This invention relates to float valves for well strings and particularly to a removable float valve for drill pipe.

During the drilling of a well, such as an oil or gas well, and the conduct of operations connected therewith, it is frequently necessary to run strings of pipe, such as drill pipe, into the well bore while the latter is filled with drilling fluid such as the conventional drilling mud. The running of such pipe strings into a well is usually done at fairly high speeds. As a result, the drilling mud being displaced by the entering string of pipe will be forced upwardly through the bore of the pipe string and at rather high velocities, and will jet out of the upper end of the pipe string in a stream which will spill over the rig floor and the operators, causing very unsatisfactory and hazardous working conditions.

To combat this condition, various types of control devices have heretofore been employed including various types of float valves, or so-called “fill up” shoes. However, the more conventional devices have the disadvantage that the valves or parts thereof normally must be left in the bore of the pipe string, forming internal projections which reduce the bore diameter of the string and thereby interferes with the operations which often have to be conducted through the bore of the string.

The present invention has for its principal object the provision of a float valve which may be installed in the bore of a pipe string and which is removable after it has served its function so as to leave the bore of the pipe string open to its full diameter and free of internal projections or obstructions.

An important object is to provide a removable float valve which is insertible in the bore of a pipe string and which is provided with releasable locking means for locking the valve in place in the bore of the pipe string and which is releasable by an upward pull upon a release member incorporated in the device to enable withdrawal of the device from the pipe string.

Other and more specific objects and advantages of this invention will become apparent from the following detailed description and the accompanying drawing which illustrates a useful embodiment in accordance with this invention.

In the drawing:

Fig. 1 illustrates a string of drill pipe in a well bore, the string being installed therein the float valve device in accordance with this invention;

Fig. 2 is a longitudinal view, partly in section, showing the device locked in place in the pipe string in the position occupied when the string is being lowered in a well;

Fig. 3 is a fragmentary view, generally similar to Fig. 2, showing the valve device being withdrawn from the pipe string; and

Fig. 4 is a cross-sectional view taken on line 4—4 of Fig. 2.

In Fig. 1, there is shown a well bore 10 in which is inserted a string of drill pipe 11, the pipe string having installed therein a float valve device, in accordance with this invention, designated generally by the numeral 12.

As best seen in Fig. 2, the float valve device comprises a tubular body 13, which is of the same overall dimensions as the drill pipe, having an axial bore 14 of the same diameter as the bore of the drill pipe. Body 13 has an internally threaded socket 15 at one end and an externally threaded pin member 16 at the other end for connecting the body into the string of pipe 11. Body 13 is thereby adapted to form a portion of the drill pipe string. Intermediate the ends of body 13, an annular lifting groove 17 is provided in the wall of bore 14, the upper end of the groove being formed to provide an upwardly and inwardly bevelled shoulder 18 merging into the wall of bore 14, a similar but downwardly tapering shoulder 19 being formed at the lower end of the groove.

Inserted in bore 14 is a valve structure, designated generally by the numeral 9, which includes a tubular valve casing 20 having a bore 21 co-axial with bore 14. A valve cage 22 is threadedly secured to casing 20 and an annular seat 23 concentric with bore 21 is clamped between cage 22 and the lower end of casing 20. A ball check valve 24 is seated in the valve cage and is provided with a plurality of intersecting passages 25 of relatively restricted cross-section which extend entirely through the ball valve. The cage 22 is of conventional form having openings in the sides thereof separated by longitudinal ribs 26 forming guides for the ball valve. By this arrangement, it will be seen that fluid in bore 14 may flow into cage 22 and thence through passageways 25 in the ball valve into bore 21 of the valve casing. A tubular slip cage 27 is mounted on the exterior of casing 20 above valve seat 23. The lower end 27a of the valve cage has a bore diameter such that it may be threadedly secured to the exterior of the casing, while the upper end 27b has an internal diameter somewhat larger than the external diameter of the casing to provide an annular space therebetween. Slip cage 27 is provided with a plurality of angularly spaced generally rectangular openings or windows 28 in which are inserted a corresponding number of slips 29 which are radially movable in the windows. As best seen in Fig. 4, slips 29 are provided with longitudinally extending edge flanges 30 which are engaged by longitudinally extending shoulderings 31 forming internal shoulders along the side edges of windows 28 whereby to retain the slips against loss outwardly from the slip cage. The upper and lower edges of the slips are bevelled on their outer corners to provide tapered shoulders 32 and 33, respectively, having slopes generally complementary to those of shoulders 18 and 19. The slips are generally arcutate in cross-section having generally smooth outer and inner faces. The thickness of slips 29 is made such that when the slips are advanced into groove 17, as best seen in Fig. 2, the inner faces of the slips will be substantially flush with the bore wall of slip cage 27 above the smaller diameter end 27a. A tubular mandrel 34 is slidable mounted concentrically about the exterior of casing 20 and has a wall thickness such that it will slide freely in the annular space between the cage 27 and casing 20. The lower end of mandrel 34 has a downwardly and inwardly tapering nose 35, and is counterbored from its upper end to a point somewhat above its lower end to form an upwardly facing internal shoulder 36. A retaining nut 37 is threaded over the upper end of casing 20 and has an external diameter such that it will be received within the bore of mandrel 34. The lower end of nut 37 forms an external shoulder 38 about casing 20 which is normally spaced from and abuttable by shoulder 36 in response to upward movements
mandrel 34 relative to casing 20, as will be more fully described hereinafter. The upper end of mandrel 34 has secured thereto a generally tubular pulling head 39 having a downward facing internal shoulder 40 adjacent its upper end. Pulling head 39 may be of any suitable form or shape, adapted to be grasped by a suitable grappling or pulling tool, such as the scissors spear 41 (Fig. 3) which may be lowered through the bore of the pipe string on a cable 42 and inserted into the bore of pulling head 39 to engage under a shoulder 40 so that an upward pull applied to cable 44 will exert an upward pull on mandrel 34. It will be understood that pulling tool 41 or its details do not form a part of this invention but is shown merely by way of illustration of a device suitable for applying an upward pull on the mandrel. Similarly, this particular form of pulling head 39 is not significant, since it may be of any suitable design adapted to be engaged by the particular pulling tool which it may desired to employ. Radial openings 43 are provided in the wall of mandrel 34 above the upper end of casing 20 to provide communication between the interior of the mandrel and casing and bore 14.

A downwardly facing resilient cup seal 44 is securely maintained between casing 20 and valve cage 22 and slip cage 27, cup seal 44 being arranged to form a fluid-tight sliding seal for the annular space between casing 20 and body 13 above valve cage 22. The cup seal, arranged as shown, will be responsive to fluid pressures exerted from below to more tightly seal this annular space.

The above-described device is employed in the following manner: Valve structure 9 will be inserted in bore 14 and positioned therein as shown generally in Fig. 2. During insertion of the valve structure mandrel 34 will be held in elevated position out of engagement with the inner faces of slips 29, as shown in Fig. 3, and the slips will thus be free to be pushed inwardly by engagement with the wall of bore 14 to the retracted position as shown in Fig. 3. Mandrel 34 will be maintained connected to casing 20 by engagement of shoulders 36 and 38. When the slips are opposite groove 17, mandrel 34 will be forced downwardly relative to casing 20, the engagement of cup seal 44 with the wall of bore 14 providing sufficient frictional resistance to hold casing 20 stationary while mandrel 34 is moved downwardly relative thereto. The tapered nose 35 of the mandrel will engage the inner faces of the slips and force them outwardly into groove 17, as the lower end portion of the mandrel moves into a position between the slips and the exterior of casing 20. The slips will thus be locked in groove 17, locking valve structure 9 to body 10 so long as the mandrel remains in position between the slips and casing 20. With the valve structure thus installed in body 10, the latter will be connected into pipe string 11 at a suitable point therein and the string will then be lowered into the well bore.

As the pipe string descends in the well bore, the fluid therein will be displaced and will enter the openings in valve cage 22. The resistance offered by the fluid to the descent of the pipe string will expand cup seal 44 which will thereby seal tightly with the wall of bore 14 and direct the fluid toward bore 21 of the valve structure. The fluid force of the fluid will thrust valve 24 against seat 23 and the fluid will thereby be forced to enter bore 21 through passages 25. Since the latter are of restricted cross-sectional area relative to the bore of the string they will act as chokes to sharply reduce the velocity of the fluid travelling upwardly through bore 21 and then through the bore of pipe string 11 above seat 23 and will obviate the danger of jetting the fluid out of the pipe string at the top of the well.

When the pipe string containing the valve has been lowered to the desired depth in the well, a grappling or pulling tool, such as spear 41 will be lowered into the bore of the pipe string and engaged with pulling head 39. By an upward pull on cable 42, mandrel 34 will be raised until slips 29 are freed for inward movement. When shoulder 36 comes up against shoulder 38, the upward pull will be transmitted to casing 20 and slip cage 27. The tapered shoulder 18 will engage the tapered surfaces 22 on the slips and will force the latter inwardly thereby releasing the valve structure from its previously latched engagement in groove 17. The entire valve structure 9 may then be pulled upwardly through the bore of pipe string 11 as illustrated in Fig. 3. As the structure is drawn upwardly ball valve 24 will drop away from seat 23 opening bore 21 fully and thereby allowing fluid inside the pipe string above the valve to drain freely back into the well bore through the openings in valve cage 22.

It will be noted that by the provision of intersecting passages 25 in ball valve 24, communication between bore 21 and valve cage 22 will always be provided irrespective of the orientation of ball valve 24 on seat 23. Thus, fluid flow through the valve can never be cut off completely and the pipe string will, therefore, always be able to descend freely through the fluid in the well bore. When valve structure 9 has thus been withdrawn from the bore of the pipe string it will be seen that the latter will have a bore of fluid arrangements similar to that shown in Figs. 14 and will be clear of any objectionable obstructions to the operation of other tools through the bore of the pipe string which will likewise be free of any restrictions on the flow of fluid, such as drilling mud or cement through the pipe string.

It will be understood that numerous alterations and modifications may be made in the details of the illustrative embodiment within the scope of the appended claims without departing from the spirit of this invention.

What we claim and desire to secure by Letters Patent is:

1. A float valve for pipe strings, comprising, a tubular body adapted to be connected into a pipe string to form a part thereof, a tubular valve casing removably insertible in the bore of said body, an annular latching groove in the bore wall of the body, a tubular slip cage mounted on the exterior of said casing, a plurality of latching slips mounted in said cage for radial movement therein, a tubular mandrel slidably mounted on the exterior of said casing to move longitudinally into and out of said cage between the slips and the exterior of said casing whereby downward movement of said mandrel into said cage will be operative to urge said slips toward said body, means for locking engagement with said groove and upward movement of said mandrel will be operative to release said slips for retraction from said groove, cooperating stop members arranged on the mandrel and the casing to limit relative longitudinal movement therebetween, means carried by the mandrel for connection to a pulling means, an annular sealing member mounted on the casing below the slip cage to form a slidable seal with the bore wall of said body, and a flow choke means in the bore of said casing to restrict the flow of fluid between the portions of said body above and below said seal.

2. A flow valve as defined by claim 1 wherein said flow choke means comprises a downwardly opening ball check valve having one or more flow passages there-through of restricted cross-sectional area.

3. A flow valve as defined by claim 1 wherein said sealing member comprises a downwardly opening annular resilient cup-type element.

4. A flow valve as defined by claim 1 wherein the upper end of said groove tapers upwardly and inwardly toward the bore of said body and the upper edges of said slips are provided with complementary tapered surfaces.

5. A flow valve as defined by claim 1 wherein said flow choke means comprises an annular valve seat in the bore of said casing, a ball check valve positioned below said
seat for movement into and out of engagement therewith, and intersecting flow passages through the ball valve of restricted cross-sectional area.

6. A float valve for pipe strings, comprising, a tubular body adapted to be connected into a pipe string to form a part thereof, a tubular valve casing removably insertible in the bore of said body, an annular latching groove in the bore wall of the body, a tubular slip cage mounted on the exterior of said casing, said cage having a plurality of circumferentially spaced rectangular windows through the wall thereof, latching slips mounted in said windows for radial movement therein, abuttable shoulder elements on the slips and the cage to limit radial outward movement of the slips in the windows, a tubular mandrel slidably mounted on the exterior of said casing to move longitudinally into and out of said cage between the slips and the exterior of said casing whereby downward movement of said mandrel into said cage will be operative to urge said slips radially outwardly into locking engagement with said groove and upward movement of said mandrel will be operative to release said slips for retraction from said groove, cooperating stop members arranged on the mandrel and the casing to limit relative longitudinal movement therebetween, means carried by the mandrel for connection to a pulling means, an annular sealing member mounted on the casing below the slip cage to form a slidable seal with the bore wall of said body, and a downwardly opening ball check valve in the bore of said casing, and intersecting choke passages through said ball check valve to restrict the flow of fluid between the portions of said body above and below said seal.

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