March 24, 1964 L. L. LOIACANO 3,126,060

WELL COMPLETION TOOL AND CEMENTING PLUG

Filed March 4, 1959 3 Sheets-Sheet 1

Fig. 4

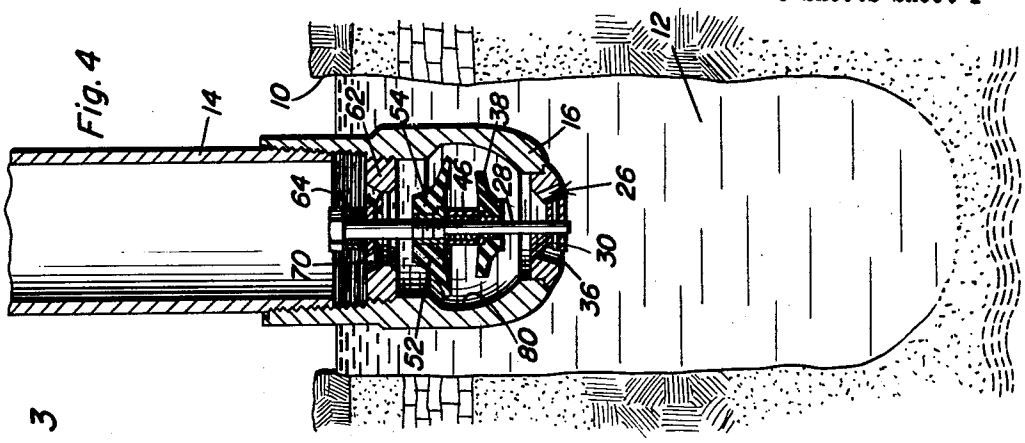


Fig. 3

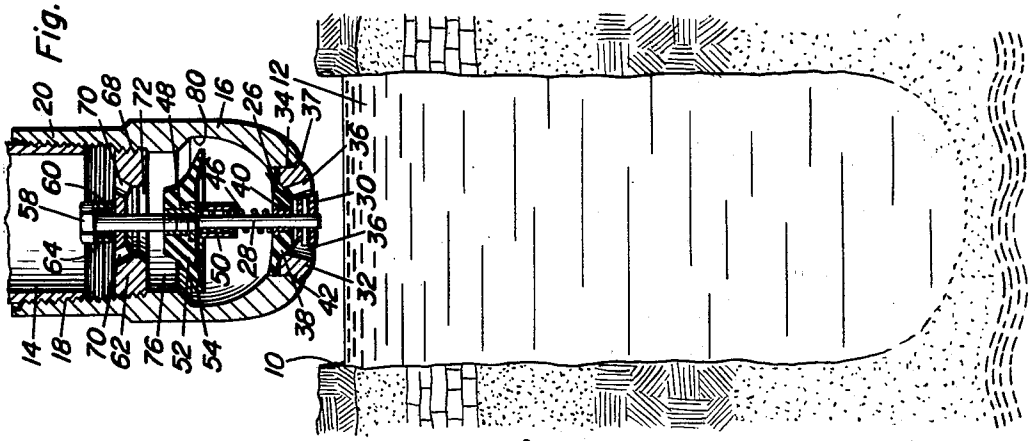


Fig. 1

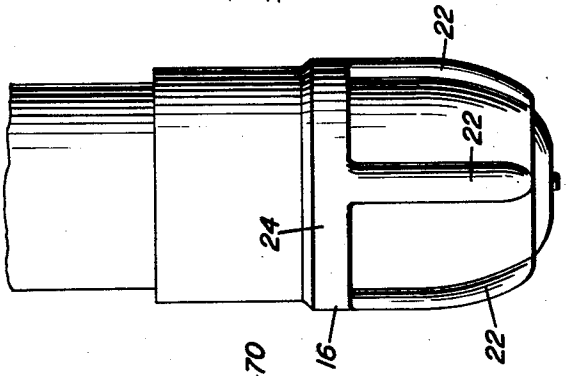


Fig. 2

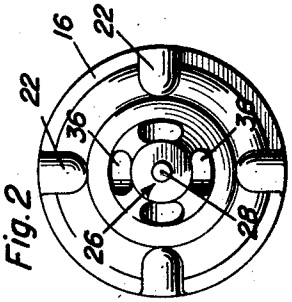
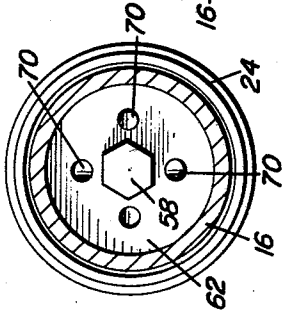


Fig. 8



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March 24, 1964 L. L. LOIACANO 3,126,060

WELL COMPLETION TOOL AND CEMENTING PLUG

Filed March 4, 1959 3 Sheets-Sheet 2

Fig. 7

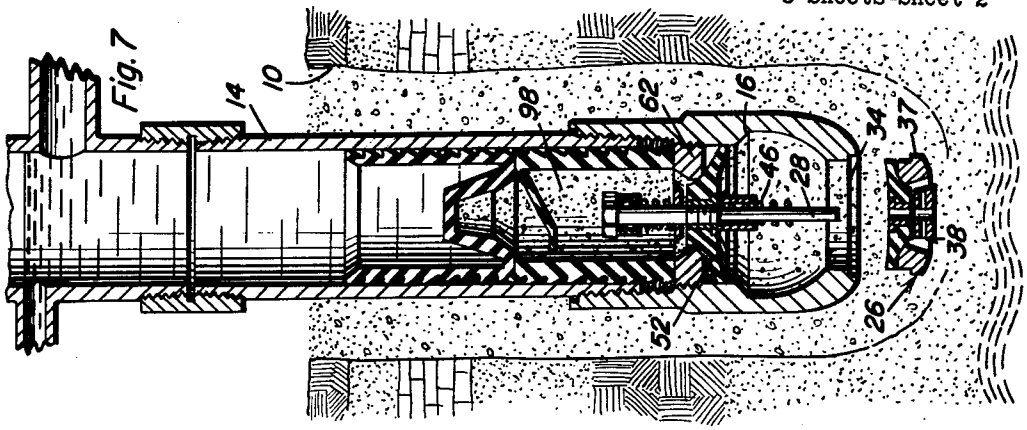


Fig. 6

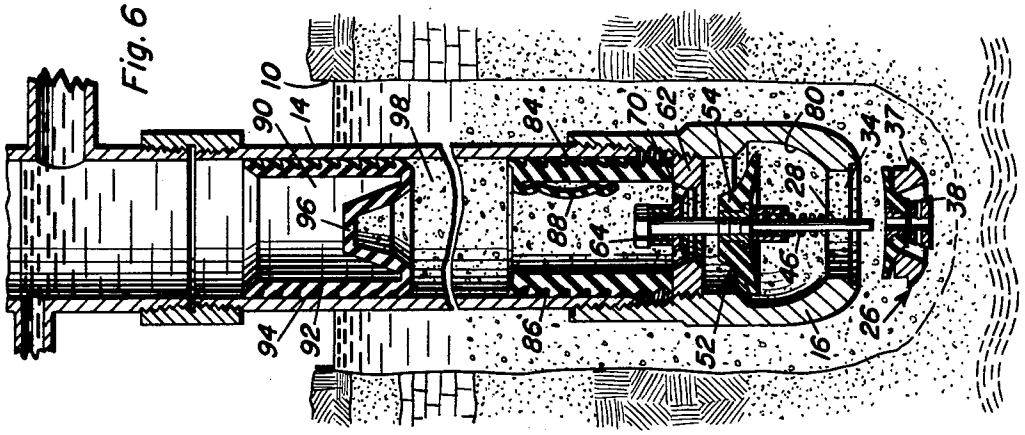


Fig. 5

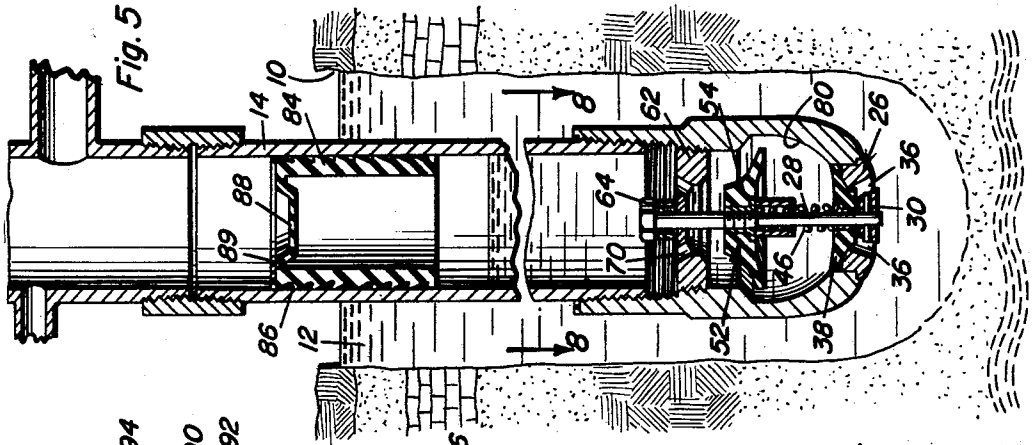


Fig. 9

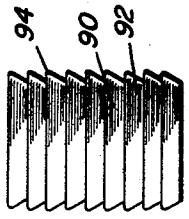
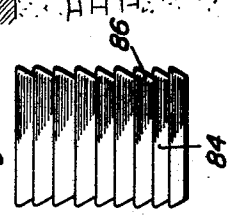


Fig. 10



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March 24, 1964 L. L. LOIACANO 3,126,060

WELL COMPLETION TOOL AND CEMENTING PLUG

Filed March 4, 1959 3 Sheets-Sheet 3

Fig. 12

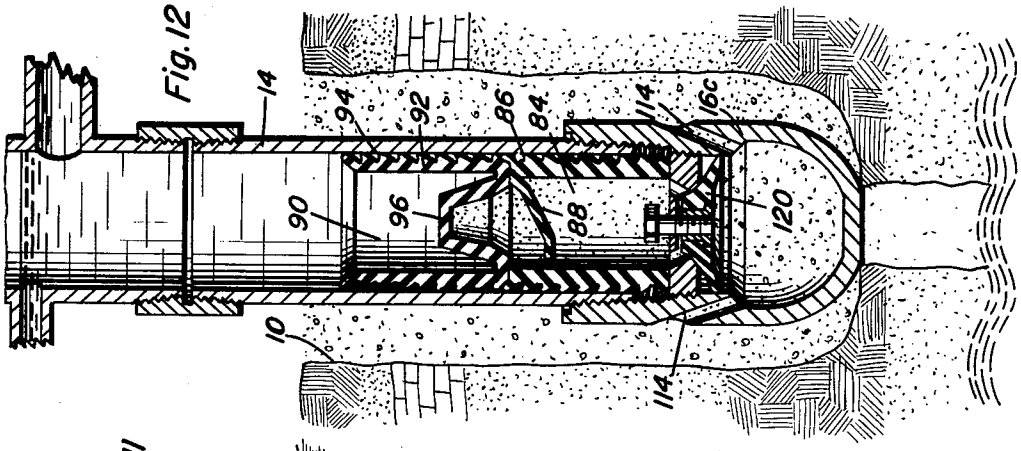


Fig. 11

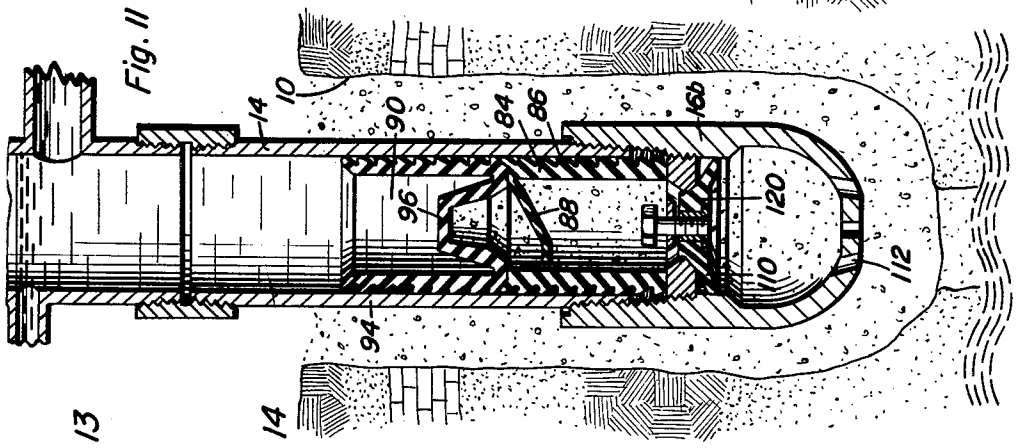


Fig. 13

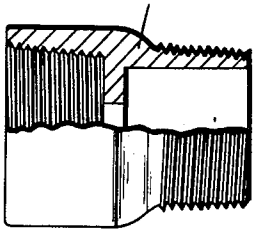


Fig. 14

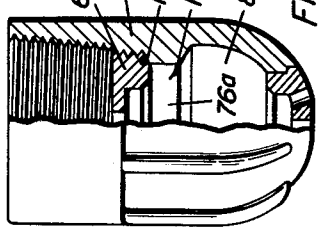


Fig. 15

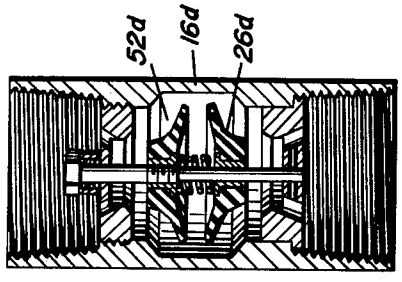


Fig. 16

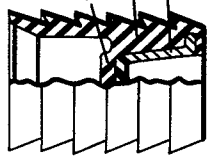
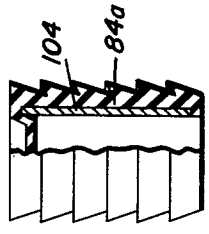


Fig. 17



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United States Patent Office 3,126,060 Patented Mar. 24, 1964

3,126,060

WELL COMPLETION TOOL AND CEMENTING PLUG

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Filed Mar. 4, 1959, Ser. No. 797,270
4 Claims. (Cl. 166—224)

This invention relates to well completion tools and cementing plugs and is principally, although not exclusively useful for shallow well producers of low pressure oil bearing sands and is equally adaptable for surface casing setting.

An object of the invention is to provide a new and considerably improved well completion tool and cementing plug assembly which are very simple in construction but yet, which are practical, avoiding undesirable washing of the wells as the casing is lowered and which guide and float the well casing in the optimum course as the well casing is being lowered.

One of the principal features of this invention is the structural detail and design of the shoe which is attached to the lowermost end of the well casing. The shoe is so constructed that upon lowering into the liquid of the well hole, a valve is opened by pressure from below enabling the liquid in the well hole to seek its own level in the well casing during the lowering procedure. As soon as pressure is applied from above by pressure generating means and conducted through the well casing, the valve in the shoe is closed by the pressure differential existing between the hydrostatic pressure of the liquid in the well hole and the dynamic pressure applied by a bottom wiper plug of the pressure generating means possessing means to prevent the plug from moving in one direction in the well casing but enabling the bottom wiper plug to move in the opposite direction namely: toward the shoe at the lower extremity of the string.

The bottom wiper plug has a gate which is forced open by internal pressures exerted either directly on the fluids, cement or an upper or top cementing plug which functions as a piston, pushing cement or the like ahead of it. The opening of the gate in the lower or bottom wiper plug enables the cement under pressure to open the valve in the shoe, for instance by blowing it off so that the cement may pass through the shoe to cement the well.

The invention is capable of being practiced in many forms and embodiments, a more simple one differing from the previously described embodiment in the structural detail of the shoe and the valving of the shoe. Further, this invention contemplates various improvements in the bottom and top plugs and in special attachments such as an automatic fill-up float collar by which the principles of the invention may be exercised.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a side elevational view of a shoe constructed in accordance with the invention.

FIGURE 2 is a bottom view of the shoe in FIGURE 1.

FIGURE 3 is a partially diagrammatic and partially sectional view showing an automatic fill up shoe on a casing before entering the fluid in a well hole containing liquid.

FIGURE 4 is a view similar to FIGURE 3 but showing the automatic fill up shoe actually being lowered into the well fluid and illustrating the open position of the lowermost valve of the shoe to admit rather freely the well hole liquid.

FIGURE 5 is a partially diagrammatic and partially sectional view showing the fill up shoe as it would appear when the bottom wiper plug has been placed ready for a wiping and cementing run.

FIGURE 6 is a partially diagrammatic and partially sectional view showing the parts in their proper positions as the top or upper cementing plug exerts pressure from above.

FIGURE 7 is a partially diagrammatic and partially sectional view showing the upper cementing plug in the fully lowered position at which time the well is being cemented.

FIGURE 8 is a sectional view taken on the line 8—8 of FIGURE 5.

FIGURE 9 is an elevational view of the top cementing plug.

FIGURE 10 is an elevational view of the lower wiper plug.

FIGURE 11 is a sectional view of a modification of the fill up shoe.

FIGURE 12 is a sectional view of another modification of fill up shoe, for finishing a well that has already been cored for communication with a pay strata.

FIGURE 13 is a partially elevational view and a partially sectional view showing a further modification of the invention.

FIGURE 14 is an elevational view with parts shown in section, this view illustrating the internal construction of a fill up shoe manufactured slightly different from the other embodiments of the invention.

FIGURE 15 is a longitudinal sectional view of an automatic fill up float collar illustrating that the invention may be practiced by using a body other than a lower extremity shoe.

FIGURE 16 is an elevational view of a modified top cementing plug.

FIGURE 17 is an elevational view, parts shown in section, of a modified lower wiper plug.

In the accompanying drawings there are a number of illustrations of a typical well hole 10 containing liquid 12 to show how the invention is to be used for well completion, especially in oil fields. A conventional well casing 14 is being used as the preferred environment of the invention, and it is lowered and conducts fluid or fluid-like material by conventional equipment (not shown) and in the ordinary ways.

Float shoe 16 is connected to the lower end of the well casing 14 by having the threaded end 18 of the well casing 14 disposed in the threaded socket 20 of the float shoe. A number of longitudinal ribs 22 are on the outside surface of float shoe 16 and depend from a circumferential band 24 intermediate the upper and lower ends of the float shoe.

Lower valve assembly 26 is carried by the float shoe and is of special construction. Elongate valve stem 28 is coaxial with the longitudinal axis of shoe 16 and has a transverse shear pin 30 near its lower end. The shear pin supports a valve seat 32 of the lower valve assembly 26, which is pressed into opening 34 at the lower extremity of the float shoe. A number of passages 36 which may have any cross sectional shape such as circular bores or slots, are in the body of valve seat 32. The lower assembly 26 includes a flexible valve element 38 is in the shape of a disc with a center reinforced by sleeve 40 and disposed on valve stem 28. The center part of the disc is reinforced by being thickened and has a portion 42 of its surface in the shape of a truncated cone which seats on a similarly shaped surface of the upper part of valve seat 32 in order to close the passages 36. Opening 34 is cylindrical so that the perimeter of valve element 38 is capable of sliding thereinto and being constrained in its movement through a short distance of

the motion of valve element 38 in a valve opening direction. The normal position of the valve assembly 26 is in the valve closed position (FIG. 3). Spring 46 having one end seated on valve element 38 and the other end seated on threaded sleeve 48, retains the valve element 38 pressed downward against the valve seat. Protective spring guide 50 is attached to threaded sleeve 48 and is concentric with the lower reduced diameter part of valve stem 28.

Upper valve assembly 52 is in the float shoe and is retained in the valve open position (FIG. 5) until the lower valve assembly 26 is blown off the valve stem 28 (FIG. 7). Upper valve assembly of the fill up or float shoe is constructed of a resilient, for instance rubber, valve element 54 which is in the shape of a disc with the center part reinforced by thickening and by sleeve 48 to which the rubber part of the disc is adhered. The sleeve 48 is threaded onto the larger diameter part of valve stem 28 whereby valve element 54 is maintained always fixed to the valve stem for movement therewith. The upper end of the valve stem has a head 58 on it, the head having a spring protecting sleeve 60 attached to it and depending therefrom to bear against the upper surface of valve seat 62. Spring 64 bears against head 58 and the center part of valve seat 62 and constantly spring urges the valve stem upward. Since the spring 64 has greater strength than spring 46, the valve assembly 26 can function to open and close while the lower valve seat 32 is held firmly fixed in place in opening 23 with the small cylindrical flange 37 disposed in the small recess or counterbore at the lower extremity of opening 34.

Valve seat 62 is attached by threads 68 to the inside of the float body and has a plurality of passages 70 extending through it. These passages remain ordinarily open and are closed only when the lower valve assembly 26 is blown off at which time spring 64 lifts valve element 54 so that the center thickened and reinforced part of the valve element 54 has its outer surface forcibly pressing against the surface 72 of valve seat 62 and through which passages 70 open. The perimeter of valve element 54 is circular and is constrained in its travel by fitting into the circular bore 76 of the body of the float shoe 16 immediately below the valve seat 62. The edges of valve element 54 are feathered, that is, they become thinner as measured from the inner part of the disc to the outer part thereof.

The use and operation of the automatic fill up or float shoe is described with reference to FIGURES 3–7. FIGURE 3 shows the automatic fill up shoe on the casing 14 before entering the liquid 12 in the well hole. Note that the upper primary valve disc is held in the open position and is centrally located with clearance all around its periphery made in the body of the shoe, for instance by undercut 80. The lower or secondary valve assembly 26 it held closed by the lower spring 46. The springs 46 and 64 are special in the sense that they are selected to suit a required accurate flow of fluids into the casing 14. By a proper selection of springs a range of fill up shoes, for instance from 20% to 80% fill up may be obtained. As illustrated in FIGURE 3 the automatic fill up shoe is ready to be lowered into the well hole 10.

FIGURE 4 shows the second step in the sequence of operation that is, where the automatic fill up shoe 16 is being lowered into the liquid of the well hole. The pressure of the liquid against the secondary or lower valve assembly 26 forces the valve 26 to open and allows fluid to flow into the casing at the percentage rate desired, this being governed by the selection of spring 46. After the casing is lowered a sufficient distance into the well hole 10, the fluid continues to flow into the casing until the buoyancy pressures are balanced. Accordingly, this means that the casing 14 is continually being filled with liquid while new strings of casing are being put on above ground.

In FIGURE 5 the third step in the sequence of operation is depicted whereby internal pressure is generated. An additional part has been added namely; the bottom wiper plug 84. This bottom wiper plug is a cylinder of resilient material, for instance a proper grade rubber either natural, synthetic or a combination of both. It has a plurality of circumferential ribs 86 on its outside surface with the ribs facing upwardly so that the plug may slide downward in the well casing but cannot move upward since the ribs will tend to reverse themselves and will bind very tightly against the inside surface of the well casing. Breakable gate 88 extends across the upper (or the lower) end of the cylinder plug and is adapted to rupture along one slightly weakened edge 89 in response to the application of a pressure level above a certain design level.

The final or upper cementing plug 90 is adapted to be inserted in the casing after insertion of the wiper plug 84. The cementing plug 90 is made of the same material as wiper plug 84 and is quite similar in shape. It has a cylindrical side wall 92 and a plurality of circumferential ribs 94 that face upwardly for the same reason as the upwardly sloping ribs 86. A wall 96 extends transversely across the bottom of the cementing plug 90 and has a dome shape for strength of construction.

Referring now again more explicitly to FIGURE 5 and the third illustrated step in the sequence of operation, when the fluid in the casing is at the static level and the fill up shoe is lowered the full desired extent, e.g., on the bottom of the well hole or very near to the bottom thereof, the wiper plug 84 is placed in the well casing and is ready for a wiping and cementing run. When the plug 84 is pushed down in the casing pressure will build up on the top of the liquid in the well casing and when this pressure reaches the static pressure, the secondary or lower valve assembly 26 is forced to the closed position. It is repeated that the gate 88 has a special thick and thin section. At this time the casing is ready for the circulation, wiping and/or cementing operations.

For these reference is made to FIGURES 6 and 7 with FIGURE 6 showing what happens when, for instance, cement is applied under pressure to the top part of bottom plug 84 by the upper cementing plug 90. The force of the cement 98 pushes the plug 84 down with the pressure exerted through the valve assembly 52 reacting on the lower valve assembly 26 and discharging it from the bottom of the shoe 16 by breaking the shear pin 30. This discharging of the lower valve assembly 26 is accomplished by internal pressure exerted either directly on the fluids in the casing or on the top of the plug 84. When the internal pressure within the casing exceeds a design level, for instance 250 p.s.i. the special shear pin 30 is sheared to blow off the lower valve assembly and this allows fluid to flow from within the casing to the outside of the same succeeding, of course, the opening of gate 88, with the fluids flowing to the outside of the casing and ultimately to return to the fluid tanks or pits.

It is noted that when the bottom plug 84 has reached the fill up shoe 16 and has been stopped or seated on the top of the valve seat 62, the gate will be forced open by internal pressures exerted either directly on the fluids or cement or on the top plug and having been opened by being torn away or by being ruptured. The gate remains hinged in the open position for clear and easy flow of fluid and/or cement, and the gate cannot and does not enter into the valve assembly that is, either the lower or upper valve assembly in the shoe 16 thereby assuring a successful cementing job.

FIGURE 7 shows the top plug 90 fully seated on the top part of the bottom plug 84 and the released valve assembly 26. More important, this view shows valve assembly 52 in the closed position thereby creating a positive leak proof seal with the releasing of the pump pressure on the well casing. This closed condition of valve 52 was accomplished and assisted by the heavier weight factor of the cement outside of the casing tending to re-

turn into the casing from the bottom and being opposed by the lighter weight of the fluid inside the casing and with the added assistance of the upper spring on the valve stem above the valve body. Undercut **80** is of special significance since additional openings or passages may be made in the shoe at this point, this shown as a modification in FIGURE 12. Further the action of valve **52** is important. The outer edge portion flexes under a smaller pressure than the thicker center portion so that in moving to the position in FIGURE 7, the outer edge portion flexes gradually and seals against the surface of bore **76** with a force which increases with pressure from below valve **52**. Note that the diameter of valve **52** in the relaxed position (FIG. 3) is slightly larger than the diameter of bore **76**.

In FIGURES 16 and 17 there are two modifications to supply additional strength where deemed necessary, in the wiper plug **84***a* and in the cementing plug **90***a*. The cementing plug has a ceramic and/or metal insert **102** in the shape of a cup to reinforce the dome shape transverse wall **96***a*. Wiper plug **84***a* has a ceramic and/or metal sleeve **104** fitting flush against the inside surface of the side wall thereof. Either of the metal reinforcing parts, that is, wall **102** or sleeve **104** may be adhered to the inside surfaces of the plugs or embedded in the rubber or rubber-like material from which these plugs are constructed.

FIGURE 14 partially illustrates an automatic fill up or float shoe **16***a* with the valve elements thereof removed, which differs from but serves the identical purpose as the body part of shoe **16** by the inclusion of an O-ring **106** at the juncture of valve seat **62***a* (having passages therein not shown) and the small inwardly directed shoulder **108** against which the valve seat bears when the valve seat **62***a* is threaded tightly in place within the body of the shoe **16***a*. This small inwardly directed wall **108** is above the undercut **80***a* and has a cylindrical inner surface **76***a* to serve the same purpose as the surface **76** in, for instance, FIGURE 3.

FIGURES 11 and 12 show simplified forms of the invention. The wiping and cementing plugs and the general shape of the shoe are the same as those described in detail. There is however, only one valve assembly **110** and this is exceedingly similar, if not identical, to the upper valve assembly **52** in the more complex shoe **16**. Instead of the lower valve assembly, FIGURE 11 illustrates a plurality of passages **112** which may be of any cross sectional shape, directly in the bottom part of shoe **16***b*. FIGURE 12 has passages **114** at a small angle to the vertical axis of the drill casing instead of passages **112**. The passages **114** open into the undercut or enlarged chamber portion of the shoe as alluded to previously.

The shoes **16***b* and **16***c* of FIGURES 11 and 12 are reverse jet action float shoes that are placed on the lower end of the drill casing before entering the liquid in the well hole. Before entering, the valve element **120** of the valve assembly in FIGURE 11 or 12 (both valve assemblies being identical in construction and function) are in the open position. However, valve assemblies **110** have their valve elements in the open position by the pull of gravity. As soon as the liquid in the well hole contacts the valve **110**, the valve will be positively closed. The jet action float shoe **16***c* is designed to set on top of a cored hole illustrated in FIGURE 12 for the purpose of preventing the pumping of cement into a pay strata shown in communication with the cored hole in FIGURE 12. The external configuration and ribs on the outside of the shoe **16***b* and **16***c* is such that the shoe passes easily through the well fluids when lowered into them and has excellent centering and seating conditions when it is finally in place (FIG. 12) in a cored hole. The jet action float shoe is primarily designed for shallow well producers of low pressure oil bearing sands, and the float shoe is equally adaptable for surface casing setting.

As the shoes **16***b* and **16***c* are lowered, the downward movement must be accompanied by the application of additional liquid applied into the well casing. Since the valve element **120** promptly closes as soon as the shoe engages the liquid in the well hole, the application of liquid must be made from above, as opposed to the liquid entering the shoe **16**. When the static level is reached, valve element **120** remains closed and then the plugs are inserted in the same manner as the plugs that have been described in connection with the embodiment of FIGURE 3. Instead of blowing off the lower valve assembly, which does not exist in the embodiments of FIGURES 11 and 12, the cement is forced past the feathered edges of the valve element of valve assemblies **110** and through the passages that the now open valve assembly **110** exposes when the plugs are sequentially lowered into the well casing.

After the top plug becomes seated as shown in FIGURES 11 and 12, the bottom plug is firmly pressed against the valve seat of valve assemblies **110**, and the pressure from an externally located pump (not shown) is relieved from above the cementing plug. The pressure inside the well hole and on the exterior of the well casing tends to return the cement up through the passages in the shoes **16***b* and **16***c*. This pressure is greater than the pressure in the casing and above the valve assemblies **110**. Therefore the valve elements **120** will close due to the unbalance in pressure and form a tight effective seal. Therefore the greater the pressure on the exterior of shoes **16***b* and **16***c* the greater will be the tendency for the valve assemblies **110** to close or retain a closed position.

FIGURE 15 illustrates a female to female automatic fill up float collar which may be installed in the drill string but which functions almost identical to the automatic fill up or float shoe **16**. The internal construction having an upper valve assembly **52***d* and a lower valve assembly **26***d* is disposed in the fill up float collar **16***d* to operate in precisely the same way as described in detail in connection with FIGURES 3–7. The only difference is that the automatic fill up float collar is not actually a shoe and may be installed anywhere in the drill casing line or may accommodate different shapes of heads at one end and be attached to the lowermost casing section at the upper end. FIGURE 13 illustrates a collar **130** which shows how the jet action float shoe **16***b* or **16***c* may be made as a float collar including an integral valve seat, said collar being adapted to be threadably connected to a string of casing **14** in place of shoe **16***b* or **16***c*, a lower casing string then capable of being threaded onto the lower outer threaded portion of collar **130**. Only the body portion of the float collar of FIGURE 13 is shown because the valve will be identical to the valve element **120**. Furthermore, all fittings, parts and shoes and collars may be made in different dimensions or may be made as adapted for female or male connections.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. A well completion tool adapted to be connected with a well casing disposed in a well hole, said well completion tool comprising a body, normally open valve means mounted in said body having a resilient valve element movably mounted relative to a valve seat mounted in the body, means for normally holding said valve means open, said valve seat having at least one passage that is opened and closed by said valve element, a valve stem operatively connected to said valve element, said valve seat having an opening through which said valve stem is passed and having a valve seat surface through which said passage opens, said valve element having a thickened center part and a reduced thickness peripheral part, said thickened center

part adapted to be disposed on said valve seat surface when said valve is closed, and said body having a cylindrical wall engageable by the peripheral part of said valve element to limit movement thereof.

2. The combination of claim 1, wherein said body includes an opening disposed below said valve means through which fluid is adapted to pass, and an undercut chamber with which the opening registers, a lower valve assembly in said body and including a valve seat member removably mounted on said body and a valve member located in said opening engageable with said valve seat member, and resilient means reacting on the last mentioned valve member and the first mentioned valve means and holding said lower valve assembly in a closed position.

3. The combination of claim 2, wherein said resilient means comprises, a spring of a preselected strength carried on said valve stem removably connected to the valve member, said lower valve assembly adapted to be opened by pressure of liquid in the well hole whereby liquid may pass into said undercut chamber of said body at a rate which is predetermined by the selection of strength of said spring, and means for holding said lower valve assembly attached to said valve stem and responsive to pressure

exerted from within the well casing for separating said lower valve assembly from said stem.

4. The combination of claim 2 wherein said peripheral part of said valve element gradually reduces in thickness from the inner part of the valve element to the outer edge of said valve element so that the outer edge portion deflects more easily than the inner portion in response to the application of pressure.

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