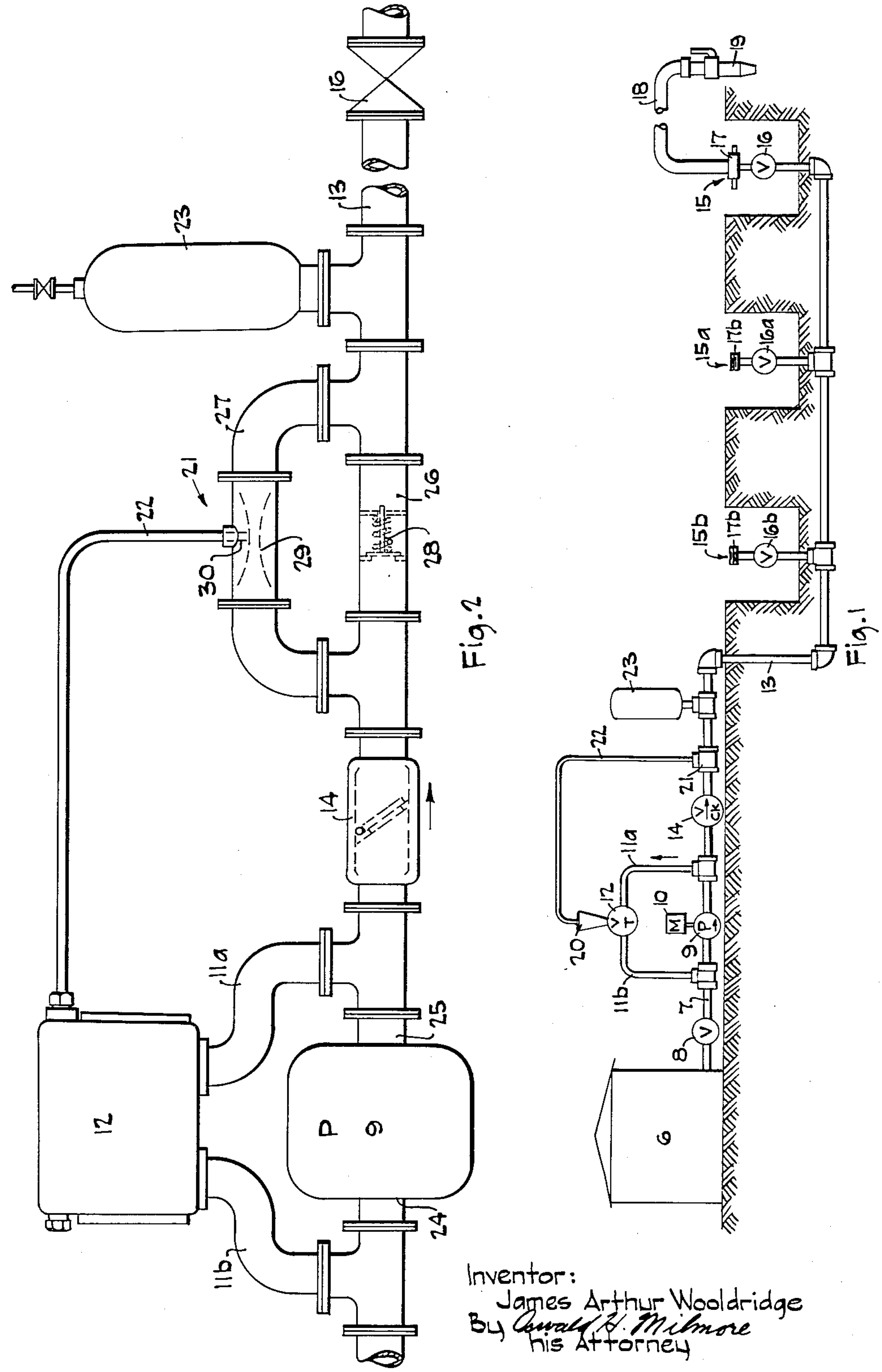
May 29, 1956 J. A. WOOLDRIDGE 2,747,598

LIQUID-DISPENSING SYSTEM WITH REMOTE CONTROL

Filed July 22, 1952 2 Sheets-Sheet 1



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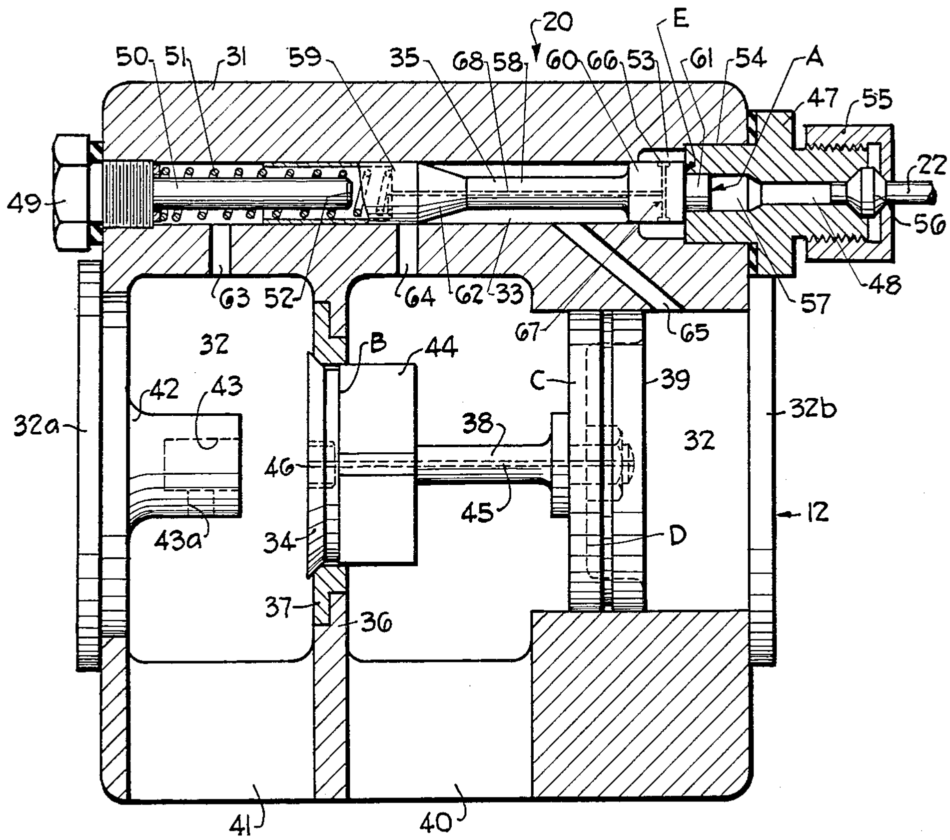

Fig. 3

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LIQUID-DISPENSING SYSTEM WITH REMOTE CONTROL

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Claims priority, application Great Britain July 31, 1951

19 Claims. (Cl. 137—108)

This invention relates to liquid-dispensing systems of the kind in which a pump delivers liquid into a line having a delivery valve at one or more dispensing points remote from the pump. The invention is especially applicable to the so-called static systems for fuelling aircraft, in which fuel is fed by a pump from a static bulk storage tank through a permanent system of pipes to a number of dispensing stations located adjacent the parking positions of the aircraft and equipped with dispensing devices. The dispensing devices, each of which is controlled by a delivery valve, are generally remote from the bulk storage tank and the pump, the latter usually being situated adjacent the tank.

The discharge of fuel at the dispensing stations is necessarily intermittent, and at the less busy aerodromes there are frequent periods when the delivery valve or valves are closed. Unless an operator is stationed at the pump house to start and stop the pump as required, the pump operates for substantial periods of time against the pressure exerted by the usual relief or by-pass valve with which such pumps are provided, with the result that unnecessary power consumption and wear and tear take place. Whilst an electrically driven pump could be controlled by the operator at the dispensing station, this woud necessitate the provision of a control circuit to each dispensing station. If the prime mover is a diesel engine, this could be started and stopped by an electric control circuit which operates relays for actuating the fuel control rack and starter motor of the engine, but again the necessary control circuit must be extended to each dispensing station. A further and more serious difficulty in the case of a diesel engine, especially where traffic conditions on the aerodrome are such that the engine would be started and stopped frequently, is the wear and tear on the engine associated with such starting and stopping.

An object of the present invention is to provide a system whereby the load on the pump is reduced automatically, whenever the delivery valve or all of them is or are closed, to a value substantially below that allowed by the relief or by-pass valves hitherto provided and without the necessity for stopping the prime mover which drives the pump.

According to the present invention a liquid-dispensing system includes a pump, a delivery line connecting the discharge side of said pump to at least one dispensing device controlled by a delivery valve, a non-return valve in said delivery line, said non-return valve permitting liquid flow from said pump to the dispensing device or devices but not vice versa, and a by-pass line providing a path between the discharge and suction sides of said pump through a by-pass valve which is operative to vary the resistance to liquid flow offered by said by-pass line in dependence upon the pressure at a point in the delivery line located between said non-return valve and the delivery valve or valves and to afford a low-resistance by-pass to said pump when the pressure at said point in the delivery line reaches a predetermined value.

Preferably the system also includes a pressure-storage vessel communicating with said delivery line at a point between said non-return valve and the delivery valve or valves.

The by-pass valve preferably includes a main valve member, the position of which determines the resistance to liquid flow offered by the by-pass line, and a pilot valve acted upon by the pressure at said point in the delivery line between the non-return valve and the delivery valve or valves, which pressure tends progressively to open said pilot valve against a force biasing said pilot valve to the closed position to vary the position of said main valve member, the disposition of said main valve member being such as to close said by-pass line when said pilot valve is closed.

The pilot valve preferably functions in such a manner as to cause the main valve member progressively to reduce the resistance to liquid flow offered by the by-pass line until the pressure at said point in the delivery line reaches a predetermined value above which said pilot valve causes said main valve member to open fully to provide a low-resistance by-pass to the pump.

The main valve member may serve in its closed position to separate two portions of a chamber housing said main valve member, in one of which portions operates a piston connected to and of larger surface area than said main valve member, means being provided whereby, on operation of the pilot valve, the liquid pressure acting on the side of the piston adjacent the main valve member is progressively transmitted so as to act on both sides of said piston to open said main valve member, and whereby on closure of said pilot valve the liquid pressure on the piston face remote from the main valve member is bled away to close said main valve member.

Advantageously the arrangement is such that the pilot valve when fully opened is caused to move to the closed position only when the pressure at said point in the delivery line falls to a value below that causing initial opening thereof.

Conveniently, the delivery line is provided with a venturi constriction at the said point between the non-return valve and the delivery valve or vales at which the pressure is determined and the by-pass valve is arranged to open fully only when liquid flow through the venturi constriction is substantially zero.

A static fuelling system for aircraft in accordance with the invention will now be described by way of example and with reference to the accompanying drawings forming a part of this specification, in which:

Figure 1 is a diagrammatic general arrangement view of a dispensing system according to the invention;

Figure 2 is an elevation view of a part of the dispensing system, namely that pertaining to the pump and its by-pass valve, parts being shown diagrammatically; and

Figure 3 is a detailed sectional view of the by-pass valve.

Referring first to Figure 1, the complete system includes the following principal elements: a source of liquid, such as a bulk storage tank or reservoir **6** from which liquid flows to a supply pipe **7** which may have a shut-off valve **8**; a pump **9** having the suction thereof connected to the supply pipe **7** and driven by any suitable motor **10**, such as a diesel engine which may be provided with the usual governor for controlling the supply of fuel thereto in accordance with the load; a by-pass line having serially connected parts **11***a*, **11***b*, interconnecting the suction and pressure discharge sides of the pump; a flow control valve **12** in the by-pass line; a pressure delivery pipe line **13** having a check or non-return valve **14** disposed to permit flow only away from the pump; one or more dispensing outlets 15, 15*a*, etc., which may be located at different dispensing stations of the airfield or other dispensing installation, for example in pits as shown, and which are connected to the delivery pipe line by suitable branches thereof, each dispensing outlet including at least a delivery shut-off valve 16, 16*a*, etc., and, if desired, either a coupling device 17, 17*a*, etc., for attaching a hose 18 fitted with a suitable nozzle 19 for attachment to the fuel tank of an aircraft, or merely a permanently attached hose; and a pressure-responsive actuating device for operating the flow control valve 12 in the by-pass line in accordance with the pressure in the delivery pipe line downstream of the check valve 14, said actuating device including a valve actuator 20 and a pressure-responsive element, which may be simply a tap 21 in communication with the interior of the pipe line 13 and further connected to the actuator 20 by any suitable device for transmitting a signal corresponding to the prevailing pressure, represented diagrammatically as a transmission line 22, it being understood that the latter may be merely an electrical cable. In its broadest aspect, the element 21 is any device for sensing the pressure in the pipe line 13 and the line 22 is any hydraulic, pneumatic, electrical, etc., device for transmitting the sensing; however, as will be explained in detail in connection with the specific embodiment of Figs. 2 and 3, it is preferred to have this element respond not only to the static pressure but also to the velocity of liquid flow in the line 13, to indicate a lower pressure upon an increase of flow. The actuator 20 is arranged to open the valve 12 either progressively or completely upon a rise in the indicated pressure above a predetermined value and to close the valve upon a fall in pressure, and the valve 12 is preferably of the type offering as low a flow resistance as practicable to the passage of liquid when fully open. Preferably, although optionally, the delivery pipe line 13 is provided at a point therein downstream of the check valve 14 with a pressure-storage vessel or reservoir 23 of any suitable type, such as one containing a compressed gas in direct contact with the liquid or isolated therefrom by a diaphragm, a gas bag, etc., as are well known in the art.

In operation, the pump 9 is normally kept in operation continuously while the airport is in condition to dispense liquid fuel. When any of the delivery valves 16, 16*a*, etc., is open, the liquid pressure in the pipe line 13 falls and the signalled or transmitted pressure of the transmission line 22 becomes sufficiently low to cause the actuator 20 to shut the main valve 12 in the by-pass line. The pump 9 is thereby enabled to force liquid fuel from the supply pipe 7 to the delivery pipe line 13 through the check valve 14, which is of the type offering a minimum of resistance. When all of the delivery valves 16, 16*a*, etc., are shut the pressure in the delivery pipe line rises, resulting in an increased higher signalled or transmitted pressure which causes the actuator 20 to open the valve 12; this decreases the pressure on the pressure discharge side of the pump, but the check valve 14 prevents backflow of liquid fuel and maintains the pressure in the pipe line 13 at the increased value. The pump is thereby enabled to pump liquid through the by-pass line 11*a*, 11*b*, against a negligible pressure head. Hence it becomes unnecessary to shut down the pump 9 and the motor 10 even though a positive displacement pump, such as a reciprocating piston pump or a rotary pump, is used, and the system can be left ready for instant operation should one or more of the delivery valves 16, 16*a*, etc., be opened. It should be understood, however, that the system may also be employed with centrifugal pumps. When any of the delivery valves is opened the pressure in the delivery pipe line falls, causing the actuator to shut the valve 12 and restoring the system to the condition first described. The usual governor on the motor 10 regulates the supply of energy to it to maintain the pump speed more or less constant, e. g., in the case of a diesel engine, by decreasing the amount of fuel supplied when the shaft speed increases due to decreased load when the by-pass valve 12 is opened; hence but little power is consumed when no liquid fuel is dispensed. It is evident that such a system is well suited to use particularly at airfields where fuelling operations occur only occasionally but are yet of sufficient frequency to make it inadvisable to start and stop the diesel or other engine which operates the pump every time it is desired to fuel an aircraft.

As will be explained in detail below, the actuator 20 need not be one which causes only complete opening or closing of the valve 12; it may be of the type that throttles the valve 12 to varying degrees. The latter is useful when, for example, several dispensing stations are provided; it then becomes desirable to shut the valve 12 completely only when liquid is being dispensed at a high rate (as when several dispensing devices are in use) and to shut the valve partially when liquid is being dispensed at a low rate.

The pressure reservoir 23 smooths out minor pressure-fluctuations in the pipe 13. Its main function is to maintains a pressure within the delivery pipe line 13 for moderately extended periods despite a slow leakage of liquid from the pipe line, thereby preventing rapidly recurring operation of the valve 12. Rapidly recurring operation of the valve or "chattering" is further avoided by arranging the actuator 20 to open the valve 12 at a higher transmitted pressure than that at which the valve is closed, and such an arrangement is facilitated by the use of the reservoir 23.

The invention will be further described with reference to a specific embodiment, which is illustrative of the diagrammatic showing of Figure 1. Referring to Figure 2, the pump has the suction side 24 thereof connected to the supply pipe 7 and to the branch 11*b* of the by-pass line. The pressure discharge side 25 of the pump is connected to the branch 11*a* of the by-pass line and to the non-return valve 14, the downstream end of the latter being connected to the delivery pipe line 13 through branched conduits 26 and 27 which collectively form a part of the pressure sensing element 21 of Figure 1. The valve 14 is of a type affording only a small resistance to the flow of liquid in the direction of the dispensing points. The branch 26 may contain a normally-closed, spring-loaded valve 28 for diverting flow through the branch 27, thereby insuring that liquid flow to the dispensing devices is always accompanied by liquid flow through the branch 27, even at low rates of flow. The spring of the valve 28 is weak enough to permit the valve to be opened by the pressure of the liquid when large rates of flow occur. The branch 27 contains a venturi constriction 29 having a port 30 connected to one end of the transmission line 22, which is in this case a bleed line and may have a small bore. The other end of the line 22 is connected to the valve acuator 20 which actuates the valve 12 in the by-pass line 11*a*, 11*b*. Connected to the delivery pipe line 13 at a point downstream of the spring-loaded valve 28 is the pressure-storage reservoir 23, which may conveniently be an air-expansion chamber, which functions to eliminate or reduce pressure fluctuations which affect the operation of the actuator 20 and by-pass valve 12, such fluctuations being, for example, the effect of leakage which may occur in the delivery pipe line or in the dispensing system on shut down.

The by-pass valve 12 and actuator 20 are shown in detail in Figure 3. They are arranged in a casing 31 provided with two cylindrical bores 32 and 33 of which the larger, namely 32, houses a main valve member 34 and the smaller, namely 33, houses a pilot valve member 35; the bores 32 and 33 are hereinafter referred to as the main valve chamber and the pilot valve chamber, respectively. The main valve chamber 32, which is closed at each end by plates 32*a* and 32*b*, is divided by an apertured partition 36 carrying a ring 37 which has a press fit with the partition

36; it is shaped to provide a valve orifice constituting a seating for the valve member 34. The valve member 34 is attached to a piston rod 38 which extends through the apertured partition and terminates in a piston 39 slidable in a smaller-diameter portion of the chamber 32. The chamber 32 is in communication with the branches 11*a* and 11*b*, connected respectively to the discharge and suction sides of the pump 9 through large ports 40 and 41, respectively, of which port 40 is situated on the piston side of the valve member 34 and port 41 is situated on the opposite side thereof. The maximum opening of the main valve member 34 is limited by a hollow stop or projection 42 formed on the end plate 32*a* and having a main bore 43 and a vertical bore 43*a* set back from the open end thereof. The valve member 34 is guided in its movement towards and away from the valve orifice by means comprising an open cylindrical framework 44 carried by the rod 38 and slidably engaging the cylindrical part of the orifice in the ring 37. A flow connection is provided between that part of the chamber 32 on the inside of the piston 39 (to the right in Fig. 3) and that on the outer face of the valve member 34, i. e., that in communication through the port 41 with the suction side 24 of the pump, to enable pressure in the space confined by the piston 39 to bleed away to suction, the said connection comprising a fine bore 45 extending axially through the piston 39, the piston rod 38 and the valve member 34. The effective size of the bore 45 is determined by a removable, apertured plug 46 that is rotatably mounted in the main valve member 34, and can be adjusted to restrict the size of the passageway through the main valve member at will to vary the rate at which the pressure can bleed away. Moreover, the vertical bore 43*a* in the stop 42 insures that communication between the bore 45 and suction from the port 41 is maintained when the valve member 34 lies fully open against the stop 42.

The pilot valve chamber 33 is closed at one end by a plug 47 having a bore 48 providing connection with the end of the bleed line 22; the other end of the chamber is closed by a screw-threaded plug 49 having an inwardly extending rod-shaped portion 50 of smaller diameter around which is disposed a compression spring 51 for biasing the pilot valve to the biased position shown. The end 52 of this portion 50 constitutes a stop for limiting the movement of the pilot valve member 35 in the chamber 33. The end of the pilot valve chamber 33 remote from the compression spring 51 is enlarged in two steps to form two adjoining portions 53 and 54, the latter of which receives the plug 47 and is closed thereby. The plug 47 carries a collar 55, threadedly connected for retaining the end of the bleed line 22 which has an enlargement 56 with a frusto-conical face for sealing contact with the plug 47. The axial bore 48 in the plug 47 has an enlarged portion 57 which opens into the pilot valve chamber 33 and provides communication between the latter and the bleed line 22. Slidably disposed within, and extending the greater part of the length of, the chamber 33 is the elongated pilot valve member 35 comprising a central stem portion 58 of smaller diameter than the bore of the chamber 33, which stem portion is enlarged at its ends to form cylindrical portions 59 and 60 which slidably engage the inner wall of the chamber 33.

The end portion 59 of the pilot valve member 35 is counterbored and the hollow end thereof encloses part of the compression spring 51, whilst the other end portion 60 carries a short cylindrical extension 61 of smaller diameter. The extension 61 has a sliding fit in the enlarged bore portion 57 and is of sufficient length to remain in sliding engagement therewith both in the closed and partly open positions of the valve member 35, but which is carried clear of the plug 47 at the fully open position of the valve member. The stem portion 58 of the valve member tapers outwardly at 62 to the full diameter of the hollow end portion 59 thereof for a purpose hereinafter explained.

Ports 63, 64 and 65 are provided between the main valve chamber 32 and the pilot valve chamber 33, of which port 63 provides communication between the part of the chamber 33 confined between the end 59 of the pilot valve 35 and the plug 49, and the part of the chamber 32 in the suction side of the valve 34, and port 65 provides communication between the part of the control valve chamber 33 containing the central valve stem 58 and the space on the inner side of the piston 39; both remain open for all positions of the pilot valve 35. Port 64, which communicates at one end with the pressure side of the main valve 34 and at the other end with an intermediate point of the chamber 33, is normally closed by the enlarged end portion 59 of the valve member and is opened progressively by movement of the valve member 35 against the spring 51.

The enlarged portion 53 of the chamber 33 is in communication with that part of the chamber 33 which is confined between the end 59 of the pilot valve member and the plug 49 by way of a circumferential channel 66 and radial bores 67 in the end portion 60 and an axial bore 68 in the stem 58.

The system operates as follows:

When the shut-off valve 8 is open and liquid is flowing from the source 6 through the supply pipe 7, pump 9 and delivery pipe line 13 to the dispensing outlets 15, 15*a*, etc., pilot valve member 35 is in its biased or closed position as shown in Figure 3. This occurs because all or part of the liquid flows through the venturi construction 29 due to the action of the valve 28, causing such a reduction in the pressure of the liquid in the bleed line 22 that the force exerted by the spring 51 overcomes the pressure exerted by that liquid on the face A of the pilot valve 35, this face being a movable wall for the pilot valve member. With the pilot valve member 35 in this position the port 64 is closed and so there is no communication between the main or central part of the chamber 32 and the inner side of the piston 39. Consequently full pump discharge pressure, transmitted through the port 40, acts on faces B and C of the valve member 34 and the piston 39, respectively, and since the area of the latter is greater than that of the face B of the valve member 34 there is a pressure difference which holds the valve member 34 closed against its seating 37, as shown in the drawing.

When the rate of liquid flow to the dispensing outlets decreases as the result of closing one or more, less than all, of the delivery valves 16, 16*a*, etc., the rate of liquid flow through the venturi 29 decreases and the liquid pressure in the bleed line 22 accordingly rises with a corresponding increase in the pressure acting on the face A of the pilot valve member 35. As a result the valve member 35 overcomes the force exerted by the spring 51 and moves progressively to open the port 64, the tapered portion 62 of the valve member providing a gradual opening of the port 64, with consequent gradual build up of pressure on the inner face D of the piston 39. This partial movement of the pilot valve stops when the spring 51 is compressed sufficiently to overcome the increased force of the fluid acting on the face A. The stiffness of the spring is such that, with at least partial liquid flow continuing through the venturi constriction, the pilot valve comes to rest at an intermediate, partly open position, with the extension 61 still within the bore 57. Liquid thus enters the right end of the chamber 32 through the port 65 at a restricted rate and simultaneously bleeds off through the bore 45. The extent to which the pressure is built up on the face D is, therefore, dependent upon the extent to which the tapered part 62 uncovers the port 64. The effect of this increase in pressure on face D is finally to remove the pressure difference holding the main valve member 34 closed, whereupon the main valve opens to an extent proportional to the pressure in the delivery line 13 to provide an alternative outlet for the liquid discharged by the pump 9. In this way the valve member 34 functions in a manner similar to that of the known pump relief valves.

As soon as the rate of liquid flow through the venturi 29 increases again as the result of an increased take off from the dispensing outlets, the pressure of the liquid in the bleed line 22 decreases correspondingly and the resulting reduction in the force acting on the face A of the pilot valve member 35 allows the valve 35 to move back to its rest position under the action of the spring 51. Communication between the discharge side 25 of the pump 9 and the inner side of the piston 39 through ports 64 and 65 is thereby cut off and the pressure acting on the face D of the piston 39 decreases by bleeding to suction through the bore 45 in the piston rod 38; the valve 34 therefore closes again as soon as the pressure difference on the adjacent sides of the valve member 34 and the piston 39 due to the difference in their surface areas is re-established.

When all the delivery valves 16, 16*a*, etc., of the dispensing system are shut down, liquid flow through the venturi 29 ceases and the pressure in the bleed line 22 increases to such an extent that the pilot valve 35 moves sufficiently to cause the extension 61 to leave the bore 57 of the plug 47. As soon as this occurs the pressure in the bleed line 22 operates over a larger area comprising the area of the face A at the end 61 and the area of the annular face E at the end of the enlarged end 60, with the result that the pilot valve continues its movement against spring 51 to uncover the whole area of the port 64, thereby admitting liquid far in excess of the rate of bleed through the bore 45 and applying maximum pressure against the face D of the piston 39. The valve 34 then opens fully and the non-return valve 14 closes with the result that the valve 12 provides a low-resistance by-pass through which liquid can be circulated by the pump 9 at a low pressure and with little expenditure of energy by the engine driving the pump.

When liquid flow to a dispensing station recommences, the pressure in the bleed line 22 decreases and the pilot valve 35 moves to the right under the action of the spring 51. However, since in the extreme open position of the pilot valve 35, the pressure of the liquid in the bleed line 22 acts on the whole of the area of the faces A and E (on the portions 61 and 60 of the member), the pilot valve 35 will move to the closed position only when the bleed line pressure falls to a value, for example 15%, below that causing initial opening of the pilot valve 35. This has the effect of compensating to a certain extent any pressure drop due to leakage in the delivery line 13 or the dispensing system, thereby avoiding chattering or sudden reciprocations of the pilot valve. During closure of the pilot valve liquid trapped in the enlarged portion 53 of the chamber 33 by the re-entry of the extension 61 of the valve member into the bore 57 flows to suction via the bore 68 in the valve member and the port 63, and the port 64 becomes progressively obturated by the valve member 35, thereby correspondingly reducing the pressure acting on the face D of the piston 39 which results in partial or complete closure of the valve member 34.

The pressure storage vessel 23, which is an optional component, also functions to retain in the delivery line 13 the pressure required to maintain the pilot valve 35 open in spite of any moderately small leakage that may occur in the delivery line 13 or in the dispensing system itself over the period during which the delivery valves are shut. The pressure storage vessel 23 also acts as a shock absorber and may thus replace any shock pressure absorber which might otherwise be needed.

It will be apparent from the foregoing description that the present invention comprises a liquid dispensing system which includes means operative automatically in response to pressure variations in the delivery line to provide the usual by-pass facility on partial shut-down of the dispensing system and in addition to provide a low-resistance by-pass for the pump on complete shut-down thereof, without the need for any control of the pump by the operator at the dispensing stations.

While the fluid in the transmission or bleed line 22 is, in the embodiments shown, the same as that flowing through the delivery pipe line, it should be understood that the invention is not limited thereto, and that the fluid acting on the movable wall A of the pilot valve may be a different liquid which may, if desired, be isolated from the liquid in the pipe line through any suitable means, such as a diaphragm or pistons.

I claim as my invention:

1. A liquid-dispensing system including: a pump having suction and discharge sides; a delivery pipe line connected to the discharge side of said pump; at least one dispensing device including a delivery valve connected to said delivery pipe line; a non-return valve in said delivery pipe line, said non-return valve being disposed to permit liquid flow from said pump to the dispensing device but not vice versa; a by-pass line providing a low-resistance flow path for liquid between the discharge and suction sides of said pump; a by-pass valve in said by-pass line which is operative to vary the resistance to liquid flow through said by-pass line; and a pressure-responsive valve actuator for said by-pass valve connected to respond to the pressure in said delivery pipe line at a point therein located between said non-return valve and the said delivery valve, said actuator being disposed to actuate the by-pass valve to decrease the said resistance to flow through the by-pass line when the pressure at said point in the delivery pipe line rises to a predetermined value.

2. A liquid-dispensing system as set forth in claim 1 wherein said valve actuator is arranged to increase the said resistance to flow through the by-pass line only when the pressure at said point in the delivery pipe line falls to a second predetermined value which is lower than said first-mentioned predetermined value.

3. A liquid-dispensing system including: a pump having suction and discharge sides; a delivery pipe line connected to the discharge side of said pump; at least one dispensing device including a delivery valve connected to said delivery pipe line; a non-return valve in said delivery pipe line, said non-return valve being disposed to permit liquid flow from said pump to the dispensing device but not vice versa; a pressure storage vessel communicating with said delivery pipe line at a point therein between said non-return valve and the said delivery valve; a by-pass line providing a low-resistance flow path for liquid between the discharge and suction sides of said pump; a by-pass valve in said by-pass line which is operative to vary the resistance to liquid flow through said by-pass line; and a pressure-responsive valve actuator for said by-pass valve connected to respond to the pressure in said delivery pipe line at a point therein located between said non-return valve and the said delivery valve, said actuator being disposed to actuate the by-pass valve to decrease the said resistance to flow through the by-pass line when the pressure at said point in the delivery pipe line rises to a predetermined value.

4. A liquid-dispensing system including: a pump having suction and discharge sides; a delivery pipe line connected to the discharge side of said pump; at least one dispensing device including a delivery valve connected to said delivery pipe line; a by-pass line providing a low-resistance flow path for liquid between the discharge and suction sides of said pump; a by-pass valve in said by-pass line including a main valve member movable to progressively different positions to vary the said resistance to liquid flow in gradations to values dependent upon the position of the valve member; a pressure-responsive valve actuator for said by-pass valve including at least one movable wall operatively connected to said main valve member for movement therewith and exposed to fluid pressure, a pilot valve having a pilot valve member movable to progressively different positions and arranged to control in gradations the admission of fluid to act on

said movable wall in accordance with the position of the pilot valve member, said pilot valve having biasing means for biasing the pilot valve member to a biased position and a second movable wall operatively connected to said pilot valve member for moving the pilot valve member progressively away from said biased position upon the application of increasing fluid pressure against said second movable wall; and a fluid pressure transmission line having one end thereof connected to the pilot valve for admitting a fluid against said second movable wall and the other end thereof connected to means for supplying fluid thereto at a pressure that depends upon the pressure in said delivery pipe line, said first-mentioned movable wall being so exposed to fluid pressure as to move said main valve member toward open position upon a rise in the said pressure in the delivery pipe line.

5. A liquid-dispensing system as set forth in claim 4, wherein the said means for supplying fluid to the fluid transmission line includes means responsive both to the rate of liquid flow through said delivery pipe line and to the static pressure therein, an increase in said static pressure acting in the same sense as a decrease in said rate of liquid flow.

6. A liquid-dispensing system as set forth in claim 5, wherein the relation of the area of said second movable wall and the said biasing means is such that said main valve is moved to fully open position only upon substantially total cessation of flow in the said delivery pipe line.

7. A liquid-dispensing system as set forth in claim 4, wherein said delivery pipe line has a non-return valve therein disposed to permit liquid flow from said pump to the dispensing device but not vice versa, and said means for supplying fluid to the fluid pressure transmission line is connected to a point in the delivery pipe line between said non-return valve and the said delivery valve and is disposed to supply fluid at a pressure determined by the pressure at said point in the delivery pipe line.

8. A liquid-dispensing system as set forth in claim 7, wherein the said means for supplying fluid to the fluid transmission line includes a venturi constriction in said delivery pipe line and a port in said venturi constriction connected to said transmission line, whereby the pressure in said transmission line becomes greater in response to an increase in the said static pressure and also in response to a decrease in said rate of liquid flow.

9. A liquid-dispensing system as set forth in claim 8, wherein the said liquid delivery pipe has at least two parallel branches at said point therein interconnected both at their upstream and downstream ends, said venturi constriction being situated in the first of said branches and all the other of said branches containing flow-restrictive means for diverting flow through the first said branch during low liquid flow rates, whereby at least some flow of liquid occurs through said venturi constriction whenever any liquid flows through said delivery pipe line.

10. A liquid-dispensing system including: a pump having suction and discharge sides; a delivery pipe line connected to the discharge side of said pump; at least one dispensing device including a delivery valve connected to said delivery pipe line; a non-return valve in said delivery pipe line, said non-return valve being disposed to permit liquid flow from said pump to the dispensing device but not vice versa; a by-pass line providing a path having low-resistance to liquid flow from the discharge side to the suction side of said pump; a by-pass valve in said by-pass line including a main valve member movable to different positions to control the said resistance to liquid flow to values dependent upon the position of the valve member; a pressure-responsive actuator for said by-pass valve including at least one movable wall operatively connected to said main valve member for movement therewith and exposed to fluid pressure, a pilot valve having a pilot valve member movable to different positions and arranged to control the admission of fluid to act on said movable wall in accordance with the position of the pilot valve member, said pilot valve having biasing means for biasing the pilot valve member to a biased position at which the admission of fluid is controlled so as to move said main valve member to impose a high resistance to flow of liquid in the by-pass line and a second movable wall operatively connected to said pilot valve member for moving the pilot valve member away from said biased position upon the application of increasing fluid pressure against said second movable wall; and a fluid pressure transmission line having one end thereof connected to the pilot valve to supply fluid under pressure to act on said second movable wall and the other end thereof connected to a point in the liquid delivery pipe line between said non-return valve and the said delivery valve to receive fluid at a pressure that rises with increasing pressure in said delivery pipe line.

11. A liquid-dispensing system including: a pump having a suction side connected to a liquid supply source and a discharge side; a delivery pipe line connected to the discharge side of said pump; at least one dispensing device including a delivery valve connected to said delivery pipe line; a non-return valve in said delivery pipe line, said non-return valve being disposed to permit liquid flow from said pump to the dispensing device but not vice versa; a by-pass line providing a low-resistance path for liquid flow between the discharge and suction sides of said pump; a by-pass valve in said by-pass line which is operative to vary the resistance to liquid flow through said by-pass line; a fluid pressure-responsive valve actuator for said by-pass valve disposed to actuate the by-pass valve to decrease the said resistance to flow through the by-pass line when the fluid pressure acting on the actuator increases and to actuate the by-pass valve to increase the said resistance upon a decrease in the said fluid pressure; and a fluid transmission line having one end thereof connected to said valve actuator to admit said fluid at a variable pressure so as to act on said actuator and having the other end thereof connected to said delivery pipe line at a point therein located between said non-return valve and said delivery valve in pressure-transmitting relation so as to subject fluid in the transmission line to a pressure that increases as the pressure in the delivery pipe line increases.

12. A liquid-dispensing system as set forth in claim 11, wherein the said delivery pipe line includes a venturi constriction at the said point therein, in said venturi constriction having a port and the transmission line being connected to the delivery pipe line through said port, the said valve actuator being arranged to move the by-pass valve to fully open position only upon a rise in the pressure in the transmission line to a predetermined value corresponding to a condition of substantially zero flow of liquid through the venturi constriction.

13. A liquid-dispensing system as set forth in claim 12, wherein said valve actuator is arranged to move the by-pass valve from its fully open position only when the fluid pressure in the transmission line falls to a second predetermined value which is lower than said first-mentioned predetermined value.

14. A liquid-dispensing system as set forth in claim 13 and including a pressure storage vessel communicating with said delivery pipe line at a point therein between said non-return valve and the said dispensing device.

15. A liquid-dispensing device as set forth in claim 11, wherein the said by-pass valve and valve actuator include: a casing having a ported partition dividing the casing into a high-pressure chamber and a low-pressure chamber connected by said by-pass line respectively to the discharge side and to the suction side of said pump, said casing having further a cylindrical chamber in open communication with the high-pressure chamber; a main valve member reciprovably mounted within said casing and having a seating against said partition for closing the port therein, the area of said cylindrical chamber being greater than the area of said valve member; a piston in said cylindrical chamber connected to said valve member, whereby pressure in said high-pressure chamber acts

with a relatively larger force on said piston urging the valve member to seat on the partition, and with a relatively smaller force on said valve member urging the valve member away from the partition; a passageway interconnecting the said high-pressure chamber and the end part of the cylindrical chamber on the side of the piston remote from the high-pressure chamber; a pilot valve for regulating the flow of liquid through said passageway; and outlet means for the discharge of liquid from said end part of the cylindrical chamber.

16. A liquid-dispensing device as set forth in claim 15, wherein said outlet means for the cylindrical chamber includes a restricted duct for bleeding into said low-pressure chamber.

17. A liquid-dispensing device as set forth in claim 15, wherein said pilot valve has a graduated passageway for regulating said flow of liquid through the passageway in gradations in accordance with the position of the pilot valve.

18. A valve actuator comprising a casing providing a fluid pressure chamber, said chamber containing therein at least one movable wall adapted for operative connection to a valve member to be actuated; a pilot valve having a pilot valve member movable to progressively different positions and arranged to control in gradations the admission of fluid to act on said movable wall in accordance with the position of the pilot valve member, said pilot valve having biasing means for biasing the pilot valve member to a biased position and a second movable wall operatively connected to said pilot valve member for moving the pilot valve member progressively away from said biased position upon the application of increasing fluid pressure against said second movable wall; and an inlet to said casing for admitting a pressure fluid against said second movable wall.

19. A valve and a valve actuator therefor comprising: a casing having a ported partition dividing the casing into a high-pressure chamber and a low-pressure chamber; openings in said casing communicating with said chambers for connecting feed and discharge pipes to the high-pressure and low-pressure chambers, respectively, said casing having, further, a cylindrical chamber in open communication with the high-pressure chamber; a main valve member reciprocably mounted with said casing and having a seating against said partition for closing the port therein, the area of said cylindrical chamber being greater than the area of said valve member; a piston in said cylindricial chamber connected to said valve member, whereby pressure in said high-pressure chamber acts with a relatively larger force on said piston urging valve member to seat on the partition, and with a relatively smaller force on said valve member urging the valve member away from the partition; a passageway interconnecting the said high-pressure chamber and the end part of the cylindrical chamber on the side of the piston remote from the high-pressure chamber; a pilot valve for regulating the flow of liquid through said passageway; and outlet means for the discharge of liquid from said end part of the cylinder.

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