May 28, 1968 L. C. KNOX 3,385,372

FLOW CONTROL FLOAT COLLAR

Filed Jan. 11, 1967

Fig. 1.

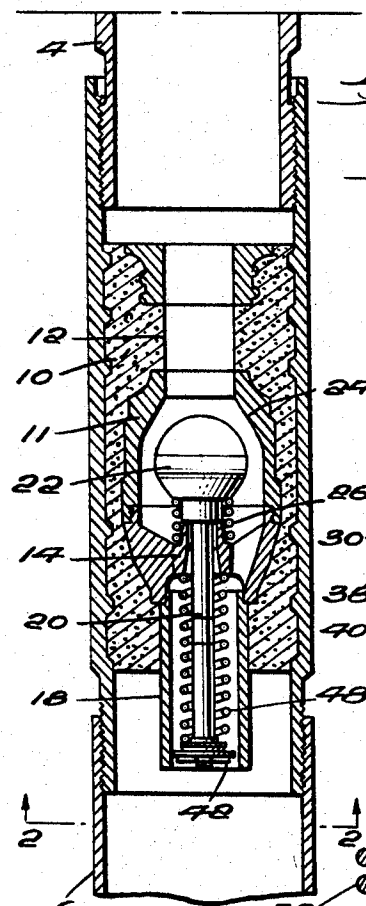


Fig. 3.

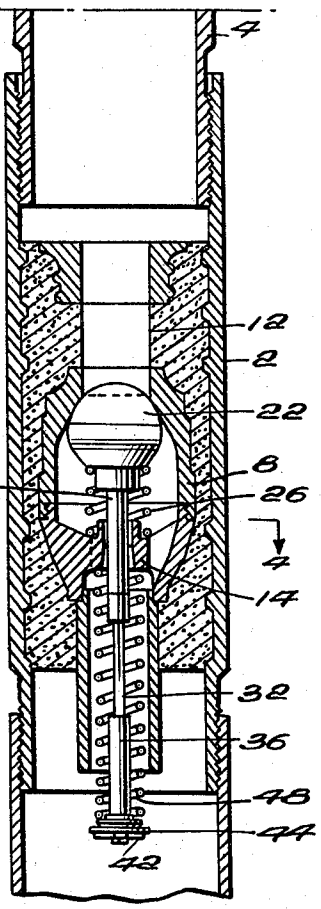


Fig. 5.

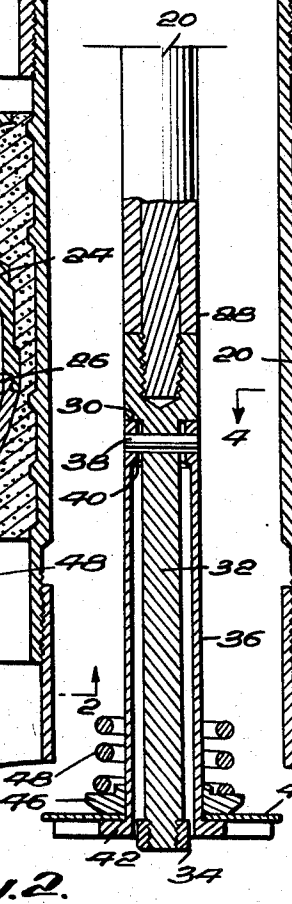


Fig. 2.

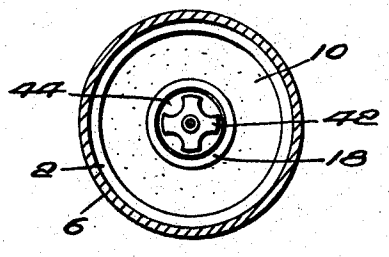
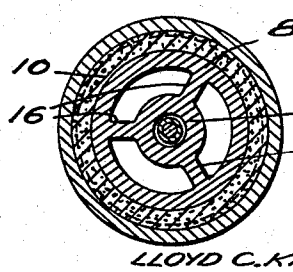


Fig. 4.



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FLOW CONTROL FLOAT COLLAR

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ABSTRACT OF THE DISCLOSURE

A valve for limiting the rate of fill-up as a casing string is lowered in a bore hole. The valve is converted to a back pressure valve by pumping fluid down the casing to break a frangible link within the valve.

Background of the invention

This invention relates to well apparatus, and more particularly to float collars for use in cementing operations.

In running a casing string in a bore hole, it is necessary to provide a valve for controlling the rate of flow of fluid from the bore hole into the casing. If the fluid is not controlled as it enters the bottom of the casing, the fluid pressure in the well may be sufficient to cause the fluid to blow out through the top of the casing. On the other hand, it is necessary to fill the casing gradually as it is lowered to compensate for the head of fluid on the outside of the casing. Various self-fill float valves have been utilized for limiting the rate of flow of fluid into the casing, as it is being lowered into the bore hole.

After the casing has reached the desired depth, it is cemented in place by conducting cement down the casing and out through the bottom of the casing, where it flows upwardly through the annular space between the casing and the bore hole wall. Accordingly, it is necessary to provide a valve which will resist the back pressure of the cement slurry in the annulus. The back pressure valve, however, should prevent flow of the slurry back into the casing, while the self-fill float valve allows a restricted flow into the casing. Since these valves operate under different conditions and during different portions of the casing cementing process, it has been proposed to combine these valves in a single unit and to render the valves operative by various means. It is important that the valves operate effectively and reliably to ensure a successful cementing operation.

Accordingly, it is an object of this invention to provide an improved flow control valve for casing strings.

It is a further object of this invention to provide a combined self-fill float and back pressure valve that operates effectively for controlling the rate of filling of the casing.

Another object of this invention is to provide a combined float and back pressure valve that may be easily tripped with a conventional rig pump at any time while running the casing in the well.

Summary of the invention

These objects are accomplished in accordance with a preferred embodiment of the invention by a collar having a tubular body with a valve guide in the body. A valve seat is formed in the body above the valve guide. A movable valve element is mounted in the valve guide in position to move upwardly into engagement with the valve seat and is spring biased toward the valve seat. A fluid reaction surface is mounted on the valve stem below the valve element. The fluid reaction surface is biased downwardly by a spring that applies a greater axial force to the valve stem than does the spring biasing the valve element. The fluid reaction surface is arranged to exert an upwardly directed force on the valve stem in response to the flow of fluid upwardly through the casing. Thus, the

reaction surface restricts or limits the rate of flow upwardly by displacing the first valve element against the valve seat. There is a frangible link joining the reaction surface to the valve stem and upon pumping fluid down the casing at a predetermined rate, the force of the fluid on the reaction surface breaks the frangible link and causes the reaction surface to be displaced downward and thereby rendered ineffective. After the frangible link is broken, the valve element is released and its spring urges the valve element against the valve seat. Therefore, the collar is converted to a back pressure valve.

Description of the drawings

This preferred embodiment is illustrated in the accompanying drawings in which:

FIG. 1 is a cross sectional view of the valve of this invention, as it is inserted in a casing string, and before the frangible link is broken;

FIG. 2 is a cross sectional view of the valve along the line 2—2 in FIG. 1;

FIG. 3 is a cross sectional view of the valve as in FIG. 1, but after the frangible link has been broken;

FIG. 4 is a cross sectional view of the valve along the line 4—4 in FIG. 3; and

FIG. 5 is an enlarged cross sectional view of the lower portion of the valve stem.

Description of the preferred embodiment

Referring to FIG. 1, the valve includes a tubular body 2 having an internal threaded portion at the upper end for receiving and being threadedly secured to a joint of casing pipe 4. The lower end of the tubular body 2 is also threaded for connection to a lower pipe joint 6. A valve housing 8 is secured in the body 2 by cast concrete 10. A central passage 12 is formed through the concrete 10 and communicates with an opening in the housing 8. The lower portion of the housing 8 includes a valve guide 14. As shown in FIG. 4, the valve guide 14 is supported at the center of the housing 8 by a plurality of radial ribs 16. The space between the ribs 16 permits fluid to pass upwardly and downwardly through the housing 8. A tube 18 is secured to the lower end of the housing 8 and is rigidly held in position by the concrete 10 which surrounds the tube.

A valve stem 20 is mounted for longitudinal movement in the valve stem guide 14 and a valve element 22 is rigidly secured to the upper end of the stem 20. The valve element 22 is preferably formed of a resilient, elastomeric material, which effectively seals against the flow of fluid upwardly when the valve element is in engagement with a valve seat 24 formed in the interior of the housing 8. The valve element is urged toward the valve seat 24 by a helical spring 26 that is compressed between the valve stem guide 14 and the valve element 22.

As shown in FIG. 5, the valve stem 20 may be made up of several components which form a bearing portion 28 which has a cylindrical surface of substantially constant diameter to cooperate with the valve guide 14. At the lower end of the bearing portion 28, a radial shoulder 30 is formed in the stem 20. An axial extension 32 projects downwardly from the shoulder 30 and a nut 34 is threaded on the lower end of the extension 32. A sleeve 36 is mounted in telescoping relation on the extension 32 and the upper end of the sleeve 36 abuts against the shoulder 30. A shear pin 38 extends through aligned holes in the sleeve 36 and in the extension 32 in order to restrict temporarily axial movement of the sleeve away from the shoulder 30. The sleeve 36 also has an internal shoulder 40 which projects inwardly from the interior of the sleeve 36.

The lower end of the sleeve 36 is in the form of an orifice plate 42. As shown in FIG. 2, the orifice plate 42

has a plurality of radial webs which extend outwardly in close proximity to the interior surface of the tube **18**. An orifice washer **44** is mounted over the orifice plate **42**, and is preferably formed of a flexible resilient material, such as rubber. The washer **44** is held in place on the orifice plate **42** by a spring guide **46**. As fluid flows upwardly between the washer **44** and the tube **18**, the peripheral edge of the washer **44** is deflected upwardly, thereby enlarging the flow area between the tube **18** and washer. A coil spring **48** urges the spring guide **46** toward the orifice plate **42**, and thereby clamping the washer **44** against the plate **42**. The upper end of the spring **48** bears against the lower side of the valve guide **14**. Preferably, the spring **48** has a higher spring rate than that of the spring **26**, so that the stem **20** is normally displaced downwardly to the position shown in FIG. 1.

The shear pin **38** is designed to break when fluid is pumped down the casing at a predetermined rate. The spring rates of the springs **26** and **48** are selected in relation to the sizes of the tube **18**, the orifice plate **42** and the washer **44**. The normal resultant force on the stem **20** when there is no fluid flow through the valve body **2**, causes the plate **42** and the valve element **22** to be positioned as shown in FIG. 1. When fluid flows upwardly through the body **2**, at a rate above the maximum rate desired for filling the casing, the force of the fluid on the orifice plate **42** and on the washer **44** exceeds the biasing force of the spring **48** and the valve element **22** is displaced upwardly against the seat **24**.

In operation, the tubular body **2** is made up in a casing string, as shown in FIG. 1. As the casing string is lowered in the hole, fluid from the bore hole enters the body **2** through the openings in the orifice plate **42**. The fluid pressure acting on the lower surface of the washer **44** tends to deflect the peripheral edge of the washer upwardly, thus increasing the effective cross sectional area of the flow path between the tube **18** and the washer **44**. The fluid pressure differential across the orifice plate **42** and the washer **44**, due to this flow of fluid upwardly through the tube **18**, imposes an axial force on the valve stem **20**. In normal operation, the rate of flow of fluid upwardly through tube **18** varies and accordingly the orifice plate **42** tends to move up and down in the tube **18**. However, since the tube **18** has a uniform internal diameter, the force on the stem **20** due to fluid flow is not affected by the longitudinal position of the orifice plate **42** relative to the tube **18**. When the rate of flow is sufficiently high to overcome the force of the spring **48**, the valve element **22** moves upwardly into engagement with the valve seat **24**. Thus, the orifice plate **42** and the washer **44** limit the rate at which fluid flows upwardly through the valve body **2**.

The valve element **22** engages the valve seat **24** when the flow rate is sufficiently high and remains in engagement with the valve seat **24** as long as a substantial pressure differential exists between the interior of the housing **8** and the passage **12** above the valve element **22**. This condition may occur when the casing is lowered in the bore hole too fast. In that event, the valve may be reopened by filling the casing from the surface and equalizing the pressure above and below the valve element **22**.

When the casing string has been lowered to the desired depth, the tool may be converted to a float collar by pumping fluid down the casing and through the body **2**. The pressure of the fluid on the upper side of the washer **44** maintains the washer flat against the orifice plate **42**. Since the peripheral edge of the washer **44** is close to the tube **18** when the washer is flat, the flow of fluid downwardly through the tube **18** is restricted. When a predetermined pressure differential is established across the washer **44**, sufficient axial force is applied to the sleeve **36** to shear the pin **38**. The action of the downwardly flowing fluid on the washer **44** and the force of the spring **48** displace the sleeve **36** downwardly until the internal shoulder **40** engages the upper end of the nut **34**. As soon as the pin **38** has sheared, the upper portion of the stem **20** is released and the spring **26** displaces the valve element **22** upwardly into engagement with the valve seat **24**. The orifice plate **42**, the washer **44**, and the spring **48** no longer control the position of the valve element **22**, and therefore, the valve functions as a back pressure valve, biased toward a closed position by the spring **26**.

The tool of this invention performs effectively as a flow rate control valve while the casing is being lowered in the bore hole, and may be readily converted to a back pressure valve merely by pumping fluid down the casing at a sufficiently great rate to break the shear pin **38**. Since the sleeve **36** is retained on the lower end of the extension **32**, there are no loose pieces which might interfere with the operation of the valve, as there would be if the lower portion of the valve completely separated upon breaking of the frangible link **38**. Also, the arrangement of the tube **18** with respect to the orifice plate **42**, and washer **44** provides an approximately uniform response to upward fluid flow, regardless of the longitudinal position of the orifice plate in the tube **18**.

While this invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

I claim:

1. Valve apparatus for controlling fluid flow through a pipe string in a well comprising:

a tubular body adapted for connection in a pipe string,

means in said tubular body forming a valve guide,

means forming a valve seat in said body, said valve seat being spaced upwardly from said valve guide,

a valve element movable upwardly into engagement with said valve seat, first means for biasing said valve element upwardly relative to said valve guide,

a fluid reaction surface spaced downwardly from said valve guide, said surface being movable relative to said valve guide, second means for biasing said reaction surface downwardly relative to said valve guide, and

frangible link means joining together said valve element and said fluid reaction surface, whereby upward flow of fluid tends to displace said valve element toward said valve seat and downward flow greater than a predetermined rate breaks said link causing said valve element and said surface to be movable independently.

2. Valve apparatus according to claim **1** wherein said first biasing means includes a coil spring between said valve element and said valve guide, and said second biasing means includes a coil spring between said reaction surface and said valve guide.

3. Valve apparatus according to claim **1** wherein said frangible link means includes a valve stem, said valve stem extending through said valve guide, and a breakable connection between said reaction surface and said valve stem.

4. Valve apparatus according to claim **1** wherein said reaction surface includes an orifice plate, and wall means surrounding the periphery of said orifice plate, said wall means and said valve seat means forming a continuous fluid passage through said body.

5. Valve apparatus according to claim **4** wherein said wall means is in the form of a tube, said frangible link means includes a valve stem, said valve stem extending through said valve guide, said tube being coaxial with said valve stem.

6. Valve apparatus according to claim **5** wherein said reaction surface includes a flexible washer overlying said orifice plate, said washer being on the upper side of said orifice plate, the peripheral edge of said washer being free to bend upwardly in response to fluid flow upwardly between said tube and said washer.

7. Valve apparatus according to claim **5** wherein said

second biasing means includes a coil spring mounted coaxially on said valve stem, said spring imposing a biasing force on said orifice plate.

8. Valve apparatus according to claim **7** wherein said valve stem includes a sleeve and an extension arranged in telescoping relation, a frangible pin extending transversely through said sleeve and said extension, said orifice plate being secured on said sleeve, whereby a downward force on said plate breaks said pin and displaces said sleeve downwardly relative to said extension.

9. Valve apparatus according to claim **8** including shoulder means on said extension limiting said downward displacement of said sleeve.

10. Valve apparatus according to claim **8** wherein said orifice plate is displaced out of said tube after said frangible pin is broken.

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