Jan. 5, 1960 H. E. SCHWEGMAN 2,919,709

FLUID FLOW CONTROL DEVICE

Filed Oct. 10. 1955 2 Sheets-Sheet 1

FIG. 1.

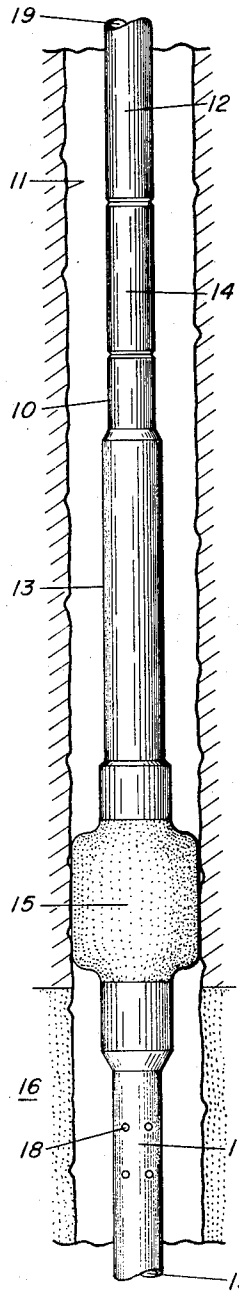


FIG. 2.

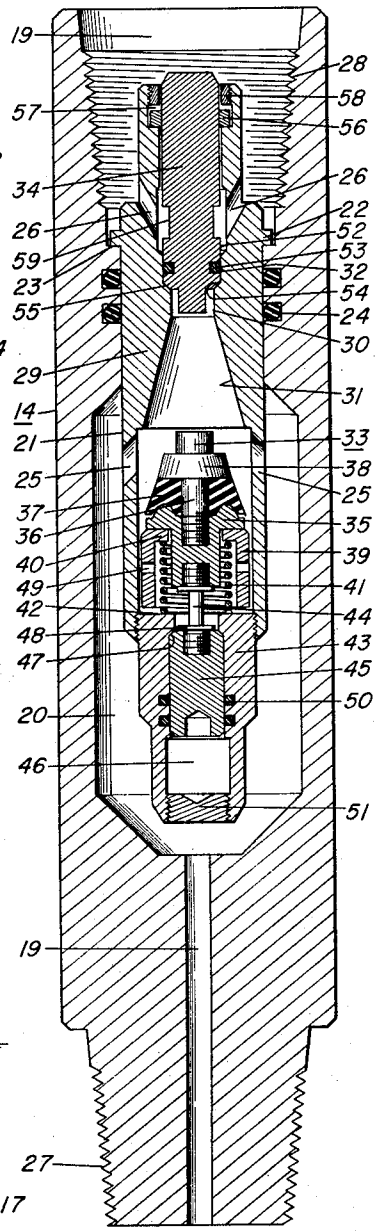
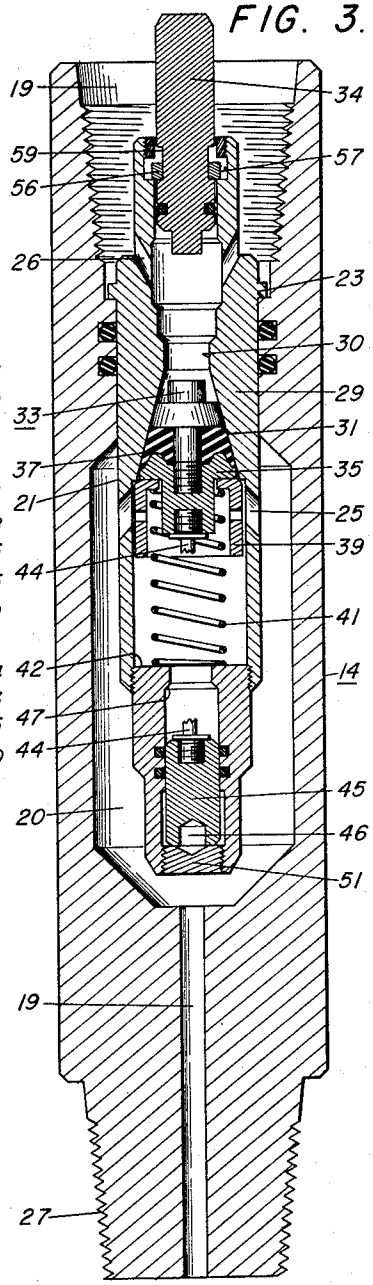


FIG. 3.



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FIG. 4.

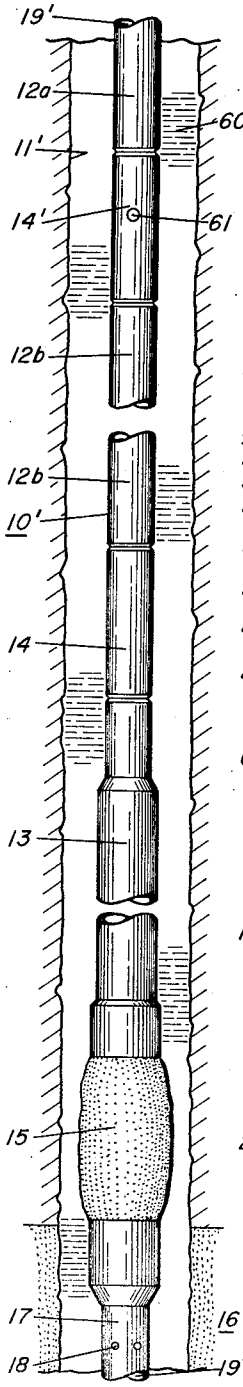


FIG. 5.

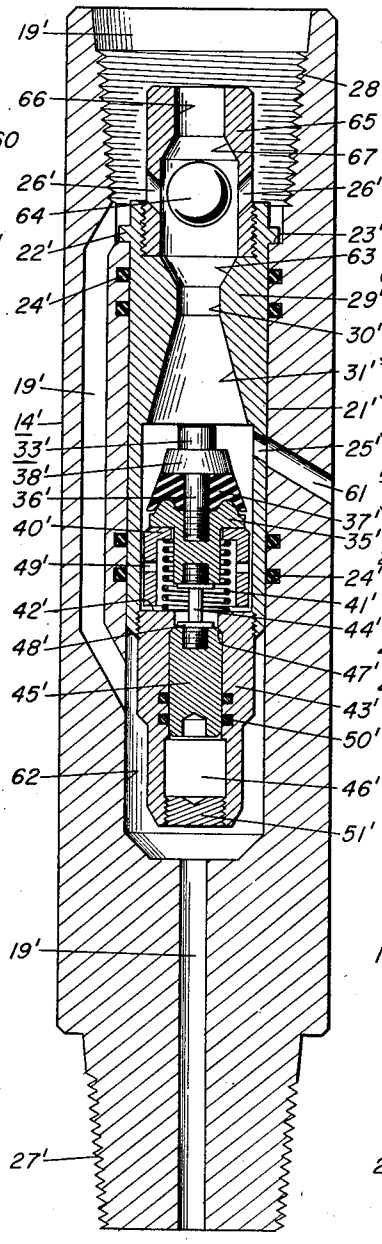
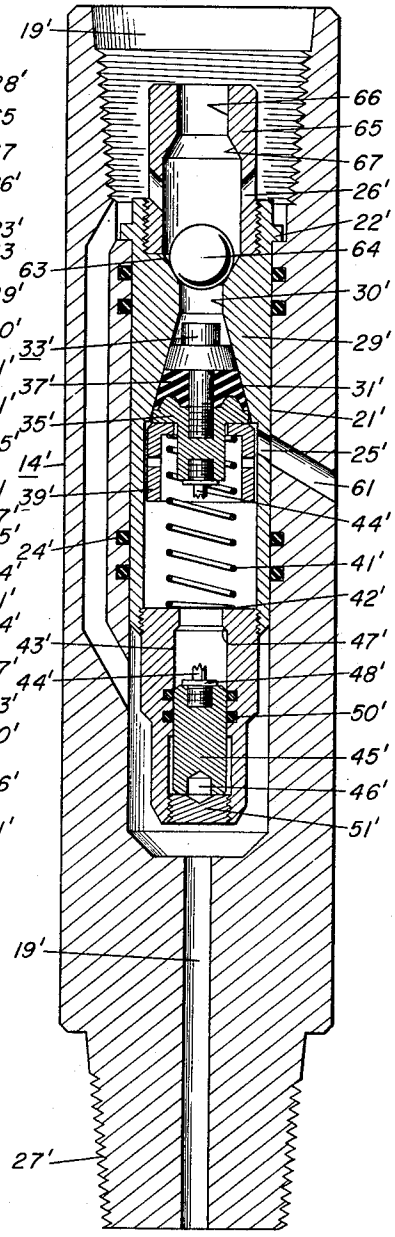


FIG. 6.



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FLUID FLOW CONTROL DEVICE

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Application October 10, 1955, Serial No. 539,522

17 Claims. (Cl. 137—68)

This invention relates to devices for controlling the flow of fluid under pressure and, more particularly, to a fluid flow control device adapted to be lowered into a well bore and used at a location therein for controlling fluid flow in accordance with the fluid pressure at or near such location.

The invention provides particular advantages when applied to an arrangement suited for use in testing zones or formations penetrated by the bore of an oil or gas well. The testing string lowered into the well bore commonly includes a hollow pipe or other conduit which extends upwardly to the surface of the ground and through which fluid is withdrawn or conducted during the performance of the testing operation, such as when the tester valve is opened. It is desirable to control such fluid flow in order to prevent excessive pressure, such as pressure in the zone or formation being tested, from causing excessive fluid flow into the hollow pipe or conduit.

The invention may also be applied in connection with the lowering of a string of well apparatus including a hollow pipe or other conduit into a well bore partially or completely filled with fluid such as drilling mud or the like. It is well known that the performance of the lowering operation will oftentimes be facilitated if the pipe or conduit is not lowered "dry." However, where the drilling mud or other fluid in the well bore is permitted to enter the pipe or conduit during the lowering thereof, it is desirable or necessary in many instances to control the entry of such fluid in order to prevent overflowing of the pipe or conduit. Also, it has been found that by limiting such fluid entry so that the pipe or conduit does not become completely filled, the lowering operation may nonetheless be facilitated and the amount of swabbing or other removal action required to subsequently clear the pipe or conduit oftentimes may be substantially reduced.

It is a general object of this invention to provide an improved fluid flow control device of the type which is responsive to fluid pressure, such as to the pressure of fluid controlled thereby.

It is another object of the invention to provide an improved fluid flow control device useful at a location in the bore of an oil or gas well or the like for controlling fluid flow in accordance with the fluid pressure at or near such location.

It is another object of the invention to provide an improved fluid flow control device for limiting or preventing excessive fluid flow into a pipe or conduit suspended in a well bore.

It is another object of the invention to provide an improved fluid flow control device for controlling the entry of fluid into a pipe or conduit during the lowering thereof into a well bore partially or completely filled with fluid.

It is another object of the invention to provide an improved excess-pressure valve of the shut-off type, such as is useful for preventing excessive fluid flow due to changes in the pressure of the fluid controlled thereby.

It is a further object of the invention to provide an improved valve for limiting or preventing excessive fluid flow into a pipe or conduit lowered into a well bore, such as may result from excessive or unexpected pressure being encountered in a zone or formation penetrated by such well bore.

The invention involves the concept of a fluid flow control device or valve including a valve member which is normally held substantially fixed in an initial position by a yieldable support. Such support is adapted to be overcome upon sufficient force being applied thereto by fluid pressure, such as by the pressure of the fluid being controlled. The valve member remains in its initial or normal position until the force applied to overcome the yieldable support reaches a predetermined value with respect to a reference force continuously exerted thereagainst independently of such fluid pressure. The reference force may be an opposing force of relatively constant value exerted by a compressible fluid confined in a chamber provided within the control device. If desired, the reference force may be due to a vacuum-like condition in the chamber.

In one arrangement the valve member is normally held substantially fixed in an open position by a support which is a yieldable pin secured at one end to the valve member and at its other end to a piston. The piston is mounted for movement from an initial and substantially fixed position within a chamber containing a compressible fluid, such as air or gas, and has a surface outside the chamber exposed to the pressure of the fluid being controlled. Upon the force applied to the piston by the fluid pressure outside the chamber becoming sufficiently greater than the force exerted thereagainst from within the chamber to part or separate the yieldable pin, the valve member is then permitted to move from its open to its closed position.

If desired, a spring or the like may be included for normally urging the valve member toward its closed position, thus causing the valve to close at about the same time that the yieldable support is overcome. Also, the piston may, if desired, have its exposed surface outside the chamber shielded to some extent against sudden or impact pressure due to movement of the fluid being controlled, such as when it is desired to change fluid flow as nearly as possible in response to force applied by the hydrostatic pressure of the fluid being controlled.

The foregoing and other objects and advantages of the invention will become more apparent from the following description when read in connection with the accompanying drawing in which similar reference characters designate similar parts and wherein:

Figure 1 is a side elevational view of a testing string positioned within a well bore after having been lowered to a desired depth therein, the spring including a testing assembly and also including one form of fluid flow control device having the invention incorporated therein;

Figure 2 is a longitudinal cross-sectional view of a portion of the string of Figure 1, showing in greater detail the fluid flow control device with its parts in their initial or normal positions;

Figure 3 is a view similar to that of Figure 2, but showing the fluid flow control device with its parts in the respective positions occupied by them at a later stage of operation;

Figure 4 is a side elevational view of a string of equipment being lowered into a well bore partially or completely filled with fluid, the string including the equipment of Figure 1 and also including an additional fluid

flow control device of modified construction also having the invention incorporated therein;

Figure 5 is a longitudinal cross-sectional view of a portion of the string of Figure 4, showing in greater detail the modified fluid flow control device with its parts in the respective positions occupied by them at one stage of the lowering operation;

Figure 6 is a view similar to that of Figure 5, but showing the modified fluid flow control device with its parts in the respective positions occupied by them at a later stage of the lowering operation.

Referring first to the arrangement of Figure 1, a testing string 10 is there shown positioned within a well bore 11 after having been lowered to a desired depth therein. The string 10 is shown as including a drill pipe 12 which extends upwardly to the surface of the ground (not shown). The string 10 also includes a testing assembly 13 which may be of conventional design and, above the assembly 13, includes a housing 14 within which is positioned one form of fluid flow control device having the invention incorporated therein, as will appear more fully hereinafter.

The housing 14 is shown connected at its upper end to the lower end portion of the drill pipe 12 and at its lower end to the upper end portion of the testing assembly 13. The testing assembly 13 is shown as including a packer 15 which has been set or expanded to effect a fluid-tight seal with the wall of the well bore 11 at or near the upper limit of a zone or formation 16 upon which the testing operation is to be performed.

The zone or formation 16 is traversed by an anchor pipe 17, which is threadedly or otherwise connected at its upper end to the lower portion of the packer 15 and has its lower end (not shown) resting on the bottom of the well bore 11. Perforations 18 are preferably provided in the anchor pipe 17 to permit the entry thereinto of fluid which is present in the portion of the well bore 11 below the packer 15 and perhaps also in the adjacent zone or formation 16.

A passageway 19 extends generally lengthwise of the entire string 10. The testing assembly 13 preferably includes a tester valve or the like, which is not shown but may be of well known design and is adapted when closed to prevent fluid entering the anchor pipe 17 from passing upwardly along the passageway 19 into the portion thereof extending through the housing 14.

Referring now to Figure 2, the passageway 19 extends upwardly into the housing 14, which has provided therein a chamber 20 forming a portion of the passageway 19. Within the chamber 20 there is positioned a hollow case 21, which is closely fitted to or, if desired, may be made integral with a portion of the wall of the housing 14.

As illustrated, the case 21 has near the upper end thereof a lateral protuberance or lug 22 which is shown engaging an abutment 23 on the housing 14 and thereby limits relative downward movement of the case 21 therein. Sealing rings 24 or the like are preferably provided between the closely fitted portions of the housing 14 and case 21 to prevent the passage of fluid therebetween. As a result, fluid in the passageway 19 upon entering the housing 14 from below is caused to pass into the hollow case 21, which has in the wall thereof one or more lower or inlet openings 25 communicating with the chamber 20 and one or more upper or outlet openings 26 communicating with the portion of the passageway 19 above the sealing rings 24.

The housing 14 is shown provided with external threads 27 on its lower end portion for making connection to the testing assembly 13 or to other well apparatus and with internal threads 28 on its upper end portion for making connection to the drill pipe 12 or to other well apparatus. It is apparent that the lug 22 on the case 21 will be in engageable relation to the lower end of the drill pipe 12 upon the housing 14 being screwed thereon, the arrangement being such that the lug 22 then limits or prevents

relative upward movement of the case 21 within the housing 14.

As illustrated, the hollow case 21 includes an intermediate seat portion 29 which extends radially inward from the wall thereof and defines a passageway or throat 30 along which fluid must travel in passing between the openings 25 and 26. The seat portion 29 is shown constructed and arranged so that the throat 30 has its lower end surrounded by a downwardly and outwardly tapered seating surface 31 and has its upper end surrounded by a vertical seating surface 32.

An upwardly closing valve member 33 is shown mounted within the hollow case 21 below the seat portion 29 thereof and is adapted when closed to effect a fluid-tight seal with the tapered lower seating surface 31. A downwardly closing valve member 34 is preferably mounted within the hollow case 21 above the seat portion 29 thereof, as shown, and is preferably adapted when closed to effect a fluid-tight seal with the vertical upper seating surface 32.

As illustrated, the upwardly closing valve member 33 includes a body 35 having a valve stem 36 screwed into the upper end thereof. A sealing member 37, which may be an inverted cup-type sealing ring made of rubber or the like, encircles the stem 36 and is held in place against the body 35 by a laterally extending ridge 38 shown provided on the stem 36 near the upper end thereof. If desired, the upper surface of the body 35 may be suitably curved, as shown, or otherwise arranged so as to cause radial expansion of the sealing ring or member 37 upon the stem 36 being screwed farther into the body 35. This arrangement permits adjustment of the sealing characteristics of the valve, such as by way of compensating for damages or changes affecting the sealing ring or member 37 or the tapered seating surface 31 engageable thereby.

The valve body 35 is shown as including a downwardly extending portion which is encircled by a sleeve 39 having a flange 40 extending radially inward from the upper end thereof. A spring 41 or the like is preferably mounted between the sleeve 39 and the downwardly extending portion of the body 35 in such manner that the flange 40 is disposed between the body 35 and the upper end of the spring 41. The lower end of the spring 41 is shown supported by a lower abutment 42, which is secured to or integral with the case 21. The abutment 42 is shown provided by the upper end of a cylinder 43 which is screwed into the lower end of the case 21.

The spring 41 is normally compressed longitudinally between the flange 40 and the abutment 42 and thus normally urges the valve member 33 toward its upward or closed position. However, the valve body 35 is normally supported in its downward or open position by a yieldable member, such as by a pin 44, which normally couples the body 35 to a piston 45 or other movable member mounted within the cylinder 43.

As illustrated, the pin 44 is threadedly connected at its upper end to the lower end portion of the valve body 35 and at its lower end to the upper end portion of the piston 45. The piston 45 is mounted for limited relative longitudinal movement within a chamber 46 provided within the cylinder 43 and is shown in Figure 2 in its normal or uppermost position therein, with a downwardly facing surface 47 on the wall of the cylinder 43 near the upper end thereof engaging a portion of the upper end of the piston 45, such as along the periphery or outer edge thereof.

The arrangement is such that the piston 45 and perhaps structure secured thereto, such as the flanged portion 48 of the pin 44, has at least a portion of its upper surface exposed to the pressure of fluid thereabove in the hollow case 21. To this end, one or more perforations 49 may be provided in the sleeve 39 to permit a portion of the fluid entering the case 21 through, for example, its lower or inlet openings 25, to contact the exposed upper surfaces of the piston 45 and the flanged portion 48 of the pin

44. Sealing rings 50 or the like are preferably provided between the piston 45 and the wall of the cylinder 43 to isolate the chamber 46 from this fluid.

The chamber 46 may contain a compressible fluid, such as air or gas. This fluid is supplied to the chamber 46 prior to making up the string 10, such as by introducing the fluid through the lower end of the cylinder 43 after removing a cap or plug 51 which is normally screwed therein.

The compressible fluid may be at atmospheric pressure or at a higher or lower pressure, but in any event the pressure thereof should be substantially independent of the fluid pressure acting downwardly on the piston 45, as aforesaid. Since the chamber 46 is isolated, such as by the sealing rings 50 and the plug 51, from the fluid controlled by the valve member 33, the force exerted on the piston 45 from within the chamber 46, which is in effect a reference force, remains at a value which is relatively constant and does not vary appreciably, if at all, upon variations occurring in the pressure of the fluid being controlled.

As illustrated, the downwardly closing valve member 34 is an elongated body having a lower vertical surface 52 which is adapted to closely engage the vertical seating surface 32 on the case 21 when the member 34 is in its downward or at rest position therein. Sealing rings 53 or the like are preferably provided between the engageable surfaces 32 and 52 so that a fluid-tight seal is effected and the upper end of the throat 30 is normally closed, as shown in Figure 2.

In order to limit relative downward movement of the valve member 34 within the case 21, there is shown provided on the seat portion 29 an upwardly facing abutment 54 which is adapted to engage a downwardly facing abutment 55 provided on the member 34 near the lower end thereof. Relative upward movement of the valve member 34 within the case 21 may be limited by a yieldable split-type snap ring 56 which is shown encircling the member 34 and mounted within an inner annular recess 57 provided in the wall of the case 21 near the upper end thereof. If desired, the upper limit of the recess 57 may be defined by a bushing 58 or the like, which is shown encircling the valve member 34 and screwed into the upper end of the case 21.

It will be noted in Figure 2 that the snap ring 56 is normally supported by the valve member 34 in its expanded position within the recess 57. Upon the valve member 34 being moved upwardly within the case 21, the snap ring 56 registers with a groove 59 extending peripherally about the member 34, whereupon the ring 56 then compresses to a position (see Figure 3) in which it is engageable both with the walls defining the upper and lower limits of the recess 57 and those defining the corresponding limits of the groove 59. The arrangement is such that the valve member 34 upon reaching its upward or open position within the case 21 becomes supported by the snap ring 56 against substantial further longitudinal movement therein.

In the performance of a testing operation using the arrangement of Figure 1, the string 10 is ordinarily lowered into the well bore 11 with the packer 15 in its relaxed or unexpanded position and with the tester valve closed. Upon the string 10 reaching a desired location in the vicinity of the zone or formation 16 to be tested, the packer 15 is moved to its set or expanded position, as shown in Figure 1 and the tester valve is then opened.

Prior to the tester valve being opened, the parts mounted within the housing 14 are in the respective positions shown in Figure 2. Thus, the valve members 33 and 34 are then in their normal or downward positions, that is, the member 34 is in its closed position and the member 33 is supported in its open position by the yieldable pin 44, as hereinbefore described.

During the lowering of the string 10 fluid such as water or drilling mud in considerable quantities may be present in the portion of the passageway 19 above the housing 14. The primary purpose of the normally closed valve member 34 is to prevent pressure surges within the case 21 due to movement of this fluid, such as may be caused by sudden changes in the rate of lowering of the string 10. Thus, there is in effect provided a protective valve which may not be required in certain operations. It is understood that any of various equivalent and equally suitable protecting valve arrangements may be employed in lieu of or in addition to that shown. For example, the tester valve commonly included in the testing assembly 13 functions when closed as a protective valve which prevents pressure surges within the case 21 due to movement of fluid in the portion of the passageway 19 therebelow.

Upon the tester valve being opened, fluid entering the anchor pipe 17, such as through its perforations 18, is then permitted to pass upwardly along the passageway 19 into the chamber 20 within the housing 14 and thence into the case 21 through its inlet openings 25. The fluid upon entering the case 21 contacts the lower surface of the valve member 34 and the upper exposed surfaces of the piston 45 and the pin 44 secured thereto.

The valve member 34 is free to move upwardly within the case 21 and will ordinarily move to its upward or open position therein, as shown in Figure 3, when force is initially applied thereto upon fluid entering the throat 30 following the opening of the tester valve. Thereafter the valve member 34 is supported by the snap ring 56 in its upward or open position, as hereinbefore described, and fluid communication is thus provided in either direction between the openings 25 and 26 of the case 31, permitting the testing and perhaps other well operations to be thereafter carried out in accordance with the usual practices.

The pressure of the fluid in the case 21 contacting the upper exposed surfaces of the piston 45 and pin 44 applies thereto a force which tends to move the piston 45 downwardly within the cylinder 43. Where the chamber 46 within the cylinder 43 contains a compressible fluid, such as air or gas, this fluid resists downward movement of the piston 45 and, in effect, exerts an opposing upwardly acting force against the lower surface of the piston 45. Where there is a vacuum-like condition in the chamber 46, such condition will itself tend to cause the piston 45 to move downwardly, in which event the downwardly acting force applied by the pressure of the fluid in the case 21 will be additive thereto, further increasing the tendency of the piston 45 to move downwardly.

Such downward movement of the piston 45 tends to move the valve body 35 in a downwardly direction within the case 21. However, the sleeve 39 in cooperation with the abutment 42 limits such downward movement of the valve body 35. Thus, as the piston 45 moves downwardly, the pin 44 normally coupling together the piston 45 and valve body 35 is subjected to force acting in a direction such as to cause elongation and eventual separation thereof.

It is apparent that the force exerted on the piston 45 from within the chamber 46 is applied independently of the pressure or flow of the fluid along the passageway 19 and through the case 21. Accordingly, the resulting force tending to part or separate the pin 44 is substantially determined by the pressure of the fluid at a location within the case 21, that is, by the pressure of the fluid contacting the upper exposed surfaces of the piston 45 and pin 44.

In the arrangement shown such exposed surfaces are shielded to some extent from sudden or impact forces due to movement of fluid between the openings 25 and 26 in the case 21. For one thing, the surfaces are shown disposed in the case 21 below the lowest of such openings 25 and 26. Also, the sleeve 39 with its perforations 49 is constructed and arranged so as to act some-

what as a "baffle" which reduces turbulence therewithin due, for example, to sudden surges of fluid into the case 21.

The pin 44 may be made of any of various suitable materials, such as metal or the like. Excellent results have been obtained using pins made of annealed yellow brass, which appears to have a relatively consistent composition and high elongation characteristics. In actual tests it has been found that the value of fluid pressure required in order to apply sufficient force to part or separate pins so constructed can be predicted with a high degree of accuracy. For example, in one series of tests using annealed yellow brass pins of varying sizes, the pins were overcome at measured pressures deviating from a minimum of 0% to a maximum of 5% with respect to the predicted pressure.

For any particular application the pin 44 is preferably selected so that it does not part or separate and, accordingly, the valve member 33 does not move to its upward or closed position, unless there occurs excessive fluid pressure which is likely to cause excessive fluid flow into the portion of the passageway 19 extending through the drill pipe 12. For example, the pin 44 may be selected so that it parts or separates only if the formation pressure causing fluid to flow upwardly along the passageway 19 is or becomes of such value as to be likely to cause the well to "blow-out" or to otherwise interfere with the performance of the testing operation.

In any event the arrangement is such that the pin 44 is overcome when the pressure of the fluid in contact with the upper exposed surfaces of the piston 45 and pin 44 applies thereto a predetermined force with respect to the force, which is in effect a reference force of relatively constant value, exerted on the piston 45 from within the cylinder 43.

Upon the pin 44 being thus overcome, the normally compressed spring 41 is permitted to expand longitudinally and thereby move the valve member 33 upwardly within the case 21, thus effecting a fluid tight seal between the sealing member 37 and the surface 31 and thereby preventing further fluid flow in an upwardly direction through the case 21 into the upper portion of the passageway 19. However, fluid may thereafter be caused to flow in a downwardly direction through the case 21 by pumping or otherwise applying sufficient force thereto to overcome the spring 41, such as in carrying out a subsequent well operation. Upon the string 10 being withdrawn from the well bore 11 and disassembled, such as upon completion of the testing operation, the pin 44 should be replaced and the valve members 33 and 34 returned to their normal or downward positions within the case 21 prior to using the apparatus in another well operation.

Referring now to the arrangement of Figure 4, an equipment string 10' is there shown during the lowering thereof into a well bore 11' substantially filled with a fluid 60, such as drilling mud or the like. The string 10' is shown as including a drill pipe 12*a* which extends upwardly to the surface of the ground (not shown) and may be identical to the pipe 12 of Figure 1. The string 10' also includes a housing 14' shown secured at its upper end to the lower end portion of the drill pipe 12*a* and at its lower end to a tubing or pipe 12*b*, which may be a section of the drill pipe 12 of Figure 1.

Below the pipe 12*b*, the string 10' is shown as including the housing 14, testing assembly 13, and associated structure hereinbefore described with reference to Figures 1 to 3, inclusive. It is understood that the string 10' may include various apparatus in addition to or other than that shown.

A passageway 19' extends generally lengthwise of the entire string 10' and includes portions of the passageway 19 of Figures 1 to 3, inclusive, insofar as the structure of the strings 10 and 10' are alike. Within the housing 14' there is positioned another form of fluid flow control device having the invention incorporated therein, such device being primarily for the purpose of controlling the entry of the fluid 60 into the portions of the passageway 19' extending through the pipes 12*a* and 12*b* during the lowering of the string 10'.

Referring now to Figure 5, the housing 14' is shown as having a lateral passageway 61 in the wall thereof and a central bore 62 which extends downwardly from the upper end thereof. Within the bore 62 there is positioned a hollow case 21', which is closely fitted to or, if desired, may be made integral with a portion of the wall of the housing 14'.

The passageway 19' is shown as extending upwardly from the lower end of the housing 14' into the bore 62, which forms a portion thereof, then along the wall of the housing 14' into the upper portion thereof, and thence into the drill pipe 12*a* when the housing 14' is secured thereto (see Figure 4). Sealing rings 24' or the like are preferably provided between the closely fitted portions of the housing 14' and case 21' to prevent the passage of fluid therebetween.

The hollow case 21' has in the wall thereof one or more lower or inlet openings 25' which communicate with the lateral passageway 61 provided in the wall of the housing 14'. Unlike the inlet openings 25 in the arrangement hereinbefore described with reference to Figures 1 to 3, inclusive, the inlet opening 25' does not communicate with the passageway 19' except through the hollow case 21', as will appear more fully hereinafter.

The hollow case 21' also has in the wall thereof one or more upper or outlet openings 26' which communicate with the upper portion of the passageway 19', that is, with the portion thereof above the valve member 34 mounted within the housing 14 (see Figures 2 and 4).

The housing 14' is shown provided with external threads 27' on its lower end portion for making connection to the pipe 12*b* or to other well apparatus and with internal threads 28' on its upper end portion for making connection to the drill pipe 12*a* or to other well apparatus.

As illustrated, the case 21' has near the upper end thereof a lateral protuberance or lug 22', which is shown engaging an abutment 23' on the housing 14' and thereby limits relative downward movement of the case 21' therein. It will be noted that the lug 22' will be in engageable relation to the lower end of the drill pipe 12*a* upon the housing 14' being screwed thereon. Thus, the lug 22' limits or prevents relative upward movement of the case 21' within the housing 14' upon the string 10' being assembled or made up.

The case 21' is shown as including an intermediate seat portion 29' which extends radially inward from the wall thereof and defines a passageway or throat 30' along which the fluid 60 entering the housing 14' through the lateral passageway 61 must pass in order to reach the outlet openings 26' and the upper portion of the passageway 19' communicating therewith. The seat portion 29' is shown constructed and arranged so that the throat 30' has its lower end surrounded by a downwardly and outwardly tapered seating surface 31', which may be identical to the surface 31 hereinbefore described with reference to the arrangement of Figures 1 to 3, inclusive. Additionally, the seat portion 29' is shown constructed and arranged so that the throat 30' has its upper end surrounded by an upwardly and outwardly tapered seating surface 63.

An upwardly closing valve member 33' is shown mounted within the hollow case 21' below the seat portion 29' thereof and is adapted when closed to effect a fluid-tight seal with the tapered lower seating surface 31' (see Figure 6). The valve member 33', together with the associated structure contained within the case 21' below the seat portion 29', may be identical to the valve member 33 and corresponding associated structure hereinbefore described with reference to the arrangement of Figures 1 to 3 inclusive, with the exception, as herein-

before indicated, that the lower or inlet opening 25' of the case 21' communicates directly through the lateral passageway 61 with the annular space surrounding the housing 14' rather than with the passageway 19'. The parts of this structure are respectively designated in Figures 5 and 6 by primed numerals similar to those used to designate the same parts in Figures 2 and 3.

A downwardly closing valve member 64 is preferably mounted within the hollow case 21' above the seat portion 29' thereof. The valve member 64 may be a ball-shaped member, as shown, which is adapted when closed (see Figure 6) to effect a fluid-tight seal with the tapered upper seating surface 63.

As illustrated, the ball valve member 64 is enclosed within a cage 65 which is screwed into the hollow case 21', forming an upper extension thereof. The cage 65 is shown as having the outlet openings 26' provided in the side wall thereof and also as having a central opening 66 provided in the upper wall thereof. The central opening 66 is surrounded by a downwardly facing surface 67 which is adapted to engage the ball valve member 64 and limit relative upward movement thereof within the cage 65.

During the lowering of the string 10' of Figure 4 into the well bore 11', the packer 15 is in its relaxed or unexpanded position, as shown, and the tester valve is ordinarily closed, so that any of the fluid 60 then entering the anchor pipe 17, such as through its perforations 18, is not permitted to pass upwardly along the passageway 19' into the lower housing 14. Accordingly, none of the fluid 60 entering the anchor pipe 17 is then permitted to enter the portion of the passageway 19' extending through the upper housing 14' and the pipes 12*a* and 12*b*.

However, a portion of the fluid 60 is permitted to enter the upper housing 14' through its lateral passageway 61 as the string 10' becomes submerged therein. Since the inlet opening 25' of the case 21' communicates with the passageway 61, the fluid 60 thus is permitted to enter the case 21' where it contacts the lower surface of the ball valve member 64 and the upper exposed surfaces of the piston 45' and pin 44'.

The ball valve member 64 is free to move within the cage 65 and upon being contacted by the fluid 60 will ordinarily move to an upward or open position therein, as shown in Figure 5, thus permitting the fluid 60 to pass through the outlet openings 26' into the passageway 19'. It will be noted that the ball valve member 64 in cooperation with the seating surface 63 provides in effect a one-way check valve which opens automatically upon the upwardly acting force applied thereto by the fluid pressure in the case 21' becoming sufficiently greater than any downwardly acting force applied thereto by fluid pressure thereabove in the passageway 19'. However, if at any time such upwardly acting force becomes insufficient with respect to such downwardly acting force to hold or maintain the ball valve member 64 in an open position, the check valve closes and thereby prevents return of the fluid 60 into the portion of the case 21' communicating with the annular space surrounding the housing 14'.

As the string 10' moves downwardly within the well bore 11' and thus becomes submerged deeper into the column of fluid 60, an increasingly larger portion of the fluid column appears above the upper exposed surfaces of the piston 45' and pin 44' mounted within the case 21'. As a result, the downwardly acting force applied to such surfaces by the pressure of the fluid 60 becomes increasingly larger, while the reference force exerted on the piston 45' from within the chamber 46' remains at a relatively constant value.

Accordingly, during the lowering of the string 10' there is applied to the piston 45' a resulting force of increasingly larger value in a direction such as to cause relative downward movement thereof within the cylinder 43'. As hereinbefore described with reference to the arrangement of Figures 1 to 3, inclusive, the pin 44' parts or separates, permitting the spring 41' to move the valve member 33' to its upward or closed position, as shown in Figure 6, upon the downwardly acting force applied to the upper exposed surfaces of the piston 45' and pin 44' reaching a predetermined value with respect to the reference force exerted on the piston 45' from within the chamber 46'.

Where the column of fluid 60 is of relatively uniform consistency so that its density does not vary appreciably throughout the length thereof, it is possible for the pin 44' to be selected so that the valve member 33' remains in its downward or open position, permitting the fluid 60 to enter the upper portion of the passageway 19', as aforesaid, until such time as the string 10' reaches any of a variety of selected depths below the surface of the column of fluid 60. Thus, the amount of fluid 60 entering the pipes 12*a* and 12*b* may be limited or controlled so that the lowering of the string 10' is facilitated without the likelihood of the pipe 12*a* overflowing, at the same time keeping at a minimum the amount of swabbing or other removal action required to subsequently remove the fluid 60 from the passageway 19', such as during or prior to performing a testing or other well operation.

It will be noted that the passageway 19' in effect bypasses the hollow case 21' mounted within the housing 14'. The arrangement is such that upon the string 10' reaching a desired depth in the well bore 11', the valve members 33' and 64 will both ordinarily be closed, as shown in Figure 6, so that the passageway 19' is then isolated from any fluid present in the annular space surrounding the housing 14', thus allowing testing or other well operations to be thereafter carried out in the usual manner.

It will be appreciated by those skilled in the art that the invention as herein disclosed may be applied to other arrangements than those illustrated. Also, various modifications of the arrangements shown within the spirit of the invention will now present themselves. Accordingly, the invention is best defined by the scope of the appended claims.

What is claimed is:

1. In a fluid flow control device, the combination of means forming a passageway for fluid under pressure, valve means in an initial and substantially fixed posi- for controlling fluid flow therein, means forming a chamber within said device remote from said passageway, a member mounted for movement within said chamber having a surface exposed to the pressure of fluid in said passageway, yieldable means normally interconnecting said movable valve means and member, and means including said yieldable means for normally holding said valve means in an additional and substantially fixed position with respect to said passageway and said member in an initial and substantially fixed position within said chamber, said yieldable means being adapted to be overcome upon the pressure of fluid in said passageway causing sufficient force to be applied to said member to change the position of said member within said chamber, whereby said valve means is then no longer held in its initial position with respect to said passageway.

2. The invention as claimed in claim 1, including means for normally urging said valve means away from its initial position, whereby said valve means automatically changes the flow of fluid in said passageway upon said yieldable means being overcome.

3. The invention as claimed in claim 1, including means for shielding said member from sudden forces resulting from sudden changes in the pressure of fluid in said passageway.

4. The invention as claimed in claim 1, wherein said yieldable means is selected to be overcome upon the force applied to said member due to the pressure of fluid in said passageway reaching a predetermined value with re-

spect to any force exerted thereon from within said chamber.

5. In a fluid flow control device, the combination of means forming a passageway for fluid under pressure, valve means including a valve member mounted for movement within said passageway for controlling fluid flow therein, means forming a chamber within said device remote from said passageway, a piston-like member mounted for limited movement within said chamber and being movable from an initial position therein in response to the pressure of fluid in said passageway, yieldable means normally interconnecting said movable valve and piston-like members, and means including said yieldable means for normally holding said valve member in an initial and substantially fixed position within said passageway and said piston-like member substantially fixed in its initial position within said chamber, said yieldable means beng adapted to be overcome upon the pressure of fluid in said passageway becoming sufficient to change the position of said piston-like member within said chamber, whereby said valve member is then no longer held in its initial position within said passageway.

6. The invention as claimed in claim 5, including means for normally urging said valve member in a direction away from its initial position within said passageway whereby the flow of fluid therein changes automatically upon said yieldable means being overcome.

7. In a fluid flow control device, the combination of means forming a passageway for fluid under pressure, valve means movable with respect to said passageway for controlling fluid flow therein, means forming a chamber adapted to confine a compressible fluid isolated from fluid in said passageway, a member mounted for limited movement within said chamber and having a surface outside said chamber exposed to the pressure of fluid in said passageway, yieldable means normally interconnecting said movable valve means and member, and means including said yieldable means for normally holding said valve means in an initial and substantially fixed position with respect to said passageway and said member in an initial and substantially fixed position within said chamber, said yieldable means being adapted to be overcome upon movement of said member from its initial position due to the force applied thereto by the pressure of fluid in said passageway reaching a predetermined value with respect to any force exerted thereon by the pressure of fluid within said chamber, whereby said valve means is then no longer held in its initial position with respect to said passageway.

8. In a fluid flow control device, the combination of means forming a passageway for fluid under pressure, a valve member mounted for movement from an initial position within said passageway for controlling the flow of fluid therethrough, means forming a chamber within said device isolated from fluid in said passageway, a piston-like member mounted for limited movement within said chamber from an initial position therein and having a surface outside said chamber exposed to the pressure of fluid in said passageway, a yieldable pin normally interconnecting said valve member and said piston-like member, abutment means between said passageway and chamber, and means including said yieldable pin and abutment means for normally holding said members substantially fixed in their respective initial positions, said yieldable pin being adapted to part and thereby separate said members upon the pressure of fluid in said passageway applying sufficient force to said piston-like member to change the position thereof within said chamber, whereby said valve member is then no longer held in its initial position.

9. The invention as claimed in claim 8, including means for at least partially shielding the surface of said piston-like member exposed outside said chamber from sudden forces due to sudden changes of the pressure of fluid in said passageway.

10. The invention as claimed in claim 8, including means for normally urging said valve member in a direction away from its initial position within said passageway whereby the flow of fluid therein changes automatically after said yieldable pin is parted and said members are separated.

11. In a fluid flow control device, the combination of means forming a passageway for fluid under pressure, an upwardly closing valve member mounted for movement within said passageway to change the flow of fluid therein, means below said valve member and remote from said passageway forming a chamber adapted to confine a compressible fluid, a piston-like member mounted for downward movement within said chamber to compress fluid confined therein and having an upper surface exposed to the pressure of fluid in said passageway, yieldable means normally interconnecting said members, abutment means between said passageway and chamber for limiting downward movement of said valve member and upward movement of said piston-like member, whereby said valve member is normally held substantially fixed in its downward position and said piston-like member is normally held substantially fixed in its upward position, said yieldable means being adapted to be overcome upon the force applied to the upper surface of said piston-like member due to the pressure of fluid in said passageway becoming sufficient to move said piston-like member to a downward position within said chamber, whereby said valve member may then be moved upwardly to its closed position.

12. The invention as claimed in claim 11, including means for normally urging said valve means upwardly toward its closed position.

13. The invention as claimed in claim 11, wherein said yieldable means is selected to be overcome upon the force applied by fluid pressure in said passageway to the upper surface of said piston-like member reaching a predetermined value with respect to the force exerted thereon by fluid pressure within said chamber.

14. A fluid flow control device comprising a case having inlet and outlet openings and a passageway for conducting fluid under pressure between said openings, means within said case and between said inlet and outlet openings forming upper and lower valve seating surfaces surrounding said passageway, a downwardly closing valve member normally engaging said upper seating surface and adapted to move upwardly therefrom in response to force applied by the pressure of fluid in said passageway, an upwardly closing valve member mounted within said case below said lower seating surface and adapted to move upwardly into engagement therewith, means for normally urging said upwardly closing valve member toward said lower seating surface, means within said case below said upwardly closing valve member forming a chamber isolated from said passageway and adapted to confine a compressible fluid, a piston-like member mounted for downward movement within said chamber and having an upper surface exposed to the pressure of fluid in said passageway, abutment means between said passageway and chamber for limiting downward movement of said upwardly closing valve member and upward movement of said piston-like member, and a yieldable pin secured at its upper end to said upwardly closing valve member and at its lower end to said piston-like member for normally supporting said upwardly closing valve member in an open position and said piston-like member in its upward position within said chamber, said yieldable pin being adapted to part and thereby permit said upwardly closing valve member to move to its closed position upon the force applied by fluid pressure in said passageway to the upper surface of said piston-like member reaching a predetermined value with respect to any force applied to said piston-like member from within said chamber.

15. A fluid flow control device as claimed in claim

14 including means for supporting said downwardly closing valve member in its open position upon said member being moved upwardly to such position by force applied due to the pressure of fluid in said passageway.

16. A fluid flow control device as claimed in claim 14 including perforated shielding means disposed within said case between said upwardly closing valve member and said piston-like member for at least partially isolating the upper surface of said piston-like member from sudden forces due to sudden changes of the pressure of fluid in said passageway.

17. A fluid flow control device as claimed in claim 14, wherein said piston-like member is disposed within said case below the lowest of said inlet and outlet openings.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,919,709 January 5, 1960

Harry E. Schwegman

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 57, for "spring" read -- string --; column 10, line 45, for "in an initial and substantially fixed posi-" read -- movable with respect to said passageway --; line 53, for "additional" read -- initial --.

Signed and sealed this 5th day of July 1960.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents