Nov. 3, 1964 G. L. LOOMIS 3,154,940

WELL TOOL WITH PRESSURE RESPONSIVE VALVE

Filed June 12, 1962 2 Sheets-Sheet 1

FIG. 1

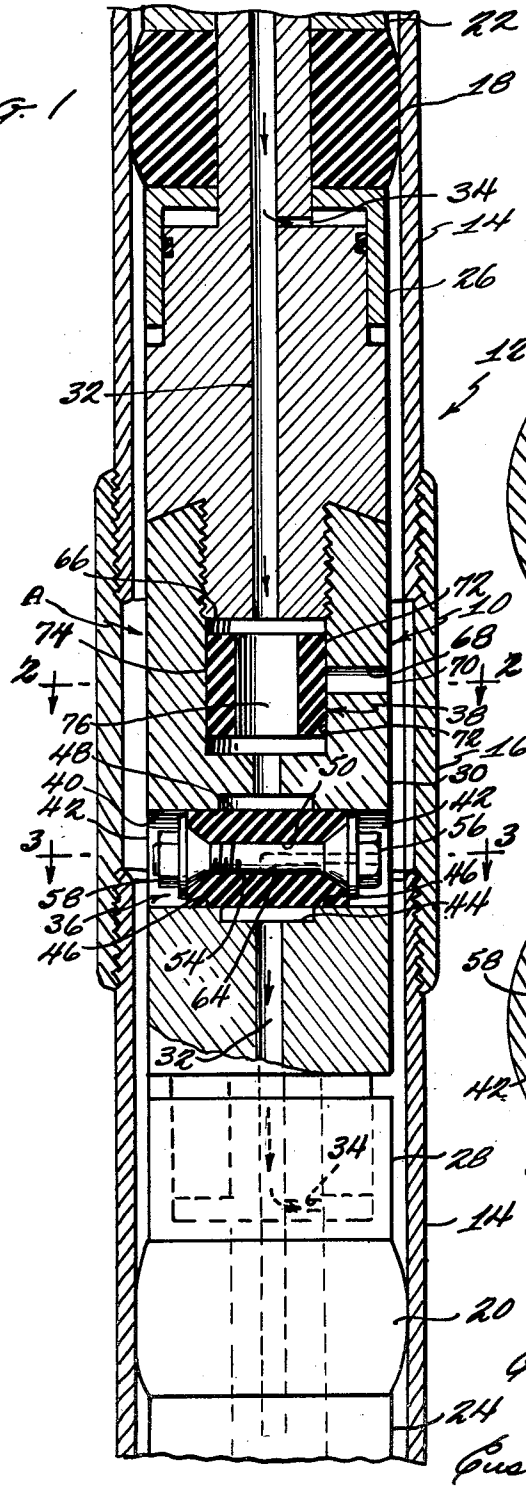


FIG. 2

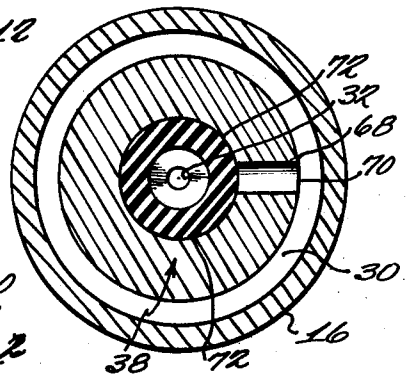
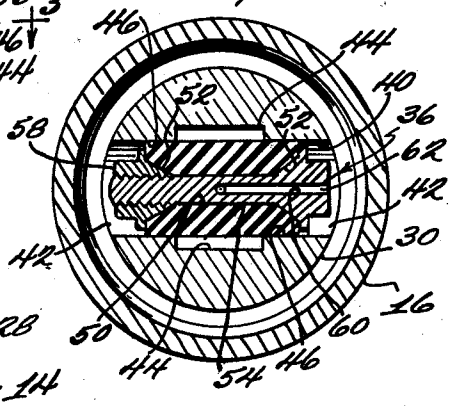


FIG. 3



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FIG. 4

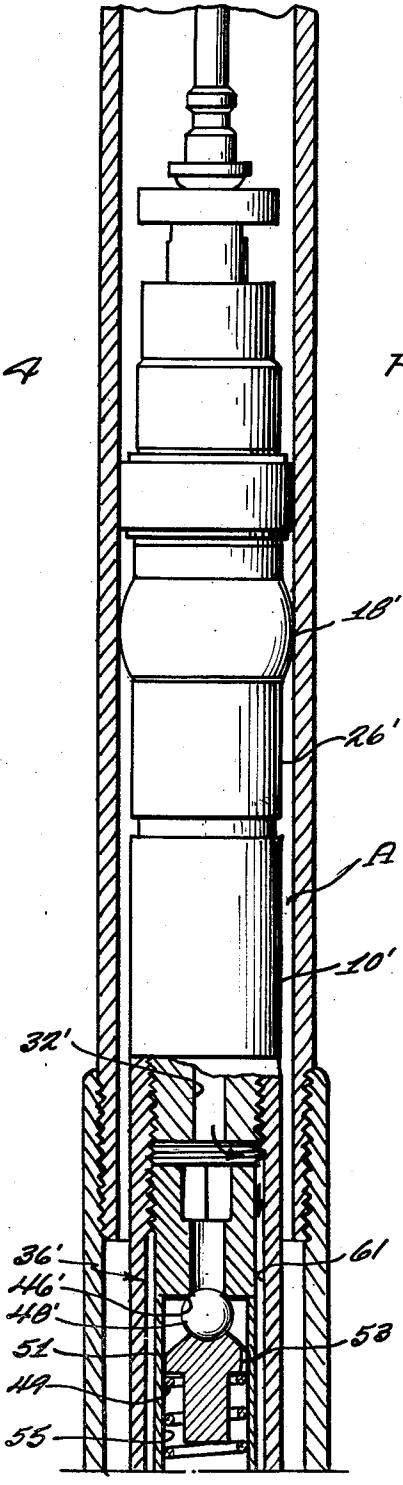
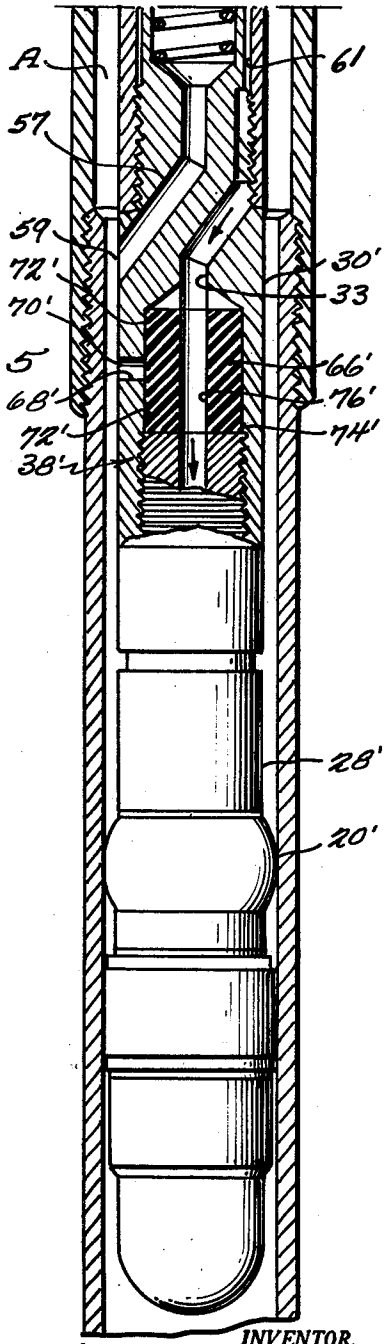


FIG. 5



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WELL TOOL WITH PRESSURE RESPONSIVE VALVE

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14 Claims. (Cl. 73—40.5)

The present invention relates to well tools of the type lowered into well pipe for the purpose of flowing a fluid into the well pipe at a predetermined pressure. More particularly, the present invention relates to improvements in pressure responsive valves for such well tools.

The present invention will be described in connection with a well tool such as a testing apparatus of the type disclosed in my prior United States Patent No. 2,841,007, issued July 1, 1958. However, it will be understood the present invention is also applicable to other tools used in wells or the like wherein fluid must be flowed at extremely high pressures and wherein the valve structure through which the fluids flow might be subjected to other fluids which would cause the valve structure to operate improperly.

The testing tool of the heretofore-mentioned Patent No. 2,841,007 includes a tool body having spaced resilient packers thereon which are adapted to be set within the well pipe to define an annular space to which testing fluid is subsequently flowed at a high pressure to test an increment of the well pipe. The packers are set by the application of fluid under pressure and then the pressure of the fluid is increased to a predetermined amount and a pressure responsive valve opens and allows fluid to flow into the annular sealed off space. After a test has been completed the valve structure closes and pressure of the fluid within the tool becomes less than the pressure of fluid in the annular space and a second pressure responsive valve structure opens to relieve pressure of any fluid exteriorly of the tool and trapped between the packers so that the packers may be released from the sealing position within the well pipe.

Quite frequently during testing operation of tubing strings being inserted in oil and gas wells, weighting mud used in the completion process is encountered inside the tubing strings. Weighting mud is a viscous mixture of water, clay, barium and cellulose particles and some of this fluid oftentimes is drawn back into the tool when pressure is relieved from the section of pipe being tested. When the mud is drawn back into the tool it results in contamination of the testing fluid and oftentimes causes the valves within the testing tool to malfunction. The same condition occurs in testing well pipe of a completed well especially when the well pipe being tested is corroded or dirty.

Heretofore pressure responsive metallic valves having a spring urged ball valve element and a valve seat or a spring urged plunger valve element and a valve seat have been used in testing apparatus as well as in other well treatment tools and the conditions mentioned above have caused a great amount of lost work time as the tools had to be frequently removed from the well, dismantled and the valves cleaned or replaced. A small flake of foreign matter lodged under such metallic valve element and its valve seat have rendered the valve and its seat inoperative.

An important object of the present invention is to provide a well tool with a pressure responsive valve system which is not critically affected by foreign matter in the testing fluid or foreign matter in other fluid encountered in the well pipe.

Another object of the present invention is to provide a well tool with a pressure responsive valve system which increases the length of work time for the tool without

repair or replacement of the valve or valves of the tool.

Ancillary to the immediately preceding object it is a further object of the present invention to provide pressure responsive valve means for well tools or the like having a large area of contact between the valve element and the valve seat, the valve element and valve seat being capable of compensating for any foreign material which may be lodged therebetween.

Another object of the present invention is to provide an improved valve structure utilizing a resilient valve element made from an elastomeric material or a plastic material, the valve element having a large area of contact with the valve seat whereby foreign matter does not affect operation of the valve.

Another advantage of the present invention is to provide a pressure responsive valve means for use in well tools which may be more easily adjusted to open at different pressures and which eliminates the use of changing metal springs and the like.

Still a further object of the present invention is to provide a pressure responsive valve system for use in well tools or the like wherein a larger volume of fluid can pass the valve at a given pressure than heretofore possible thereby allowing a faster testing operation.

The term "pressure responsive valve" as used throughout the specification and claims is intended to cover a valve through which fluid is positively flowed at a given pressure or a valve which is used as a relief valve to relieve the pressure of fluid in a given space.

These and other objects and advantages of the present invention will appear more fully from the following specification, claims and drawings in which:

FIGURE 1 is a fragmentary vertical sectional view, partly in elevation, of a testing apparatus of the present invention incorporating the improved pressure responsive valve system, the apparatus being shown in a well pipe at a position for testing a collar joint between two stands of well pipe making up a string;

FIGURE 2 is a sectional view taken on the line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken on the line 3—3 of FIGURE 1;

FIGURE 4 is a vertical sectional view, partly in elevation, of the upper portion of a modified form of testing tool of the present invention; and

FIGURE 5 is a vertical sectional view, partly in elevation, of the lower portion of the testing tool of FIGURE 4.

Referring now to the drawings wherein like character or reference numerals represent like or similar parts, the present invention is illustrated in connection with a testing tool generally designated by the numeral 10 for testing an increment of well pipe generally designated by the numeral 12. The well pipe 12 comprises a plurality of stands 14 coupled together by threaded collars 16. While the well pipe has been illustrated as flow tubing for a gas or oil well, it will be understood that it could be the casing for such a well.

Testing tool 10 which is suspended into the well pipe 12 to a point where a test is to be conducted includes spaced packer elements 18 and 20 which abut packer back-up rings 22 and 24 respectively. The packer elements 18 and 20 are resilient and made of an elastomeric material such as rubber, synthetic rubber or the like. Cylindrically shaped piston elements 26 and 28 slidable on a body member 30 of the testing tool 10 are adapted to be simultaneously extended by application of fluid pressure beneath their respective heads against the packer element 18 and 20 to compress the same longitudinally and expand the same transversely so that the packer elements seat against the wall of the well pipe as shown

in FIGURE 1. In more detail, the body member 30 is provided with an axially extending passage 32, the upper end of the passage 32 being open and in fluid communication with a flexible conduit leading to a suitable source of fluid pressure (not shown). The lower end of the passage 32 is closed and laterally extending passages 34 in the body member 30 communicate with the passage 32 and the area beneath the heads of the respective pistons 26 and 28.

As shown in FIGURE 1 fluid under pressure flows down the passage 32 and through the transverse passages 34 moving the pistons 26 and 28 against the packer elements to seat the same in the well pipe. While the packer elements have been disclosed as piston actuated packer elements, it is of course within the scope of the invention to utilize other types of packer elements such as those shown in my United States Patent No. 2,807,955, issued October 1, 1957.

In order that fluid can be flowed into the annular space A between packers 18 and 20 after the same have been set, the testing apparatus or tool 10 is provided with a fluid pressure responsive valve means 36. The valve means 36 is operable at a pressure of testing fluid flowing through the conduit 32 higher than the pressure necessary to set the packers 18 and 20 and, thus, the valve means opens after the packer elements set and when the pressure builds up within the tool to the predetermined amount. The fluid will then flow into the annular space A and the threaded joint of the collar 16 as well as the walls of the stands 14 between the packer elements are tested for leaks.

After a test has been conducted, pressure of the fluid within the passage 32 is relieved and the valve means 36 immediately closes. Also the pressure beneath the piston elements 26 and 28 is simultaneously relieved and the piston elements tend to return to their normal retracted position. Often-times there is fluid trapped between the packer elements 18 and 20 which has a pressure sufficient to maintain the packer elements in their set position and to relieve this pressure, a second pressure responsive valve means or relief valve means 38 is provided. The pressure responsive valve means 38 is opened when the pressure of the fluid in the annular space A is higher than the pressure of the fluid within the testing apparatus 10.

In more detail, the pressure responsive valve means 36 includes an enlarged bore 40 extending transversely of the body member 30, the bore 40 intersecting the passage 32 and opening at its ends in diametrically opposed ports or openings 42 on the surface of the body member 30. A counterbore 44 is provided in the bore 40 and provides an arrangement encircling the bore so as to permit a continuous passage of fluid through the passage 32 past the valve means 36 when the packer elements are set. The walls of the bore 40 on each side of the counterbore 44 define annular valve seats 46 spaced apart by the width of the counterbore.

Cooperating with and supported in the annular valve seats 46 is an elongated cylindrically shaped resilient valve element 48 which in its relaxed position has a radial thrust into sealing engagement with the valve seats. The cylindrically shaped valve element 48 is preferably made of an elastomeric material such as rubber, synthetic rubber or rubber substitutes which have an elastic memory. It may also be made of any plastic materials having elastic memory.

The operation of the valve means 36 may be briefly described as follows. After fluid flows down the passage 32 around the counterbore 44 to the lower portion of the passage 32 and both the lower and upper packer elements have been set the pressure of the fluid within the passage 32 and counterbore 44 is then increased to a predetermined value. When the pressure fluid reaches the predetermined value, the fluid acting on the portion of the valve element 48 bridging the bore 44 causes a deformation of the cylindrical valve element 48 as a cold flow of the material occurs. This causes unseating of the valve element from both of the annular seats 46 and the fluid can flow outwardly of both sides of the bore through the diametrically opposed ports or openings 42 into the annular space A. As soon as pressure within the passage 32 is relieved, the elastic memory of the valve element 48 causes it to return to its relaxed position where it exerts a radial thrust on the annular seats 46. Should a flake or particle enter between the valve element and a valve seat, the valve element will deform about the flake or particle still forming a seal with the valve seat and, thus, the valve will perform its normal function when pressure is initially applied to set the packer elements during a subsequent test.

The valve means 36 may be adjusted to open at different fluid pressures. To accomplish this, the valve element 48 is provided with an axial bore 50 tapered at each end as indicated at 52 and an adjusting screw 54 having a head 56. The screw is inserted through the bore 50 and a nut 58 is threaded onto the end of the adjusting screw 54. Both the nut 58 and the head 56 have tapered surfaces complimentary to the tapered surfaces 52 of the bore 50. By tightening the nut, the valve element 48 is compressed longitudinally and exerts a great thrust radially on the valve seats 46. The greater the thrust exerted on the valve seats 46 by the valve element 48, the greater the pressure necessary to cause cold flow and escape of fluid outwardly of the bore into the annular space A.

The adjusting screw 54 is provided with a by-pass passage 60 having one end 62 opening to the bore 40 and annular space A and the other end 64 opening to the interior surface of the bore 50 of the valve element 48. When the pressure of fluid acting on the open end 62 of the by-pass passage 60 is greater then the pressure of fluid in the counterbore 44 and passage 32, it will act on the interior of the valve element 48 forcing the same into tight seating engagement with the valve seats 46 and thereby assisting in preventing fluid from entering the body member 30.

As mentioned heretofore, in order to relieve pressure in the annular space A after a test has been completed and when the pressure has been relieved on the fluid in the passage 32, the pressure responsive relief valve means 38 is provided. This valve means 38 includes an enlarged bore 66 provided in the passage 32, the bore 66 communicating with a laterally extending passage 68 having an opening 70 on the surface of the body member 30. The passage 68 divides the bore into spaced annular valve seats 72 which are adapted to support a cylindrically shaped resilient valve element 74. The valve element 74 is made of the same material as the valve element 48 and is provided with an enlarged axial bore 76 therethrough so that fluid can flow from the upper portion of the passage 32 to the lower portion of the passage 32. Normally the elastic memory of the material of the cylindrical valve element 74 sets the same against the valve seats 72 when the pressure within the body member 30 is greater than the pressure of fluid externally of the body member. Also, the higher pressure of fluid flowing through the passage 32 and through the bore 76 of the valve element 74 causes the valve element to have a high radial thrust and, thus, tighter seating engagement.

The pressure responsive valve means 38 unseats or opens when fluid pressure in the annular space A is higher than pressure of fluid within the body member 30, the pressure in the space A acting through the passage 68 against the outside of the cylindrical valve element 38 to cause the same to deform or cold flow away from the seat or seats 72. The fluid will flow between the valve seat and the valve element into the bore 66 in passage 32. It will be noted that the valve element 74 has a length slightly less than the length of the bore 66 so that the fluid passing the valve seat and the valve element can flow into the passage 32.

While the valve element 74 has been shown with an unobstructed bore 76 therethrough, it will be understood that an adjusting screw mechanism such as that described with respect to the valve element 48 may be utilized to adjust the radial thrust of the valve element 74 against its valve seat 72. Of course, a suitable passage by-passing around the valve means 38 would have to be provided so that fluid could flow through to the lower portion of the passage 32.

Referring now to FIGURES 4 and 5 a slightly modified form of testing apparatus is illustrated. In FIGURES 4 and 5 the testing tool 10' is provided with spaced packers 18' and 20' operable in an identical manner to those previously described by pistons 26' and 28'. Valve means 36' provided at the lower end of passage 32' includes a metallic ball valve element 48' which seats against an annular seat 46'. A spring 49 urges a follower 51 together with the ball 48' toward the seat 46'. The follower 51 is provided with suitable longitudinally extending grooves 53 so that fluid can pass thereby into the lower section of a bore 55 which houses the valve. A passage 57 extending from the bore 55 to an opening at 59 on the surface of the tool body member 30' permits fluid to flow to the annular space A when a test is to be accomplished.

The tool body 30' is provided with a by-pass passage 61 which communicates with the passage 32' up-stream of valve means 46'. The passage 61 communicates with a lower passage 33 which extends to a position adjacent the lower piston 28'. In passage 33, an enlarged bore 66' is provided, the bore 66' communicating with a laterally extending passage 68' opening to the surface of the tool body member 30' as indicated at 70'. A cylindrical resilient valve element 74' supported in the bore 66' and having engagement with the valve seats 72' defined by the wall of the bore on either side of the passage 68' functions as a pressure responsive relief valve 38' in an identical manner to the relief valve 38. The bore 76' through the valve element 74' permits fluid to pass through the valve element so as to actuate the flow piston 28'.

The testing tool illustrated in FIGURES 4 and 5 operates in an identical manner with the testing tool previously described with respect to FIGURES 1 through 3 in that the packer elements 18' and 20' are first set and then the pressure on the fluid within the testing tool is increased to a predetermined amount to cause the ball 48' to unseat and permit fluid flow to the annular space A externally of the tool. The relief valve 38' operates identically when fluid pressure within the tool is relieved to a point where it is less than the pressure of fluid externally of the tool. While the testing tool illustrated in FIGURES 4 and 5 is not as preferred an embodiment as that shown in FIGURES 1 through 3, it does have the advantage over prior testing tools in that utilization of the specific pressure responsive relief valve means 38' is advantageous over the use of a metallic valve such as shown in the prior art. There is less likelihood of a flake or particle lodging between the valve seat and valve element of the valve 36' than there is between the valve seat and valve element of the valve 38' and consequently the conventional metallic spring urged ball valve can be utilized at this position in the tool.

The terminology used in the specification is for the purpose of description and not limitation the scope of the invention being defined in the claims.

I claim:

1. A pressure responsive valve mechanism comprising a body member having a bore therein and a flow passage for fluid under pressure, said bore having at least two ends with at least one of the ends open, said flow passage extending in said body member transversely of said bore and opening to said bore intermediate the ends of said bore, said bore having walls on each side of the opening of said passage thereto defining spaced annular valve seats, a cylindrically shaped valve element carried in said bore with its ends supported in sealing engagement in said spaced annular valve seats, said cylindrically shaped valve element being made from a resilient material having an elastic memory whereby a predetermined pressure of fluid in said flow passage deforms the valve element off of at least one of said valve seats and permits flow from said passage between said valve element and the valve seat outwardly of said bore.

2. A pressure responsive valve as claimed in claim 1 including means to adjust outward pressure of said valve element against said valve seats whereby pressure of fluid necessary to unseat said valve element may be varied.

3. A pressure responsive valve mechanism comprising a body member having a bore therein and a flow passage for fluid under pressure, said bore having at least two ends with at least one of the ends open, said flow passage extending in said body member transversely of said bore and opening to said bore intermediate the ends of said bore, said bore having walls on each side of the opening of said passage thereto defining spaced annular valve seats, a cylindrically shaped valve element carried in said bore with its ends supported in sealing engagement by said spaced annular valve seats, said cylindrically shaped valve element having an axial bore therethrough, said cylindrically shaped valve element being made from a resilient material having an elastic memory whereby a predetermined pressure of fluid in said flow passage deforms the valve element off at least one of said valve seats and permits flow from said passage between said valve element and the valve seat outwardly of said bore, an adjusting screw extending through the axial bore in said valve element, and a nut threaded onto said screw for compressing said valve element longitudinally and causing radial thrust of said valve element against said valve seats whereby the predetermined pressure of fluid at which said valve element unseats may be adjusted.

4. A pressure responsive valve as claimed in claim 3 wherein said adjusting screw includes a by-pass passage opening at one end to said bore and at the other end to the wall of the axial bore in said valve element.

5. A pressure responsive valve as claimed in claim 3 wherein the opening of said passage into said bore includes a counterbore in the said bore encircling said valve element.

6. A pressure responsive valve as claimed in claim 3 wherein said axial bore in said valve element is tapered at each of its ends and wherein said adjusting screw and said nut are provided with complimentary tapered surfaces for engaging the tapered ends of the axial bore.

7. A pressure responsive valve mechanism comprising a body member having a bore therein and a flow passage for fluid under pressure, said bore having at least two ends with at least one of the ends open, said flow passage extending in said body member transversely of said bore and opening to said bore intermediate the ends of said bore, said bore having walls on each side of the opening of said passage thereto defining spaced annular valve seats, a cylindrically shaped valve element carried in said bore with its ends supported in sealing engagement with said annular valve seats, said cylindrically shaped valve element having an axial bore therethrough and at least one end terminating short of at least one end of said bore, said cylindrically shaped valve element being made from a resilient material having an elastic memory whereby a predetermined pressure of fluid in said flow passage deforms the valve element off at least one of said valve seats and permits flow from said passage between said valve element and the valve seat outwardly of said bore.

8. In an elongated well tool insertable into well pipe and having spaced packers thereon set by the application of fluid under pressure flowing through the tool, the improvement comprising: an elongated body mem-

ber on which the spaced packers are mounted, said body member having a fluid passage extending therethrough for applying fluid to set the packers, said body member having a first pressure responsive valve means operable at a predetermined pressure higher than the pressure necessary to set the packers for supplying fluid outwardly of said body member to a space between the set packers, said pressure responsive valve means including a transversely extending bore in said body communicating with said fluid passage by an opening intermediate its ends, said bore having diametrically opposed openings on the surface of said body member, a resilient cylindrical shaped valve element carried in said bore and making sealing engagement with the same on each side of the opening of said passageway with said bore, and a second pressure responsive valve means for flowing fluid from externally of the tool into said fluid passageway.

9. A well tool as claimed in claim 8 in which said opening of said fluid passage with said bore includes a counter-bore in said bore intermediate the diametrically opposed end openings of the same.

10. A well tool as claimed in claim 8 wherein said first pressure responsive valve means includes means to adjust the thrust of said resilient valve element against the wall of said bore.

11. A well tool as claimed in claim 10 wherein said adjustment means includes an adjustment screw extending axially through said valve element and having a head abutting one end of the same and a nut carried on the other end of said screw and abutting the opposed end of said valve element.

12. A well tool as claimed in claim 11 wherein said screw has a passage therein having one end opening in said bore and the other end opening against the interior of said valve element, said passage providing a by-pass whereby fluid in said bore under a greater pressure than fluid in said fluid passage maintains said valve element in tight sealing engagement with the wall of said bore.

13. A well tool as claimed in claim 8 wherein said second pressure responsive valve means includes an enlarged bore in said fluid passage, a resilient cylindrical shaped valve element carried in said bore and having a length less than the length of said bore and a transverse passage in said body extending from the exterior of the tool to the bore and exterior of the cylindrical shaped valve element.

14. A tool as claimed in claim 13 wherein said cylindrical shaped valve element of the second pressure responsive valve includes an axial bore therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

2,662,485	Ilfrey	Dec. 15, 1953
2,719,536	Stone	Oct. 4, 1955
2,841,007	Loomis	July 1, 1958
2,954,043	Canalizo	Sept. 27, 1960
3,022,796	Cummings	Feb. 27, 1962