

(19)



(11)

EP 2 650 539 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

16.10.2013 Bulletin 2013/42

(51) Int Cl.:

F04B 17/04 (2006.01)

F04B 35/04 (2006.01)

(21) Application number: **12305423.1**

(22) Date of filing: **11.04.2012**

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA ME

(71) Applicant: **TI Automotive Fuel Systems SAS**

51000 Châlons-en-Champagne (FR)

(72) Inventors:

- **Fromont, Jean-Sébastien**
51520 SARRY (FR)
- **Renaut, Stéphane**
51140 JONCHERY SUR VESLE (FR)
- **Bouvet, Romain**
51600 SAINT HILAIRE LE GRAND (FR)

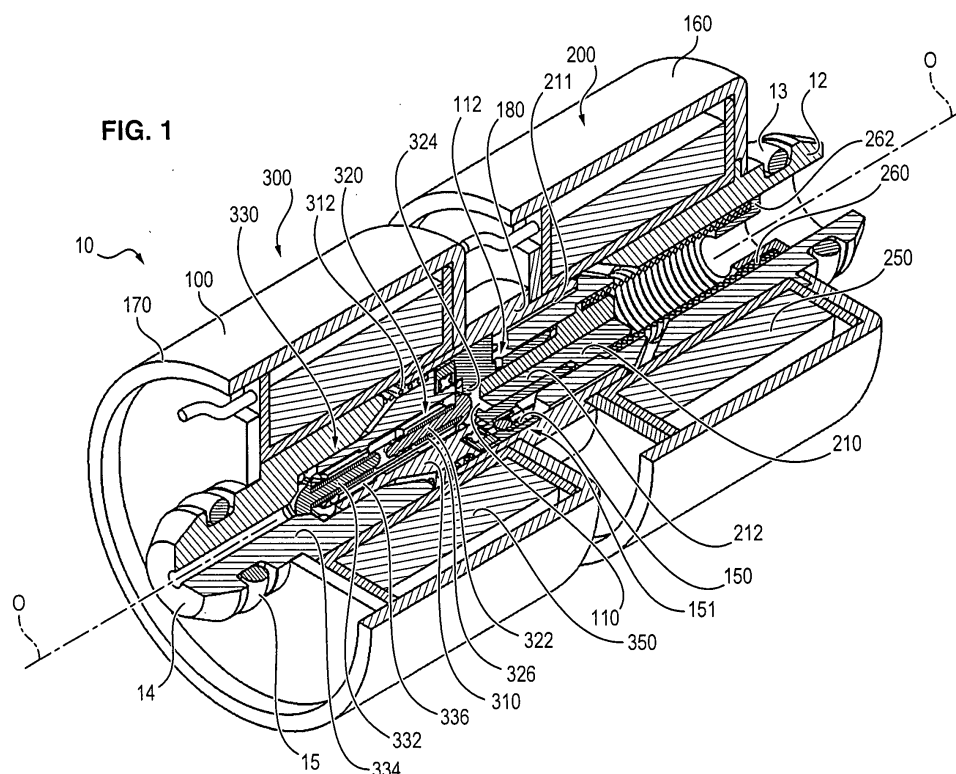
(74) Representative: **Regimbeau**

**20, rue de Chazelles
75847 Paris Cedex 17 (FR)**

(54) **Solenoid piston pump for injection of an additive, with integrated reverse flow mode and able to create and regulate high pressure**

(57) A pump comprising a casing (100) which houses a piston (210) actuated in reciprocate displacement thanks to a coil (250) so as to successively suck liquid from a tank and expel such liquid to an output (14), in a

pumping mode, characterized in that said casing (100) further includes on said output (14) a valve module (300) actuated by an auxiliary coil (350) so as to selectively reverse the way of liquid circulation into the casing.



EP 2 650 539 A1

Description

FIELD OF THE INVENTION

[0001] The invention relates to the field of fluid pumps, and more particularly to the field of solenoid piston pumps.

[0002] The invention relates specifically to the field of pumping an additive for a waste gas cleaning catalyst of a vehicle internal combustion engine.

BACKGROUND OF THE INVENTION

[0003] Solenoid piston pumps generally comprise a casing which houses a piston actuated in reciprocate displacement thanks to a coil so as to successively suck fluid from a tank and expel such fluid to an output.

[0004] New legislations which target the reduction of pollutant emissions from motor vehicles lead to systems for eliminating nitrogen oxides NO_x from exhaust gases of vehicles.

[0005] One of the technologies developed, known as SCR for "Selective Catalytic Reduction", consists in injecting into the fuel tank or inside the exhaust line, a solution containing a precursor of ammonia (generally urea) which chemically reduces the NO_x to nitrogen. The SCR technology relates particularly to diesel engines.

[0006] The vehicles are therefore provided with an additive tank and means for pumping an injecting the precursor when needed.

[0007] However the aqueous urea solution generally used for this purposes, made by a water/urea eutectic containing 32,5 wt% of urea, is very corrosive.

[0008] Consequently for allowing fine dosing capability in a corrosive environment known additive pumps are often quite complex.

[0009] Moreover the aqueous urea solution used in SCR freezes at -11°C .

[0010] Consequently on most of the urea injection systems, the hydraulic circuit from urea tank to the injector on the exhaust must be drained to prevent from damage due to urea freezing. This is usually ensured with complex hydraulic architecture and additional electromagnetic valve.

[0011] Additionally in most Urea injection systems, the pressure regulation for the injector setting point is achieved thanks to either the use of a passive pressure regulator or a pressure sensor associated with dedicated algorithm in embedded electronic device. This leads to complex and expensive architectures with lower power efficiency.

SUMMARY OF THE INVENTION

[0012] The present invention aims to solve the above problems by providing a simple fluid pump than that proposed according to the state of the art and with better liability than the known pumps.

[0013] For this purpose, the present invention relates to a pump comprising a casing which houses a piston actuated in reciprocate displacement thanks to a coil so as to successively suck liquid from a tank and expel such liquid to an output, in a pumping mode, **characterized in that** said casing further includes on said output a valve actuated by an auxiliary coil so as to selectively reverse the way of fluid circulation into the casing.

[0014] According to an advantageous embodiment the pump comprises a spring which urges said piston towards a rest position corresponding to an expelling position so that the delivery pressure of the liquid corresponds to the force exerted by the spring. Using a spring adapted to reach high pressure allows high pressure of delivery. Moreover adjusting the force of the spring allows easy adjustment of the delivery pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Additional and other objects, features and advantages of the invention will become apparent from the description set forth hereinafter when considered in conjunction with the accompanying drawings, in which :

FIG 1 is a general overview of a solenoid piston pump in accordance with the present invention;

FIG 2 is a schematic longitudinal sectional view of the pump in accordance with the invention at the beginning of a sucking step;

FIG 3 is a schematic longitudinal sectional view of the pump in accordance with the invention at the beginning of an expelling step;

FIG 4 is a schematic longitudinal sectional view of the pump in accordance with the invention at the beginning of a draining step; and

FIG 5 is a schematic longitudinal sectional view of the pump in accordance with the invention in a second time of the draining step.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

[0016] The pump 10 in accordance with the present invention which is illustrated in the enclosed figures comprises :

- a casing 100, which houses
- a pump module 200 including a piston 210 actuated in reciprocate displacement thanks to a coil 250 so as to successively suck liquid from a tank and expel such liquid to an output, in a pumping mode, and
- a valve module 300 provided on said output and actuated by an auxiliary coil 350 so as to selectively reverse the way of fluid circulation into the casing.

[0017] The above elements are centered on a longitudinal axis O-O.

[0018] The valve module 300 includes a valve core 310

which bears two check valves 320 and 330. The state of the two check valves 320, 330, respectively opened and closed, is inverted depending of the position of the valve core 310 under the control of the auxiliary coil 350. The valve core 310 is biased towards a rest position by a spring 312. The valve core 310 is translated along O-O axis when auxiliary coil 350 is supplied.

[0019] The input of the pump is referenced 12. The output of the pump is referenced 14. Said input 12 and said output 14 are both provided with an external O-ring 13, 15 for establishing sealing in the system receiving the pump.

[0020] The casing 100 defines a pumping chamber 110 in which a part 212 of the piston 210 displaces along O-O axis under control of the coil 250.

[0021] Said pumping chamber 110 is defined in a central piece 116 which operates guiding of the piston 210 in its displacement in translation along the longitudinal axis O-O of the pump.

[0022] Circulation of liquid between input 12 and the pumping chamber 110 is defined by a pumping channel 211 on the periphery of the piston 210, said pumping channel leading to the pumping chamber 110 by way of a transverse bore 112 provided in the guiding piece 116.

[0023] Piston 210 is urged by a spring 260 towards a rest position illustrated on figure 2 wherein said part 212 of the piston is mainly inside the pumping chamber and covers the bore 112.

[0024] In the rest position the piston 210 bears on an O-ring 218 interposed between an axial end of the guiding piece 116 and an enlarged head of the piston 210. Said O-ring 218 dampers shocks of the piston 210 against the guiding piece 116 under biasing by the spring 260.

[0025] When the piston 210 is displaced against the force of the spring 260 in the state illustrated on figure 3 by supplying the control coil 250, displacement of the part 212 induces a vacuum in the pumping chamber 110 and finally opens the bore 112 allowing sucking of liquid from the input 12 into the pumping chamber 110 through the pumping channel 211 and via the bore 112.

[0026] In the above operation the check valve 320 is closed. Consequently the axial end of the pumping chamber 110 opposite the input 112 and facing the valve module 300 is closed.

[0027] When stopping the supplying of the coil 250, the force of the spring 260 urges the piston 210 towards the rest position, covering the bore 112 and expelling the liquid from the pumping chamber 110 toward the output 14, via the checking valve 320 which is forced in open position. Delivery of liquid is made through a delivery channel 311 provided inside the valve core 310 and leading to the output 14.

[0028] The first check valve 320 comprises a shutter 322 biases towards a valve seat 324 along O-O axis by a spring 326. Check valve 320 is on the side of the valve module 300 adjacent the pumping chamber. Valve seat 324 corresponds to the axial end of the pumping chamber 110 opposite the input 112 and facing the valve module

300.

[0029] The second check valve 330 comprises a shutter 332 biases towards a valve seat 334 along O-O axis by a spring 336. Check valve 330 is on the side of the valve module 300 adjacent the output 14. In its closed position the second check valve 330 closes the output 14.

[0030] Both springs 326 and 336 rest on the valve core 310.

[0031] When the auxiliary coil 350 is not supplied first check valve 320 is closed while the second check valve 330 is open.

[0032] When the auxiliary coil 350 is supplied, displacement of the valve core 310 changes the bearing support of the springs 326 and 336 and consequently the first check valve 320 is open while the second check valve 330 is closed.

[0033] Moreover the pump comprises an auxiliary passage 150 between the pumping channel 211 of the pumping module 200 and the delivery channel 311 of the valve module 300, said auxiliary passage 150 being controlled by an auxiliary valve 151 comprising a ball shutter 152 biases towards a seat 154 by a spring 156 so that auxiliary passage 150 opens when a high pressure is applied in the delivery channel 311.

[0034] For draining fluid (liquid or air) in the reverse direction, from the output 14 towards the input 12, the auxiliary coil 350 is supplied so that the first valve 320 is open while the second valve 330 is closed as illustrated in figure 4.

[0035] When the piston 210 is displaced against the force of the spring 260 in the state illustrated on figure 5 by supplying the control coil 250, displacement of the part 212 induces a vacuum in the pumping chamber 110 and allowing sucking of fluid from the output 14 into the pumping chamber 110 through the delivery channel 311 forcing the second check valve 330 in the open state.

[0036] When stopping the supplying of the coil 250, the force of the spring 260 urges the piston 210 towards the rest position, expelling the fluid from the pumping chamber 110 toward the input 12, via the checking valve 320 which is in open position, the auxiliary passage 150 and the pumping channel 211.

[0037] The spring 260 is designed to work in a small displacement range, such as a fixed system pressure is achieved. The spring 260 bears on a calibrating support 262 which can be displaced initially during assembly process on a part of the casing, for example in a central bore 11 of the input 12, so as to adjust precisely the delivery pressure.

[0038] As illustrated on the figures, preferentially O-rings 316 and 318 are facing respectively on each axial end of the valve core 310 so as to damper shocks of the valve core 310. Said O-rings 316 and 318 bear respectively one on the central guiding piece 116 and the other on the setback of the output 14.

[0039] The casing 100 comprises two cases 160 and 170 which receives respectively one the main coil 250 and the other the auxiliary coil 350. The two cases 160

and 170 are mechanically linked by an intermediate sheath 180. The intermediate sheath supports internally the guiding piece 116. Input 12 is fitted in a central chamber of the case 160 while output 14 is fitted in a central chamber of the case 170.

[0040] Preferentially all the elements (input 14, piston 210, intermediate linking piece 180, valve core 310 and output 14) operating to control the magnetic field generated by the coils 250, 350 and which are in contact with the liquid, such as corrosive urea, are made from a magnetic material such as magnetic ferritic stainless steel. Contrarily the shutters 322 and 332 and the guiding piece 116 are made from a non-magnetic stainless steel.

[0041] The pump in accordance with the present invention allows precise dosing at high pressure with a precise adjustment of the pressure.

Analytical studies (units are in USI if not saecified):

[0042] Spring dimensioning :

Let's call :

- K : spring stiffness
- L0 : free length
- X0 : initial spring compression when "initiated" by the coil

[0043] Piston data :

Let's call :

- C : piston stroke
- D : piston diameter

[0044] System needs :

- Q : minimum flow rate
- Pmax : maximum needed pressure
- f : Driving frequency of the pump (Hz)
- dP : maximum pressure variation among one piston stroke (spring compression decrease of C mm)

[0045] If we note x, the piston displacement from maximum spring compression until end of stroke ($x \in [0;C]$)

[0046] The applied pressure to the fluid P(x) is :

$$P(x) = \frac{K(x + X_0)}{\frac{\pi D^2}{4}};$$

5

$$P_{\max} = P(C) = \frac{K(C + X_0)}{\frac{\pi D^2}{4}},$$

[0047] The mean flow rate of the pump is :

10

$$Q = f \cdot C \cdot \frac{\pi D^2}{4}$$

15

[0048] Pmax and Q are imposed.

[0049] We will fix first the value of C (constraint due to coil performance : C must not be too high in order to minimize the air gap inside the electromagnetic field).

[0050] Then we can calculate the piston diameter :

20

$$D = 2 \sqrt{\frac{Q}{\pi f C}}$$

25

[0051] We deduce the maximal force on the spring

30

$$F_{\max} = \frac{P_{\max}}{\frac{\pi D^2}{4}}$$

35

[0052] Two parameters remain to be calculated : K and X0 ; this can be done thanks to the equation system :

40

$$\left\{ \begin{array}{l} K \cdot (X_0 + C) = F_{\max} = \frac{P_{\max}}{\frac{\pi D^2}{4}} ; \\ dP = \frac{C \cdot K}{\frac{\pi D^2}{4}} \end{array} \right. \quad 30$$

45

50

dP being the maximum pressure variation allowed on one full stroke (typical objective 2% of Pmax)

[0053] We finally obtain :

55

$$\begin{cases} X_0 = C \left(\frac{P_{\max}}{dP} - 1 \right) \\ K = \frac{\pi D^2}{4} \frac{dP}{C} \end{cases}$$

[0054] Application example :

If we consider :

- Pmax = 5 bar
- Q=31/h
- dP = 0.1 bar
- C = 1 mm
- F = 40 Hz

[0055] We obtain :

D = 5.15 mm
Fmax = 10.42 N
X0 = 49 mm
K = 208 N/mm

[0056] We can notice that the initial compression of the spring is quite high. A way to reduce it is to allow a flow rate higher than the one specified and a higher pressure variation.

[0057] We can, for instance allow a maximum pressure of 5.1 bar and a maximum variation of pressure of 0.2 bar.

[0058] In this case, we obtain 24.5 mm of initial compression and a spring stiffness of 417 N/m.

[0059] Depending on the spring choice, we could also allow an increase of the piston diameter, that would only change the flow rate (increased) and the spring stiffness (increased).

[0060] The invention offers numerous advantages in regard of the state of the art.

[0061] The big advantage of the present invention is to propose in the same pump packaging, the integration of two functions which are pressure regulation and reverse mode. This will create a really compact pumping system by saving space and components.

[0062] While the invention has been shown and describes by referring to a preferred embodiment thereof, it is to be understood that the invention is not limited to the specific form of this embodiment and that many changes and modifications may be made therein without departing from the scope of the invention.

Claims

1. A pump comprising a casing (100) which houses a piston (210) actuated in reciprocate displacement thanks to a coil (250) so as to successively suck liquid from a tank and expel such liquid to an output (14),

in a pumping mode, **characterized in that** said casing (100) further includes on said output (14) a valve module (300) actuated by an auxiliary coil (350) so as to selectively reverse the way of fluid circulation into the casing.

2. Pump according to claim 1 comprising a spring (260) which urges said piston (210) towards a rest position corresponding to an expelling position so that the delivery pressure of the liquid corresponds to the force exerted by the spring (260).

3. Pump according to claim 2 comprising a calibrating support (262) bearing the spring (260) and which can be displaced initially during assembly process on a part of the casing (100) so as to adjust precisely the delivery pressure.

4. Pump according to one of claims 1 to 3 wherein the valve module (300) includes a valve core (310) which bears two check valves (320, 330), the state of which is inverted depending of the position of the valve core (310) under the control of the auxiliary coil (350).

5. Pump according to claim 4 wherein each check valve (320, 330) comprises a shutter (322, 332) biases towards a valve seat (324, 334) by a spring (326, 336).

6. Pump according to one of claims 4 or 5 wherein one of the two check valves (320) controls opening of a pumping chamber (110) while the other of the two check valves (330) control opening of the output (14).

7. Pump according to one of claims 1 to 6 wherein the casing (100) defines a pumping chamber (110) in which a part (212) of the piston (210) displaces under control of the auxiliary coil (250), and a pumping channel on the periphery of the piston (210), said pumping channel leading to the pumping chamber (110) by way of a transverse bore (112) which is covered by the part of the piston (210) in the rest position and which is free and the displaced position of said part of the piston (210).

8. Pump according to one of claims 1 to 7 wherein the pump comprises an auxiliary passage (15) between a pumping channel of the pumping module and a delivery channel of the valve module (300), said auxiliary passage (150) being controlled by an auxiliary valve (152, 154, 156) so that auxiliary passage (150) opens when a high pressure is applied in the delivery channel.

9. Pump according to one of claims 1 to 8 further comprising means, such as O-rings (218, 316, 318), for damper effect on moving parts (210, 310) displaced by the main coil (250) and/or the auxiliary coil (350).

10. Pump according to one of claims 1 to 9 wherein elements (14, 210, 180, 310, 14) operating to control the magnetic field generated by the coils (250, 350) and which are in contact with the liquid, are made from a magnetic material such as magnetic ferritic stainless steel. 5

10

15

20

25

30

35

40

45

50

55

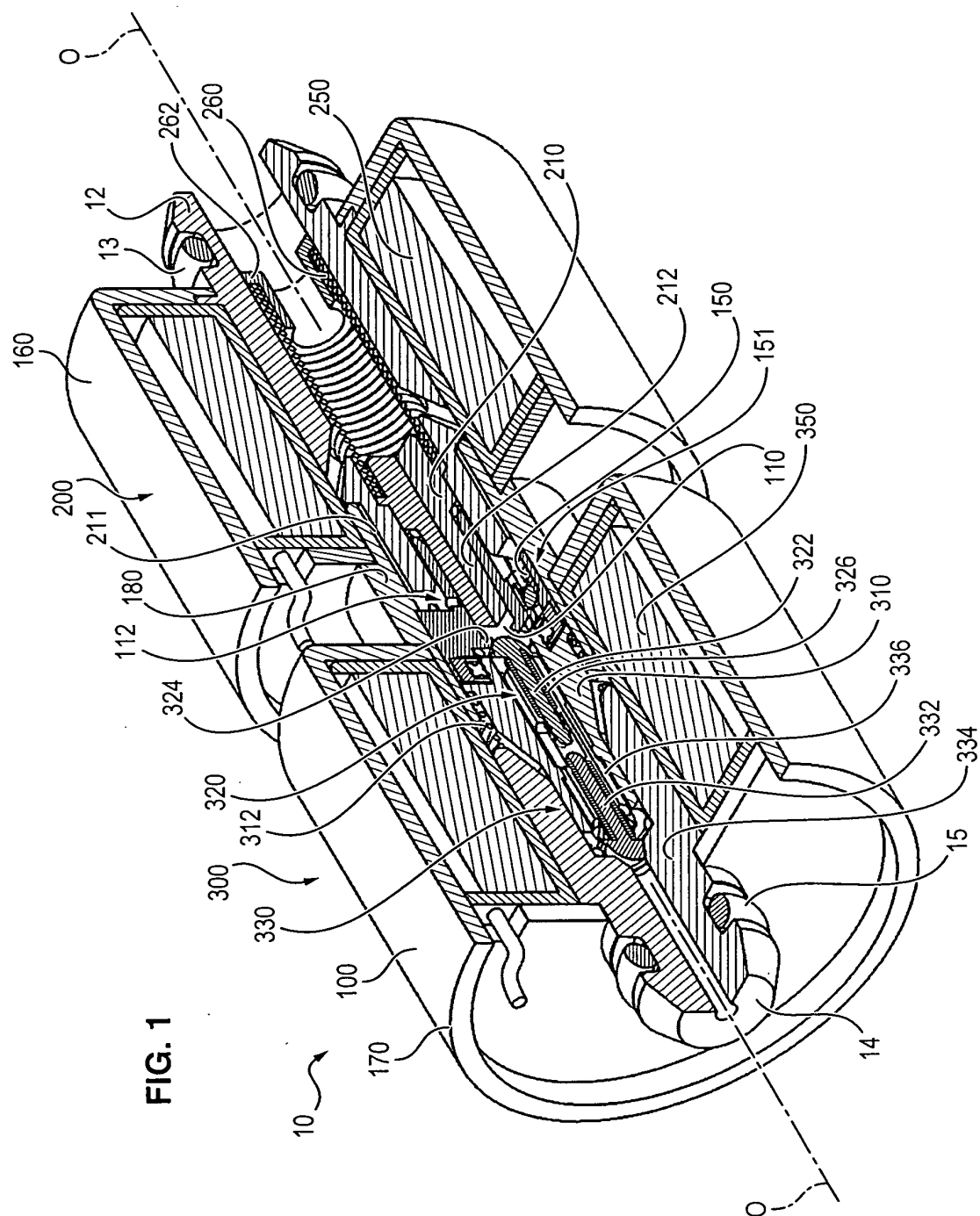


FIG. 1

FIG. 2

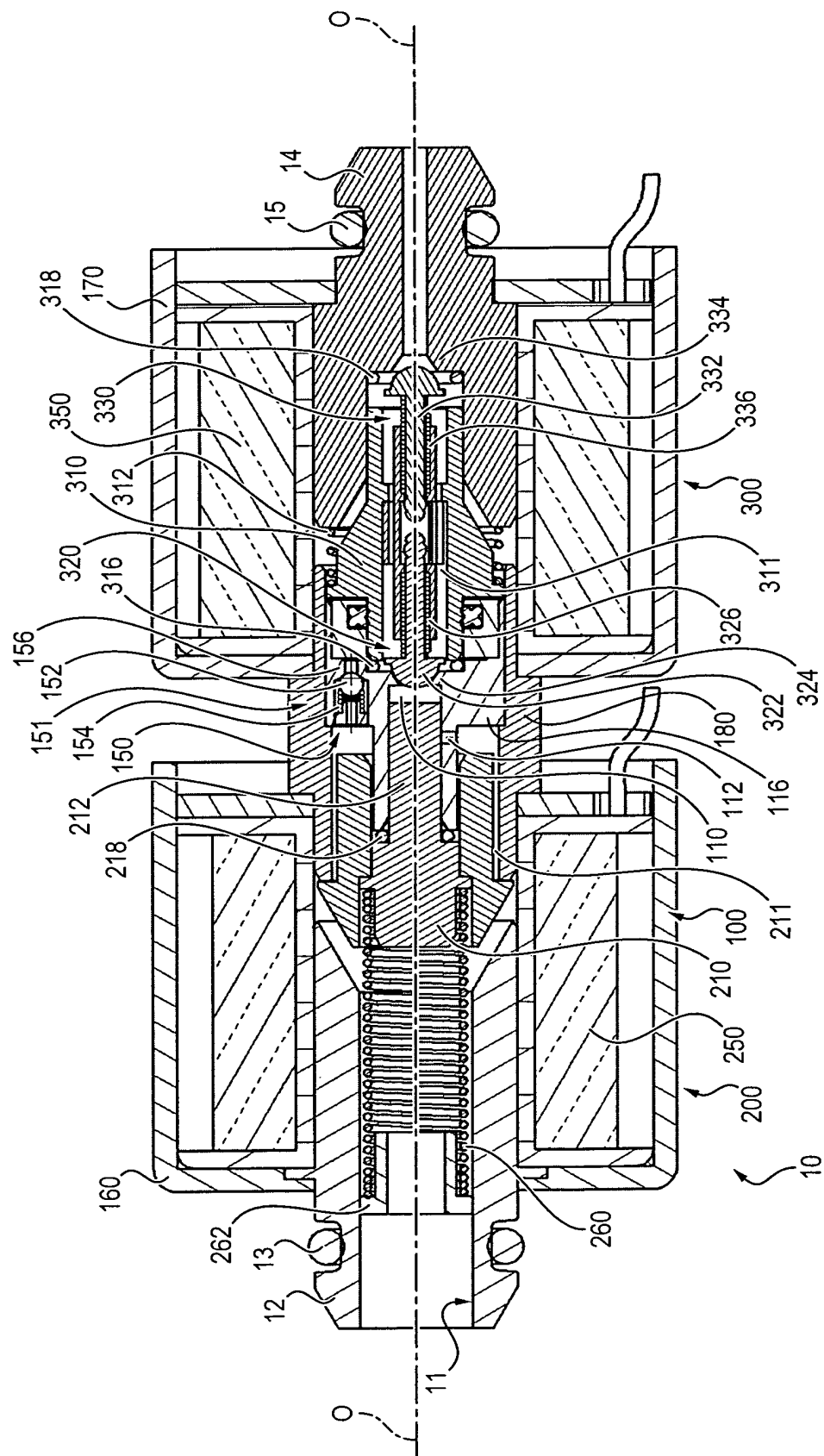


FIG. 3

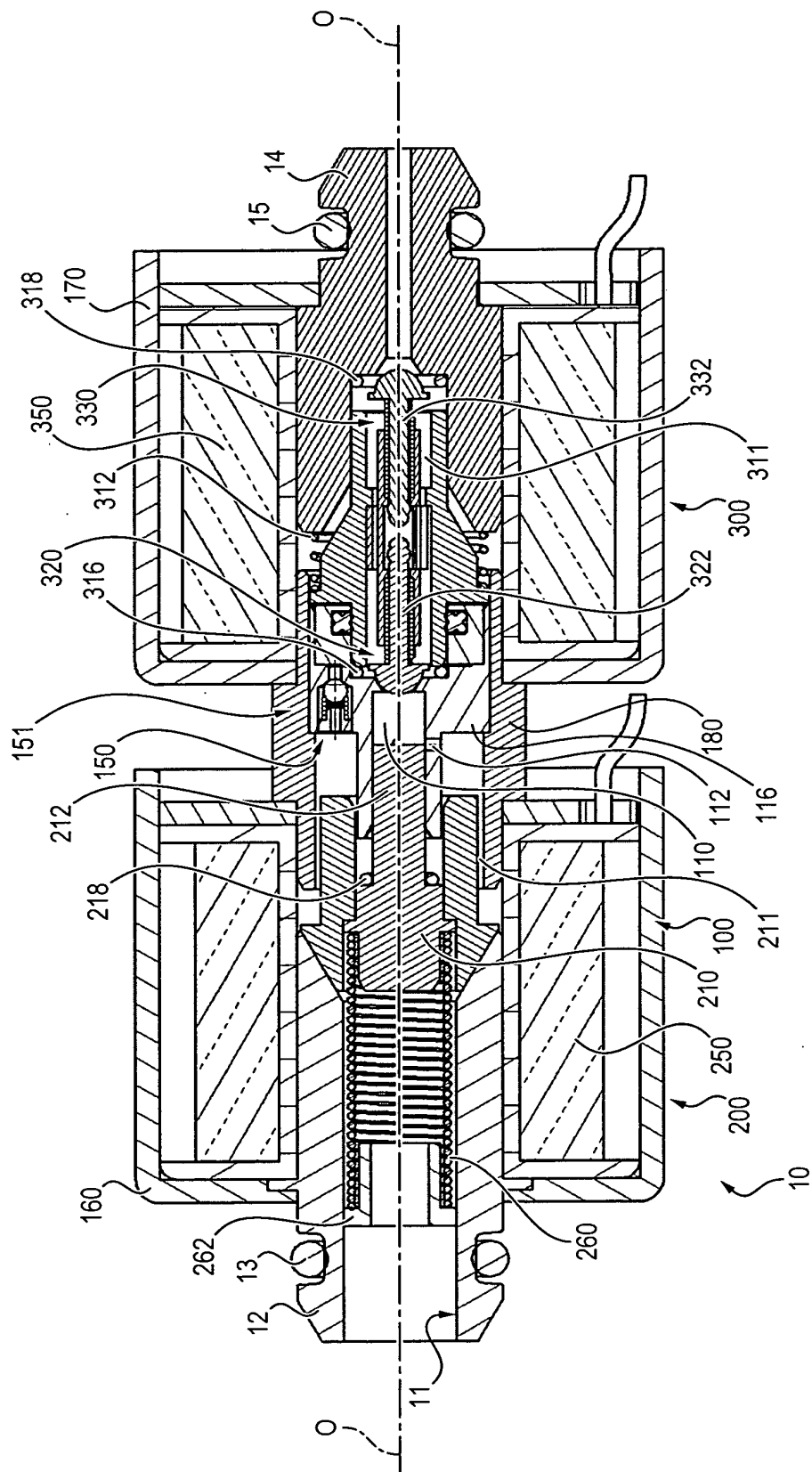


FIG. 4

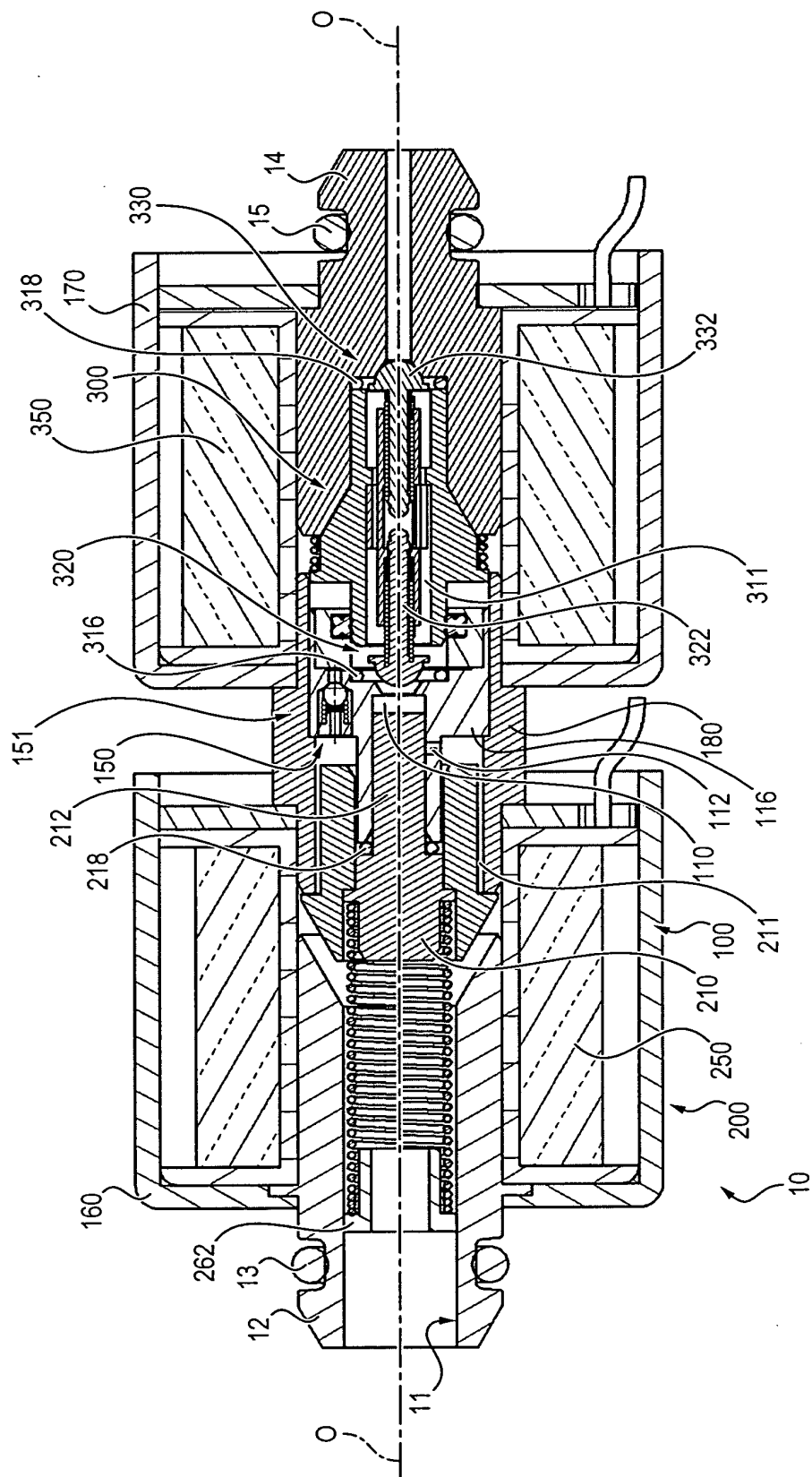
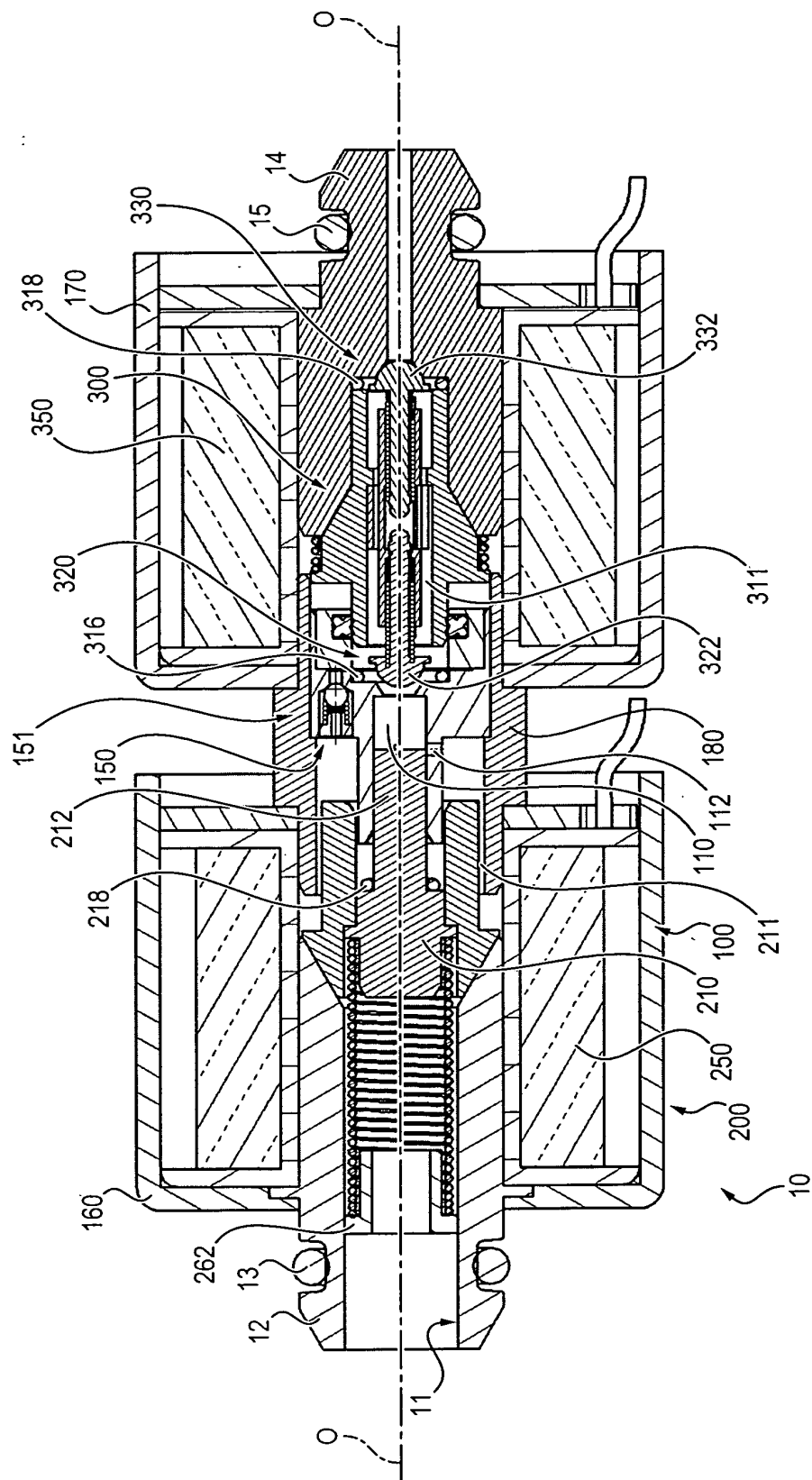


FIG. 5





EUROPEAN SEARCH REPORT

Application Number
EP 12 30 5423

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 2006/013704 A1 (SAWADA TERUYA [JP] ET AL) 19 January 2006 (2006-01-19) * the whole document *	1-10	INV. F04B17/04 F04B35/04
X	US 5 833 211 A (BERLING JAMES T [US]) 10 November 1998 (1998-11-10) * claim 1; figures 18A,18B *	1-10	
A	US 2009/191073 A1 (KOPECEK HERBERT [DE] ET AL) 30 July 2009 (2009-07-30) * paragraph [0006] - paragraph [0009] *	1	
A	US 2012/063924 A1 (SIMMONS TOM M [US] ET AL) 15 March 2012 (2012-03-15) * paragraph [0164] - paragraph [0170] *	1	
A	WO 2009/083179 A1 (HAHN SCHICKARD GES [DE]; BRAUN MELSUNGEN AG [DE]; KUECK HEINZ [DE]; BE) 9 July 2009 (2009-07-09) * abstract *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F04B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 25 September 2012	Examiner Fistas, Nikolaos
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			

 1
EPO FORM 1503 03.82 (P04C01)

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

EP 12 30 5423

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

25-09-2012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006013704 A1	19-01-2006	NONE	
US 5833211 A	10-11-1998	US 5833211 A	10-11-1998
		US 5833440 A	10-11-1998
US 2009191073 A1	30-07-2009	NONE	
US 2012063924 A1	15-03-2012	TW 201221771 A	01-06-2012
		US 2012063924 A1	15-03-2012
		WO 2012034010 A2	15-03-2012
WO 2009083179 A1	09-07-2009	DE 102008003020 A1	10-09-2009
		WO 2009083179 A1	09-07-2009