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APPARATUS FOR CONTROLLABLY FILLING WELL CASING

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Fig. 1.

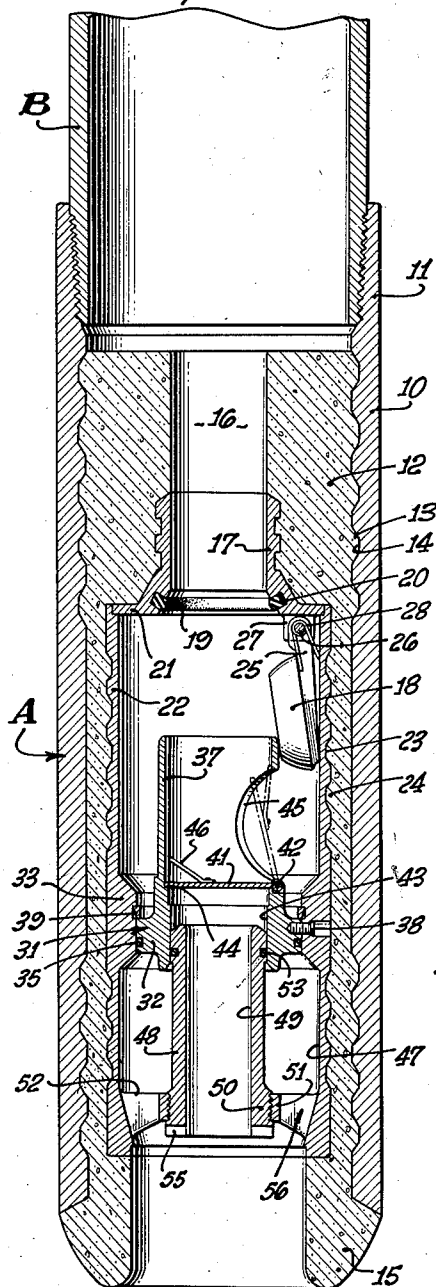
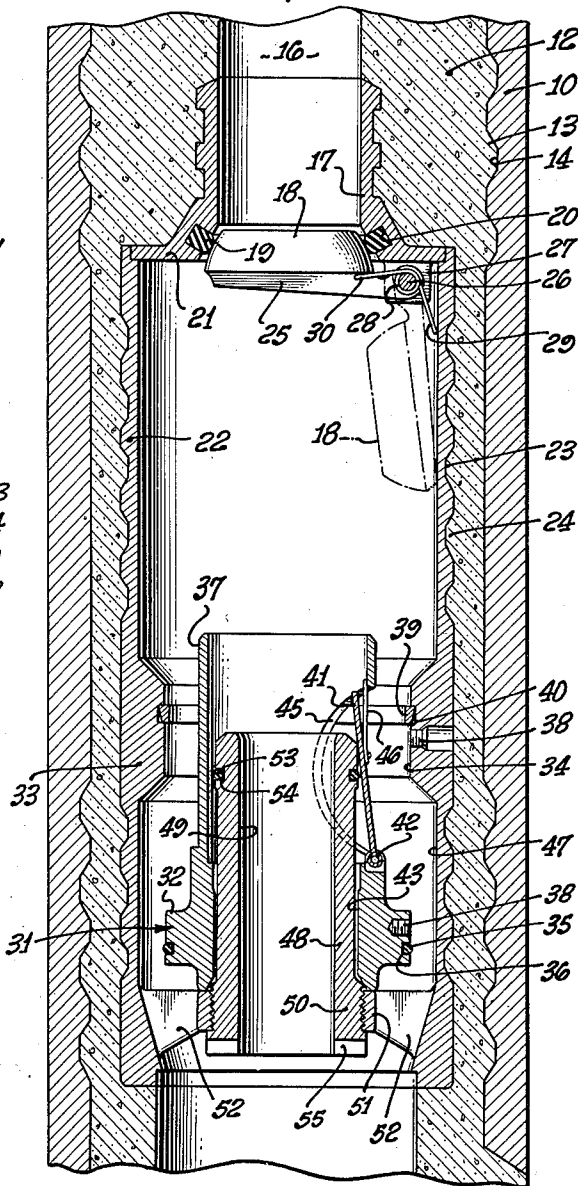


Fig. 2.



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APPARATUS FOR CONTROLLABLY FILLING
WELL CASING

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The present invention relates to subsurface well apparatus, and more particularly to apparatus for controlling the flow of well bore fluid into a conduit string as the latter is lowered in the well bore.

A conduit string, such as a string of casing or drill pipe, is to be allowed to fill automatically with the well bore fluid as it is lowered in the well bore. However, unless the flow of the fluid into the conduit string is controlled, it tends to overflow at the top of the hole and drench the surface equipment and personnel, rendering the site unsafe and otherwise undesirable for working. If the conduit string embodies an upwardly closing back pressure valve, such valve will prevent the well bore fluid from flowing into the string for the purpose of filling it, unless the valve is prevented initially from closing.

An object of the present invention is to provide improved apparatus for controlling the flow of the well bore fluid into the conduit string as the latter is lowered into the well bore, the apparatus preventing the conduit string from overflowing at the top of the hole.

Another object of the invention is to provide apparatus that retards the upward flow of fluid into a conduit string as it is lowered in the well bore, but which still permits relatively unimpeded downward flow of the fluid in the conduit string.

A further object of the invention is to provide apparatus which may be incorporated in the conduit string and embodying a back pressure valve to prevent upward flow of fluid in the conduit string, in which the back pressure valve is held in open position during lowering of the conduit string in the well bore, the rate of fluid flow into the conduit string being retarded by causing the fluid to flow through an orifice, or similar restricted passage, the back pressure valve being freed, whenever desired, to allow its movement to closed position. In a more limited aspect of the invention, when the back pressure valve is released, downward flow of fluid through the apparatus may be permitted in a comparatively unrestricted manner. Release of the back pressure valve is preferably effected hydraulically in a positive manner.

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 embodying the invention, with the parts disclosed in the position they occupy when the apparatus is being lowered through a well bore;

Figure 2 is a view similar to Fig. 1, on an enlarged scale, with the parts of the apparatus occupying another operative position.

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The apparatus A disclosed in the drawings is designed to form part of a conduit string B to be run in a well bore. As specifically illustrated, it is constituted as a casing shoe forming the lower terminals of the casing string, but it could be incorporated in another type of conduit string to be lowered in the well bore, such as a string of drill pipe. In addition, it can be incorporated in the conduit string at an intermediate point along its length, in which event it would be considered to be a collar.

The apparatus includes an outer tubular member 10 having an upper threaded box 11 for threaded attachment to the lower end of an adjacent casing section B. The tubular member has a cementitious plug 12 cast therein, ribs 13 in the plug being formed during the casting operation by external grooves 14 in the tubular member, for the purpose of inseparably uniting the parts against relative movement. The lower end 15 of the cementitious plug is rounded to provide a guiding nose for facilitating passage of the casing string through obstructions and restrictions in the well bore, as it is being lowered there-within.

The cementitious plug has a central passage 16 therethrough. This passage is surrounded by a valve seat 17 cast within the plug 12 and adapted to be engaged by a back pressure valve element 18, which may be in the form of a flapper valve head. In order to prevent leakage between the valve head 18 and the seat 17, a seal ring 19 is disposed within a groove 20 in the valve seat.

The valve seat 17 has a lower flange 21 piloted within the upper end of a housing 22 disposed centrally within the cementitious plug 12. This housing is also inseparably united to the plug 12 by virtue of the longitudinally spaced, circumferential grooves 23 in the housing that receive plug ribs 24, formed during the casting of the cementitious plug in the apparatus. This housing 22 contains the back pressure valve member 18, as well as the parts of the apparatus for preventing the back pressure valve member initially from moving upwardly into engagement with its companion seat 17. In addition, the housing has incorporated therein a device for controlling the flow of fluid upwardly through the casing shoe A and into the casing string B.

As shown in the drawing, the flapper valve head 18 has a laterally extending arm 25 mounted on a pivot or hinge pin 26 secured to a lug 27 depending from the valve seat 17. The head 18 is urged in an upward direction toward engagement with its companion seat 17 by a spring 28 coiled around the hinge pin 26 and having one arm 29 engaging the housing 22 and another arm 30 engaging the valve head 18. The valve head can be moved to the fully open position disclosed in Fig. 1 against the force of this spring 28.

As stated above, the valve head 18 is initially prevented from engaging its seat 17. This is accomplished by providing a retainer and barrier member 31 in the housing having a lower portion 32 fitting snugly within an inwardly extending intermediate portion 33 of the housing. Leakage of fluid between the retainer member and the cylindrical wall 34 of the housing portion 33 may be precluded by a suitable side seal ring 35 disposed within a peripheral ring groove 36 in the retainer member 32 and engaging the cylindrical housing wall.

The retainer member 31 may include an upwardly projecting extension 37, preferably in the form of a tubular sleeve, which is adapted to engage the flapper valve head member 18, for the purpose of holding it in fully open position away from its companion valve seat 17, and preferably out of the path of flow of fluid through the shoe passage 16. The tubular sleeve 37, and the retainer member 31 itself, are initially disposed in a position to hold the flapper valve member 18 to one side of its seat 17

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by one or more frangible devices in the form of shear pins 38 extending radially between the housing 22 and the retainer member. The tubular retainer member 31 is properly located within the housing 22 by having its lower portion 32 engage a stop ring 39, which may be in the form of a split, expansible ring disposed within a companion internal groove 40 in the housing portion 33. This ring 39 will prevent upward movement of the retainer member 31 within the housing 22, but it will not preclude downward movement of the retainer member when the frangible pins 38 are disrupted, in the manner described hereinbelow.

Fluid may flow in an upward direction through the retaining member 31 and its tubular extension 37, for continued upward flowing through the housing 22 and valve seat 17, and on into the casing section B above the shoe A. However, the flow of fluid in a downward direction is precluded by a flapper valve, that may be in the form of a disc 41 pivotally mounted on a hinge pin 42 secured to the retainer member 31. This flapper valve 41 is adapted to extend across the central passage 43 through the retainer member 31, moving downwardly into engagement with a companion seat 44. The fluid flowing in an upward direction can shift the flapper valve 41 in an upward direction, as to the dotted line position disclosed in Fig. 1, to allow fluid to flow upwardly through the apparatus. The extent of movement of the flapper valve 41 is enhanced by providing a window or opening 45 in the side wall of the tubular sleeve member 37. The flapper valve, however, is prevented from pivoting to too great an extent about its hinge pin 42 by suitably securing a leaf spring 46 on the flapper valve, the free end of which will engage the upper portion of the tubular sleeve extension 37, and cause the flapper valve 41 to move downwardly by gravity to closed position against its seat 44, in the event that downward flow of fluid through the apparatus tends to occur.

When it is desired to free the upper flapper valve member 18 to permit its upward movement into engagement with its seat 17, the fluid in the casing string B above the apparatus A may be subjected to pressure, which will insure the downward closing of the lower flapper valve 41 and subject the frangible pin or pins 38 to a shearing force. When the fluid pressure exceeds the shear value of the pins 38, the latter are disrupted, the entire retaining member 31 then being shifted downwardly into an enlarged bore portion 47 of the housing 22, and into a position in which the tubular extension 37 moves off the flapper valve 18, which action allows the flapper valve 18 to move upwardly into engagement with its companion seat 17. Since the retainer member 31 has been shifted downwardly into the enlarged bore 47 (Fig. 2), fluid can then pass downwardly of the casing string B, to shift the flapper valve 18 to open position and then flow around the retainer member 31 and out of the casing shoe A.

In the form of apparatus disclosed in the drawing, it is desired to restrict or retard the passage of fluid upwardly in the casing string B as the latter is being lowered through the drilling mud or other fluid in the well bore. For that reason, a tubular member 48 having an orifice or restricted passage 49 therethrough is secured in the housing 22. As disclosed, the lower portion 50 of the tubular member 48 is threaded within a central hub portion 51 secured to the outer wall of the housing 22 by a plurality of circumferentially spaced ribs 52. The tubular orifice member 48 extends upwardly to a substantial extent from this hub 51 and has its upper portion piloted within the retainer member 31. Leakage between the cylindrical wall 43 of the retainer member and the upper portion of the orifice member may be prevented by a suitable sealing ring 53 disposed in a ring groove 54 in the orifice member and engaging the cylindrical wall 43 of the retainer member 31.

The orifice member may be inserted readily within the housing 22 and the retainer member 31, and removed therefrom, by placing a suitable tool (not shown) in radial

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slots 55 provided in the lower portion of the orifice member 48.

The upper end of the orifice member 48, when it is threaded completely within the hub 51, is disposed a substantial distance below the downwardly closing disc valve member 41, to permit the latter to close and allow the retainer member 31 to shift downwardly to a sufficient extent, for the purpose of completely shearing the frangible pins 38 before the disc valve member 41 engages the upper end of the orifice member 48.

The parts are assembled in the manner disclosed in Fig. 1, and the casing shoe A then secured to an adjacent casing section B thereabove. The casing string is then lowered through the fluid in the well bore, the fluid passing upwardly through the orifice 48, which may have a predetermined internal diameter to restrict the rate at which the well bore fluid can enter the casing. This fluid will, of course, shift the disc valve member 41 upwardly to open position, the tubular sleeve extension 37 preventing the upper flapper valve member 18 from engaging its companion seat 17. The tubular sleeve extension 37 will hold the flapper valve member 18 substantially completely out of the path of fluid flow in an upward direction, whereupon the fluid can continue upwardly through the upper valve seat 17, and on through the shoe passage 16 into the tubular section B thereabove.

When the casing string B has reached the desired depth in the well bore, it will be substantially completely filled with fluid. Pressure can then be applied to this fluid, which will act over the entire cross-sectional area of the retainer member 31 and the downwardly closing flapper valve 41, for the purpose of shearing the pins 38 and shifting the retainer member 31 downwardly until its lower end engages the hub 51 (Fig. 2). After moving partially downward, the flapper valve member 41 will engage the upper end of the orifice member 48, which will swing it about its pivot pin 42 to an open position, such as disclosed in Fig. 2, the retainer member 31 being then disposed within the enlarged bore 47 in the housing 22. Accordingly, the flapper valve member 41 is then precluded from engaging its companion seat 44, so that fluid pumped downwardly through the casing string can then flow through the orifice member 48, as well as around the retainer member 31, and out through the passages or spaces 56 between the ribs 52. Of course, during the downward movement of the retainer member 31, the flapper valve member 18 has been freed and is then capable of engaging its companion valve seat 17, in the event reverse flow of fluid through the shoe tends to occur.

For the purpose of insuring that the hydraulic movement of the retainer member 31 downwardly along the housing 22 and the orifice member 48 will effect upward swinging of the flapper valve disc 41 to open position, it is preferred that the annular area over which the fluid under pressure can act, defined between the cylindrical wall 34 of the housing and the periphery of the valve seat 44, shall be greater than the area of the flapper valve 41 itself. Accordingly, when the shear pins 38 have been disrupted, and the retainer member 31 moved downwardly to engage the flapper valve disc 41 with the upper end of the orifice member 48, there is a greater force acting on the above annular area of the retainer member 31 than upon the flapper valve 41, insuring the downward movement of the retainer member 31 along the orifice member 48 and housing 22, and the shifting of the flapper valve 41 to open position by the upper portion of the orifice member 48, in order to fully open the orifice passage 49 to the downward flow of fluid through the apparatus.

With the apparatus disclosed, assurance can be had that the tubular string B will fill with the drilling mud in the well bore, without the tubular string overflowing at the top of the hole. To prevent such overflowing from occurring, the cross-sectional area of the orifice passage 49 can be selected so that substantial retarding of the rate

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of upward flow of fluid through the apparatus is obtained. The cross-section selected will depend upon the characteristics of the drilling mud, or other fluids in the well bore. Because of the design of the apparatus, the orifice can be changed at the well location by unthreading one size orifice 48 and threading another size orifice in its place. The only difference between orifices will be in the internal diameters of their passages 49.

It is, accordingly, apparent that apparatus has been provided for controlling the upward flow of fluid through a tubular string B as it is lowered through the fluid in the well bore. The control of upward flow of fluid can occur at a restricted rate, but downward flow of fluid can still take place in a comparatively unrestrained manner, because of the ability of the fluid to by-pass around the retainer member 31, after it has been disposed within the enlarged housing bore 47. In addition, removal of the downwardly seating flapper valve member 41 from its position of engagement with its seat 44 also makes the orifice passage 49 available for the downward passage of fluid. The presence of the downwardly closing flapper valve 41 insures a positive hydraulic release of the frangible pins 38, since it prevents any fluid from by-passing the retainer member 31 until the pins have been disrupted and the retainer member shifted to its lower position. Moreover, the flapper valve member 13 is held in fully open position away from its seat 17 by the tubular sleeve 37, which minimizes cutting by the fluid on the flapper member 18 as it flows upwardly thereby. The fluid passes substantially directly from the sleeve extension 37 into the valve seat 17 above the flapper valve member 18. Accordingly, when the flapper valve member 18 is released, it is in proper condition for effecting a leakproof seal against its companion seat 17 and seal ring 19.

The inventors claim:

1. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back pressure valve means to prevent closing of said back pressure valve means; means for closing said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said retainer member to release said securing means and shift said retainer member to a position allowing said back pressure valve means to close; and means in said tubular member engaging said closing means to shift said closing means to passage opening position after release of said securing means.

2. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back pressure valve means to prevent closing of said back pressure valve means; a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member to release said releasable means and shift said retainer member to a position allowing said back pressure valve means to close; and means in said tubular member engaging said valve member to shift said valve member to passage opening position after release of said securing means.

3. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back

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pressure valve means to prevent closing of said back pressure valve means; and a valve member pivotally mounted on said retainer member and movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member and release said securing means and shift said retainer member to a position allowing said back pressure valve means to close.

4. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage extending therethrough from its upper to its lower end that is entirely coaxial of said tubular member; means releasably securing said retainer member in said constricted bore and in position to engage said back pressure valve means to prevent closing of said back pressure valve means; and means for closing said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said retainer member to release said securing means and shift said retainer member into said enlarged bore to allow said back pressure valve means to close and also to permit fluid to flow around said retainer member.

5. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage extending therethrough from its upper to its lower end that is entirely coaxial of said tubular member; means releasably securing said retainer member in said constricted bore and in position to engage said back pressure valve means to prevent closing of said back pressure valve means; and a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member and release said securing means and shift said retainer member into said enlarged bore to allow said back pressure valve means to close and also to permit fluid to flow around said retainer member.

6. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; frangible means releasably securing said retainer member in said constricted bore and in position to engage said back pressure valve means to prevent closing of said back pressure valve means; and a valve member pivotally mounted on said retainer member movable downwardly into engagement with said retainer member to close said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said retainer member to disrupt said frangible means and shift said retainer member into said enlarged bore to allow said back pressure valve means to close and also to permit fluid to flow around said retainer member.

7. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough, said retainer member including a tubular portion; means releasably securing said retainer member in said constricted bore with its tubular portion engaging said back pressure valve means to prevent closing of said back pressure

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valve means; and a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member to release said releasable securing means and shift said retainer member into said enlarged bore to allow the back pressure valve means to close and also to permit fluid to flow around said retainer member.

8. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back pressure valve means to prevent closing of said back pressure valve means; means for closing said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said retainer member to release said securing means and shift said retainer member to a position allowing said back pressure valve means to close; and means providing a flow restricting passage in said tubular member extending into said retainer member passage.

9. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back pressure valve means to prevent closing of said back pressure valve means; a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member and shift said retainer member to a position allowing said back pressure valve means to close; and means providing a flow restricting passage in said tubular member extending into said retainer member passage.

10. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said tubular member in position to engage said back pressure valve means to prevent closing of said back pressure valve means; a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member to release said securing means and to shift said retainer member to a position allowing said back pressure valve member to close; and means providing a flow restricting passage in said tubular member extending into said retainer member passage; the annular cross-sectional area of said retainer member around said valve member being greater than the cross-sectional area of said valve member.

11. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said constricted bore and in position to engage said back pressure valve means to prevent closing of said back pressure valve means; means for closing said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said retainer member to release said securing means and shift said retainer member into said enlarged bore to allow said back pressure valve means to close and also to permit fluid to flow around said

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retainer member; and means in said enlarged bore providing a flow restricting passage extending into said retainer member passage.

12. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; back pressure valve means in said tubular member to prevent upward flow of fluid therethrough; a retainer member having a passage therethrough; means releasably securing said retainer member in said constricted bore and in position to engage said back pressure valve means to prevent closing of said back pressure valve means; a valve member movable downwardly into engagement with said retainer member to close said passage to enable fluid pressure in said tubular member to act downwardly on said retainer member and release said securing means and shift said retainer member into said enlarged bore to allow said back pressure valve means to close and also to permit fluid to flow around said retainer member; and means in said enlarged bore providing a flow restricting passage extending into said retainer member passage.

13. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; a barrier member having a passage therethrough; means releasably securing said barrier member in said tubular member; means for closing said passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said barrier member to release said securing means and shift said barrier member downwardly; and means providing a flow restricting passage in said tubular member extending into said barrier member passage, said last-mentioned means engaging said closing means to shift it to open position when said releasable securing means is released and said barrier member is shifted downwardly.

14. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; a barrier member having a passage therethrough; means releasably securing said barrier member in said tubular member; means providing a flow restricting passage in said tubular member extending into said barrier member passage; and a valve member movable downwardly into engagement with said barrier member to close said barrier member passage to enable fluid pressure in said tubular member to act downwardly on said barrier member and release said releasable securing means and shift said barrier member along said flow restricting passage means to a position in which said flow restricting passage means engages said valve member and shifts it to open position.

15. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore; a barrier member having a passage therethrough; means releasably securing said barrier member in said tubular member; means providing a flow restricting passage in said tubular member extending into said barrier member passage; and a valve member movable downwardly into engagement with said barrier member to close said barrier member passage to enable fluid pressure in said tubular member to act downwardly on said barrier member and release said releasable securing means and shift said barrier member along said flow restricting passage means to a position in which said flow restricting passage means engages said valve member and shifts it to open position; the annular cross-sectional area of said barrier member around said valve member being greater than the cross-sectional area of said valve member.

16. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; a barrier member having a passage therethrough;

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means releasably securing said barrier member in said constricted bore; means providing a flow restricting passage in said tubular member extending into said barrier member passage and disposed in said enlarged bore; and valve means for closing said barrier member passage against downward flow of fluid therethrough to enable fluid pressure in said tubular member above said barrier member to release said releasable securing means and shift said barrier member into said enlarged bore and to cause said flow restricting passage means to engage said valve member and shift it to open position, whereby fluid is permitted to flow downwardly through said flow restricting passage and also around said barrier member.

17. In well apparatus: a tubular member having means thereon for securing said member in a conduit string to be lowered in a well bore, said member having a constricted bore therein and an enlarged bore below said constricted bore; a valve seat in said tubular member; a valve head pivotally carried in said tubular member and movable upwardly into engagement with said valve seat; a retainer member having a passage therethrough; frangible means securing said retainer member in said constricted bore and in position to engage said valve head to prevent said valve head from moving upwardly into engagement with said seat; means providing a flow restricting orifice in said tubular member extending into said

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retainer member passage and depending from said retainer member; and a valve member pivotally mounted on said retainer member movable downwardly into engagement with said retainer member to close said retainer member passage to enable fluid pressure in said tubular member above said retainer member to release said frangible means and shift said retainer member along said flow restricting orifice means into said enlarged bore to release said retainer member from said valve head and to cause said flow restricting orifice means to engage said valve member and shift it to open position, whereby fluid may flow downwardly through said flow restricting orifice and also around said retainer member.

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