United States Patent

[11] 3,556,468

[72] Inventors **Cedric A. Barrett**
Grand Rapids;
William Phillips, Wyoming, Mich.

[21] Appl. No. **831,604**
[22] Filed **June 9, 1969**
Division of Ser. No. 621,912, Mar. 9, 1967, Patent No. 3,468,336.
[45] Patented **Jan. 19, 1971**

[73] Assignee **Pall Corporation**
Glen Cove, N.Y.
a corporation of New York. by mesne assignments

---

[54] **UNLOADING VALVE STRUCTURE**
2 Claims, 10 Drawing Figs.

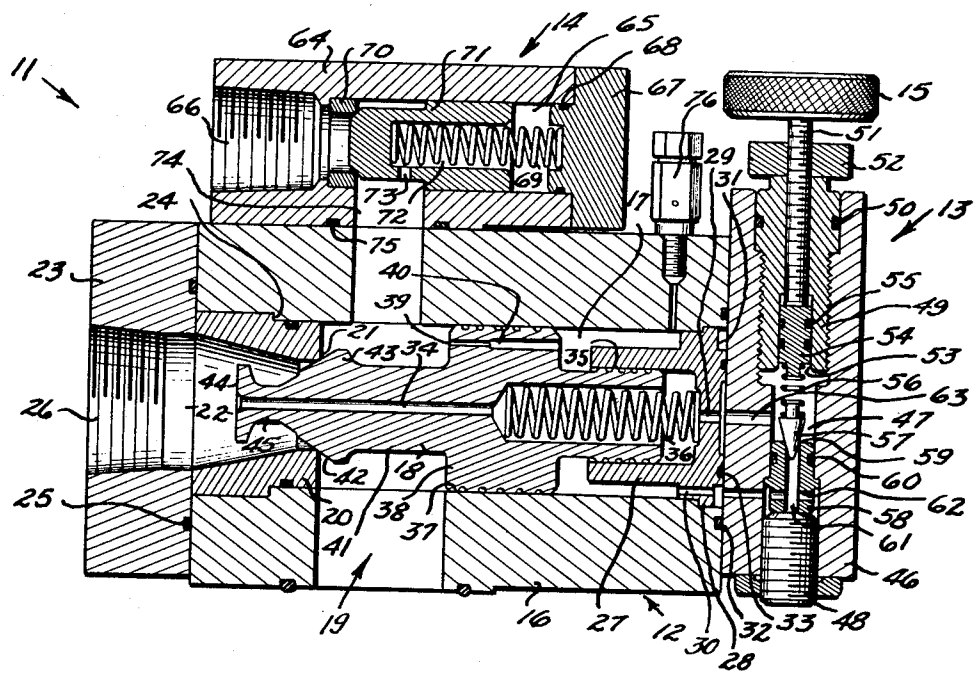
[52] **U.S. Cl.** **251/121**
[51] **Int. Cl.** **F16k 47/00**
[50] **Field of Search** ..... 137/art from previous case; 251/121; 137/118

[56] **References Cited**
UNITED STATES PATENTS

2,388,820	11/1945	Bonnell	137/491
2,393,442	1/1946	Yellott et al.	251/121

Primary Examiner—Henry T. Klinksiek
Attorney—Miller, Morriss, Pappas and Mc Leod

ABSTRACT: A valve structure useful in control of flow in unloading hydraulic situations and having a snubber and buffer relationship adjacent the seat thereof thereby providing smooth operation over a relatively wide range of capacity at high pressures.



PATENTED JAN 19 1971

3,556 468

SHEET 1 OF 3

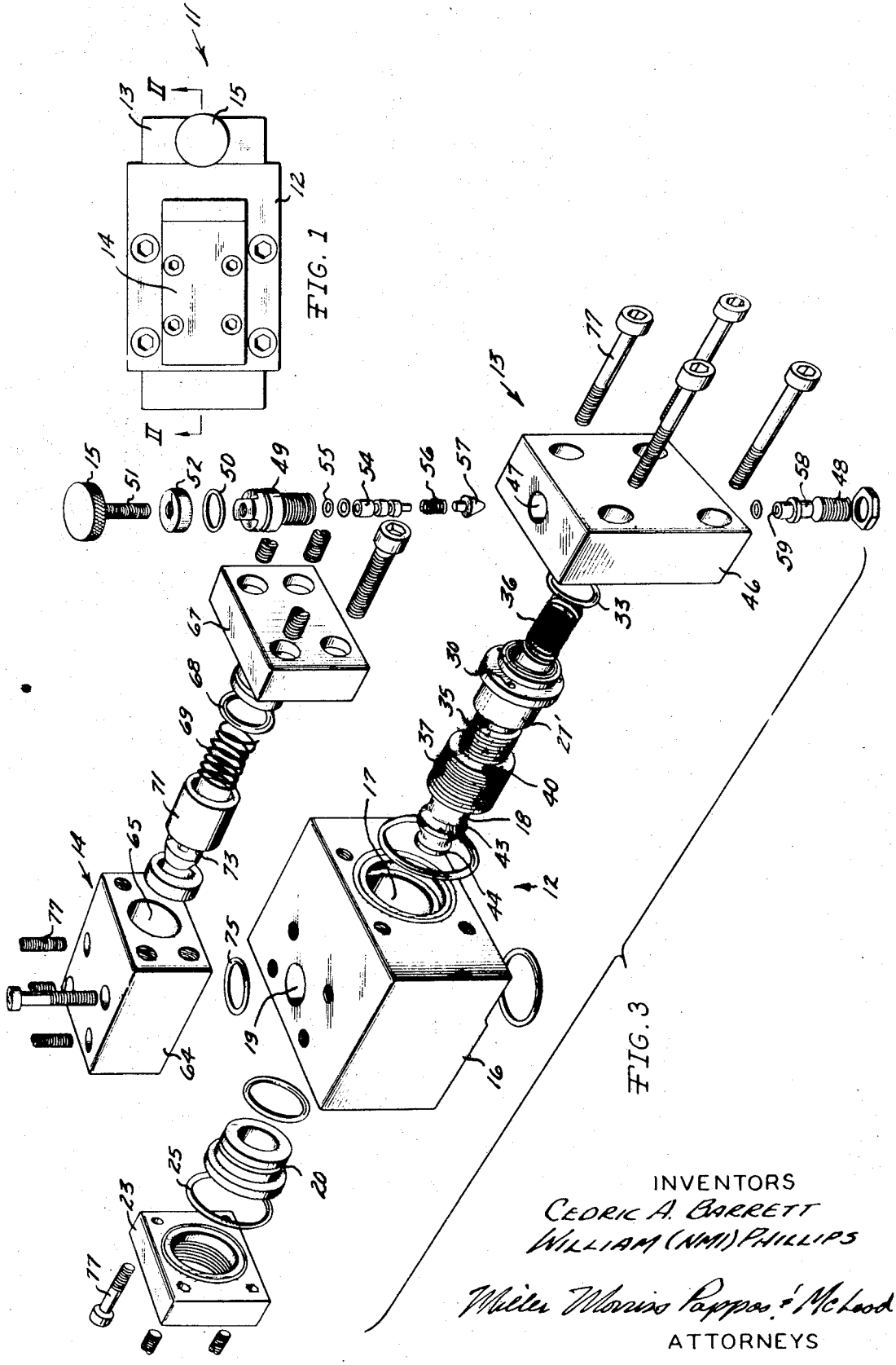


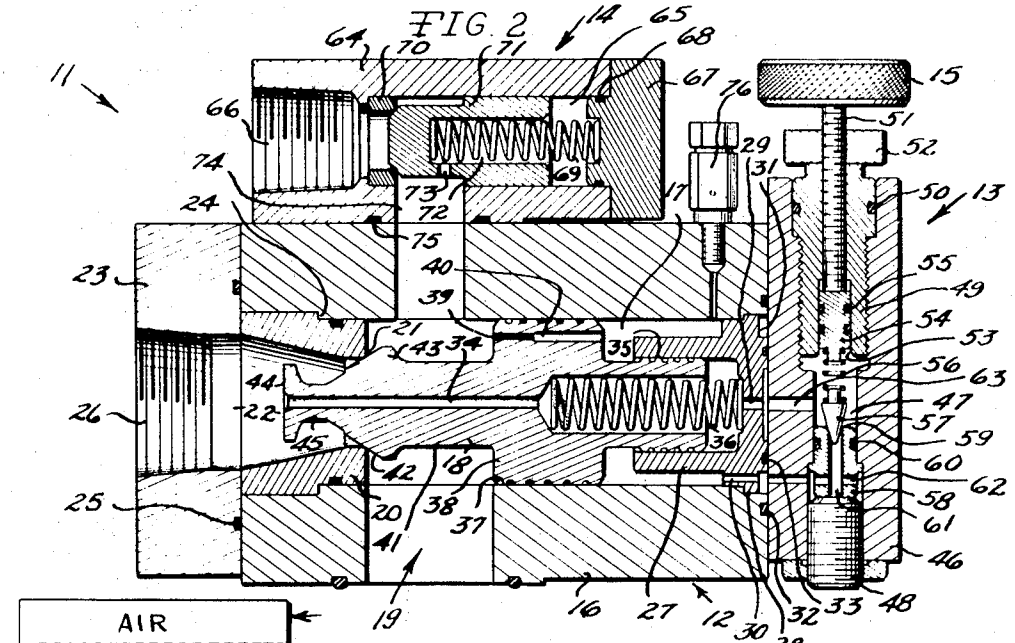
FIG. 1

FIG. 3

INVENTORS
CEDRIC A. BARRETT
WILLIAM (NMI) PHILLIPS

Miller Morriss Pappas & McLeod
ATTORNEYS

FIG. 2



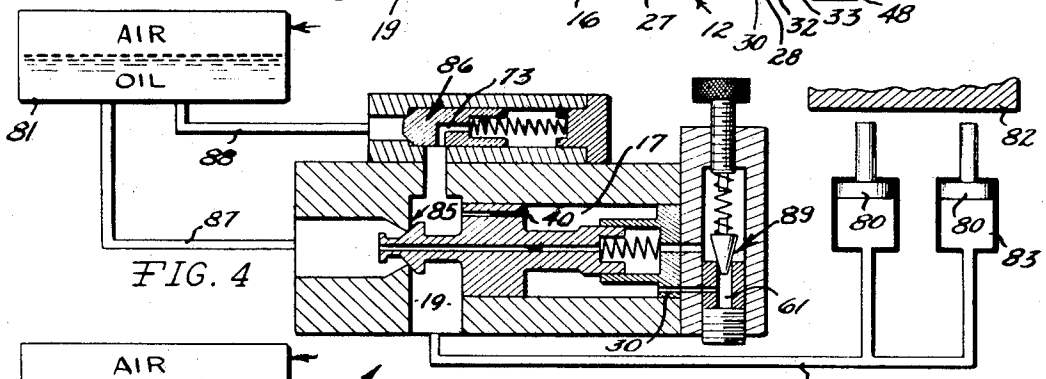


FIG. 4

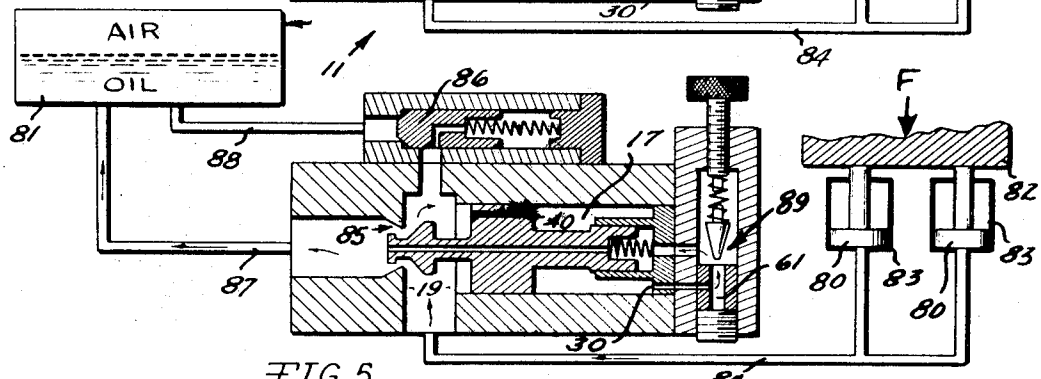


FIG. 5

11

INVENTORS

CEORK A. BARRETT

WILLIAM (NMI) PHILLIPS

Miller Morriss Pappas & Mcleod

ATTORNEYS

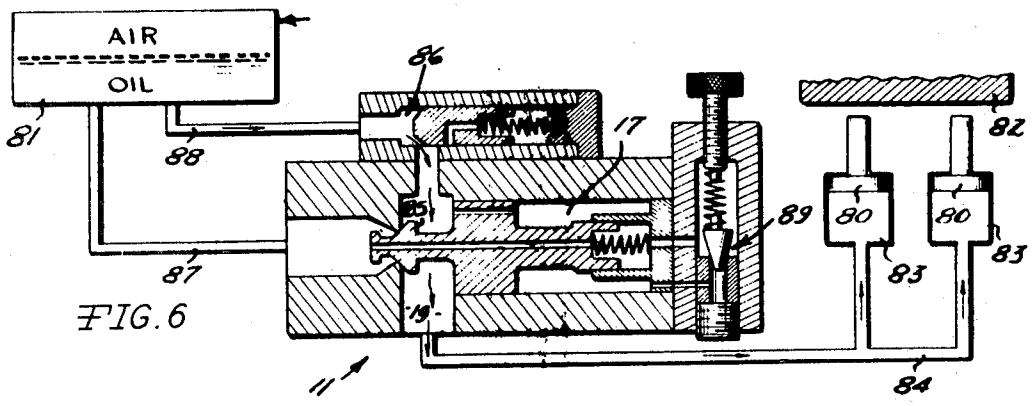


FIG. 6

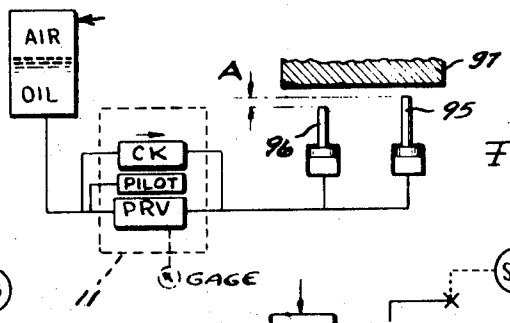


FIG. 7

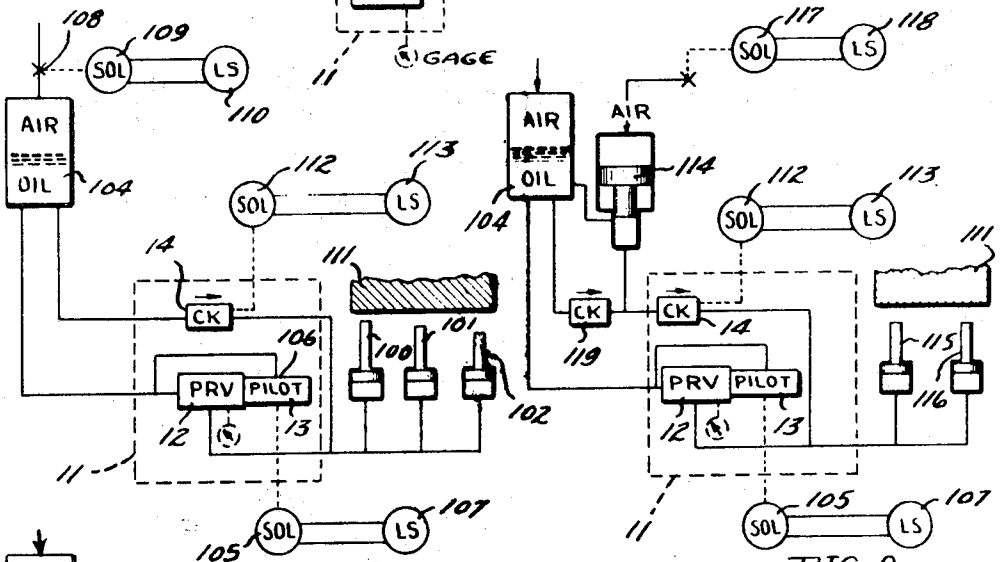


FIG. 8

FIG. 9

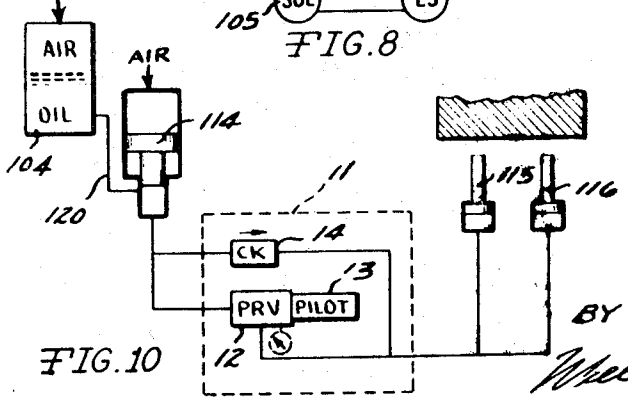


FIG. 10

INVENTORS
CEDRIC A. BARRETT
WILLIAM (NMI) PHILLIPS
BY
Willie Morris Pappas & McLeod
ATTORNEYS

UNLOADING VALVE STRUCTURE

This application is a division of our previously filed copending application Ser. No. 621,912 filed on Mar. 9,1967, now U.S. Pat. No. 3,468,336, granted Sept. 23, 1969.

SUMMARY

The present invention relates to a combination valve especially useful with press actuated hydraulic cylinders and including a pilot section, and unloading section and a check valve section wherein the pilot responsive unloading valve includes a new and improved relieved snubber or buffer providing a wider range of capacity in any given valve size and amenability to circuit integration.

Energy storage systems in dies and presses originated with springs, allowing a part of the energy expended by the press upon closing to be stored and used to extend portions of the die or to perform a variety of work functions. Earliest applications of such devices in conversion to an elastic media such as air or combinations of a compressible gas on an uncompressible liquid were recognized for example in the U.S. patent art in U.S. Pat. Nos. to Nelson 1,503,131, Rode 1,706,073 and Glasner 1,849,711. As applied solely to dies, the U.S. Pat. to Brown 1,577,446 established the same basic circuit. As the versatility of these systems began to be appreciated, means were incorporated in the basic circuit to increase the capacity of the system, to selectively delay the release of stored energy, to enhance the power available in return and to apply varying resistance to the press action in a single stroke and even to release pressures sequentially. At the heart, however, of each of these systems, the circuit requires a pressure relief valve to provide set resistance to flow in one direction as the press closes and a check valve assuring flow through the pressure relief valve on the closure of the press or die and bypass around the pressure relief valve on return of fluid. Characteristically, best control is accomplished by piloted relief valves in which the pilot is the relief valve energizing or opening a dumping or unloader valve section. A small volume of oil at operating pressure moves through the pilot and a large volume is controlled through the associated unloading section. The use of a pilot also provides a simple means to override the set resistance by mechanical, hydraulic, electrical or pneumatic means or combinations of these at selected press positions.

In a similar manner, the check valve may be overridden or blocked to prevent or delay return flow as desired.

As die complexity has increased, the number of actuators or cylinders and pistons resisting press motion or requiring actuation on return has increased and the master control valves have required additional capacity range while retaining high sensitivity to flow factors characteristic of presses, either mechanical or hydraulic. Hence, the selection and performance of an operating or control valve in hydraulic circuits for dies in presses is very critical. The operations performed by the valves must be smooth over a substantial variance in capacity at any given pressure setting. At the same time, the performance must be sensitive and accurate and provision must be included for accessory attachment in the circuit along with ease of fabricating and simplicity of assembly and disassembly.

Accordingly, the principal object of the present invention is to provide control valve structure for use with cushion pistons in dies for press usage which is modular in structure.

Another object is to provide a control valve with a new and improved snubber cushioning the impact of opening and closing of the unloading section and hence providing smooth valve performance over the full capacity range of a particular valve size.

Other objects including simplicity, rugged dependability and ease of servicing will be readily appreciated by those skilled in the art as the description proceeds.

GENERAL DESCRIPTION

Generally, the valve structure of the present invention is positioned intermediate a tank or reservoir for hydraulic fluid and one or more actuating pistons.

The unloading valve element is of the spool valve type normally biased closed and preventing flow to or from the tank. A double stepped snubber or buffer extends from the unloading valve element and beyond the unloading valve seat and into the cavity of the tank connection. The unloader valve element is conically flared where it meets the valve seat and thereafter abruptly drops away to a substantially reduced dimension at the valve body. The unloader valve intersects but does not interfere with the flow in the merging check valve passage. Hence, the major cavity in the unloader valve section is in communicating relation to both check valve and unloader with consequent reduction in friction factors, since the major cavity is large in relation to connecting conduits or hydraulic lines.

Fine and smooth valve performance results from the unloading section without objectionable slamming and performs equally well at lowest and highest capacity rating, of the particular valve. The relation of the unloading valve to the pilot valve, check valve, and delay elements as best generally described in U.S. Pat. No. 3,468,336.

In the Drawings:

FIG. 1 is a top elevation view of a valve structure in accord with the present invention with no bleeder included.

FIG. 2 is a longitudinal section elevation view taken on the line II–II of FIG. 1 and revealing the simple internal and interrelated structure of the valve sections as seen in FIG. 1 and indicating a bleeder in preferred position.

FIG. 3 is an exploded view of the valve structure of the present invention and revealing fabrication simplicity of the valve structure.

FIG. 4 is somewhat schematic sectional elevation view of the valve as seen in FIG. 2 and characteristically related operationally between piston and tank before energization of pistons.

FIG. 5 is the same as FIG. 4, but indicating the unloader valve in the open position during movement of the pistons in the direction of closing of the press, platen, or die.

FIG. 6 is the same schematic structure as represented in FIGS. 4 and 5 but now indicating the flow of hydraulic fluid returning the pistons to their extended positions as the press platen, die, or press opens. On the return of the pistons, air drive is illustrated as moving the hydraulic fluid through the check valve.

FIG. 7 is a schematic diagram illustrating a typical circuit in which the valve of the present invention is utilized and in which a preload piston is provided.

FIG. 8 is a diagram of a modified circuit in which solenoid control elements or accessories are utilized on the check valve section and on the unloader pilot section to selectively block return or accomplish relief or dumping at any selected press or die position as monitored by limit switches. A solenoid valve is also seen on the pressure tank allowing selective relief of air drive as by venting.

FIG. 9 is a diagram of another modified circuit and indicating the insertion of a booster to provide enhanced timed application of hydraulic pressure for stripping, or working as in reverse forming, punching or the like where work beyond the capabilities of normal air pressure in the tank is required.

FIG. 10 is a schematic diagram illustrative of another booster circuit in which the valve of the present invention is integrated.

SPECIFIC DESCRIPTION

Referring to the drawings and particularly the FIG. 1, a valve structure 11 in accord with the present invention is seen isolated from any application in any particular circuit. The valve structure 11 includes an unloader section 12, a pilot section 13 serving the unloader 12, and a check valve section 14. The adjusting knob 15 is seen at the top of the pilot section 13. These are in modular block form, the main block comprising unloader section 12. Pilot section 13 is also in block form secured to the unloader section. The check valve section 14 is seen in block form capping the main block of unloader section 12.

In FIG. 2, the interrelationship of the unloader section 12, pilot section 13 and check valve section 14 is shown. The unloader section comprises a main valve case 16 in block form provided with a longitudinal through opening 17 in which the movable unloader valve body 18 is axially reciprocable. A main cavity 19 intersects the opening 17 and penetrates the case 16 vertically as shown in the drawing. A cylindrical valve seat element 20 is inserted in one end of the opening 17 and provides an annular valve seat 21 for the unloader valve body 18. The axial opening 22 is flared outwardly in a venturi form. A connector block 23 secures the valve seat element 20 in place against the annular shoulder 24 and is sealed against the main valve case 16 by compression of the O-ring 25 positioned between main valve case 16 and connector block 23. The connector block 23 is provided with opening 26 therethrough in register with the longitudinal through opening 17 and secures the valve seat element 20 in the main valve case 16. The connector block 23 is provided with connector means such as threads in the opening 26 to provide a connection to the tank, as will be seen, through selected conduit.

The other end of the longitudinal opening 17 is provided with valve body receiver element 27 comprising a generally cylindrical body of less diameter than the opening 17 and a flanged base 28 which shoulders against the main valve case 16 across the opening 17. Hence the receiver element 27 is coaxial with the opening 17 and projects into the opening 17. An axial bore is provided in the receiver 27 and an axial through opening 29 of reduced diameter is provided through the receiver element 27. As will be later seen the receiver 27 may be substantially tubular and flanged. Communicating openings 30 are provided transversely through the flange 28 of the receiver element 27 which connect with the opening 17 and annular recess 31 formed in the outboard base of the receiver element 27. An annular exterior seal such O-ring 32 is provided in the main valve case 16 concentric about the opening 17, and an inner seal or O-ring 33 is provided in concentric relation around the axial opening 20. Both seals 32 and 33 are in substantially in the same plane and aside from preventing leakage as between main valve case 16 and the pilot section 13, they also isolate flow through axial opening 29 and the openings 30 in the flange 28. As will be seen, this is important to the pilot control of the unloader valve body 18.

The unloader valve body 18 is of the stepped piston type and is longitudinally provided with an axial through opening 34. One piston surface (small) 35 guidably and axially moves in the bore 28 of the valve receiver element 27. A compression spring 36 between receiver element 27 and valve body 18 applies axial force to the valve body 18 urging the valve body to closed position on the seat 21. The larger piston surface 37 formed by flange portion 38 is axially movable in the longitudinal opening 17. Both small 35 and large 37 piston surfaces are integral in the valve body 18. An orifice 39 is provided in a passage 40 through the flange 38 so that communication is provided at all times between the space ahead and behind the large piston surface 37 in the longitudinal opening 17. Rings or annular grooves may be used on both piston surfaces 35 and 37 as shown.

The stem portion 41 of the valve body 18 is of reduced diameter to maximize flow through the main cavity 19 and through which the stem 41 projects. This reduced diameter, as shown in FIG. 2, is substantially the same as the diameter of the seat. A double snubber or buffer arrangement is employed where the valve body 18 engages the valve seat 21. The surface 42 engaging the valve seat 21 is frustoconical in section extending a small distance both ways of the annular line engagement with the seat. This provides an annular flared portion 43 of the stem 41 and then drops back to the stem dimension. At the nose of the valve element 18 a flanged snubber portion 44 ahead of a necked-in portion 45 is provided in a smooth merger with the frustoconical surface 42. As will be seen this described arrangement adjacent the seat of the valve projects one snubber portion 44 into the venturi passage 22 of the seat 20 and positions the other snubber or buffer 43 in the main cavity 19 assisting in smooth valve operation in avoidance of hammer and chatter in rapid cycling.

The pilot section 13 comprises a pilot valve block 46 flush mounted to the unloader valve case 16 in sealed relation by the concentric O-rings 32 and 33. An axial opening 47 is provided longitudinally through the pilot valve block 46. The opening 47 is closed at the lower end as shown by threaded plug 48. The upper end of the opening 47 is plugged by threaded bushing 49, its associated seal 50, the axial threaded adjusting screw 51 rotatable by knob 15. Threaded lock nut 52 is provided on the screw 51 to fix the position of adjustment, once established. A coaxial cylindrical recess 53 is provided in the bushing 49 and guide piston 54 with concentric seals 55 is axially movable therein by selected threaded adjustment of the screw 51. A spring 56 biases the piston 54 into axial engagement with the screw 51 and extends axially in the opening 47 to guided retention with the pilot valve element 57. A valve seat insert 58, retained in the lower portion of the opening 47 by the plug 48 provides a valve seat 59 against which the valve element 57 closes under the normal selected bias of the spring 56. The seal 60 eliminates leakage around the insert 58.

An axial passage 61 is provided through the insert 58 and case 46. This axial passage is provided with a radial opening 62 in axial register with the opening 30 through the flange 28 of the receiver 27. Similarly, a transverse opening 63 is provided through the pilot valve case 46 connecting with the axial opening 29 in the receiver element 27. Hence, as shown, flow from the longitudinal opening 17 of the unloader valve section can pass through the ports 30 and openings 62 to the valve seat 59 and may, as will be seen, open the valve element 57 off its seat 59. Flow through the valve seat 59 in passing the valve element 57 will move through the opening 63 and axially through unloader valve body 18. Hence, main cavity pressure is sensed through the valve body 18 to the pilot section 13 and when the valve element 57 is unseated the resulting imbalance will be seen to unseat the unloader valve body 18 in synchronized response to any quantum of flow within the size capacity of the unloader valve.

Blocking axial flow through the main cavity 19 is the check valve section 14. The check valve comprises a valve case 64 having a longitudinal bore 65 therethrough. One end of the valve case 64 and bore 65 is provided with threads 66 for circuit connection as will be hereinafter appreciated. The other end of the bore 65 is plugged as by end plate 67 with its seal 68. The end plate 67 serves as a spring retainer for the spring 69. An annular seat 70 is positioned in the open end of the bore 65 in shouldered relation thereagainst and in concentric relation to the axis of bore 65. The valve element 71 is reciprocably positioned in the bore 65 and is provided with a longitudinal coaxial recess 72 which receives the spring 69. The spring 69 normally biases the valve element 71 against the seat 70. A radial opening 73 penetrates the valve element 71 communicating with the recess 72. Transverse to the bore 65 is the passage 74 which is in axial register with the main cavity 19. O-ring 75 concentrically about the passage 74 and upper opening of cavity 19 provides a seal as between the main unloading valve case 16 and the check valve case 64.

An air bleeder 76 is positioned in the unloader valve case 16 for bleeding air from the longitudinal bore 17 of the unloader valve case.

As will be seen assembly of the valve structure 11 is easily accomplished as best shown in FIG. 3 using recessed headed bolts 77 as seen. Hence the unloader valve section 12 indicated by reference to its case 16 is provided with the two transverse intersecting through openings 17 and 19. The unloader valve elements exemplified by seat insert 20 and valve stem body 18 and piston receiver 27' nd spring 36. In the FIG. 3 the flanged receiver element 27 is slightly modified from the form shown in FIG. 2 by allowing the spring 36 to bias at one end directly against the pilot case 46, thereby avoiding the machining of the receiver to provide an internal thrust shoulder for the spring 36'. Operation of both forms of receiver 27 and 27' is otherwise identical. The pilot valve case 46 of the pilot section 13 closes the assembly of the unloader valve at one end and the connector block 23 closes the seat assembly.

The pilot valve seat insert **58** is assembled in the bottom of the pilot case **46** and secured in position by plug **48**. Pilot valve element **56** is assembled over it and piston **54** with its seals is inserted in the bushing **49**. Bushing **49** is then screwed into the opening **47** and the threaded adjusting stem **51** is turned into the axial opening through the bushing **49** and through lock nut **52** and with seals as indicated. As will be appreciated the pressure holding the valve element **57** in closed relation on the seat **59** may be varied by adjustment of the stem **51** by turning the knob **15**. In this manner the valve pressure relief or holding pressure point is selected. This selected pressure provides a constant resistance against closing of the press or die.

By reference to FIGS. **4**, **5** and **6** the cycling of the valve structure **11** as exemplified in FIGS. **1**, **2** and **3** is expressed in a simplified schematic manner in a typical die-press arrangement. In FIG. **4**, the work pistons **80** are fully extended as by hydraulic fluid under pressure as from the compressed gas in the tank **81** acting on the fluid. The pressure of the gas in the tank **81** is by means of a compressor not shown. The press platen or die section **82** served by the pistons **80** is shown elevated indicating for example that the press is in an open position preliminary to its downward stroke, or in the case of the pistons being positioned in the platen or die section secured to the platen, before press closing.

A conduit **84** from the cylinders **83** leads to the valve structure **11** and to the main cavity **19** thereof. The cavity **19** is filled and no flow to tank **81** occurs because the unloader valve **85** and check valve **86** blocks any return flow to the tank **81** via lines **87** or **88**. However, fluid is behind the major piston of unloader valve **85** through the port **40** and is in pressure contact with the pilot valve **89** through the passage **30** and **60** but at a standing value lower than the set point of the pilot valve **89**. Fluid also augments the spring closure of check valve **86** by movement through passage **73** and tending to close the check valve **86**.

In FIG. **5** the press has begun to close for the full stroke of pistons **80** in cylinders **83**, as shown. During this time the relatively incompressible fluid commences to move as the pistons **80** are the resistance against movement provided by the pistons **80** is dependent upon the pressure setting of the pilot valve **89**. For example if the pilot valve **89** is set to open at 1,000 pounds per square inch, then when that pressure is achieved in the main cavity **19** it is present in the bore **17** by virtue of opening **40** and this pressure is communicated to he pilot valve through openings **30** and **61** thereby overcoming the bias on the valve **89**. The pilot valve **89** opens and spills through the stem of valve **85** to tank **81**. This unbalances the unloader valve **85** and it opens buffered by the construction previously described and is cushioned or dampened by the orificial flow relation occurring by reason of the restricted flow through port **50**. The opening of the unloader valve **85** allows flow to the tank **81** through the line **87**. Flow cannot occur through the check valve **86**. Since a mechanical press follows a crank arm motion the resultant kinetics cause variance in press closing and opening velocities. The valve as presently described accommodates automatically to these variances so that action of the unloading valve is smooth and resistance is even within the capacity range of a given valve size.

Through the entire closing of the press the resistance of the pistons **80** are determined by the setting of the pilot valve **89**.

In FIG. **6** the platen or die section **82** is opening from the point indicated in FIG. **5** and during this motion the pistons **80** follow the retraction of the platen or die section **82** by reason of the piston return pressure provided by the compressible gas in the tank acting on the fluid or oil. Since the pistons **80** stopped their closing movement the pilot valve **89** closed and the valve **85** also is closed but the bias on the check valve **86** is overcome by the differential in pressure between tank **81** and cavity **19** and flow from the tank **81** is made possible through the check valve **86**, thence through the main cavity **19** and thence through conduit **84** elevating the pistons **80** in the cylinders **83**.

The FIGS. **7—10** indicate operative settings in which the valve structure of the present invention is used. These are particularly described in U.S. Pat. No. 3,468,336.

In control of various circuits in which the valve structure **11** may be employed those skilled in the art will appreciate many variations depending upon the availability and reliance of electrical, pneumatic, hydraulic, and mechanical means to achieve selected results in a given circuit. Substantially all of these variations in circuit may utilize the basic valve structure **11** as described herein and accessories, as indicated, are easily provided in a modular manner to any selected work conditions. Repair and replacement is facilitated and the pressure relief valve elements comprising pilot section **13** and unloader section **12** work neatly together in providing chatter-free smooth valve performance with repetitive accuracy over substantially the entire capacity range of the selected valve.

We claim:

1. A valve and valve seat arrangement for high speed reciprocating valve units comprising:
   - a frustoconical valve element;
   - a coaxial annular seat against which said frustoconical valve element closes; a portion of said valve element being larger than said seat;
   - an axial extension of said frustoconical valve element beyond said seat and including an annularly flared disc-shaped buffer at the end thereof; and
   - an annular recess adjacent the frustoconical portion of and in the stem portion of said valve element, the diameter of the stem at the bottom of the recess being substantially the same as the diameter of said seat, whereby an annular buffering flange is formed back of said seat.

2. In the combination as set out in claim **1** wherein said annular seat is at one end of a venturi-type opening.

23-005 Div.

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,556,468 Dated January 19, 1971

Inventor(s) Cedric A. Barrett and William Phillips

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In column 4, line 66, "nd" should be --and--.
Column 5, line 40, after "80 are", please insert --displaced and--; line 45, "he" should be --the--.

Signed and sealed this 1st day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR
Commissioner of Patents