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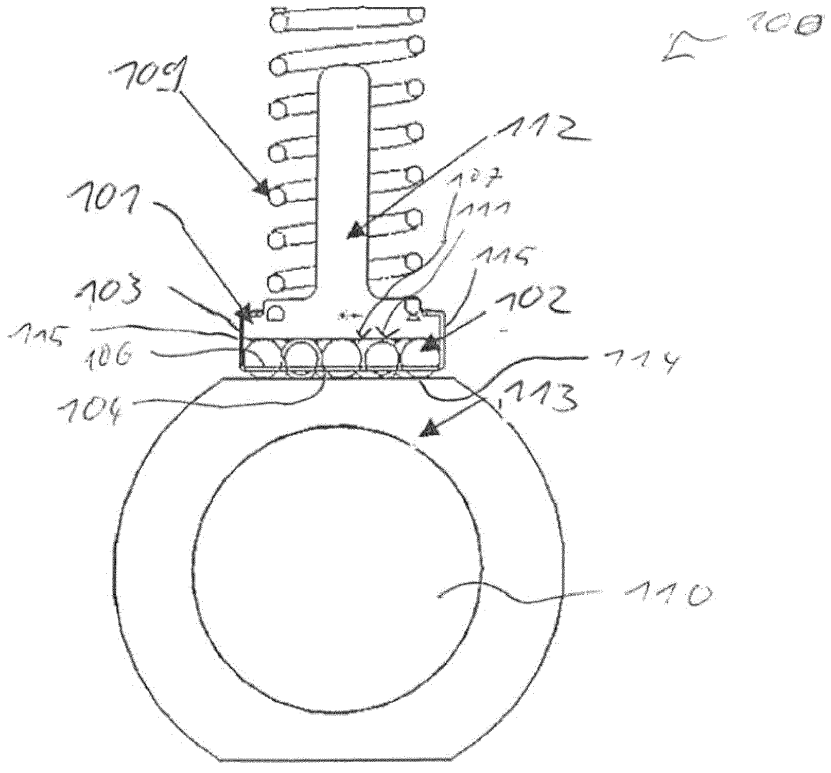
(71) Applicant: **Continental Automotive GmbH**
30165 Hannover (DE)

(72) Inventor: **Rosu, Cristian Adrian, Dr.**
93051 Regensburg (DE)

(54) **Plunger arrangement for a high-pressure pump**

(57) A plunger arrangement for a high pressure pump comprises:
- a plunger (112) with a flat end part (101),
- a multitude of bearing balls (102) that are arranged along the flat end part (101),
- a ball holder (103) for coupling the multitude of bearing balls (102) with the flat end part (101), the ball holder (103) being coupled to the plunger (112) such that the bearing balls (102) are arranged between the flat end part (101) and the ball holder (103) and each bearing ball (102) projects partly over the ball holder (103) for coupling the plunger (112) with a drive shaft (110).

FIG 1



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Description

[0001] The invention relates to a plunger arrangement for a high-pressure pump, particularly a plunger arrangement for a high-pressure fuel pump for use in an internal combustion engine.

[0002] In today's automotive engine systems, there is an increased demand for low cost, direct injection. In common rail injection systems, the fuel is delivered by means of a high pressure pump from a fuel tank to a fuel rail which serves as a storage reservoir for the fuel. The fuel is under high pressure in the fuel rail (or common rail) and can be injected directly into the cylinders via injection valves connected to the rail.

[0003] Fuel pumps, for example common rail pumps, need to be cost effective and durable. The sliding common rail pump mechanism is made either of a tappet, a spring seat and a plunger or of a footed plunger. These pumping mechanisms slide on a component named rider. A variant of a hydro-dynamic footed plunger is the hydrostatic footed plunger. The scuffing issue on the foot is eliminated due to the hydrostatic lifting film that separates the foot from the rider during the pumping phase. The fluid under pressure is brought straight from the pumping chamber via a channel manufactured along the plunger. The flow used to lift the plunger foot can reduce the volumetric efficiency of the pump. A lower volumetric efficiency will negatively affect the overall efficiency of the pump leading to increase in power consumption. This is seen as a major inconvenience due to the automotive market drive to reduce the fuel consumption. Another pumping concept available in common rail pumps is a roller and shoe running on a single or multi-lobe cam. This design has the advantage of producing less heat. However, the pressure capability is currently limited to a maximum of 2200 bar due to the limited space available in the engine.

[0004] It is desirable to provide a plunger arrangement for a high-pressure pump which is cost effective and durable.

[0005] According to an aspect of the invention, a plunger arrangement for a high-pressure pump comprises a plunger with a flat end part. The plunger arrangement comprises a multitude of bearing balls that are arranged along the flat end part. The plunger comprises a ball holder for coupling the multitude of bearing balls with the flat end part. The ball holder is coupled to the plunger such that the bearing balls are arranged between the flat end part and the ball holder. The ball holder is coupled to the plunger such that each bearing ball projects partly over the ball holder for coupling the plunger with a driveshaft.

[0006] The multitude of bearing balls coupled to the flat end part of the plunger by the ball holder provides a ball bearing for the plunger. In the high-pressure pump, the bearing balls are in contact with a cam of the driveshaft. The cam comprises a flat part, the rider. The number of the bearing balls of the multitude of bearing balls and the size of the bearing balls are calculated to obtain a low stress on the balls. Thus, the plunger arrangement is durable. The bearing balls are cost effective. For example, the ball holder is made from steel. The plunger arrangement does not require special tooling. Therefore, the plunger arrangement is cost effective. Due to the little friction between the plunger, the bearing balls and the rider, the internal heat generation is low. Further, the contact area between the plunger and the rider is extended and thus an additional pressure capability is provided. Further, the low friction between the plunger and the rider reduces the driving torque and the components' wear. Therefore, the plunger arrangement is usable for stop-start engine technology. According to aspects, the heat generation in the cambox is reduced by 10 to 20 % °C.

[0007] According to further aspects, the plunger comprises a multitude of notches at the flat end part facing the ball holder. Each bearing ball of the multitude of bearing balls is arranged partly in one notch of the multitude of notches. Thus, the high of the plunger arrangement is reduced. Further, the contact stress is reduced.

[0008] According to further aspects, the plunger arrangement comprises a coating on the flat end part to reduce the friction between the flat end part and the bearing balls. Thus, the wear is further minimized.

[0009] According to further aspects, the plunger arrangement comprises a fluid channel that reaches through the plunger to the flat end part. The fluid channel is used for additional lubrication of the contact area between the multitude of bearing balls and the flat end part.

[0010] Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings. The same elements, elements of the same type and elements having the same effect may be provided with the same reference symbols in the figures.

FIG. 1 schematically shows a plunger arrangement and a rider according to an embodiment,

FIG. 2 schematically shows a plunger according to an embodiment, and

FIG. 3 schematically shows a plunger arrangement and a rider according to an embodiment.

[0011] A plunger arrangement 100 comprises a plunger 112. The plunger comprises an elongated board and a flat end part 101. The flat end part faces a driveshaft 110.

[0012] The driver 110 comprises a cam with a rider 113 with a flat surface 114. The flat end part 101 and the surface 114 are arranged opposite each other.

[0013] Between the flat end part 101 and the surface 114, a multitude of bearing balls 102 is arranged. The bearing balls 102 each are free to rotate relatively to the plunger 112 and the rider 113.

[0014] The bearing balls 102 are coupled to the plunger

112 by a ball holder 103. The ball holder comprises a multitude of openings 106. Each bearing ball 102 is positioned in one of the openings 106 such that the bearing balls 102 extend through the ball holder 103. The openings 106 comprise a smaller diameter than the diameter of the bearing balls 102.

[0015] The ball holder 103 comprises a first part 104 that is arranged between the flat end part 101 and the surface 114. The openings 106 are located at the part 104. According to embodiments, the ball holder 103 comprises one or more further parts 115 that are aligned across the part 104 and are in contact with the plunger 112 to couple the ball holder 103 with the plunger 112.

[0016] A spring 109 is coupled with the flat end part 109 on a side opposite the bearing balls 102. The spring 109 is arranged to extend a spring force on the plunger 112 in the direction of the driveshaft 110.

[0017] For example, the plunger arrangement 100, the spring 109 and the driveshaft 110 are part of a common rail fuel pump of radial pump design. The driveshaft 110 is engine-driven and drives the rider 113 in use. As the rider 113 is driven in use, the plunger 112 is caused to reciprocate within a bore of the pump housing. The plunger 112 causes pressurization of fuel within the pump chamber defined at one end of the bore. For example, the delivery of fuel from the pump chambers to a common high-pressure supply line is controlled by means of delivery valves. The high-pressure line supplies fuel to a common rail or other accumulator volume for delivery to downstream injectors of a common rail fuel system.

[0018] Due to the coupling of the plunger 112 with the driveshaft 110 by the bearing balls 102, the heat generated in use is reduced. Further, the pressure capability is increased. Therefore, the pump can be downsized and fitted on small engines. Further, the friction between the plunger 112 and the rider 113 is reduced and thus, the driving torque and the components' wear is reduced. Therefore, the heat generation is reduced by 10 to 20 % °C according to embodiments with respect to conventional footed plungers. At the same time, the coupling by the multitude of bearing balls 112 provides an additional pressure capability. According to aspects, the plunger arrangement is operated without forced cooling through the bearings.

[0019] According to further aspects, a surface 111 of the plunger 112 facing the driveshaft 110 comprises a coating 107. The balls 102 are arranged along the surface 111 and the coating 107 further reduces the friction between the balls 102 and the plunger 112.

[0020] According to aspects, the surface 111 is smooth and on one level. FIG. 2 schematically shows the plunger 112 according to further embodiments. In contrast to the plunger 112 of FIG. 2, the surface 111 is not smooth. The surface 111 comprises a multitude of notches 105. During operation, each bearing ball 102 is arranged in one notch of the notches 105. Thus, the high of the pump and the contact stress is reduced. The bearing balls 102 each are partly arranged in the plunger 112.

[0021] FIG. 3 schematically shows the plunger arrangement 100 according to further embodiments. The plunger 112 comprises a fluid channel 108. The fluid channel 108 reaches through the plunger to the flat end part and provides a fluid communication through the plunger 112 to the bearing balls 102. Additional lubrication is brought to the area of the bearing balls 102 through the fluid channel 108. According to further embodiments, more than one fluid channel 108 is provided in the plunger 112 for additional lubrication.

Claims

1. Plunger arrangement for a high pressure pump, comprising:

   - a plunger (112) with a flat end part (101),
   - a multitude of bearing balls (102) that are arranged along the flat end part (101),
   - a ball holder (103) for coupling the multitude of bearing balls (102) with the flat end part (101), the ball holder (103) being coupled to the plunger (112) such that the bearing balls (102) are arranged between the flat end part (101) and the ball holder (103) and each bearing ball (102) projects partly over the ball holder (103) for coupling the plunger (112) with a drive shaft (110).

2. Plunger arrangement according to claim 1, the plunger (112) comprising a multitude of notches (105) at the flat end part (101) facing the ball holder (103), each bearing ball (102) of the multitude of bearing balls (102) being arranged in one notch (105) of the multitude of notches (105).

3. Plunger arrangement according to claim 1 or 2, wherein the ball holder (103) comprises a multitude of openings (106), the openings (106) each comprising a diameter smaller than the diameter of the bearing balls (105), each bearing ball (105) of the multitude of bearing balls (105) being arranged in one opening (106) of the multitude of openings (106).

4. Plunger arrangement according to one of claims 1 to 3, comprising a coating (107) on the flat end part (101) to reduce the friction between the flat end part (101) and the bearing balls (102).

5. Plunger arrangement according to one of claims 1 to 4, comprising a fluid channel (108) that reaches through the plunger (112) to the flat end part (101).

FIG 1

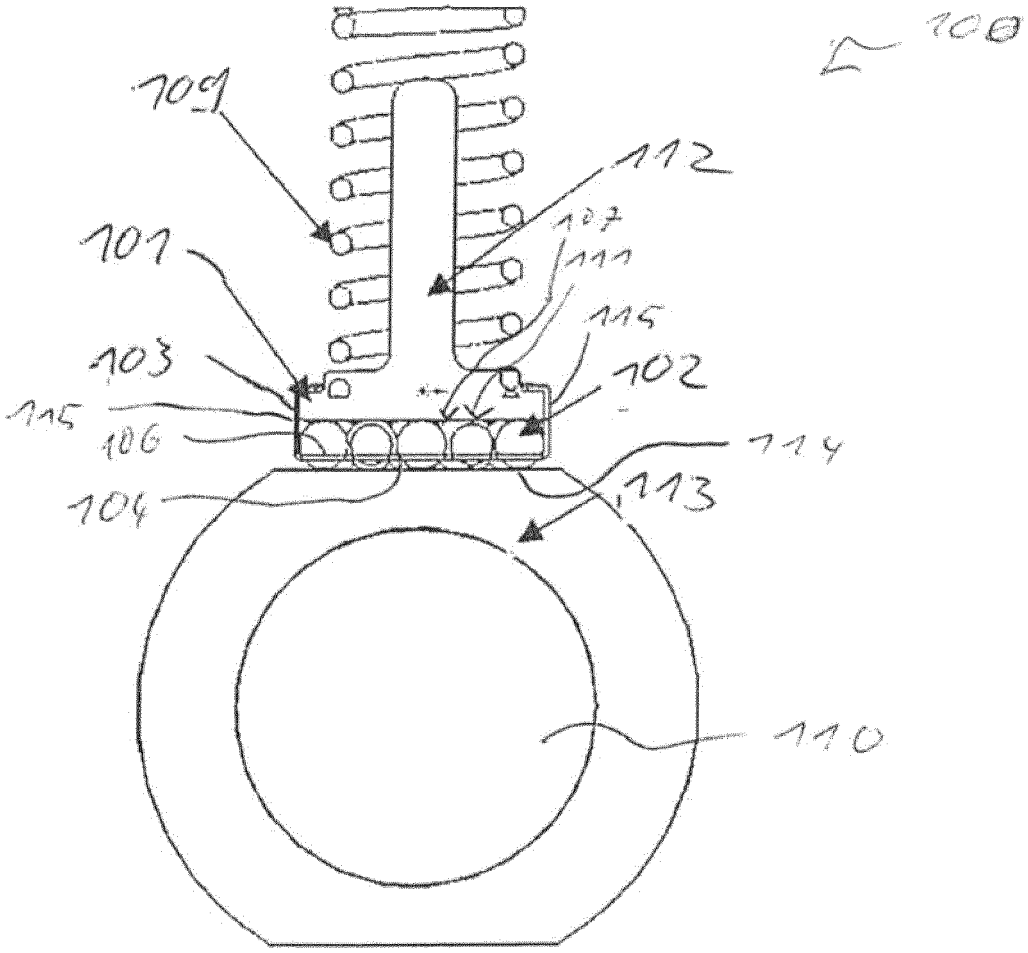


FIG 2

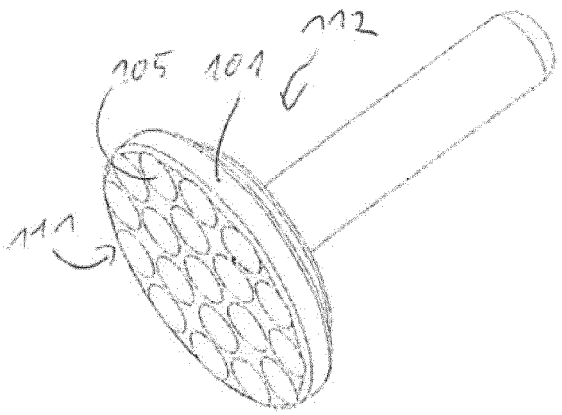
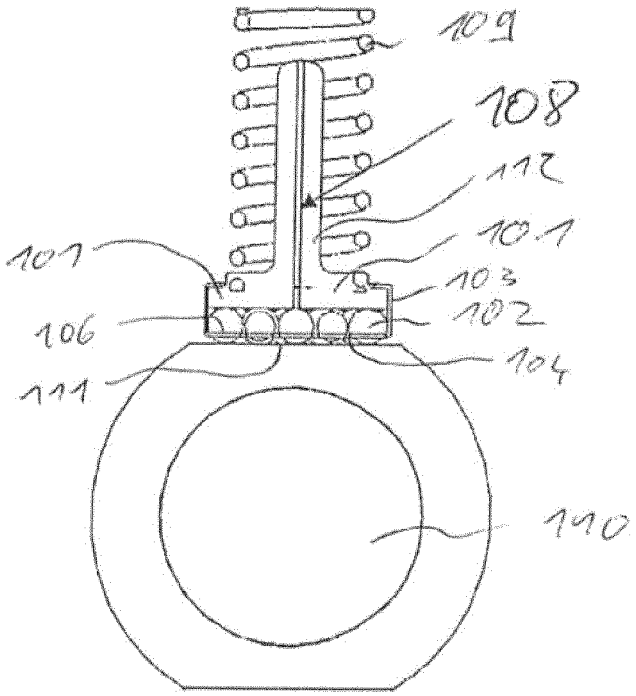


FIG 3



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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 5589

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TECHNICAL FIELDS SEARCHED (IPC)

F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 February 2013	Pinna, Stefano

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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