft 6 causes the cam portion 10 to impart force, for example via a cam rider and cam follower, to one or more pumping elements such as plungers.

[0003] The driveshaft is supported within the pump housing 4 by bearings, such as a front bearing 40 and a rear bearing 42 (only shown in Figure 1).

[0004] As illustrated schematically in Figure 2, in a typical force-fed bearing circuit, the system is fully pressurised, and lubrication and cooling of the bearings is achieved by a forced flow of fuel from the cambox 8. An inlet 16 is supplied by a lift pump 54; the inlet 16 supplies fuel for a high pressure circuit 102 via an inlet metering valve (IMV) 46 and also supplies fuel directly to the cambox 8 via an entry 88.

[0005] The cambox 8 is pressurised, to allow leakage past the bearing clearances. The leakage is evacuated to a backleak path, via a cambox exit 96 and orifice 98. In the embodiment illustrated in Figures 1 and 2, leakage is also evacuated to the backleak path via an axial drilling 34 provided in the drive shaft 6.

[0006] Low pressure is maintained in the circuit by a seal 82, which is also linked to the backleak path, via a radial drilling 66 (shown in Figure 1) provided in the driveshaft 6, which communicates with the axial drilling 34.

[0007] In the known embodiment of Figures 1 and 2, the fuel is at lift pump pressure in the entry 88 and in the cambox 8. Fuel exiting the cambox 8 via the aperture 98 or being forced over the bearings to the axial drilling reduces to a backleak pressure.

[0008] The known pump assembly of Figures 1 and 2 force feeds the bearings, thereby providing them with adequate flow to prolong durability of the pump. However, the known embodiment does not allow higher temperature fuel from plunger leakage to pass over the bearing surfaces. Furthermore, debris from component wear is unable to pass over the surfaces of the bearings. The life of the bearing surfaces of the prior art embodiment is therefore limited.

[0009] As expected delivery pressure increases, the quantity and temperature of plunger leakage will also increase, thereby increasing the above problem. Furthermore, it has become common to feed a fuel injector backleak flow into the pump inlet; this fuel has an increased temperature and therefore increases the above problems.

[0010] Cambox debris may also block an orifice of the exit from the cambox, thereby increasing the temperature of the cambox and increasing the amount of heat transferred to the bearing surfaces, and thereby presenting difficulty in maintaining the bearing material, for example polyether ether ketone (PEEK), at a reduced temperature.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a high pressure pump which at least mitigates the problems encountered with known embodiments.

[0012] Accordingly the present invention provides, in a first aspect, a pump assembly according to claim 1.

[0013] The chamber of the pump assembly may be in fluid communication with a rear bearing and a rear journal surface over which the rear bearing is located, wherein the chamber is also in fluid communication, via drillings provided in the driveshaft, with a front bearing and a front journal surface of the front journal over which the front bearing is located, and/or with a rider bearing and a rider bearing surface of the cam portion over which the rider bearing is located.

[0014] The drillings provided in the driveshaft may comprise an axial drilling, a first radial drilling provided in the cam portion, and a second radial drilling provided in the front journal portion, wherein the axial drilling communicates the first radial drilling and the second radial drilling with the chamber, the first radial drilling communicates the axial drilling with the rider bearing and the rider journal surface, and the second radial drilling communicates the axial drilling with the front bearing and front journal surface.

[0015] Fuel flowing from the chamber via the rear bearing and rear journal surface, and via the rider bearing and rider journal surface, may flow into a volume within the cambox, wherein fuel flowing from the chamber via the front bearing and front journal surface flows either into the volume with the cambox or into an annular gallery provided within the pump housing around the driveshaft, and wherein the backleak path comprises, a first exit pathway section providing unrestricted fluid communication between the volume within the cambox and a common backleak pathway section; and a second exit pathway section, providing fluid communication between the gallery and the common backleak pathway section.

[0016] The second exit pathway section may be provided by a drilling having a cross-sectional area which is less than a cross-sectional area of the first pathway section.

[0017] The pump assembly may further comprise at least one channel provided in the pump housing and leading from the chamber to the cambox. A throttle, comprising a section of channel having a reduced cross-sectional area, may be provided in the or each channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figures 3 is a cross-sectional representation of a pump assembly in accordance with the present invention;
and

Figure 4 is a schematic representation of a fuel flow circuit of the pump assembly of Figure 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] An embodiment of the present invention is described below in relation to the orientation of the figures. Terms such as upper, lower, above, below, left, right and behind are not intended to be limiting.

[0020] Referring to Figure 3, the present invention comprises a pump assembly 102 for a vehicle fuel system, the pump assembly 102 comprising a pump housing 104 and a driveshaft 106, which is rotatable within the pump housing 104, thereby to cause a reciprocating motion of one or more pumping elements (not shown) of a pump head. The embodiment illustrated in Figures 3 and 4 includes a first pump head 112 and a second pump head 114.

[0021] The driveshaft 106 comprises a front journal portion 120 towards a first, front end 130 of the driveshaft 106, and a rear journal portion 122 towards a second, rear end 132 of the driveshaft 106. The driveshaft 106 further comprises a cam portion 110, between the front and rear journal portions 120, 122, and within a cambox 108 of the pump housing 104.

[0022] The driveshaft is supported within the pump housing 104 by bearings. A front bearing 140 is located over a front journal surface 126 of the front journal portion 120, a rear bearing 142 is located over a rear journal surface 128 of the rear journal portion 122, and a rider bearing 144 is located over a rider journal surface 124 of the cam portion 110.

[0023] An inlet 116, supplied with fuel from a fuel tank 150 via a filter 152 and lift pump 154, provides fuel to at high pressure (for example 4 bar), to a high pressure circuit 202, via an IMV 146. The inlet 116 also supplies high pressure fuel to the pump housing 104, via an entry 164.

[0024] Fuel from the fuel tank 150 is the cleanest, i.e. has fewer debris particles, and is at a lower temperature, than other fuel in the vehicle fuel system.

[0025] The inlet 116 supplies fuel, via the entry 164, to a chamber 158. The chamber 158 comprises an area behind the second, rear end 132 of the driveshaft 106, i.e. behind the rear journal portion 122 of the driveshaft 106. The chamber 158 communicates with the clearances of the rear bearing 142. Clean, filtered, and low temperature fuel supplied to the chamber 158 therefore is forced through the clearances of the rear bearing 142, i.e. between the rear bearing 142 and the rear journal surface 128 of the driveshaft 106, and between the rear bearing 142 and the pump housing 104, to the cambox 108. The forced flow of fuel over the rear bearing 142 is shown schematically by the arrowed line X, above the rear bearing 142 in Figure 4.

[0026] Fuel from the chamber 158 also flow into an axial drilling 134, which is provided partially through the centre of the driveshaft 106.

[0027] The driveshaft 106 further comprises a first radial drilling 136, through the cam portion 110, which communicates the axial drilling 134 with a cambox volume 118. Clean, filtered, and low temperature fuel from the inlet is therefore also force fed from the chamber 158 to the cambox volume 118, via the axial drilling 134 and the first radial drilling 136, thereby lubricating and cooling the rider journal surface 124 and the rider bearing 144. The forced flow of fuel over the rider bearing 144 is shown schematically by the arrowed line Y, above the rider bearing 144 in Figure 4.

[0028] The driveshaft 106 also comprises a second radial drilling 138, through the front journal portion 120, which communicates the axial drilling 134 with the front journal surface 126. Clean, filtered, and low temperature fuel from the inlet 116 is therefore also force fed from the chamber 158 through the clearances of the front bearing 140, i.e. between the front bearing 140 and the front journal surface 126 of the driveshaft 106, and between the front bearing 140 and the pump housing 104. Fuel being force fed to the front journal surface 126 and the front bearing 140 flows (to the right in the orientation of the Figures) into the cambox 108, or (to the left in the orientation of the Figures) into an annular gallery 180, provided in the pump housing 104 towards the first, front end 30 of the driveshaft 106. (The annular gallery 180 is only indicated in Figure 3). The forced flow of fuel over the front bearing 140 is shown schematically in Figure 2 by the arrowed line Z, above the front bearing 140 in Figure 4.

[0029] As discussed above, fuel passing over the clearances of the front bearing 140 flows into the cambox 108 or into the annular gallery 180. The annular gallery 180 is sealed by a seal 182 provided around the driveshaft 106 towards the first, front end 130. The seal 182 operates at backleak pressure, which could typically be 0.5 bar.

[0030] The first radial drilling 136 and the second radial drilling 138 are not dependent upon each other, i.e. a first radial drilling 136 could be provided and a second radial drilling 138 omitted, or vice versa.

[0031] In an alternative embodiment wherein the first radial drilling 136 is not provided, the rider journal surface

124 and/or rider bearing 144 is force fed with fuel from the chamber 158. In such an embodiment, the flow required by the lift pump 154 would be advantageously reduced, however disadvantages of a non-pressure fed rider journal would be present.

[0032] The present invention may optionally comprise one or more fuel take-offs, i.e. channels, leading from the chamber 158 to the cambox volume 118 surrounding the rider journal surface 124 of the driveshaft 106. In the embodiment illustrated in Figures 3 and 4, a first fuel take-off channel 160 and a second fuel take-off channel 162 are provided.

[0033] The first fuel take-off channel 160 communicates the chamber 158 with a region of the cambox volume 118 between the first pump head 112 and the rider journal surface 124 of the driveshaft 106. Similarly, the second fuel take-off channel 162 is provided which communicates the chamber 158 and a region of the cambox volume 118 between the second pump head 114 and the rider journal 124 of the driveshaft 106.

[0034] A first throttle 170 and a second throttle 172 are provided in the first channel 160 and the second channel 162 respectively. The throttles 170, 172 comprise reduced diameter drillings, i.e. sections of the channels 160, 162 having a reduced cross-sectional area.

[0035] The driveshaft 106 interfaces with the pump heads 112, 114 within the cambox volume 118, for example, via a cam rider / cam follower interface (not shown). During use of the pump assembly 104, such interfaces are subject to very high temperature fuel from pumping element leakage. The clean, filtered and low temperature fuel supplied from the inlet 116 via the channels 160, 162 acts to cool the interfaces. Cooling of the interfaces, even by a relatively small amount, provides improvements in the durability of the pump assembly 104.

[0036] The size of the axial drilling 134 and the radial drillings 136, 138 in the driveshaft 106 are selected so as to throttle the flow of fuel from the inlet 116, thereby to provide adequate bearing cooling, whilst maintaining a high efficiency of the lift pump 154.

[0037] Fuel which has been forced into the cambox volume 118 and into the annular gallery 180 via the bearing surfaces is evacuated back to the fuel tank 150 via a backleak path.

[0038] The backleak path comprises a first exit pathway section 190, which communicates the cambox volume 118 with a common pathway section 194, and a second exit pathway section 192, which communicates the annular gallery 180 with the common pathway section 194. The common pathway section 194 communicates the first and second exit pathway sections 190, 192 with the fuel tank 150, i.e. backleak from the system is returned to the fuel tank 150.

[0039] The common pathway section 194 and the first backleak section 190 are drilled to the largest possible diameters given dimensioning constraints of the pump housing 104, and specifically, a backleak pathway route from the cambox volume 118 the common pathway section 194 and first backleak section 190 do not contain the orifice of the prior art embodiment. Resistance to the lift pump 154 (via the bearing clearances) is thereby minimised, thereby providing potential further reduction in CO2 emissions.

[0040] As the first backleak section 190 communicates directly with the cambox volume 118, leakage from the pumping element, i.e. increased temperature leakage, is evacuated from the cambox volume 118 without passing over the surfaces of the bearings 140, 142, 144 thereby preventing any further increase in the temperature of the bearings 140, 142, 144.

[0041] Furthermore, as there is no backleak orifice in the cambox 108, i.e. the first exit path section 190 and common pathway section 194 comprise an unrestricted channel from the cambox 108 to the backleak, there is no opportunity for blockage. Therefore, there is no requirement for a stucken filter in the present invention, as an unrestricted path is provided for debris to be evacuated from the pump assembly 102.

[0042] The second backleak pathway section 192 comprises a relatively narrow drilling, i.e. the cross-sectional area of the second backleak pathway section 192 has a smaller cross-sectional area than that of the first exit pathway section 190 and the common pathway section 194. This acts to reduce pressure spikes occurring due to fluctuations in the cambox volume 118, for example as a result of pumping element leakage. In a specific pump assembly 102, the specific diameter of the second backleak pathway section 192 will depend upon the clearance of the bearings 140, 142, however could typically be approximately 1mm to 2 mm.

[0043] When the pumping assembly 102 of the present invention is in use, fuel flowing through the in the entry 164, the chamber 158, sections of the channels 160, 162 between the chamber 158 and throttles 170, 172, the axial driveshaft drilling 126, and the radial driveshaft drillings 134, 136, is at high pressure, i.e. lift pump pressure. Due to the reduction of pressure by the throttles 170, 172 and the effect of the fuel squeezing through the bearing clearances, fuel in the sections of the channels 160, 162 between throttles 170, 172, in the cambox volume 118, in the annular gallery 136, and in the backleak circuit 192, 190, 194, is at low pressure, i.e. backleak pressure.

[0044] The present invention provides a positive driveshaft low pressure circuit, providing force-fed lubrication and cooling of the bearings 140, 142, 144 during a hydrodynamic filling stage, which is further pressurised by hydrodynamic support action of the bearings 140, 142, 144.

[0045] Force-feeding fuel to the rider journal surface 124 acts to increase the load bearing capacity of the rider journal portion 122. The life of a PTFE bearing could therefore be extended, or alternatively PEEK material could be used for the rider bearing 144.

[0046] The lubrication and cooling fuel circuit of the present invention provides a bearing-biased lubricating flow of the lowest temperature, cleanest fuel available to the pump assembly 102. The present invention thereby improves the durability of PEEK material bearings by reducing the opportunity for material creep caused by heat. The load capacity of the bearings 140, 142, 144 can therefore be increased, allowing for the use of bearings of a reduced diameter, and accordingly a decrease in pump packaging volume.

REFERENCES

Prior art

[0047]

- pump assembly 2
- pump housing 4
- driveshaft 6
- cambox 8
- cam portion 10
- inlet 16
- front journal portion 20
- rear journal portion 22
- rider journal surface 24
- IMV 46
- axial drilling 34
- front bearing 40
- rear bearing 42
- lift pump 54
- Radial drilling 66
- seal 82
- entry (to cambox) 88
- cambox exit to backleak 96
- orifice 98
- high pressure circuit 102

Invention

[0048]

- pump assembly 102
- pump housing 104
- driveshaft 106
- cambox 108
- cam portion 110
- first pump head 112
- second pump head 114
- inlet 116
- cambox volume 118
- front journal portion 120
- rear journal portion 122
- rider journal surface 124
- front journal surface 126
- rear journal surface 128
- first, front end 130
- second, rear end 132
- axial drilling 134
- first radial drilling 136
- second radial drilling 138
- front bearing 140
- rear bearing 142
- rider bearing 144
- IMV 146
- fuel tank 150
- filter 152
- lift pump 154
- chamber 158
- first fuel take-off channel 160
- second fuel take-off channel 162
- (chamber) entry 164
- first throttle 170
- second throttle 172
- annular gallery 180
- seal 182
- backleak first exit pathway section 190
- backleak second exit pathway section 192
- common pathway section 194
- high pressure circuit 202

Claims

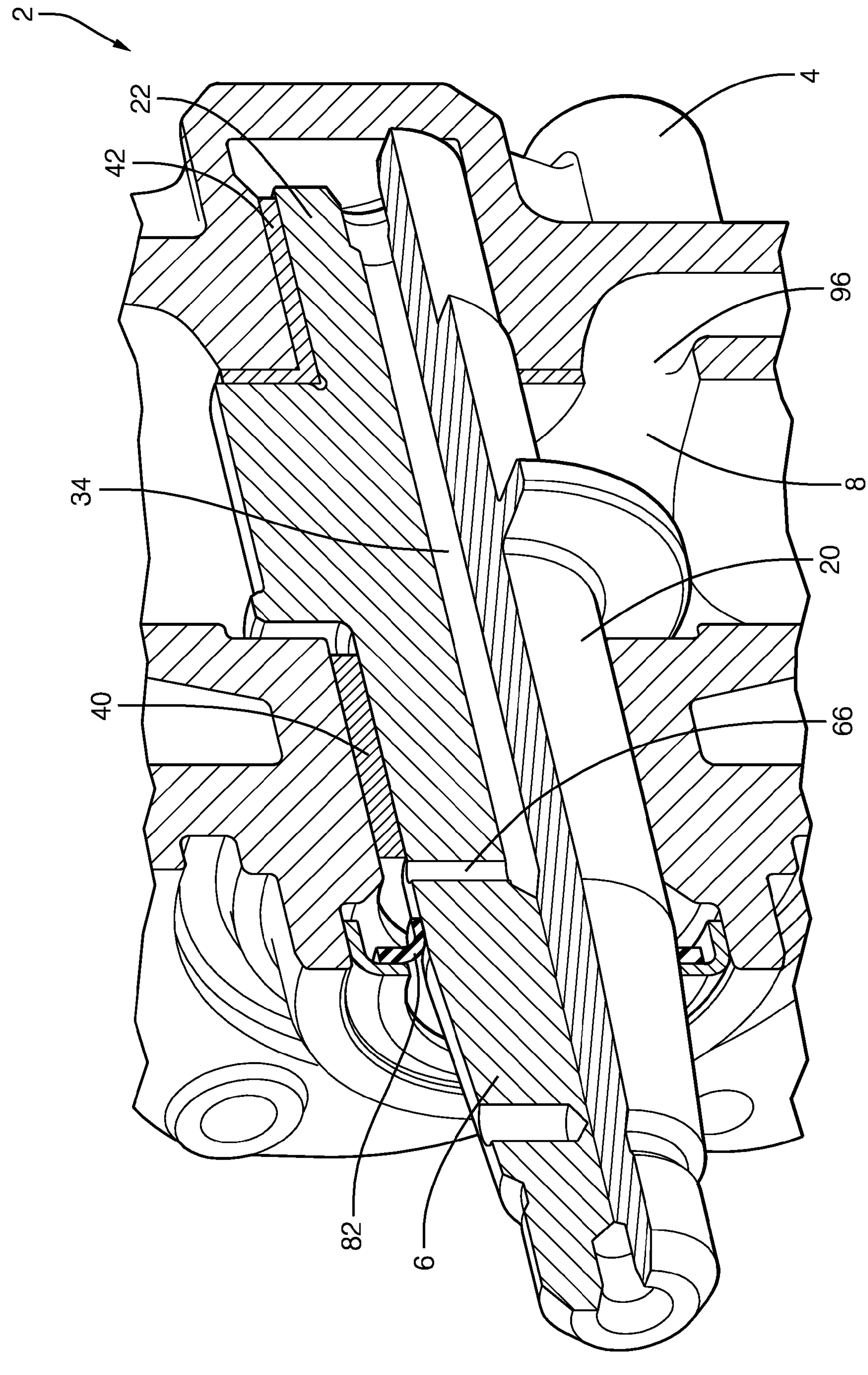
1. A high pressure pump assembly (102) comprising a pump housing (104) and a driveshaft (106) which is rotatable within the pump housing (104), the driveshaft (106) comprising a front journal portion (120), a rear journal portion (122), and a cam portion (110), located between the front journal portion (120) and the rear journal portion (122) and within a cambox (108) of the pump housing (104);
wherein rotation of the driveshaft (106) causes the cam portion (110) to impart a force upon and cause reciprocating motion of a pumping element of at least one pump head (112, 114);
wherein the driveshaft (106) is supported in the pump housing (104) by at least one bearing (140, 142, 144) located over a journal surface (124, 126, 128) of the driveshaft (106);
characterised in that the pump housing (104) comprises a chamber (158) adjacent to an end (132) of the driveshaft (106), wherein the chamber (158) is supplied with fuel from an inlet (116) which is supplied by a fuel tank (150), and wherein the chamber (158) is in fluid communication with at least one bearing (140, 142, 144) and at least one journal surface (124, 126, 128), such that in use of the pump assembly (102), fuel is forced from the chamber (158) to a backleak path, via the at least one bearing (140, 142, 144) and journal surface (124, 126, 128),
wherein the chamber (158) is in fluid communication with a rear bearing (142) and a rear journal surface (128) over which the rear bearing (142) is located;
and wherein the chamber (158) is also in fluid communication, via drillings (134, 136, 138) provided in the driveshaft (106), with a front bearing (140) and a front journal surface 126 of the front journal portion

120 over which the front bearing (140) is located, and/or with a rider bearing (144) and a rider journal surface (124) of the cam portion (110) over which the rider bearing (144) is located,
wherein the drillings (134, 136, 138) provided in the driveshaft (106) comprise an axial drilling (134), a first radial drilling (136) provided in the cam portion (110), and a second radial drilling (138) provided in the front journal portion (120);
wherein the axial drilling (134) communicates the first radial drilling (136) and the second radial drilling (138) with the chamber (158);
the first radial drilling (136) communicates the axial drilling (134) with the rider bearing (144) and the rider journal surface (124);
and the second radial drilling (138) communicates the axial drilling (134) with the front bearing (140) and the front journal surface (126),
wherein fuel flowing from the chamber (158) via the rear bearing (142) and rear journal surface (128), and via the rider bearing (144) and rider journal surface (124), flows into a volume (118) within the cambox (108), and wherein fuel flowing from the chamber (158) via the front bearing (140) and front journal surface (126) flows either into the volume (188) within the cambox (108) or into an annular gallery (180) provided within the pump housing (104) around the driveshaft (106);
and wherein the backleak path comprises:

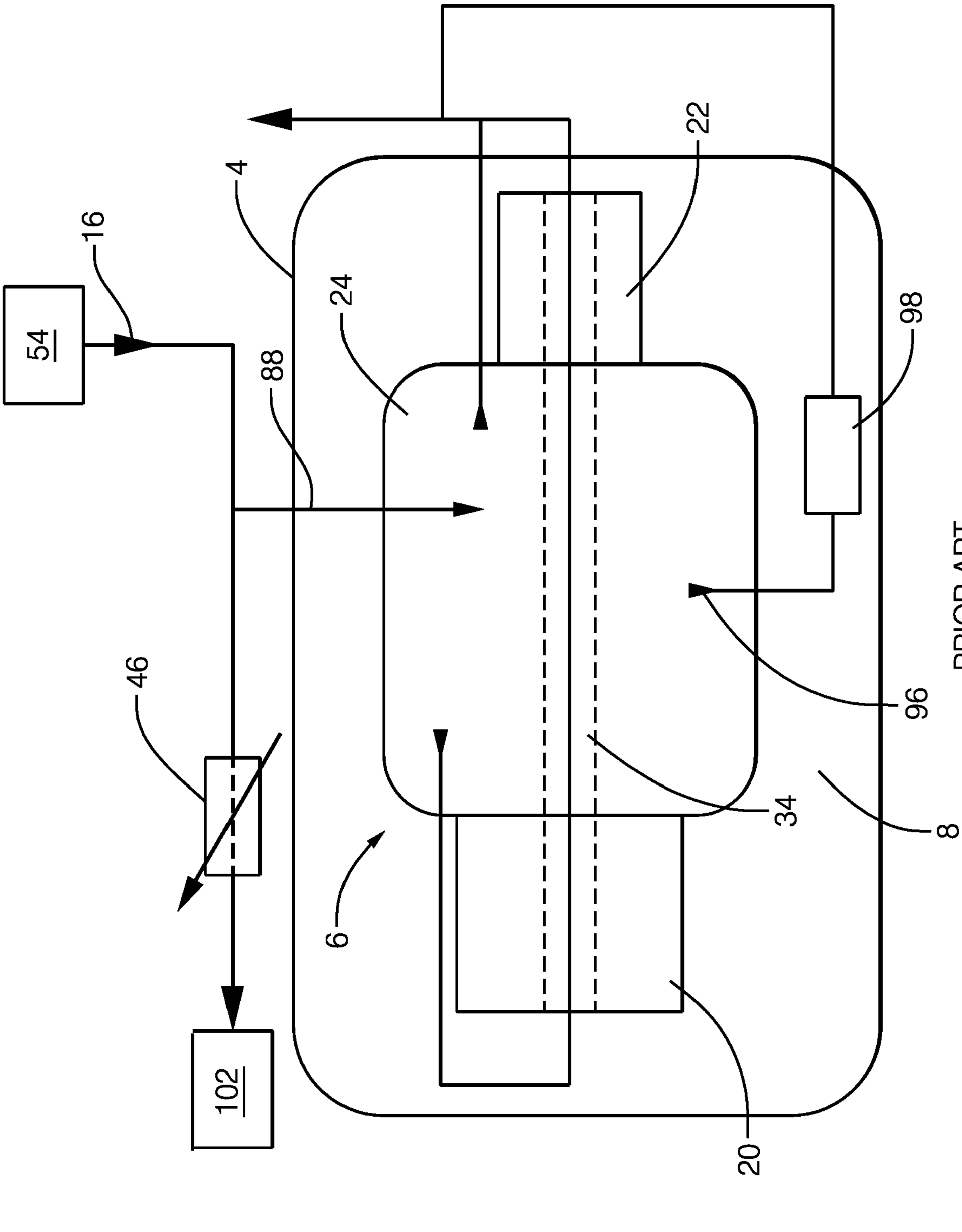
a first exit pathway section (190) providing unrestricted fluid communication between the volume (118) within the cambox (108) and a common backleak pathway section (194);
and
a second exit pathway section (192), providing fluid communication between the gallery (180) and the common backleak pathway section (194), wherein the second exit pathway section (192) is provided by a drilling having a cross-sectional area which is less than a cross-sectional area of the first pathway section (190).

2. A pump assembly (102) as claimed in any one of the preceding claims further comprising at least one channel (160, 162) provided in the pump housing (104) and leading from the chamber (158) to the cambox (108).

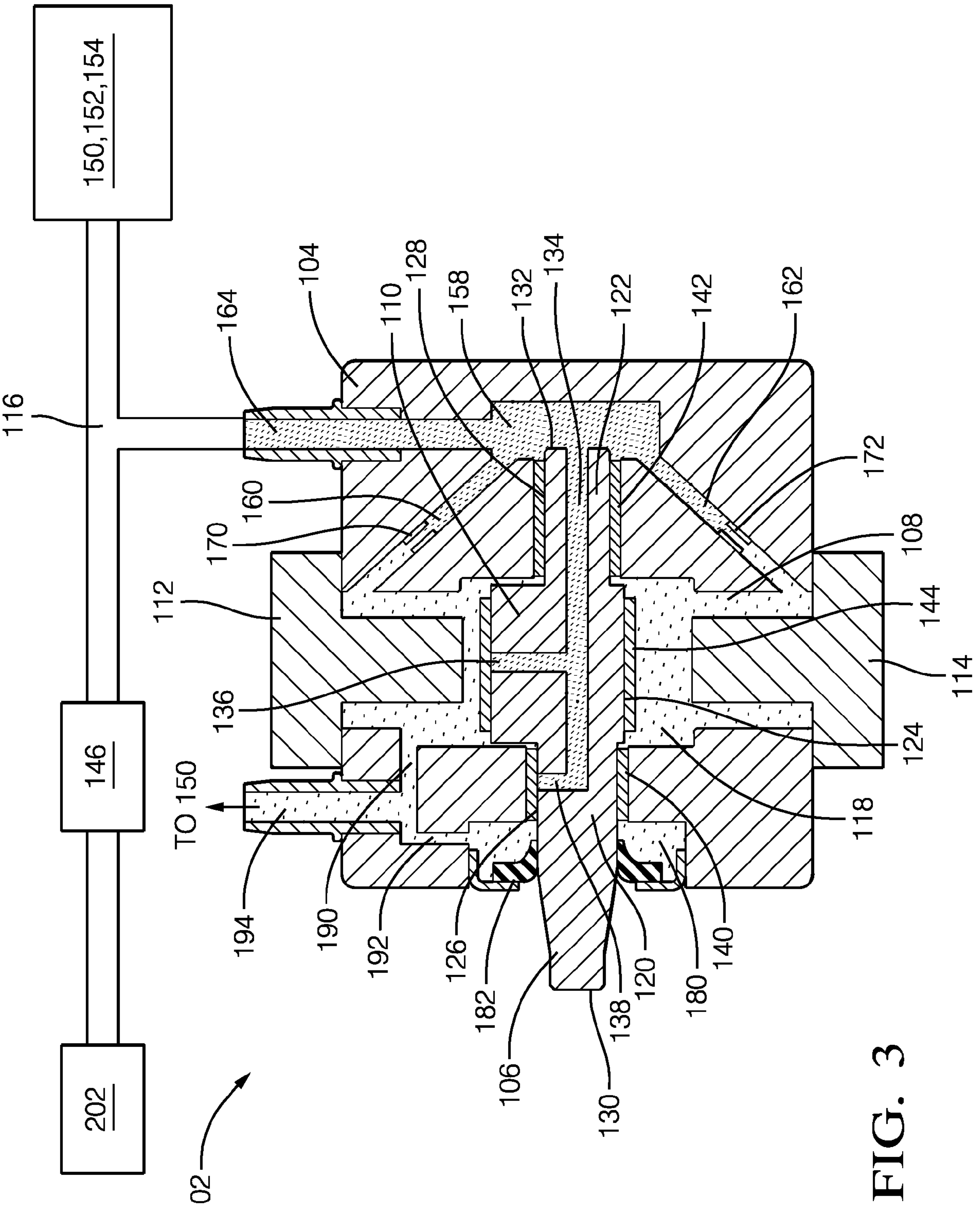
3. A pump assembly (102) as claimed in claim 2 wherein a throttle (170, 172), comprising a section of channel having a reduced cross-sectional area, is provided in the or each channel (160, 162).



PRIOR ART
FIG. 1



PRIOR ART
FIG. 2


150,152,154
116
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TO 150
102
164
104
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172
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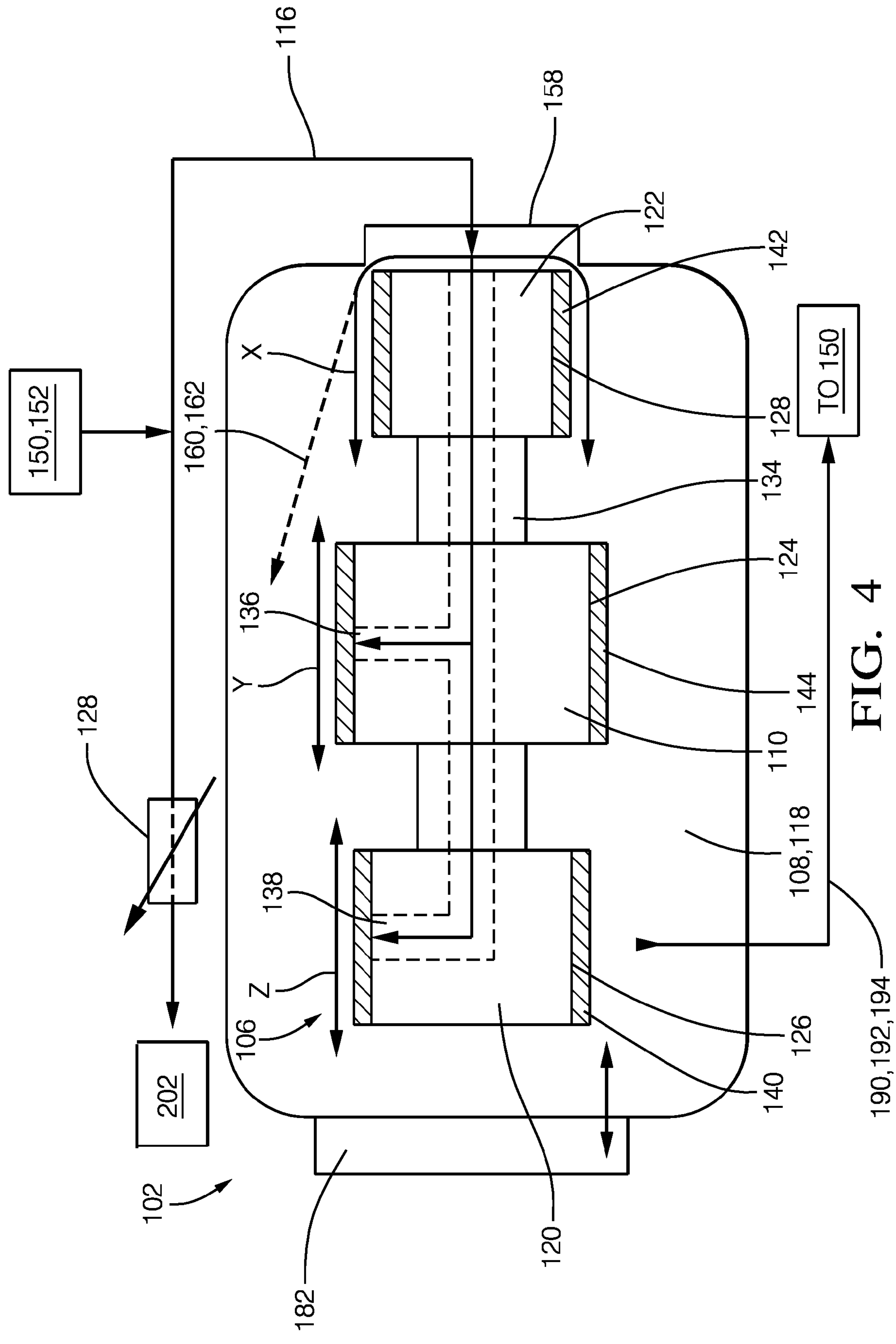
140
130

FIG. 3


116
158
122
142
150,152
X
160,162
128
TO 150
134
124
136
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108,118
138
Z
106
126
190,192,194
140
202
102
120
182

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 16 15 7228

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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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TECHNICAL FIELDS SEARCHED (IPC)

F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	5 July 2016	Lange, Christian

CATEGORY OF CITED DOCUMENTS

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