May 28, 1957 O. J. BORNGESSER 2,793,620

PRESSURE INTERLOCKED-QUICK RELEASE VALVE

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Fig. 1

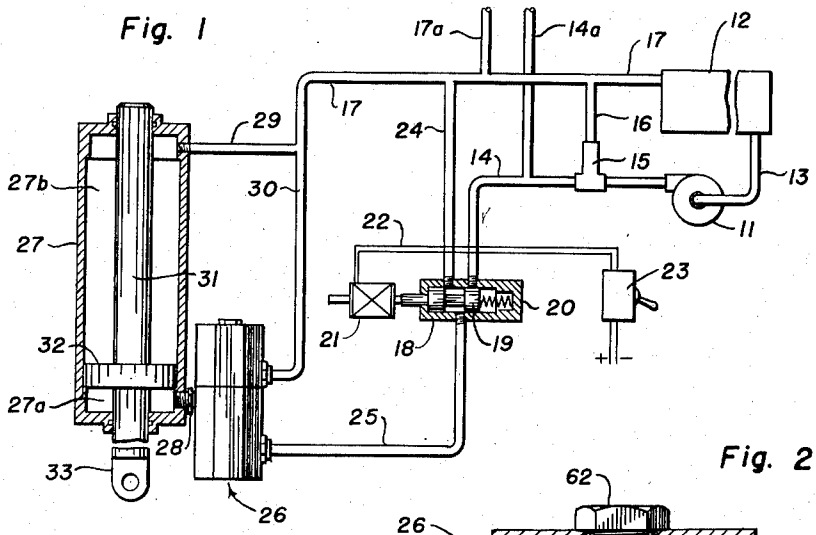


Fig. 2

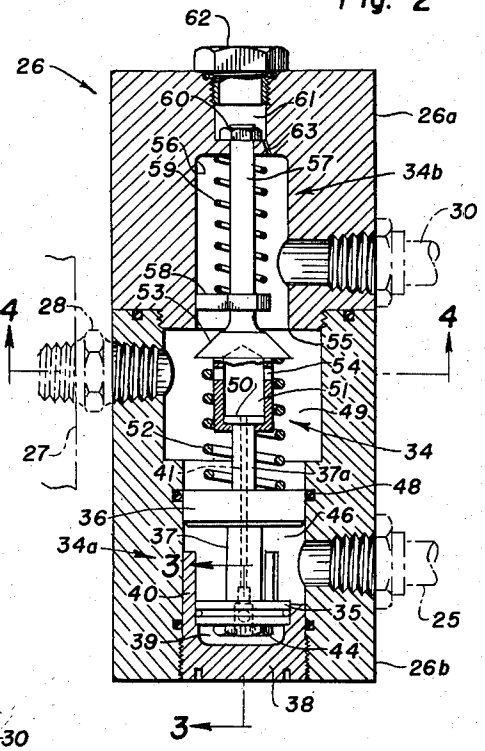


Fig. 3

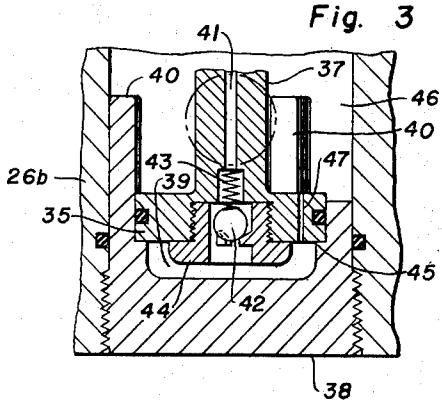
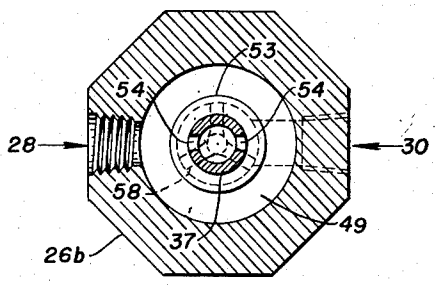


Fig. 4



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PRESSURE INTERLOCKED-QUICK RELEASE VALVE

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8 Claims. (Cl. 121—38)

The present invention relates to automatic valves adapted for use in connection with single acting type hydraulic motors to normally connect one end of the piston chamber to the other while on the other hand being responsive to the application of operating pressure to interrupt such interconnection while connecting one end of the piston chamber to the pressure line and the other end to the return line.

Single acting hydraulic motors are of course employed in applications to apparatus requiring a power stroke in one direction only and usually some means such as a return spring, an inertia device or the like is depended upon to restore the mechanism to its original or unoperated condition. Normally the operating hydraulic medium is supplied to and exhausted from the chamber portion existing on one side of the motor piston. However, the valve constituting the present invention is specially intended for use in conjunction with single acting motors wherein the liquid operating medium is supplied to both sides of the piston in a novel arrangement, the purpose of which will become apparent as the description proceeds.

In the present instance, the subject valve has been invented for use in an hydraulic system wherein its associated motor is but one of many supplied by a common pressure source. In such systems particularly intended for incorporation in airplanes, it is essential that the total weight of the system be kept to a minimum. In accomplishing this designers utilize the smallest sized conduits and the smallest capacity pumps, accumulators, and other items that can possibly do a satisfactory job. In normal operation of such systems, it can be expected that only a certain percentage of the total attached load will be operated at the same time and if this fact has been utilized in the design of the system overloading can easily occur in case of abnormal demand. In fact even normal demand in a minimum size element system might result in poor regulation, that is a marked reduction in operating pressure available at the motors. This condition becomes a factor of importance on two counts. In the first place when the single acting motor is moved by action of the spring, or gravity or other actuating means, the temporarily inactive operating fluid in the piston chamber of the motor must be forced out into the return line. If the return line is of small size, it greatly restricts the rate of outflow and thus slows down the movement of the motor. In certain applications, the motor movement by mechanical means represents the principal function and its rate should be the highest possible; the movement proceeding without hindrance. Where the supply lines are of minimum size, rapid emptying of the working piston chamber can be had by merely transferring the liquid to the opposite side of the piston in contrast to forcing it through the small size return line back to the system reservoir. To accomplish this some means must be provided which preferably would act automatically to interconnect the opposite ends of the piston chamber at appropriate times while also acting at other times to separate these chambers so that the introduction of liquid under pressure to the working portion of the piston chamber will be effective to cause the operation of the motor and so that the liquid that must be exhausted from the other portion of the piston chamber will be routed into the system return line.

The second factor of importance is brought into the picture if the stated means for accomplishing the foregoing functions is of automatic type operable in response to application of system pressure to the hydraulic motor. As was indicated previously, in a minimum size element hydraulic system the regulation or maintenance of normal system pressure at the several operating motors is subject to considerable fluctuation. Therefore an automatic valve means responsive to system pressure to accomplish a switching function appropriate to hydraulic operation of a motor and furthermore, being responsive to lack of system pressure to accomplish a different switching function appropriate to mechanical operation of the same motor, must preferably be so designed that it will operate only if there is sufficient pressure available to actuate the motor and/or will not operate if the system back pressure existing in the return conduit rises to an otherwise appreciable level. In addition when once operated the valve should hold its attained operational setting thereafter even though the available operating pressure may drop to an appreciably lower level.

Therefore it is a principal object of this invention to provide a valve for use in applications typified by a motor unit which is hydraulically energized for operation in at least one direction and which must have special local facilities for caring for the operating liquid during movement of the motor in the other direction. In other words, a valve is provided which, with appropriate connections, adapts the motor to act as its own local reservoir during one phase of its operation.

Another object is to provide a valve of this type which is automatically operable. A still further object is to provide a valve which will respond to the application of system pressure to accomplish its function automatically. Other objects are to provide a valve that will not respond automatically unless the system pressure is up to a predetermined level but which after having so responded will retain its operational setting even though the system pressure may fluctuate above or below previous levels. Still another object is to provide a valve, the operation of which is controllable by differential pressures, with means operable only upon the attainment of a predetermined pressure level for establishing the differential pressure.

One particular embodiment of the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic showing of a typical hydraulic system incorporating the subject valve;

Fig. 2 is a cross-sectional view of the valve showing the internal details of construction;

Fig. 3 is a further section taken on the line 3—3 of Fig. 2 showing an enlarged detail of part of the operating mechanism; and

Fig. 4 is a section taken transversely on the line 4—4 of Fig. 2.

Considering first the system layout which is Figure 1, such a typical system may include a source of pressure such as a pump 11 receiving a continuous supply of operating liquid from reservoir 12 through connecting conduit 13. The output of the pump is carried by a pressure line 14 in which is connected a conventional unloading valve 15 having a relief line 16 connecting to the system return line 17 which terminates in the reservoir 12. It is expected that the pressure source including the pump 11 and the other previously listed units would constitute a common supply for a number of hydraulically ac-

tuated devices which could be connected to the branches 14*a* and 17*a* of the supply and return conduits 14 and 17.

In the arrangement of Figure 1 the supply system has connected thereto at least one motor operating subsystem as shown which would include the valve of this invention. This subsystem might preferably include a control valve 18 connected to receive pressure from conduit 14. It might take any suitable form but a satisfactory type would include a reciprocable distributor 19 of spool type having spaced lands which by covering or uncovering the valve ports control the flow through the valve in a well known manner. The spool 19 is urged to one extreme of its travel by a spring 20 while there is provided a connected solenoid 21 which when energized would overcome the resistance of the spring and move the spool to the other extreme. The solenoid 21 is connected by electrical leads 22 to a source of power and a suitable control switch 23 by means of which a person can remotely control the setting of valve 18. In the illustrated position of the spool, the inlet port of pressure line 14 is closed off but there is internal communication through the valve between two other ports to which are connected external conduits 24 and 25. The first of these leads to a junction with return conduit 17 while the second leads to valve device 26 which is thus interposed in the flow path of pressure fluid proceeding from valve 18 to motor 27, the motor being connected at one end to valve 26 by a nipple 28. At its other end the motor is connected by a conduit 29 to return line 17 and these in turn are joined by a conduit 30 connecting also to the valve 26.

The motor 27 is of the single acting type, its casing forming the usual hollow interior working chamber containing a piston rod 31 and a piston 32 which divides the chamber into two separated parts 27*a* and 27*b*. In regard to the piston rod 31, it should be noted that one end terminates in a connection 33 through which it may be connected to the device to be operated by the motor.

Turning now more particularly to the detail of Figures 2 to 4, it may be seen that the valve 26 may conveniently be formed of two interfitted parts 26*a* and 26*b* which are formed with a central bore extending therein along the common longitudinal axis to constitute the working chamber of the valve. As may be seen this bore has sections of different diameter forming several chambers in series. Contained within the bore is a two-part, spool-type piston valve element 34 of which the lower and upper parts are respectively designated 34*a* and 34*b*. Valve element part 34*a* consists principally of two spaced piston members 35 and 36 of which the second is preferably formed to a somewhat larger diameter. The two piston members are integrally connected by a spindle-like portion 37. As is illustrated, the lower end of the central bore is closed by a threaded plug 38. This plug on its inner surface has a dish-shaped cavity 39 and the plug is further characterized by a circular series of extensions 40 forming guides along which the piston 35 may move while being retained in a centered position in the bore. Extending from one end to the other of piston valve portion 34*a* is a small diameter passageway 41 designed to provide a leak passage from cavity 39. As shown in Figure 3, the lower end of passageway 41 may be fitted with a normally-open, spring-pressed ball check, the ball being designated by the numeral 42 and its spring as 43. These elements are retained in a cavity formed as an enlargement of the end of passageway 41 by a threaded plug 44. With the valve spool in normal position as shown, the piston portion 35 will seat in the end of dish-shaped cavity 39 on an annular shoulder 45 and due to the inclusion of an O-ring seal in the piston, leakage past the piston into cavity 39 will be prevented in the position of the parts as shown but, however, whenever the piston 35 moves upwardly on the guides 40 a sufficient distance to clear the end of the cavity 39, then, of course, the sealed relationship will no longer exist and liquid from the space 46 may freely enter, this space 46 receiving

the pressure flow from conduit 25 whenever such flow is directed therethrough by appropriate setting of valve 18. A final feature of piston portion 35 is a bleed orifice 47 extending completely through the piston for a purpose which will be made apparent hereinafter.

Considering further, the piston portion 36 which lies in cavity 46, it may be seen that there is inset into the wall of space 46 an O-ring seal 48 which cooperates with the piston to seal its periphery when the two are in contact although it should be noted that as the piston valve 34 moves upwardly, the piston portion 36 will move beyond the location of seal 48 and in fact it is intended that it move sufficiently far in the cavity 46 in the direction of larger cavity 49 so as not to obstruct movement of liquid from conduit 25 through space 46 into space 49; at such time the valve spool being held centered by the guides 40.

The spindle 37 is continued on the upper side of piston 36, that part being designated 37*a*, and terminates in an end flange 50. This end flange is received in an elongated hollow chamber 51 formed in the lower end of the upper part 34*b* of the spindle valve. Since the flange is thin in relation to the depth of chamber 51, it is possible for relative movement between parts 34*a* and 34*b* to take place, such movement, however, being influenced by the reaction of a spring 52 which is compressed between piston 36 and a valve plug 53 in surrounding relationship to both spindle portion 37*a* and the lower end of 34*b*. The chamber 51 of course receives any discharge from the passageway 41 and to provide a through connection to chamber 49, there are radial ports 54 in the wall of this chamber.

The part-conical plug valve 53 normally assumes an open position as shown spaced away from the valve seat 55 forming the entrance to a chamber 56 which has an outlet port to which duct 30 is connected. Plug valve 53 is an integral part of upper piston valve part 34*b* which is completed by an upwardly extending stem portion 57 which carries a three-armed spider 58 acting to help center the stem in the chamber 56. Surrounding this stem portion 57 is a compression spring 59 reacting between the spider 58 and the upper end wall of chamber 56. This spring serves to retain the upper valve element 34*b* in the position shown, downward movement under urging of the spring being stopped when the nut 60 on the end of stem portion 57 contacts the lower wall of chamber 61. This chamber merely serves to accommodate the movement of the end of stem 57 and its outer end is closed off by screw plug 62. Also a vent orifice 63 is provided to connect chambers 56 and 61.

The operation of the illustrated system and more especially the essential functioning of the valve 26 will now be described. First, however, it should be explained that the motor 27 is intended in this exemplary showing to be connected to an extendible item of aircraft equipment such as a rocket launcher which extends when unlocked under the action of gravity and air forces. The motor has no function at that time but is installed to provide power retraction of such equipment. Under such circumstances of use, the motor must not impede the extension of the equipment which it certainly would do if the hydraulic system were such that the hydraulic fluid in the motor had to be forced out of motor chamber 27*a*, all the way back through return line 17 to the reservoir 12. When the piece of airplane equipment is in retracted position, the piston 32 of the retracting motor 27 will be at the opposite end of its stroke or in a full-up position and the chamber 27*a* will be filled with hydraulic fluid. Under such conditions the spool 19 of valve 18 will occupy the position shown in Figure 1 so that the system pressure, which might be of the level of 3000 pounds per square inch, will be cut-off at that point and will not be present in conduit 25 and consequently not in valve 26. Therefore the moving parts in the interior of valve 26 will occupy the positions shown in

Figure 2 and as is apparent therefrom, an unrestricted path will exist from chamber 27*a* through nipple 28 into chamber 49 and from thence into chamber 56 out through duct 30, through duct 29 and into upper motor chamber 27*b*. This is a relatively short flow path and relatively high flow rates can be achieved. If desired, the size of conduits 30 and 29 could be selected to be greater than that of the system piping such as supply lines 14 and 17, for instance. This would ensure almost complete freedom for unrestricted flow from chamber 27*a* to chamber 27*b*.

Now if the equipment to which motor 27 is connected be unlocked and allowed to extend under the action of gravity, all of the liquid in chamber 27*a* will be forced rapidly out through nipple 28 under pressure of the descending piston 32. At the same time the tendency to form a vacuum in chamber 27*b* will assist in the transfer of liquid from one chamber to the other and there will be no appreciable impediment to speedy extension of the attached equipment. Thus if this equipment be a rocket launcher, it can reach rocket firing position without delay, which is highly important as the time element is critical.

Considering the alternate phase of operation of the system in which the motor 27 is operated by applied hydraulic pressure to cause retraction of the equipment attached thereto, such operation is initiated by moving switch 23 which in turn causes movement of valve spindle 19 so that one land closes off the port leading into duct 24 while the other uncovers the port associated with duct 14 to thereby release the system pressure into the interior of the valve and consequently into the duct 25. When present in duct 25, this pressure then is also present in chamber 46. This pressure will act on the exposed face of piston portion 36 as well as in the opposite direction on the smaller face area of piston portion 35. Thus a differential or unbalanced force will be developed on piston 36 as compared with that on piston 35 and this will act against the resistance of spring 59 (which is weaker than spring 52) tending to move piston valve element 34 upwardly. If the system pressure level is below some predetermined design level, say 500 p. s. i., it will have no practical effect on the movable parts. If the system pressure is higher than this minimum level, say for example at approximately the normal system level of 3000 p. s. i., the rate of bleed through orifice 47 into cavity 39 will be such that a pressure gradient will tend to build up in cavity 39 and will seat ball check 42 to close off leak passageway 41. The pressure then acting on the underface of piston 35 will in part offset that acting downwardly on the upper face of piston 35. The net result will still be a force tending to keep piston 35 from moving upwardly. At the same time the applied system pressure acting on the one face of piston 36 exposed thereto will develop a force larger than that acting on the upper face of piston 35 and this force on piston 36 will be even larger than the net or resultant force acting on piston 35. The design relationships are such that the differential or resultant force will be sufficient to overcome the resistance of spring 59 with the result that piston valve element 34 will move upwardly. As may be seen from the drawings, particularly Figures 2 and 3 thereof, after a short interval, the piston 35 moves on the guides 40 to a point where it clears the sides of cavity 39 and then the full pressure in chamber 46 becomes effective on the underface of piston 35 so that it fully offsets the opposite pressure on the upper face. This results in a greatly increased effective force acting to move valve element 34 upwardly since it represents the full force acting on piston 36 without any reduction due to force acting oppositely on piston 35. The effective force is now relatively great and represents a surplus over that required to cause compression of spring 59. This surplus or margin is a useful factor not only in causing rapid operation of the valve but also because once the valve has operated, a fall of system pressure, say to

1500 p. s. i., will not result in a reverse movement of the valve parts to cause interruption of the cycle of operation of associated motor 27. At such lower pressures even appreciably below the 1500 pound level, the force developed on piston 36 will still be capable of overcoming spring 59.

Due to the relative strength of spring 52 which is greater than that of spring 59, valve parts 34*a* and 34*b* will move as a unit until plug valve 53 contacts the seat 55 and cuts off communication between chambers 49 and 56. At this point, further movement of valve part 34*b* is prevented but movement of part 34*a* continues under the applied pressure, this being possible due to the fact that the flange 50 on the end of the spindle extension 37*a* can now move upwardly in cavity 51. To allow this, spring 52 must then begin to compress. When the movement has progressed to a certain point, piston 36 will clear O-ring seal 48 and thereafter the pressurized liquid in chamber 46 will be able to flow into chamber 49 and thence by way of the passage in nipple 28 will flow into chamber 27*a* of the motor to actuate its piston. At the same time the liquid in chamber 27*b* will be forced out into return line 17.

The main reason for designing the subject valve so that it would not proceed automatically with its cycle of operation unless the applied pressure was above a predetermined minimum, say 500 p. s. i., lies in the particular system for which it was specially intended. In this system, back pressures of as much as 500 p. s. i. occasionally occur. These would be carried through conduits 24 and 25 and would appear on piston 36, and would tend to cause movement thereof while at the same time having little if any influence in preventing such movement by acting through duct 30.

When it is desired to terminate operation of motor 27, control switch 23 is actuated to restore control valve 18 to normal condition which cuts off the supply of pressure medium to valve 26. The moving parts of valve 26 will then be restored to normal condition by action of springs 52 and 59.

While the form and application of the valve herein described constitutes the preferred form, it is to be understood that other forms or modifications are possible within the spirit of this invention and the scope of the appended claims.

I claim:

1. In a fluid pressure system for operating an expansible chamber motor of the type having a movable piston dividing the piston space into two chambers, an automatic control valve adapted in one position to interconnect the chambers on both sides of the motor piston to allow unrestricted movement of the piston by external means and in another position to disestablish such interconnection of the said chambers to permit hydraulic power operation of the motor, comprising a casing, a shiftable valving element operable therein, and pressure responsive means having an operating connection to the said element, the pressure responsive means including a first pressure responsive element acting to move the valving element, a second pressure responsive element opposing the action of the first, a third pressure responsive element, and valve means associated with said third pressure responsive element responsive only to pressures above a predetermined level, the said third pressure responsive element being exposed to the pressure prevailing in a space having an outlet by which it is normally vented to a low pressure region, the said valve means being adapted to close off the said outlet, the said third pressure responsive element at certain times being thereby adapted to impose a counterbalancing pressure on the second pressure responsive element to nullify its action in opposing movement of the shiftable valving element by the first pressure responsive element.

2. In a fluid pressure system for operating a single-acting motor having a piston dividing the piston space

into two parts constituting a working chamber and an inactive space an automatic control valve adapted to provide respective ported connections to a source of pressure, to the working chamber on one side of the piston of said motor and to the normally inactive space on the other side of the piston, the said valve including pressure responsive means controlling the internal flow between the ported connections comprising a shiftable element having a first position providing a direct connection between the ports connected respectively to the working chamber of the motor and to the inactive space on the other side of the motor piston while blocking off the port leading to the source of pressure, having a second position providing a connection between the ports connected to the working chamber of the motor and to the source of pressure while blocking off the port connected to the inactive space on the other side of the motor piston and having means responsive to pressure applied to the pressure port connection adapted to move the shiftable element from the first position to the second, the said means comprising a compound piston unit in the casing arranged to define a closed chamber containing the pressure port whereby pressure in the chamber acts on the pistons in opposite directions, one of said pistons being of lesser cross-sectional area than the other, a bleed orifice leading to the opposite side of the smaller piston, a pressure chamber formed on the opposite side of the smaller piston into which the orifice empties, a restricted leak passage leading from the said pressure chamber to a low pressure region, and yieldable means resisting movement of the shiftable element from the first to the second position.

3. A pressure operated valve comprising a casing, a valve element therein movable from a first to a second position, a pressure port adapted to permit connection of the valve to a pressure source, a compound piston operable in the casing connected to cause movement of the valve element, the said compound piston consisting of spaced piston elements defining a closed chamber containing the pressure port whereby pressure in the chamber acts in opposite directions on the pistons, a bleed orifice leading from the closed chamber to the opposite side of one piston, a pressure chamber formed on the opposite side of the said one piston into which the orifice empties, a restrictive leak passage leading from the said pressure chamber to a low pressure region, and yieldable means adapted to resist movement of the shiftable element from the first to the second position.

4. A valve according to claim 3 which in addition to the pressure port, has other ports adapted to be directly connected through the interior of the valve when the valve element occupies the specified first position, the said valve element being further adapted to close off the connection between the said other ports when moved to its second position.

5. A valve according to claim 4 in which the valve element is adapted to connect the said pressure port to one of the said other ports during movement to the second position.

6. A pressure operated valve comprising a casing, a movable valve element operative therein, a pressure port adapted to permit connection of the valve to a source of pressure, a compound piston operable in the casing

and connected to cause movement of the valve element, the said compound piston consisting of separate piston elements subjected to the pressure introduced through the said port, the piston elements being so oriented relatively that the pressure acting thereon develops respective forces tending to move the compound piston in opposite directions, an additional piston element comprising a pressure responsive member adapted to develop a force opposing that acting on one of the first said piston elements, a pressure chamber containing the additional piston element, a bleed orifice leading from the vicinity of the pressure port to the said chamber, a leak passage leading from the pressure chamber to a region of low pressure, and pressure responsive valve means adapted to close off the leak passage upon the attainment of a predetermined pressure in the said pressure chamber.

7. A pressure operated valve comprising a casing, a valve element located therein adapted for movement from one position to another position, a pressure port adapted to permit connection of the valve to a source of pressure, a compound piston operable in the casing and connected to cause movement of the valve element, the said compound piston consisting of spaced piston elements defining a closed chamber containing the pressure port, whereby pressure in the chamber acts in opposite directions on the pistons, the said pistons having effective piston areas of such relative size that any resultant force tending to move the valve element is insufficient to cause such movement, a bleed orifice leading from the chamber to the opposite side of one piston, a pressure chamber formed on the opposite side of the said one piston into which the orifice empties, a leak passage leading from the pressure chamber to a low pressure region, and pressure responsive valve means adapted to close off the leak passage upon the attainment of a predetermined pressure in the pressure chamber.

8. In an automatic valve including a pressure actuated valve element, means to inhibit operation of the valve unless the applied pressure is above a predetermined minimum comprising a surface operatively associated with the valve element and subjected to the applied pressure, the operative association being such that the force developed on the surface acts to oppose movement of the valve element, a second surface operatively associated with the valve element so disposed as to develop a force when subjected to fluid pressure acting in opposition to that developed on the first surface, and means subjected to the applied pressure and responsive thereto on attainment of the predetermined minimum pressure to cause application of the pressure to the second surface whereby the forces developed on the two surfaces act in opposition so that the valve element is substantially freed of the restraint against movement provided originally by the force developed on the first said surface.

References Cited in the file of this patent

UNITED STATES PATENTS

1,731,145	McMillan	Oct. 8, 1929
2,267,284	Livers	Dec. 23, 1941
2,406,284	Fitch	Aug. 20, 1946
2,582,546	Klein	Jan. 15, 1952
2,646,025	Deardorf	July 21, 1953
2,706,487	Wilson	Apr. 19, 1955