(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 086 632**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **83300678.6**

(22) Date of filing: **10.02.83**

(51) Int. Cl.³: **F 15 B 13/02**

(30) Priority: **11.02.82 AU 2669/82**

(43) Date of publication of application: **24.08.83 Bulletin 83/34**

(84) Designated Contracting States: **BE DE FR GB IT SE**

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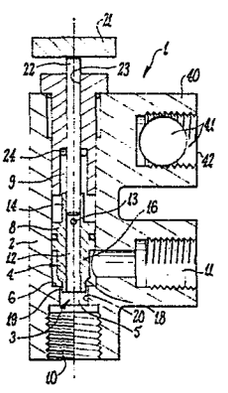
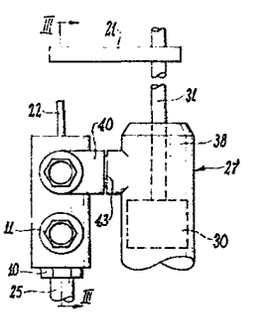
(54) Control valve.

(57) A control valve (1) for an hydraulic piston-cylinder assembly (28) having one port (10) connected to the cylinder (27) and another port (11) connectable into a circuit which controls relative movement between the cylinder (27) and piston (30). The two ports (10, 11) communicate through the body (2) of the valve (1) and a closure member (4) is movable between positions at which it opens ans closes that communication. A striker (21) associated with the piston-cylinder assembly (28) and responsive to relative movement thereof in one direction, is engagable with an abutment (22) of the closure member (4) so as to move that member (4) towards the valve closed position. As the closure member (4) approaches the closed position, a throttling portion (19) of that member (4) becomes operative to restrict fluid flow between the valve ports (10, 11) and thereby creates a pressure differential which acts across the closure member (4) to move that member (4) free of the influence of the striker (21) and into the closed position. When the throttling portion (19) is inoperative, fluid pressure within the valve (1) tends to urge the closure member (4) towards the open position.





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"Control Valve"

This invention relates to valves for controlling fluid flow and is particularly although not exclusively applicable to controlling the operation of a piston-cylinder assembly. It will be convenient to hereinafter describe the invention with particular reference to controlling operation of a hydraulic-piston assembly.

In some circumstances it is of advantage to be able to limit the travel of the piston rod of a piston-cylinder assembly from a fully extended position to a predetermined partially retracted position. It is known to provide valves which respond to movement of the piston rod and operate to trap fluid in the cylinder to prevent retraction of the piston rod beyond the predetermined position. A difficulty with those prior arrangements is that the valve is moved into the fully closed position by pressure applied by the piston rod and the valve can be damaged by the resulting stresses, especially if the piston rod tends to over-travel because of some malfunction.

It is an object of the present invention to provide a valve for controlling fluid flow of a system incorporating a movable member, such as a piston-cylinder assembly, which will close without engagement by or direct connection with the movable member and is therefore free of stresses imposed by that member when the valve is in and approaching the closed condition. The term "direct connection" is to be understood as embracing any situation in which the movable member or a part attached thereto directly applies a closing force to the valve.

A valve according to the invention is characterized in that, when in use, it is initially influenced by the member which it controls to move from an open condition towards a closed condition, but final movement into the closed condition occurs independant of that member. That is, the valve is arranged to have a self-closing facility at the final stage of its closing movement and in that way it is freed from stresses imposed by the member which it controls, or at least those stresses will be reduced. The self-closing facility is achieved by progressively throttling the passage of fluid through the valve so that a pressure differential

is created such as to urge a closure member of the valve into a position such as to close the valve.

The essential features of the invention, and further optional features, are described in detail in the following passages of the specification which refer to the accompanying drawings. The drawings however, are merely illustrative of how the invention might be put into effect, so that the specific form and arrangement of the features (whether they be essential or optional features) shown is not to be understood as limiting on the invention.

In the drawings:

Figure 1 is a diagrammatic illustration of one form of system involving an embodiment of the invention;

Figure 2 is an enlarged fragmentary view taken along line II-II of figure 1;

Figure 3 is a cross sectional view taken along line III-III of figure 2 showing the control valve in the fully open position;

Figure 4 is a view similar to figure 3 but showing the valve moved part way towards the closed position;

Figure 5 is a view similar to figure 4 but showing the valve in a throttling condition approaching the fully closed position;

Figure 6 is a view similar to figure 5 but on an enlarged scale and showing the valve in the fully closed position;

Figure 7 is a view of part of the circuit shown in figure 1 and showing the circuit switched to the condition at which the cylinder piston rod is to be retracted.

The example valve 1 shown in the drawings includes a body 2 having a cylindrical chamber 3 which slidably receives a closure member 4 and which has a valve orifice 5 at one end (figures 3 to 6). The valve orifice 5 is of smaller diameter than the chamber 3 and is surrounded by a valve seat 6 against which the closure member 4 engages to prevent communication between the orifice 5 and the adjacent section 7 of the chamber 3. The closure member 4 is in the form of a plunger having a head section 8 which divides the chamber 3 transversely into primary and secondary sections 7 and 9

which are respectively adjacent and remote from the valve orifice 5 and the respective volumes of chamber sections 7 and 9 varies according to the axial position of the plunger 4 within the chamber 3.

Two ports 10 and 11 are provided in the valve body 2 and are arranged to communicate with the primary chamber section 7. The port 10 will be hereinafter called the load port and that port communicates with the primary section 7 through the valve orifice 5 as shown. The other port 11 will be hereinafter called the transfer port and that port communicates with the primary section 7 at a location such as to be connectable with the load port 10 by way of the valve orifice 5.

Communication between the load port 10 and the secondary chamber section 9 may be effected by way of passage means provided through the plunger 4. In the arrangement shown, that passage means includes an axial bore 12 extending through the end of the plunger 4 adjacent to the valve orifice 5, and one or more lateral passages 13 connected to the bore 12 and exposed to the secondary chamber section 9 at a location behind the plunger head section 8. As shown, the or each passage 13 may extend through the cylindrical surface of an axially extending rear end portion 14 of the plunger 4 which is of reduced diameter relative to the head section 8. An annular space 15 is therefore provided between that end portion 14 and the surrounding surface of the chamber 3 and that space 15 forms part of the secondary chamber section 9.

As shown, a barrel section 16 of the plunger 4 may extend axially forwardly from the head section 8 towards the valve orifice 5 and has a diameter less than the head section 8. The resulting annular space 17 between that barrel section 16 and the chamber wall constitutes part of the primary chamber section 7. It is preferred as shown, that the barrel section 16 is stepped to create an annular shoulder 18 which is engagable with the valve seat 6 to close the valve orifice 5 and that shoulder 18 may slope at an appropriate angle. The resulting small diameter end portion 19 of the barrel section 16 is able to locate

within the valve orifice 5 and will be hereinafter called the throttling portion of the plunger 4. That throttling portion 19 preferably has a diameter only slightly smaller than that of the valve orifice 5 so there is relatively little clearance 20 between it and the orifice wall when it is located within the orifice 5 (figure 5). The shoulder 18 is located relative to the head section 8 so that in the closed condition of the valve (figure 6) the transfer port 11 will communicate with the annular space 17 surrounding the barrel section 16.

Part of the plunger 4 or a member attached thereto preferably extends rearwardly out of the valve body 2 for engagement with a striker 21 as hereinafter described. In the form as shown, a pin 22 is secured to the rear end portion 14 of the plunger 4 and extends axially from the plunger 4 through an opening or bore 23 in the adjacent end of the valve body 2. The pin 22 is secured to the plunger 4 for movement therewith and is slidably mounted in the bore 23. Appropriate sealing means 24 may be provided between the pin 22 and the valve body 2. It is preferred that the diameter of the pin 22 is substantially the same as the diameter of the plunger bore 12.

Figure 1 shows an example fluid system including the control valve 1 as described above. In that example, the load port 10 is connected by conduit 25 to the head end 26 of the cylinder 27 of a piston-cylinder assembly 28 to be controlled by the valve 1. The head end 26 receives pressurized fluid from a circuit including a pump 29 in order to urge the piston 30 (figure 2) in a direction so as to extend the piston rod 31 out of the cylinder 27. The transfer port 11 is connected by conduit 32 to a spool valve 33 or other device which is selectively operable to connect the port 11 to the pump 29 or drain 34 according to whether the assembly 28 is being extended or retracted.

Assuming the assembly 28 is to be extended, before that operation commences the valve 1 will be in the closed condition as shown in figure 6 and the end face 34 of the plunger 4 located within the orifice 5 will be exposed to the fluid pressure in the head end 26 of the cylinder 27.

The same pressure will also apply within the secondary chamber section 9 because of the connection provided by the bore 12 and passages 13. As a result, the head end pressure will act against rear end surfaces 35 and 36 of the plunger 4 which have a total area substantially equal to the cross sectional area of the chamber 3 less the cross sectional area of the plunger pin 22.

Connection of the transfer port 11 to the pump 29 as shown in figure 1, will cause pressurized fluid to enter the primary chamber section 7 and the pressure within that section 7 will be at least equal to the aforementioned head end pressure as applying within the secondary chamber section 9. Assuming that the two pressures are equal, the total area of the plunger front end surfaces 34, 18 and 37 exposed to that pressure will be greater than the toal area of the exposed rear end surfaces 35 and 36 so that a resultant force will act to move the plunger 4 away from the valve seat 6. That is, the total area of the exposed front end surfaces 34, 18 and 37 will be substantially equal to the cross sectional area of the chamber 3 less the area of the zone of engagement between the valve seat 6 and the plunger shoulder 18. If the valve seat 6 is a relatively sharp edge the last mentioned area will be negligible, but in any event it will be less than the cross sectional area of the plunger pin 22.

Under normal circumstances the initial pressure within the primary chamber section 7, as applied by the pump 29, will be higher than the pressure within the cylinder head end 26 so the resultant valve opening force will be higher than indicated above. As the valve 1 opens, the head end 26 of the cylinder 27 is exposed to the higher fluid pressure and the piston 30 is thereby urged to extend the piston rod 31 further out of the cylinder 27. It will be usual for the opposite end 38 of the cylinder 27 to be connected to the drain 34 through the spool valve 33 as shown in figure 1 so that extension of the piston rod 31 is not impeded.

When it is desired to retract the piston rod 31 to the predetermined retracted position, the spool valve 33 is operated to adopt a position as shown in figure 7 at which the valve transfer port 11 is connected to the drain 34 so

that fluid is able to escape from the cylinder head end 26 by way of the primary chamber section 7. The striker 21 is adapted to respond to the consequent retracting movement of the piston rod 31 and is arranged to engage the exposed end of the plunger pin 22 as shown in figure 4, at an appropriate position in the course of that movement. Preferably, the striker 21 is secured directly to the piston rod 31, but other arrangements are possible.

After the striker 21 and pin 22 engage, continued retraction of the piston rod 31 causes the plunger 4 to be pushed towards the valve closing condition. A position is eventually reached at which the throttling portion 19 of the plunger 4 enters the valve orifice 5 thereby hindering escape of fluid from the cylinder head end 26. As a result, a pressure differential is created on opposite sides of the valve seat 6 with the lower pressure occurring within the primary chamber section 7. Continued penetration of the throttling portion 19 into the valve orifice 5 (figure 5) increases the throttling effect and consequently the magnitude of the pressure differential. The throttling however, does not affect the pressure within the secondary chamber section 9 which remains exposed to the relatively high head end pressure through the bore 12 and passages 13 in the plunger 4.

A stage is therefore reached at which the pressure within the primary chamber section 7 is so low that the fluid pressure generated force acting against the rear end surfaces 35 and 36 of the plunger 4 exceeds the force acting against the front end surfaces 34, 18 and 37. That force imbalance will operate to move the plunger 4 forwardly towards the valve seat 6 independant of the influence of the striker 21 and as a consequence the plunger pin 22 will be separated from the striker 21 (figure 5). When the valve 1 closes (figure 6) the cylinder piston 30 is naturally brought to a halt because fluid can no longer escape from the cylinder head end 26. At that position, a space 39 exists between the striker 21 and the plunger pin 22 so the plunger 4 is not subjected to stresses as might otherwise be imposed by the piston rod 31.

It is preferred to arrange the striker 21 so that, in the event of unintentional fluid leakage from the cylinder head end 26, it will engage the adjacent end of the cylinder 27 rather than the exposed end of the plunger pin 22. Also, the striker 21 may be arranged to slide along the piston rod 31 if the rod 31 is forced to retract further. Assuming the system is a hydraulic one, it is preferred to vent the head end 26 of the cylinder 27 to avoid formation of an air cushion which could be compressed to allow momentary engagement between the striker 21 and cylinder end when the valve 1 is closed.

In the particular form of the control valve 1 as shown, the valve body 2 has a boss 40 formed thereon which has a passage 41 therethrough and opposite ends 42 and 43 of that passage 41 are adapted for connection to the spool valve 33 and the cylinder 27 respectively. The cylinder connection is preferably a direct one and is at the end portion 38 of the cylinder 27 remote from the head end 26 so the valve plunger pin 22 is arranged for engagement by the piston rod striker 21. The spool valve connection may be direct also or by way of an appropriate conduit 44 as shown. In any event the passage 41 does not communicate with the valve chamber 3.

It will be apparent from the foregoing description that a valve according to the invention has the valuable advantage of automatically freeing itself from the influence of a member which initially causes it to close. That concept can be embodied in various valve forms and the valve is adaptable to a wide variety of applications.

Various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention as defined by the appended claims.

C L A I M S

1. A control valve for a fluid operated piston-cylinder assembly including a hollow body (2), a load port (10) connectable to the cylinder (27) of said assembly (28), a transfer port (11) connectable into a fluid circuit associated with said assembly (28), both said ports (10,11) communicating with the interior of said body (2), an orifice (5) within said body (2) through which said ports (10,11) communicate to transfer fluid between said cylinder (27) and said circuit, a closure member (4) mounted within said body (2) for movement between a closed position at which it prevents said communication through said orifice (5) and an open position at which it does not substantially obstruct said communication, and closure abutment means (22) engagable by part (21) of said assembly (28) when the piston (30) of said assembly (28) is moving in one direction so that said closure member (4) is moved towards said closed position in response to said piston movement; characterized in that throttling means (19) is operable to restrict passage of fluid through said orifice (5) and create a pressure differential across said closure member (4) to cause said closure member (4) to move towards said closed position independant of influence of said assembly part (21), said throttling means (19) being responsive to movement of said closure member (4) and becoming operative when said closure member (4) is between said closed and open positions and said assembly piston (30) is moving in said one direction.

2. A control valve according to claim 1, wherein said closure abutment means (22) includes a pin (22) secured to said closure member (4) for movement therewith and extending axially from an end of said closure member (4) remote from said orifice (5) to project out of said body (2), at least when said closure member (4) is in or adjacent said open position, and said closure member (4) is slidably mounted within said body (2) for said movement.

3. A control valve according to claim 1 or 2, wherein said throttling means (19) includes an end portion (19) of said closure member (4) which locates within said orifice (5) to restrict passage of fluid therethrough when said closure member (4) is moving towards said closed position, and passage

means (12,13) is provided to allow fluid to impinge against oppositely facing surfaces (34, 18, 37 and 35,36) of said closure member (4) which extend substantially transverse to the direction of movement of said closure member (4).

4. A control valve according to claim 3, wherein a chamber (3) is formed within said body (2), a cylindrical head section (8) of said closure member (4) is slidably contained within said chamber (3) and divides that chamber into primary and secondary sections (7,9) which are respectively adjacent to and remote from said orifice (5), and said passage means (12,13) provides communication between said primary and secondary sections (7,9).

5. A control valve according to claim 3 or 4, wherein said oppositely facing surfaces (34,18,37 and 35,36) are of different total area such that equal pressures within said primary and secondary sections (7,9) produce a resultant force which urges said closure member (4) towards said open position.

6. A control valve according to claim 3, 4 or 5, wherein said passage means (12,13) includes passages (12,13) formed through said closure member (4).

7. An assembly including a cylinder (27), a piston (30) slidably mounted within said cylinder (27), said cylinder (27) being connectable to a fluid circuit which is operable to cause relative axial movement between said cylinder (27) and piston (30), striker means (21) movable in response to said relative movement, a control valve body (2), a chamber (3) formed within said body (2), a load port (10) connecting said cylinder (27) to said chamber (3), a transfer port (11) for connecting said circuit to said chamber (3), an orifice (5) within said body (2) through which said ports (10,11) communicate, a closure member (4) mounted within said chamber (3) for movement between positions at which it respectively closes and opens said orifice (5), and abutment means (22) engagable by said striker means (21) in one direction of said relative movement and being operative to thereby cause said closure member (4) to move towards said closed position; characterized in that throttling means (19) is operable to restrict passage of fluid through said orifice (5) and to

thereby create a pressure differential across said closure member (4) such as to cause said closure member (4) to move towards said closed position independant of influence of said striker means (21), said throttling means (19) being operative when said closure member (4) is between said closed and open positions and said relative movement is in said one direction, whereby said closure member (4) is initially moved from said open position towards said closed position by direct influence of said striker means (21) and is subsequently freed from that influence and moved into the closed position by fluid pressure.

8. An assembly according to claim 7, wherein a rod (31) is secured to said piston (3) for movement therewith and projects through one end of said cylinder (27), said striker means (21) is secured to said rod (31) externally of said cylinder (27) for movement therewith, and said valve body (2) is secured to said cylinder (27).

9. An Hydraulic system including, an assembly according to claim 7 or 8 and a fluid circuit including pump means (29) for directing fluid under pressure into said cylinder (27) and valve means (33) which is operable to selectively connect said transfer port (11) to said pump means (29) and a drain (34) respectively, and said relative movement is in said one direction when said transfer port (11) is connected to said drain (34).

10. A system according to claim 9, wherein fluid pressure acting between said cylinder (27) and said control valve (1) urges said closure member (4) towards said open position when said throttling means (19) is inoperative.

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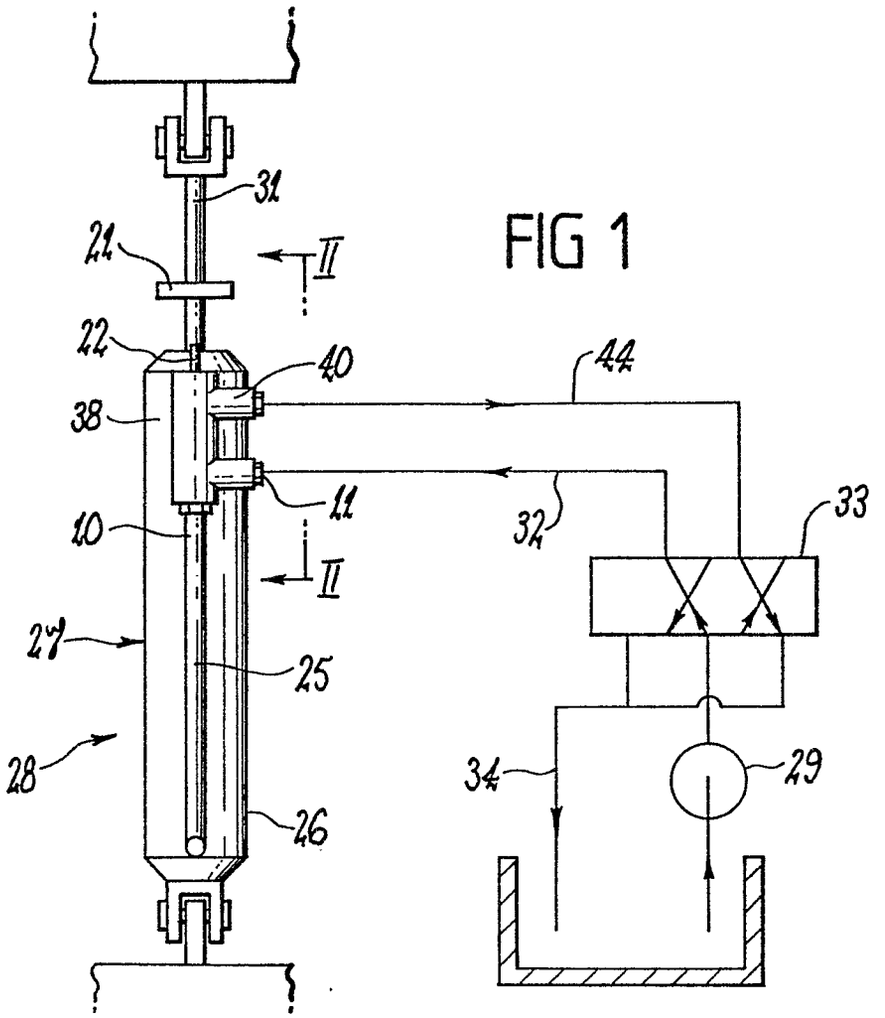

FIG 1

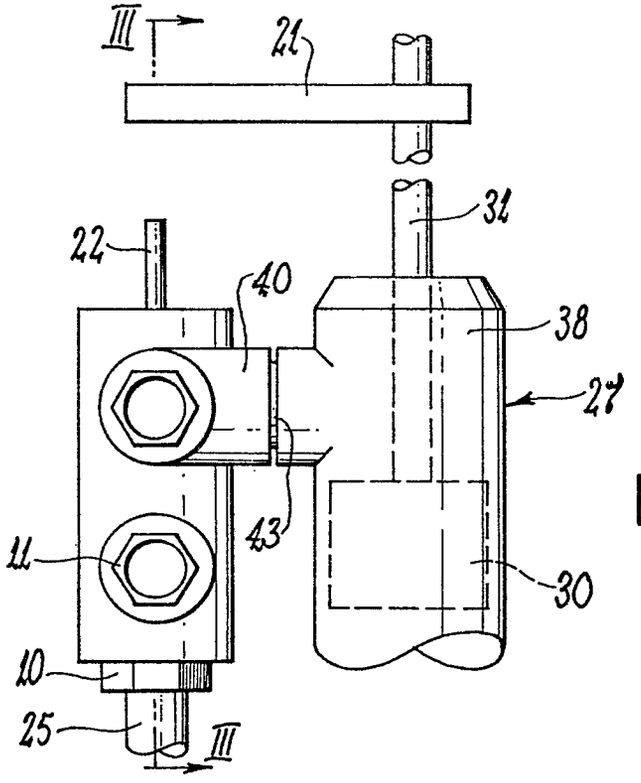

FIG 2

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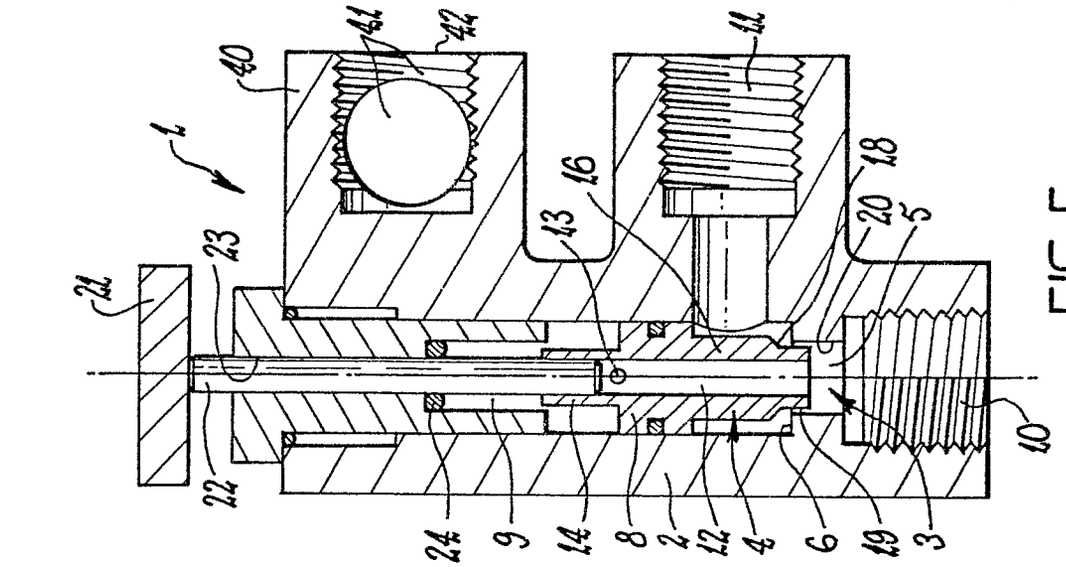

FIG 5

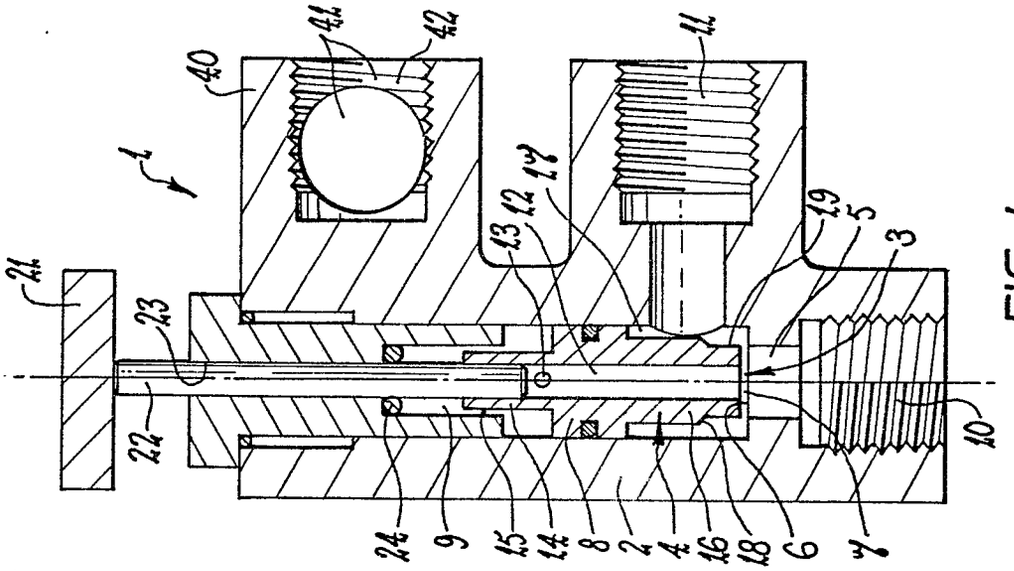

FIG 4

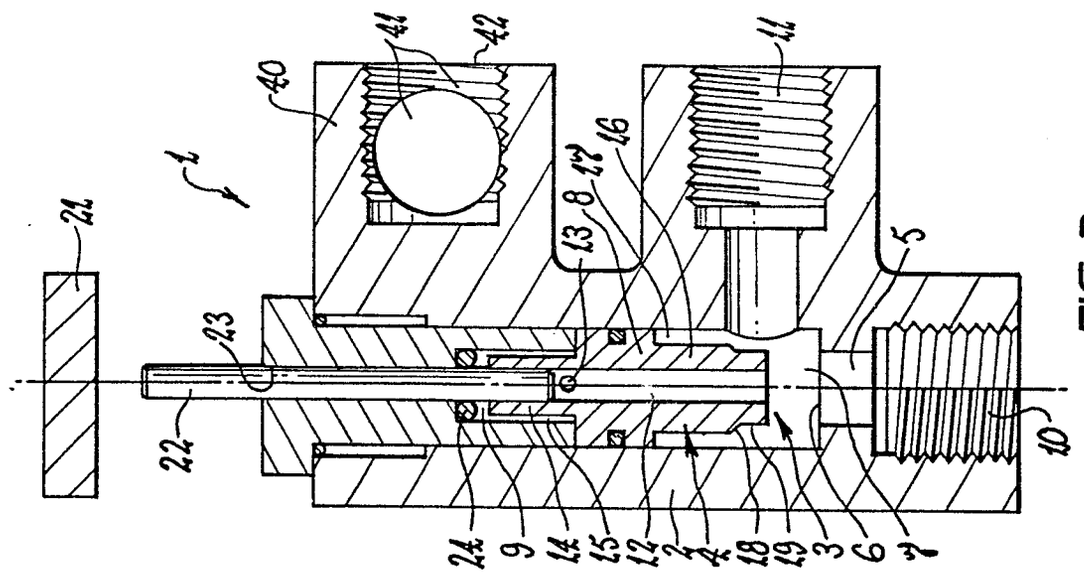

FIG 3

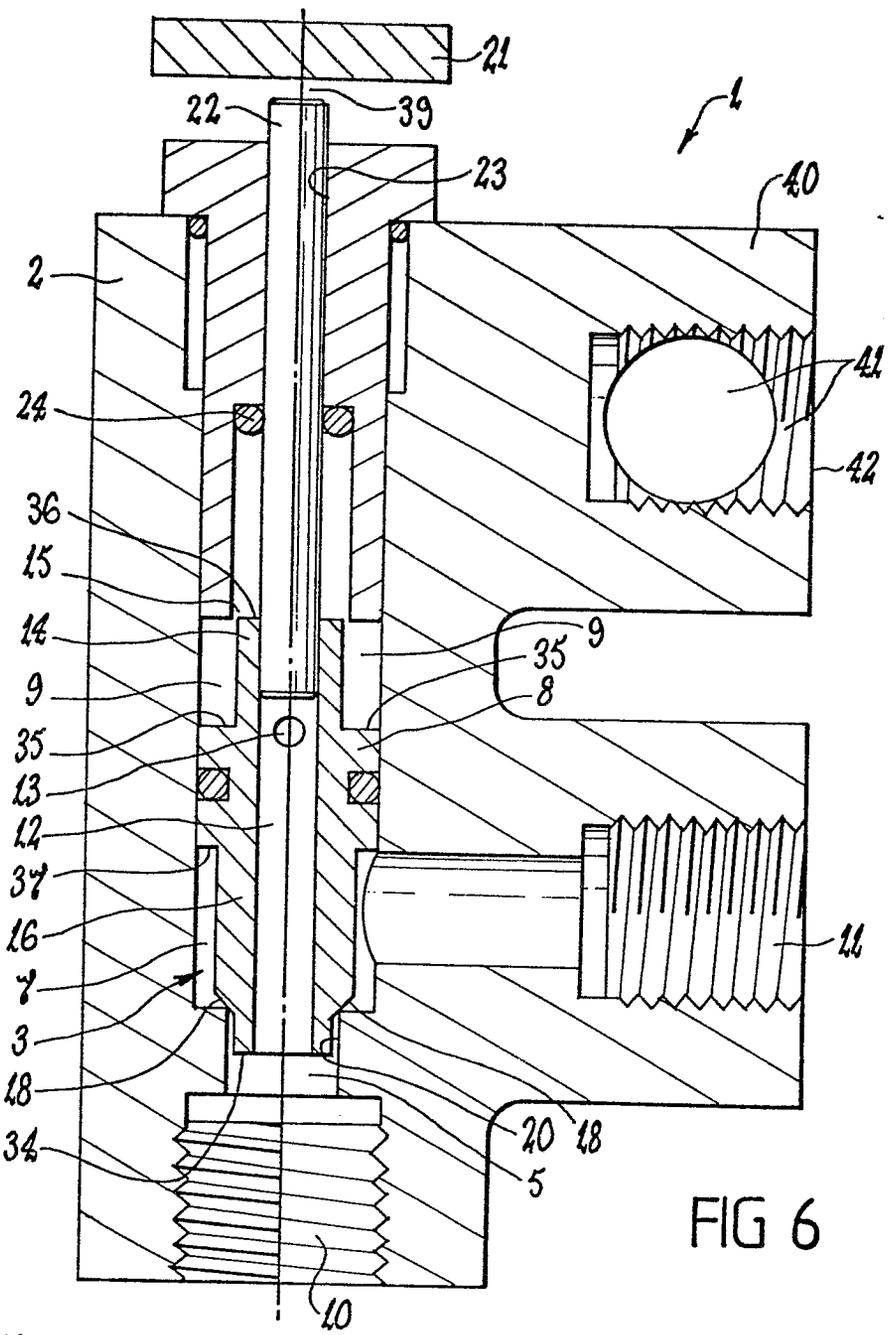
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FIG 6

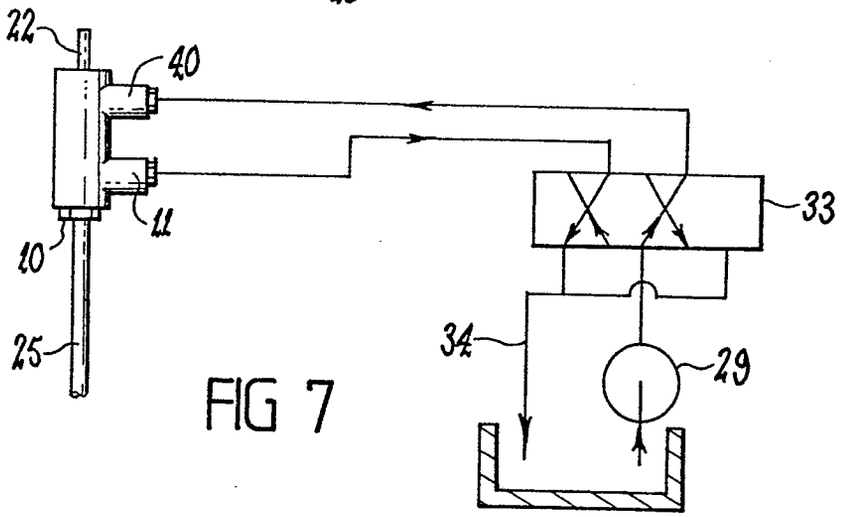
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FIG 7