Title: A PROPORTIONAL HYDRAULIC SOLENOID VALVE

Abstract: The solenoid valve (1) comprises a body (2) in which a valve seating (6) extends between an inlet (3), connected to a source of liquid under pressure, and an outlet (4) ; a diaphragm (7) which has a peripheral portion (7a) attached to the body (2), an intermediate portion (7b) which separates the inlet (3) from a control chamber (12) opposite the valve seating (6) with respect to the diaphragm (7), and a central portion (7c) with which is associated a main closure (7c, 9) which cooperates with the seating (6) and in which at least one discharge aperture (10, 11) is formed capable of placing the control chamber (12) in communication with the outlet (4) ; a narrow passage (13) arranged to place the inlet (3) in communication with the control chamber (12) ; a control closure (16) fitted movably in the body (2), in a passage (17) which opens into the control chamber (12) positioned so as to face the discharge passage (10, 11) of the main closure (7c, 9) ; a control solenoid (19) integral with the body, and an associated moving armature (21) arranged in the abovementioned passage (17), at the opposite end to the main closure (7c, 9) with respect to the control closure (16) ; and a spring (15) tending to press the control closure (16) into a rest position in which it is at a distance from the discharge passage (10, 11) of the main closure (7c, 9).
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Proportional hydraulic solenoid valve

The present invention relates to a hydraulic solenoid valve of the proportional type.

More specifically, the subject of the invention is a proportional hydraulic solenoid valve which can be used to control a flow of water, in particular of hot water, in a mixer unit, for example for a wall-mounted water heater or similar, or in a washing machine or dishwasher.

The solenoid valve according to the invention comprises
- a body in which a valve seating extends between an inlet channel, connected in operation to a source of liquid under pressure, and an output channel;
- a diaphragm which has a peripheral portion attached to the body, an intermediate portion which separates the inlet channel from a control chamber formed in the body on the opposite side to the valve seating, with respect to the diaphragm, and a central portion with which is associated a main closure which cooperates with said valve seating and in which at least one discharge aperture is formed, capable of placing the control chamber in communication with said outlet channel;
- at least one narrow passage arranged to place the inlet channel in communication with the control chamber;
- a control closure fitted movably in the body, in a passage which opens into the control chamber, positioned so as to face the discharge passage of the main closure;
- an electromagnetic actuator comprising a control solenoid which is integral with the body and which extends around the direction of movement of the control closure, arranged in the above-mentioned passage, on the opposite side
to the main closure with respect to the control closure; and a spring means tending to push the closure into a rest position in which it is at a distance from the discharge passage of the main closure;

the arrangement being such that when, in operation, the control solenoid is de-energized, the control closure assumes a retracted rest position under the action of the associated spring means and the liquid under pressure in the inlet channel is capable of pushing the main closure towards the control closure, into a fully open position in which said main closure uncovers the associated valve seating and allows a flow of liquid at maximum delivery rate between the inlet channel and the outlet channel, and when the solenoid is energized, the armature pushes the control closure to a partially extended position in which it limits the distance between the main closure and said valve seating, so that the main closure is then capable of allowing a flow of liquid between the inlet channel and the outlet channel at a reduced delivery rate corresponding to the value of the mean current with which said solenoid is energized.

Furthermore, the invention relates to a valve unit comprising a proportional solenoid valve of the type specified above and a solenoid shut-off valve, that is of the on/off type, connected at an earlier point, that is at the input to this proportional solenoid valve.

Other characteristics and advantages of the invention will become clear from the following detailed description which is given purely by way of non-limiting example, with reference to the appended drawing, which is a partial view in axial cross-section of a solenoid valve according to the invention.
In the drawing, the number 1 indicates as a whole a proportional hydraulic solenoid valve according to the present invention.

As will become clear from what follows, this solenoid valve is of the normally open type.

The solenoid valve 1 comprises a body indicated as a whole by the number 2 which in the example illustrated is produced in two parts 2a, 2b connected to each other so as to form a liquid-tight joint.

In the body 2 of the solenoid valve are formed an inlet channel 3, connected in operation (in a manner which is not shown) to a source of liquid under pressure, and an outlet channel 4.

An annular wall 5 extends between the channels 3 and 4, and at the top forms a valve seating 6.

The solenoid valve 1 also comprises a diaphragm indicated as a whole by the number 7, for example of elastomer material. This diaphragm has a peripheral portion 7a attached to the body 2, an intermediate portion 7b, and a central annular portion 7c. This last portion of the diaphragm has a central aperture 8 having a rigid body 9 of substantially annular form inserted into and retained in it. This body 9 forms an axial discharge passage 10 coaxial with the aperture 8 in the diaphragm 7. The upper end portion of the channel 10 has a reduced diameter and at the top opens into a valve seating 11 in the body 9.

The intermediate portion 7b of the diaphragm 7 separates the
inlet channel 3 from a control chamber 12 formed in the body 2 on the opposite side to the valve seating 6 with respect to the diaphragm.

The channel 10 is capable of placing the control chamber 12 in communication with the outlet channel 4.

In the intermediate portion 7b of the diaphragm 7 is arranged at least one narrow aperture 13 which places the inlet channel 3 in communication with the control chamber 12. In the example illustrated, the diaphragm has two such narrow apertures 13. In any case the narrow aperture or apertures in the diaphragm 7 advantageously have a cross-section smaller in total than the cross-section of the passage in the upper end portion of the channel 10 produced in the body 9.

The narrow aperture or apertures in question may moreover also be produced in the central portion 7c or in the peripheral portion 7a of the diaphragm, or again may be produced in the body 2, in the form of one or more by-pass channels between the inlet channel 3 and the control chamber 12.

The upper portion 2b of the body 2 of the solenoid valve has an integral tubular formation 2c with a substantially vertical axis, the upper end 2d of which is closed, and the lower end of which opens into the control chamber 12, positioned so as to face the discharge passage 10 which passes through the central portion 7c of the diaphragm 7 which functions as the main closure associated with the valve seating 6.

In particular, in the embodiment illustrated by way of
example, an annular reaction element 14 having a limited axial extension is secured in the lower end 2e of the tubular formation 2c. A helical spring 15 bears upon this reaction element 14 and its upper end is seated under the head portion 16a of a control closure indicated as a whole by the number 16. This control closure 16 is fitted slidably in the passage 17 formed inside the tubular portion 2c of the body, and the spring 15 tends to keep it in the raised or retracted position shown in the drawing in which its lower end is at a distance from the seating 11 associated with the discharge passage 10 of the main closure 7c/9.

The operating position of the control closure 16 relative to the body 2 of the solenoid valve is controlled by means of an electromagnetic actuator indicated as a whole by the number 18. This actuator comprises a control winding or solenoid 19 carried by a spool 20 secured around the formation 2c of the solenoid valve body. The control solenoid 19 is substantially coaxial with the direction of movement of the control closure 16.

The actuator 18 also comprises a movable magnetic armature 21 arranged in the passage 17 in the tubular formation 2c, on the opposite side to the main closure 7c/9 with respect to the control closure 16.

At rest, that is with the solenoid 19 de-energized, the spring 15 holds the control closure 16 and the associated movable armature 21 in the position illustrated in the drawing.

In use, the inlet channel 3 of the solenoid valve 1 is connected to a source of liquid under pressure, while the
outlet channel 4 is connected to a consumer device.

At rest, that is with the solenoid 19 de-energized, the pressure of the liquid in the inlet channel 3 pushes the diaphragm and therefore the main closure 7c towards the control closure 16 which is in the retracted state illustrated in the drawing. In this state the solenoid valve is fully open: the main closure 7c uncovers the valve seating 6 and allows a flow of liquid between the inlet channel and the outlet channel 4 at maximum delivery rate.

When the solenoid 19 is energized, that is has an electric current with a predetermined mean value passing through it, the magnetic field generated by this solenoid causes the armature 21 and the control closure 16 to descend against the reaction force of the spring 15.

The control closure 16 is thus pushed into a partially extended position, in which it projects into the control chamber 12, limiting the distance between the main closure 7c and the associated valve seating 6, so that this main closure 7c is capable of then allowing a flow of liquid between the inlet channel 3 and the outlet channel 4 at a reduced delivery rate having a value corresponding to the value of the mean current flowing in the solenoid 19.

When the current intensity supplied to the solenoid 19 is varied, the rate of delivery of the liquid allowed between the inlet channel 3 and the outlet channel 4 varies accordingly.

At maximum, the solenoid 19 may be energized with a current intensity such as to cause the liquid from the inlet channel
3 to the outlet channel 4 to be shut off completely.

In any case, when the energising current supplied to the solenoid 19 is varied, the position of the main closure 7c relative to the valve seating 6 varies both due to the effect of the change in position of the control closure 16 which is pushed by the movable armature 21, and due to the effect of the pressure which the liquid present in the control chamber 12 exerts on the diaphragm 7 and on the exposed surface of the body 9. In other words, the liquid present in the control chamber 12 has the effect of assisting the movement of the main closure.

A shut-off solenoid valve of the on/off type may be connected the inlet of a proportional solenoid valve of the type described above, to form as a whole a solenoid valve unit capable by means of the shut-off solenoid valve to allow or prevent a flow of fluid and, by means of the proportional solenoid valve, to control the rate of delivery of this flow.

Naturally, the principle of the invention remaining the same, the forms of embodiment and details of construction may be varied widely with respect to those described and illustrated purely by way of non-limiting example, without thereby departing from the scope of the invention as defined in the appended claims.

Thus for example, slots may be made in the valve seating 6 or in the associated closure 7c so that even when the main closure 7c bears upon this seating, a minimum predetermined flow of liquid can flow between the inlet channel and the outlet channel.
CLAIMS

1. A proportional hydraulic solenoid valve (1) comprising
   - a body (2) in which a valve seating (6) extends between an inlet channel (3), connected in operation to a source of liquid under pressure, and an outlet channel (4);
   - a diaphragm (7) which has a peripheral portion (7a) attached to the body (2), an intermediate portion (7b) which separates the inlet channel (3) from a control chamber (12) formed in the body (2) on the opposite side to the valve seating (6) relative to the diaphragm (7), and a central portion (7c) with which is associated a main closure (7c, 9) which cooperates with said valve seating (6) and in which at least one discharge aperture (10, 11) is formed capable of placing the control chamber (12) in communication with said outlet channel (4);
   - at least one narrow passage (13) arranged to place the inlet channel (3) in communication with the control chamber (12);
   - a control closure (16) are fitted movably in the body (2), in a passage (17) which opens into the control chamber (12) positioned so as to face the discharge passage (10, 11) of the main closure (7c, 9);
   - an electromagnetic actuator (18) comprising a control solenoid (19) which is integral with the body and which extends around the direction of movement of the control closure (16), and a moving armature (21) arranged in the above-mentioned passage (17), on the opposite side to the main closure (7c, 9) with respect to the control closure (16); and
   - spring means (15) tending to push the control closure (16) into a rest position in which it is at a distance from the discharge passage (10, 11) of the main closure (7c, 9);
the arrangement being such that when, in operation, the control solenoid (19) is de-energized, the control closure (16) assumes a retracted rest position under the action of the associated spring means (15) and the liquid under pressure in the inlet channel (3) is capable of pushing the main closure (7c, 9) towards the control closure (16), into a fully open position in which the main closure (7c, 9) uncovers the valve seating (6) and allows a flow of liquid at maximum delivery rate between the inlet channel (3) and the outlet channel (4), and when the solenoid (19) is energized the armature (21) pushes the control closure (16) towards a partially extended position, in which it limits the distance between the main closure (7c, 9) and said valve seating (6), so that the main closure (7c, 9) is capable of then allowing a flow of liquid between the inlet channel (3) and the outlet channel (4) at a reduced rate of delivery having a value corresponding to the value of the mean current with which said solenoid (19) is energized.

2. A proportional hydraulic solenoid valve according to claim 1, in which said at least one narrow passage (13) is produced in the diaphragm (7).

3. A proportional hydraulic solenoid valve according to claim 2, in which said that least one narrow passage (13) is produced in the intermediate portion (7b) of the diaphragm (7).

4. A proportional hydraulic solenoid valve according to any one of the preceding claims, in which said seating (6) and/or the main closure (7c) has one or more slots such that when the main closure (7c) bears upon said seating (6), a minimum delivery of liquid can flow between the inlet channel (3) and
the outlet channel (4).

5. A valve unit, comprising a solenoid valve according to one or more of the preceding claims to the inlet of which a shut-off valve is connected.
**INTERNATIONAL SEARCH REPORT**

A. **CLASSIFICATION OF SUBJECT MATTER**

IPC 7 F16K31/10 F16K31/06 F16K31/40

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)

IPC 7 F16K G05D B60T

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

EPO-Internal, PAJ, WPI Data

C. **DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>US 2 705 608 A (PHILLIPS GLENN M) 5 April 1955 (1955-04-05) column 1, line 33 - line 37 column 1, line 71 - column 3, line 10; figures</td>
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* Further documents are listed in the continuation of box C.  
* Patent family members are listed in annex.

**SPECIAL CATEGORIES OF CITED DOCUMENTS:**

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**Date of the actual completion of the international search**

27 October 2005

**Date of mailing of the international search report**

16/11/2005

**Name and mailing address of the ISA**

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