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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) **Fluid Pump**

(57) A fluid pump (10) for use in delivering fuel to a common rail of an internal combustion engine comprises a drive shaft housing (26), a drive shaft (14) for driving at least one pumping plunger (16) and a bearing (30) for supporting the drive shaft (14) within the drive shaft housing (26). The pump provides a means (56, 48) for supplying fluid to the bearing (30) and means (40) for maintaining a fluid pressure difference across the bearing (30) which, in so doing, increases the effect of convection cooling on the bearing (30), in use.

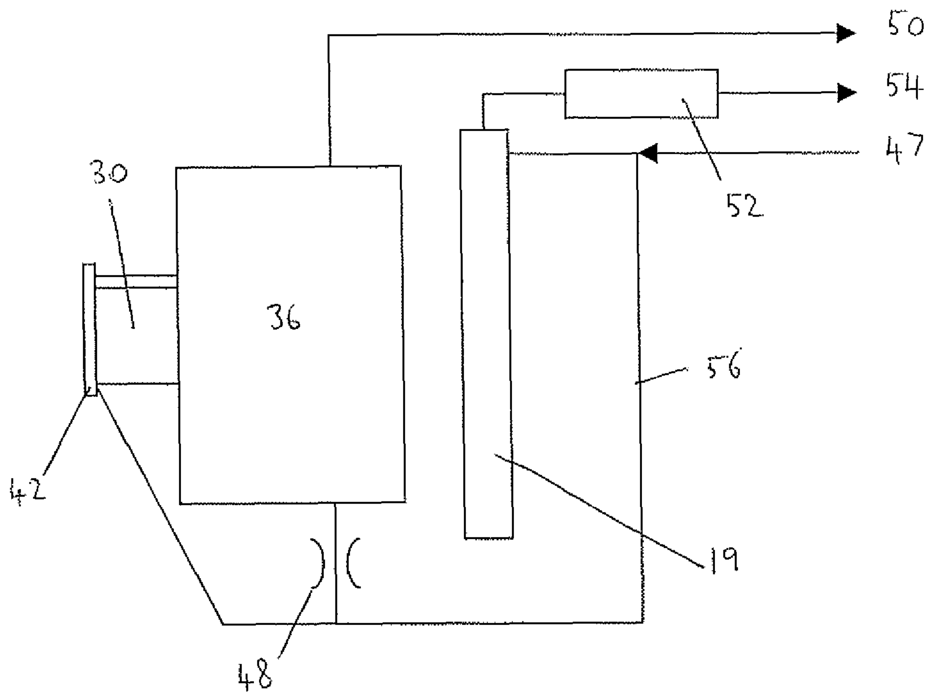

Figure 6

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Description

Technical Field

[0001] The invention relates to a fluid pump. In particular, but not exclusively, the invention relates to a pump for delivering pressurised fuel to a fuel injection system of an internal combustion engine.

Background to the Invention

[0002] In known common rail engines, the fuel pump typically pressurises fuel at relatively low pressure to in excess of 2000 bar for delivery to the associated fuel injection equipment. Such fuel pumps commonly take the form of a positive displacement pump. Positive displacement pumps work by receiving a known volume of relatively low pressure fuel and subsequently displacing the volume of fuel once pressurised.

[0003] One such positive displacement pump is a radial pump housing a plurality of pump assemblies, all of which are driven by a common drive shaft. The drive shaft, which carries a cam, is supported in a drive shaft housing by a front bearing and a rear bearing and is driven by the engine.

[0004] Because the pump is required to pressurise fuel to several thousand bar, high pumping loads are transmitted to the drive shaft and, hence, to the front and rear bearings. In known pumps, the rear bearing is commonly recognised as the weakest bearing due to inadequate cooling, often leading to pump failure.

[0005] The present invention provides a means of modifying the drive shaft housing to reduce the operational temperature of the rear bearing and, in so doing, increases the service life of the pump and the speeds and loads which can be applied to the bearings.

Summary of the Invention

[0006] According to the invention, a fluid pump comprises a drive shaft for driving at least one pumping plunger, a drive shaft housing and a bearing for supporting the drive shaft within the drive shaft housing. The fluid pump further comprises means for supplying fluid to the bearing, and means for maintaining a fluid pressure difference across the bearing to maintain fluid flow across the bearing to effect cooling thereof.

[0007] The invention is particularly useful when applied to a fuel pump where, preferably, the fluid is fuel. For example, the fuel pump may be for use in delivering fuel to a common rail of an internal combustion engine. The pump may be a radial pump having a plurality of pumping plungers radially spaced around the drive shaft.

[0008] In the above mentioned application, because the bearing is continually cooled by the fluid flow across it, the operational fatigue experienced by the bearing is reduced and, as a result, the service life and the performance of the pump is increased.

[0009] In one embodiment the fluid pressure difference is maintained between a first chamber at one end of the bearing and a second chamber spaced from the first chamber along the length of the bearing. In a preferred embodiment of the invention, the second chamber is positioned at the opposite end of the bearing from the first chamber.

[0010] Preferably the first chamber of the pump forms a rear chamber located at a rear end of the bearing, and the second chamber of the pump forms a front chamber which defines a cam box of the pump suitable for housing a cam carried by the drive shaft. Typically the bearing is a rear bearing carried towards the rear of the drive shaft, the drive shaft carrying a front bearing also towards its front end.

[0011] A source of pressurised fluid may be used for supplying fluid to the first and second chambers through a flow path. The flow path communicates with the first chamber directly so that the pressure of fluid in the flow path is substantially the same as that within the first chamber. The flow path also communicates with the second chamber, but through an orifice, which serves to lower the fluid pressure in the second chamber with respect to the fluid pressure in the first chamber, therefore maintaining the pressure difference across the two chambers. One such source of pressurised fluid takes the form of a pump, for example a transfer pump or electric lift pump.

Brief Description of the Figures

[0012] The state of the art and the preferred embodiment of the present 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 state of the art fuel pump;

Figure 2 is a cross-sectional view of a drive shaft housing of the pump in Figure 1 prior to assembly with the drive shaft and associated bearings;

Figure 3 is a sectional view of the drive shaft housing in Figure 2;

Figure 4 is a cross-sectional view of the drive shaft housing in Figures 2 and 3 with the rear bearing and drive shaft assembled;

Figure 5 is a fuel flow circuit diagram of the pump in Figures 1 to 4; and,

Figure 6 is a fuel flow circuit diagram of a fuel pump of the present invention.

[0013] An example of a known fuel pump suitable for delivering pressurised fuel to the fuel injection system of an engine is the common rail diesel fuel pump described in EP 1629191. Referring to Figures 1 to 4, the fuel pump 10 takes the form of a radial pump having three pump assemblies 12 arranged at equally spaced locations around a drive shaft 14. Each pump assembly 12 includes a plunger 16 which is driven by means of a tappet 18 so as to pressurise fuel within an associated pumping chamber 19.

[0014] An engine-driven drive shaft 14 carrying a cam 20 extends through a housing bore 24 provided in a drive shaft housing 26. The drive shaft 14 is mounted on a front bearing (not shown) provided in a front region of the housing bore 24 (referred to as the front housing bore 28) and on a rear bearing 30 provided in a rear region of the housing bore 24 (referred to as the rear housing bore 32). The front housing bore 28 is so-called because it is the region of the pump 10 that is nearest to the engine (not shown). The cam 20 is located adjacent to a shoulder 34 between the front housing bore 28 and the rear housing bore 32 and, therefore, the front housing bore 28 defines a chamber in the form of the engine's cam box 36. The drive shaft 14 carries a cam rider 33 which, on its internal diameter, cooperates with the drive shaft 14 and, on its external diameter, is provided with three flats 35, each of which cooperates with a respective one of the tappets 18.

[0015] As the cam 20 rotates with the drive shaft 14, cooperation between the rider 33 and the tappets 18 causes the tappets 18 to be driven radially outward from the drive shaft 14 in a phased cyclical manner. The tappets 18 return along the same path, in a radially inward direction, under the influence of an associated spring 38. Movement of the tappets 18 causes the plungers 16 to perform a pumping cycle including a pumping stroke in which the plungers 16 are driven radially outwards from the drive shaft 14, and a return stroke in which the plungers 16 are returned radially inwards towards the drive shaft 14. Fuel is drawn into the pumping chambers 19 during the return stroke from a relatively low pressure source of fuel 40 and fuel that is pressurised during the pumping stroke is delivered through an associated outlet valve 41 to an accumulator volume (the common rail, not shown) that is common to all three pump assemblies 12.

[0016] Fuel within the pumping chambers 19 is typically pressurised to a level in excess of 2000 bar and, thus, the pumping loads acting on the plungers 16, and hence on the tappets 18 and the drive shaft 14, are high. As a consequence, considerable heating of the front and rear bearings occurs, and particularly the rear bearing 30.

[0017] The rear housing bore 32 has a region of enlarged diameter at its rear end to provide a chamber 42 which is in communication with the cam box 36 by way of a bearing drilling 44. One end of the bearing drilling 44 opens into the cam box 36 at the shoulder 34 between the front housing bore 28 and the rear housing bore 32 and the other end of the bearing drilling 44 opens into the chamber 42. The bearing drilling 44 extends along the length of the rear bearing 30 parallel to the rear housing bore 32. The rear bearing 30 supports the drive shaft 14 in the rear housing bore 32 and allows the drive shaft 14 to rotate about its axis 46.

[0018] The purpose of the bearing drilling 44 in the drive shaft housing 26 is illustrated with reference to Figure 5 which shows the fuel flow paths to and from the fuel pump 10. An outlet 47 from the pressurised fuel source 40 delivers fuel to the pumping chambers 19, as described above, and to a flow path 56 which communicates with the cam box 36 via a pressure-reducing orifice 48, which serves to reduce the pressure of the fluid going into the cam box 36 relative to that at the outlet 47. Fuel delivered to the cam box 36 is able to flow through the bearing drilling 44 into the chamber 42 and is also able to flow through a clearance (or clearances) between the rear bearing 30 and the rear housing bore 32. Fuel delivered to the cam box 36 is also able to flow back to the engine fuel tank via a backleak passage 50, ensuring a constant supply of fuel through the cam box 36. The pumping chambers 19 deliver pressurised fuel to a high pressure circuit 52 for delivery to the common rail.

[0019] The fuel pressure distribution across the bearing drilling 44 connecting the chamber 42 to the cam box 36 is substantially uniform, so that there is only a minimal net fluid flow between the chamber 42 and the cam box 36. A uniform pressure distribution also exists across the clearances between the rear bearing 30 and the rear housing bore 32, which also connect the chamber 42 to the cam box 36, and across internal clearances of the rear bearing 30. As the pressure difference across the bearing drilling 44 is minimal or non-existent, only a moderate amount of heat transfer (or substantially no heat transfer) away from the rear bearing 30 is achieved by convection due to the limited flow through the bearing drilling 44, resulting in a concentration of hot fuel in the chamber 42. Likewise, there is only minimal, or substantially no, heat transfer by convection due to lack of a fuel pressure difference across the bearing clearances or between the rear bearing 30 and the rear housing bore 32. The amount of heat transfer through conduction is not sufficient to remove the concentration of hot fuel in the chamber 42 and, therefore, the extent of cooling of the rear bearing 30 is relatively low and has been found to be inadequate in certain circumstances.

[0020] The present invention improves the above-described pump by modifying the drive shaft housing 26 to reduce the operational temperature of the rear bearing 30 by increasing the effect of convection cooling. The construction of the drive shaft housing 26 is the same as described previously, in terms of the front and rear bearings, the housing bore 24 and the cam box 36, but differs in key respects.

[0021] Referring to Figure 6, in the present invention the bearing drilling 44 of the known pump, between the chamber 42 and the cam box 36, is removed. In addition, the flow path 56 from the pressurised fuel source 40 is connected to the chamber 42 at the rear end of the rear housing bore 32. In other words, the pressurised fuel source 40 is in direct communication with the chamber

42, rather than communicating with the chamber 42 only via the orifice 48 and the cam box 36.

[0022] Fuel from the pressurised fuel source 40 which is delivered to the cam box 36 is therefore divided into two fuel streams: one fuel stream flows through the orifice 48 and into the cam box 36 directly and a second fuel stream flows into the chamber 42 at the rear end of the rear housing bore 32 and from there into the cam box 36 through the clearances between the rear bearing 30 and the rear housing bore 32. Fuel pressure in the cam box 36 is substantially equal to fuel pressure at the outlet of the orifice 48, and fuel pressure in the chamber 42 is substantially equal to fuel pressure delivered from the outlet 47 of the pressurised fuel source 40. Therefore, a substantial pressure difference exists across the rear bearing 30, between the chamber 42 and the cam box 36, which is maintained during pump operation meaning that a net flow of fuel is maintained through the internal clearances of the rear bearing 30 and between the rear housing bore 32 and the rear bearing 30.

[0023] The connection of the outlet 47 of the pressurised fuel source 40 to the chamber 42 at the rear end of the rear housing bore 32 provides a means of maintaining a pressure difference across the rear bearing 30 to cause fuel to flow from the chamber 42, through the internal clearances of the rear bearing 30 and into the cam box 36, thereby increasing cooling of the rear bearing 30 by convection.

[0024] It will be appreciated that the present invention is not limited to the type of pump described with references to Figures 1 to 5. The invention could be applied to any type of fluid pump, and not necessarily a fuel pump, where the support bearings for the drive shaft are prone to wear due to heating effects. The pump may include any number of pump assemblies and plungers (e.g. one, two, three or more than three) and may be applied to pump configurations other than radial. Also, the means for establishing a significant pressure difference across the rear bearing need not derive from a transfer pump, but may be any other source of pressurised fluid or fuel. In some applications it is possible for a fluid source other than a fuel to be used to cool the rear bearing.

Claims

1. A fluid pump comprising a drive shaft (14) for driving at least one pumping plunger (16), a drive shaft housing (26), a bearing (30) for supporting the drive shaft (14) within the draft shaft housing (26), means (56, 48) for supplying fluid to the bearing (30), and means (40) for maintaining a fluid pressure difference across the bearing (30) to maintain fluid flow across the bearing (30) to effect cooling thereof.

2. The pump as claimed in claim 1, wherein the means for supplying fluid includes a flow path (56) provided with an orifice (48) through which fluid flows into the drive shaft housing (26).

3. The pump as claimed in claim 2, including a source of pressurised fluid for supplying fluid to the flow path (56).

4. The pump as claimed in claim 3, wherein the source of pressurised fluid is a pump (40).

5. The pump as claimed in any one of claims 2 to 4, wherein the drive shaft housing (26) includes a first chamber (42) at one end of the bearing (30) and a second chamber (36) spaced from the first chamber (42) along the bearing (30), whereby the fluid pressure difference is maintained across the first and second chambers (42, 36).

6. The pump as claimed in claim 5, wherein the second chamber (36) is at the other end of the bearing (30).

7. The pump as claimed in claim 5 or claim 6, wherein the flow path (56) communicates with the second chamber (36) through the orifice (48).

8. The pump as claimed in claim 7, wherein the flow path (56) communicates with the first chamber (42) directly so that the pressure of fluid in the flow path (56) is substantially the same as that within the first chamber (42).

9. The pump as claimed in any one of claims 1 to 8, wherein the fluid is fuel.

10. The pump as claimed in claim 9, for use in delivering fuel to a common rail of an internal combustion engine.

11. The pump as claimed in claim 10, wherein the pump is a radial pump (10) having a plurality of pumping plungers (16) radially spaced around the drive shaft (14).

Amended claims in accordance with Rule 137(2) EPC.

1. A fluid pump comprising a drive shaft (14) for driving at least one pumping plunger (16), a drive shaft housing (26), a bearing (30) for supporting the drive shaft (14) within the draft shaft housing (26), means (56, 48) for supplying fluid to the bearing (30), and means (40) for maintaining a fluid pressure difference across the bearing (30) to maintain fluid flow across the bearing (30) to effect cooling thereof,
wherein the means for supplying fluid includes a flow path (56) provided with an orifice (48) through which fluid flows into the drive shaft housing (26),
wherein the drive shaft housing (26) includes a first

chamber (42) at one end of the bearing (30) and a second chamber (36) spaced from the first chamber (42) along the bearing (30), whereby the fluid pressure difference is maintained across the first and second chambers (42, 36),
wherein the flow path (56) communicates with the second chamber (36) through the orifice (48), and
wherein the flow path (56) communicates with the first chamber (42) directly so that the pressure of fluid in the flow path (56) is substantially the same as that within the first chamber (42).

2. The pump as claimed in claim 1, including a source of pressurised fluid for supplying fluid to the flow path (56).

3. The pump as claimed in claim 2, wherein the source of pressurised fluid is a pump (40).

4. The pump as claimed in anyone of claims 1 to 3, wherein the second chamber (36) is at the other end of the bearing (30).

5. The pump as claimed in any one of claims 1 to 4, wherein the fluid is fuel.

6. The pump as claimed in claim 5, adapted to deliver fuel to a common rail of an internal combustion engine, in use.

7. The pump as claimed in claim 6, wherein the pump is a radial pump (10) having a plurality of pumping plungers (16) radially spaced around the drive shaft (14).

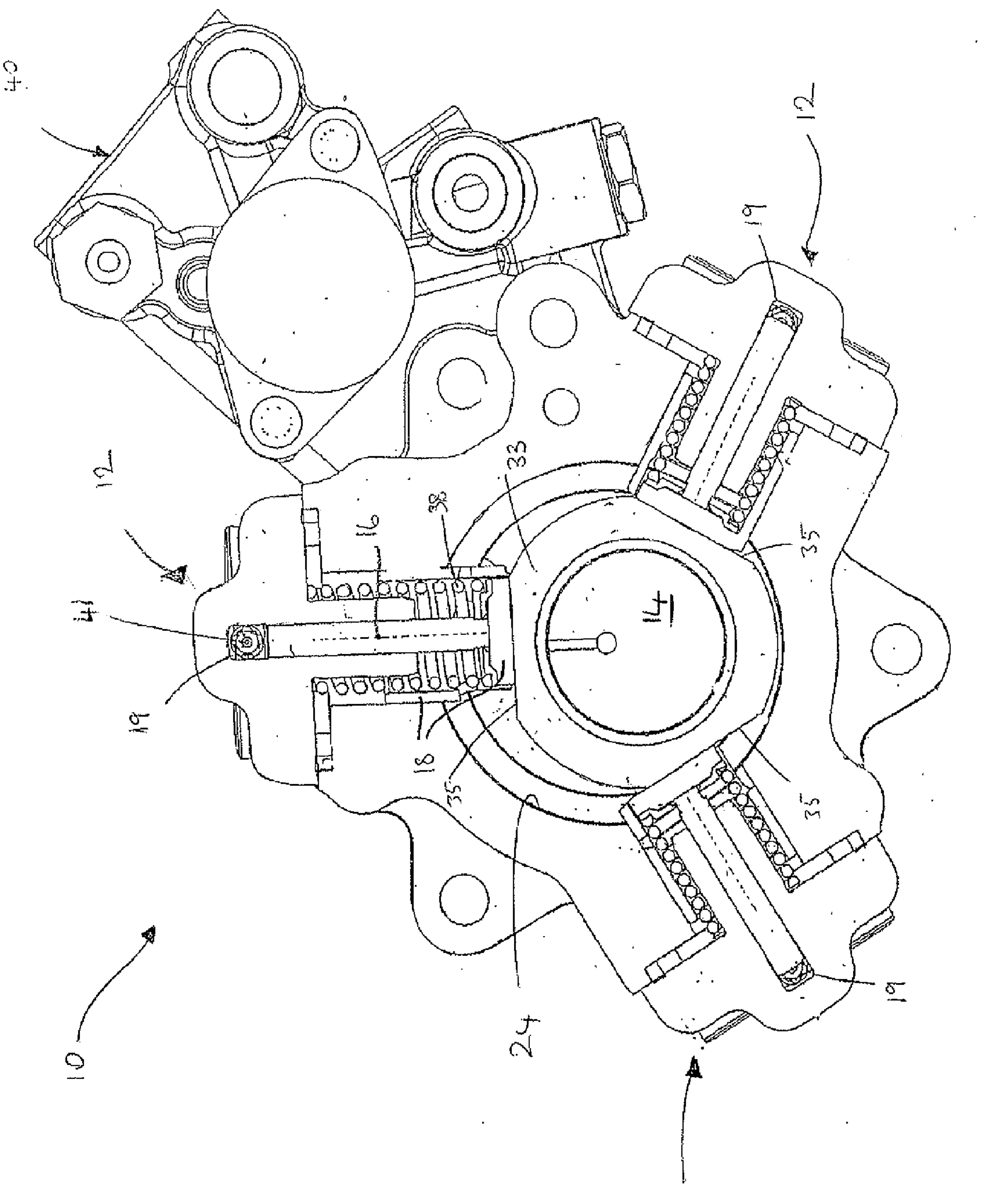

Figure 1

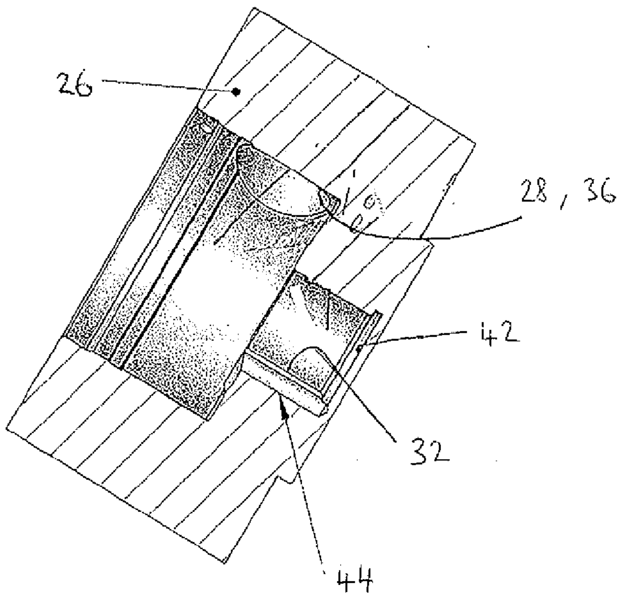

Figure 2

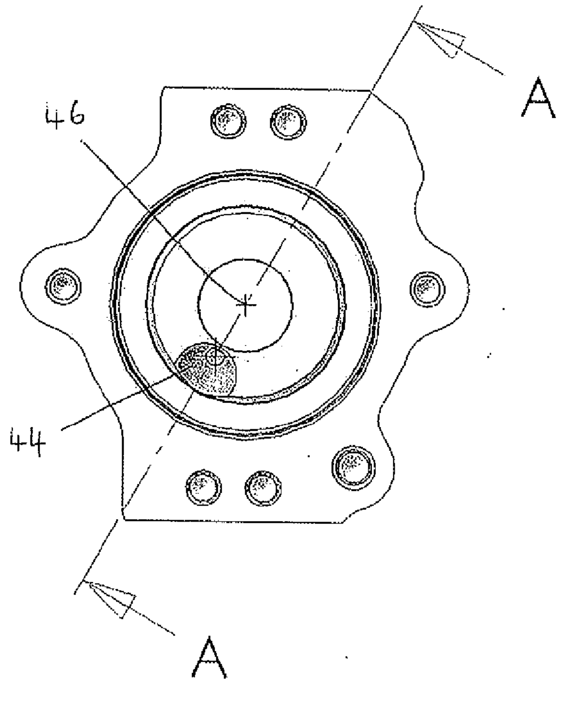

Figure 3.

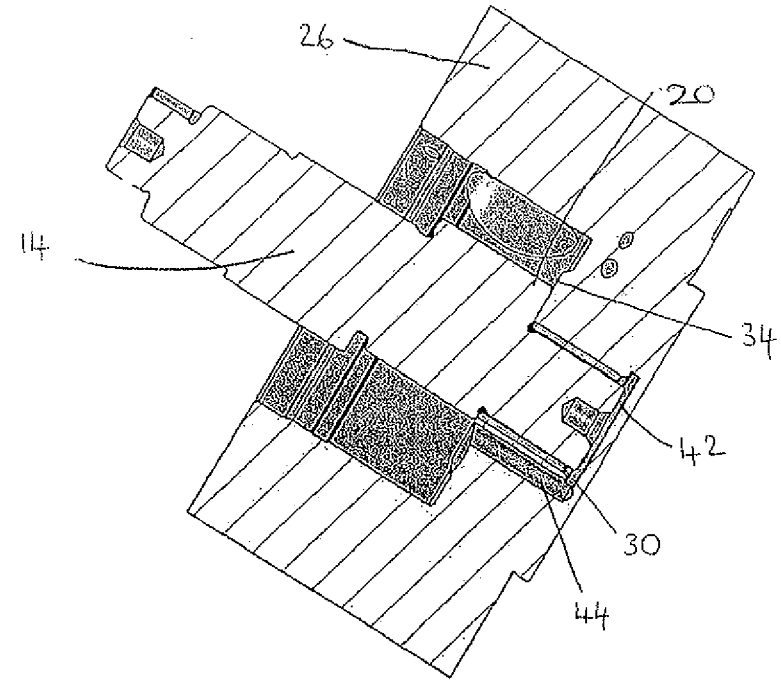

Figure 4

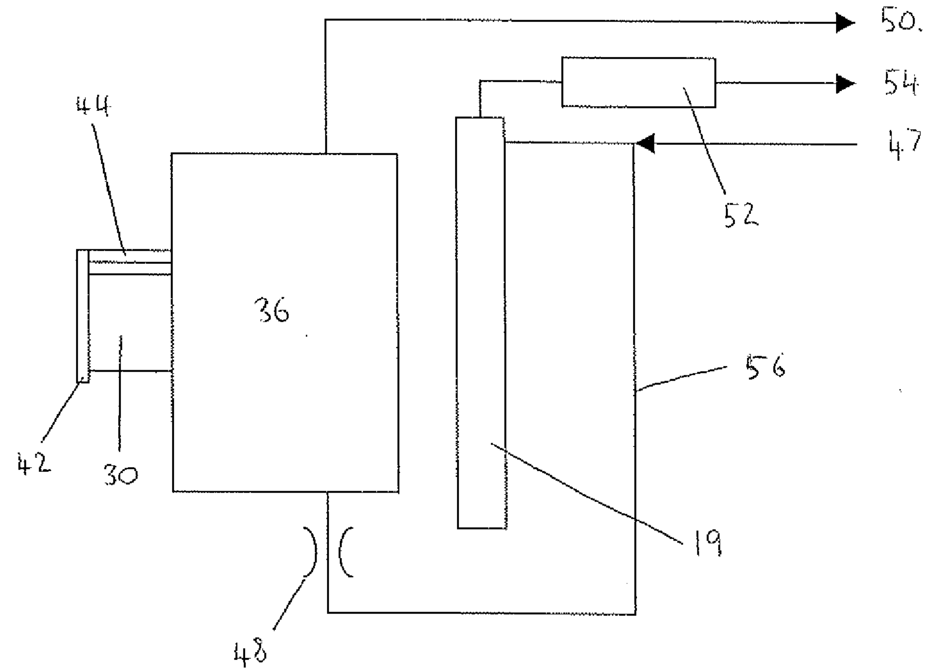

Figure 5

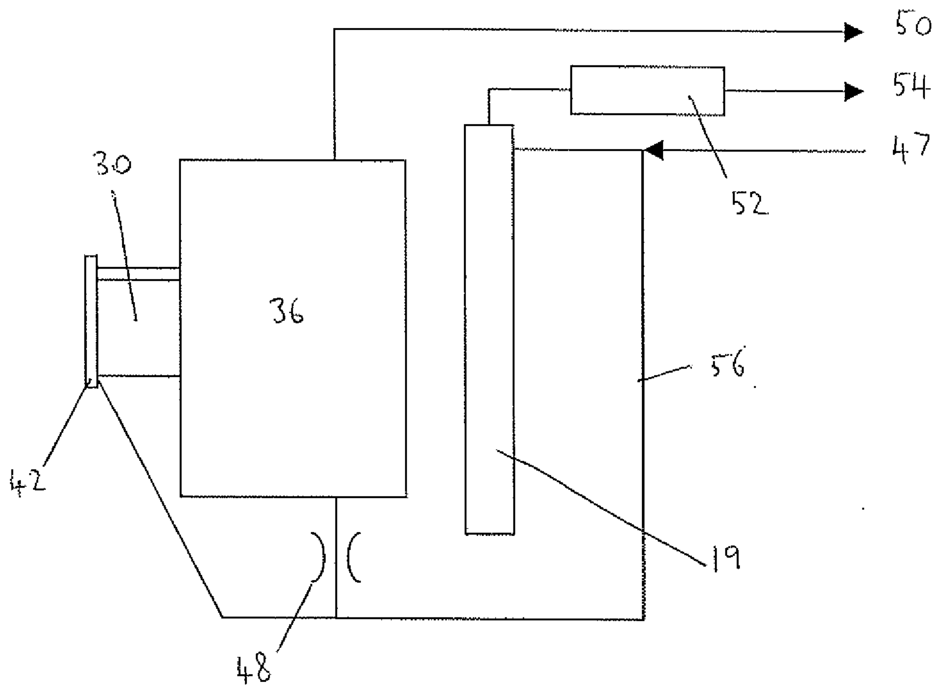

Figure 6

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EUROPEAN SEARCH REPORT

Application Number
EP 08 15 5497

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2006 013165 A1 (BOSCH GMBH ROBERT [DE]) 27 September 2007 (2007-09-27) * paragraphs [0006], [0010], [0038]; figure *	1-4,9-11	INV. F02M59/06 F02M59/10 F04B53/00 F04B53/08 F04B53/18
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A	* page 9, paragraph 3RD; figure 1 *	8	
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A	* claims 21,24; figures *	3-6	
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TECHNICAL FIELDS SEARCHED (IPC)

F02M
F04B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	27 October 2008	Landriscina, V

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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