

(54) Title: A LIQUID FLOW CONTROL ASSEMBLY

(57) Abstract

Liquid flow through a passage (9) in a body member (7) is controlled by a relatively movable poppet valve member (8). A frusto-conical first guide surface (11) on the poppet valve (8) merges smoothly with a second guide surface (12 and 13) which, in cross-section, has part-circular portion (12) and an outlet end (13). Liquid passing through an aperture (10) between the body member (7) and the poppet valve member (8) flows along the first guide surface (11) and the second guide surface (12 and 13) and adopts a toroidal vortex flow pattern and this controls the collapse of those bubbles which form as a result of cavitation so as to diminish audible and inaudible vibrations.
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A Liquid Flow Control Assembly

Technical Field
The invention relates to a device for the flow controlling elements of valves and other similar devices employed in hydraulic systems, so constructed as to reduce the noise, mechanical vibration and pressure fluctuation generated within such devices.

Background Art
It is known to provide a liquid flow control assembly in which a body member, providing at least one passage, and a closure member are relatively movable between a first condition in which the closure member prevents flow of liquid through the or each passage and a second condition in which the body member and the closure member define at least one aperture for the flow of liquid between the body member and the closure member.

Thus, many devices used within a hydraulic system employ means whereby the pressure or flow rates of the system working fluid is controlled by passing the working fluid through a narrow aperture. The control of fluid pressure or flow may form part or the whole of the function of the device.

Commonly, the aperture is formed by an annular gap between a cone and a circular orifice concentric with the axis of the cone and of diameter less than the base diameter of the cone. Variation in the flow area available through the annular gap is commonly achieved by movement of the cone and orifice relative to one another along the axis of the cone. Such an arrangement is often referred to as a "cone and seat", "plug and seat", "poppet valve" or "globe valve" assembly.

Alternatively, the narrow aperture hereinabove mentioned may be formed by the circumferential gap between the end of a cylinder and openings formed in a close fitting sleeve around the cylinder. Variation in the flow area available through the openings in the
sleeve may be achieved by relative movement of the sleeve and cylinder along the cylinder axis, such that the cylinder covers a greater or smaller part of the sleeve openings. Such an arrangement is commonly referred to as a "spool and sleeve valve" assembly.

As a further alternative, the narrow aperture hereinbefore mentioned may be formed by the crescent shaped gap between a circular conduit and a circular plate partially blocking off this conduit. Variation in the flow area may be achieved by movement of the circular plate along a line perpendicular to the axis of the conduit. Such an arrangement is commonly referred to as a "gate valve" assembly.

It is a known feature of "poppet valve", "spool and sleeve valve" and "gate valve" assemblies that high fluid velocities can occur in the region of the aperture between the body member and the closure member comprising the controlling elements and that this results in low local pressures in the fluid after it has passed through the aperture. Gas and vapour bubbles commonly form in this region, giving rise to cavitation which is frequently in the form of a "plume" of cavitation bubbles emerging from the assembly.

The presence of cavitation within a hydraulic device may result in noise, mechanical vibration, fluid pressure fluctuations, and physical damage. It is therefore desirable that the shapes of the pressure or flow controlling elements within any hydraulic device be such as to reduce as far as possible the tendency for cavitation to occur and to control and contain any cavitation "plume" that may form. It is also desirable that the flow or pressure controlling elements of a hydraulic device be so formed as to reduce the tendency for "instability", or low frequency oscillation, of the controlling elements.

Disclosure of the Invention

It is intended, by means of the invention, to provide a liquid flow control assembly with which it is possible to control and contain any cavitation bubbles formed at a body member and a closure member which
are movable into and out of a first condition in which liquid flow is prevented, thereby reducing the noise output from, and potential cavitation damage to, the assembly.

This is achieved by providing a first guide surface downstream of an aperture defined by the first and second parts, when in a second condition, for liquid flow therebetween; and a second guide surface for directing liquid flowing along the first guide surface into a vortex flow path.

The second guide surface is so shaped as to cause a vortex to form in the fluid emerging from the aperture and the process by which the reduction in cavitation noise is effected is thought to be by centrifugal action in the rapidly spinning vortex which causes cavitation bubbles to migrate away from the outside solid boundary of the vortex (thereby reducing structural noise and damage) and also tends to promote continuous accumulation and merging together of cavitation bubbles rather than discrete bubble collapse, thereby reducing both the level and frequency of the fluid borne noise generated. The shape and position of the second guide surface is such that the forces imposed upon it by the fluid emerging from the aperture tend to counteract the flow forces acting on the first and second parts, thereby reducing the tendency for low frequency instability of the assembly.

It is a specific characteristic of the invention that control over fluid pressure or flow, and the loss of fluid energy associated with this control, is caused by the first and second parts and the aperture between them, not by the fluid vortex formed in the emerging fluid.

Conveniently, the second guide surface for generating the fluid vortex may be provided by shaping one or other of the body member and closure member to a form which takes as design parameters the velocity and vapour pressure of the liquid emerging from the aperture between the body member and the closure member.
The first and second guide surfaces preferably merge smoothly with each other and the second guide surface is preferably concave and, in each section which contains the axis of the body member and passes perpendicularly through the second guide surface, has a part-circular portion and an outlet end.

Where the first guide surface forms part of the conical surface of a poppet valve then, in any radial section containing the axis of the passage with which the poppet valve cooperates, the first guide surface extends tangentially of the second guide surface. In all other cases, where the first guide surface is concave and, in each section which contains the axis of the body member and the axis of the passage and passes through the second guide surface, the first and second guide surfaces merge at a point of common tangency.

Where the closure member is a poppet valve member, the first guide surface may be formed on the poppet valve member as a surface of revolution which extends divergently downstream of the aperture. An extension of this surface may project convergently inwards so as to lie within the liquid conduit.

Alternatively, the first guide surface may be provided on the body member which provides the passage. In either case, the second guide surface may be formed on one of the two members other than the one on which the first guide surface is formed and this second guide surface may face and conform to the first guide surface.

The second guide surface may be provided on guide means which surround the first guide surface. These guide means may be formed integral with whichever of the first and second parts on which the first guide surface is formed or may be formed on one or more detachable parts.

In another embodiment of the invention, the body member, such as a sleeve, has a bore; the or each passage is provided by an inlet port each of which extends on a radial axis perpendicular to the axis of
the bore and opens into the bore; at least one outlet port is formed in the body member, on a radial axis perpendicular to the axis of the bore, and opens into the bore; the closure member is a spool which is reciprocable within the bore; the spool has a cylindrical land which blocks the inlet port when the assembly is in its first condition and clears at least part of the inlet port when the assembly is in its second condition; a circumferential groove formed in said spool, adjacent the cylindrical land, overlaps at least part of said inlet port and at least part of said outlet port when the assembly is in its second condition; the first guide surface is a surface of revolution extending from said cylindrical land and forms a first part of the cylindrical groove; and the second guide surface is a surface of revolution extending from said first guide surface and forms a second part of the cylindrical groove.

Where the spaced radial axes lie in two axially spaced radial planes, additional inlet and outlet ports may be provided on axes lying in said planes.

In a further embodiment, the body member is a gate valve body providing a passage and having upstream and downstream ends and an integral sealing surface; the closure member is a gate valve member having a sealing edge and is reciprocable on an axis perpendicular to the axis of the gate valve body between a position in which the sealing edge engages the sealing surface, when the assembly is in its first, i.e. closed, condition, and a position in which the sealing edge is spaced from the sealing surface, when the assembly is in its second, i.e. open, condition; a formation is provided within the gate valve body on the downstream side of the sealing surface, on the gate valve body, adjacent that part of the gate valve body to which the gate valve member moves when moving into the position the gate valve member occupies when the sealing edge engages the sealing surface and the assembly is in its first condition; the first guide surface is formed on said formation and extends from the sealing surface; and the second guide surface is formed on said formation and extends from said first guide surface.
Six embodiments of the invention are hereinafter described, by way of example, with reference to the accompanying drawings.

**Brief Description of the Drawings**

Figure 1 is a schematic sectional side elevation of a poppet valve assembly in accordance with the invention;

Figure 2 is a schematic sectional side elevation of a practical embodiment of the poppet valve assembly shown in Figure 1;

Figure 3 is a schematic sectional side elevation of a spool and sleeve valve assembly, in accordance with the invention;

Figure 4 is an axial section of the assembly shown in Figure 3, taken across the Section IV - IV;

Figure 5 is a schematic sectional side elevation of a practical embodiment of the spool and sleeve valve assembly shown in Figures 3 and 4;

Figure 6 is a schematic sectional side elevation of a valve assembly similar to the construction illustrated in Figures 3 and 4;

Figure 7 is an axial section of the assembly shown in Figure 6, taken across the section VII-VII; and

Figure 8 is a schematic sectional side elevation of a gate valve assembly in accordance with the invention.

**Modes for Carrying out the Invention**

As shown in Figure 1, a poppet valve assembly 1 comprises a tubular body member 7, providing a liquid passage 9, and a closure member in the form of a poppet valve member 8. The poppet valve member 8 and the tubular body member 7 are relatively movable along the axis 14 of the liquid passage 9 to block the liquid passage 9 or to vary the size of the annular aperture 10 between the tubular body member 7 and
the poppet valve member 8.

As shown, the poppet valve member 8 has a frusto-conical surface 11 part of which extends divergently away from the aperture 10 and part of which projects convergently into the liquid passage 9.

5 As shown in the sectional view illustrated in Figure 1, the first guide surface 11 is tangential to a second guide surface 12 and 13 which has a part-circular portion 12 and an outlet end 13 directed towards a third guide surface 16 formed on the body member 7.

Thus, when the aperture 10 is narrow enough to promote cavitation of the liquid flowing through the aperture 10, this liquid flows along the first guide surface 11, then around the second guide surface 12 and 13, and thereafter follows a toroidal vortex flow pattern before flowing away from the assembly. This permits the collapse of any bubbles which are formed in such a way that there is a diminution in audible and inaudible vibration.

As shown, the second guide surface 12 and 13 is formed on guide means 17 which are integral with the poppet valve member 8. However, these guide means 17 may be in the form of one or more separable parts and, moreover, where the first guide surface 11 is provided on the tubular body member 7, the guide means providing the second guide surface 12 and 13 may be formed integral with or attached to the tubular body member 7.

When the tubular body member 7 and the poppet valve member 8 are sufficiently separated to ensure that there is no cavitation in the liquid flowing through the aperture 10, only part of this liquid flows along the first guide surface 11 and, from there, around the second guide surface 12 and 13. The remainder of the liquid is unimpeded and escapes freely from the assembly.

In the practical embodiment of the poppet valve assembly 2, shown in
Figure 2, the second guide surface 12 and 13 is semi-circular in cross-section and the third guide surface 16 extends perpendicular to the first guide surface 11, and therefore perpendicular to the outlet end 13 of the second guide surface 12 and 13, and is tangential to an imaginary circle conforming to the second guide surface 12 and 13. Surfaces 29 and 30 extend divergently away from the third guide surface 16 to facilitate flow of liquid from the passage 9.

In modifications of the embodiment shown in Figure 2, the second guide surface 12 and 13 includes a part-circular portion which leads from the first guide surface 11 and extends through less than 180°, for high flow rate applications. In this case, the third guide surface 16 extends perpendicular to the outlet end 13 of the second guide surface 12 and 13 and so is no longer perpendicular to the first guide surface 11.

The edge 31 of the body member 7 which cooperates with the closure member 8 to define the aperture 10 may be bevelled to provide a small flat surface.

In the spool and sleeve valve assembly 3 shown in Figures 3 and 4, a body member in the form of a sleeve 7 is formed with a bore 18, four inlet ports 9, constituting liquid passages, and four outlet ports 19. The inlet ports 9 and the outlet ports 19 lie, respectively, on radial axes 15 and 20 respectively defining planes which extend perpendicular to the axis 14 of the sleeve 7 and which are spaced apart along this axis 7. However, these ports 9 and 19 need not be circular in cross-section and may comprise circumferentially extending slots.

The closure member is in the form of a spool 8 which is formed with a cylindrical land 21, at one end, and a circumferential groove 22, adjacent the cylindrical land 21.

The spool 8 is reciprocable along the axis 14 of the sleeve 7 between a position in which the cylindrical land 21 blocks the inlet ports 9
and a position in which the groove 22 overlaps both the inlet ports 9 and the outlet ports 19 so as to permit liquid to flow into the groove 22, through the inlet ports 9, and out of the groove 22, through the outlet ports 19.

As shown, a first guide surface 11, in the form of a surface of revolution, extends from the cylindrical land 21 and forms a first part of the circumferential groove 22 and a second guide surface 12 and 13, in the form of a surface of revolution, extends from the first guide surface 11 and forms a second part of the circumferential groove 22. As shown, in the sectional elevation illustrated in Figure 3, the first guide surface 11 and the second guide surface 12 and 13 are concave and the second guide surface 12 and 13 is part-circular.

Thus, when the spool 8 is moved to a position in which the groove 22 overlaps each inlet port 9 to provide an aperture 10 which is sufficiently small to cause liquid flowing through the inlet port 9 into the circumferential groove 22 to cavitate, the collapse of cavitation bubbles which are formed is effected with a diminution in audible and inaudible vibration by causing the liquid to flow along the first guide surface 11 and the second guide surface 12 and 13, which meet at a point of common tangency, so as to adopt a toroidal vortex flow pattern before discharging through the outlet ports 19.

When each aperture 10 is sufficiently large to ensure that there is no cavitation, only part of the liquid entering the circumferential groove 22 through the inlet ports 9 flows around the first guide surface 11 and the second guide surface 12 and 13. The remainder of this liquid flows unimpeded through the circumferential groove 22 and out through the outlet ports 19.

In the practical embodiment of the spool valve assembly 4, shown in Figure 5, the groove 22 has first and second parts formed, respectively, by the first guide surface 11 and by the second guide
surface 12 and 13 as well as a third part formed by the surface 23 of a necked-down portion of the spool 8. First guide surface 11 is inclined at an angle 0 to a plane perpendicular to the axis 14 of the bore 18 and, in accordance with established spool valve theory, $\theta$ equals $69^\circ$.

In each axial cross-section, the second guide surface 12 and 13 has a part-circular portion 12, extending through less than $180^\circ$, and a radially extending outlet end 13 which is tangential to the part-circular portion 12 and perpendicular to the third guide surface 16, forming part of the bore 18 of the sleeve 7 which is tangential to an imaginary circle conforming to the part-circular portion 12 of the guide surface 12 and 13.

The spool valve assembly 5 shown in Figures 6 and 7 is similar to the spool and sleeve valve assemblies 3 and 4 shown, respectively, in Figures 3 and 4 and in Figure 5. However, in this case the bore 18 is formed in a body member 7 which is not a sleeve. Moreover, the inlet ports 9 communicate with a circumferential groove 23 formed in the internal surface of the bore 18. In this case the aperture 10 is cylindrical in shape.

It is to be understood that the outlet ports 19 may also communicate with a circumferential groove in the internal surface of the bore 18. Similarly, it is also to be understood that the assemblies 3 and 4 illustrated in Figures 3 and 4 and in Figure 5 may also be modified by the provision of a circumferential groove in the internal surface of the bore 18 for communication with the inlet ports 9 and/or the outlet ports 19.

In the gate valve assembly 6, shown in Figure 8, a body member in the form of a gate valve body 8 has upstream and downstream ends 24 and 25 and a liquid passage 9 extending along an axis 14. A closure member in the form of a gate valve member 9 is reciprocable perpendicular to the axis 14 in a groove 32 formed in the inner surface of the gate valve body 7. The groove 32 has an internal
sealing surface 26 and a sealing edge 27 on the gate valve body 9 engages the sealing surface 26 to prevent the flow of liquid along the liquid passage 9 when the gate valve member 8 is in its closed position and the assembly 6 is in its first condition.

To control cavitation when the gate valve member 8 is moved away from its closed position, to form a crescent shaped aperture 10 between the sealing surface 26 and the sealing edge 27, a formation 28 is provided on the gate valve body 7, adjacent that part of the gate valve body 7 to which the gate valve member 8 moves when moving into the position the gate valve member 8 occupies when the sealing edge 27 engages the sealing surface 26 and the assembly 6 is in its first condition.

As shown in the sectional elevation illustrated in Figure 8, a first guide surface 11 is formed on the formation 28 and extends from the sealing surface 26 and this first guide surface 11 merges smoothly with a second guide surface 12 and 13, which has part circular portion 12, at a point of common tangency.

Thus, when the gate valve member 8 is moved out of its closed position, the collapse of cavitation bubbles which form is effected with a diminution in audible and inaudible vibration as a result of the fact that the liquid flows around the first guide surface 11 and the second guide surface 12 and 13 so as to adopt a vortex flow pattern before flowing over the formation 28 and then along the passage 9. To facilitate this flow of liquid over the formation 28, a rebate 33 is formed in the downstream side of the gate valve member 8.

When the gate valve member 8 is moved sufficiently from its closed position to ensure that there is no cavitation in the liquid flowing through the aperture 16, only part of this liquid flows along the first guide surface 11 and the second guide surface 12 and 13; the remainder flows unimpeded over the formation 28.
In each of the embodiments, the exact form of the first guide surface 11 and the second guide surface 12 and 13 and the members which provide these guide surfaces will vary with the size and function of the assembly and, as described with reference to assembly 1, illustrated in Figure 1, the means providing the first and second guide surfaces may be formed integral with or separable from the body member and closure member of the assembly.
Claims

1. A liquid flow control assembly (1 to 6) in which a body member (7), providing at least one passage (9), and a closure member (8) are relatively movable between a first condition in which the closure member (8) prevents flow of liquid through the or each passage (9) and a second condition in which the body member (7) and the closure member (8) define at least one aperture (10), to control the flow of liquid between the body member (7) and the closure member (8); characterised in that:

a first guide surface (11) is provided downstream of said aperture (10); and

a second guide surface (12 and 13) is provided for directing liquid flowing along the first guide surface (11) into a vortex flow path.

2. An assembly (1 to 6), according to Claim 1, in which the first guide surface (11) and the second guide surface (12 and 13) merge smoothly with each other.

3. An assembly (1 to 6), according to Claim 2, in which the second guide surface (12 and 13) is concave and, in each section which contains the axis (14) of the body member (7) and the axis (14 or 15) of a passage (9) provided by the body member (7) and passes through the second guide surface (12 and 13), the second guide surface (12 and 13) includes at least a part-circular portion (12) which extends from the first guide surface (11).
4. An assembly (2 or 4), according to Claim 3, in which:

a third guide surface (16) is spaced from the second guide surface (12 and 13); and

the second guide surface (12 and 13) has an outlet end (13) directed perpendicularly towards the third guide surface (16).

5. An assembly (3, 5 or 6), according to Claim 3, in which the first guide surface (11) is concave and, in each section which contains the axis (14 or 15) of the liquid passage (9) and passes perpendicularly through the second guide surface (12 and 13), the first guide surface (11) and the second guide surface (12 and 13) merge at a point of common tangency.

6. An assembly (1 or 2), according to Claim 3, in which in each section which contains the axis (14 or 15) of the liquid passage (9) and passes perpendicularly through the second guide surface (12 and 13), the first guide surface (11) extends rectilinearly and is tangential to the second guide surface (12 and 13).

7. An assembly (1 or 2), according to Claim 6, in which:

the closure member (8) is a poppet valve member; and

the first guide surface (11) is frusto-conical in shape.

8. An assembly (2), according to Claim 7, in which:
in each section which contains the axis (14) of the body member (7) and passage (9), the second guide surface (12 and 13) comprises a semi-circular portion (12) with an outlet end (13); and

a third guide surface (16) extends perpendicular to the first guide surface (11) and tangential to an imaginary circle conforming to the semi-circular portion (12) of the second guide surface (12 and 13).

9. An assembly (1 or 2), according to Claim 5 or Claim 6, in which:

the closure member (8) is a poppet valve member; and

10 the first guide surface (11) is a surface of revolution which extends divergently from said aperture (10).

10. An assembly (1 or 2), according to any one of Claims 7 to 9, in which the first guide surface (11) is provided on the poppet valve member (8) and the second guide surface (12 and 13) is provided on guide means (17) surrounding the first guide surface (11).

11. An assembly (3, 4 or 5), according to Claim 5 or Claim 6, in which:

the body member (7) has a bore (18);

20 the or each passage (9) is provided by an inlet port each of which extends on a radial axis (15) perpendicular to the axis (14) of the bore (18) and opens into the bore (18);
at least one outlet port (19) is formed in the body member (7), on a radial axis (20) perpendicular to the axis (14) of the bore (18), and opens into the bore (18);

the closure member (8) is a spool which is reciprocable within the bore (18);

the spool (8) has a cylindrical land (21) which blocks the inlet port (9) when the assembly (3, 4 or 5) is in its first condition and clears at least part of the or each inlet port (9) when the assembly (3, 4 or 5) is in its second condition;

a circumferential groove (22) formed in said spool (8), adjacent the cylindrical land (21), overlaps at least part of the or each inlet port (9) and at least part of the or each outlet port (19) when the assembly (3, 4 or 5) is in its second condition;

the first guide surface (11) is a surface of revolution extending from said cylindrical land (21) and forms a first part of the circumferential groove (22); and

the second guide surface (12 and 13) is a surface of revolution extending from said first guide surface (11) and forms a second part of the circumferential groove (22).

12. An assembly (4), according to Claim 11, in which:

the circumferential groove (22) has a third part provided by the surface (23) of a necked-down portion of the spool (8);

in each section which contains the axis (14) of the bore (18), the first guide surface (11) is inclined to a plane perpendicular to the axis of the bore (18);
the part-circular portion (12) of the second guide surface (12 and 13) extends through less than 180°;

the second guide surface (12 and 13) has a radially extending outlet end (13) which is tangential to the part-circular portion (13); and

a third guide surface (16) forming part of the bore (18), extends perpendicular to the outlet end (13) of the second guide surface (12 and 13) and tangential to an imaginary circle conforming to the part-circular portion (12) of the second guide surface (12 and 13).

13. An assembly (5), according to Claim 12, in which the inlet port (9) communicates with a circumferential groove (23) formed in the internal surface of the bore (18).

14. An assembly (6), according to any one of Claims 1 to 3 and 5, in which:

the body member (7) is a gate valve body providing a passage (9) and having upstream and downstream ends (24 and 25) and an internal sealing surface (26);

the closure member (8) is a gate valve member having a sealing edge (27) and is reciprocable on an axis perpendicular to the axis (14) of the gate valve body (7) between a position in which the sealing edge (27) engages the sealing surface (26), when the assembly (6) is in its first condition, and a position in which the sealing edge (27) is spaced from the sealing surface (26), when the assembly (6) is in its second condition;

a formation (28) is provided within the gate valve body (7) on the downstream side of the sealing surface (26), adjacent that part of
the gate valve body (7) to which the gate valve member (8) moves when moving into the position the gate valve member (8) occupies when the assembly (6) is in its second condition;

the first guide surface (11) is formed on said formation (28) and extends from said sealing surface (26); and

the second guide surface (12 or 13) is formed on said formation (28) and extends from said first guide surface (11).

15. A liquid flow control assembly (1 to 6) substantially as hereinbefore described with reference to and as illustrated in Figures 1, Figure 2, Figures 3 and 4, Figure 5, Figures 6 and 7, or Figure 8 of the accompanying drawings.
AMENDED CLAIMS

[received by the International Bureau on 20 September 1983 (20.09.83); original claims 1 to 15 have been amended and replaced by claims 1 to 14]

1. A liquid flow control assembly (1 to 6) in which:

a body member (7), providing at least one passage (9), and a closure member (8) are relatively movable between a first condition in which the closure member (8) prevents flow of liquid through the or each passage (9) and a second condition in which the body member (7) and the closure member (8) define at least one aperture (10), to control the flow of liquid between the body member (7) and the closure member (8);

a first guide surface (11) is provided downstream of said aperture (10); and

a second guide surface (12 and 13) is provided for directing liquid flowing along the first guide surface (11) into a vortex flow path; characterised in that:

the first guide surface (11) is at least part of a surface of revolution which extends downstream from the or each aperture (10); and

in each cross-section which contains the axis (14) of the body member (7) and the axis (14 or 15) of the or each passage (9) provided by the body member (7) and passes through the first guide surface (11), the outline of the first guide surface (11) is non-convex.

2. An assembly (1 to 6), according to Claim 1, in which the first guide surface (11) and the second guide surface (12 and 13) merge smoothly with each other.
3. An assembly (1 to 6), according to Claim 2, in which the second guide surface (12 and 13) is at least part of a surface of revolution and, in each cross-section which contains the axis (14) of the body member (7) and the axis (14 or 15) of the or each passage (9) provided by the body member (7) and passes through the second guide surface (12 and 13), the outline of the second guide surface (12 and 13) is concave and includes at least a part-circular portion (12) which extends from the outline of the first guide surface (11).

4. An assembly (2 or 4), according to Claim 3, in which:

a third guide surface (16) is spaced from the second guide surface (12 and 13); and

the second guide surface (12 and 13) has an outlet end (13) directed perpendicularly towards the third guide surface (16).

5. An assembly (3, 5 or 6), according to Claim 3, in which:

in each cross-section which contains the axis (14) of the body member (7) and the axis (14 or 15) of the or each liquid passage (9) and passes perpendicularly through the first guide surface (11) and the second guide surface (12 and 13), the outline of the first guide surface (11) is concave; and

the outlines of the first guide surface (11) and the second guide surface (12 and 13) merge at a point of common tangency.

6. An assembly (1, 2 or 4), according to Claim 3, in which:
in each cross-section which contains the axis (14) of the body member (7) and the axis (14 or 15) of the or each liquid passage (9) and passes perpendicularly through the first guide surface (11) and the second guide surface (12 and 13), the outline of the first guide surface (11) extends rectilinearly and is tangential to the outline of the second guide surface (12 and 13).

7. An assembly (1 or 2), according to Claim 6, in which:

the closure member (8) is a poppet valve member; and

the first guide surface (11) is frusto-conical in shape.

10 8. An assembly (2), according to Claim 7, in which:

in each cross-section which contains the axis (14) of the body member (7) and passage (9), the second guide surface (12 and 13) comprises a semi-circular portion (12) with an outlet end (13); and

a third guide surface (16) extends perpendicular to the first guide surface (11) and tangential to an imaginary circle conforming to the semi-circular portion (12) of the second guide surface (12 and 13).

9. An assembly (1 or 2), according to Claim 5 or Claim 6, in which:

the closure member (8) is a poppet valve member; and

the first guide surface (11) is a surface of revolution which
extends divergently from said aperture (10).

10. An assembly (1 or 2), according to any one of Claims 7 to 9, in which the first guide surface (11) is provided on the poppet valve member (8) and the second guide surface (12 and 13) is provided on guide means (17) surrounding the first guide surface (11).

11. An assembly (3, 4 or 5), according to Claim 5 or Claim 6, in which:

the body member (7) has a bore (18);

the or each passage (9) is provided by an inlet port each of which extends on a radial axis (15) perpendicular to the axis (14) of the bore (18) and opens into the bore (18);

at least one outlet port (19) is formed in the body member (7), on a radial axis (20) perpendicular to the axis (14) of the bore (18), and opens into the bore (18);

the closure member (8) is a spool which is reciprocable within the bore (18);

the spool (8) has a cylindrical land (21) which blocks the inlet port (9) when the assembly (3, 4 or 5) is in its first condition and clears at least part of the or each inlet port (9) when the assembly (3, 4 or 5) is in its second condition;

a circumferential groove (22) formed in said spool (8), adjacent the cylindrical land (21), overlaps at least part of the or each inlet port (9) and at least part of the or each outlet port (19) when the assembly (3, 4 or 5) is in its second condition;
the first guide surface (11) is a surface of revolution extending from said cylindrical land (21) and forms a first part of the circumferential groove (22); and

the second guide surface (12 and 13) is a surface of revolution extending from said first guide surface (11) and forms a second part of the circumferential groove (22).

12. An assembly (4), according to Claim 11, in which:

the circumferential groove (22) has a third part provided by the surface (23) of a necked-down portion of the spool (8);

10 in each cross-section which contains the axis (14) of the bore (18), the outline of the first guide surface (11) is inclined to a plane perpendicular to the axis of the bore (18);

the part-circular portion (12) of the outline of the second guide surface (12 and 13) extends through less than 180°;

15 the outline of the second guide surface (12 and 13) has a radially extending outlet end (13) which is tangential to the part-circular portion (12); and

a third guide surface (16) forming part of the bore (18), extends perpendicular to the outlet end (13) of the outline of the second guide surface (12 and 13) and tangential to an imaginary circle conforming to the part-circular portion (12) of the outline of the second guide surface (12 and 13).

13. An assembly (5), according to Claim 12, in which the inlet port (9) communicates with a circumferential groove (23) formed in
the internal surface of the bore (18).

14. An assembly (6), according to any one of Claims 1 to 3 and 5, in which:

the body member (7) is a gate valve body providing a passage (9) and 5 having upstream and downstream ends (24 and 25) and an internal sealing surface (26);

the closure member (8) is a gate valve member having a sealing edge (27) and is reciprocable on an axis perpendicular to the axis (14) of the gate valve body (7) between a position in which the sealing edge (27) engages the sealing surface (26), when the assembly (6) is in its first condition, and a position in which the sealing edge (27) is spaced from the sealing surface (26), when the assembly (6) is in its second condition;

a formation (28) is provided within the gate valve body (7) on the 15 downstream side of the sealing surface (26), adjacent that part of the gate valve body (7) to which the gate valve member (8) moves when moving into the position the gate valve member (8) occupies when the assembly (6) is in its second condition;

the first guide surface (11) is formed on said formation (28) and 20 extends from said sealing surface (26); and

the second guide surface (12 or 13) is formed on said formation (28) and extends from said first guide surface (11).
FIG. 1.

FLUID FLOW

FIG. 2.
INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 83/00103

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *
acci. to International Patent Classification (IPC) or to both National Classification and IPC

IPC: F 16 K 47/04

II. FIELDS SEARCHED

Classification System: Minimum Documentation Searched *

| IPC | F 16 K 47/00; F 16 K 25/00; F 15 D 1/00 |

Documentation Searched other than Minimum Documentation to the extent that such documents are included in the fields searched *

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

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  "O" document referring to an oral disclosure, use, exhibition or other means
  "P" document published prior to the international filing date but later than the priority date claimed

IV. CERTIFICATION

Date of the Actual Completion of the International Search 3 8th July 1983
Date of Mailing of this International Search Report 2 26 JUL 1983
International Searching Authority 1 EUROPEAN PATENT OFFICE

Signature of Authorized Officer 10 G.L.M. Kruyderberg
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