

May 4, 1943.

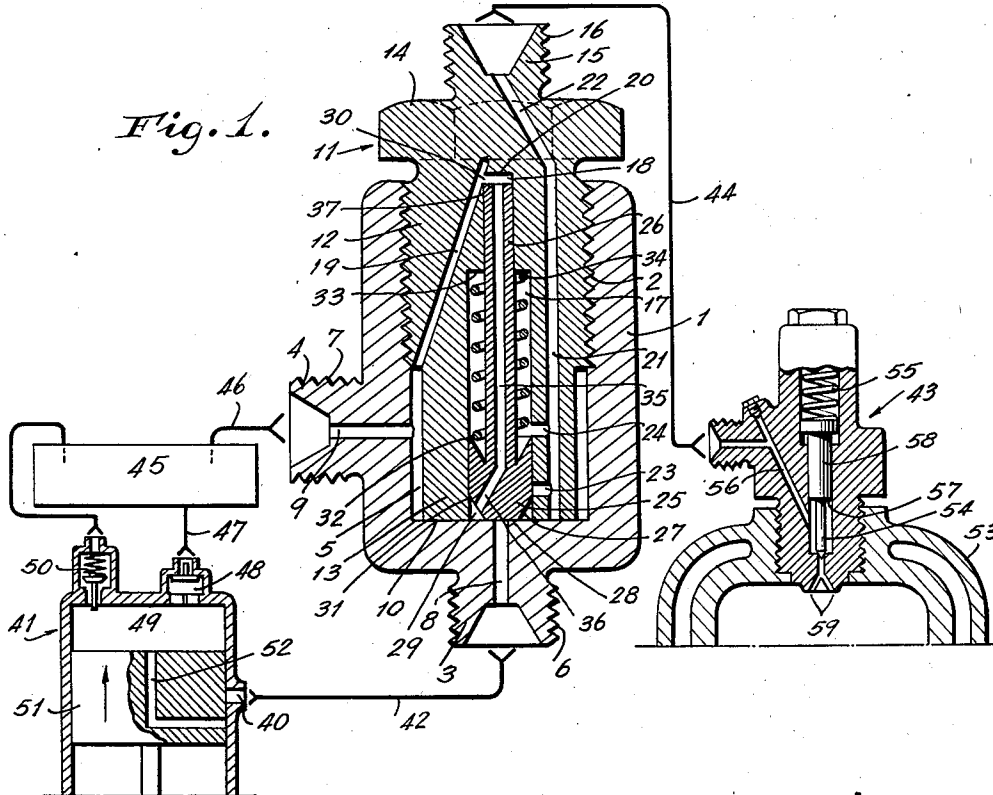
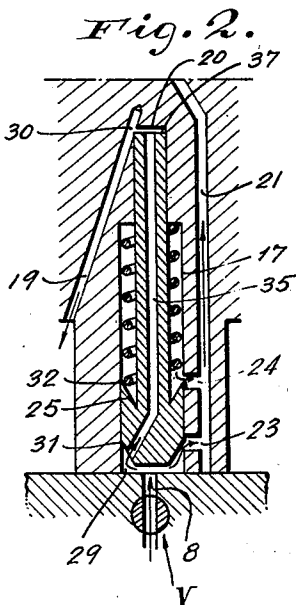
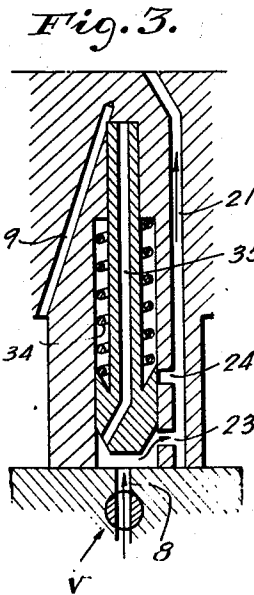
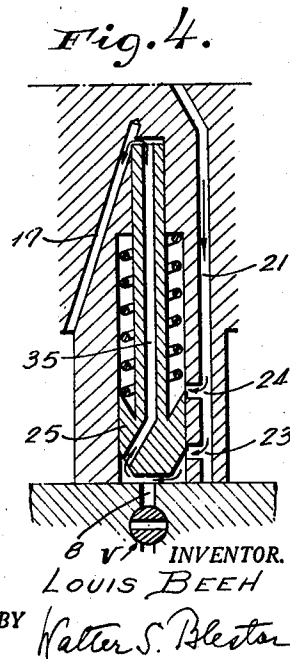
L. BEEH

2,318,449

DELIVERY VALVE

Filed Sept. 18, 1942

2 Sheets-Sheet 1



INVENTOR.
LOUIS BEEH
BY *Walter S. Blester*

ATTORNEY

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L. BEEH

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2 Sheets-Sheet 2

Fig. 5.

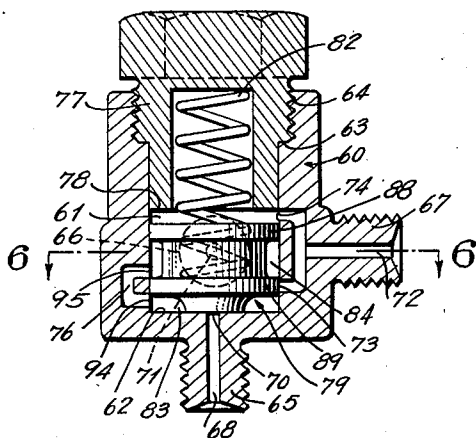


Fig. 5.a

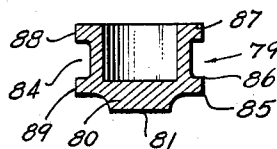


Fig. 6.

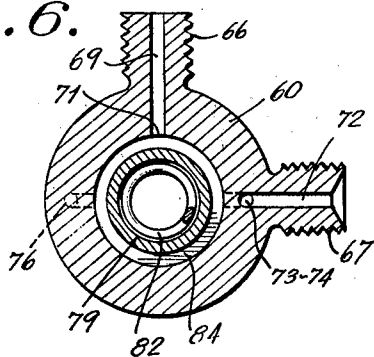


Fig. 7.

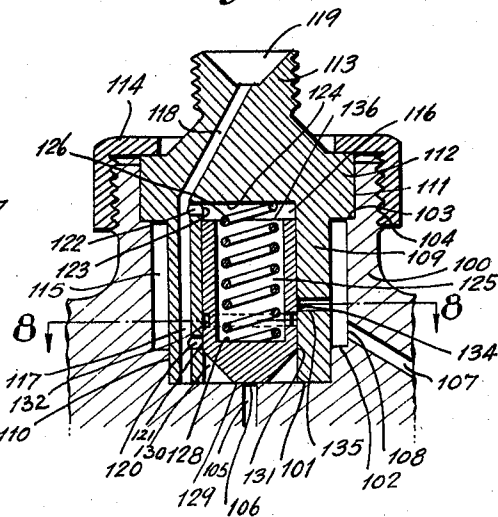
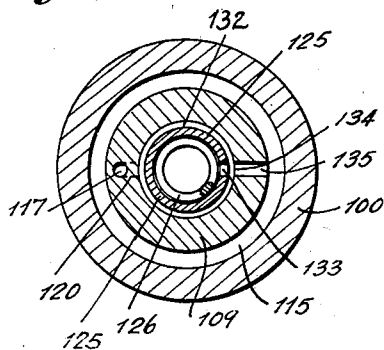


Fig. 8.



INVENTOR.
LOUIS BEEH
BY Walter S. Gleason
ATTORNEY

UNITED STATES PATENT OFFICE

2,318,449

DELIVERY VALVE

Louis Beeh, Long Meadow, Mass.

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11 Claims. (Cl. 251-144)

This invention relates to a delivery valve for hydraulic systems in which a line is periodically passed by quantities of fluid under high pressure. Such a system is, for instance, the conventional feeding system of an internal combustion engine of the injection type in which fuel under high pressure is supplied by a metering pump to the injection nozzle of a cylinder of the engine. In my co-pending application Serial No. 409,663, filed September 5, 1941, I have more explicitly explained certain pressure oscillations occurring in the conduit of such a system between the fuel pump and the nozzle and causing harmful secondary and even tertiary injections as a reaction to the abrupt closing of both the nozzle and the delivery valve of the pump, and I have disclosed in that application a new delivery valve with the aid of which such oscillations can be avoided. However, the valve according to that application is useful for the indicated purpose and with the desired result only if a by-pass is open in connection with the pump or between the pump and the delivery valve immediately after the end of the feeding period. Contrary thereto, the present invention contemplates the provision of a valve whereby the aforementioned pressure oscillations can be avoided or at least minimized regardless of whether or not there is a by-pass in connection with the pump or other source supplying the fluid under high pressure.

The invention consists of a delivery valve which embodies a by-passing means for the line to which the valve is connected, wherein said by-passing means is operative during the closing period of the valve to relieve the associated line from high pressure.

The invention further contemplates the provision and consists of means whereby a valve inserted intermediate the ends of a line and opening in response to a predetermined value of fluid pressure originating from the one line end is operative during the closing of the valve owing to a pressure drop in the branch from whose end the pressure originates to relieve both line branches, at least partly, of the pressure remaining therein.

Other details and objects of the invention will be apparent from the description given hereinafter and the accompanying drawings illustrating embodiments thereof by way of example.

In the drawings,

Fig. 1 is a longitudinal cross-section of an embodiment of the invention, applied to a line between a pump and a nozzle, both shown in a diagrammatical manner.

Figs. 2 to 4 are diagrams showing the valve poppet in different positions, respectively.

Fig. 5 is a longitudinal cross-section of another embodiment.

Fig. 5a is a sectional view of the poppet of Fig. 5.

Fig. 6 is a cross-section along line 6-6 of Fig. 5.

Fig. 7 is a longitudinal cross-section of a third embodiment, and

Fig. 8 is a cross-section along line 8-8 of Fig. 7.

Referring now to the drawings, the illustrated valve comprises a substantially cylindrical housing 1 which is open at its top and provided with an internal threading 2 in its upper portion. The housing has two projecting sockets 3 and 4. Socket 3 extends axially downward, and socket 4 projects laterally of the housing. Both are suitably shaped for the attachment of a pipe or conduit and, for this purpose, are provided with external threadings 6 and 7, respectively, and with bores 8 and 9, respectively. The bore 8 of socket 3 opens in the bottom surface 10 of the interior of the housing, and bore 9 communicates with an annular space 5 between the inner housing wall and a plug-like headed body 11. Body 11 comprises an upper externally threaded portion 12 and a cylindrical portion 13, the lower face of which seats tightly on the bottom face 10 when the body is screwed with a tight fit into the threading 2 of the housing. The diameter of the portion 13 is smaller than the inner diameter of the housing so as to form the aforementioned free annular space 5. The head 14 of body 11 is hexagonal for application of a wrench when the parts are to be assembled or disassembled, and a third socket 15 with external threading 16 projects axially from the head 14. The body 11 is provided with an axial bore 17 with an extension 18 of smaller diameter reaching upward approximately as far as the head 14. Another bore 19 passes slantingly through body portion 12 from space 5 upward so that it intersects the edge of the bottom 20 of the bore extension 18, and that a small port 30 exists between the bores 18 and 19. There is also a third bore 21 arranged laterally of bore 17 and closed at its lower end by the bottom surface 10 of the housing. The upper continuation 22 of bore 21 opens in the top of socket 15. Two spaced passages 23 and 24 at a distance from surface 10 connect bore 17 with bore 21. Bore 17 constitutes a cylindrical chamber in which the valve poppet 25 is movable. The latter is shaped as a plunger with a rod 26 slidingly engaging in extension 18.

The lower plunger edge is chamfered at 27, so, however, that a central bottom face 28 can seat on surface 10 and close the bore 8 in socket 3. In this position of the plunger, chamfer 27, surface 10 and the inner wall of chamber 17 form a ring space 29 of triangular cross-section. The upper edge 31 of the chamfer and the upper edge 32 of the plunger are controlling elements to close and open the passages 23 and 24 in a predetermined relationship as it will be explained hereinafter. Between plunger 25 and the top shoulder 33 of the chamber 17 a compression spring 34 is inserted tending to urge the plunger downward on its seat. The plunger rod has a bore 35 forming a knee 36 in the plunger body and opening in the chamfer 27 so that there is a connection between space 29 and the top portion of the extension 18 of chamber 17 when the plunger is on its seat. If, however, the plunger is in its upper end position, the top face 37 of the rod 26 bears upon surface 20 so that the top end of bore 35 is closed.

In order to explain the operation of the valve it is shown connected with its socket 3 to the delivery port 40 of a metering pump 41 by means of a pipe 42, with its socket 15 to a nozzle 43 by means of pipe 44 and with its socket 4 to a fuel storage tank 45 by means of pipe 46. The pump 41 receives the fuel from tank 45 through a conduit 47 and an inlet valve 48. The pump chamber 49 is equipped with a relief valve 50 returning excess fuel to the tank 45, and, the plunger 51 is provided with a channel 52 which temporarily connects chamber 49 with delivery port 40 in the course of the plunger movement. The nozzle 43 shown attached to a cylinder head 53 comprises a needle valve 54 which can be lifted against the restraint of a strong spring 55 when the fuel entering through the channel 56 exercises sufficient pressure on the annular face 57 of a piston 58, integral with needle 54, so that the fluid can enter the cylinder 53 through orifices 59.

In Figs. 2 to 4 a valving element V is shown diagrammatically in connection with bore 8. This is done in order to indicate in Figs. 2 and 3 that the conduit from the pump 41 to the delivery valve is open, and in Fig. 4, that the conduit is closed.

Assuming that the movable parts of the system are in the position illustrated in Fig. 1, no flow occurs from the pump 41 to the cylinder 53 because all valving elements are in closed position. Port 40 of the pump is shut by the plunger 51; the valve poppet 25 is on its seat 10; and the injector needle 54 is urged down by spring 55. Only the ring space 29 of the valve is in communication with the tank 45 through the bore 35 in the poppet 25 and its rod 26, bores 18 and 19, ring space 5, bore 9, and pipe 46. Similarly, the pipe line 44 between the valve and the nozzle is in connection with the bore 17 through the lateral conduit 21 of the valve, and passage 24. When, now, owing to the movement of the pump plunger 51, channel 52 registers with port 40, fluid from pump chamber 49 will be forced through channel 52 and port 40 into the pipe 42. Consequently, an abrupt rise of pressure occurs underneath poppet 25 which will be lifted from its seat 10 against the restraint of the spring 34. However, no material flow can set in through the valve to the nozzle 43 during the first portion of the movement of the poppet because the latter still bars or obstructs, at least partly, the entrance of passage 23 as clearly shown in Fig. 2 illustrating the poppet in a medium position. Only some fluid can

escape from underneath the poppet through the bore 35, port 30, and the other parts of the drain leading back to the storage tank 45, while simultaneously, fluid from chamber 17 whose volumetric capacity is decreased by the lift of the poppet, will be expelled through passage 24 into the line leading to the nozzle 43. In the meantime, the pressure in pipe 42 acts not only on the central bottom face 28 but also on the remainder of the poppet cross-section. This pressure accelerates the movement of the poppet which in a very short time reaches its top position shown in Fig. 3, in which the upper end of rod 26 abuts against face 20 of bore 18 thus closing the port 30 and the drain conduit 19. The lifting of the poppet to its end position is also assisted by the dynamic pressure built up by the increasing flow through the valve. During this period, passage 24 has also been closed whereas passage 23 has been completely opened owing to the movement of the control edges 32 and 31, respectively, which are spaced for this purpose a distance equal to that between the centers of the passages 23 and 24. With the poppet in its top end position, full line pressure prevails in the pipe 44 and nozzle 43 with the effect that needle 54 is lifted and fluid will be injected through orifices 59.

When, now, the plunger 51 of pump 41 continuing its upward stroke, closes port 40, a pressure drop will occur in the whole system causing spring 55 of the nozzle to urge needle 54 on its seat so that the line from the pump to the nozzle is closed at both ends. Consequently, the flow through the valve stops, and, although the pressure in the line is still high, it has become static underneath the poppet and insufficient to hold the poppet in its top position. In consequence, the poppet begins to drop, thereby opening the port 30. Simultaneously, however, also passage 24 begins to open, so that, as illustrated by Fig. 4, on the one hand the fluid under the remaining pressure in the pipe 44 can enter chamber 17 to increase the pressure urging the poppet downward while another portion can escape through passage 23 and bore 35 into the drain conduit constituted by bore 19 and from there to the tank 45. On the other hand, the pressure remaining in pipe 42 will be relieved also through bore 35 and its communication with the drain conduit. It will be apparent that this line pressure relief takes place practically instantaneously because only minute quantities of the fluid need to escape in order to drop the pressure. Hence, when the poppet has once started its downward movement, it will continue this movement until it is seated on surface 10. In more general terms, it may be said: When, according to communication of the pump chamber with the valve inlet, pressure acting on the poppet rises beyond the predetermined opening pressure, the valve will open abruptly against the restraint of the spring. Simultaneously, the pressure will be built up in the conduit between valve and nozzle owing to the opening of the communication between that conduit and the inlet, and assisted by the decrease of the volumetric capacity of the chamber above the piston whereby fluid will be expelled into the conduit. The nozzle will open and the flow through the valve established when the pressure value in the conduit is higher than that for which the nozzle is set. As soon as the pump discontinues delivering fluid, a slight pressure drop causes the poppet to begin its downward movement, thereby opening the drain and simultaneously connecting the nozzle conduit to the

space on top of the poppet with the effect that the difference in pressure above and below the poppet will be greatly increased so as to abruptly close the valve, and with the further effect that the pressure in the line between the valve and the nozzle will be sufficiently decreased to prevent crests of pressure oscillations from reaching the valve at which the nozzle would open again for a secondary injection.

The embodiment of the invention illustrated in Figs. 5 and 6 operates in a similar manner. It comprises a substantially cylindrical housing 60 with an axial chamber 61 having a bottom 62. The top end of the chamber is of a larger diameter so as to form a shoulder 63, and has an internal threading 64. The housing is provided with three externally threaded sockets 65, 66, and 67 for the attachment of connecting pipes. The first-named socket projects axially downwardly, whereas the two others are laterally arranged. Sockets 65 and 66 have straight bores 68 and 69, respectively, which open into the chamber 61, so as to constitute ports 70 and 71. Similarly, socket 67 has a bore 72 which, however, is branched so as to form two ports 73 and 74 of the chamber 61 on different levels. The chamber has two further ports 94 and 95 connected to each other by a conduit 76 provided in the wall of the housing 60. A hollow headed plug 77 is screwed into the threading 64 so as to bear on the shoulder 63 and to project with its lower end tightly fitting into chamber 61. The bottom face 78 of the plug forms an abutment for a piston or poppet 79 which is movable in chamber 61. Piston 79 has a lower portion 80 with a bottom surface 81 serving to close the port 70 when surface 81 bears on housing surface 62 under the action of a compression spring 82 provided in the hollows of both the poppet and the plug 60. In this position, the poppet and the housing form an annular space 83 and a second annular space on a higher level is formed by a peripheral groove 84 in the upper portion of the poppet 79. Three edges of the poppet serve as controlling edges with respect to the opening and closing of the various ports hereinbefore mentioned, and the arrangement is such that with the poppet in its lowest position when port 70 is closed, communication exists between annular space 83 and conduit 69 of socket 66 through port 94, conduit 76, port 95, groove 84 and port 71. Simultaneously, conduit 72 of socket 67 communicates with the space of chamber 61 on top of poppet 79 through port 74. When the poppet moves upward, the lowest poppet edge 85 begins to open port 73 whereas simultaneously edge 86, which is the lower one adjacent to groove 84, and the top edge 87 of the poppet close the ports 95 and 74, respectively, at the same rate, so that when the poppet in its highest position abuts against shoulder 78, the chamber space above the poppet has no outside connection, port 74 being closed by poppet zone 88, and the chamber space below the poppet is in connection with the conduits 68 and 72, port 73 being opened and port 95 being closed by poppet zone 89.

It will be apparent that this valve operates in substantially the same manner as, and can be substituted for, the first described valve in the system illustrated in Fig. 1, if sockets 65, 66, 67 are respectively connected to the pipes 42, 46, and 44.

Whereas in the two embodiments first described the space or chamber portion underneath the poppet has ports for communication with

the delivery conduit and with the drain conduit, the purpose of the invention can be accomplished also with a valve in which the space above the poppet is provided with the mentioned two kinds of ports, and the space below the poppet is provided with merely an inlet and a delivery port. This is shown by the embodiment illustrated in Figs. 7 and 8. In this embodiment, the valve housing 100 is part of a machine such as a pump to which the valve may be applied. However, it is to be understood that the housing may be a separate piece as in the case of the embodiments first described, or conversely, in the case of embodiments illustrated in Figs. 1 to 6, the housing may be constructed as integral with a machine for which the valve is destined. Housing 100 is formed as a substantially cylindrical projection having a stepped bore with a bottom face 101, a first annular shoulder 102 and a second annular shoulder 103. The top end of the housing is externally threaded at 104. A conduit 105 with port 106 opens axially in bottom 101 and another conduit 107 has a port 108 in the wall between the two shoulders 102 and 103. Conduit 105 is destined to be connected as the inlet of a fluid under high pressure, and conduit 107 is a drain conduit leading from the valve to a space (not shown) where relatively low pressure prevails. A plug-like body 109 is inserted in the housing so as to seat tightly on the bottom face 101 and to fit the wall of the lowest interior housing portion 110 underneath shoulder 102. The plug fits also into the top housing portion 111 with a flange 112 bearing on shoulder 103 and from which an externally threaded socket 113 projects upward in axial direction. A cap nut 114 engages the threading 104 and urges the flange 112 and thus the plug body 109 on its seat. An annular space 115 is formed by the described structure of the plug and the housing wall between the shoulders 102 and 103. The plug is provided with a relatively wide axial bore 116 of constant diameter from the bottom upward approximately as far as the flange 112. Laterally of bore 116, a narrow conduit 117 reaches also from the bottom upwards and opens with a slanting portion 118 in a top recess 119 of the socket 113. A lower passage 120 with port 121, and an upper passage 122 with port 123, connect the bores 116 and 117, port 123 being arranged immediately underneath the top surface 124 of the bore 116. Interiorly of bore 116 a hollow piston 125 or poppet is urged downward by a spring 126 bearing against face 124 and bottom 128 of the hollow of the poppet so that its bottom surface 129 of reduced diameter closes port 106. The lower portion of the poppet is chamfered so as to form a triangular ring space 130 in bore 116 underneath the control edge 131 which cooperates with port 121. The poppet is also provided with a peripheral control groove 132 which has an opening 133 into the interior of the poppet. This groove cooperates with a port 134 of a passage 135 which extends through the wall of the plug into the ring space 115. The arrangement of the controlling elements is such that in the illustrated position in which inlet port 106 is closed, control edge 131 is underneath port 125, groove 133 underneath port 134, and the top edge 136 of the poppet underneath port 123. Hence, there is only communication between the space above the poppet and conduit 117, 118. In the other end position, i. e., when the top rim 136 of the poppet bears against surface 124, port 123 will be closed, the groove 132 will register

with port 134, and the edge 131 will be above port 121. In consequence, the upper portion of the space above the poppet, or more correctly, the space between the two surfaces 124 and 123, will be in communication with the drain conduit 107, and the space underneath the poppet will connect the inlet conduit 105 with the delivery conduit 117.

It will be apparent that in the embodiment just described, pressure relief of the delivery conduit 118 occurs via port 123, space 116, groove 132, port 135, space 115 and drain 107. The pressure of the inlet conduit 105 will be relieved during the closing movements of the valve through space 130, port 121, passages 120 and 117, and further on the same way as explained in connection with the delivery conduit. It will also be seen that after the closing of the valve the pressure remaining in conduit 118 will build up on top of the poppet 125 in addition to the spring pressure.

In all other respects, particularly in the effect of preventing pressure oscillations in the connected lines from reaching dangerously high crests, the described embodiments operate in a similar manner. Many alterations and modifications of the structures hereinbefore described will be apparent to those skilled in the art and may be made without departing from the spirit and essence of the present invention which, for this reason, shall not be limited but by the scope of the appended claims.

I claim:

1. A delivery valve comprising a casing with two chambers therein, the first one of said chambers having an inlet port, delivery port and a drain port, the second chamber having a connecting port communicating with said delivery port, a poppet being movable in both said chambers and having two end positions, said poppet being so arranged and constructed as to open said inlet and delivery ports and to close said drain port and said connecting port, when moving from its first to its second end position, and to close said inlet and delivery ports and to open said drain port and connecting port when moving from its second to its first end position, and a spring in said second chamber and bearing on said poppet so as to tend to urge said poppet into its first position against an existing inlet pressure.

2. A delivery valve comprising a casing with a chamber therein, a poppet movable in said chamber so as to divide said chamber into a first and a second part on top and below said poppet respectively, said first part chamber having an inlet port, a delivery port and a drain port, said second part chamber having a connecting port communicating with said delivery port, said poppet having two end positions and being so constructed and arranged as to open said inlet and delivery ports and to close said drain port and connecting port when moving from its first to its second position, and to close said inlet and delivery ports and to open said drain port and connecting port when moving from its second to its first end position, and a spring in said second part chamber and bearing on said poppet so as to tend to urge said poppet into its first position against an existing inlet pressure.

3. A delivery valve comprising a casing with three chambers therein, the first one of said chambers having an inlet port and a delivery port, said second chamber having a connecting port communicating with said delivery port, said third chamber being of a smaller volumetric

capacity than either one of the other chambers, and having a drain port, a passage from said first to said third chamber; a poppet movable in said three chambers and having two end positions, said poppet being so constructed and arranged as to open said inlet and delivery ports and to close said connecting port and said passage when moving from its first end position into the second, and to open said passage and said connecting port, and to close said delivery and inlet ports when moving from its second into its first position, and a spring in one of said chambers and bearing on said poppet so as to tend to urge said poppet into its first position against an existing inlet pressure.

4. A delivery valve comprising a casing with two chambers therein, said chambers being coaxially arranged, the diameter of the second chamber being smaller than that of the first chamber, a poppet including a body and a rod, and having two end positions, said body being operative in said first chamber and so arranged as to divide said first chamber into a first positioned and a second part chamber, said rod being operative in said second chamber, said first part chamber having an inlet and a delivery port, said second part chamber having a connecting port in communication with said delivery port, said second chamber having a drain port, a passage from said first part chamber to said second chamber, said poppet being so constructed and arranged that said body will open said inlet and delivery ports and close said connecting port and said rod will close said drain port when the poppet moves from its first to its second position, and that the body will close the inlet and delivery ports and open the connecting port and the rod will open the drain port when the poppet moves from its second to its first position, and a spring in said second part chamber and bearing on said body so as to tend to urge said poppet into its first end position.

5. A delivery valve comprising a casing with two cylindrical and co-axial chambers therein, the second chamber having a smaller diameter than the first chamber, an inlet port in the bottom and a delivery port in the side wall of said first chamber, a drain port at the top of said second chamber and a conduit between said first and said second chamber, a poppet including a stepped plunger, having a first portion operative in said first chamber and a second portion operative in said second chamber, said first plunger portion having at its bottom a valving surface in relation to said inlet port and a control edge of its side wall in relation to said delivery port, and said second plunger portion being in valving relation to said drain port to close said drain port when said first plunger portion has completely opened said inlet and delivery ports.

6. A valve as claimed in claim 5 further comprising a connecting port in said first chamber in communication with said delivery port, and a second control edge of said first plunger portion positioned in relation to said connecting port so as to close said connecting port while said first edge opens said delivery port.

7. A valve as claimed in claim 5 wherein said conduit between said first and said second chamber is provided by a bore in said plunger from its bottom laterally of said valving surface to the free end of said second plunger portion.

8. A delivery valve comprising a substantially hollow cylindrical casing open at its top and provided with an internal threading at its up-

per portion, a substantially cylindrical plug including a head and a body, the upper body portion being externally threaded and screwed into said casing so as to seat tightly on the bottom of said casing, and to form an annular space between its lower portion and said casing, said casing having an inlet port in its bottom and a drain conduit in communication with said annular space, said plug having in its body portion a stepped axial bore wider in its lower portion than in its top portion, so as to form two communicating chambers, a drain passage between said top chamber and said annular space, and a delivery conduit laterally of said bore and with a delivery port and a connecting port, the latter above the former, in the side wall of said lower chamber, and a spring-loaded poppet operative in both chambers and positioned in relation to said ports and said drain passage, so as to close said passage and said connecting port while said inlet and delivery ports are completely opened.

9. In a valve of the type described, a plug-like body having a flat bottom surface and embodying means to secure said body in a housing with a tight fit of its bottom surface therein, said body being provided with a central bore from its bottom through a portion of its length, and with a plurality of ports opening into said central bore, two of said ports being arranged on different levels and in communication with a delivery conduit and one of said ports being in connection with a drain conduit, and a spring-provided piston-like poppet in said central bore, said poppet having a bottom surface of a diameter smaller than that of said central bore and formed as a valving surface exposed to a pressure acting against it, said poppet also embodying controlling edges in operative relation to said ports.

10. A delivery valve comprising a housing open

on top, a member in closing connection with said housing, an inlet port in the bottom surface of said housing, a delivery port, a drain port and a connecting port all in said housing on different levels, a piston movable in said housing and having a bottom surface in valving relation to said inlet port, and three control edges in operative relation to said last mentioned three ports, respectively, so as to close said drain port and said connecting port simultaneously with the opening of said inlet port and said delivery port, and a spring between said closing member and said poppet so as to urge said poppet in a position to close said inlet and said delivery port.

11. A delivery valve comprising a housing having an inlet port in its bottom, a delivery port, a drain port, and a connecting port in communication with said delivery port, said last mentioned three ports being arranged on different levels, a hollow piston-like poppet open at its top and being movable in said housing, said poppet having a bottom face of a diameter smaller than that of the major poppet portion, two controlling edges, and a peripheral groove with an opening into the hollow of said poppet, said edges being in cooperative relation to said delivery port and said connecting port respectively, and said groove being in cooperative relation to said drain port, so as to establish communication between said inlet port and said delivery port, and between said drain port and the hollow space of the poppet, and to close said connecting port when the poppet moves in the one direction, and to close said inlet port, said drain port, and said delivery port, and to establish communication between said connecting port and the interior space of the poppet when the latter moves in the opposite direction.

LOUIS BEEH.