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CASING BOTTOM FILL DEVICE

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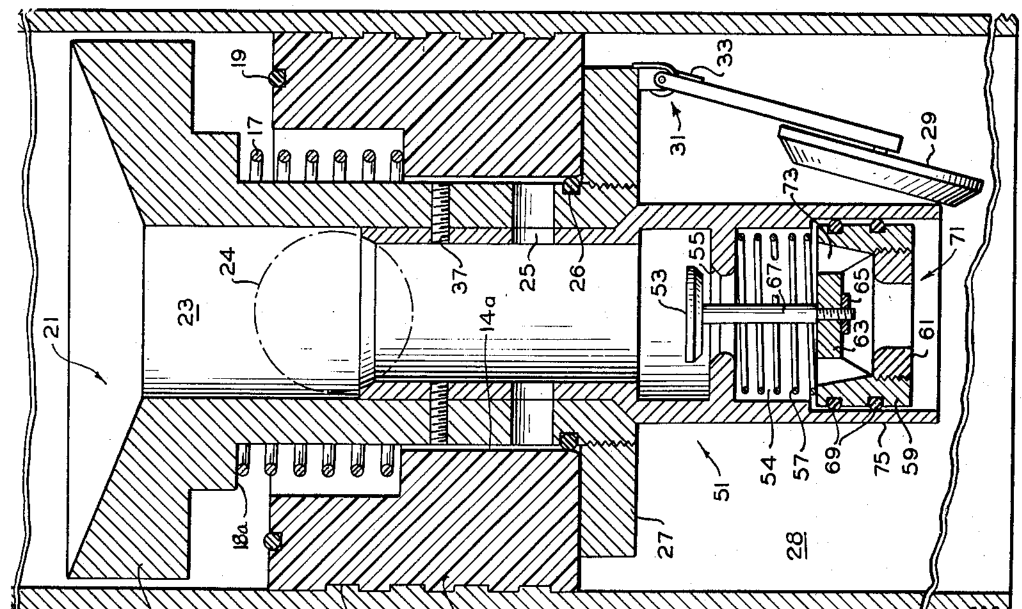

FIG. 2.

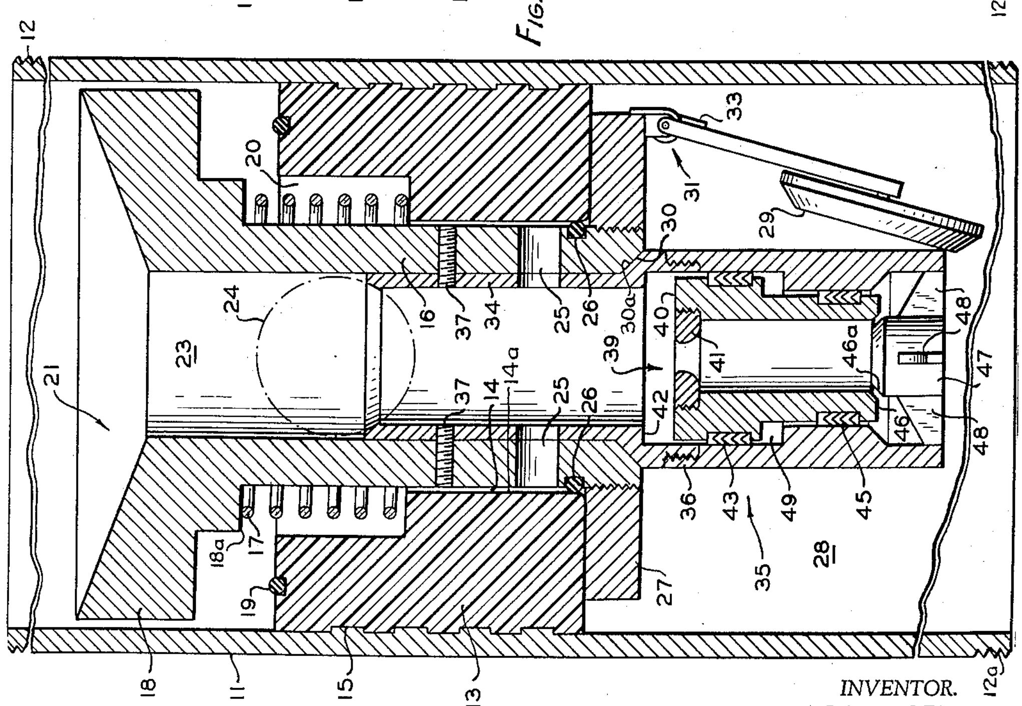

FIG. 1.

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3,013,612

CASING BOTTOM FILL DEVICE

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This invention relates to a casing bottom fill device. In one aspect it relates to a casing bottom fill device coupled with a wash circulation valve and a back pressure valve, and their use for casing deep wells. In another aspect it relates to a casing bottom fill device for use in running casing in deep wells with provision for circulating the hole at any time without loss of the bottom fill feature, and an additional feature converts the device to a back pressure valve for use in cementing operations.

To complete an oil or gas well many operators prefer to install a "float shoe" or a "float collar" near the bottom of the casing being run. Such a shoe or collar contains a check valve which allows downward flow of fluid through the casing but prevents backflow. Although such a device has certain advantages, there are also very serious disadvantages in some fields. One disadvantage in the use of a float valve is that it is necessary to interrupt the casing running operation periodically to fill the casing with drilling fluid from above to prevent collapse of the casing due to the weight of the fluid in the annulus between the casing and the walls of the well because there is no fluid in the casing for pressure balance. The loss of time occasioned by such filling operations, is, in itself, a disadvantage but a more serious disadvantage is the difficulty occasioned with stuck casing which in some areas is likely to occur when the casing running process is interrupted for more than a short interval of time.

Another disadvantage in the use of conventional float valves is the large pressure build-up or pressure surges which occur outside the lower end of the casing while being run due to the drilling fluid being displaced by the casing. This displaced drilling fluid is forced upward through the annulus between the casing and the walls of the well each time the casing is lowered. In many cases this pressure build-up results in a break down of permeable sections of earth formations with ultimate loss of drilling fluid, thus increasing the danger of a blowout. Even if a blowout does not occur, such formations may continue to take fluid after the cementing operations begin and thus may prevent the cement from rising to the desired height outside of the casing.

Another disadvantage of filling the casing from the top is that air is often entrained in the drilling mud.

Some bottom fill devices now on the market have been, and can be, inadvertently and prematurely operated by the pressure surges and waves set up either when the casing is lifted suddenly or when the downward movement of the casing is stopped too quickly. The device of my invention permits casing movement of any magnitude, direction or frequency, purposeful or accidental, at any time or times during the running operation, without actuating a back pressure flapper valve and without overflow of drilling fluid on the drilling platform.

The actuation of my back pressure flapper valve is independent of fluid flow through the device in either direction, that is, fluid can flow upward through the device and can flow downward through the device at any rate without releasing the back pressure flapper valve to a seating position. Many and various attempts have been made to solve the above mentioned problems and to circumvent the above-mentioned disadvantages. Many of the bottom fill device improvements have solved some of the problems but, to my knowledge, none have solved

all of the problems in a manner as simple and as really foolproof as the bottom fill device of this invention.

An object of my invention is to provide a casing bottom fill and check valve assembly for use in deep well casing running and cementing operations.

Yet another object of my invention is to provide such a bottom fill and check valve device which permits fluid circulation at any time.

Another object of my invention is to provide such an apparatus which is simple, inexpensive to construct and simple and certain in operation.

Yet another object of my invention is to provide such an apparatus for use in deep wells wherein the check valve cannot be inadvertently released to its operable position prior to completion of the running of the casing.

Still another object of my invention is to provide a bottom fill device which definitely eliminates overflow of mud from the casing to the drilling platform.

Still other objects and advantages of my invention will be obvious to those skilled in the art upon reading the following specification and drawing which respectively describes and illustrates preferred embodiments of my invention.

In the drawing FIGURE 1 is an elevational view, partly in section, of one of the embodiments of my invention.

FIGURE 2 illustrates an elevational view, partly in section, of another embodiment of my invention.

Among the additional advantages of my invention, it provides for maximum relief of down hole pressure surges, assurance that the casing will not run over during running of the casing, ability to allow for circulation of the hole at any time without losing the benefits of the bottom fill, and ability to serve as a check valve for cementing operations.

Referring now to the drawing and specifically to FIGURE 1, reference numeral 11 illustrates a section of pipe, usually of the same diameter as that of the casing to which it is to be attached. In the drawing is a threaded section 12 on the top end of pipe 11 for fastening to an adjacent section of casing. The embodiments of FIGURE 1 and FIGURE 2 are, if desired, constructed as casing shoes and in that case the shoes are attached to the bottom end of the casing; or they are constructed in the form of collars which join two sections or joints of casing. Threaded section 12*a* is for attaching to a lower joint of pipe in case the device is used as a collar. In case either of the embodiments of FIGURES 1 or 2 are used as collars, more than one joint of casing is, if desired, run into the well prior to the fill and choke collar.

Thus pipe 11, whether it be a casing shoe or a collar, is provided with an annular baffle plug 13 which is rigidly attached to the inner walls of the pipe 11. Plug 13 is, if desired, threaded into pipe 11 or it is cast into the pipe and in this latter case reference numeral 15 refers to grooves and ridges in the plug and pipe for holding the plug immovable with respect to the pipe. In case the plug is threaded into the pipe reference numeral 15 is intended to identify threads. Disposed within opening 14 in plug 13 and extending above and below the plug is an annular valve body 21. This valve body is constructed substantially as illustrated with an annular slidable intermediate portion 16 and an upper enlarged portion 18. Disposed in a recess 20 is a compression spring 17 which is intended to bias the slide valve in an elevated and closed position as illustrated in the drawing. At the bottom of the intermediate portion 16 is disposed a flange 27 which is threaded or otherwise attached thereto. Obviously flange 27 prevents the slide valve from sliding upward and out of the plug 13 under the bias of spring 17 while the upper enlarged portion 18 and shoulder 18*a* against which spring 17 biases, prevents the slide valve from sliding downward and entirely out of plug **13**. An O-ring **26** seals annulus **14***a* between plug **13** and the intermediate portion **16** against leakage of fluid when flange **27** is resting against plug **13**. One or more openings or ports **25** are provided in the intermediate portion **16** of the valve body **21** as illustrated. These ports are for the purpose of passage of drilling fluid downward through the assembly when the annular slidable valve body **21** is at the bottom end of its extent of movement, that is, when compression spring **17** is fully or substantially fully compressed. At this time it is intended that drilling fluid pass through the bore **23**, ports **25** into a space **28** below the baffle plug **13**, thus providing free fluid flow through the apparatus.

A differential valve assembly **35** includes an inner support sleeve **34** which extends upward from the level of flange **27** into the lower portion of bore **23** in the intermediate portion **16** of the annular slide valve **21**, a differential valve slide **39** with its case **36** and a valve seat member **47**. The sleeve **34** is detachably fixed to this intermediate portion **16** by one or more shear pins **37** as illustrated. The case **36** of the differential valve assembly **35** is larger in diameter than the sleeve **34**. A beveled surface **30** is provided at the lower end of the intermediate portion **16** and a corresponding beveled surface **30***a* is provided intermediate the inner sleeve **34** and the case **36** as illustrated. A flapper valve **29** is attached to flange **27** by a spring loaded hinge **31**. The beveled surface **30** serves at least two purposes, one being to limit upward movement of the differential valve assembly **35** and the second is that it serves as a seat for the flapper valve or valve head **29**. The case **36** of the differential valve assembly **35** also serves a double purpose, one being to house the differential valve slide **39** and the other being to serve as a retainer or holding mechanism to hold flapper valve **29** in an inoperative position. The valve head or flapper valve **29**, seat **30** and valve head holding mechanism **36** of FIGURE 1 are herein termed a check valve assembly. The general shape or form of the differential valve slide **39** is such that the effective area of the upper surface **40** is larger than the area of the effective lower surface of valve head **46** in a ratio to be described hereinbelow. A pair of packings **43** and **45** are provided for effectively sealing the differential valve slide **39** fluid-tight against the inner surface of case **36** of this differential valve assembly. A space **49** which is intermediate packings **43** and **45** is intended to be free of liquid, that is, it contains air which was included therein when the apparatus was assembled in the shop. The valve seat member **47** is supported by webs **48** as illustrated, the actual seating surface **46***a* being the upper bevel portion of the seat member.

At the upper end of the differential valve slide **39** is threaded a removable orifice member **41**. This orifice member is so constructed that the opening therein is of such a diameter as to admit drilling fluid upward into the casing at a desired and predetermined rate when casing is run at a predetermined running rate.

The determination of the diameter of the opening in this removable orifice member **41** is fully disclosed in a copending application Serial No. 361,647, now Patent 2,804,928. The calculations involved in determining the diameter of the opening in the orifice member take into account the pressure differential across the orifice, the density and viscosity of the drilling mud, rate of casing running, and numerous other pertinent factors.

Flapper valve **29** pivots around a spring loaded hinge **31**, the spring of said hinge being identified by reference numeral **33**.

With the differential valve slide **39** raised or opened from its seat **46***a*, upon pumping fluid downward in the casing, the differential valve slide **39** is forced downward and valve head **46** is forced against its seat **46***a* thus closing off flow of fluid through the differential valve assembly **35** and this operation causes the entire annular slidable valve body **21**-differential valve assembly **35** to move downward with the simultaneous compression of spring **17** thereby opening ports **25** to the free flow of fluid as mentioned above. The O-ring **26** is provided at the location indicated in FIGURE 1 to prevent leakage of fluid through the small annular space **14***a* between the outer wall of the intermediate portion **16** of the slidable valve body and the inner wall of the baffle plug **13**. A second O-ring **19** is provided at the location illustrated to make certain that drilling fluid does not inadvertently leak downward between the slidable valve body **21** and the baffle plug **13** when the upper enlarged portion **18** of the annular slidable valve body **21** is forced downward with compression of spring **17** by downward pressuring of ball **24** in the position indicated in the drawing.

When running casing provided with the bottom fill device illustrated in FIGURE 1, with the fluid pressure outside the casing and pipe **11** being greater by a predetermined amount than the pressure within the casing and above the bottom fill device, the differential valve slide **39** snaps upward until the upper surface **40** contacts surface **42**. In this position a fluid passageway is provided between valve seat **46***a* and the lower end surface of valve head **46** of the valve and there is then flow of mud through this passageway and through the orifice member **41** into the casing. The effective area of the opening between lower surface of valve head **46** and valve seat **46***a* is greater under all conditions than the area of the opening in the orifice member **41** so that the rate of inlet of drilling fluid is regulated by the diameter of the opening in the orifice member **41**. Also, the snap action of the differential valve by reason of the pressure drop across the orifice of member **41** is a definite advantage because it prevents excessive cutting of the seat **46***a*, the seating portion of the valve.

At any time during the casing running operation, for example, if it appears that the casing is being pinched by swelling of the walls of the borehole or by caving or any other reason, the casing running operation can be stopped and mud is then pumped downward through the casing and pipe **11**. When the downward force on the upper surface **40** is greater than the upward force exerted on surface of valve head **46**, the differential valve slide **39** snaps closed and mud pressure then forces the annular slide valve **21** downward compressing spring **17** and providing free passage of mud through bore **23**, ports **25** into space **28** below the above-mentioned members. This mud which then flows downward through my apparatus leaves the bottom of the casing or shoe and flows upward around the casing tending to wash out the above-mentioned obstructions. This circulation is continued until the casing is freed. The mud circulation is then stopped and another joint of casing is attached at the wellhead and the casing running operations are again started. When mud circulation is stopped, compression spring **17** lifts the annular slidable valve body **21** thereby closing ports **25** so that when casing running operations are started, mud cannot flow upward through ports **25**. Upon beginning of the casing running operations when the pipe **11** is lowered in the well, mud pressure below pipe **11** increases with the result that the differential valve slide **39** is snapped upward and open thereby allowing controlled upward passage of drilling mud therethrough.

When the casing and bottom fill member are run in the well and landed and it is desired to carry out the cementing operations it is merely necessary to drop a ball **24** into the casing and pump this ball downward and into contact with the upper surface of inner sleeve **34** of the differential valve assembly **35**. Upon pressuring drilling mud against the ball, shear pins **37** are sheared and the entire differential valve assembly **35** is forced downward which movement frees the flapper valve **29** to allow the spring loaded hinge to operate to close the valve. The ball, of course, is also pumped downward through bore **23** along with the differential valve assembly into the space 28 below the flange 27 and valve 29.

In this condition this assembly is then ready for carrying out a cementing operation. Upon passage of a sufficient amount of cement through bore 23 and outward around the bottom end of the casing and up the annulus and upon release of the pump pressure, the spring loaded hinge 31 closes flapper valve 29 to hold the cementing pressure until such time as the cement is properly set. Since all of the interior apparatus parts of this bottom fill device are made of drillable material such as plastic material, brass or the like, after the cement is set, the drill can be lowered down the casing and all of the apparatus parts within pipe 11 are drilled out and drilling of the hole is then continued in case the well is to be deepened.

The apparatus of FIGURE 2 is, in general operation, more or less similar to that explained relative to FIGURE 1. However some apparatus parts are different. In FIGURE 2, pipe 11 and the apparatus parts which are identified with the same numerals as used in FIGURE 1 are the same. The main differences in these two embodiments lies in the differential valve assemblies. In FIGURE 2 a differential valve assembly 51 is provided with a poppet type valve 53 which is provided with a valve stem 67 which in turn is supported by a holder 63. The lower end of the valve stem extends through holder 63 and is fastened thereto by a nut and washer, or lock nut assembly, or other suitable fastening means. Support 63 is held rigidly in its proper position by several fins or ribs 73 as illustrated. These ribs 73 are in turn supported by a support member 59 which is provided with one or more O-rings 69 as illustrated. The O-rings 69 provide a seal between the outer surface of support 59 and the inner surface of case 75. A valve seat 55 is provided as shown for closure of valve 53. A compression spring 57 biases the slide support downward and valve 53 closed against seat 55.

Reference numeral 61 identifies a removal orifice member which is similar to orifice member 41 of FIGURE 1. This orifice member 61 is constructed according to calculations mentioned above relative to orifice member 41. Thus an orifice member of proper diameter or opening is used to provide a predetermined rate of mud inlet into the casing while running the casing, taking into account desired running speed, viscosity of the mud, its density and other variables.

Reference numeral 54 identifies the space below valve 53.

When running the casing employing the bottom fill device of FIGURE 2, the rate of running is dependent, of course, upon the opening through orifice member 61. When first lowering the bottom fill device into the well, valve 53, of course, is biased closed and when the bottom fill device is lowered a predetermined distance in the fluid in the well, the valve 53 opens because fluid pressure outside the casing is greater than the fluid pressure within the casing, the pressure outside the casing being high because there is no fluid in the casing. As the bottom fill device and casing are lowered further and a greater pressure differential is exerted on the bottom side of valve 53, it fully opens and admits drilling fluid.

The actuation of my back pressure valve 29 is independent of fluid flow through the device in either direction, that is, fluid can flow upward through the valve 39 and can flow downward through bore 23, ports 25 when spring 17 is compressed and the annular slidable valve body 21 is at the bottom end of its extent of movement, at any rate without releasing the back pressure valve 29 to a seating position. Many and various attempts have been made to solve the above-mentioned problems and to circumvent the above-mentioned disadvantages. Many of the bottom fill device improvements have solved some of the problems but, to my knowledge, none have solved all of the problems in a manner as simple and as really foolproof as the bottom fill device of this invention.

From this point on running the casing is carried out in the usual manner. Whenever casing running is stopped, however, mud continues to enter the casing until the compression spring 57 overcomes the pressure difference across orifice member 61 and valve 53 then closes.

The apparatus parts included within casing 11 in the apparatus of FIGURE 2 are also made of drillable material so that upon landing of the casing and after cementing, the apparatus can be drilled in case the well is to be deepened.

The differential valve assembly 51 of FIGURE 2 is removed from the bottom fill device by a ball pumped down the casing in the same manner as was the differential valve assembly 35 of FIGURE 1. Shear pins 37 of FIGURE 2 are sheared and the entire differential valve assembly and ball are forced downward, which operation frees flapper valve 29 for seating. Cement is then pumped downward and upon release of pump pressure flapper valve 29 seats and the cement is allowed to set.

The chamber, which contains spring 17, in both figures serves as a dashpot or buffer chamber to cushion the downward movement of the upper enlarged portion 18 of the slide valve when ball 24 reaches the dotted position 24 shown.

When running casing using the bottom fill device of FIGURE 2, the hole can be circulated in the same manner as explained relative to the device illustrated in FIGURE 1. In both devices, the hole can be circulated at any time without making inoperable the bottom fill portion of the device.

The functioning of the differential valve assembly 35 of FIGURE 1 is different in principle from the functioning of the differential valve assembly 51 of FIGURE 2 although the differential valves serve the same purpose. In FIGURE 1 the differential valve slide 39 of the valve assembly 35 opens by moving upward in response to a predetermined ratio of the pressure acting upward from below the valve to the pressure above the valve acting downward. Since the area of the upper surface 40 is intentionally constructed larger than the effective area of valve head 46, a greater pressure acting upward on the smaller area is required to open the valve. This greater pressure is achieved when the bottom fill device and casing are lowered some distance into the mud in the well. When the ratio of slide valve areas (bottom to top) is say .9, then the slide valve is static when the mud level in the casing is, say 900 feet above the valve and the mud level above the valve outside the casing is 1000 feet. Under such ratio of areas when the casing is lowered farther into the mud the mud level above the valve outside the casing increases and the valve opens. Upon continued flow of mud from outside the casing through the valve into the casing the mud level inside the casing rises, and at the time the mud level ratio becomes more than .9 (level inside casing to level outside casing) the valve closes. The ratio of the hydrostatic heads of mud outside and inside of the well casing are inversely proportional to the areas on the bottom and on the top of the slide valve. Since the area on the top of the valve is greater than the area on its lower side the hydrostatic head of mud inside the casing will be less than the hydrostatic head of the mud outside the casing. The level of the mud in the casing is always lower than the level of the mud outside the casing depending on the ratio of the areas of the bottom of the top of the slide valve.

When the area of the top surface 40 of the differential valve slide 39 bears a predetermined ratio to the area of the effective lower surface of valve head 46 and the pressure acting upward against the effective lower surface of valve head 46 bears the same ratio to the downward pressure against surface 40, the valve will remain closed. When the casing is lowered the upward pressure bears greater ratio to the downward pressure than the ratio of surface areas, the valve opens. If the casing were elevated or the mud allowed to flow through the valve into the casing until the ratio of pressure below the valve to the pressure above the valve, is smaller than the above-mentioned ratio, the valve closes. Thus, by carefully selecting the effective lower surface area of valve head area **46** and the valve upper area **40** to give a predetermined ratio, of say 0.9 (bottom area to top area); then the valve will close when the mud height in the casing is greater than 90% of the height of the mud in the annulus around the casing. This ratio is the same regardless of how deep the casing extends into the mud.

The opening of the spring loaded valve **53** of FIGURE 2 is dependent on the compressive strength of the spring **57**. Thus by selecting a stronger spring the bottom fill device of FIGURE 2 and casing have to be lowered a greater distance in the mud in the well before the valve opens than if a less strong spring were used. Thus by using the spring loaded valve assembly, if the compressive strength of the spring is such that it compresses when the head of the well fluid in the annulus is 100 feet higher than the well fluid in the casing, the valve will open. When sufficient mud enters the casing that the difference in height between the mud in the annulus and the mud in the casing is less than 100 feet, the spring will close the valve. Thus the apparatus of FIGURE 2 operates at a fixed value dependent on the compressive strength of the spring. The areas exposed to fluid on both sides of the valve head are equal; thus the differential pressure required to open the valve is dependent only on the spring.

While certain embodiments of the invention have been described for illustrative purposes, the invention obviously is not limited hereto.

I claim:

1. Apparatus for insertion and use in a well casing comprising in combination, an annular valve body sealable with said casing and having an axial bore to be positioned in said casing with its axis upright; means for sealably mounting said valve body in said casing; a transverse annular valve seat in said valve body at the lower end of said bore; a sleeve in said bore coaxial with said valve body and mounted thereon by a shearable transverse projection on said sleeve engaging said valve body, said sleeve extending above and below said valve seat and below said valve body and being provided with a seat on its upper end adapted to sealably engage a displacing member pumped down said casing to displace said sleeve completely from said valve body by pumping pressure; a flapper valve hingedly supported on the lower side of said valve body substantially at the level of said valve seat, and held off said valve seat by the section of said sleeve extending below same; and means for biasing said flapper valve toward said valve seat.

2. Apparatus for insertion and use in a well casing comprising in combination, an annular valve body sealable with said casing and having an axial bore to be positioned in said casing with its axis upright; means for sealably mounting said valve body in said casing; a transverse valve seat in said valve body circling the lower end of said bore; a sleeve in said bore extending above and below said valve seat and below the bottom of said valve body; shearable means extending between said sleeve and said valve body for holding said sleeve in position, the upper end of said sleeve forming a seat for a plug capable of being pumped with said sleeve thru said bore; and a flapper valve hingedly supported on the bottom of said valve body, held off said seat by the lower section of said sleeve, and spring-biased toward said seat so as to move onto same and seal said bore upon downward displacement of said sleeve completely out of said valve body, thereby preventing upward flow of fluid thru said bore.

3. Apparatus for insertion and use in a well pipe string comprising in combination, a pipe provided with means for attaching to said pipe string; a valve body forming a closure with the inner wall of said pipe and having a bore therethru longitudinal of said pipe; means for sealably mounting said valve body in said pipe to form said closure; a valve seat on said valve body at the lower end of said bore; a sleeve in said bore detachably engaging said valve body by a shearable transverse projection on said sleeve extending to said valve body, said sleeve extending above said valve seat and below said valve seat and said valve body; a flapper valve hingedly supported in said pipe adjacent the level of said valve seat, held off said valve seat by the lower section of said sleeve, and spring biased toward said seat so as to move onto same to seal said bore upon downward displacement of said sleeve, thereby preventing upward flow of fluid thru said bore.

4. The apparatus of claim 3 including means for displacing said sleeve downwardly thru said bore.

5. The apparatus of claim 3 wherein the lower end of said sleeve below said valve body houses a differential valve assembly comprising means for closing said bore to flow below said valve body when fluid pressure within said bore is greater than fluid pressure in said pipe string below said sleeve.

6. The apparatus of claim 3 wherein said flapper valve is supported on the lower end of said valve body.

7. The apparatus of claim 3 wherein the lower end of said sleeve below said valve body houses a differential valve assembly comprising a differential valve slide slidably and sealably engaging the inner wall of said sleeve, said valve slide having an axial bore with a second valve seat on its lower end; and including a valve seat member supported at intervals from the wall of said sleeve to provide flow around said valve seat member, said valve slide being slidable to engage said second seat on said valve seat member to close the bore of said sleeve to flow thru said lower end.

8. The apparatus of claim 7 including an annular plug surrounding an intermediate section of said valve body; an external flange on the lower end of said valve body providing a first shoulder for engagement with the lower end of said plug; an upper enlarged section on said valve body overlapping said plug to provide a second shoulder for engagement with said plug, the distance between said first and second shoulders being greater than the height of said plug to provide for limited vertical movement of said valve body within said plug; a spring intermediate said plug and said enlarged section biasing said valve body in its uppermost position with said first shoulder engaging said plug; a port extending from the bore of said sleeve thru the walls of said sleeve and said valve body at a locus therein which is above the level of the lower end of said plug when said first shoulder is in engagement with said plug and which is below the level of the lower end of said plug when said second shoulder is in engagement with said plug; and means for sealing said valve body with said plug when said valve body is in its uppermost and lowermost positions.

9. The apparatus of claim 3 including an annular plug surrounding an intermediate section of said valve body and engageably attached to the wall of said pipe; outwardly extending shoulders on the upper and lower ends of said valve body spaced apart a distance greater than the height of said plug to provide limited vertical movement of said valve body within said plug; flexible biasing means holding said valve body in its uppermost position; means for sealing said valve body with said plug when said valve body is in its uppermost and lowermost positions; valve means for closing the lower end of said sleeve to fluid flow when said valve body is depressed by downward differential fluid pressure to its lowermost position and for opening said sleeve to fluid flow when said valve body is elevated by upward differential pressure, said valve means including a flow restricting orifice; and port means thru said sleeve and the lower end of said valve body open to fluid flow from said bore to the pipe string

bore below said sleeve when said valve body is forced to its lowermost position, and closed to fluid flow therethru when said valve body is in its uppermost position, the flow capacity of said port means being greater than that of said orifice.

10. The apparatus of claim 9 wherein said valve means comprises a differential valve slide slidably and sealably engaging the inner wall of said sleeve and provided with an axial bore and a valve seat at the lower end of said bore, the upper end of said valve slide having greater effective surface area than its lower end; a valve seat member supported from the wall of said sleeve at intervals to engage last said valve seat when said valve slide is in its lowermost position; a shoulder in the bore of said sleeve above said slide valve to limit upward movement of same.

11. The apparatus of claim 9 wherein said valve means comprises a poppet valve spring biased downwardly toward a valve seat in a transverse closure in the bore of said sleeve, said poppet valve being closable on its seat upon downward differential fluid pressure and openable upon upward differential fluid pressure.

References Cited in the file of this patent

UNITED STATES PATENTS

2,139,899	Le Bus	Dec. 13, 1938
2,630,178	Brown	Mar. 3, 1953
2,642,140	Brown	June 16, 1953
2,768,695	Althouse et al.	Oct. 30, 1956
2,781,774	Baker et al.	Feb. 19, 1957
2,872,983	Renouf	Feb. 10, 1959