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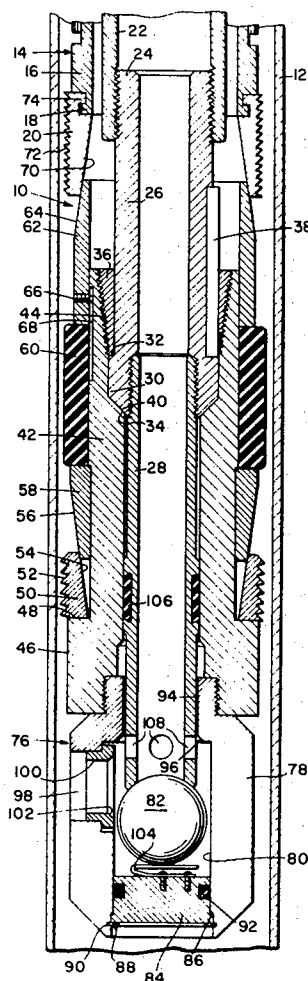
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[54] **CEMENT RETAINER VALVE FOR WELL
PACKERS**
8 Claims, 2 Drawing Figs.

[52] U.S. Cl..... **166/128,**
166/133, 166/226
[51] Int. Cl..... **E21b 23/00,**
E21b 33/12
[50] Field of Search..... 166/128,
133, 226

ABSTRACT: A cementing valve that is used in conjunction with well packers. The cementing valve includes a valve member that functions automatically to prevent the movement of fluid from within the packer into the well bore and to prevent the movement of fluid from the well bore into the packer. The cementing valve also includes an elongated hollow stinger member that extends through the packer for engagement with the valve member. The stinger member when engaged with the valve member, holds the valve member in an open position permitting fluid flow through the valve whereby cementing of the well can be accomplished.



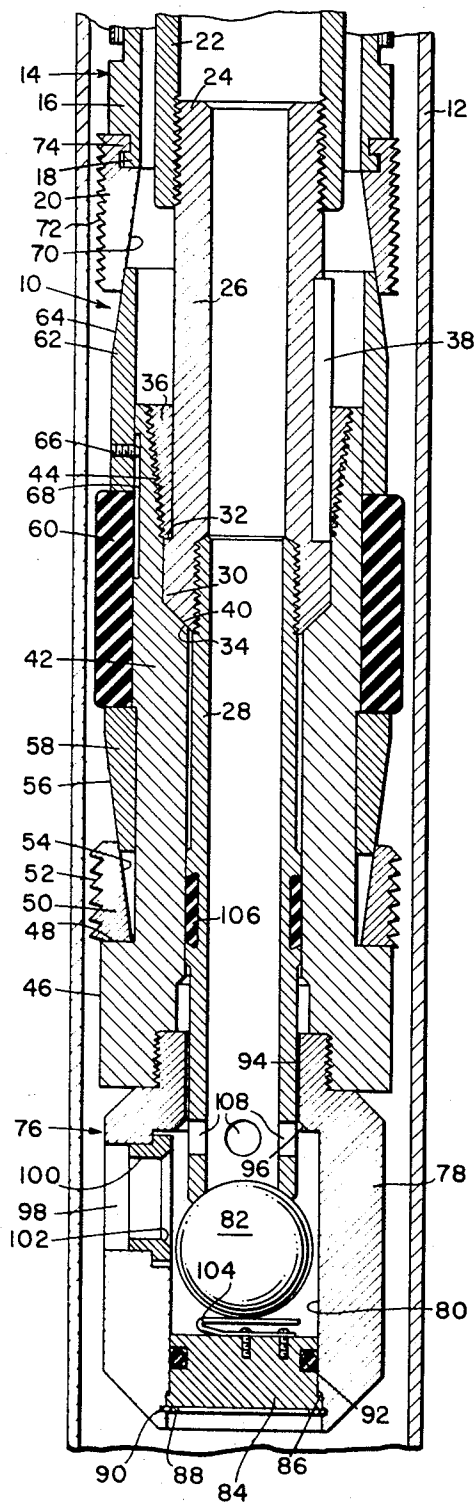


FIG. 1

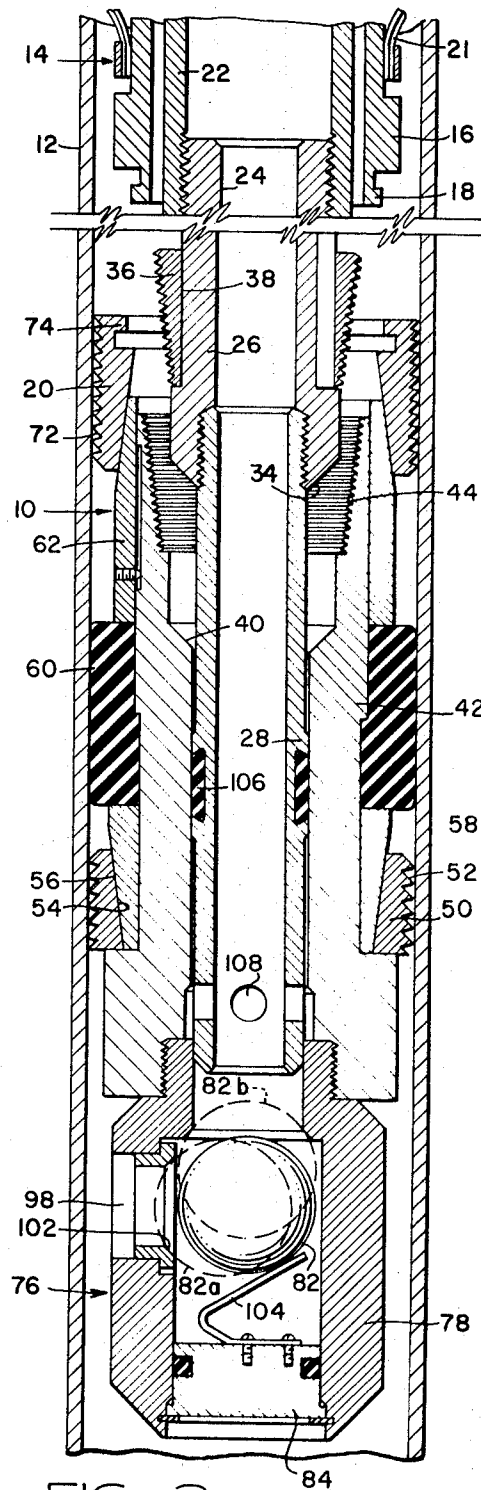


FIG. 2
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CEMENT RETAINER VALVE FOR WELL PACKERS

BACKGROUND OF THE INVENTION

One type of cementing valve previously constructed was of the balanced, sleeve-type construction illustrated in the U.S. Pat. No. 3,306,363 issued to H. W. McZilky, Jr. on Feb. 28, 1967. While this type of valve has performed satisfactorily, problems have arisen in its use. The valve illustrated in the McZilky patent is actuated by collet fingers located on the upper end of the sleeve valve that are engageable with a stinger inserted through the interior of the packer. Since the valves are used primarily in cementing operations, viscous slurry is generally pumped through the valve. The viscous slurry sometimes causes the sleeve valve to stick in the open position so that it requires a force to close the valve that exceeds the force capable of being transmitted through the collet fingers. When this occurs, the sleeve valve remains in the open position and high pressure in the well below the packer and valve can force cement upwardly through the valve into the interior of the packer.

Cementing valves are generally run into the well bore in the open position, that is, with the sleeve valve member in the lower position, and then moved to an upper or closed position to permit pressure testing of the tubing string prior to the cementing operation. In the sleeve-type cementing valves, deleterious materials accumulate in the lower portion of the valve body below the valve member during the testing of the tubing string and sometimes prevent movement of the valve member from the upper, closed position to the lower, open position.

SUMMARY OF INVENTION

This invention provides apparatus for use in a well bore that includes a packer having packing means thereon sealingly engaging the well bore wall, retaining means thereon engaging the well bore wall to prevent movement of the packer in the well bore and having a hollow mandrel extending through the packer. The improvement comprises an elongated hollow stinger member that extends through the mandrel; connection means releasably connecting the mandrel and stinger member, seal means encircling the stinger member and forming a fluid-tight seal between the mandrel and stinger member, and a hollow valve housing connected to the lower end of the mandrel. The valve housing has a first opening arranged for receiving one end of the stinger member, a second opening extending through the wall thereof and first and second valve seats encircling the first and second openings, respectively. A valve member is movably disposed in the housing and is engageable with the stinger member. The valve member is engageable with the first seat or second seat to prevent flow through the first or second opening, respectively, when the valve member is out of engagement with the stinger member. When the stinger member is in engagement with the valve member, the valve member is held out of engagement with the first and second seats permitting fluid flow through the valve housing.

Thus, this invention provides improved apparatus for use in a well bore having a valve thereon containing a valve member that is movable manually and retained in a position wherein flow can occur therethrough in either direction.

Another object of the invention is to provide an improved valve for use with a well packer in a well bore that includes a valve member that is moved by fluid flow into sealing engagement with the valve housing to prevent flow through the valve in either direction.

Another object of the invention is to provide an improved cementing valve for use with a well packer in a well bore that automatically closes to permit pressure testing of the tubing string connected with the packer.

Another object of the invention is to provide an improved cementing valve for use with a well packer that is positively moved to and retained in the open position.

Still another object of the invention is to provide an improved cementing valve for use with a well packer that auto-

matically closes to prevent fluid flow therethrough as a result of a differential in pressure across the packer either from above or from below.

The foregoing and additional objects and advantages of the invention will become more apparent as the following detailed description is read in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a well packer disposed in a cased well bore. Attached to the lower end of the packer is a cementing valve constructed in the accordance with the invention.

FIG. 2 is a cross-sectional view similar to FIG. 1, but illustrating the packer in the set condition in the well bore and the cementing valve in another operating position.

DISCLOSURE OF A PREFERRED EMBODIMENT

Referring to the drawings and to FIG. 1 in particular, shown therein and designated generally by the reference character 10 is a packer assembly disposed in a casing 12. In the normal use of the apparatus, the casing 12 is disposed in a well bore (not shown).

During lowering of the packer assembly 10 into the casing 12, the packer assembly 10 is connected at its upper end to a setting device 14. The setting device 14 includes an outer sleeve 16 that is interconnected by a radial flange 18 with upper slips 20 of the packer assembly 10. Drag springs 21 (see FIG. 2) carried on the exterior of the setting device 14 frictionally engage the casing 12. A tubing string 22 extends through the setting device 14 and is releasably connected therewith by threads (not shown) or by a J-slot and pin arrangement (not shown) so that the tubing string 22 can be moved relative to the sleeve 16 of the setting device 14. The tubing string 22 extends from the packer assembly 10 to the surface of the well.

The stinger 24 includes an upper portion 26 that is threadedly connected at its upper end with the tubing string 22 and at its lower end with a lower portion 28. The lower end of the upper portion 26 has an outwardly extending flange 30 providing an upwardly facing shoulder 32 and a downwardly facing shoulder 34.

A threaded nut 36 encircles the upper portion 26 of the stinger 24 and is slidably located thereon. To prevent relative rotation between the nut 36 and the upper portion 26, one or more splines or keys 38 extend longitudinally of the stinger 24 in engagement with both the exterior of the stinger 24 and with the nut 36. The downwardly facing shoulder 34 of the upper portion 26 engages an upwardly facing interior shoulder 40 that is located on the interior of a mandrel 42 that also extends through the packer assembly 10.

The interior of the mandrel 42 above the upwardly facing shoulder 40 includes female threads 44 that are arranged to receive the threaded nut 36 carried by the stinger 24. The threaded nut 36 and the threads 44 releasably interconnect the stinger 24 with the mandrel 42 of the packer assembly 10. Preferably, the threads 44 and the mating threads on the nut 36 are left-handed so that right-hand rotation of the stinger 24 and nut 36 disengages the nut 36 from the mandrel 42.

An outwardly extending flange 46 encircles the lower end of the mandrel 42 providing an upwardly facing surface 48 that engages the lower slips 50.

The lower slips 50 are provided with teeth 52 on the exterior thereof. The teeth 52 are arranged to bite into the casing 12 wherein engagement with the casing 12 prevents movement of the packer assembly 10 therein. A tapered surface 54 on the interior of the lower slips 50 slidably engages a mating outer tapered surface 56 on a lower expander 58.

The lower expander 58 slidably encircles the exterior of the mandrel 42 and has its upper end abutting an annular sealing member 60. The sealing member 60 is illustrated as being constructed from a single piece of resilient material, such as a

natural, or synthetic rubber or the like, but it may be constructed from a stack of alternating metallic and resilient rings as is well known in the packer art.

The upper end of the sealing member 60 engages an upper expander 62 having an outer tapered surface 64 thereon. A pin 66 extends through the upper expander 62 into a slot 68 formed in the exterior of the mandrel. The pin 66 limits the travel of the upper expander 62 and prevents relative rotation between the mandrel 42 and the upper expander 62. The pin 66, moving axially in the slot 68, permits the upper expander 62 to slide axially with respect to the mandrel 42 to deform the sealing member 60 into sealing engagement with the casing 12.

As clearly shown in the drawing, the tapered surface 64 on the upper expander 62 mates with a tapered surface 70 on the interior of the upper slips 20. The upper slips 20 are provided with exterior teeth 72 that holdingly engage the casing 12 to prevent movement of the packer assembly 10 therein. Preferably, the teeth 52 on the lower slips 50 and the teeth 72 on the upper slips 20 are oriented in relatively opposite directions to provide a holding force to prevent movement of the packer assembly 10 in either direction in the casing 12. The upper slips 20 have inwardly projecting shoulders 74 that engage the annular flange 18 on the setting device 14 when the packer assembly 10 is being lowered into the well bore.

Threadedly secured to the lower end of the mandrel 42 is a cementing valve generally designated by the reference character 76. The cementing valve 76 includes a valve housing 78 having a bore 80 extending from the lower end thereof, a valve member 82 positioned in the bore 80, and a plug 84 closing the lower end of the bore 80.

The valve member 82 is illustrated as being spherical in shape. Preferably, the valve member 82 is constructed to have a specific gravity that is slightly less than the specific gravity of the liquid being moved through the valve 76. Cement slurry is the usual material with which the valve 76 is used. Since cement slurry normally has a specific gravity greater than water, it has been found that if the valve member 82 has a specific gravity less than 1.2 the valve 76 operates without difficulty.

The plug 84 is secured between a downwardly facing shoulder 86 on the housing 78 and a lock ring 88 that is disposed in an annular groove 90 that encircles the bore 80. A seal ring 92, carried by the plug 84, forms a fluid-tight seal between the housing 78 and the plug 84.

An opening 94 extends through the upper end of the valve housing 78 coaxially with the interior of the mandrel 42. The opening 94 is sized to receive the lower end of the lower portion 28 of the stinger 24. Encircling the lower end of the opening 94 is a valve seating surface 96 that is sized and arranged to sealingly engage the valve member 82.

A second opening 98 extends through the side wall of the valve housing 78. An annular valve seat 100 is located in the opening 98 providing a seating surface 102 that is also sized and arranged to sealingly engage the valve member 82.

As previously mentioned, the lower portion 28 of the stinger 24 extends through the mandrel 42 and through the opening 94 in the valve housing 78. The lower portion 28 is sufficiently long so that the lower end thereof engages the valve member 82, holding it away from either of the openings 94 or 98 when the shoulder 34 on the stinger 24 is in engagement with the shoulder 40 on the mandrel 42.

The valve member 82, when engaged by the stinger 24, depresses a spring 104 that is suitably mounted on the plug 84. The spring 104 is provided to bias the valve member 82 toward, but not into engagement with the seating surfaces 96 and 102 as will be described more fully hereinafter.

The lower portion 28 of the stinger 24 carries an annular seal 106 on its exterior that is in sealing engagement with the interior of the mandrel 42 when the stinger 24 is disposed therein. The lower end of the stinger 24 is provided with one of more ports 108 to permit fluid flow from the interior of the stinger 24 into the valve 76 when the lower end of the stinger is in engagement with the valve member 82 as illustrated in FIG. 1.

OPERATION OF THE PREFERRED EMBODIMENT

To utilize the apparatus hereinbefore described, the tubing string 22, setting device 14, packer assembly 10 and cementing valve 76 are assembled as shown in FIG. 1. The apparatus is then extended into the casing 12 and lowered therein to the position in the well wherein the packer assembly 10 is to be set.

Upon reaching the desired location, the tubing string 22 is manipulated properly to release the connection between the setting device 14 and the tubing string 22. After releasing the setting device 14, the tubing string 22 and the attached packer assembly 10 are elevated by pulling upwardly on the tubing string 22. The drag springs 21, through their frictional engagement with the casing 12, hold the outer sleeve 16 of the setting device 14 and the interconnected upper slips 20 in a fixed position relative to the remainder of the packer assembly 10.

As the tubing string 22 is pulled upwardly, the upper expander 62, which is slidably positioned on the mandrel 42, is raised relative to the upper slips 20. The upper slips 20 are moved radially outwardly due to the engagement between the surface 64 on the upper expander 62 and the surface 70 on the upper slips 20. When the upper slips 20 are moved into engagement with the casing 12, the teeth 72 bite into the casing 12 to retain the upper slips 20 in a fixed position relative to the upper expander 62 and casing 12.

Additional upward movement of the tubing string 22 and the mandrel 42 carries the lower slips 50, lower expander 58, and the sealing member 60 upwardly relative to the fixed upper slips 20. Since the upper end of the sealing member 60 is in engagement with the lower end of the upper expander 62, the upward movement of the lower expander 58 deforms the packing member 60 in a radial direction forcing the outer surface thereof into sealing engagement with the casing 12.

When the sealing member 60 has been deformed, substantially shown in FIG. 2, no further upward movement of the lower expander 58 can occur and the lower slips 50 are forced upwardly and outwardly by the upwardly facing surface 48 on the mandrel 42 and the engagement of the tapered surfaces 54 and 56 on the lower slips 50 and the lower expander 58, respectively. The lower slips 50 continue their upward and outward movement until the teeth 52 securely engage the casing 12. The packing assembly 10 is then in the set condition and the packer assembly 10 cannot move in either direction in the casing 12 and the sealing member 60 thereon is in fluid-tight sealing engagement with the casing 12 as shown in FIG. 2.

The stinger 24 and valve member 82 are positioned as illustrated in FIG. 1 during the movement of the apparatus into the well bore. With the valve parts in the condition shown, fluid enters through the opening 98 in the sidewall of the valve housing 78, passing through the ports 108 in the lower end of the stinger 24 and upwardly therethrough, filling the tubing string 22 as the apparatus is lowered into the casing 12.

After the packer assembly 10 has been set in the well bore, and before the pumping of cement slurry into the well, it is desirable to pressure test the tubing string 22 to be certain that there are no leaks therein. In order to pressure test the tubing string 22, the cementing valve 76 must be placed in the closed position.

To place the cementing valve 76 in the closed position, the tubing string 22 is rotated to the right unscrewing the nut 36, which has left-hand threads thereon, from the threads 44 in the mandrel 42. When the nut 36 is unscrewed, the stinger 24 is free of the mandrel 42 and may be moved relative thereto. The tubing string 22 is then elevated lifting the stinger 24 therewith and moving the stinger 24 to the position shown in FIG. 2.

With the stinger 24 elevated, the spring 104 biases the valve member 82 into the position shown in solid lines in FIG. 2. It will be noted that the valve member 82 is not in the sealing engagement with either of the seating surfaces in the valve housing 78, but is in a position relatively therebetween. It should also be pointed out that if the valve member 82 has a specific

gravity less than the specific gravity of the liquid in the valve, the spring 104 is not necessary since the valve member 82 will float toward the seating surface 96.

Pressure applied to the liquid in the tubing string 22 initiates fluid flow through the interior of the stinger 24, through the opening 94 in the valve housing 78 and outwardly through the opening 98. Since the valve member 82 is located in this flow path, a very small amount of flow will move the valve member 82 into sealing engagement with the seating surface 102, that is, to the position illustrated in dash lines in FIG. 2 and indicated by the reference character 82a. When the valve member 82 seats on the surface 102, fluid flow through the tubing string 22 is stopped and the pressure can be increased in the tubing string 22 to the desired amount for testing.

After the tubing string 22 has been pressure tested, and when the cementing operation is to commence, the tubing string 22 is lowered, moving the stinger 24 downwardly until the shoulder 34 on the lower end of the upper portion 26 engages the upwardly facing interior shoulder 40 in the mandrel 42. In this position, and as shown in FIG. 1, the lower end of the stinger 24 is in engagement with the valve member 82 depressing the spring 104 and positioning the ports 108 in the lower end of the stinger 24 within the bore 80 of the valve housing 78. In this position, the flow path through the valve 76 is reestablished permitting the pumping of the cement slurry through the valve 76.

After the desired quantity of cement slurry has been placed into the casing 12, the tubing string 22 is again elevated, moving the stinger 24 upwardly. If desired, the tubing string 22 can now be removed from the well simply by pulling upwardly thereon. As shown in FIG. 2, the radial movement of the upper slips 20 has disengaged the shoulders 74 thereon from the flange 18 on the lower end of setting device 14. Thus, the upward movement of the tubing string 22 carries the setting device 14 therewith to remove it from the well bore also.

Generally, a differential in pressure will exist across the packer assembly 10 either from above or from below. In either instance, it is necessary to avoid flow or contamination of the cement that would result from the imposition of the differential on the newly deposited cement slurry. As can be readily appreciated, a high differential below the packer assembly 10 would displace the unset cement slurry upwardly through the valve 76 and packer assembly 10 unless some means is provided to prevent such flow. Similarly, if the differential exists from above the packer assembly 10, contaminated fluids could be displaced through the packer assembly 10 and valve 76 into the freshly deposited cement slurry.

When the cementing valve 76 is used, it can be seen that after the stinger 24 has been removed, a differential in pressure existing from above the packer assembly 10 will move the valve member 82 into sealing engagement with the seating surface 102, that is, into the position shown in dash lines in FIG. 2 and indicated by the character 82a. Thus, the valve 76 automatically closes to prevent flow therethrough as a result of such differential pressure.

If the differential in pressure exists from below the packer assembly 10, the valve member 82 is moved upwardly into sealing engagement with the seating surface 96, that is, to the position shown in dash lines and indicated by the reference character 82b. Thus, the valve 76 also automatically closes to prevent the flow of the freshly deposited cement through the valve 76 and packer assembly 10.

From the foregoing detailed description, it can be appreciated that this invention provides a valve that is positively retained in the open position during fill-up of the tubing as the apparatus is lowered into the well bore, automatically closed during pressure testing of the tubing, positively returned open during the cementing operation, and automatically closed to prevent flow through the valve in either direction as a result of a differential in pressure either from above or below the packer assembly 10.

While the cementing valve has been described in conjunction with a particular type of packer, it should be understood that various other types of packers can be utilized therewith. The embodiment described is presented by way of example only and many modifications and changes can be made thereto without departing from the spirit or scope of the invention.

I claim:

1. Apparatus for use in a well packer disposed in a well bore, said packer including packing means sealing by engaging the well bore wall, retaining means engaging the well bore wall to prevent movement of the packer and a hollow mandrel having upper and lower ends extending therethrough, said apparatus comprising:

an elongated stinger member extending through said mandrel;
connection means releasably connecting said mandrel and stinger member;

a hollow valve housing connected to the lower end of said mandrel having a first opening arranged to receive one end of said stinger member, a second opening extending through the wall thereof and first and second valve seats encircling said first and second openings, respectively; and

a valve member movably disposed in said housing and engageable with said stinger member, said valve member being engageable with said first seat or said second seat to prevent flow through said first or second opening, respectively, when said valve member is out of engagement with said stinger member, said stinger member holding said valve member out of engagement with said first and second seats when in engagement with said valve member.

2. Apparatus for use in a well bore comprising:

a conduit extending into said well bore;

a well packer having a hollow mandrel extending therethrough;

an elongated hollow stinger member releasably connected with said mandrel and slidable relative thereto, said stinger member having a first end connected with said conduit and having a second end;

annular seal means engageable with said stinger member intermediate said ends forming a fluid-tight seal between said stinger member and mandrel;

valve means connected with said mandrel, said valve means including a valve body having a chamber therein, a first opening communicating with the interior of said mandrel and chamber and sized to receive the second end of said member, and a second opening in the sidewall of said body arranged to provide communication between said chamber and the well bore; and

a valve member movably positioned in said body, said valve member engaging said body in a first position to close said first opening and open said second opening engaging said body in a second position to close second opening and open said first opening and engaging the second end of said stinger member for movement to a third position wherein said first and second openings are open.

3. The apparatus on claims 1 or 2 wherein said valve member is substantially spherical.

4. The apparatus of claims 1 or 2 wherein said valve member is substantially spherical and has a specific gravity of less than 1.2.

5. The apparatus of claims 1 or 2 wherein said apparatus also includes a resilient member biasing said valve member relatively toward said first and second openings.

6. The apparatus of claims 1 or 2 wherein said apparatus also includes a spring in engagement with said valve member and biasing said valve member into position for closing said first and second openings.

7. Apparatus for use in a well packer disposed in a well bore, said packer including packing means sealingly engaging the wall of the well bore, retaining means engaging the well

bore wall to prevent movement of the packer and a hollow mandrel extending therethrough, said apparatus comprising:
an elongated hollow stinger member extending through said mandrel;

connection means releasably connecting said mandrel and stinger member;

seals means encircling said stinger member forming a fluid-tight seal between said mandrel and stinger member;

a hollow valve housing connected to the lower end of said mandrel having a first opening arranged to receive one end of said stinger member, a second opening extending through the wall thereof and first and second valve seats encircling said first and second openings, respectively;

a generally spherical valve member having a specific gravity of less than 1.2, said valve member being disposed in said housing and engageable with said stinger member, said valve member being alternately engageable with said first seat and second seat to prevent flow through the first and second opening, respectively, when said valve member is out of engagement with said stinger member, said stinger member holding said valve member out of engagement with said first and second seats when in engagement with said valve member; and

a spring located in said valve housing having one end in engagement with said valve member and another end in engagement with said valve housing for biasing said valve member relatively toward said first and second seats.

8. Apparatus for use in a well bore having a conduit located

therein, said apparatus comprising:

an elongated hollow stinger member having a first end arranged to be connected with the conduit and a second end having at least one port adjacent said second end through which fluid may flow from the interior of said stinger member;

a packer mandrel having first and second ends encircling said hollow stinger member;

packing means encircling said mandrel arranged to form a seal between said mandrel and the wall of said well bore;

connection means releasably connecting said first end of said mandrel and hollow stinger member;

valve means connected to the second end of said mandrel, said valve means including a valve body having a bore extending therethrough and defining first and second openings into said valve body, said first opening being located and sized to receive the second end of said stinger member and said second opening extending through the sidewall of said valve body; and

a valve member disposed in said bore and movable by fluid flow into sealing engagement with said valve body adjacent said first or second opening whereby continuing fluid flow through said bore is prevented, said valve member being engageable with the second end of said stinger member for movement into a position to permit flow in both directions through said bore and port.