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(54) CONTROL VALVE ARRANGEMENT

STEUERVENTILANORDNUNG

DISPOSITIF DE CONTROLE DE SOUPAPE

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Description

TECHNICAL FIELD

[0001] The present invention relates to the valve control arrangement of a fuel injector.

BACKGROUND OF THE INVENTION

[0002] High pressure fuel injectors are provided with needle or shafts that are hydraulically piloted via a control valve arrangement. It is known that to minimize undesirable exhaust emissions the lift of the needle must happen at a controlled speed while the closing must be extremely prompt. In EP2093410, WO2010088781 and in DE102007055895 are disclosed valve arrangements provided with a control valve associated to a restriction orifice and with a larger filling valve. A remaining issue is to properly damp hydraulic waves that occur at each injection event.

SUMMARY OF THE INVENTION

[0003] Accordingly, it is an object of the present invention to provide a control valve arrangement of a fuel injector. The arrangement comprises a valve housing wherein are arranged a filling channel extending from a high pressure fuel supply line to a filling chamber that is in a first fluid communication with a first control chamber. The first fluid communication is controlled by a filling valve normally biased open, by a first spring, away from a first seat arranged in the valve housing. A communication channel extends from the first control chamber to a second control chamber that is in a second fluid communication with a low pressure outlet line. The second fluid communication is controlled by a control valve normally biased closed, by a second spring, in complementary abutment against a second seat arranged in the housing, the control valve cooperating with an actuator to commute from the normally closed position to an open position. The arrangement further comprises a bore in which a piston is slidably arranged, the piston piloting the injection of the fuel into a compression chamber. The bore is in a third fluid communication with the first control chamber. According to the invention, the bore directly opens into the first control chamber, said third fluid communication being unrestricted.

[0004] The communication channel is provided with a restriction spill orifice so that the fuel pressure decreases when entering the second control chamber. The volume of the second control chamber is arranged to be minimal.

[0005] The filling valve and the control valve are poppet valves each provided with a stem, the two valves being coaxially arranged and in close vicinity. The second control chamber is between the extremity of the filling valve stem and the control valve so that the volume of said second control chamber is minimal.

[0006] Furthermore, in an embodiment, the communication channel axially extends throughout the filling valve.

[0007] Also, the filling channel is provided with another restriction arranged before the filling chamber.

[0008] More particularly, the first spring is a coil spring arranged inside the filling chamber around the stem of the filling valve and, the second spring is a leaf spring having a relatively flat form, engaged around the stem of the control valve.

[0009] Also, the filling valve is provided with a lift stop that limits the valve displacement between the open position and the closed position.

[0010] In a particular embodiment, the second valve seat is arranged near the top of the valve housing leaving a relatively thin wall between said seat and the low pressure chamber. The thin wall is able to flex slightly under changes of pressure in the second control chamber so that, the combination of a flexible seating, short and stiff control valve and low volumes ensures that a good force signal is transmitted to the actuator caused by the control pressure increase after nozzle needle closure.

[0011] The invention is also related to a fuel injector wherein a movable needle cooperates with a nozzle to enable or prohibit fuel injection, the needle being hydraulically piloted by a control valve arrangement as described in the preceding paragraphs.

BRIEF DESCRIPTION OF THE FIGURE

[0012] The present invention is now described by way of example with reference to the accompanying the figure that is a sectional view of a control valve arrangement as per the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] In the following description, similar elements will be designated with the same reference numbers.

[0014] For clarity and concision purposes the vertical orientation of the figure will be utilized. Furthermore, words such as "right, left, top, bottom, upward, downward" may be serve the description without any intention to limit the scope of protection of the invention, especially in regards of the numerous possibilities of installation of an injector.

[0015] A fuel injector 10 comprises a control valve arrangement 12 is now described in reference to the figure. Such fuel injectors 10 generally comprise a needle guide housing 14 in which a needle is slidable within a bore 18 and engageable with a needle seat, not represented, to control the flow of fuel from a high pressure fuel supply line 20 through the housing 14.

[0016] On the top of the needle guide housing 14 is fixed a valve housing 22 provided with a through hole extending along a vertical valve axis A2, slightly offset relative to the main vertical axis A1. Said through hole comprises several coaxial sections now described from bottom to top.

[0017] A first cylindrical section forming a first control chamber 24 axially A2 extends and its section restricts to form a first frustroconical valve seat 26 that opens into a filling chamber 28. The filling chamber 28 has a toric wall 30 and above said filling chamber 28 axially A2 extends a cylindrical guide portion 32 which at its very top further restricts forming a second frustroconical valve seat 34. The central aperture of said second valve seat 34opens into a large low pressure chamber 36 where from departs a return low pressure line 38.

[0018] As can be seen on the figure, the axial offset A1, A2, is sufficiently limited so more than half of the section of the bore 18 directly opens into the first control chamber 24 creating an unrestricted fluid communication between the first control chamber 24 and the bore 18.

[0019] A first poppet valve 40, identified as the filling valve 40, is arranged so to cooperate with the first valve seat 26. The disc-plug portion 42 of the valve occupies the vast majority of the volume of the first control chamber 24 and the stem 44 of the filling valve 40 axially upwardly extends from said disc-plug 42 through the filling chamber 28 and is vertically A2 guided in the guide portion 32. In the filling chamber 28 a coil spring 46 arranged around the stem 44 is compressed between the top portion of the toric wall 30 and the upper face of the disc-plug 42 so that, the coil spring 46 permanently solicits the filling valve 40 in an open position away from the first valve seat 26.

[0020] The filling valve 40 is further provided with an internal axial communication channel 48 extending throughout valve 40 from the lower face of the disc-plug portion 42 to the top surface 50 of the stem 44. In the vicinity of said top surface 50 the section of the communication channel 48 is restricted by a spill orifice 52.

[0021] As can been observed on the figure, the communication channel 48 downwardly opens in the first control chamber 24 and also in the bore 18.

[0022] On the lower face of the disc-plug portion 42, the filling valve 40 is provided with a lift stop 54 that downwardly protrudes from said lower face so to limit the range of displacement of the filling valve 40, the lift stop 54 abutting against the top face of the needle guide housing 14 when the filling valve 40 opens.

[0023] A second poppet valve 56, identified as the control valve 56, is arranged above the filling valve 40, so to cooperate with the second valve seat 34. The control valve 56 is smaller than the filling valve 40 and is similarly provided with a disc-plug portion 58 and a stem 60 upwardly extending into the low pressure chamber 36. In said low pressure chamber 36 a spring 62 is arranged around the stem 60 so upwardly solicit the control valve 56 in a closed position, the disc-plug 58 being in complementary abutment against the second valve seat 34.

[0024] In a preferred embodiment, represented on the figure, the spring 62 is a flat spring maintained arranged around the stem 60 by a key 64. Indeed, the stem 60 is provided at its top with a radially outwardly extending face in which is engaged the key 64. In the figure said face follows a conical portion; other alternatives are possible such as a groove. The flat spring 62 can for instance be a leaf spring or a disc spring.

[0025] Not represented on the figure is a piloted actuator such as an actuator 66 which cooperates with the control valve 56 to downwardly open it in pushing it away from the second valve seat 34.

[0026] A second control chamber 68 is formed inside the cylindrical guide portion 32 between the top surface 50 of the filling valve stem 44 and the lower face of the control valve 56. As can be seen the arrangement 12 is such that the second control chamber 68 is very small as the top face 50 of the stem 44 is arranged to be in the close vicinity to the lower face of the control valve 56.

[0027] From the supply line 20 inwardly radially extends a filling channel 70 in which is arranged a further restriction orifice 72 that opens in the toric wall 30 of the filling chamber 28.

[0028] The operational mode of the valve arrangement 12 is now described.

[0029] In a first phase the injection of fuel is prohibited as the needle is in a downward position in complementary abutment against the needle seat. The actuator 66 is not energized and therefor the control valve 56 is normally closed and the filling valve 40 is normally open. A continuous fluid communication is established between the high pressure line 20, the filling channel 70, the filling chamber 28, the first control chamber 24, the top portion of the bore 18, the communication channel 48 and the second control chamber 68. This volume is filled with high pressure fuel maintaining the needle in the downward position.

[0030] In a second phase an injection event is initiated by energizing the actuator 66 which downwardly pushes open the control valve 56. The high pressure fuel inside the second control chamber 68 immediately flows into the low pressure chamber 36 which, thanks to the small volume of the second control chamber 68, suddenly depressurises the second control chamber 68 upwardly aspiring the filling valve 40 that moves in closed position. The fluid communication described here above is now interrupted by the closing of the filling valve 40. The high pressure fuel inside the top portion of the bore 18 flows through the communication channel 48, the flowing velocity being limited by the section of the spill orifice 52 and, in flowing through the spill orifice 52 the fuel pressure decreases. The pressure in the bore 18 decreases and the needle moves up at a controlled speed depending upon the section of the spill orifice 52.

[0031] In a third phase the injection event started above is ended by ending to energize the actuator 66. The flat spring 62 upwardly pulls the control valve 56 toward closing the second valve seat 34. The fuel contained in the top portion of the bore 18, in the communication channel 48 and in the second control chamber 68 quickly adjusts to a common pressure. The filling valve 40, now mainly solicited by the combined forces of the coil spring 46 and the high pressure fuel contained in the

filling chamber 28, opens re-establishing the full volume in fluid communication as detailed above. In said volume the fuel quickly re-pressurizes pushing the needle toward closing the nozzle seat and ending the injection event.

[0032] Thanks to the further restriction orifice 72 arranged in the filling channel 70, any hydraulic wave displacing in the high pressure line 20 and in the filling channel 70 is quickly damped in the said restriction orifice 72 and in the filling chamber 28.

[0033] A complementary feature of the preferred embodiment is that the second valve seat 34 being placed near the top of the valve housing 22 leaves a relatively thin wall 74 between said seat 34 and the low pressure chamber 36. This thin wall 74 is able to flex slightly under changes of pressure in the second control chamber 68. The combination of a flexible seating, short and stiff control valve and low volumes ensures that a good force signal is transmitted to the actuator caused by the control pressure increase after nozzle needle closure.

Claims

1. Control valve arrangement (12) of a fuel injector (10) comprising a valve housing (22) wherein are arranged a filling channel (70) extending from a high pressure fuel supply line (20) to a filling chamber (28) that is in a first fluid communication with a first control chamber (24), said first fluid communication being controlled by a filling valve (40) normally biased open, by a first spring (46), away from a first seat (26) arranged in the valve housing (22) and, a communication channel (48) extending from the first control chamber (24) to a second control chamber (68) that is in a second fluid communication with a low pressure outlet line (38), said second fluid communication being controlled by a control valve (56) normally biased closed, by a second spring (62), in complementary abutment against a second seat (34) arranged in the housing (22), the control valve (56) cooperating with an actuator (66) to commute from the normally closed position to an open position and, a bore (18) in which a piston (16) is slidably arranged, the piston (16) piloting the injection of the fuel into a compression chamber, the bore (18) being in a third fluid communication with the first control chamber (24),
   characterized in that the bore (18) directly opens into the first control chamber (24), said third fluid communication being unrestricted, the volume of the second control chamber (68) being minimal and wherein,
   the filling valve (40) and the control valve (56) are poppet valves each provided with a stem (44, 60), the two valves (40, 56) being coaxially (A2) arranged and in close vicinity, the second control chamber (68) being between the extremity of the filling valve stem (44) and the control valve (56) so that the volume of said second control chamber (68) is minimal.

2. Control valve arrangement (12) as set in the preceding claim wherein the communication channel (48) is provided with a restriction spill orifice (52) so that the fuel pressure decreases when entering the second control chamber (68).

3. Control valve arrangement (12) as set in claim 1 wherein the communication channel (48) axially (A2) extends throughout the filling valve (40).

4. Control valve arrangement (12) as set in any of the preceding claim wherein the filling channel (70) is provided with another restriction (72) arranged before the filling chamber (28).

5. Control valve arrangement (12) as set in any of the preceding claim wherein the first spring (46) is a coil spring arranged inside the filling chamber (28) around the stem (44) of the filling valve (40).

6. Control valve arrangement (12) as set in any of the preceding claim wherein the second spring (62) is a leaf spring having a relatively flat form, engaged around the stem (60) of the control valve (56).

7. Control valve arrangement (12) as set in any of the preceding claim wherein the filling valve (40) is provided with a lift stop (54) that limits the valve displacement between the open position and the closed position.

8. Control valve arrangement (12) as set in any of the preceding claim wherein the second valve seat (34) is arranged near the top of the valve housing (22) leaving a relatively thin wall (74) between said seat (34) and the low pressure chamber (36), said thin wall (74) being able to flex slightly under changes of pressure in the second control chamber (68) so that, the combination of a flexible seating, short and stiff control valve (56) and low volumes ensures that a good force signal is transmitted to the actuator caused by the control pressure increase after nozzle needle closure.

9. Fuel injector wherein a movable needle cooperates with a nozzle to enable or prohibit fuel injection, the needle being hydraulically piloted by a control valve arrangement as set in any of the preceding claim.

Patentansprüche

1. Steuerventilanordnung (12) eines Kraftstoffinjektors (10) mit einem Ventilgehäuse (22), in dem angeordnet sind ein Füllkanal (70), der sich von einer Hochdruckkraftstoffzufuhrleitung (20) zu einer Füllkam-

mer (28) erstreckt, die in einer ersten Fluidverbindung mit einer ersten Steuerkammer (24) ist, wobei die erste Fluidverbindung durch ein Füllventil (40) gesteuert wird, das normalerweise durch eine erste Feder (46) weg von einem in dem Ventilgehäuse (22) angeordneten ersten Sitz (26) geöffnet beeinflusst wird, und ein Verbindungskanal (48), der sich von der ersten Steuerkammer (24) zu einer zweiten Steuerkammer (68) erstreckt, die in einer zweiten Fluidverbindung mit einer Niederdruckauslassleitung (38) ist, wobei die zweite Fluidverbindung durch ein Steuerventil (56) gesteuert wird, das normalerweise durch eine zweite Feder (62) komplementär gegen einen in dem Gehäuse (22) angeordneten zweiten Sitz (34) geschlossen beeinflusst wird, wobei das Steuerventil (56) mit einem Aktuator (66) kooperiert, um von der normalerweise geschlossenen Position in eine offene Position zu wechseln, und eine Bohrung (18), in der ein Kolben (16) verschiebbar angeordnet ist, wobei der Kolben (16) die Einspritzung des Kraftstoffs in eine Kompressionskammer steuert, wobei die Bohrung (18) in einer dritten Fluidverbindung mit der ersten Steuerkammer (24) ist,
dadurch gekennzeichnet, dass sich die Bohrung (18) direkt in die erste Steuerkammer (24) öffnet, die dritte Fluidverbindung uneingeschränkt ist, das Volumen der zweiten Steuerkammer (68) minimal ist, und wobei
das Füllventil (40) und das Steuerventil (56) Tellerventile sind, die jeweils mit einem Schaft (44, 60) vorgesehen sind, wobei die zwei Ventile (40, 56) koaxial (A2) angeordnet und in unmittelbarer Nähe zueinander sind, wobei die zweite Steuerkammer (68) zwischen dem Ende des Füllventilschafts (44) und dem Steuerventil (56) angeordnet ist, so dass das Volumen der zweiten Steuerkammer (68) minimal ist.

2. Steuerventilanordnung (12) gemäß dem vorhergehenden Anspruch, wobei der Verbindungskanal (48) mit einer Begrenzungsaustrittsöffnung (52) vorgesehen ist, so dass der Kraftstoffdruck bei Eintreten in die zweite Steuerkammer (68) abnimmt.

3. Steuerventilanordnung (12) gemäß Anspruch 1, wobei sich der Verbindungskanal (48) axial (A2) durch das Füllventil (40) erstreckt.

4. Steuerventilanordnung (12) gemäß einem vorhergehenden Anspruch, wobei der Füllkanal (70) mit einer weiteren Begrenzung (72) vorgesehen ist, die vor der Füllkammer (28) angeordnet ist.

5. Steuerventilanordnung (12) gemäß einem vorhergehenden Anspruch, wobei die erste Feder (46) eine Schraubenfeder ist, die innerhalb der Füllkammer (28) um den Schaft (44) des Füllventils (40) angeordnet ist.

6. Steuerventilanordnung (12) gemäß einem vorhergehenden Anspruch, wobei die zweite Feder (62) eine Blattfeder mit einer relativ flachen Form ist, die um den Schaft (60) des Steuerventils (56) herum in Eingriff ist.

7. Steuerventilanordnung (12) gemäß einem vorhergehenden Anspruch, wobei das Füllventil (40) mit einem Hebestopp (54) vorgesehen ist, der den Ventilversatz zwischen der offenen Position und der geschlossenen Position begrenzt.

8. Steuerventilanordnung (12) gemäß einem vorhergehenden Anspruch, wobei der zweite Ventilsitz (34) in der Nähe des oberen Endes des Ventilgehäuses (22) angeordnet ist und eine relativ dünne Wand (74) zwischen dem Sitz (34) und der Niederdruckkammer (36) lässt, wobei sich die dünne Wand (74) unter Druckänderungen in der zweiten Steuerkammer (68) leicht biegen kann, so dass die Kombination eines flexiblen Sitzes, eines kurzen und steifen Steuerventils (56) und eines niedrigen Volumens sicherstellt, dass ein gutes Kraftsignal an den Aktor übertragen wird, das durch den Steuerdruckanstieg nach einem Schließen der Düsennadel verursacht wird.

9. Kraftstoffinjektor, wobei eine bewegliche Nadel mit einer Düse kooperiert, um eine Kraftstoffeinspritzung zu ermöglichen oder zu verhindern, wobei die Nadel hydraulisch durch eine Steuerventilanordnung gemäß einem vorhergehenden Anspruch gesteuert wird.

Revendications

1. Agencement de vanne de commande (12) d'un injecteur de carburant (10) comprenant un boîtier de vanne (22) dans lequel sont agencés un canal de remplissage (70) s'étendant depuis une ligne d'alimentation de carburant à haute pression (20) vers une chambre de remplissage (28) qui est dans une première communication fluidique avec une première chambre de commande (24), ladite première communication fluidique étant commandée par une vanne de remplissage (40) normalement sollicitée en ouverture, par un premier ressort (46), en éloignement d'un premier siège (26) agencé dans le boîtier de vanne (22), et un canal de communication (48) s'étendant depuis la première chambre de commande (24) jusqu'à une deuxième chambre de commande (68) qui est dans une deuxième communication fluidique avec une ligne de sortie à basse pression (38), ladite deuxième communication fluidique étant commandée par une vanne de commande (56) normalement sollicitée en fermeture, par un deuxième

ressort (62), en butée complémentaire contre un deuxième siège (34) agencé dans le boîtier (22), la vanne de commande (56) coopérant avec un actionneur (66) afin de commuter depuis la position normalement fermée vers une position ouverte et, un perçage (18) dans lequel un piston (16) est agencé en coulissement, le piston (16) pilotant l'injection du carburant jusque dans une chambre de compression, le perçage (18) étant dans une troisième communication fluidique avec la première chambre de commande (24),
caractérisé en ce que le perçage (18) ouvre directement sur la première chambre de commande (24), ladite troisième communication fluidique étant non restreinte, le volume de la deuxième chambre de commande (68) étant minimal, et dans lequel,
la vanne de remplissage (40) et la vanne de commande (56) sont des vannes champignon, chacune étant équipée d'une tige (44, 60), les deux vannes (40, 56) étant agencées coaxialement (A2) et dans une proximité intime, la deuxième chambre de commande (68) étant entre l'extrémité de la tige de la vanne de remplissage (44) et la vanne de commande (56) de telle manière que le volume de ladite deuxième chambre de commande (68) est minimal.

2. Agencement de vanne de commande (12) selon la revendication précédente, dans lequel le canal de communication (48) est muni d'un orifice de déversement avec restriction (52) de manière à ce que la pression du carburant diminue lorsque celui-ci entre dans la deuxième chambre de commande (68).

3. Agencement de vanne de commande (12) selon la revendication 1, dans lequel le canal de communication (48) s'étend axialement (A2) à travers la vanne de remplissage (40).

4. Agencement de vanne de commande (12) selon l'une quelconque des revendications précédentes, dans lequel le canal de remplissage (70) est muni d'une autre restriction (72) agencée avant la chambre de remplissage (28).

5. Agencement de vanne de commande (12) selon l'une quelconque des revendications précédentes, dans lequel le premier ressort (46) est un ressort hélicoïdal agencé à l'intérieur de la chambre de remplissage (28) autour de la tige (44) de la vanne de remplissage (40).

6. Agencement de vanne de commande (12) selon l'une quelconque des revendications précédentes dans lequel le deuxième ressort (62) est un ressort à lame ayant une forme relativement plate, engagé autour de la tige (60) de la vanne de commande (56).

7. Agencement de vanne de commande (12) selon l'une quelconque des revendications précédentes, dans lequel la vanne de remplissage (40) est munie d'une butée de levée (54) qui limite le déplacement de la vanne entre la position ouverte et la position fermée.

8. Agencement de vanne de commande (12) selon l'une quelconque des revendications précédentes, dans lequel le deuxième siège de vanne (34) est agencé à proximité du sommet du boîtier de vanne (22) laissant une paroi relativement mince (74) entre ledit siège (34) et la chambre à basse pression (36), ladite paroi mince (74) étant capable de fléchir légèrement en cas de fluctuations de pression dans la deuxième chambre de commande (68) de sorte que la combinaison entre une vanne de commande courte et rigide, à siège flexible, (56) et de faibles volumes, fait en sorte qu'un bon signal de force est transmis à l'actionneur résultant de de l'augmentation de la pression commandée après la fermeture du pointeau de la buse.

9. Injecteur de carburant dans lequel un pointeau mobile coopère avec une buse pour permettre ou empêcher l'injection de carburant, le pointeau étant piloté hydrauliquement par un agencement de vanne de commande selon l'une quelconque des revendications précédentes.

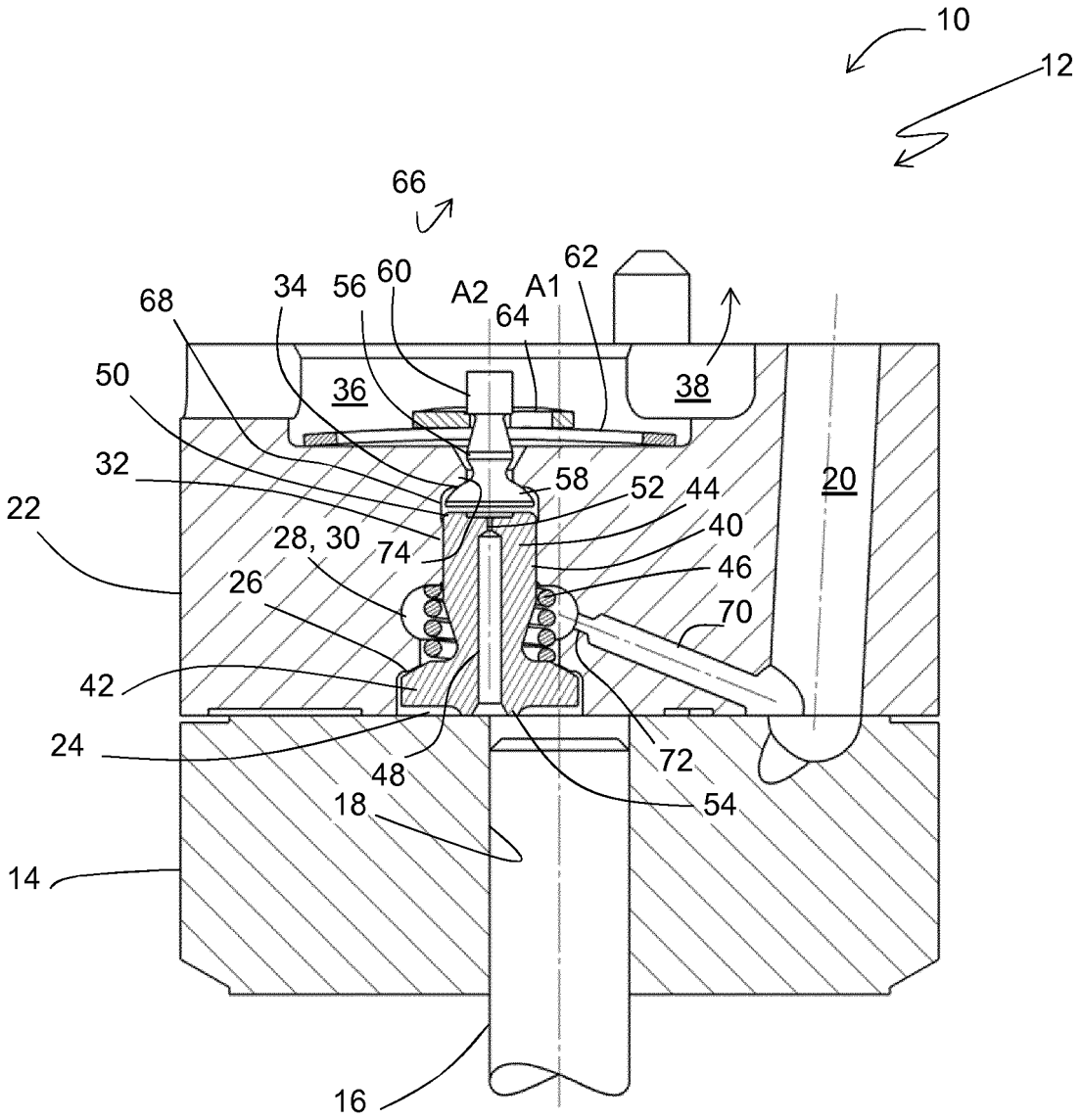
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Figure 1

REFERENCES CITED IN THE DESCRIPTION

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