May 1, 1962 E. H. CLARK, JR 3,032,050

APPARATUS FOR AUTOMATICALLY FILLING WELL CONDUITS

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FIG. 1.

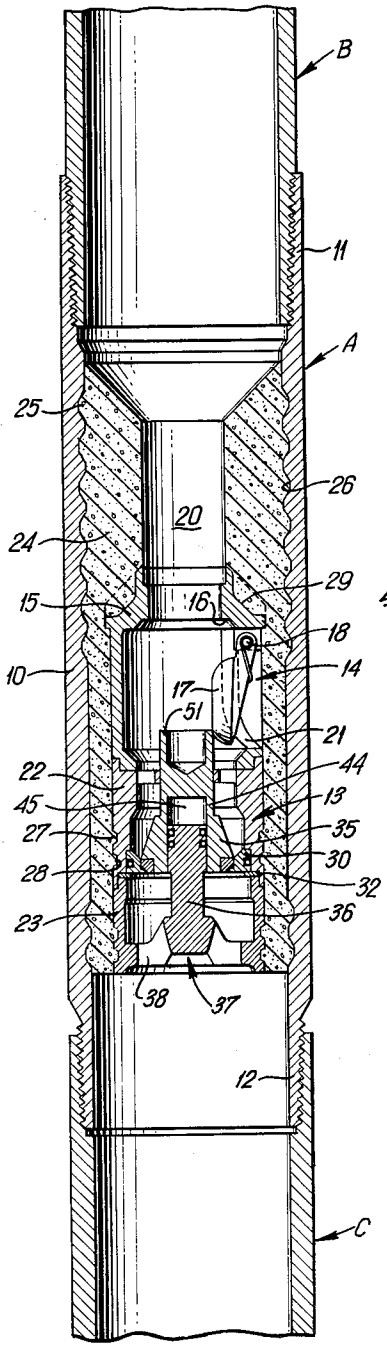

FIG. 2.

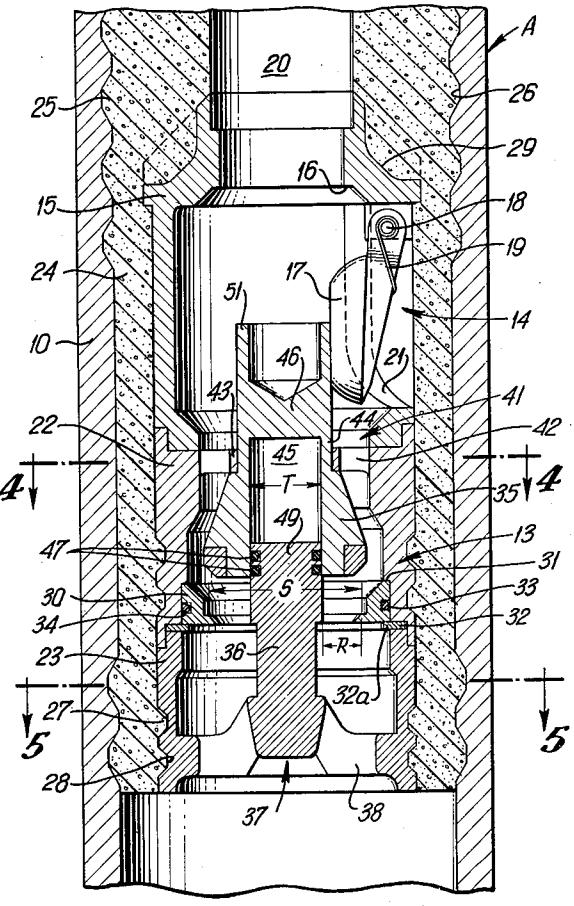

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FIG. 3.

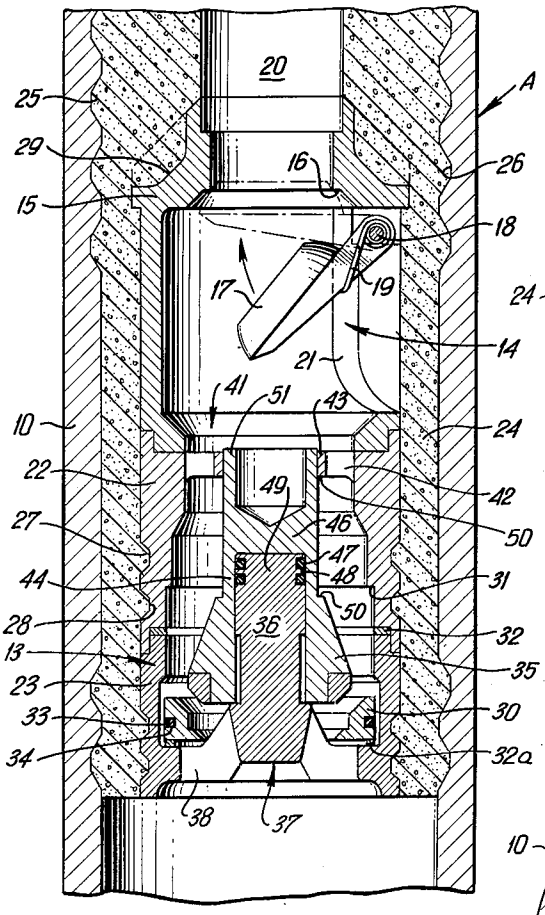


FIG. 4.

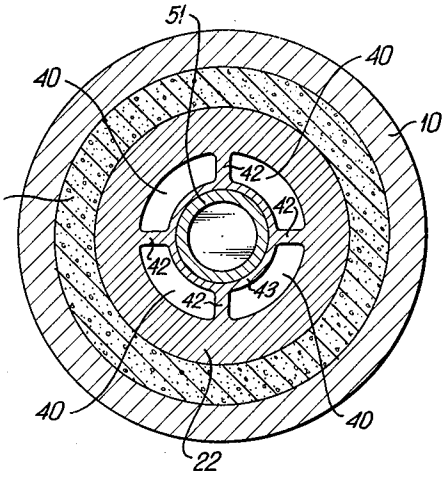
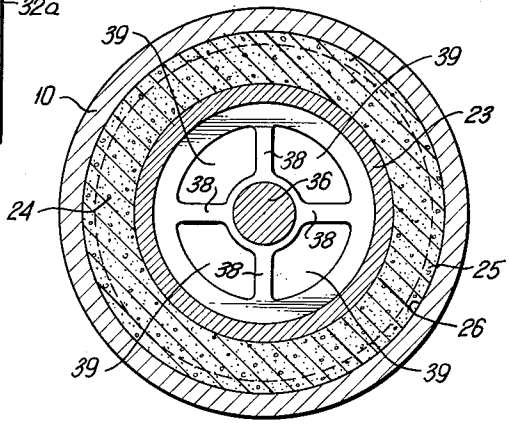


FIG. 5.



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APPARATUS FOR AUTOMATICALLY FILLING WELL CONDUITS

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1 Claim. (Cl. 137—68)

The present invention relates to apparatus for automatically filling a conduit string, such as well casing, as it is being lowered through fluid in a well bore.

An object of the invention is to provide an improved apparatus for automatically filling a conduit string, as it is being lowered in a well bore, to a substantially lesser level than the level of the liquid in the well bore surrounding the conduit string, in which the apparatus can be conditioned to permit fluid to be pumped downwardly through the conduit string and to prevent reverse or upward flow of fluid in the conduit string.

A further object of the invention is to provide apparatus of the type above indicated, which is relatively simple to construct and economical to manufacture, and in which the movable parts can shift easily without danger of sticking or wearing.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through an apparatus embodied in a casing string, in condition for lowering the casing string in a well bore, and with the automatic filling valve in closed position;

FIG. 2 is an enlarged section similar to FIG. 1 disclosing the automatic filling valve in open position;

FIG. 3 is a view similar to FIG. 2 illustrating the valve in condition to permit downward circulation of fluid therethrough, but to prevent reverse or upward passage of fluid therethrough;

FIG. 4 is a cross-section taken along the line 4—4 on FIG. 2;

FIG. 5 is a cross-section taken along the line 5—5 on FIG. 2.

The apparatus is illustrated in the drawings as constituting a casing collar A adapted to connect upper and lower sections B, C of a casing string in spaced relation. The apparatus, however, could be provided at the lower terminus of the casing string, in which event it would be constituted as a casing shoe.

As shown in the drawings, the apparatus includes an outer tubular member 10 having an upper threaded box 11 for threaded attachment to an adjacent upper section B of the casing string, which will extend to the top of the well bore. The tubular member also has a lower threaded pin 12 for threaded attachment to a lower casing section C of the casing or conduit string. It is desired to permit controlled upward flow or filling of fluid in the casing string as it is lowered in the well bore. For that reason, an automatic filling valve 13 is embodied in the tubular member. After the casing string has been lowered to the desired depth in the well bore, the filling valve 13 can be conditioned to allow downward flow of fluid therethrough, at which time an upper back pressure valve 14 is released so that it can close to prevent upward flow of fluid through the well apparatus A and into the casing string B thereabove.

The back pressure valve 14 includes a valve body or upper housing 15 having a valve seat 16 adapted to be engaged by a valve head 17, in the form of a flapper member pivotally mounted on a hinge pin 18 on the upper valve housing or cage. A spring 19 urges the flapper valve head 17 upwardly into engagement with its seat 16. The valve head 17, when in open position, is disposed to one side of the passage 20 through the housing and within an opening 21 in the upper housing wall.

The lower end of the upper valve cage or housing 15 is piloted within an intermediate housing 22, the lower end of which fits over the upper portion of a lower housing member 23. The upper, lower and intermediate housings 15, 22, 23, in effect, constitute a single valve body or cage secured to the outer tubular member 10 by an intervening cementitious plug 24 cast in the tubular member and also in portions of the exterior of the housing structure. The cementitious plug 24 is anchored to the tubular member by circumferential ribs 25 fitting within companion grooves 26 in the tubular member. It is also secured to the housing 15, 22, 23 by circumferential cementitious ribs 27 fitting within companion external grooves 28 in the housing and in recesses 29 in the upper end of the valve body or housing.

The filling valve portion 13 of the apparatus includes an annular valve seat 30 initially secured in the lower portion of the intermediate housing 22 by engaging an upper shoulder 31 on the housing, the valve seat being held against such shoulder and initially confined in the housing by a shear ring 32 clamped between the intermediate and lower housing sections 22, 23 and extending under the valve seat 30. Leakage of fluid around the exterior of the valve seat 30 may be prevented by a suitable side seal ring 33 mounted in a peripheral groove 34 thereof, which seals against an inner wall of the intermediate housing 22.

An axially shiftable valve 35 is movable downwardly into engagement with the seat 30 to prevent passage of fluid therethrough, and upwardly from engagement with the seat to permit upward passage of fluid therethrough. This axially shiftable valve member or head 35 is slidable along a stationary guide or stem 36 integral with and extending upwardly from a spider 37 which is integral with the lower housing member 23. This spider has a plurality of circumferentially spaced generally radial ribs 38 securing the stationary guide 36 to the housing 23, there being ports 39 defined between these ribs through which fluid can pass through the spider 37 in both directions. Fluid can flow upwardly through such ports and around the stationary guide 36, then continuing through the valve seat 30, when the valve head 35 is in its elevated position out of engagement with the seat, and around the valve head 35, continuing upwardly through ports 40 in an upper spider 41 integral with the upper portion of the intermediate housing 22, and then continuing on upwardly through the back pressure valve seat 16 for continued flowing through the central passage 20 in the cementitious plug 24 and into the casing string B thereabove. The ports 40 through the upper spider 41 are defined by circumferentially spaced generally radial ribs 42 integral with the housing 22 and also with a spider hub 43, through which the upper portion 44 of the axially slidable valve head 35 extends. The spider hub 43 functions as a bearing or guide for the valve head 35 in conjunction with the stationary guide 36 extending upwardly from the lower spider 37.

The stationary guide or stem 36 extends into a central cylindrical bore 45 in the valve head 35 projecting upwardly from its lower end and terminating in an imperforate end wall 46. Fluid is prevented from entering the cylindrical bore 45 by one or more seal rings 47, such as rubber or rubber-like O rings, in grooves 48 in the

upper piston portion 49 of the stationary guide 36, which slidably and sealing engage the cylindrical wall of the bore, which initially will contain air at substantially atmospheric pressure. The axially movable valve 35 can slide downwardly along the stationary stem 36 into engagement with the seat 30 to prevent passage of fluid therethrough, its upward movement away from the seat being determined by engagement of a stop shoulder 50 on the head with the upper spider hub 43. During the upward and downward movement of the valve head 35 into and from engagement with the seat 30, a retainer portion or extension 51 extending upwardly from its end wall 46 remains in engagement with the flapper valve head 17 to hold it in its pendant position out of engagement with the back pressure valve seat 16.

The apparatus A is incorporated in the casing string with the parts in the position illustrated in FIG. 1, in which the retainer portion 51 of the lower valve head 35 engages the flapper valve head 17 and prevents it from engaging its seat 16. As the casing string is lowered through the fluid in the well bore, such fluid will flow into the casing string at a region below the apparatus A, this fluid flowing through the lower ports 39 and acting upon the lower area R of the valve head 35, which is the area between the wall of the cylindrical bore 45 and the sealing diameter of the valve head 35 against the companion valve seat 30. Any fluid within the casing string B above the apparatus A will be acting in a downward direction over the valve head 35 across the full area S of the latter corresponding to the sealing diameter of the valve head 35 against the companion valve seat 30. Thus, the upwardly facing area S of the valve head, over which fluid in the conduit string above the apparatus is acting, is greater than the area R, over which fluid below the valve head is acting, by the area T of the cylindrical bore 45. The fluid pressure in the apparatus below the valve head cannot act on the valve head 35 over the area of the cylindrical bore, since fluid is prevented from entering such bore.

As the casing string is lowered through fluid in the well bore, the hydrostatic head of fluid externally of the casing string will act in an upward direction over the head 35 and shift it upwardly away from the valve seat 30 to the extent determined by engagement of its shoulder 50 with the spider hub 43. The fluid will flow through the ports 40 in the upper spider 41, and through the upper passage 20 of the apparatus into the casing string B thereabove. The fluid in the casing string B above the apparatus A is acting in a downward direction on the valve head 35, and when it reaches a predetermined level it will force the valve head 35 downwardly in the spider hub 43 and along the stationary stem 36 back into engagement with its companion valve seat 30, thereby precluding further upward flow of fluid through the valve seat 30.

The fluid level in the casing string B above the apparatus A will always be maintained at a lower level than the fluid in the well bore around the casing string. Thus, the maximum level that the fluid in the casing string can reach as a result of automatically flowing upwardly through the filling valve 13 will bear the same ratio to the fluid level surrounding the casing string as the area R of the valve head (between the cylindrical bore 45 and the sealing point with the valve seat 35) bears to the area S of the valve head 35 across its full sealing diameter with the valve seat 30. For example, if this last-mentioned area is ten percent greater than the first-mentioned area, then the fluid level in the casing string B will rise to a height that is ten percent less than the fluid level in the well bore externally of the casing string.

As lowering of the casing string continues, the valve head 35 will again be shifted by the differential pressure, or difference in hydrostatic heads of fluid, between its opened and closed positions to permit the casing string to fill automatically with the well bore fluid up to a predetermined height. When such predetermined height is reached, the valve head 35 automatically shifts down into engagement with the seat 30 or to a closed position.

After a casing string has been lowered to a desired depth in the well bore, downward circulation of fluid in the casing string is to be accomplished. The casing string B is first filled with fluid up to the top of the hole and pressure imposed thereon. Such pressure will act in a downward direction over the entire cross-sectional area S of the valve head 35 and also over the valve seat 30 itself. In effect, the valve head 35 and seat 30 function as a single member, the downward pressure being transmitted therethrough to the shear ring 32. When the pressure imposed exceeds the shear strength of the ring, its inner portion 32*a* is sheared away from its outer portion, and the valve head 35 and seat 30 shifted downwardly within the housing 15, 22, 23. The valve head can only move downwardly along the stem 36 to the limit of engagement of its end wall 46 with the upper end of the piston or stationary guide 49. The valve seat 30, however, can move downwardly to a further extent into engagement with the spider 37 of the lower housing 23, there then remaining an annular space 52 (FIG. 3) between the valve head 35 and the seat 30 through which fluid can pass downwardly, for continued downward flow through the spider ports 39 and into the casing string C therebelow.

The retainer portion 51 of the valve member 35 is of such length that it will remain in engagement with the flapper valve head 17, to prevent its upward shifting into engagement with its seat 16, throughout the length of travel of the slidable valve head member 35 from a position of engagement with the upper spider hub 43 to a position of engagement with the valve seat 30 when the shear ring 32 is intact.

However, following disruption of the shear ring 32 and downward shifting of the slidable valve head 35 to bring its end wall 46 into engagement with the upper end of the stationary guide 36, 49, the retainer portion 51 moves downwardly to a sufficient extent out of engagement with the flapper valve head 17, which will then permit the latter to swing upwardly into engagement with its companion seat 16, the parts then being in the position illustrated in FIG. 3. Fluid can now be circulated down through the apparatus, displacing the flapper valve head 17 to one side and continuing on down through the filling apparatus 13 between the valve head 35 and its companion seat 30 into the casing string C therebelow, then discharging from the casing string into the surrounding annulus. If desired, cement slurry, or the like, can also be pumped down through the casing string and through the apparatus for discharge from the casing string at a point below the apparatus. Upon relieving the pressure in the casing string, the flapper valve head 17 will swing upwardly into engagement with its companion seat 16 to prevent return flow of fluid into the casing string. Any cement slurry that has been displaced from the casing is thereby precluded from re-entering the casing B by the upward closing of the flapper valve against its companion seat.

The apparatus illustrated contains relatively few parts and substantially all of such parts can be made of readily drillable material. After the cement deposited behind the casing string has set and hardened, the entire inner portion of the apparatus A can be drilled out by use of a suitable drill bit, including the cementitious plug 24, the housing structure 15, 22, 23 and the portion of the valve device within the housing structure, leaving an unobstructed bore through the apparatus A having an internal diameter therein substantially no less than the internal diameter through the casing string B, C itself.

It is found that the automatic fill valve portion of the apparatus moves freely in shifting between open and

closed positions. The spider hub **43** and the stationary stem **36** provide spaced guides insuring appropriate straight line movement of the valve head **35** into and from engagement with the companion valve seat **30**. The seal rings **47** that prevent passage of fluid into the cylindrical bore **45** in the valve head are small in diameter and will not stick or seize, insuring freedom of passage of the valve head to and from engagement with the companion valve seat, as well as downward shifting of the valve head **35** to its fullest extent along the stationary guide **36**, following disruption of the shear ring **32**. Accordingly, definite assurance is had that the flapper valve head **17** will be freed for upward swinging into engagement with its companion valve seat **16**.

The inventor claim:

In apparatus of the character described: a tubular member adapted to be secured to a conduit section to be disposed in a well bore; a valve housing secured in said tubular member; a valve seat in said housing; a lower stationary guide member within and secured to said housing against movement in both longitudinal directions; an upper stationary guide member secured to said housing against movement in both longitudinal directions; a valve member telescoped over said lower guide member in leakproof relation with respect thereto to provide a confined space closed by said valve member and lower guide member and into which well bore fluid cannot enter; said valve member having a portion slidable along said upper guide member; said valve member being slidable downwardly along said guide members into engagement with said seat; a shear ring engaging said valve seat and housing releasably securing said valve seat to said housing against downward movement and in a position to be engaged by said valve member, shearing of said ring enabling said seat to move downwardly in said housing away from such position of engagement by said valve member; said upper guide member having stop means engageable by said valve member to limit upward movement of said valve member from said seat; back pressure valve means in said tubular member adapted to close to prevent upward flow of fluid in said tubular member; means on said valve member engageable with said back pressure valve means to prevent said back pressure valve means from closing; said preventing means moving downwardly with said valve member after disruption of said ring to a position permitting said back pressure valve means to close.

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