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(54) **Hydraulic lash adjuster**

(57) A hydraulic lash adjuster is provided with a pressure relief valve operable to release oil from the lash ad-

juster's oil chamber to enable the hydraulic lash adjuster to be able to retract when required.

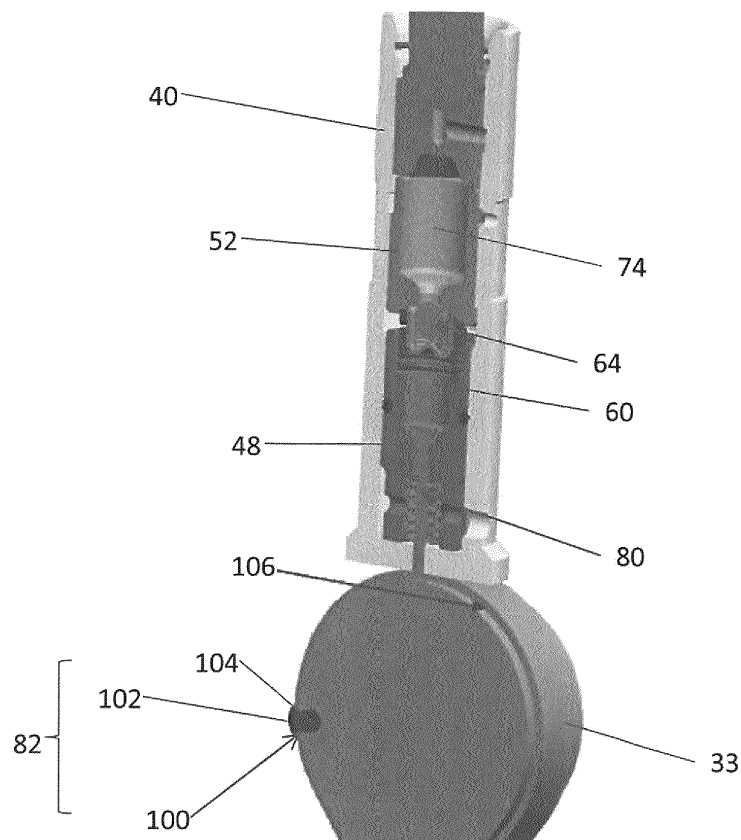


Figure 3

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Description

Field of the Invention

[0001] The present invention relates to a hydraulic lash adjuster.

Background of the Invention

[0002] A typical hydraulic lash adjuster (HLA) comprises an oil-containing chamber defined between an outer body and a plunger assembly slidably mounted within the outer body, and a spring arranged to enlarge the chamber by pushing the plunger assembly outwardly from the outer body to extend the HLA. Oil flows into the chamber via a one way valve, but can escape the chamber only slowly, for example, via closely spaced leak down surfaces. Accordingly, a HLA can extend to accommodate any slack in a valve train assembly, such as between the cam and the roller but after it is extended, the incompressible oil in the chamber provides sufficient rigid support for the HLA to open the valve when a rocker arm pivots (i.e. the incompressible oil prevents the plunger assembly being pushed back inwardly of the outer body so that the HLA acts as a solid body). Typically, the HLA has a second chamber, defined by the plunger assembly, on the other side of the one way valve from the first chamber and which is in fluid communication with the engine's oil supply. Oil supplied from the engine's oil supply is retained within the second chamber and flows into the first chamber through the one way valve when the HLA extends.

[0003] Heavy and medium duty diesel engines often use an exhaust engine brake as an auxiliary brake for a vehicle. A typical exhaust engine brake system comprises a valve provided in the engine's exhaust manifold. When the exhaust brake is applied, the valve in the exhaust manifold closes and the engine fuel supply is interrupted. The closed valve causes a high back pressure to be generated in the exhaust manifold, which acts against each piston in the engine during its exhaust stroke, generating a negative torque (i.e. braking power) that slows the vehicle down. Exhaust brakes are most commonly used on large vehicles like trucks and buses.

[0004] The high back pressure generated in the exhaust manifold often causes an engine cylinder's exhaust valve to open slightly even when that valve's actuator (e.g. a lifter or rocker arm) engages the base circle of that valve's rotating exhaust cam (i.e. during the period in the cam's rotation when the exhaust valve would normally be closed). This additional valve opening renders HLAs incompatible for use in valve trains for engines which use exhaust braking. This is because a HLA would expand when the valve opened on the base circle but would not collapse again in time to allow the valve to close again before the next exhaust part of the engine cycle.

[0005] Known valve trains that are used in conjunction

with engine brake systems are very sensitive to mechanical lashes in the valve train and require regular maintenance by highly skilled mechanics. Indeed, it is not uncommon for such maintenance to have to be performed on a truck or bus engine every 80,000 Km which is a relatively small distance in comparison with the typical engine life span of about 1.6 million Km.

[0006] It is desirable to provide an improved Hydraulic lash adjuster, preferably one that can be used in a valve train used with an engine exhaust brake system.

Summary of the Invention

[0007] According to the invention, there is provided A hydraulic lash adjuster for adjusting for lash in a valve train assembly, the hydraulic lash adjuster comprising: a first body; a second body mounted for reciprocal sliding movement with respect to the first body; a first biasing means biased to move the second body so as to extend the hydraulic lash adjuster; a chamber between the first and second bodies for receiving hydraulic fluid via a hydraulic fluid input valve in response to the second body moving so as to extend the hydraulic lash adjuster; and characterised by: a pressure relief valve operable to release fluid from the chamber to enable the second body to be moved so as to retract the hydraulic lash adjuster.

[0008] According to the invention, there is also provided a method of operating such a hydraulic lash adjuster, the method comprising opening the pressure relief valve to release fluid from the chamber to enable the second body to be moved to retract the hydraulic lash adjuster.

[0009] According to the invention, there is also provided a valve train assembly comprising such a hydraulic lash adjuster and an actuator means for opening the pressure relief valve.

[0010] According to the invention, there is also provided a method of operating an engine exhaust brake system, the method comprising: closing a valve in an exhaust manifold to generate back pressure in the exhaust manifold; causing a hydraulic lash adjuster to extend in order to remove lash introduced into a valve train as a result of an exhaust valve opening in response to the back pressure in the exhaust manifold; and opening a pressure relief valve in the hydraulic lash adjuster to drain hydraulic fluid from the hydraulic lash adjuster to enable the hydraulic lash adjuster to retract to enable the exhaust valve to close.

Brief Description of the Drawings

[0011]

Figure 1 is a schematic illustration of a valve train assembly with some of the components shown in cross section;

Figure 2 is a cross sectional schematic illustration of a HLA;

Figure 3 is a cross sectional perspective illustration

of a HLA and cam shaft;

Figure 4 is schematic perspective view of a valve train assembly;

Figure 5 is a plot of valve lift against cam shaft rotation;

Figure 6 is a schematic illustration of a valve train assembly with some of the components shown in cross section;

Figure 7 is a schematic illustration showing part of the valve train assembly of Figure 6, in which a HLA and cam shaft are shown in cross section;

Figure 8 shows the HLA of the valve train assembly of Figure 7; and

Figure 9 illustrates a component used to activate a pressure relief valve in the HLA of Figure 8.

Detailed Description of Illustrated Embodiments of the Invention

[0012] Figure 1 illustrates a valve train assembly 1 embodying the present invention and comprising a rocker arm 3, a valve bridge 5 engaging a pair of exhaust valves 7 for an engine cylinder 9 of an engine (not shown), a push rod 11, a HLA 13 and a camshaft 15. The rocker arm 3 is mounted for pivotal movement on a rocker shaft 17. A first end 19 of the rocker arm 3 comprises a first spigot 21 connected to a centrally located socket 23 of the valve bridge 5, and a second end 25 of the rocker arm 3 comprises a second spigot 27 connected to an end socket 29 of the push rod 11. The push rod 11 comprises at its other end a third spigot 31 connected to the HLA 13.

[0013] The camshaft 15 comprises an exhaust cam 33 that has a base circle 35 and a lift portion (i.e. lobe) 37. During engine operation, as the cam shaft 15 rotates (as indicated by the arrow), the lift profile 37 starts to engage the HLA 13 as the engine enters the exhaust part of the engine cycle. The lift profile 37 pushes the HLA 13, and consequently the push rod 11, upwards which causes the rocker arm 3 to pivot anti-clockwise (as viewed in Figure 1) pushing the valve bridge 5 and pair of exhaust valves 7 downwards to open the pair of exhaust valves 7 (i.e. to perform a valve 'lift'). As the peak of the lift profile 37 passes out of engagement with the HLA 13, valve return springs (not shown) begin to close the pair of valves 7 (i.e. the pair of valves 7 and valve bridge 5 are moved upwards in the sense of the page, the rocker arm pivots clockwise and the push rod 11 and HLA are pushed downwards). When the base circle 35 again engages the HLA 13 the pair of valves 7 is fully closed and the exhaust valve lift event is complete. Those skilled in the art will recognise that the valve train assembly 1 is a so called 'Type 5' assembly.

[0014] The valve train assembly 1 is for use in combination with an exhaust brake system which comprises a valve 37 for opening and controlling an exhaust manifold 39.

[0015] Referring to Figure 2, the HLA 13 comprises a hollow outer body 40 comprising a flat base end 42 for

engaging the cam 33 and an open upper end 44 for receiving the spigot 31 of the push rod 11. The spigot 31 is retained within the open upper end 44 by means of a first retaining clip 46. The HLA 13 further comprises a first inner body 48, fixed within the outer body 40 at the base end 42 by means of a second retaining clip 50, and a second inner body 52, slidably mounted within the outer body 40 above the first inner body 48. A third inner body 53, resting on the second inner body 52, defines a socket for the spigot 31.

[0016] The first inner body 48 defines a stepped bore 54 comprising an upper section 54a and a lower narrower section 54b. The upper section 54a locates a spring 56 arranged to bias the second inner body 52 away from the first inner body 48. The bore 54 together with the space 58 defined in the outer body 40 between the first inner body 48 and the second inner body 52 form a chamber 60 for containing pressurised oil. The HLA 13 is further provided with a ball valve 64 which comprises a ball 66 captured by a cage 68 and biased by a spring 70 to a position closing an aperture 72 defined by the bottom of the second inner body 52. The aperture 72 connects the high pressure oil chamber 60 with a second oil pressure chamber 74 defined by the second inner body 52 which acts as a reservoir for oil received from the engine's oil supply (not shown) via an oil supply gallery in the engine block (not shown) and an oil supply hole 75 formed in the outer body 40.

[0017] In use, if a lash (i.e. a gap) develops between any of the components in the valve train assembly 1, the spring 56 expands the overall effective length of the HLA 13 by pushing the second inner body 52 away from the first inner body 48 so as to take up the slack in the valve train assembly 2. During the course of this motion, the ball valve 64 allows oil to flow from the second oil chamber 74 to the high pressure chamber 60 through the aperture 72 so that the high pressure chamber 60 is maintained full of pressurised oil. The oil is prevented from flowing back from the high pressure chamber 60 to the second chamber 74 by the ball valve 64.

[0018] This pressurised oil in the chamber 60 is incompressible so that the first inner body 48 and the second inner body 52 behave as a 'solid body' during a valve lift event (i.e. they move upwards as one as the valve opens and likewise move downwards as one as the valve closes).

[0019] The components and function of the HLA 13 described so far are conventional. In a conventional hydraulic lash adjuster, the oil in the high pressure chamber can only escape very slowly via closely spaced leak down surfaces (for example, such as might exist between the outer surface of the second inner body 52 and the inner surface of the outer body 40). In the example of Figures 1 to 4, however, the high pressure chamber 60 of the HLA 13 is provided with a pressure relief valve 80 and the valve train assembly 1 with a mechanism 82 (see Figures 2 and 3) for periodically opening the pressure relief valve 80 to allow oil to quickly drain from the cham-

ber 60 when required, so that the HLA 13 can collapse. In the preferred example, the valve train assembly 1 is for an engine that operates an exhaust engine brake system. When the engine brake is applied (i.e. the valve 37 is closed), the back pressure generated in the exhaust manifold 39 causes the exhaust valves 7 to open slightly, even though the HLA 13 is engaging the base circle 35 of cam 33. This slight opening of the exhaust valves 17 introduces a small lash into the valve train assembly 1 and, as is conventional, the HLA 13 extends to remove this lash. Advantageously, the mechanism 82 for opening the pressure relief valve 80 is arranged to open the valve 80 (so that the pressurised oil flows from the high pressure chamber 60) at a point in the cam's 33 rotation that enables the HLA to collapse (and hence the valves 7 to close when the pressures in the exhaust manifold and cylinder are balanced) in time for the next exhaust part of the engine cycle (i.e. the next main lift of the exhaust valves 7).

[0020] In this example, the pressure relief valve 80 comprises a poppet valve 83 comprising a tapered valve head 84, a valve stem 85 and a valve spring 86. The valve head 84 is located within the chamber 60 and when the valve 80 is closed it sits on a valve seat 88 defined by the first inner body 48 at the bottom of the chamber 60 closing an aperture 90. Below the aperture 90, the first inner body 48 defines a second stepped bore 92 comprising a first portion 92a immediately below the aperture 90 and a second wider portion 92b. The valve stem 85 extends longitudinally through the bore 92 and through a small aperture 94 formed through the bottom of the outer body 40. The valve spring 86 sits in the wider portion 92b of the bore 92 and is arranged to bias the valve 80 to its closed position.

[0021] The opening mechanism 82 comprises an actuation member 100 comprising a head portion 102 and a stem 104. The cam 33 comprises a groove 106 (see Figures 3 and 4) formed all of the way around a central circumference and the member 100 is located in bore formed at a position at the bottom of the groove 106. The stem 104 is fixed (e.g. a force fit) in the bore and the head portion 102 sits in the groove 106 with its base resting against the bottom of the groove 106. The end of valve stem 85 extends into the groove 106 and, when the valve is in the closed position, it is slightly above the groove 106 bottom. As the cam shaft 15 rotates, once per rotation, the head portion 102 of the actuation member 100 is brought into sliding contact with the end of valve stem 85 lifting the valve 80 upwards, against the bias of the valve spring 86 to open the valve, enabling oil to drain from the chamber 60 down the aperture 108 to exit the first inner body 48 through oil release conduits 108 and exit the HLA 13 through oil release conduit 110 formed through a side wall of the outer body 40. The peak (i.e. high point) of the opening of the valve 80 occurs when the peak of the head portion 102 is in contact with the valve stem 85. As the peak of the head portion 102 passes out of engagement with the valve stem 85, the valve

80 begins to close under the action of the valve spring 86 and becomes fully closed as the head portion 102 passes out of engagement with the valve stem 85.

[0022] The point in the engine cycle at which the valve 80 is opened is determined by the position on the circumference of the cam 33 where the actuation member 100 is located. Accordingly, the positioning of the actuation member 100 on the circumference of the cam 33 (and hence the timing of the closing of the valves 7 relative to piston position in the cylinder) can be selected for any given engine implementation so as to provide desired gas exchange characteristics (i.e. for the flow from the exhaust manifold into the cylinder) for that particular engine implementation.

[0023] Referring now to Figure 5, there is illustrated a plot of valve lift (ordinate) against cam shaft rotation when the engine is operating in exhaust brake mode. The line 200 indicates the lift of the exhaust valves 7 and the line 210 the lift of a corresponding pair of inlet valves (not shown in the drawings) for the cylinder, controlled by a further rocker arm, push rod, HLA arrangement (all not shown) in response to an inlet cam (not shown) mounted on the camshaft 15. The vertical lines 215 indicate the Top Dead Centre points of the cylinder piston's exhaust strokes, the vertical lines 217 indicate the Top Dead Centre points of the piston's compression strokes and the vertical lines 219 indicate the piston's Bottom Dead Centre points between these Top Dead Centre points. The first bump 221 in the line 200 indicates the main lift of the exhaust valves 7 during the exhaust part of an engine cycle, the bump 223 indicates the main lift of the inlet valves during the intake part of the subsequent engine cycle and the second bump 225 in the line 200 indicates the main lift of the exhaust valves 7 during the exhaust part of that subsequent engine cycle. The horizontal lines 227 indicate periods where the exhausts valves 7 are slightly open because of the back pressure generated by the closed exhaust brake valve 37. In this example, the actuation member 100 is located on the cam 33 in a position that causes it to open the pressure valve 80 very shortly before the main exhaust valve lift of an engine cycle is due to start (as indicated by the arrows 230). Accordingly, this allows the exhausts valves 7 to close before the exhaust valve lift begins.

[0024] Figures 6 to 9 illustrate an alternative arrangement in which a valve train assembly 101 comprises a rocker arm 103, mounted for pivotal movement on a rocker shaft 117. At one end 119 of the rocker arm 103 there is provided a pivot 102 on which is pivotally mounted a valve bridge 115 which engages a pair of exhaust valves 7 for an engine cylinder 9. At the other end 125 of the rocker arm 113 there is a cavity 114 in which is mounted a HLA 113. The HLA 113 comprises, at its lower end, a pair of opposing side walls 116 (only one is visible in the Figures) each defining a respective aperture for receiving a shaft 104 on which is rotatably mounted a roller 106 for engaging an exhaust cam 33 mounted on a cam shaft 15. In a conventional fashion, as the cam 33 rotates,

when the lift profile engages the roller 106, the rocker arm is caused to pivot about shaft 117 to open the valves 7.

[0025] The HLA 113 is similar to the HLA 13 described above and its integers which correspond to those of the HLA 13, including the pressure relief valve 80, have like reference numerals. For reasons of brevity these features will not be described in detail again. In this example oil is supplied to the chamber 74 from the engine's oil supply (not shown) via a conduit (not shown) through the rocker shaft 117 and a conduit 105 through the rocker arm 103.

[0026] In this example, the mechanism for activating the pressure relief valve 80 comprises a body 120, mounted upon the shaft 104, and a pair of mushroom shaped members 122 (only one is visible in the Figures) located on the cam shaft 15, in a line parallel with the rotational axis of the shaft 15, one either side of the cams' 33 base circle 35. As shown in Figure 9, the body 120 comprises a ring shaped section 124, a pair of opposing sides 126a and 126b extending downwardly from the ring section 124 and each having a lobed end 128, and a top section 130 extending across the diameter of the ring section 124. Each of the sides 126a and 126b defines a respective aperture 132 through which the shaft 104 extends so that the body is positioned with the top section 130 facing and in close proximity to the exposed end of the valve stem and the roller 106 is between the side walls 126a and 126b. Each member 122 comprises a stem portion 122a located in a bore formed in the cam shaft 15 and a head portion 122b that sits on the cam shaft 15. Once per cam shaft rotation, the head portions 122b slidably engage the lobed ends 128 lifting the body 120 upwards from a rest position so that the top section 130 pushes the valve 80 open. A spring 134 is provided which is biased to return the body 120 to its rest position.

[0027] The peak (i.e. high point) of the opening of the valve 80 occurs when the peaks of the head portion 122b are in contact with the lobed ends 128. As the peaks of the head portions 122b pass out of engagement with the lobed ends 128, the spring 134 pushes the body 120 back towards its rest position, allowing the valve 80 to close under the action of the valve spring 86.

[0028] In this example, as the HLA 13 is in the rocker arm 103 on the cam side of the rocker arm, there is no requirement to provide valve lash adjustment screws that normally otherwise would be located over the valve bridge, and so consequently, the valve bridge 115 can be formed of a stamped metal sheet, integrated with the rocker arm, which provides cost savings.

[0029] The above embodiments are to be understood as an illustrative example of the invention only. In particular, although the described embodiments of the invention are described for use in combination with an engine exhaust brake system, it will be appreciated that this is not essential and that other embodiments of the invention may not involve engine exhaust brake systems. Further embodiments of the invention are envisaged. It is to be

understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

Claims

1. A hydraulic lash adjuster for adjusting for lash in a valve train assembly, the hydraulic lash adjuster comprising:

a first body;
a second body mounted for reciprocal sliding movement with respect to the first body;
a first biasing means biased to move the second body so as to extend the hydraulic lash adjuster;
a chamber between the first and second bodies for receiving hydraulic fluid via a hydraulic fluid input valve in response to the second body moving so as to extend the hydraulic lash adjuster;
and **characterised by:**

a pressure relief valve operable to release fluid from the chamber to enable the second body to be moved so as to retract the hydraulic lash adjuster.

2. The hydraulic lash adjuster according to claim 1, wherein the pressure relief valve comprises a valve head, a valve stem and a second biasing means, wherein the valve is moveable, in response to a force exerted on the valve stem, from a closed position in which the valve head seals an aperture in the chamber and an open position in which the aperture is unsealed, wherein the second biasing means biases the valve towards the closed position.
3. The hydraulic lash adjuster according to claim 2 wherein an end of the valve stem extends outside of the second body.
4. A valve train assembly comprising the hydraulic lash adjuster according to any of claims 1 to 3 and an actuator means for opening the pressure relief valve.
5. A valve train assembly according to claim 4, the valve train assembly comprising a camshaft and a cam mounted on the camshaft, wherein, the actuator means is at least in part provided on the cam.
6. A valve train assembly according to claim 4 or 5, wherein the cam is for engaging a surface of the

hydraulic lash adjuster, and the actuator means comprises a member for periodically contacting the pressure relief valve, as said cam shaft rotates, to actuate the pressure relief valve.

7. A valve train assembly according to claim 6 wherein the cam comprises a groove formed along a base circle of the cam, and wherein the member is located within the groove.

8. A valve train assembly according to claim 5, wherein the member comprise a stem portion fixed in an aperture in the bottom of the groove and a head portion for contacting the pressure relief valve.

9. A valve train assembly according to claim 5, wherein the actuator means comprises an actuator body that is periodically lifted into engagement with the pressure relief valve, as said cam shaft rotates, to actuate the pressure relief valve.

10. A valve train assembly according to claim 9, further comprising a rocker arm, a cam mounted on a cam shaft, and a rocker arm roller mounted on an axle for engaging the cam and wherein the actuator body is supported in a first position by the axle, and wherein, as said cam shaft rotates, the actuator body is lifted out of the first position by at least one actuator member positioned on the cam shaft to actuate the pressure relief valve.

11. A valve train assembly according to claim 10 wherein, the hydraulic lash adjuster is carried by the rocker arm.

12. A valve train assembly according to any of claims 4 to 11 used in combination with an exhaust brake system, wherein the hydraulic lash adjuster is for adjusting lash in the valve train between an exhaust valve and an exhaust cam, mounted on a cam shaft, associated with the exhaust valve, wherein, when the exhaust brake system is activated the exhaust valve is opened by exhaust manifold back pressure and in response to the opening of the valve the hydraulic lash adjuster extends and wherein, the actuator means is arranged so as to open the pressure relief valve to enable the hydraulic lash adjuster to retract to allow the opened exhaust valve to close prior to the exhaust cam causing a lift of the exhaust valve.

13. A method of operating a hydraulic lash adjuster as claimed in any of claims 1 to 3, the method comprising opening the pressure relief valve to release fluid from the chamber to enable the second body to be moved to retract the hydraulic lash adjuster.

14. A method of operating an engine exhaust brake sys-

tem, the method comprising:

closing a valve in an exhaust manifold to generate back pressure in the exhaust manifold; causing a hydraulic lash adjuster to extend in order to remove lash introduced into a valve train as a result of an exhaust valve opening in response to the back pressure in the exhaust manifold; and opening a pressure relief valve in the hydraulic lash adjuster to drain hydraulic fluid from the hydraulic lash adjuster to enable the hydraulic lash adjuster to retract to enable the exhaust valve to close.

15. A method according to claim 14, wherein the time at which the pressure relief valve is opened is controlled by actuator means positioned at least in part on a cam or a cam shaft of the valve train.

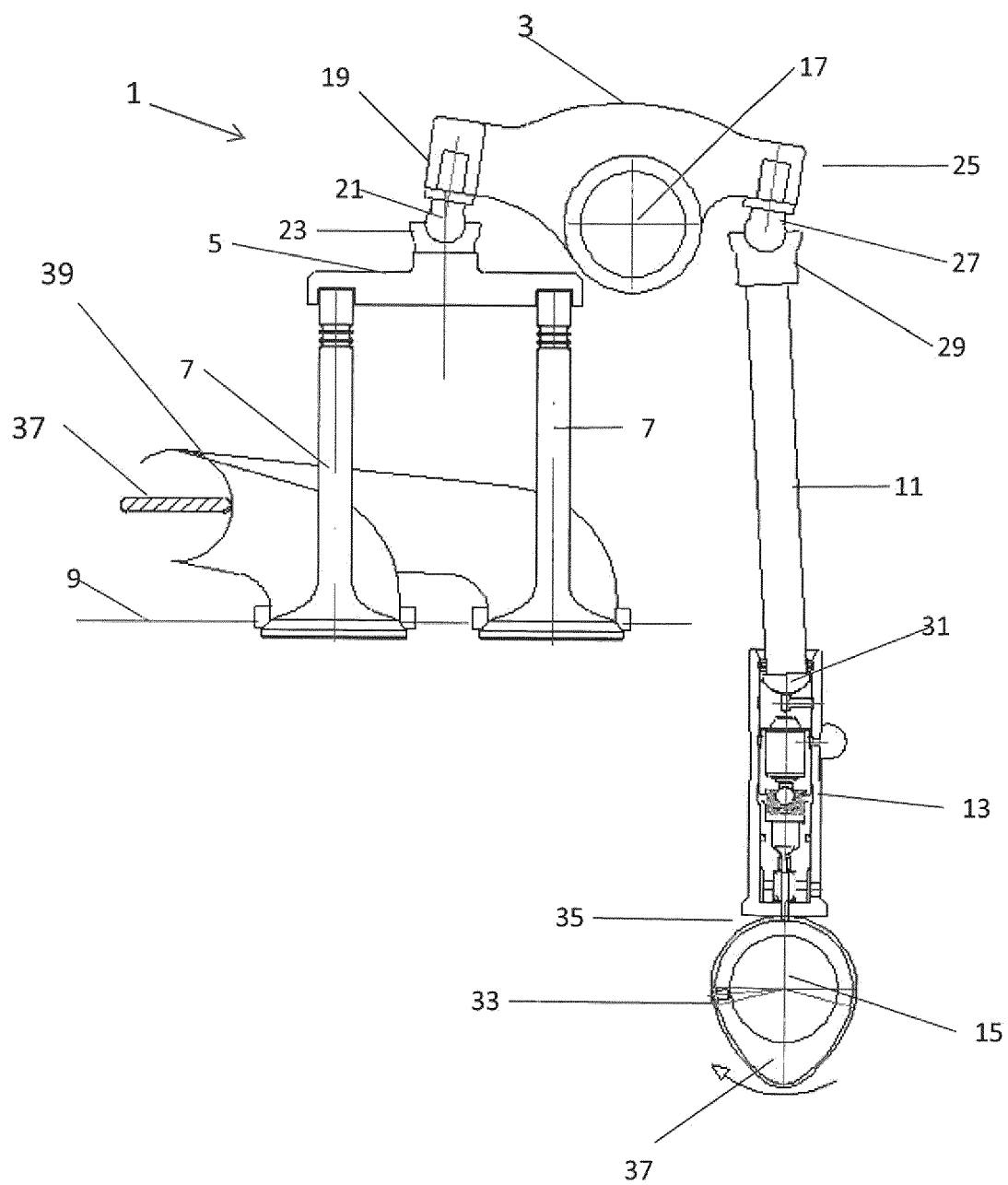


FIGURE 1

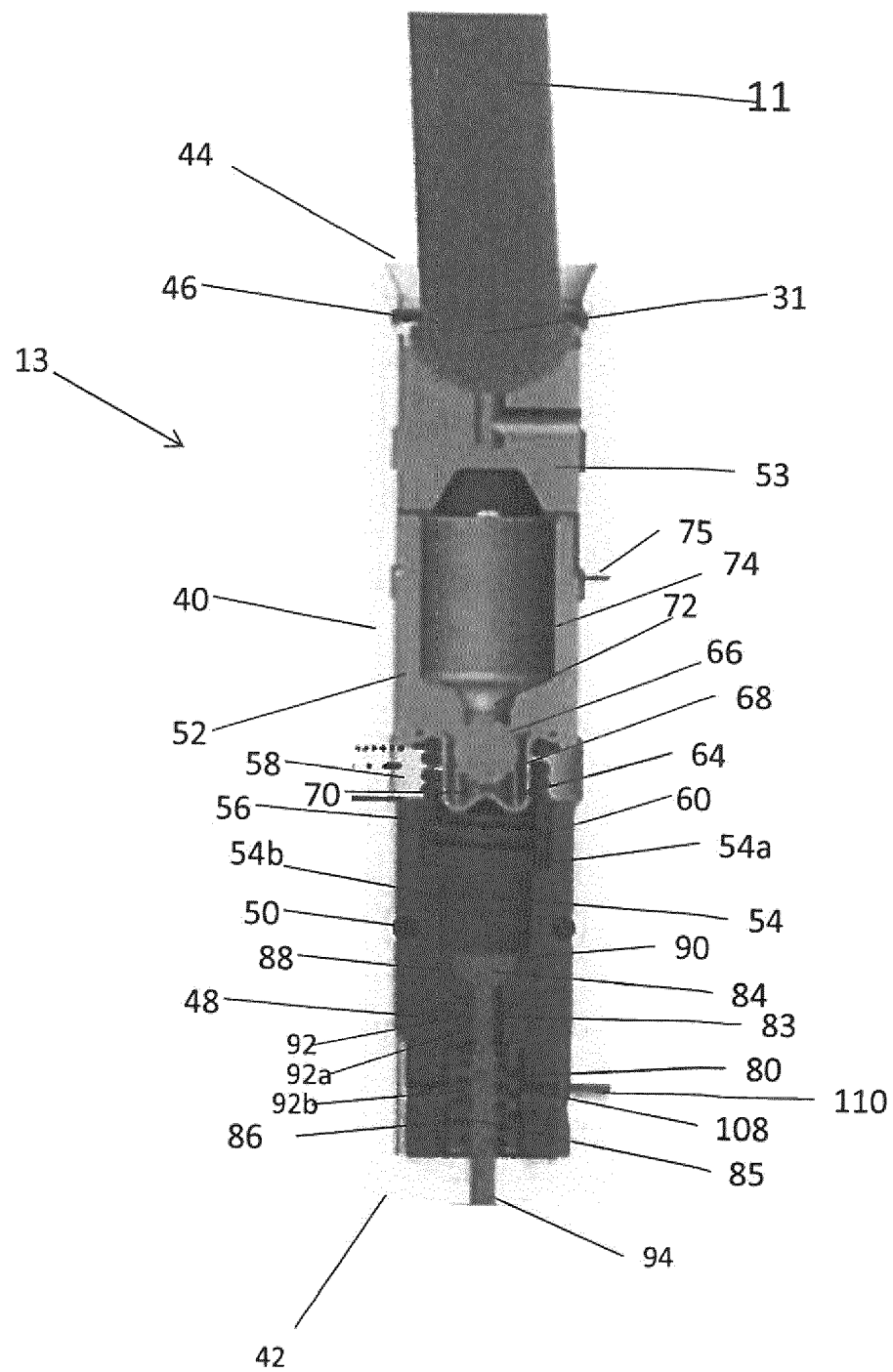


Figure 2

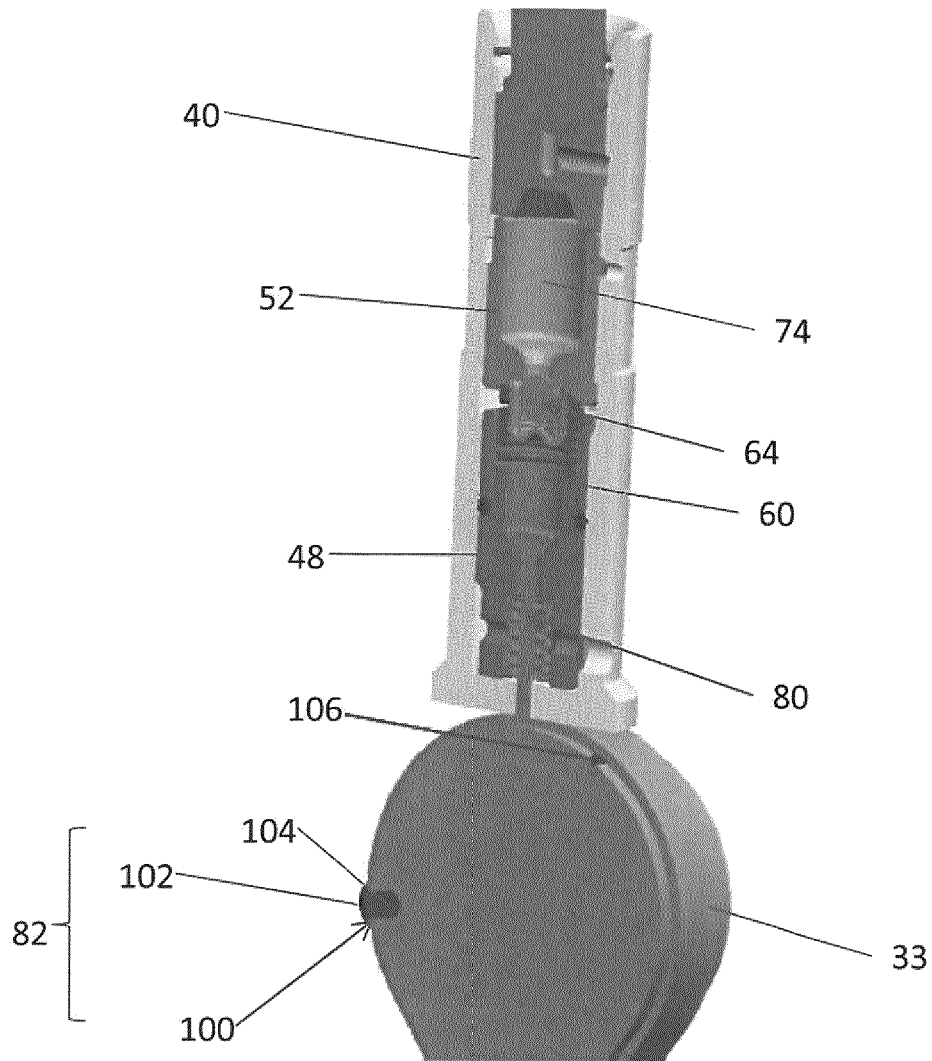


Figure 3

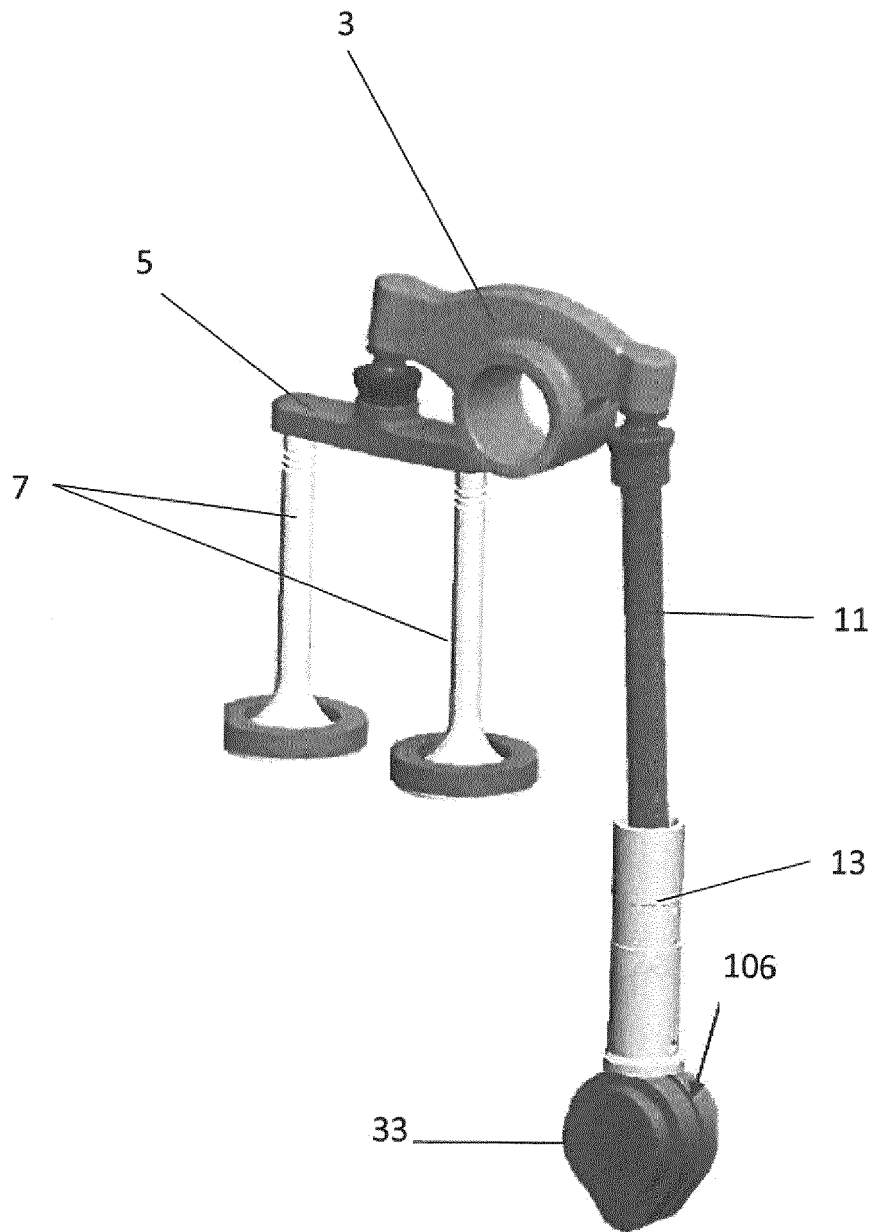


Figure 4

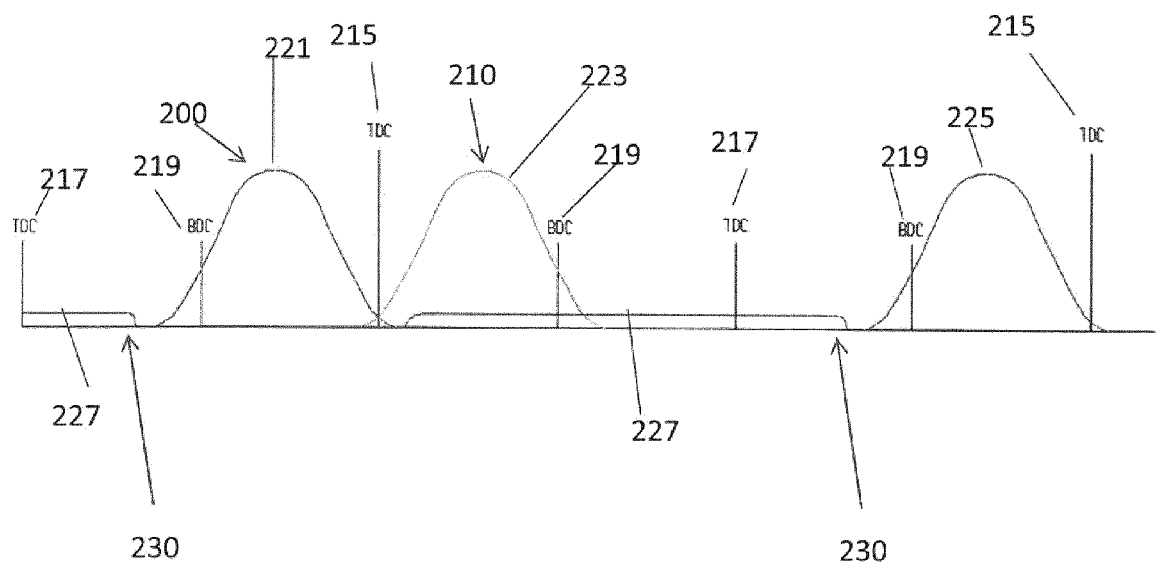


Figure 5

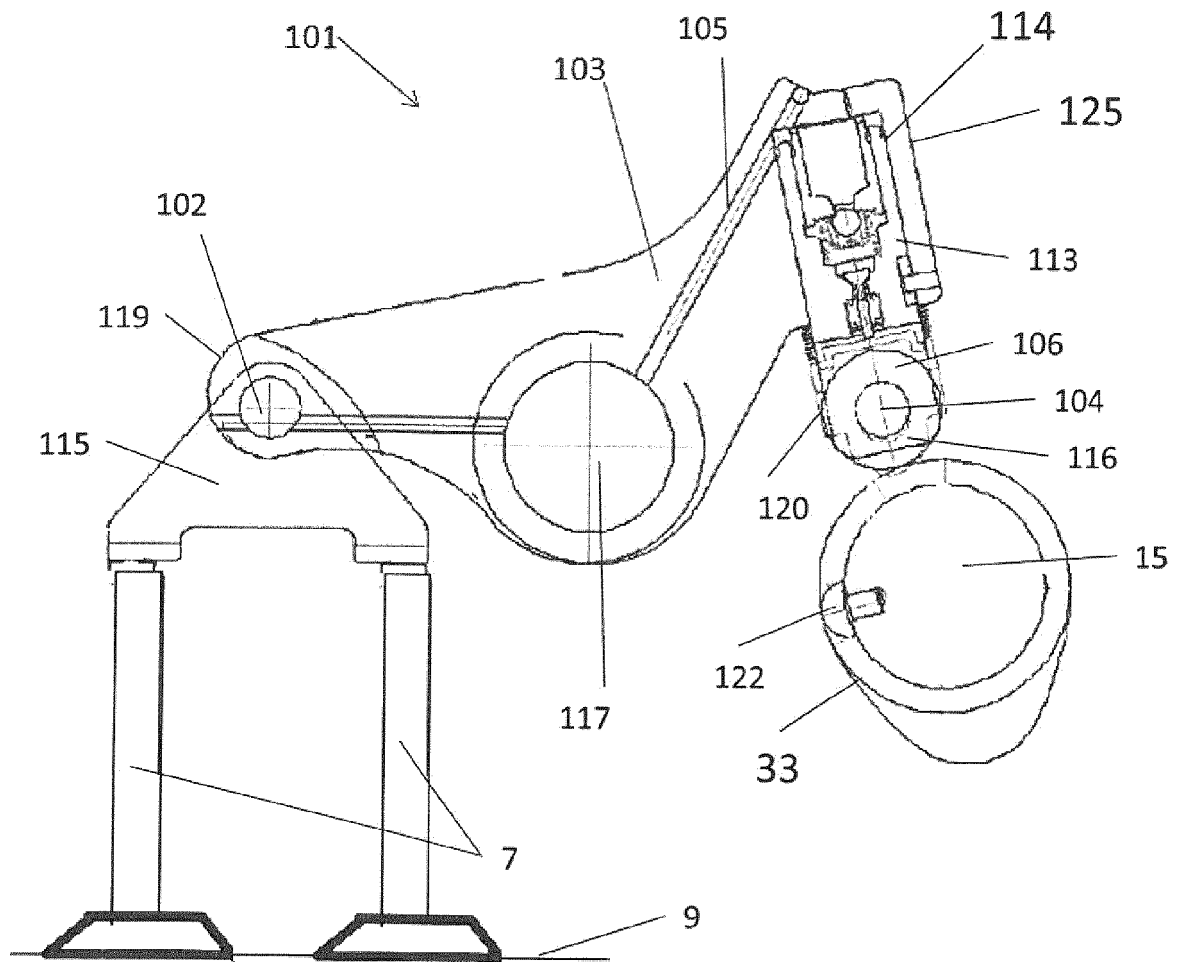


Figure 6

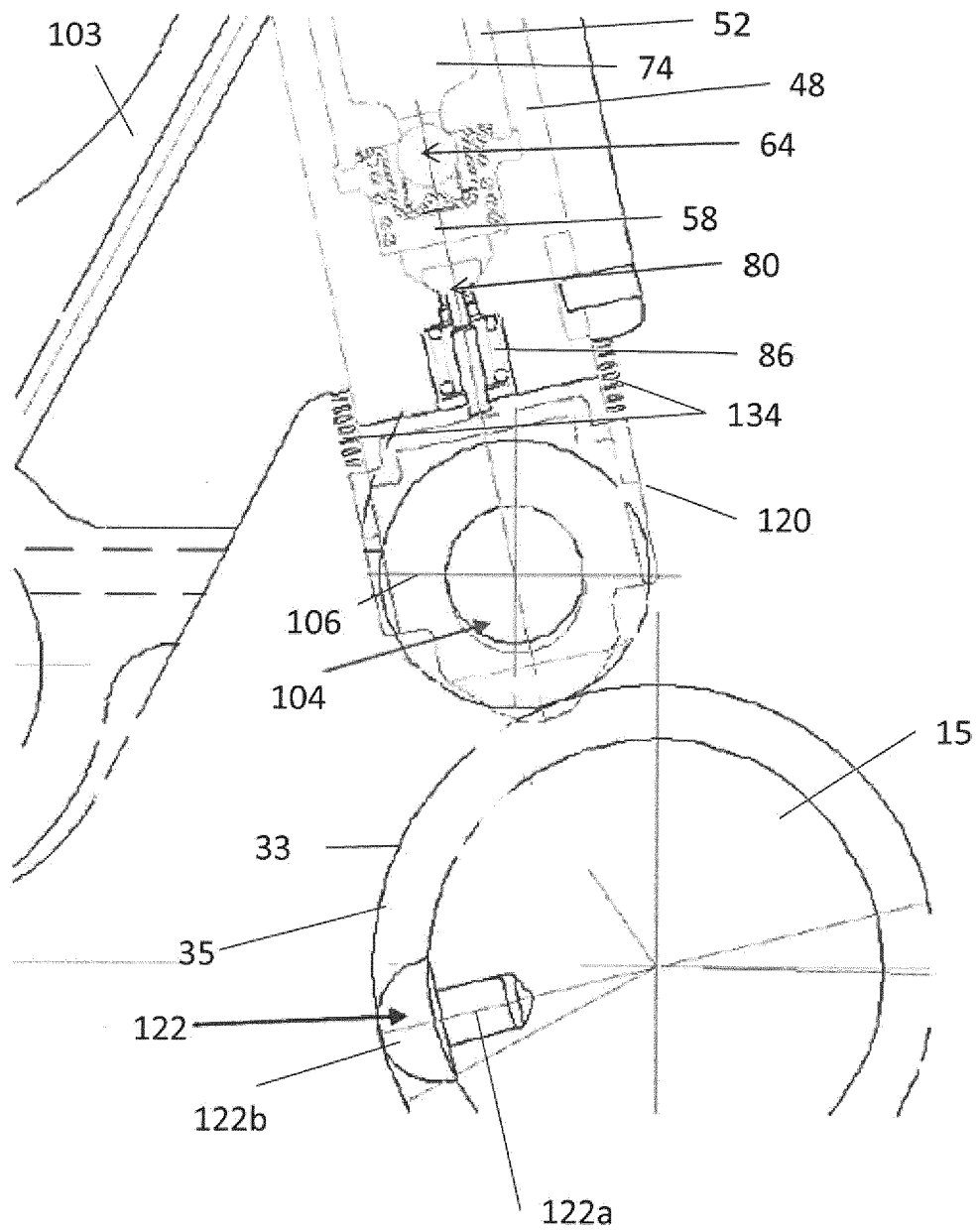


Figure 7

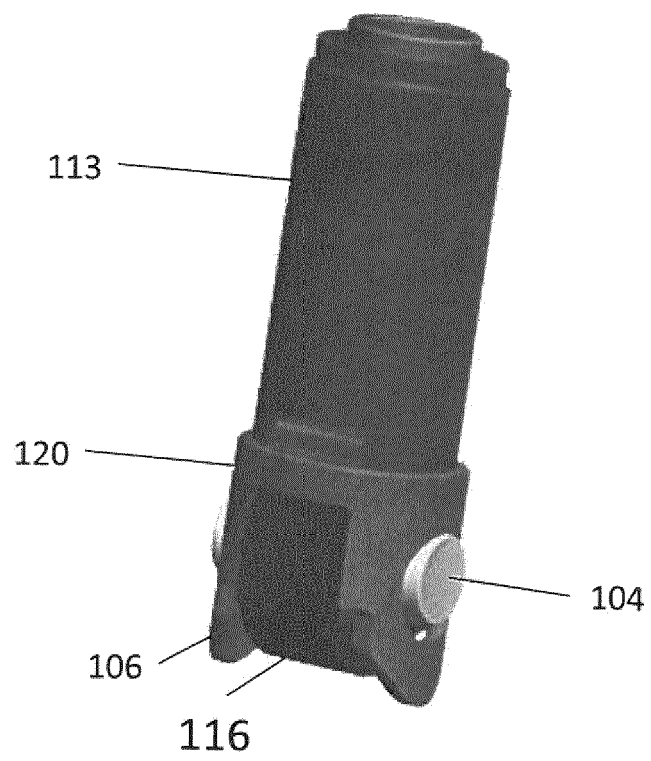


Figure 8

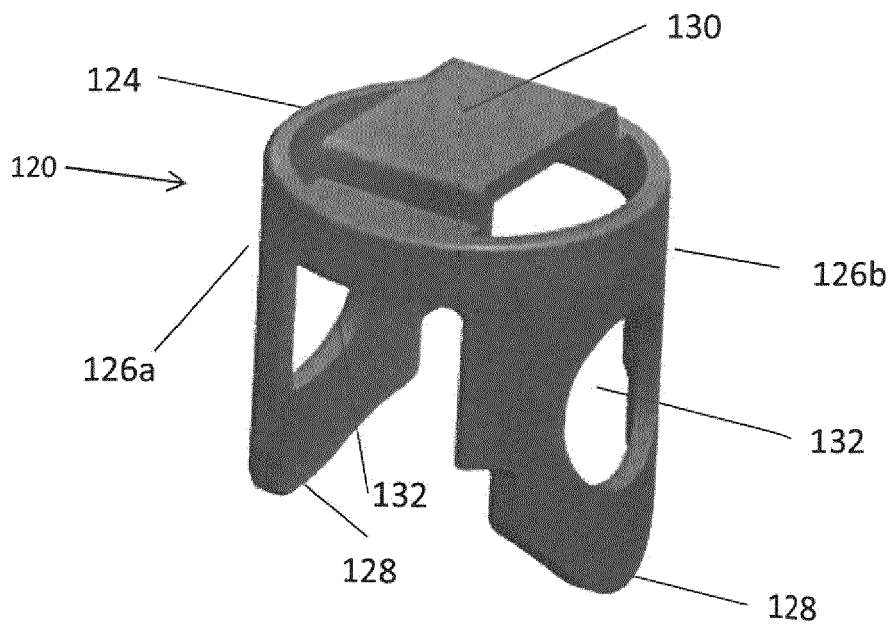


Figure 9



EUROPEAN SEARCH REPORT

Application Number
EP 12 16 4705

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	US 4 164 917 A (GLASSON RICHARD E) 21 August 1979 (1979-08-21)	1-4, 12-14	INV. F01L13/06
Y	* the whole document *	5-11,15	F01L1/24 F01L1/25 F01L1/08
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			TECHNICAL FIELDS SEARCHED (IPC)
			F01L
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 3 September 2012	Examiner Klinger, Thierry
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 16 4705

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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03-09-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4164917	A	21-08-1979	NONE	

DE 19745907	A1	22-04-1999	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82