

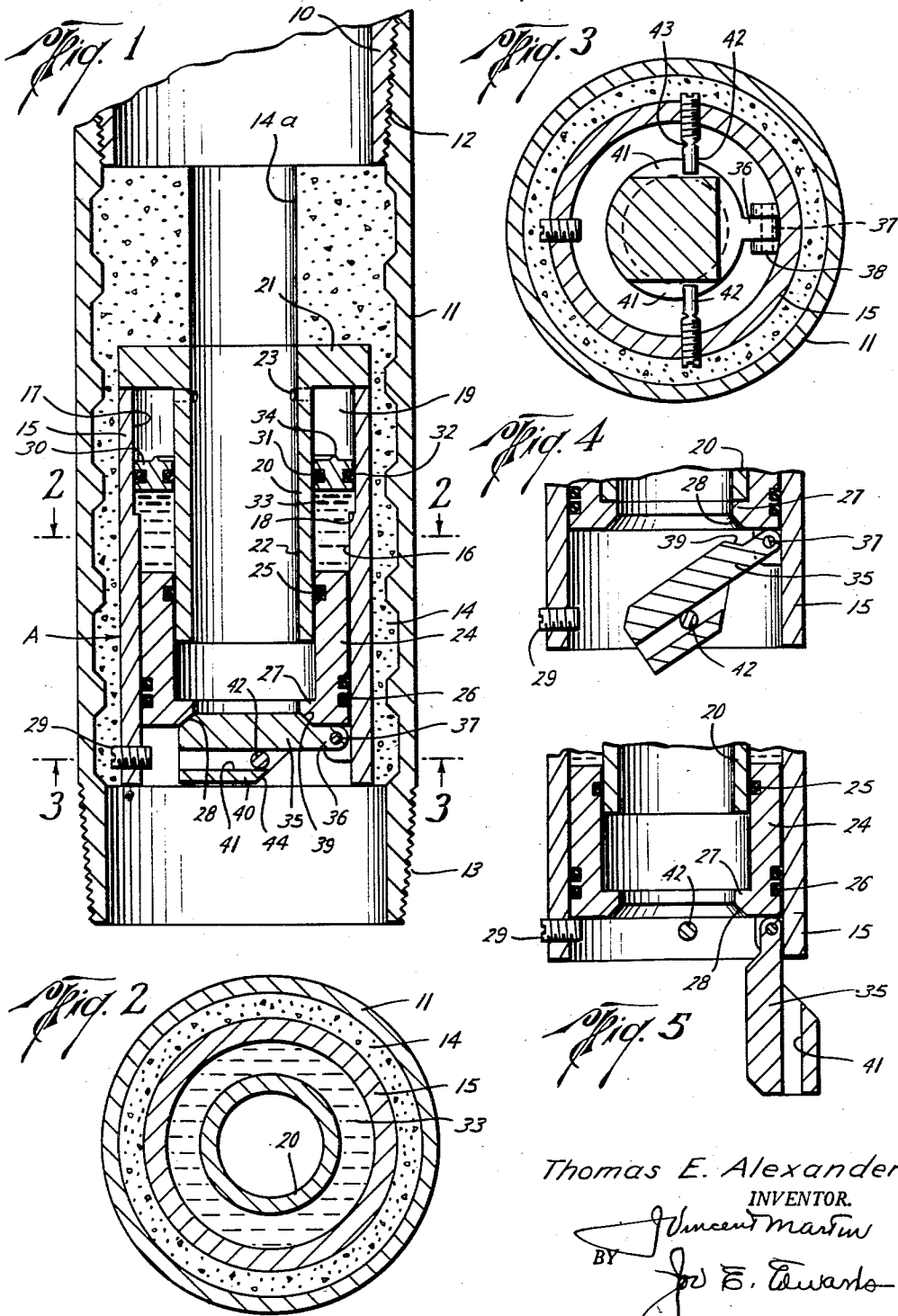
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FLOAT SHOE

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2,931,439

FLOAT SHOE

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This invention relates to new and useful improvements in devices for automatically filling well conduits.

One object of the invention is to provide an improved device for automatically controlling the filling of a string of well casing, or the like, as it is being lowered in the well bore, the fluid level internally of the casing being prevented from rising above a predetermined level which is below the fluid level in the well bore externally of the well.

Various types of devices for controlling the filling of well casing have come into general use and employ valves which are operated by the pressure differential thereacross. One such type of device is illustrated in the patent to Baker, No. 2,717,647, wherein a tubular valve member presenting different areas at its upper and lower ends is actuated by the differential in pressure acting upon said ends. However, in order to assure actuation by the pressure differential it is necessary that the exterior of the valve member and the inner surface of the housing in which the member is slidable be shouldered or stepped with suitable sealing means being provided between said member and housing. This arrangement results in an annular space between a portion of the valve member and its housing which is necessarily at substantially atmospheric pressure. When the device is lowered into the well, the interior of the tubular valve, as well as its ends, are subjected to the well pressures and to the relatively high hydrostatic head pressures of the fluid within the well. However the annular space surrounding a portion of the valve is at substantially atmospheric pressure and this condition produces an excessive differential across the sealing means on the exterior of the valve member which may cause leakage; further, the lesser pressure surrounding a portion of the member with the higher pressure acting internally thereof, may result in an outward or radial distortion or expansion of the member to such an extent that free movement of the member within its housing is interfered with.

It is, therefore, an important object of this invention to provide a device, of the character described, which employs a tubular or sleeve-like valve member but which is so constructed that detrimental and undesirable pressure differentials interiorly and exteriorly thereof are eliminated and also excessive pressure differentials across the sealing elements of the valve member are not present.

Another object is to provide a device for controllably filling a well casing, wherein a tubular valve member, having its wall of a substantially constant, effective cross-sectional area, is movable within a housing and is arranged to co-act with a valve seat to control flow into the well casing; the device also including a novel force-transmitting assembly which is associated with one end of the valve member and which functions in co-operation with the member to control the position thereof in accordance with the differential in pressures interiorly

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and exteriorly of the casing to control filling in a desired manner.

A further object is to provide a device of the character described, wherein the upper end of the tubular valve member is slidable within an annulus, with said annulus having an enlarged upper end within which a force-transmitting element of larger cross-sectional area than the valve member is reciprocable; that portion of the annulus between the upper end of the valve member and the lower end of the force-transmitting element containing a non-compressible liquid which functions to transmit movement of the member and element to each other, whereby different effective areas may be presented to the pressures interiorly and exteriorly of the well casing without requiring a valve member of varying cross-sectional area which results in the requirement of an air space in surrounding relationship to a portion of the valve member.

A particular object is to provide a device, of the character described, which includes a hinged type valve seat element, together with an improved means for normally maintaining the seat element in position to co-act with the valve member; said seat element being releasable from its normal position by the application of a predetermined pressure so that said seat element may thereafter function as an upwardly closing back-check valve through which a cementing operation may be carried out.

A further object is to provide a seat element which is hinged adjacent the lower end of the valve member and is engaged by disconnectable means connected to the housing, whereby movement of the member within the housing results in a movement of said member relative to the seat element; disengagement of the disconnectable means freeing said seat element to function solely as a hinged back check valve at the lower end of the member.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a longitudinal sectional view of a device, constructed in accordance with the invention and illustrating the valve member in closed position preventing upward flow of fluid into the casing,

Figure 2 is a transverse, sectional view, taken on the line 2-2 of Figure 1,

Figure 3 is a transverse, sectional view, taken on the line 3-3 of Figure 1,

Figure 4 is a partial longitudinal sectional view, illustrating the movement of the valve member with respect to the valve seat element, the latter being in a position connected with the housing, and

Figure 5 is a view, similar to Figure 4, with the valve seat element in released position.

The device constituting the present invention is what is commonly referred to as a casing or cementing shoe or collar and is arranged to be connected near or to the lower end of a string of well casing or pipe 10 which is adapted to be lowered through the fluid within a well bore. It is pointed out, however, that the device may be connected at any desired intermediate point in the casing or pipe so that in such event it may be considered as a casing collar forming part of the string.

As illustrated in Figure 1, the device includes an outer tubular body 11 which has a threaded box 12 at its upper end for connection with the lower end of the casing or

pipe 10. The lower end of the tubular body may be tapered and threaded as illustrated at 13. A valve assembly, generally indicated by the letter "A," is mounted within the tubular body 11 and is secured therein by an annular layer of cementitious material 14, and this material functions to bond or secure the valve assembly A within the body 11. As illustrated, the cementitious material 14 may overlie the upper end of the valve assembly and may be provided with an axial bore 14a. The valve assembly is of the type which will control the entry of fluid from the well bore into the casing or well pipe 10 during the lowering movement, but when the string has been lowered to the desired elevation in the well bore, the valve assembly can be placed in a condition in which upward flow of fluid into the well casing will be shut off; however, fluid may be pumped downwardly through the casing or pipe to perform a cementing or other operation.

The valve assembly A includes an outer shell or casing 15 which has a bore 16 extending entirely therethrough. The upper portion 17 of the bore of the shell is enlarged in diameter, whereby an internal annular shoulder 18 is formed therein. As illustrated, the lower end of the shell 15 terminates in alignment with the lower end of the cementitious material 14 which is at a point spaced above the extreme lower end of the outer body 11.

Co-acting with the shell 15 to form an annular space or chamber 19 which will hereinafter be referred to as an annulus 19 is an inner sleeve member 20 and as illustrated this sleeve is provided with an annular flange 21 at its upper end which overlies and rests upon the upper end of the shell 15; however for convenience of manufacture the flange may be made separately from the sleeve with a suitable interconnection therebetween. The flange as well as the shell are surrounded by the cementitious material 14 so as to maintain the parts in position with respect to each other. The sleeve 20 has an axial bore 22 which is of substantially the same diameter as the bore 14a through the material 14 so that an upward passage through the device is provided. The lower end of the sleeve 20 terminates at some distance above the lower end of the shell 15 as is clearly shown in Figure 1. A plurality of openings or ports 23 extend radially through the sleeve 20 just below the flange 21 and these openings establish a communication between the bore 22 of the sleeve and the upper end of the annulus 19 which is formed between the sleeve 20 and the shell 15.

By reason of the annular shoulder or off-set 18, it will be evident that the annulus 19 is of greater cross-sectional area above said shoulder so that the lower portion of the annulus is in fact somewhat reduced in cross-sectional area. An annular valve member 24 has its upper portion slidable within the lower portion of the annulus 19 and said valve member is movable axially within the annulus. A sealing ring 25 seals between the bore of the valve member and the exterior of the sleeve 20, while sealing rings 26 seal between the exterior of the valve member and the bore of the shell. An inwardly directed flange 27 is formed on the lower end of the valve member and is provided with a bevelled seating surface 28 on its under side. The flange functions to limit the upward movement of the valve member 24 by engagement with the lower end of the sleeve 20; downward movement of the valve member is limited by a stop screw 29 which is suitably secured within the lower portion of the wall of the outer shell 15.

The effective cross-sectional area of the valve member 24 is substantially the same at its upper and lower end and, as has been noted, its upper end is slidable within the reduced lower portion of the annulus 19. Movable within the upper portion of the annulus 19, which is of larger cross-sectional area, is an annular piston or collar 30. Sealing rings 31 and 32 mounted on the piston seal with the walls of the sleeve 20 and shell 15. Since the piston or collar 30 is disposed within the larger upper

portion of annulus 19, it has an effective cross-sectional area which is greater than the effective cross-sectional area of the valve member 24. Confined between the piston 30 and the upper end of the valve member is a suitable liquid 33 which may be oil or some other non-compressible fluid. Since the openings or ports 23, which extend through the upper end of the sleeve 20, communicate with the upper end of the annulus 19, it is apparent that the upper surface of the piston or collar 30 is exposed to the pressure within the bore of the sleeve 20, which, as has been stated, is in communication with the bore of the well casing or pipe 10 in which the device is connected. To assure that the pressure interiorly of the well casing will act upon the piston or collar 30 at all times, the upper surface of the piston or collar is provided with an annular projection 34 which, when the piston is in its fully raised position, will engage the under side of the flange 21 of the sleeve 20, and will prevent the upper surface of said piston from sealing with the under side of the flange. Any pressure acting upon the upper surface of the piston 30 will be transmitted through the liquid 33 to the upper end of the valve member 24; similarly, any pressure acting against the under side of the valve member 24, which would tend to urge the valve upwardly, will be transmitted through the liquid 33 to the under side of the piston 30 and will tend to slide the same in an upward direction.

Secured to the lower end of the valve member 24 is a valve seat element 35. This element is generally circular in shape and is provided with an extension or mounting lug 36 which is located at one radial point and this lug is adapted to be pivoted on a pin 37 between supporting ears 38 (Figure 3), whereby the valve seat element is hinged to the lower end of the valve member, the supporting ears 38 being suitably secured or formed integral with said valve member. The element 35 is formed with an annular surface 39, which is engageable with the seating surface 28, at the lower end of the valve. Since the element 35 is pivoted at 37 to the valve member 24, it will be apparent that upward movement of the valve member will result in an upward movement of the lug 36, which will tend to move the seat element upwardly with the valve member.

In order to disengage the seating surface 28 of the valve member 24 from the co-acting surface 39, upon an upward movement of the valve member, the valve seat element 35 is formed with longitudinal grooves 41 provided in opposite sides of a portion 40 of the valve (Figure 3). Engaged within each groove 41 is a restraining pin 42, each pin having its outer end threaded through the outer shell 15 of the valve assembly. With the pins 42 engaged within their respective grooves, as shown in Figure 3, an upward movement of the valve member, which will result in an upward movement of the hinge pin 37 will cause the valve seat element 35 to be swung in the manner shown in Figure 4. At this time the retaining pins 42 will prevent upward travel of the valve seat element 35 but will permit a swinging movement thereof because the pins will in effect move along their respective grooves 41. Therefore, so long as the pins 42 are engaged with the grooves, an upward movement of the valve member 24 will result in an unseating of the valve member from the seat element and will allow a flow through the bore of the valve assembly.

The restraining pins 42 are capable of being fractured or broken, and if desired, may be provided with annular grooves 43 which will facilitate fracture at this point. By applying a downward pressure from within the well casing or pipe against the valve seat element, the valve member having the valve seat element secured thereto is urged downwardly. The application of pressure against the valve member and against the seat element to a predetermined degree will result in fracturing or breaking the connecting pins 42 and thereafter the valve seat element 35 may be swung downwardly in the manner shown

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in Figure 5. Thereafter, the seat element is merely hinged at 37 to the valve member and will function as a back check valve to prevent upward flow into the casing or pipe string. If desired, a spring (not shown) may surround the hinge pin in the usual manner and may urge the seat element toward a closed position. However, any pressure below the valve member and seat element will function to move the seat element to a closed position. It is noted that the extension 40 on the lower surface of the seat element may have an inclined or bevelled end as indicated at 44, and when the valve swings to an open position as shown in Figure 5, the bevelled surface is disposed below the lower end of the shell 15. With this arrangement any upward movement of the valve member 24 within the annulus will cause this bevelled surface 44 to engage the lower end of the shell and this will result in moving the element 35 into the path of the pressure. Therefore it is assured that the valve seat element 35 will move to a closed position.

The operation of the device is believed obvious from the foregoing. The parts are in the position shown in Figure 1 and the device is connected to the well casing or pipe which is to be lowered into the well. The lower end of the valve member 24 is being acted upon by the pressure of the fluid which is present in the area outside of the well casing or pipe and this pressure is urging the valve member to a raised position so that the upper portion of the valve member is being urged upwardly within the annulus 19. At the same time the pressure within the well casing or pipe is acting through the ports 23 against the upper surface of the piston or collar 30 and is urging the collar downwardly. The forces applied to the upper surface of the piston, which is of a larger cross-sectional area than the effective cross-sectional area of the valve member 24, are transmitted downwardly through the liquid 33 to the valve member; at the same time the upward forces acting against the valve member are also transmitted through the liquid to the piston or collar. By controlling the areas of the piston or collar 30 and the effective cross-sectional area of the valve member 24, a desired operation of the valve assembly may be accomplished.

Assuming that the pressure exteriorly of the casing or pipe, that is, the pressure acting on the under side of the valve member 24, is sufficiently greater than the pressure acting against the piston or collar, the valve member is moved upwardly within the annulus 19 and such upward movement results in a swinging of the valve seat element 35 in the manner shown in Figure 4. This permits the entry of fluid into the well casing or pipe and entry of the fluid continues until the pressure within the pipe builds up sufficiently to urge the piston or collar 30 in a downward direction against the pressure acting on the valve member. When this occurs the parts are returned to the position shown in Figure 1. This action of the valve continues as the pipe or casing is lowered within the well bore and thus fluid is automatically admitted to the interior of the casing or pipe during the lowering operation. The relationship of the area of the upper end of the piston or collar 30 to the effective cross-sectional area of the tubular valve member 24 will determine just how much fluid is admitted and what the relationship of the fluid column inside the well pipe or casing to the fluid level outside the casing will be.

It might be pointed out that by providing the liquid medium 33 as the force transmitting means between the piston or collar 30 and the upper end of the valve member, the pressure inside the cylinder 19 is always equalized with the pressure outside thereof. In other words, the pressure which would act against the bore of the sleeve 20 would tend to distort this sleeve in an outward direction, but since this same pressure is acting upon the piston 30 and is applied to the liquid 33 in the space between the piston and valve member, the wall of the sleeve 20 is subjected to exactly the same pressure. If there was

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an air space between the piston 30 and valve member, instead of being substantially filled with liquid, a pressure differential across the wall of the sleeve would be present and there would be a tendency for the sleeve to be distorted radially outwardly so as to cause a binding of the movement of both the piston and the valve member within the annular cylinder. Furthermore, because of the same forces being present on each side of the piston at all times, the sealing rings 31 and 32 of the piston are never subjected to a pressure differential thereacross. With respect to the seals 25 and 26 on the valve member, the maintenance of the pressure in the area between the upper end of the valve member 24 and the lower surface of the annular collar 30 reduces or minimizes the pressure differential which will be present across these seals under all operating conditions.

After the device has been lowered to the desired position, within the well bore, a pressure may be built up within the well casing or drill pipe and this pressure will be directly applied to the valve seat element 35. Through this element the pressure is transmitted to the frangible pins 42 and upon these pins being fractured, the valve seat element 35 is released for actuation as a back check to prevent upward flow of fluid into the well casing or pipe. It is noted that when the pins 42 are engaged within their respective grooves 41, in the valve seat element 35, these pins function as the downward limit of movement of the annular valve member 24. However, after these pins have been fractured, the downward movement of the valve member 24 is limited by the stop 29 (Figure 5). After the valve seat element 35 has been released, it may fall to the position shown in Figure 5 if the pressure within the pipe is greater than that below the assembly, and therefore a free downward flow of fluid may occur. In the event of a build up of a greater pressure below the assembly, the valve seat element 35 will be swung upwardly to engage the seating surface 28. As explained, this movement of the valve seat element would be assisted by the bevelled or inclined surface 44 striking the lower end of the shell 15 as the valve member 24 began to move upwardly. The co-action between this inclined surface and the lower end of the shell would swing the valve seat element into the path of the pressure and would assure closing. However, if desired, a small spring could surround the pin 37 which would tend to constantly urge the seat element toward a closed position.

The liquid 33 which is disposed between the piston or collar 30 and the upper end of the tubular valve member 24 may completely fill this space. However, if desired, a slight air space could be provided. The provision of a slight air space between the upper surface of the liquid 33 and the under surface of the piston or collar 30 would result in a slower opening of the tubular valve member 24 because pressure acting against the under side of the valve would have to move upwardly a sufficient distance to first compress the slight amount of air before any upward movement would be accomplished to move the piston or collar 30 upwardly within the annulus. Of course, after the valve once opens, the operation would be identical.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What I claim is:

1. A device for controlling the filling of a well pipe including a tubular body having a valve assembly therein comprising, a tubular member having a bore therethrough, an annulus within said tubular member surrounding said bore and having an open lower end and a closed upper end, a tubular valve member having its upper portion reciprocable within the lower portion of

the annulus, means limiting the movement of said valve member with respect to the annulus, a valve seat element within the tubular member and below the valve member, said valve member being movable relative to the valve seat element to control flow through the tubular member, an annular piston reciprocable within the upper portion of the annulus, a liquid within the annulus between the piston and the upper end of the valve member, the lower end of the valve member having an effective pressure area exposed to the pressure of the fluid below the body, and port means establishing communication between the interior of the tubular member and that area of the annulus above the piston whereby the upper effective area of the piston is exposed to the pressure of the fluid within the well pipe, said upper effective area of the piston being greater than the effective pressure area of the lower end of the valve member.

2. A device as set forth in claim 1 together with means for pivotally securing the valve seat element to the valve member, and means for releasably securing said valve seat element to the tubular member whereby upward movement of the valve member causes a swinging of the valve seat element to disengage the valve member from said seat.

3. A device as set forth in claim 1, together with means for pivotally securing the valve seat element to the valve member and means for releasably securing said valve seat element to the tubular member whereby upward movement of the valve member causes a swinging of the valve seat element to disengage said member from said seat, the releasable securing means for the valve seat element being disconnected by application of downward pressure thereto, whereby said valve may subsequently function as a back check preventing upward flow through the tubular member.

4. A device of the character described comprising, a tubular body, a tubular casing axially mounted in the body, a cylindrical sleeve mounted axially within the casing and spaced from the internal wall thereof, the annular space between said tubular member and sleeve forming an annulus open at its lower end, a tubular valve member having its upper end slidable between predetermined limits within the lower portion of the annulus, a valve seat within the casing below the valve member and engageable by the lower end of the valve member to close off flow through the sleeve, disengagement of said valve member from the valve seat allowing flow through the sleeve, an annular piston within the upper portion of the annulus, a liquid between said piston and the upper end of the valve member, and port means for establishing communication between the interior of the sleeve and the upper end of the annulus above the piston so that the upper surface of the piston is exposed to the pressure of the fluid within the sleeve, the lower end of the valve member being exposed to the pressure of the fluid below the body, said piston, liquid and valve member being movable with respect to the valve seat by the pressures acting upon the surface of said piston and the lower surface of said valve member.

5. A device as set forth in claim 4 wherein the effective pressure area of the upper end of the piston is greater than

the effective pressure area of the lower end of the valve member.

6. A device for automatically filling well conduits including, a tubular body adapted to be secured to a conduit section to be disposed in a well bore and having a valve assembly therein comprising, a tubular member having a bore therethrough, a valve seat in the lower portion of said bore in the tubular member, said tubular member having an annulus formed therein, which annulus is spaced upwardly from said valve seat, the upper portion of said annulus being of a larger cross sectional area than the lower portion thereof, an annulus valve member having its upper portion slidable within the lower end of the annulus and movable relative to the valve seat to open or close off flow through the tubular member, the lower end of the annular valve member being exposed to the pressure of fluid below the body, a force-transmitting element slidable in the upper enlarged portion of the annulus, a liquid in said annulus between said element and the upper end of the annular valve member, and port means conducting the pressure of the fluid above the tubular member within the conduit against the upper surface of the force-transmitting element.

7. A device for automatically filling well conduits including, a tubular body adapted to be secured to a conduit section to be disposed in a well and having a valve assembly therein comprising, a tubular member, said tubular member having a bore therethrough, a valve seat mounted in the lower portion of the bore and extending part way thereacross, said tubular member having an annulus formed therein which is spaced upwardly from said valve seat, an annular valve member having its upper portion slidable within the lower end of the annulus and movable relative to the valve seat to open or close off flow through the tubular member, an annular piston slidable within the upper portion of the annulus and having an effective cross sectional area larger than the effective cross sectional area of the lower end of the tubular valve member, and a liquid within said annulus between the upper end of the valve member and the lower end of the piston for transmitting movement from one to the other, the lower end of the valve member being exposed to the pressure of the fluid below the body, and port means in the upper portion of the tubular member and establishing communication between the bore above the valve seat and the annulus above the piston.

8. A device as set forth in claim 7 together with a pressure seal means carried by the valve member for sealing between the walls of the annulus and the surfaces of the valve member, and additional seal means on said piston for sealing between the piston and the annulus.

References Cited in the file of this patent

UNITED STATES PATENTS

2,592,325	Otis et al.	Apr. 8, 1952
2,630,178	Brown	Mar. 3, 1953
2,642,140	Brown	June 16, 1953
2,717,647	Baker	Sept. 13, 1955
2,812,820	Nelson	Nov. 12, 1957
2,812,821	Nelson	Nov. 12, 1957