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FILLING WELL PIPE

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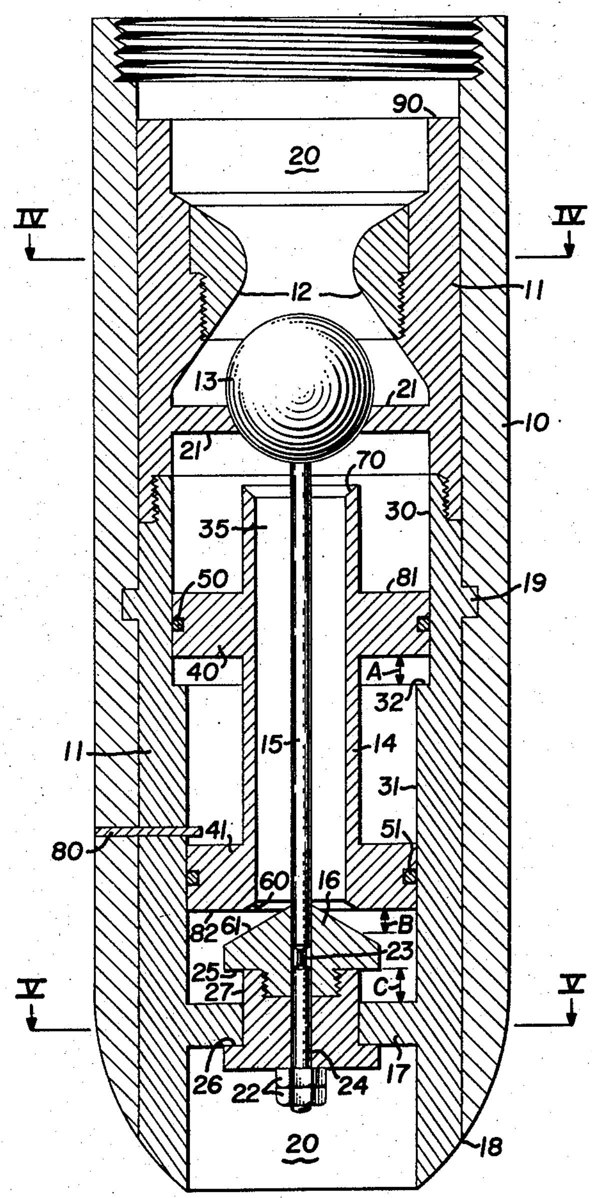

FIG.-1

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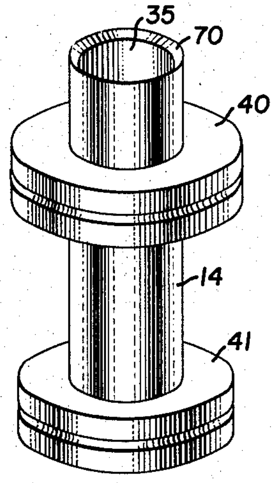

FIG.-2

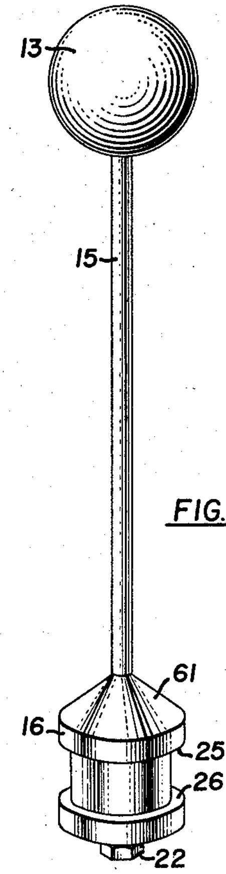

FIG.-3

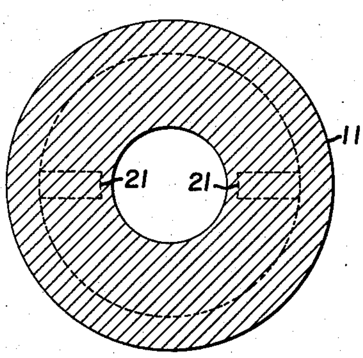

FIG.-4

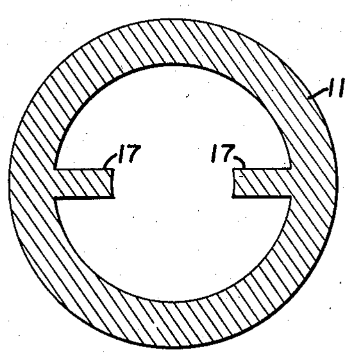

FIG.-5

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FILLING WELL PIPE

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The present invention broadly relates to subsurface well apparatus and more particularly to an improved means for positioning pipe within a well bore. The invention especially concerns an improved apparatus for automatically filling a string of casing or other well pipe as it is lowered within a well bore. The invention is particularly characterized by its ability to provide continuous protection against well blowouts up through the casing or other well pipe.

It is a well known practice in the art of petroleum production to install casing or other pipe within a well bore. It is also well known in the art to provide a shoe on the lower end of a string of casing in order to guide the casing through a well bore and protect the casing from damage by contact with the wall of the well bore. In some instances it has been the practice to use a type of shoe which either totally excludes well fluid from the interior of the casing string or which permits a limited amount of such fluid to enter the string. Shoes of this type are popularly referred to as float shoes and differential float shoes, respectively.

Float collars and differential float collars are also conventionally employed within strings of casing to provide substantially the same casing filling performance as float shoes and differential float shoes, respectively. In general, fillup collars are employed in addition to fillup shoes and are usually provided as a safety precaution in the event that the shoes fail to function. Furthermore, many operators employ a fillup collar at several casing joints removed from the bottom of a casing string in order to make sure that the bottom of the well bore is adequately cemented.

An object of the present invention is to provide an improved apparatus for automatically filling a string of well casing or other well piping as it is lowered through the fluid in a well bore. It is a further object of the invention to provide improved apparatus in the form of differential fillup float shoes and collars which not only automatically fill a string of well casing but also protect against well blowouts up through the casing.

It is a particular object of the invention to provide a differential valve in subsurface well apparatus for automatically filling well casing with well bore fluid in which the level of fluid within the casing may be automatically maintained at a level which bears a predetermined position relative to the level of fluid in the annular space between the casing and the well bore. It is a further particular object of the invention to provide a differential valve of the type just described which incorporates a releasable valve adapted to prevent well blowouts up through the casing.

These and related objectives of the invention are attained in accordance with the present invention by utilizing a tubular member which is insertable in a string of casing or other well pipe. The tubular member includes first valve means which is adapted to block or prevent upward flow of fluids through the member and the well casing in the event that predetermined excessive magnitudes of upward fluid flow are encountered. Second valve means are provided within the tubular member and arranged to provide flow in either direction through the tubular member and the well casing to provide a predetermined level of fluid within the well bore exterior of the casing. Means are also provided within the tubular member of a character to inactivate the second valve means and substitute a check valve of a character to provide downward fluid flow through the casing and the tubular member but not upward flow. The check valve and the first valve means are preferably provided in a unitary valve structure.

The nature and scope of the invention as well as the objectives of the invention will be more clearly apparent from a consideration of the attached drawing which illustrates a preferred embodiment thereof.

Figure 1 is a vertical cross section view of a differential float shoe which incorporates the principles of the invention.

Figure 2 is a perspective view of the differential piston component of the apparatus illustrated in Figure 1.

Figure 3 is a perspective view of the ball check and differential valve seat assembly of the apparatus in Figure 1.

Figure 4 is a cross sectional view of the apparatus in Figure 1 taken along the section lines IV—IV.

Figure 5 is a cross section view of the apparatus in Figure 1 taken along the section lines V—V.

Referring to the drawing, it will be seen that the apparatus is a differential float shoe which includes a conduit member **10**, liner **11**, check valve seat **12**, ball valve **13**, free floating piston element **14**, valve stem **15**, differential valve body **16**, lugs **17**, and nose **18**.

Conduit member **10** is preferably tubular and threaded or otherwise adapted at its upper end to be connected to the lower end of a string of well casing. The lower end of the member **10** is rounded off to form nose **18** which provides the function of guiding the shoe and its attached casing through a well bore.

Tubular element **10** is preferably formed of a material such as steel or the like which is strong and sufficiently durable to withstand the rough surfaces within a well bore and to provide support for a string of well casing.

While the illustrated differential float shoe may be constructed entirely of steel or other metal parts, it is preferred that all internal parts other than tubular element **10** be constructed from material which is frangible in the sense that it can be readily broken and ground up by the action of a conventional drill bit without injury to the bit. Thus, tubular element **10** preferably has an internal diameter which is substantially equal to the interior diameter of the casing to which it is attached.

Liner **11** is preferably constructed from synthetic resins or cementitious material which is readily removed by means of a conventional drill bit. It is preferably molded or otherwise mounted within tubular element **10** so that these two members are rigidly secured to one another. One or more lands or the like **19** may be provided between tubular element **10** and liner **11** in order to prevent longitudinal or rotary relative movement between these two members.

Liner **11** is provided with a centrally disposed passageway **20**, which near the upper end of the liner is narrowed to form valve seat **12**. This valve seat preferably faces downwardly and is attached to form a fluid tight seal in combination with ball **13**.

Ball **13** is positioned below valve seat **12** and is preferably constructed of a material which renders the ball buoyant in casing cementing fluids or other well fluids. It will be recognized, then, that ball **13** in combination with valve seat **12** forms a check valve which is capable of functioning to restrict upward flow of fluids and to permit downward flow of fluids through the float shoe.

As a string of casing with the illustrated float shoe is lowered within a well bore, ball 13 is normally spaced below valve seat 12 and in contact with upper lugs 21 which are secured to or form part of liner 11. Ball 13—in the presence of well fluids—is held down against upper lugs 21 by means of valve stem 15 which extends through valve seat member 16. Valve stem 15 is threaded at its lower end and engages one or more lock nuts 22 which lock against the lower surface of valve seat body 16. Stem 15, however, is of a character to break or otherwise part under a predetermined stress loading. For example, stem 15 may be provided with a portion 23 of reduced diameter which is weaker in tensile strength than the remainder of this member. Stem 15, furthermore, is of a character to form a sliding fit within passageway 24 but also to maintain a substantially fluid tight relationship therebetween.

Valve seat body 16 is preferably substantially cylindrical in shape and is provided with upper and lower shoulders 25 and 26 respectively on its outer cylindrical surface. The portion of the surface lying vertically intermediate these two shoulders is adapted to engage lower arms or lugs 17 which are secured to or form part of liner 11. The lugs are preferably at least slightly smaller in a vertical dimension than is the vertical dimension of cylindrical surface 27 so that a limited amount of vertical relative movement is possible between valve seat body 16 and lugs 17.

At this point it will be noted that valve stem 15 is preferably of a length such that the lower shoulder of valve seat body 16 engages the lower surface of lugs 17 when ball 13 engages upper lugs 21. Furthermore, the distance C between shoulder 25 and the upper surface of lugs 17 must be greater than the distance A, which in turn must be greater or at least as great as the distance B. The necessity for this relationship between these distances will become more apparent in the description that follows.

As illustrated in Figure 1, the inner wall surface of liner 11 is shaped to provide two cylindrical surfaces 30 and 31. Cylindrical surface 30, which is disposed above cylindrical surface 31, is larger in diameter than the latter surface thereby creating an intermediate shoulder 32.

Moving vertically within passageway 20 is piston member or sleeve valve element 14 which has a centrally disposed fluid passageway 35 extending vertically throughout this member. The piston element or sleeve valve has an upper piston 40 and a lower piston 41 which engage the inner wall surface of liner 11 in a fluid tight sliding relationship. Thus, upper piston 40 moves vertically along cylindrical surface 30; and piston 41 moves vertically along cylindrical surface 31. Piston rings 50 and 51 or other suitable devices such as seal rings, rubber grommets, packing elements, and the like may be positioned between pistons 40 and 41 and their respective wall surfaces 30 and 31 to insure adequate fluid tight relationships between these members.

The lower end of passageway 35 forms a valve surface 60 which is adapted to engage the upper inclined valve seating surface 61 of valve seat member 16 upon downward movement of sleeve valve 14 so that fluid flow through passageway 35 may be prevented. Similarly, the upper end of passageway 35 forms a valve seat 70 which is engageable with and adapted to form a fluid tight sealing surface with the under surface of ball valve 13. Contact between valve seat 70 and ball 13 occurs when sleeve valve 14 is urged upwardly within liner 11.

Having enumerated the structural components of the apparatus in the drawing, attention is now directed toward a brief presentation of the manner in which the apparatus operates. For this purpose, it will be assumed that the illustrated apparatus is attached to the lower end of a string of casing, and that the casing is being lowered within a fluid-filled well bore.

With this assumption, fluid from the well bore upon entering the lower end of passageway 20 exerts a force upon the under surface of piston 41, thus driving sleeve valve 14 vertically upward. Upon moving vertically upward, sleeve valve 14 moves valve surface 60 away from valve seat 61 thereby permitting well fluids to enter and flow through central passageway 35. It will be appreciated that the well fluids flow freely through and around lower lugs 17 and upper lugs 21 and thence up into the string of casing. Ball valve 13 is restrained at this time from engaging valve seat 12 by the restraining action of valve stem 15 in conjunction with lock nut 22, shoulder 26 and the under surface of lugs 17.

It will be noted that it may be desirable on occasion to provide a shear pin 80 along the wall surfaces of cylinder 31 to prevent premature or inadvertent closure of valve seat 70 with ball valve 13. By suitable preselection of the weight of the sleeve valve or differential piston 41 as well as the degree of friction between the piston and the surrounding cylindrical surfaces, it is considered that such a shear pin or other device is not necessary. It is contemplated that the velocity of up-flowing well fluid within the passageway 20 will never be sufficient when running casing into a well to rupture the valve stem 23, except possibly in the event that the casing is ruptured. Rupture of the valve stem and resulting closure of the valve seat 70 with ball valve 13 would be desirable at that time in order to provide the falling casing with increased buoyancy.

It will be recognized that the upper surface 81 of piston 40 is greater in area than the under surface 82 of piston 41. Thus when a sufficient head of well fluid has been formed above surface 81, a sleeve valve 14 moves downwardly and again closes the valve formed by surfaces 60 and 61. The precise amount of fluid required within the casing to close this valve may be readily predetermined by suitable design and preselection of the surface areas 81 and 82. Generally speaking, it is desired that a smaller head of fluid usually be maintained within a casing than exists in the well bore surrounding the casing.

When the desired amount of casing has been placed within the well bore it is then desirable to render the sleeve valve 14 inactive and to activate the ball check valve 13. This may be readily accomplished by completely filling the casing string with fluid of sufficient total weight to cause sleeve valve 14 to move downwardly and seat against valve surface 61. It will be apparent, however, that the vertical movement of sleeve valve 14 is not terminated here since the head of fluid within the casing is now substantially greater than the head of fluid surrounding the casing. Therefore, sleeve valve 14 continues to move in a downward direction and causes valve seat element 16 to move downwardly thereby stressing and ultimately fracturing the reduced portion 23 of valve stem 15.

When rupture of valve stem 15 occurs, valve 13 being buoyant rises within passageway 20 and seats against valve seat 12. Meanwhile, valve seat member 16 is urged downwardly until shoulder 25 engages the upper surface of lugs 17. Simultaneously, sleeve valve 14 continues in a downward direction until the under surface of piston 40 engages shoulder 32. At this point it will be apparent that piston 40 engages shoulder 32 before shoulder 25 engages lugs 17 thereby insuring a free passageway between the valve seating surfaces 60 and 61. In short, the differential valve action of sleeve valve 14 is now terminated and ball check valve 13 is rendered operative. Fluid can now be passed down the casing through the float shoe and thence into the well bore, but flow in a contrary direction is prevented by the ball check 13. A conventional cementing operation can thus be carried out by pumping cement down through the casing and the shoe into the well bore. A conventional two-plug system for carrying out the cementing operation may be readily employed, the shoulder 90 providing ample seating surface for the leading plug. Following the cementing operation, the interior components of the shoe may be readily removed along with excess cement by drilling through these components with a conventional drill bit.

In addition to the features of the valve outlined above, the apparatus in the drawing has the additional characteristics of providing continuous protection against a well blowout through the casing. It will be recognized, of course, that well blowouts in the annular space between the casing and well bore are conventionally prevented by the presence of wellhead blowout preventers. It will also be recognized that blowouts through the casing present a continuous hazard in a casing operation when additional lengths of casing are incorporated within a casing string.

The blowout prevention feature of the apparatus in the drawing becomes operative in the following manner. Thus, a sudden rush or influx of well bore fluid within passageway **20** causes sleeve valve **14** to be moved sharply upward thus shearing pin **80** and seating valve surface **70** against ball check **13**. The seating of this valve automatically creates a pressure buildup within passageway **35** and on the lower surface **82** of piston **41** thus shearing reduced section **23** of valve stem **15**. Ball **13**, being buoyant within the well fluid, is carried upwardly and seats against valve seat **12**. The blowout having thus been prevented, mud or other suitable well killing fluid may then be pumped down through the casing string to alleviate the blowout condition.

It will be understood that the present invention is not to be limited in its scope by the structural and process features that are illustrated in the drawing but instead only by the claims that follow this description. It will further be apparent that numerous modifications may be incorporated within the illustrated apparatus without departing from the spirit or scope of the invention. Furthermore, it will be recognized that the principles of the invention may be employed in differential fillup collars as well as differential fillup shoes such as the shoe illustrated in the drawing. For example, the lower end of the shoe in the drawing may be threaded in a conventional manner to engage a length of casing in substantially the same fashion as the upper end of the shoe presently does.

It will also be apparent that the various structural components of the apparatus in the drawing may in turn be assemblies of two or more parts to provide for increased ease of manufacture and fabrication.

What is claimed is:

1. A valve mechanism adapted to be mounted within the lower portion of a string of well pipe which comprises a conduit member open at each end, a first valve seat at the upper end of said conduit member, a free floating piston vertically moveable along the wall within said conduit member, a passageway extending vertically through said piston, a first valve below said first valve seat and adapted to engage said first valve seat, yieldable means supported from said conduit member normally maintaining said first valve in a vertically spaced relationship with said first valve seat, a second valve seat within said conduit and below said piston, a second valve on the lower end of said piston adapted to engage said second valve seat and to block fluid flow through said passageway, said yieldable means responsive to a predetermined magnitude of upward movement of said piston arranged to seat said first valve on said first valve seat, and said yieldable means also responsive to a predetermined magnitude of downward movement of said piston to seat said first valve on said first valve seat.

2. An apparatus as defined in claim 1 wherein said piston has an upper lateral surface which is greater in area than the lower lateral surface of the piston, and wherein the inner periphery of the conduit member varies in size to accommodate said upper and lower lateral surfaces.

3. A valve assembly for use in well operations which comprises a cylindrical tubular member adapted to be mounted within a string of well pipe, said tubular member in an operative position being vertically disposed, the lower portion of said tubular member having a smaller internal diameter than the upper portion, a piston including upper and lower portions having different diameters adapted to slide along the walls within the two portions of said tubular member, a passageway extending throughout the length of said piston and terminating at its ends in upper and lower valve seats, a downward-facing check valve seat supported by and within the upper portion of the tubular member, a buoyant valve member adapted to seat upon said check valve seat, a valve stem holder slidably supported from and within said lower portion of said tubular member, a frangible valve stem held at one end by said valve stem holder, the opposite end of said valve stem extending through said passageway and normally suporting said buoyant valve member in vertically spaced relationship with and between said check valve seat and said upper valve seat, said upper valve seat being adapted to seat against said buoyant valve member upon a predetermined upward movement of said piston, the upper surface of said valve stem holder defining a valve adapted to seat on said lower valve seat, said valve stem holder being vertically movable relative to said tubular member and adapted to drop out of any possible engagement with said piston upon fracture of said frangible valve stem.

4. A valve assembly for use in a string of well pipe which comprises a cylindrical tubular member attachable within said pipe string and vertically disposed when in an operative position; a piston fitted within and movable along the length of said tubular member; a passageway extending throughout the length of said piston and terminating at its ends in upper and lower valve seats; a check valve seat supported by and within the upper end of said tubular member; a first valve member normally in a position in spaced relation between said check valve seat and said upper valve seat; means releasably holding said first valve member in said position in said tubular member; means for releasing said first valve member from said releasably holding means to seat on said check valve seat in response to a predetermined upward movement of said piston; a second valve member supported from said tubular member below said piston, said second valve member being adapted to seat upon said lower valve seat and cooperable with said piston to maintain a predetermined pressure differential across said piston.

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