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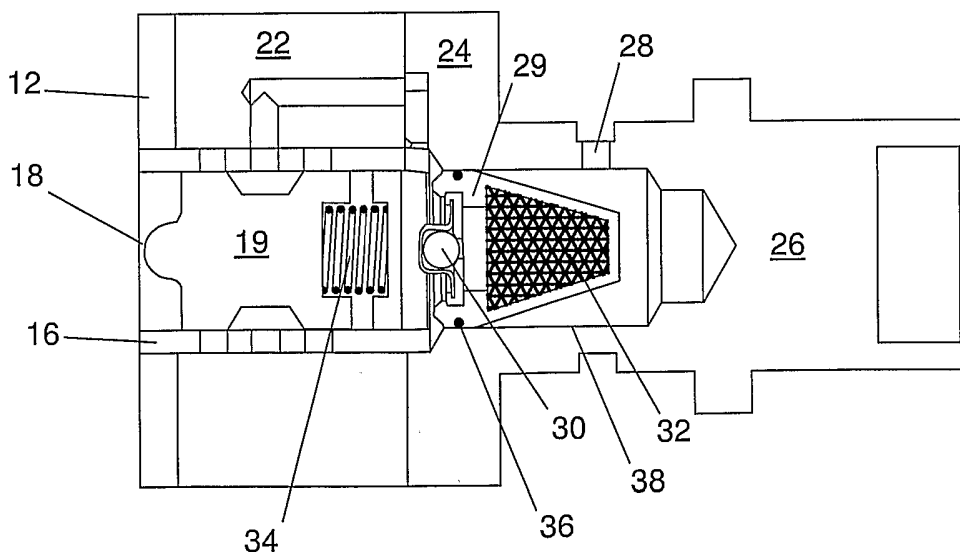
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(54) Title: INTEGRATED CHECK VALVE



(57) Abstract: The check valve includes an integral filter screen. The check valve is preferably an inlet check valve mounted in the camshaft or cam phaser for cam torque actuated variable cam timing. The inlet check valve may also be used for torsion assist or oil pressure actuation. The screen-mounting feature preferably holds the check valve and prevents unfiltered oil from going into the check valve or the phaser. The integrated check valve may also be mounted in the head of the oil feed line to the camshaft, in the end of the cam, in the rotor, or in any place that feeds oil to the cam phaser.

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INTEGRATED CHECK VALVE

REFERENCE TO RELATED APPLICATIONS

This application claims an invention which was disclosed in Provisional Application Number 60/683,607, filed May 23, 2005, entitled "INTEGRATED CHECK VALVE". The benefit under 35 USC §119(e) of the United States provisional application is hereby claimed, and the aforementioned application is hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The invention pertains to the field of variable cam timing devices. More particularly, the invention pertains to an inlet check valve with an integral filter screen.

DESCRIPTION OF RELATED ART

Various mechanisms have been employed with internal combustion engines to vary the angle between the camshaft and the crankshaft for improved engine performance or reduced emissions. The majority of these variable camshaft timing (VCT) mechanisms use one or more "vane phasers" on the engine camshaft (or camshafts, in a multiple-camshaft engine). In most cases, the phaser has a rotor with one or more vanes, mounted to the end of the camshaft, surrounded by a housing with the vane chambers into which the vanes fit. The vanes may also be mounted to the housing, and the chambers may be in the rotor. The outer circumference of the housing forms the sprocket-, pulley-, or gear-accepting drive force through a chain, a belt, or gears, usually from the camshaft, or from another camshaft in a multiple-cam engine.

Check valves are commonly used in variable cam timing to introduce fluid to the chambers but prevent fluid from exiting the chamber.

Fig. 1 through Fig. 3 show a prior art cam torque actuated (CTA) phaser. In a CTA phaser, torque reversals in the camshaft caused by the forces of opening and closing the valves move the vane 76. In a CTA system, the control valve, which usually includes a spool valve 74 with a spool 79, allows the vanes 76 in the phaser to move by permitting
5 fluid flow from the advance chamber 78 to the retard chamber 80 or vice versa, depending on the desired direction of movement. The spool valve 74 is internally mounted and includes a sleeve 87 for receiving a spool 79 with lands 79a, 79b. Positive cam torsionals are used to retard the phaser and negative cam torsionals are used to advance the phaser. During operation of the CTA phaser, an inlet check valve 89 maintains pressure for both
10 the advance 78 and retard chambers 80 simultaneously, and the spool valve 74 directs oil circulation to and from the chambers 78, 80. Typically, two fluid lines 82, 83 provide fluid communication between the spool valve 74 and the chambers 78, 80, and two check valves 84, 85 allow flow from a central fluid line 86 to the other fluid lines 82, 83, respectively, but prevent fluid flow in the opposite direction.

15 More specifically, in the null position, as shown in Fig. 1, the spool lands 79a, 79b block the fluid lines 82, 83, respectively, and the vane 76 is locked into position by fluid pressure. With both fluid lines 82, 83 blocked, fluid is prevented from flowing from the advance chamber 78 to the retard chamber 80 and vice versa. The inlet flow check valve 89 maintains system pressure by allowing additional fluid to the phaser from an external
20 source through a supply line 88 to make up for losses due to leakage. In some engines the cam torque energy dissipates at high speeds, and the CTA VCT is not able to move without cam torque energy, because by the nature of the CTA hydraulic circuit, equal source pressure is applied to both sides of the vane such that the vane does not move.

To move the phaser toward retard, as shown in Fig. 2, the spool 79 is moved to the
25 left, so that the spool lands 79a, 79b do not block the advance and central fluid lines 82, 86. Only the retard fluid line 83 is blocked. In this spool position, fluid exits the advance chamber 78 through the advance fluid line 82 then travels through the spool 79 between the lands 79a, 79b and into the central line 86. The fluid then feeds into the retard fluid line 83 through the open check valve 85, thereby supplying fluid to the retard chamber 80.
30 The spool 79 and a check valve 84 prevent return flow from the retard fluid line 83. This movement of fluid causes the vane 76 to move in a retard direction 90.

To move the phaser toward advance, as shown in Fig. 3, the spool 79 is moved to the right, so that the spool lands 79a, 79b do not block the retard and central fluid lines 83, 86. Only the advance fluid line 82 is blocked. In this spool position, fluid exits the retard chamber 80 through the retard fluid line 83 then travels through the spool 79 between the lands 79a, 79b and into the central line 86. The fluid then feeds into the advance fluid line 82 through the open check valve 84, thereby supplying fluid to the advance chamber 78. The spool 79 and a check valve 85 prevent return flow from the advance fluid line 82. This movement of fluid causes the vane 76 to move in an advance direction 92.

Engine oil degrades over time such that it is advantageous to filter the oil in order to reduce wear on the phaser components. This is usually done with a separate oil filter located upstream of the inlet check valve.

Check valves with filters are known in the art.

U.S. Patent No. 5,411,123, "CARTRIDGE BALL CHECK VALVE HAVING INTEGRAL FILTER FOR AN AUTOMATIC TRANSMISSION CLUTCH", discloses a check valve with an oil filter for use with a transmission clutch.

European Patent Publication 1 447 602 A1, "OIL FLOW CONTROL VALVE FOR A CAM PHASER", published August 18, 2004, discloses a flap-type check valve integrated in an inlet filter of an oil flow control valve.

There is a need in the art for a check valve with an integral oil filter for a variable cam timing system in order to eliminate the need for separate check valves and oil filters to reduce the number of parts and simplify the VCT system.

SUMMARY OF THE INVENTION

The check valve includes an integral filter screen. The check valve is preferably an inlet check valve mounted in the camshaft or cam phaser for cam torque actuated variable cam timing. The inlet check valve may also be used for torsion assist or oil pressure actuation. The screen-mounting feature preferably holds the check valve and prevents unfiltered oil from going into the check valve or the phaser. The integrated check valve

may also be mounted in the head of the oil feed line to the camshaft, in the end of the cam, in the rotor, or in any place that feeds oil to the cam phaser.

The variable cam timing phaser for an internal combustion engine includes a housing, a rotor, an oil supply line, and an inlet check valve. The housing has an outer circumference and accepts drive force. The rotor is connected to a camshaft coaxially located within the housing. The housing and the rotor define at least one vane separating a chamber into an advance chamber and a retard chamber. The rotor is capable of rotation within the housing to shift the relative angular position of the housing and the rotor. The oil supply line maintains fluid pressure in the rotor and supplies fluid to the rotor. The inlet check valve is mounted in the oil supply line and includes a check valve body, a ball check valve, and an oil filter screen. The ball check valve is attached to the check valve body and allows fluid flow in the oil supply line only into the phaser. The oil filter screen is integrated with the check valve body for filtering fluid entering the inlet check valve.

In one embodiment of the present invention, the inlet check valve is mounted in an end of the camshaft. In another embodiment, the inlet check valve is sealed against an interior surface of the camshaft in a mounting flange of the camshaft. In yet another embodiment, the check valve is sealed against an interior surface of a control valve sleeve extending into a mounting flange of the camshaft. The inlet check valve is preferably sealed by an o-ring or a raised seal located downstream of the oil filter screen. In another embodiment, the inlet check valve is mounted in the rotor.

The oil filter screen is preferably upstream of the ball check valve. In one embodiment, the oil filter screen is molded into the check valve body. In another embodiment, the oil filter screen is clipped onto the check valve body. The oil filter screen preferably has either a frustoconical shape or a cylindrical shape.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a prior art vane phaser in a null position.

Fig. 2 shows a prior art vane phaser moving toward a retard position.

Fig. 3 shows a prior art vane phaser moving toward an advance position.

5.

Fig. 4 shows an end view of a camshaft and phaser assembly perpendicular to the axis of rotation.

Fig. 5 shows a first embodiment of the present invention taken along line 5-5 of Fig. 4.

Fig. 6 shows the embodiment of Fig. 5 taken along line 6-6 of Fig. 4.

5 Fig. 7 shows an expanded view of the circle region 7 of Fig. 6.

Fig. 8 shows a second embodiment of the invention taken along line 6-6 of Fig. 4.

Fig. 9 shows an expanded view of the circle region 9 of Fig. 8.

Fig. 10 shows a third embodiment of the invention taken along line 6-6 of Fig. 4.

DETAILED DESCRIPTION OF THE INVENTION

10 A check valve including an integral filter screen is preferably an inlet check valve mounted in the camshaft or cam phaser for cam torque actuated (CTA) variable cam timing. The inlet check valve may also be used for torsion assist (TA) or oil pressure actuated (OPA) cam phasers. For example, the inlet check valve with an integral filter screen may be used in the torsionally assisted systems disclosed in U.S. Patent Nos.
15 6,883,481 or 6,763,791, herein incorporated by reference. The screen-mounting feature preferably holds the check valve and prevents unfiltered oil from going into the check valve or the phaser. The integrated check valve may also be mounted in the head of the oil feed line to the camshaft, in the end of the cam, in the rotor, or in any place that feeds oil to the cam phaser.

20 A check valve with an integral filter of the present invention is preferably an inlet check valve attached to the phaser or mounted to the end of the cam. The check valve is preferably a ball-type check valve. In one embodiment, the integral oil filter has a frustoconical shape, while in another embodiment, the oil filter has a cylindrical shape. The integral oil filter is preferably oriented upstream relative to the ball valve. In one
25 embodiment of the present invention, the check valve is sealed against an interior surface of the camshaft in the mounting flange of the camshaft. In another embodiment, the check valve is sealed against an interior surface of the control valve sleeve that extends into the

mounting flange of the camshaft. The check valve is preferably sealed by either a raised seal or an o-ring located behind the filter. The filter is preferably molded into or clipped onto the check valve housing.

Referring to Fig. 4, a front plate 12 covers the end of the rotor and vanes 14 extend outward from the rotor in a preferred phaser incorporating the present invention. A sleeve 16 surrounds the control valve 18 located on the axis of the phaser assembly 20.

Fig. 5 shows a vertical cross section of the camshaft and phaser assembly of Fig. 4 along line 5-5 with a check valve 29 of the present invention. The rotor 22 sits on the end of the cam phaser mounting flange 24 of the camshaft 26. Oil enters the camshaft 26 at a supply oil inlet 28 as part of the oil supply line. The oil supply line maintains fluid pressure in the rotor. For CTA, the oil supply line supplies fluid to make up for losses due to leakage. For TA and OPA, the oil supply line supplies oil to the phaser during operation. The oil enters a chamber in the camshaft 26, where it passes through an inlet check valve with a ball-type check 30 and an integral filter screen 32 into passageways in the rotor. The oil filter screen 32 has a frustoconical shape. The control valve 18 includes a spool 19 and is biased by a spring 34. A seal 36 against a cylindrical surface 38 of the camshaft 26 prevents any leakage of oil around the check valve.

Fig. 6 shows a horizontal cross section of the camshaft and phaser assembly of Fig. 4 along line 6-6 with a check valve of the present invention. In this cross section, the vanes 14 of the phaser are visible. A close-up view of the area inside circle 7 of Fig. 6, including integrated check valve 29, is shown in Fig. 7.

A second embodiment of the present invention is shown in Fig. 8 and Fig. 9. A front plate 112 covers the end of the rotor 122 and vanes 114 extend outward from the rotor. A sleeve 116 surrounds the control valve 118 located on the axis of the phaser assembly. The rotor 122 sits on the end of the cam phaser mounting flange 124 of the camshaft 126. The oil enters a chamber in the camshaft 126, where it passes through an inlet check valve 129 with a ball-type check 130 and an integral filter screen 132 into passageways in the rotor 122. A close-up view of the area inside circle 9 of Fig. 8, including integrated check valve 129, is shown in Fig. 9. The control valve 118 includes a

spool 119, which is biased by a spring 134. A seal 136 against a cylindrical surface 138 of the sleeve 116 prevents leakage of oil around the check valve 130.

Referring to Fig. 10, a third embodiment of the present invention is shown. The integrated check valve 229 includes a ball-type check 230 and a cylindrically shaped filter screen 232. A seal 236 against a cylindrical surface 238 of the camshaft 226 prevents leakage of oil around the check valve 229. Alternatively, as in the embodiment of Fig. 8, the seal 236 may be against a cylindrical surface of the sleeve 216. The control valve includes a spool 219 biased by a spring 234. The control valve controls fluid entry and movement in the rotor 222 of the phaser.

Accordingly, it is to be understood that the embodiments of the invention herein described are merely illustrative of the application of the principles of the invention. Reference herein to details of the illustrated embodiments is not intended to limit the scope of the claims, which themselves recite those features regarded as essential to the invention.

What is claimed is:

1. A variable cam timing phaser for an internal combustion engine comprising:

a housing with an outer circumference for accepting drive force;

a rotor for connection to a camshaft coaxially located within the housing, the housing and the rotor defining at least one vane separating a chamber into an advance chamber and a retard chamber, the rotor being capable of rotation within the housing to shift the relative angular position of the housing and the rotor;

an oil supply line for maintaining fluid pressure in the rotor and for supplying fluid to the rotor; and

an inlet check valve mounted in the oil supply line and comprising:

a check valve body;

a ball check valve attached to the check valve body for allowing fluid flow in the oil supply line only into the phaser; and

an oil filter screen integrated with the check valve body for filtering fluid entering the inlet check valve.

2. The variable cam timing phaser of claim 1, wherein the inlet check valve is mounted in an end of the camshaft.

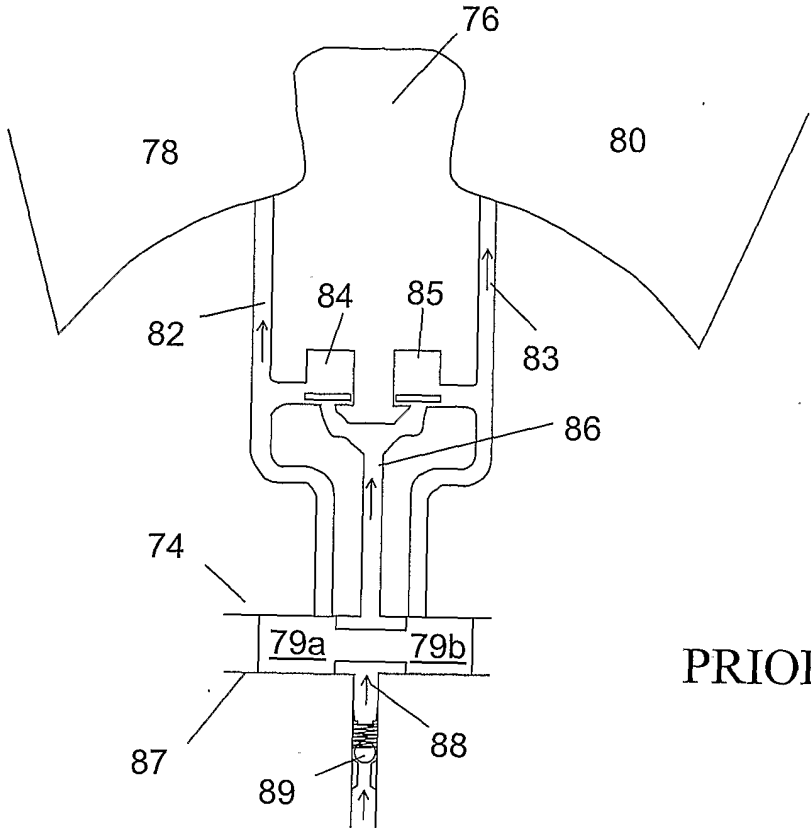
3. The variable cam timing phaser of claim 1, wherein the inlet check valve is sealed against an interior surface of the camshaft in a mounting flange of the camshaft.

4. The variable cam timing phaser of claim 3, wherein the inlet check valve is sealed by an o-ring located downstream of the oil filter screen.

5. The variable cam timing phaser of claim 3, wherein the inlet check valve is sealed by a raised seal located downstream of the oil filter screen.

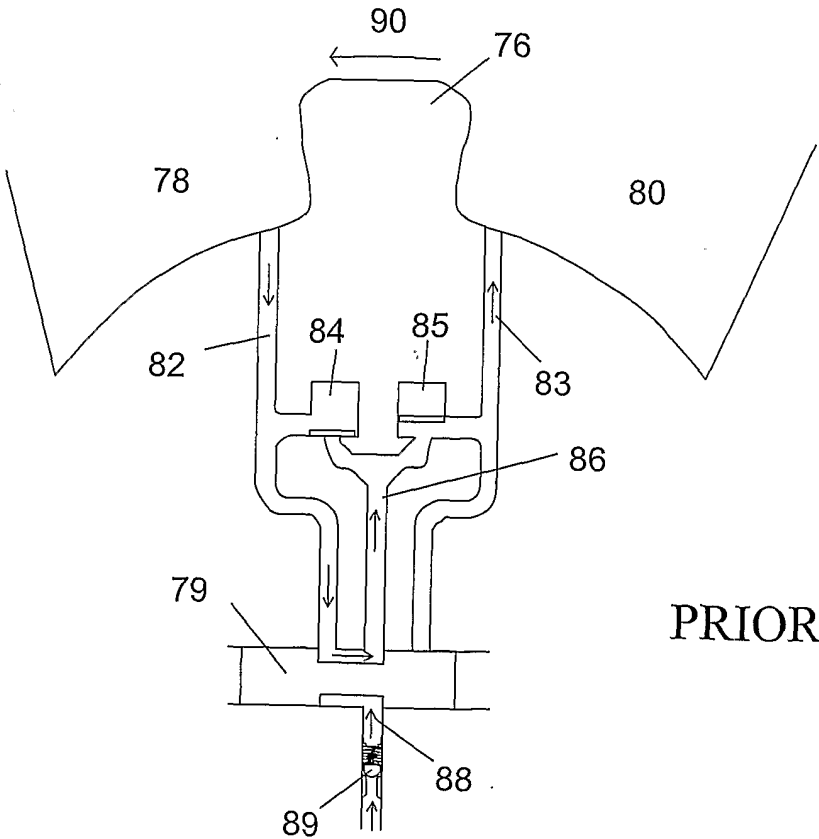
- 1 6. The variable cam timing phaser of claim 1, wherein the inlet check valve is sealed
2 against an interior surface of a control valve sleeve extending into a mounting
3 flange of the camshaft.
- 1 7. The variable cam timing phaser of claim 6, wherein the inlet check valve is sealed by an
2 o-ring located downstream of the oil filter screen.
- 1 8. The variable cam timing phaser of claim 6, wherein the inlet check valve is sealed by a
2 raised seal located downstream of the oil filter screen.
- 1 9. The variable cam timing phaser of claim 1, wherein the oil filter screen is upstream of
2 the ball check valve.
- 1 10. The variable cam timing phaser of claim 1, wherein the oil filter screen is molded into
2 the check valve body.
- 1 11. The variable cam timing phaser of claim 1, wherein the oil filter screen is clipped onto
2 the check valve body.
- 1 12. The variable cam timing phaser of claim 1, wherein the inlet check valve is mounted in
2 the rotor.
- 1 13. The variable cam timing phaser of claim 1, wherein the oil filter screen has a
2 frustoconical shape.
- 1 14. The variable cam timing phaser of claim 1, wherein the oil filter screen has a
2 cylindrical shape.
- 1 15. The variable cam timing phaser of claim 1, wherein the phaser is cam torque-actuated.
- 1 16. The variable cam timing phaser of claim 1, wherein the phaser is torsion-assisted.
- 1 17. The variable cam timing phaser of claim 1, wherein the phaser is oil pressure-actuated.

Fig. 1



PRIOR ART

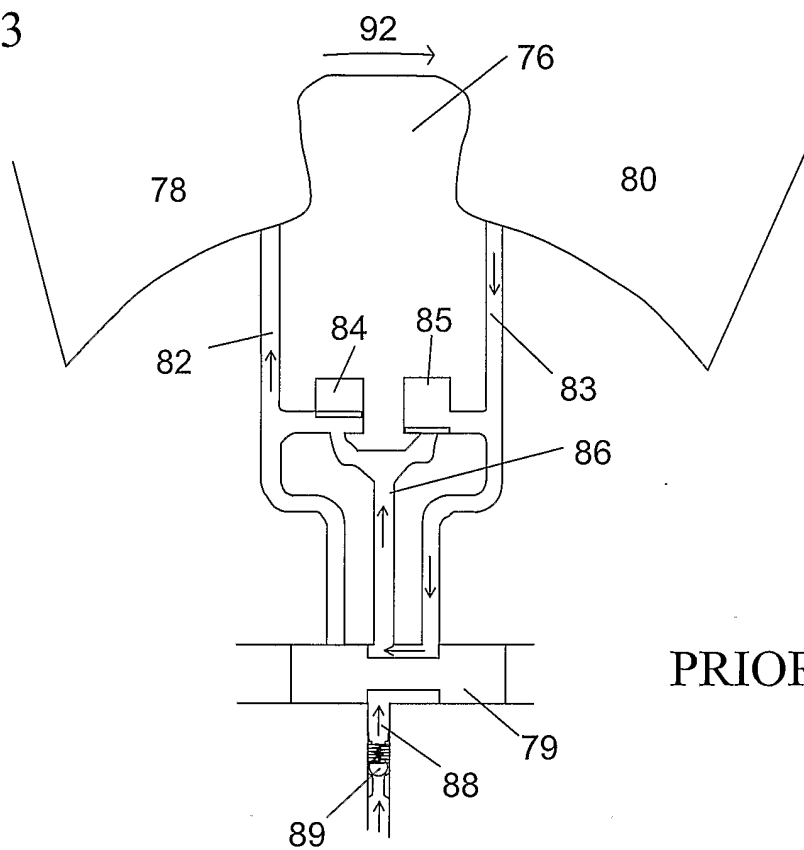
Fig. 2



PRIOR ART

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Fig. 3



PRIOR ART

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Fig. 4

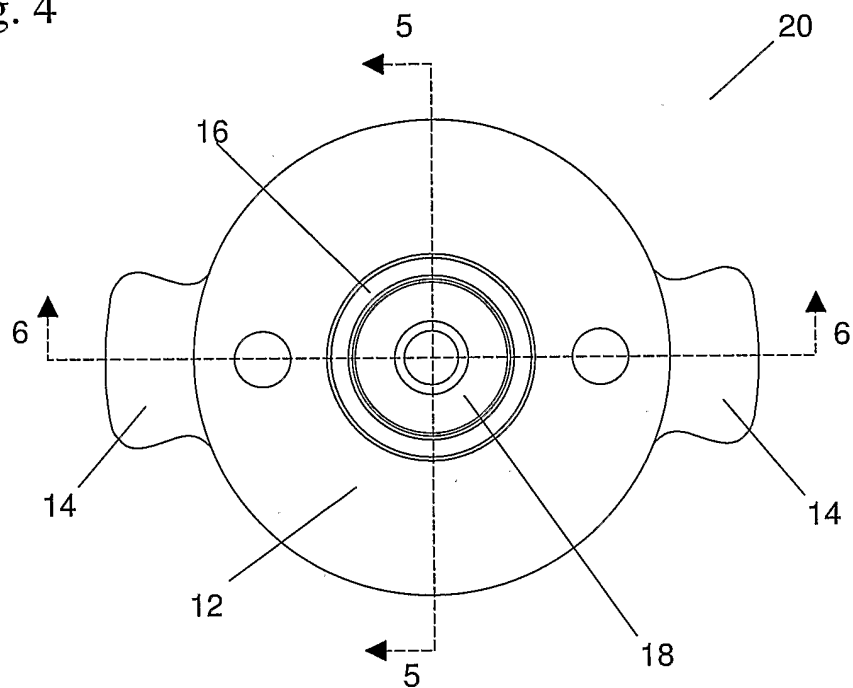
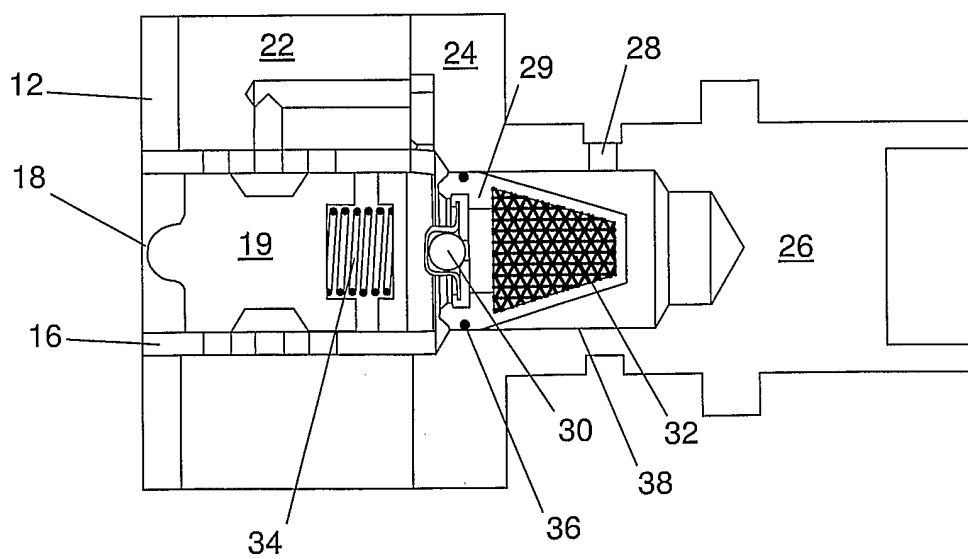


Fig. 5



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Fig. 6

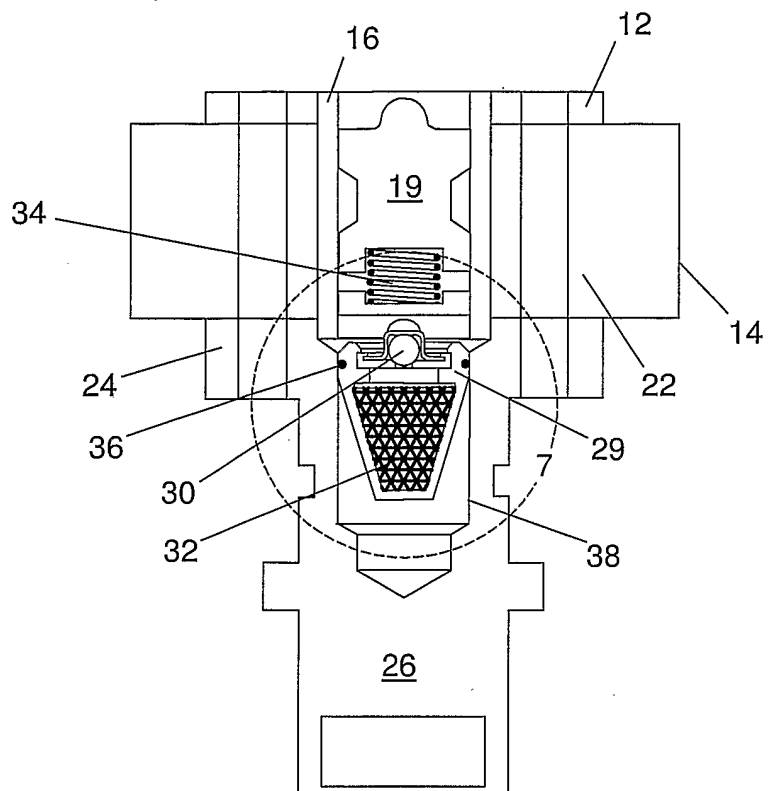
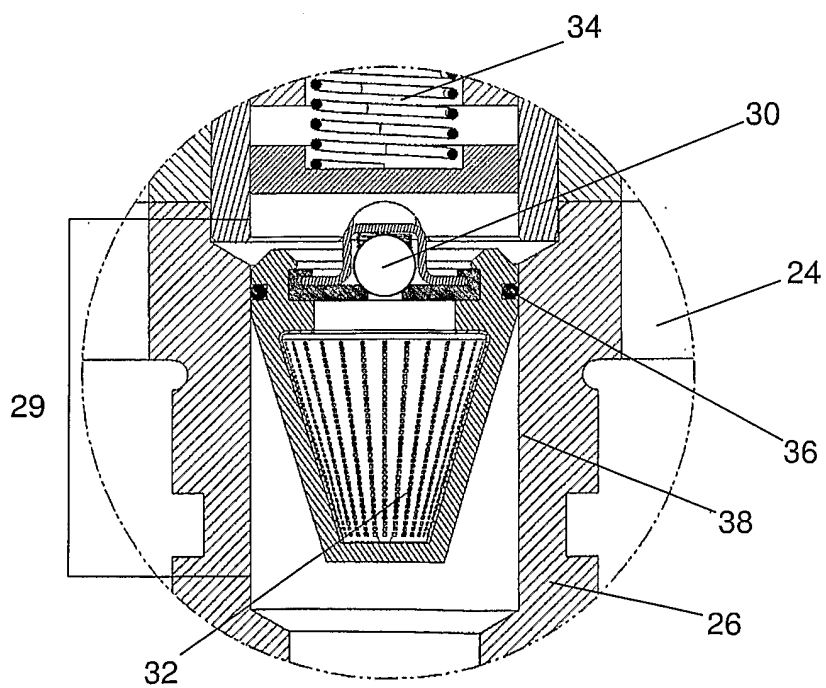


Fig. 7



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Fig. 8

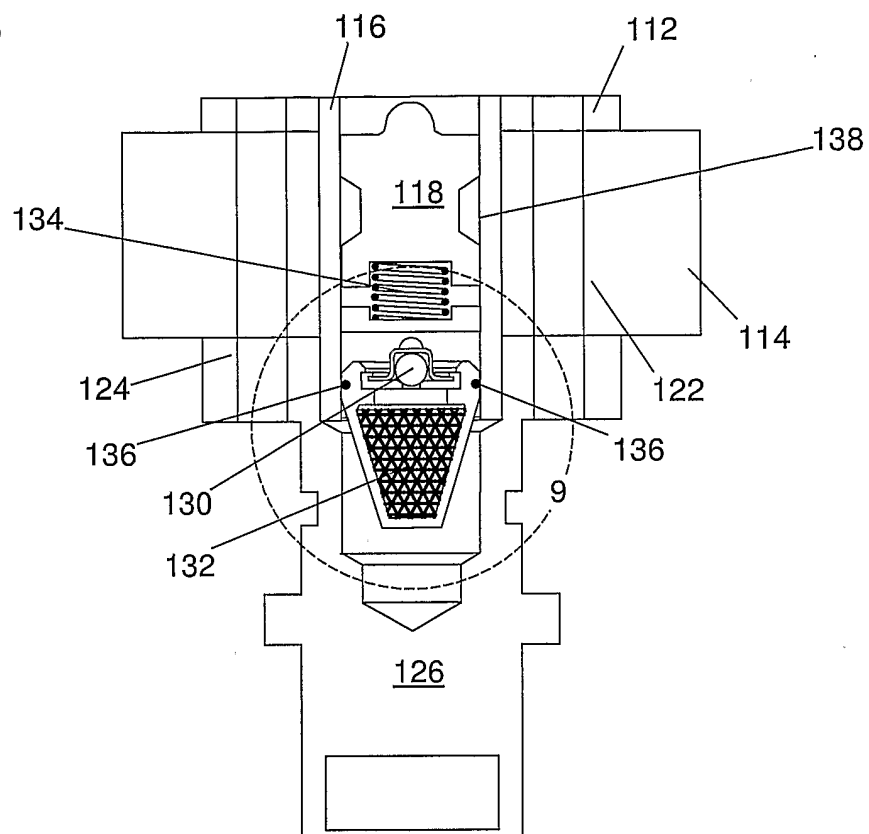
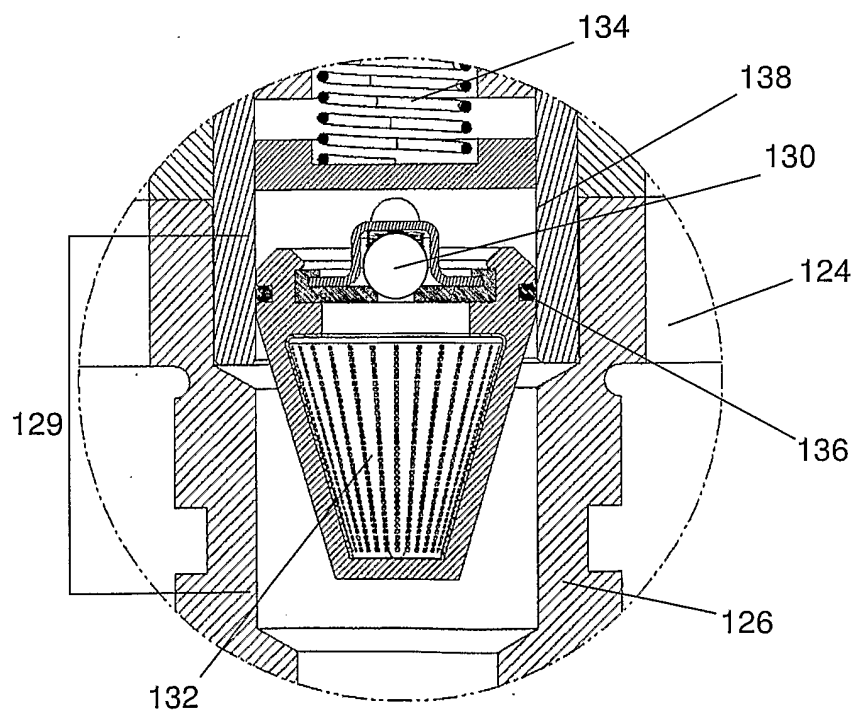
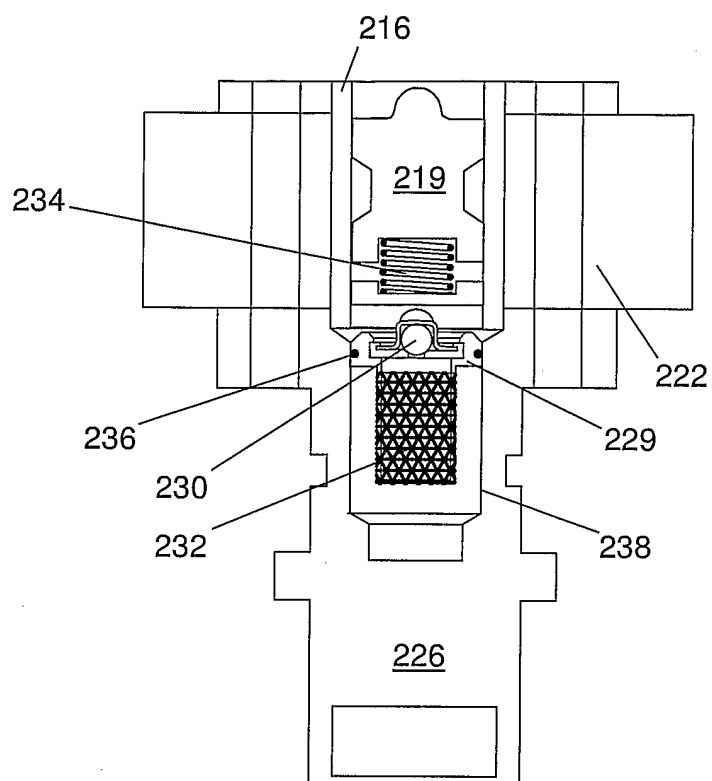


Fig. 9



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Fig. 10



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2006/019051

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01L1/344

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01L B01D F16K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 477 636 A (HYDRAULIK RING GMBH [DE]) 17 November 2004 (2004-11-17) paragraphs [0017] - [0019]; claims 11-14; figures 1,5	1-3,6, 9-12, 14-17
Y	US 2005/056249 A1 (HEINZE MATTHIAS [DE] ET AL) 17 March 2005 (2005-03-17) paragraphs [0031], [0034], [0035]; figures 2,4	1-3,6, 9-12, 14-17
Y	US 5 411 123 A (REJ DAWN A [US] ET AL) 2 May 1995 (1995-05-02) column 1, lines 19-40; figures 1,3,4 -/--	9-11

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2006/019051

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 447 602 A (DELPHI TECH INC [US]) 18 August 2004 (2004-08-18) the whole document -----	1,14
A	US 6 883 481 B2 (GARDNER MARTY [US] ET AL) 26 April 2005 (2005-04-26) column 5, lines 24-41; figures 5-8 -----	1,12
A	US 2004/226526 A1 (PALESCH EDWIN [DE] ET AL) 18 November 2004 (2004-11-18) claim 49; figure 1 -----	1
A	DE 100 29 261 A1 (DEUTZ AG [DE]) 20 December 2001 (2001-12-20) column 3, lines 40-51; claim 5; figure 1 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2006/019051

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