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[Continued on next page]

(54) Title: HYDRAULIC LASH ADJUSTER ARRANGED IN A SERVO INJECTOR

(57) Abstract: A hydraulic lash adjuster (20) adapted to be interposed in a hydraulic volume (V), between an actuator (18) and a control valve assembly (22) of a servo injector (10), said volume (V) being, in use, filled with fuel. The adjuster (20) comprises a lower piston (52) in which is slidably arranged an upper piston (46), an external spring (72) and an internal spring (64), both springs (72, 64) biasing the upper piston (46) toward the actuator (18). The lower piston (52) has a cylindrical cup-like shape with a peripheral wall (54) and a bottom wall (58) on which is arranged the internal spring (64) compressed between said bottom wall (58) of the lower piston (52) and the under- face of the upper piston (46).

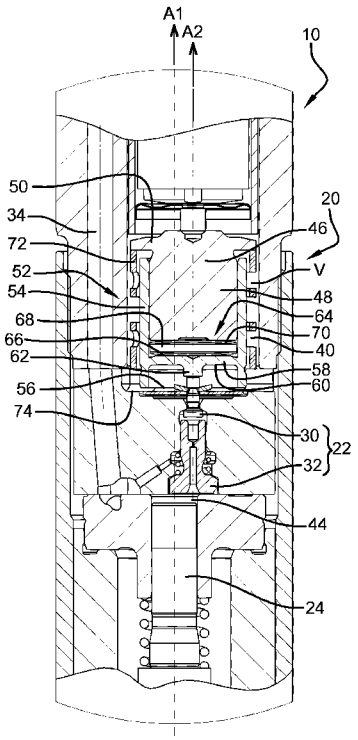

Fig. 2

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DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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Hydraulic lash adjuster arranged in a servo injector

TECHNICAL FIELD

The present invention relates to a hydraulic lash adjuster that is arranged in a servo injector.

BACKGROUND OF THE INVENTION

Servo injectors provided with piezo or magneto restrictive actuator are provided with hydraulic lash adjuster arranged between the actuator and the control valve of the injector, this in order to transmit force of displacement from the actuator to the valve. Therefore, the valve commutes between an open position, enabling fuel at high pressure to exit a control chamber and, a closed position forbidding said exit of fuel.

DE102009000203 and DE102010029106 disclose hydraulic lash adjuster, also identified as a hydraulic coupler, of similar embodiments. The adjusters comprise an actuator-side member, connected to the actuator, and a valve-side member connected to the valve. The actuator-side member is solicited toward the actuator by a very stiff cage spring while the valve-side member is solicited by a lesser stiff coil spring toward a closed position of the control valve. Between the actuator-side member and the valve-side member is provided a chamber which in use is filled with fuel, so that the displacement of the actuator is transmitted to the valve-side member.

A recurring problem is the important overall length of the lash adjuster which consequently has a mass detrimental to fast valve movements.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to resolve or at least mitigate the above mentioned problems in providing a hydraulic lash adjuster adapted to be arranged in a servo injector, interposed in a hydraulic volume, that in use is filled with fuel, between the actuator and a control valve assembly. In a servo injector the actuator is typically a piezo injector or a magneto restrictive actuator. The adjuster comprises a lower piston, an upper piston, an external spring and an internal spring. Specifically, the lower piston has a cylindrical cup-

like shape with a peripheral wall defining an internal bore in which is slidably arranged the upper piston and, a bottom wall on which is arranged the internal spring compressed between said bottom wall of the lower piston and the under-face of the upper piston. Both springs bias the upper piston toward the actuator.

This advantageous arrangement enables to limit the total height of the adjuster.

Also, the internal spring comprises a disc having a curved shape, or a conical shape so that it provides elasticity.

In an alternative, the internal spring may comprise a stack of a plurality of discs complementary arranged in order to obtain the required stiffness.

More particularly, each disc is substantially circular and is provided with curvature on one plane.

The hydraulic lash adjuster further comprises an adjusting shim arranged between said bottom of the lower piston and the under-face of the upper piston so that the internal spring load is adjusted and the hydraulic volume occupied by fuel is minimized.

More particularly, the upper piston comprises a main cylindrical body and a head cap radially protruding beyond the edge of the body. The external spring is compressed under head cap radial protrusion and it axially biases the upper piston toward the actuator.

In an alternative embodiment, the head cap of the upper piston is an independent component positioned and placed onto the main cylindrical body.

Also, the main cylindrical body may be made hollow in order to reduce mass of the moving parts.

More particularly, the external spring is a cage spring.

The invention further extends to a servo fuel injector comprising a lash adjuster as described above.

The actuator can be a piezo-actuator or alternatively a magneto restrictive actuator.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Figure 1 is a servo fuel injector provided with a hydraulic lash adjuster as per the invention.

Figure 2 is a magnified view of the lash adjuster of figure 1.

Figure 3 is an alternative embodiment of a lash adjuster.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

To ease and clarify the following description the top-down orientation of the figures is arbitrarily chosen and, words and expressions such as "above, under, over, below..." may be utilized without any intention to limit the invention. Also, similar features fulfilling similar functions in different embodiments may be identified with same reference numbers.

Figure 1 represents a servo fuel injector 10 which extends generally along a main axis A1 from an injector head 12, drawn at the top of the figure, to an injector nozzle 14, drawn at the bottom of the figure. The injector 10 mainly comprises an injector body 16 constituted of the assembly of several components fixed to each other and, in said body 16 are arranged, from head 12 to nozzle 14, an actuator 18, that is either a piezo or a magneto restrictive actuator, an hydraulic lash adjuster 20, a control valve assembly 22 and a needle valve 24. Also, electrical links 26 are provided to energize the actuator 18, said links extending from the actuator 18 to a connector 28 arranged in the injector head 12 of the injector 10.

The actuator 18 and the control valve assembly 22 extend along a second axis A2 parallel and offset for the main axis A1 that is also the axis of the needle valve 24.

Said offset was first introduced in EP1693563 and, although it has multiple advantages, the present invention can be implemented in an injector not having said offset.

As previously described in application number GB1314826, the valve assembly 22 comprises an upper valve 30 normally closed and a lower valve 32 normally open. Each of the two valves is a two-way valve, or "on-off" valve, the arrangement of said two two-way valves operating similarly to a three-way valve.

The persons skilled in the art are invited to learn from GB1314826 about the detailed operation of the control valve assembly 22.

The injector body 16 further accommodates a high pressure circuit 34, extending from an inlet 36 arranged in the injector head 12 to a plurality of spray holes 38 arranged a the tip of the nozzle 14 and, a low pressure return circuit 40 extending from the control valve 22 to an outlet 42 also arranged in the head 12 of the injector. The high pressure circuit 34 and the low pressure circuit 40 interconnect in the area of the control valve 22.

For illustration purposes and without any intent to limit the present invention, nor to detail the operation of fuel injection equipment's, the "high pressure" is typically superior to 2000 bars, or 2500 bars or even 3000 bars.

A preliminary general description of the operation is now given. In use, when the actuator 18 is not energized it retracts and does not bias the lash adjuster 20, which in turn enables the upper valve 30 to rest in its normal closed position CPV. Then, fuel at high pressure fills a control chamber 44 situated right above the needle valve 24, the pressure in the chamber 44 biasing said needle valve 24 in a closed position CPN and forbidding spray of fuel.

When the actuator 18 is energized, it elongates and biases the lash adjuster 20, which in turn biases the upper valve 30 into an open position OPV. The fuel is now enabled to exit the control chamber 44 toward the low pressure return circuit 40, the pressure in the chamber 44 decreasing allowing the needle 24 to move upward to an open position OPN and, high pressure fuel is sprayed through the spray holes 38.

An advantage of a servo actuator, such as a piezo actuator, over an electromagnetic actuator, is that for same dimensions, when energized the servo actuator generates a much superior force than the electromagnetic actuator, said superior force enabling to displace components that would require, otherwise a much large actuator.

As can be seen on the figures, the lash adjuster 20 is in arranged in a volume V that, in use, is filled with fuel.

The lash adjuster 20 is now described in reference to figure 2. The lash adjuster 20 axially extends along the second axis A2 and it comprises an upper piston 46 having a cylindrical body 48 covered by a head cap 50 radially

extending beyond the peripheral edges of cylindrical body 48. The upper piston 46 is axially slidably arranged in cup-like lower piston 52.

Said lower piston 52 has a peripheral cylindrical wall 54 defining an internal bore, and a bottom wall 58 forming the cup-like shape and, below the bottom wall 58, the peripheral wall 52 downwardly extends toward a lower rest face 56. At the centre of the under face 60 of the bottom wall 58 downwardly extends a protrusion 62 that, in use, contacts the upper face of the top of the stem of the upper valve 30

Inside the cup-like lower piston 52, against the bottom wall 58 is arranged a leaf-spring 64 assembly comprising a lower disc 66, an adjusting shim 68 and an upper disc 70. As observable on figure 2, the leaf-spring assembly 64 is sandwiched between the bottom wall 58 of the lower piston 52 and the under face of the upper piston 46. In order to provide the necessary resilience to the discs 66, 70, each disc is slightly curved. It may also have a conical shape similarly to the known Belleville washers. Another alternative is to utilize wave-washers springs. Also, the discs 66, 70, are complementary arranged so under load their respective axial deflection add-up. This can be achieved by arranging the discs so their respective protrusions, or conical tip, extend in opposite directions.

The skilled person also knows other arrangements of such assembly having either only one disc or, to the contrary more than two discs axially stack-up to provide further elasticity or to increase the overall assembly stiffness. The adjusting shim 68 represented has fills a gap between the two discs spring 66, 70, and then to minimize the volume filled by the fuel. The adjusting shim 68 also eases the assembly since, has it is arranged between the discs, the orientation of the curvatures of each disc has no influence on the resilient ability of the leaf-assembly 64.

The lash adjuster 20 further comprises a cylindrical cage spring 72 externally surrounding the peripheral wall 54 of the lower piston 52 and axially compressed between a transversal face 74 of the injector body 16, said face being known by the skilled person as the upper face of the valve body and, the under face of the protruding portion of the upper piston cap-head 50. Cage springs are known by persons skilled in the art of servo fuel injectors under the name of tubular springs or sleeve springs. A typical cage spring has a tubular body

extending along an axis, the cylindrical wall of the body being provided with plurality of elongated apertures, the elongation axis being transversal to the axis of the tubular body. The cage spring 72 has very high compression stiffness, much higher than the stiffness of the disc-spring assembly 62 and, the cage-spring 72 permanently solicits upwardly the upper piston 46 toward the actuator 18.

The operation of the lash adjuster 20 is now detailed in complement to the general operation description provided previously.

When the actuator 18 is not energized it retracts. The cage spring 72 axially expands and upwardly displaces the upper piston 46. The low stiffness disc-spring assembly 64 downwardly pushes the lower piston 52 so the protrusion 62 comes in contact against the stem of the upper valve 30 without exercising sufficient force to displace said upper valve 30 away from its normal closed position CPV and thus, spray of fuel is forbidden.

When the actuator 18 is energized, it elongates and downwardly solicits the upper piston 46. The downward displacement of the upper piston 46 compresses the cage-spring 72. The fuel captured below the upper piston 46 at the bottom of the lower piston 52 compresses and, consequently the leaf-spring assembly 64 also compresses to the point that the force generated by the actuator 18 is integrally transmitted to the lower piston 52 which then, biases the upper valve 30 in the open position OPV, and consequently enables fuel spray through the nozzle 14.

An alternative embodiment is now described in reference to figure 3 by ways of differences with the embodiment described above.

In order to minimize mass, and especially mass of moving components so that inertia is reduced and fast displacements is made possible, the upper piston 46 is hollow. Its cylindrical body 48 and its cap head 50 are distinct components that are fixed to each other after being machined.

The cylindrical body 48 has the same external shape and dimensions as previously but it is provided with a central void 76 upwardly opening. The head cap 50 has substantially the shape of a thick disc and it is adjusted above the cylindrical body 48 so it radially extends all around the peripheral edge of the cylindrical body 48. To ease positioning, the head cap 50 is provided on its inner

face 78 with a central protruding portion 80 that adjusts in the opening of the void 76.

Fixation of head cap 50 onto the cylindrical body 48 may be done using any known technology such as welding, brazing and gluing. In another alternative, as the lash adjuster is permanently under compression forces, the head cap 50 can be simply positioned and not fixed above the cylindrical body 48.

As a non-limiting example, hydraulic lash adjusters successfully tested had an upper piston of 7mm diameter and a mass ranging from 1 to 3 grams depending on material used. Pistons were made from steel, titanium or ceramic.

The following references have been utilized in this description:

10	injector
12	head of the injector
14	nozzle of the injector
16	injector body
18	actuator
20	hydraulic lash adjuster
22	control valve
24	needle valve
26	electrical links
28	connector
30	upper valve
32	lower valve
34	high pressure circuit
36	inlet
38	spray holes
40	low pressure return circuit
42	outlet
44	control chamber
46	upper piston
48	cylindrical body
50	head cap
52	lower piston

54	peripheral wall
56	rest face of the lower piston
58	bottom wall
60	under face of the bottom wall
62	protrusion
64	leaf-spring
66	lower disc
68	adjusting shim
70	upper disc
72	cage spring
74	upper face of the valve body
76	central void
78	inner face of the head cap
80	protruding central portion

A1	main axis
A2	second axis
CPV	close position of the valve
CPN	close position of the needle
OPV	open position of the valve
OPN	open position of the needle
V	volume wherein is arranged the lash adjuster.

CLAIMS

1. Hydraulic lash adjuster (20) adapted to be arranged in a hydraulic volume (V) interposed between the actuator (18) and a control valve assembly (22) of a servo injector (10), said volume (V) being in use filled with fuel;

the adjuster (20) comprising a lower piston (52), an upper piston (46), an external spring (72) and an internal spring (64), characterized in that

the lower piston (52) has a cylindrical cup-like shape with a peripheral wall (54) defining an internal bore in which is slidably arranged the upper piston (46) and, a bottom wall (58) on which is arranged the internal spring (64) compressed between said bottom wall (58) of the lower piston (52) and the under-face of the upper piston (46) and wherein, both springs (72, 64) bias the upper piston (46) toward the actuator (18).

2. Hydraulic lash adjuster (20) as claimed in the preceding claim wherein the internal spring (64) comprises a disc having a curved shape or a conical shape (66).

3. Hydraulic lash adjuster (20) as claimed in claim 2 wherein the internal spring (64) comprises a stack of a plurality of said discs (66, 70) complementary arranged.

4. Hydraulic lash adjuster (20) as claimed in any one of the claims 2 or 3 wherein each of said disc (66) is substantially circular and is provided with curvature on one plane.

5. Hydraulic lash adjuster (20) as claimed in any one of the preceding claims further comprising an adjusting shim (68) arranged between said bottom (58) of the lower piston (52) and the under-face of the upper piston so that, the internal spring (64) load is adjusted and the hydraulic volume occupied by fuel is minimized.

6. Hydraulic lash adjuster (20) as claimed in any one of the preceding claims wherein the upper piston (46) comprises a main cylindrical body (48) and a head cap (50) radially protruding beyond the edge of the body (48), the external spring (72) being compressed under head cap radial protrusion and axially biasing the upper piston (46) toward the actuator (18).

7. Hydraulic lash adjuster (20) as claimed in claim 6 wherein the head cap (50) of the upper piston (46) is an independent component positioned and placed onto the main cylindrical body (48).

8. Hydraulic lash adjuster (20) as claimed in claim 7 wherein the main cylindrical body (48) is hollow.

9. Hydraulic lash adjuster (20) as claimed in any one of the preceding claims wherein the external spring is a cage spring.

10. Servo fuel injector (10) comprising a hydraulic lash adjuster (20) as claimed in any one of the preceding claims.

11. Servo fuel injector (10) as claimed in claim 10 wherein the actuator (18) is a piezo-actuator.

12. Servo fuel injector (10) as claimed in claim 10 wherein the actuator (18) is a magneto restrictive actuator.

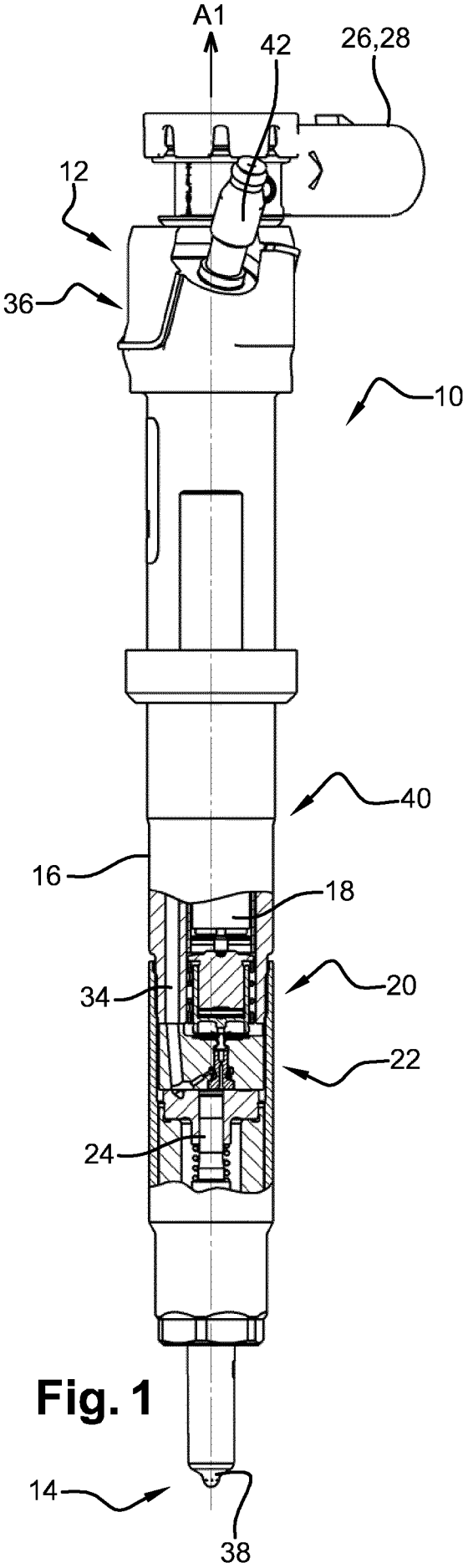
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Fig. 1

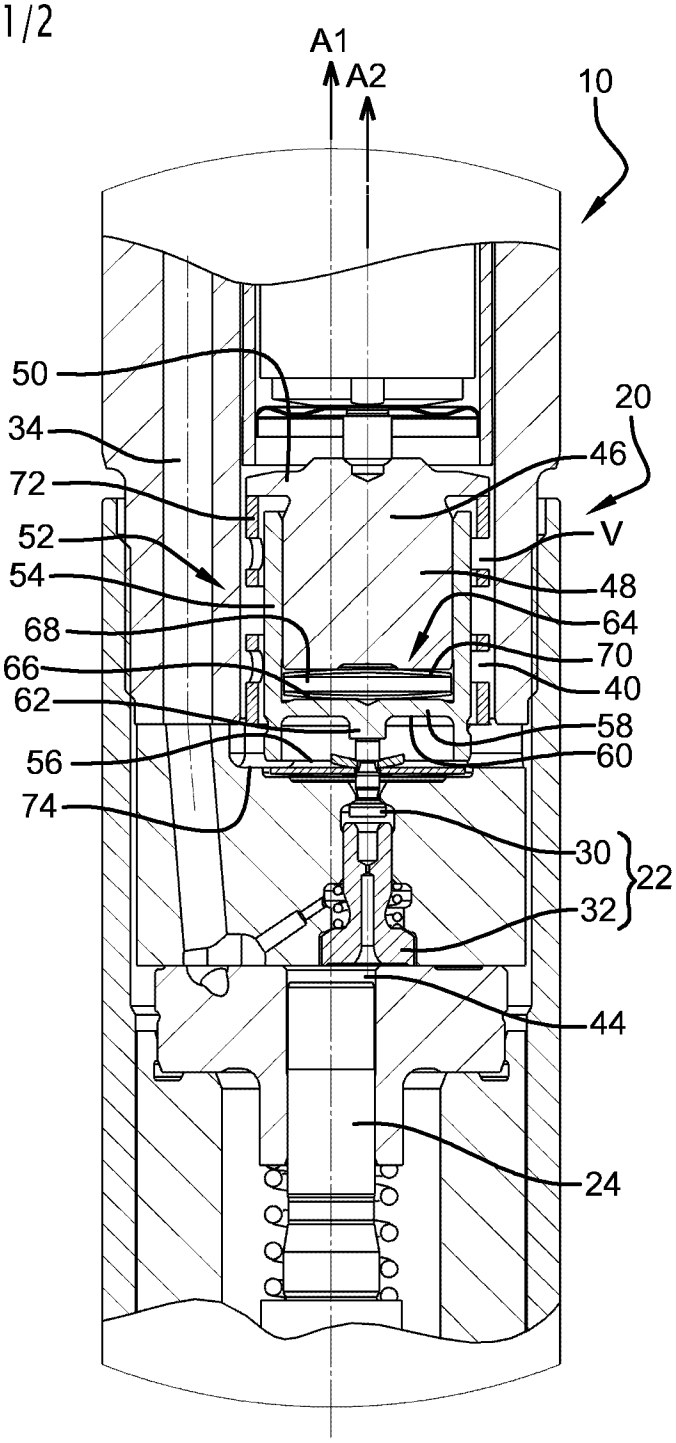
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Fig. 2

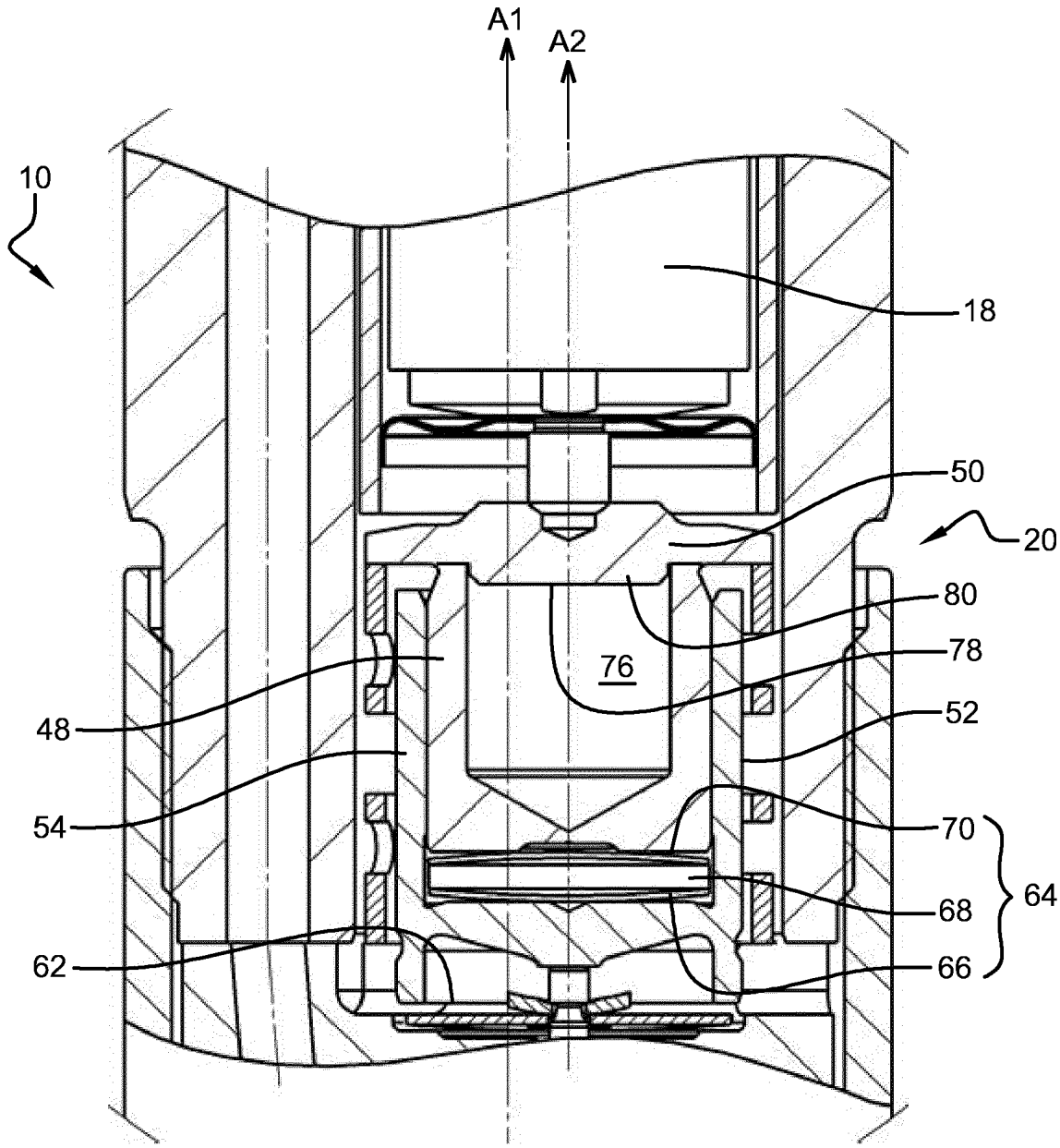

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M61/16
ADD.

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)
F02M

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 practicable, search terms used)
EPO-Internal, WPI Data

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Y	figure 1	2-5,9
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A	figure 1	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
17 February 2016	24/02/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Boye, Michael

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INTERNATIONAL SEARCH REPORT

International application No
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2

INTERNATIONAL SEARCH REPORT

Information on patent family members

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