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DRILL PIPE FLOAT VALVES

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Fig. 1

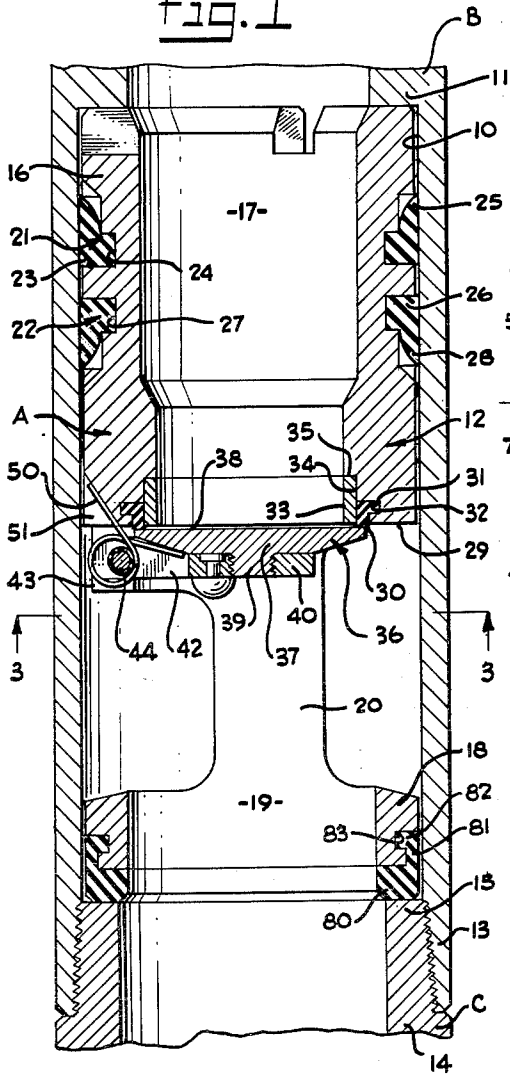


Fig. 2

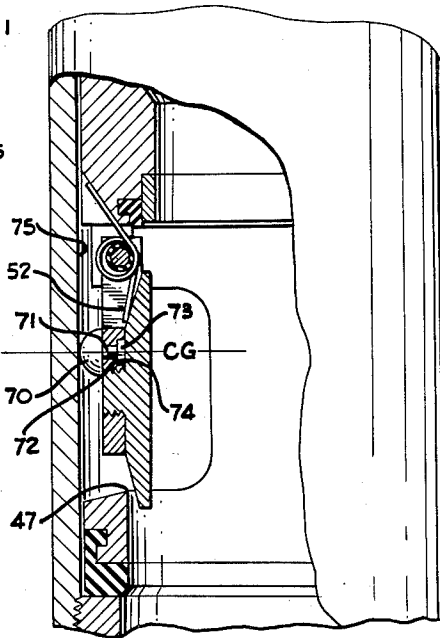


Fig. 3

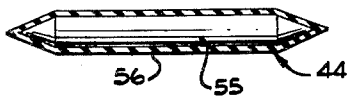
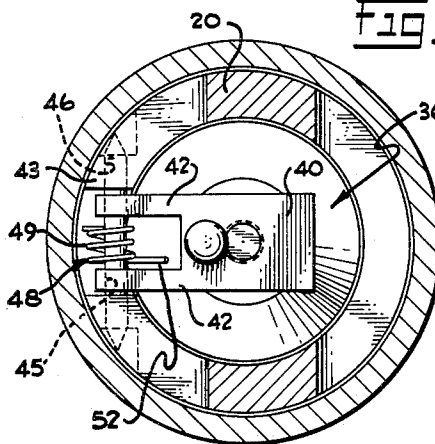


Fig. 4

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1

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DRILL PIPE FLOAT VALVES

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The present invention relates to subsurface well bore equipment, and more particularly to drill pipe float valves used in strings of drill pipe during the drilling of the well bore.

Drill pipe float valves are incorporated in rotary strings of drill pipe near the drill bit to relieve the weight of the drill pipe on the derrick during lowering of the drilling string through the fluid in the well bore, to reduce the chance of plugging the drill bit, to prevent blowouts, to prevent wetting of the rig floor and equipment, to minimize damage in the event the drill string should part, and to accomplish other known purposes. The drill pipe float valve is essentially a back pressure valve capable of opening in a downward direction to allow drilling mud and the like to be pumped down through the drill pipe for discharge from the bit, but which closes in an upward direction to prevent reverse or upward flow of the drilling mud in the drill pipe.

Heretofore, drill pipe float valves have been subjected to the erosive wear of the drilling mud being pumped through them which has resulted in fluid cutting of the parts and a consequent shortening of their useful life. Such erosive wear has occurred not only upon the metallic members of the valves, but also on the rubber or rubber-like sealing elements, which at times have been washed out of their assembled location on the valve apparatus. The valves have also leaked, which is believed to be due to improper seating of the valve head against its companion valve seat. Failure of certain valve parts has also occurred from other causes, one of which is believed to be vibration imparted by the rotary drill bit to the drilling string as the cutter teeth of the drill bit roll around the bottom of the well bore, or the wall of the well bore.

With the valve in an open position during the rotary drilling operation, centrifugal force tends to hold it in an open condition and its relatively movable parts in engagement with each other. The centrifugal force places a load upon the valve parts engaging each other, and the vibrations set up by the toothed cutters of the rotary drill bits cause such parts to rub or vibrate on one another, effecting a physical wearing away of the contacting surfaces, particularly where such contacting surfaces are metallic. This wearing away is increased considerably when the valve is operated in an abrasive medium, such as the drilling mud used in a drilling operation.

Accordingly, an object of the present invention is to provide a drill pipe float valve in which the effect of centrifugal force in causing wear of the valve parts is greatly minimized.

Another object of the invention is to provide a drill pipe float valve in which centrifugal force due to rotation of the valve is prevented from being imposed on certain of the valve parts, thereby minimizing wear on such parts, particularly as a result of the vibrations produced by a rotary drill bit.

A further object of the invention is to provide a drill pipe float valve in which centrifugal force is prevented from being imposed to any substantial extent on certain of its parts, and in which vibrations induced by a rotary drill bit are dampened so that they are not transmitted in full measure to the valve parts.

An additional object of the invention is to provide a drill pipe float valve embodying a vibration damper capa-

2

ble of minimizing the transmission of vibrations from a rotary drill bit to the float valve parts.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURE 1 is a longitudinal section through an apparatus embodying the invention, with the valve in closed position;

FIG. 2 is a view similar to FIG. 1, partly in side elevation, with the valve in open position;

FIG. 3 is a cross-section taken along the line 3—3 on FIG. 1;

FIG. 4 is a section through a hinge pin embodied in the apparatus.

As illustrated in the drawings, the drill pipe float valve A is placed within a string of drill pipe B, such as in the counterbore 10 of a drill collar, the upper end or counterbore providing a stop shoulder 11 against which the upper end of the valve body or cage 12 can bear. The lower end of the drill collar may be constituted as a threaded box 13 adapted to be threadedly secured to a threaded pin 14 of an adjacent drill pipe section or drill bit C. The drill bit ordinarily used has roller cutters (not shown). The upper end 15 of the pin forms a lower stop shoulder for preventing downward movement of the valve cage or body 12.

The valve cage or body includes an upper portion 16 having a central passage 17 therethrough, the upper end of this upper portion being adapted to engage the upper stop shoulder 11. It also includes a lower portion 18 adjacent to the lower stop shoulder 15, and also having a large diameter central passage 19 therethrough. These two portions 16, 18 are held in spaced relation longitudinally from one another by a plurality, such as a pair, of diametrically opposite legs 20 which are preferably integral with both of the portions.

Leakage of fluid around the upper body portion 16 and the wall of the counterbore 10 in both longitudinal directions is prevented by upper and lower oppositely facing side seal rings 21, 22. Thus, the upper seal ring 21 includes a base portion 23 fitting within a peripheral groove 24 in the body, there being an upwardly directed lip portion 25 adapted to sealingly engage the wall of the counterbore. The lower seal ring 22 includes a base portion 26 fitting within a peripheral groove 27 in the body of the tool and having a downwardly extending lip portion 28 sealing against the wall of the counterbore 10. The valve cage 12 is slipped up into the counterbore 10 prior to attachment of the lower pipe section C to the drill pipe or collar B, the lower member C then being threaded into the box 13 to hold the valve cage in proper position within the drill collar, with the upper and lower seals 21, 22 preventing passage of fluid around the upper portion 16 of the valve body in both longitudinal directions.

The lower end of the upper body portion 16 is constituted as a valve seat 29 having a gasket type of rubber or rubber-like sealing element 30 secured therewithin and preferably projecting below the lower metallic face of the valve seat. The rubber or rubber-like seal ring 30 is secured to the upper valve body portion by virtue of an outwardly directed upper flange 31 of the ring fitting within a companion internal circumferential groove 32 in

the valve body. The seal ring 30 is protected from the action of the fluid that may be pumped down through the valve apparatus by a retainer sleeve 33 which fits within a counterbore 34 in the valve body, the upper end of the sleeve abutting a shoulder 35 provided by the upper end of the counterbore, and the lower end of the sleeve terminating substantially in the same transverse plane as the lower face 29 of the upper valve body portion 16. This sleeve 33 makes a press fit within the valve body 12 and also fits across the inner surface of the seal ring 30 except for the lower end of the latter projecting below the lower end of the retainer sleeve 33. The inside diameter of the retainer sleeve is substantially the same as the inside diameter of the body passage 17 immediately thereabove, so as to provide a smooth, continuous passage through the upper valve body portion 16.

The valve is closed against upward passage of fluid whenever a valve head member 36 swings upwardly into engagement with the lower end of the seal ring 30, as disclosed in FIG. 1. This valve head includes an inner portion 37 of disc shape having its upper face 38 adapted to engage the lower end of the seal ring 30. The inner portion 37 has a threaded stem 39 threadedly received within an arm 40 of the valve head, which is pivotally supported at one side of the valve body 12.

The arm portion 40 extends to the side of the body, the outer parts 42, 42 of the arm being bifurcated and being disposed between depending bearings or ears 43 that are integral with the upper valve cage body portion 16. A hinge pin 44 extends through aligned holes or bores 45 in the bifurcations 42 and also through aligned bores 46 in the ears or bearings 43, thereby providing a pivotal support for the valve head 36 to one side of the valve body 12, whereby the valve head can swing downwardly to one side of the valve body and substantially completely out of the path of the fluid being pumped down through the apparatus, to provide a full opening through the apparatus. The valve head is urged in an upward direction by a spring 48 which includes an intermediate coil portion 49 encircling the hinge pin 44, there being one arm 50 of the spring received within a slot 51 in the valve body 12 and bearing against the latter, and another arm 52 of the spring extending from the coil portion 49 and engaging the valve head 36 to urge it in an upward direction. The spring 48 is disposed between the bifurcations 42 of the arm 40 and its coil portion 49 may have a diameter substantially greater than the diameter of the hinge pin 44.

The hinge pin 44 includes a metallic central or core portion 55 that has a pliant, elastic cover 56 thereon, such as a rubber or a rubber-like covering. This cover 56 has a substantial thickness. As an example, its thickness may be of the order of $\frac{1}{32}$ of an inch. The rubber thickness is such that the overall diameter of the pin conforms to the diameters of the bores 45, 46 through the bifurcations 42 and the bearing ears 43. However, it is found that it is not necessary for a snug fit to be secured. In fact, the valve head 36 may pivot on the pin 44, which may turn or rotate within the bearings 43.

In the use of the apparatus described, the valve head 36 will engage the sealing element 30 and prevent upward flow of fluid through the string of drill pipe. However, when the drilling mud or other fluid is pumped down through the drill pipe, it will swing the flapper valve head 36 against the force of the spring 48 to its full open position, there then being a very large bore or passage through the apparatus through which the drilling fluid can flow in an unimpeded manner and into the drill pipe or drill bit C therebelow. During the downward pumping of the fluid, it will not move along the rubber sealing element 30, since the latter is protected by the retainer sleeve 33. The absence of direct impinging of the drilling fluid on the seal element also prevents the latter from being inadvertently washed out of its assembled position on the upper valve body portion 16.

While the rotary drilling action is taking place and the drilling mud is being pumped down through the drilling string and the valve apparatus A contained therein, the rolling of the drill bit teeth on the bottom of the hole sets up vibrations in the drill string and in the valve apparatus itself. Such vibrations do not cause the valve head 36 to pound upon the hinge pin 44 and wear the latter or cause its failure, as well as possible failure of the valve head arm 40 itself. The rubber 56, which is interposed between the valve head 36 and the hinge pin 55 and also between the hinge pin and the bearings 43 acts as an effective shock absorber or vibration damper, completely eliminating any hammering action on the parts that could cause their failure while the apparatus is in use in the well bore.

In the absence of the drilling fluid being pumped down through the apparatus, the valve head 36 will swing upwardly into engagement with its companion rubber seat 30. Proper seating is insured since the intervention of the pliant material 56 between the valve head arm 40 and the hinge pin 55 and also the intervention of the rubber material between the hinge pin and the bearing ears 43 permits the valve head to have a sufficient freedom or universality of movement in substantially all directions so that it adjusts itself safely and insures a flat and proper contact of the valve head surface 38 against the seal ring 30 around the complete circumference of the coengaging parts. In the absence of the intervening rubber or cushioning material 56, the valve head could only swing about the axis of the hinge pin and the proper flat engagement of the valve head surface 38 against the sealing ring 30 might not occur, introducing an area of leaking that could increase as fluid passes therethrough, particularly during lowering of the drill pipe apparatus in the well bore and at substantial depths in which the hydrostatic head of fluid acting upon the valve apparatus is very large and of the order of several thousand pounds per square inch.

While the rubber covering 56 on the hinge pin acts as a vibration damper which minimizes wear on the parts and their failure, wear on certain parts could still occur when the valve head 36 is swung downwardly to its full open position during the pumping of the drilling mud downwardly therethrough, and the rotation of the entire drilling string B and drill bit C, as well as of the valve parts themselves. Centrifugal force incident to such rotation tends to maintain the valve head 36 in its open condition and tends to force it in a lateral outward direction. Such centrifugal force is transmitted from the valve head to the hinge pin 44 and in the absence of the present invention, causes the flapper valve head 36 to engage the lower valve body portion 18 as at the point 47, which functions as a stop. With such engagement of the valve head against the stop 47, the centrifugal force is transmitted between the valve head 36 and the hinge pin 44 at the upper portion of the valve head, and between the valve head and the stop 47 at the lower portion of the valve head. The vibrations produced by the drill bit tooth cutters operating upon the formation are transmitted through the drill string to the several valve parts, and because of the centrifugal force tending to hold these parts in engagement with one another, relative vibration or movement occurs between the valve head 36 and valve arm 40, on the one hand, and the hinge pin 44 and the stop member 47 on the other hand. The centrifugal action causes these parts to bear against one another with substantial force, and this fact, coupled with the relative vibratory movement between the parts, causes the coengaging surfaces to physically wear away. Although the rubber-coated hinge pin 44 assists considerably in minimizing the effects of the bit vibrations, yet the centrifugal force imparted thereon causes wear between the parts and a shortening of its life.

By virtue of the present invention, the centrifugal force transmitted between the valve head 36 and its arm 40, and other parts of the valve device is reduced to a con-

5

siderable extent. As disclosed, a pliant, elastic bumper and vibration damper 70, which may be in the form of a button, is secured to the flapper valve head arm 40, as by having an inner shank 71 thereof extend through a bore 72 in the arm, the inner shank portion 73 being enlarged to be received within a counterbore 74 in the arm, thereby preventing the bumper 70 from becoming inadvertently dismantled from the arm. The bumper, which may be made of rubber or rubber-like material, is mounted on the arm 40 as close to the center of gravity of the flapper valve head 36 and its arm 40 as is possible. As the valve head 36 is moved downwardly by the drilling mud, or other drilling fluid being pumped through the apparatus, and because of the centrifugal force imparted to the apparatus due to its rotation with the string of drill pipe B and the lower drill bit C, the valve head 36 and its arm 40 will move outwardly until the rubber or rubber-like bumper and vibration damper 70 engages the inner wall 75 of the drill collar B. Such engagement preferably occurs to prevent outward swinging of the valve head to the extent at which it will engage the stop portion 47 on the valve body and cage. Accordingly, the bumper device 70 prevents any metallic contact between the valve head or arm and the valve cage 12, and thereby precludes the vibratory action induced by the toothed cutters of the rotary drill bit from wearing away these parts. In addition, since the bumper or contact element 70 is disposed adjacent to the center of gravity of the flapper valve head 36 and its arm 40, substantially all of the centrifugal force of the arm and the valve head is transmitted through the bumper 70 directly to the drill collar B, and the force transmitted through the rubber covering 56 and the hinge pin 44 is very small. Accordingly, the vibrations incident to operation of the drill bit on the formation are not transmitted through parts that are moved relative to one another with a large bearing force being transmitted therebetween. Accordingly, relative wear between the parts is reduced to a considerable extent, if not almost completely eliminated.

The rubber or rubber-like bumper element 70 not only functions to relieve the hinge pin 44 of centrifugal force loads, and prevents contact between the flapper valve head 36 or its arm 40 and the valve cage 12, but because it is a pliant, elastic member it will tend to dampen vibrations that would otherwise be transmitted to the flapper valve head 36 and from the flapper valve head and its arm 40 to the hinge pin 44. The bumper 70, therefore, acts as a cushioning member between the drill collar B, to which the vibrations are imparted by the drill bit, and the flapper valve head and its arm. Such dampening action minimizes the vibrations imparted to the head 36 and to the hinge pin 44 and also results in a reduction of the wear of the parts.

The vibrations of the drill bit may also be dampened, so that they are not transmitted to the valve assembly A in as great a magnitude, by providing a vibration damper at the lower end of the valve cage or body 12 between its metallic portion and the adjacent drill pipe section or drill bit C. Thus, a pliant, elastic ring 80, which may be made of rubber or rubber-like material, is secured to the lower portion 18 of the valve body or cage. This ring 80 may have the same inside diameter as the lower cage portion 18 and has an upper part 81 encircling the lower cage portion, there being an inwardly directed flange 82 on the rubber or rubber-like ring received with a peripheral groove 83 in the cage, to secure the rubber ring to the cage.

It is evident that the lower end of the vibration damper ring 80 will bear against the upper end of the lower member C. During the downward pumping of the drilling mud through the apparatus, the pressure of the drilling mud acts downwardly on the valve cage body 12 and tends to maintain the rubber ring 80 in engagement with the upper end of the lower tool C. The vibrations produced by the tooth cutters of the rotary drill bit are not

6

directed to the metallic cage 12, but pass into the lower pliant, elastic ring 80, which effectively imposes a dampening action on a substantial portion of these vibrations, so that they are considerably reduced, only a part thereof being transmitted to the metallic valve cage 12 itself. Thus, the ring 80 reduces the vibrations that are imparted to the metallic valve cage, whereas the pliant, elastic bumper 70 dampens and considerably reduces the vibrations imparted to the valve head 36 and arm 40. The rubber sleeve 56 also effects a dampening of the vibrations transmitted between the valve head arm 40 and the hinge pin 44 and between the hinge pin and the valve cage 18. All of these vibration dampening elements, coupled with the considerable reduction, if not substantially full elimination of the centrifugal force load imposed upon the hinge pin 44, results in the vibrations producing very little wear on the parts, the entire valve assembly actually having a life several times that of prior devices of the same character.

The inventor claims:

1. In combination: tubular means adapted to form part of a rotary drilling string for drilling a bore hole extending downwardly from the top of the ground; a valve body in said tubular means and having a passage therethrough surrounded by a valve seat; a valve head movable upwardly into engagement with said seat; means pivotally mounting said head for swinging movement about a pivot axis to and from engagement with said seat, said mounting means including a pivot pin, rubber material between said head and pin, and a rubber material between said pin and body; and rubber means acting upon said valve head substantially at its center of gravity for limiting movement of said head in a direction away from said seat, to prevent engagement of said head with said valve body, and to substantially relieve said mounting means of the centrifugal force of said valve head incident to rotation of said tubular means.

2. In combination: tubular means adapted to form part of a rotary drilling string for drilling a bore hole extending downwardly from the top of the ground; a valve body in said tubular means and having a passage therethrough surrounded by a valve seat; a valve head movable upwardly into engagement with said seat; means pivotally mounting said head for swinging movement about a pivot axis to and from engagement with said seat, said mounting means including a pivot pin, rubber material between said head and pin, and a rubber material between said pin and body; and a rubber bumper secured to said head and adapted to engage said tubular means to limit movement of said head away from said seat, and to prevent engagement of said head with said valve body.

3. In combination: tubular means adapted to form part of a rotary drilling string for drilling a bore hole extending downwardly from the top of the ground; a valve body in said tubular means and having a passage therethrough surrounded by a valve seat; a valve head movable upwardly into engagement with said seat; means mounting said head for lateral movement to and from engagement with said seat, said mounting means including a pivot pin, rubber material between said head and pin, and a rubber bumper means acting upon said head and tubular means substantially at the center of gravity of said head to limit movement of said head away from said seat, to prevent engagement of said head with said valve body, and to substantially relieve said mounting means of the centrifugal force of said valve head incident to rotation of said tubular means.

4. In combination: tubular means adapted to form part of a rotary drilling string for drilling a bore hole extending downwardly from the top of the ground; a valve body in said tubular means and having a passage therethrough surrounded by a valve seat; a valve head movable upwardly into engagement with said seat; means pivotally mounting said head for swinging movement about a pivot

7

axis to and from engagement with said seat, said mounting means including a pivot pin, rubber material between said head and pin, and a rubber material between said pin and body; rubber bumper means acting upon said head and tubular means to limit movement of said head away from said seat, and to prevent engagement of said head with said valve body.

5. In combination: tubular means adapted to form part of a rotary drilling string for drilling a bore hole extending downwardly from the top of the ground; a valve body in said tubular means and having a passage therethrough surrounded by a valve seat; a valve head movable upwardly into engagement with said seat; means pivotally mounting said head for swinging movement about a pivot axis to and from engagement with said seat, said mounting means including a pivot pin, rubber material between said head and pin, and a rubber material between said

8

pin and body; a rubber bumper secured to said head substantially at its center of gravity and adapted to engage said tubular means to limit movement of said head away from said seat, to prevent engagement of said head with said valve body, and to substantially relieve said mounting means of the centrifugal force of said valve head incident to rotation of said tubular means.

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