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CONTROL VALVE APPARATUS FOR DRILL PIPES

Original Filed April 14, 1958

FIG. 1.

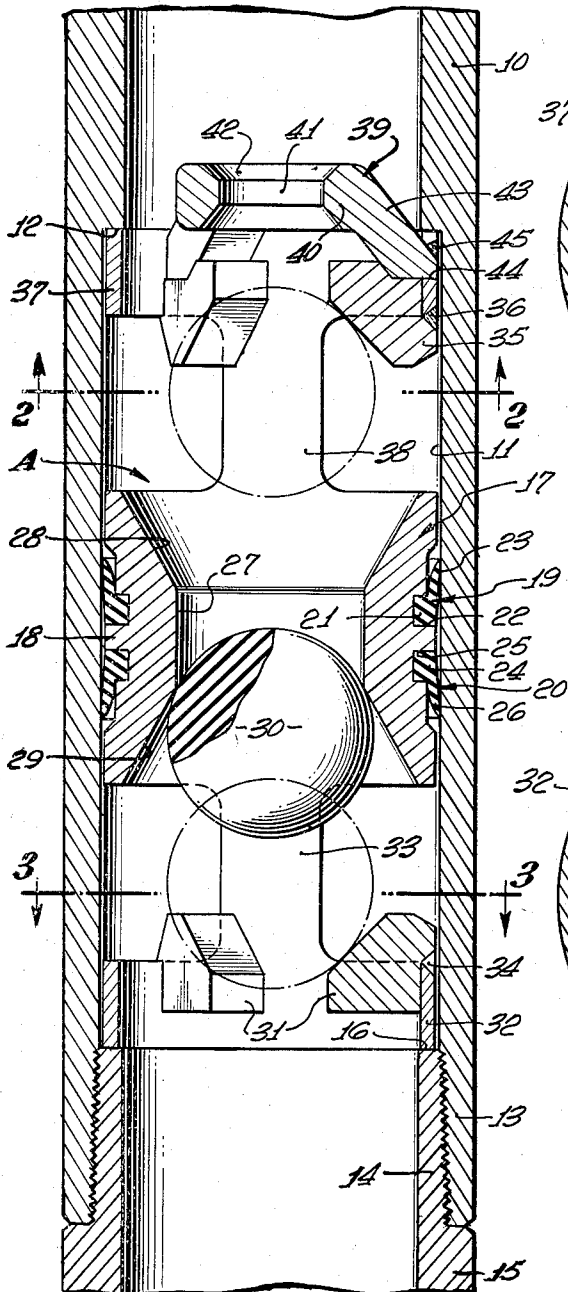


FIG. 2.

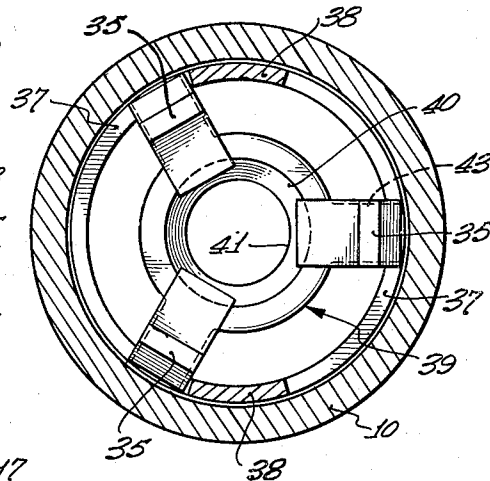
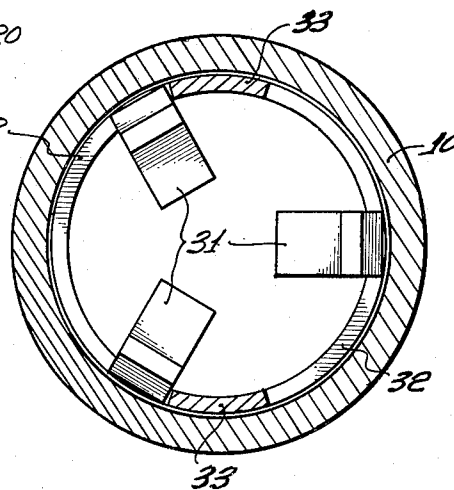


FIG. 3.



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CONTROL VALVE APPARATUS FOR DRILL PIPES
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Continuation of abandoned application Ser. No. 728,148,
 Apr. 14, 1958. This application Sept. 19, 1960, Ser.
 No. 56,931

8 Claims. (Cl. 166—224)

The present invention relates to valve apparatus, and more particularly to valve apparatus adapted to be incorporated in strings of drill pipe to control the passage of fluids therethrough.

This application is a continuation of my application for "Control Valve Apparatus for Drill Pipes," Serial No. 728,148, filed April 14, 1958, now abandoned.

As the result of the performance of a drilling operation in a well bore, the fluid in the well bore annulus becomes weighted with the cuttings, so that the breaking of a drill pipe joint or connection at the top of the hole, either to add another stand of drill pipe or to remove a stand of drill pipe in withdrawing the latter from the well hole, causes the heavier fluid in the annulus to force the lighter fluid in the drill pipe upwardly and out through the upper end of the pipe, the drilling fluid spilling over and wetting the working area and personnel at the top of the hole.

It has been proposed to avoid the aforementioned disadvantageous result by incorporating an upwardly closing float valve in the string of drill pipe, usually near its lower end. Such a float valve prevents the drilling fluid in the well bore from entering the drill pipe as it is being lowered in the well bore. The drill pipe then functions as a large piston, imposing relatively large pressures, or a "ram" effect, on the well bore fluid while being lowered at a fairly rapid rate in the well hole, such pressures tending to break down some formations through which the well bore passes. In addition to the undesirable "ram" effect, the use of a float valve makes it necessary for the drill pipe to be filled from the top of the hole to prevent its being subjected to the high hydrostatic pressure differential of the surrounding column of drilling mud within the well bore. Such filling of the drill pipe is a time consuming and costly operation.

Accordingly, it is an object of the present invention to provide an apparatus to be incorporated in a string of drill pipe, which enables the drill pipe string to fill automatically with the well bore fluid as it is being lowered therewithin, but which still prevents the surrounding well bore fluid from spilling over at the top of the hole whenever a drill pipe joint is disconnected.

Another object of the invention is to provide apparatus of the character indicated that permits fluid to drain from the drill pipe as it is being elevated in the well bore, and which also allows unimpeded pumping of the drilling fluid through the drill pipe during the performance of the drilling operation.

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 illus-

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trating 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, parts being shown in elevation;

FIG. 2 is a cross-section taken along the line 2—2 on FIG. 1;

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

The apparatus A illustrated in the drawings is adapted to be incorporated in a string of drill pipe extending from the top of the hole to the usual drilling bit (not shown) at its lower end. The apparatus may be disposed within a tubular sub or drill collar 10 having a counterbore 11, the upper end of which provides an upper stop shoulder 12. The drill string member may have a lower threaded box 13 for threaded attachment to a threaded tool joint pin 14 of an adjacent lower section 15 of drill pipe, drill collar, or the drill bit itself. The upper end 16 of the pin forms a lower stop shoulder for retaining the valve apparatus A within the drill pipe section 10.

The valve apparatus consists of a main valve cage or body 17 having an external diameter substantially the same as the internal diameter of the counterbore 11, so as to make a relatively close fit therewith. The intermediate portion 18 of the valve cage has a pair of oppositely facing side seals 19, 20 mounted thereon. Thus, an upper side seal 19, which may be made of rubber or rubber-like material, has a base portion 21 fitting within a peripheral groove 22 in the body, with an upwardly extending lip portion 23 engaging the wall of the counterbore. The lower side seal 20, which may also be made of rubber or rubber-like material, has a base portion 24 fitting within a peripheral groove 25 in the body and a downwardly extending lip portion 26 sealingly engaging the wall of the counterbore. Thus, fluid in both directions is prevented from passing between the intermediate portion 18 of the body and the wall of the counterbore 11.

The intermediate portion of the valve body has a restricted passage or throat 27 therethrough merging into an upwardly diverging or tapered valve seat 28 and also into a downwardly diverging tapered valve seat 29. Each of these valve seats is adapted to be engaged by a valve element 30, shown as being in the form of a solid rubber or rubber-like ball, having a diameter substantially greater than the internal diameter through the throat or restricted passage 27 in the body. The rubber ball valve member 30 can move upwardly into engagement with the lower valve seat 29, and when so engaged will prevent upward flow of fluid through the drill pipe. However, when sufficient upward pressure is imposed on the rubber ball valve element 30, it will be squeezed through the throat 27 to the other side of the intermediate valve body portion 18. For example, a pressure differential of 400 to 500 lbs. p.s.i. might be necessary to squeeze the rubber ball member through the throat. Such pressure, of course, can be varied, depending upon the diameter of the rubber member and its hardness. As an example, if the rubber ball has a diameter of 2 1/8 inches and an 80 Shore hardness, the throat diameter being 1 1/2 inches, it is found that pressure differentials of about 400

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to 500 p.s.i. are required to squeeze the ball valve 30 through the throat 27 from one side to the other.

If the ball is above the intermediate portion 18, then essentially the same pressure differential imposed in the fluid within the drill pipe string and acting downwardly on the ball is necessary to squeeze it back through the throat 27 to the lower portion of the apparatus.

Downward movement of the ball 30 with respect to the apparatus is limited by its engagement with a plurality of circumferentially spaced lower stop elements or lugs 31 extending inwardly from a lower ring 32 resting upon the lower tool joint pin 14. This lower ring 32 may be secured to the intermediate portion 18 of the valve body through a plurality, such as a pair, of arms 33 integral with the ring 32 and with the intermediate portion 18. The lower lugs 31 may be secured to the lower ring 32, as by the use of welding material 34.

Similarly, when the ball valve element 30 is above the upper valve seat 28, its upward movement is limited by its engagement with a plurality of circumferentially spaced and inwardly extending upper stop elements or lugs 35 which are secured, as through the use of welding material 36, to an upper ring portion 37 of the valve cage, this upper ring portion being secured and carried by the intermediate portion 18 through the agency of the plurality, such as a pair, of diametrically opposed upper arms 38 integral with the intermediate portion 18 and with the ring 37. If desired, a spider 39 for seating of a directional recording instrument, or the like, may be attached to the upper ring 37. The spider includes a central hub portion 40 having a passage 41 therethrough and an upper seat 42 for engagement by the directional recording instrument. It also has a plurality of circumferentially spaced, downwardly diverging legs 43, the outer ends of which may fit in slots 44 in the upper ring, where the legs are integrated to the ring, as through the use of welding material 45.

In the use of the apparatus A, it is mounted in the counterbore 11 of the drill string member 10, and is held in place by threading the lower drill pipe 15 into the box 13. The rubber ball 30 may be disposed either below or above the intermediate portion 18. If disposed below the intermediate portion, it will engage the lower valve seat 29 as the string of drill pipe is being lowered in the fluid in the well bore, and will at first prevent the external drilling fluid from flowing upwardly into the string of drill pipe. However, as lowering of the drill pipe in the well bore proceeds, the hydrostatic pressure acting on the ball will eventually squeeze the ball valve element 30 through the throat 27, and it will come to rest against the upper stop lugs 35, the fluid in the well bore then flowing upwardly through the valve apparatus and into the drill pipe thereabove. The valve element will remain in its upper position during lowering of the string of drill pipe in the well bore to the desired location, the well bore fluid automatically flowing upwardly through the throat 27, around the ball valve element 30 and through the arcuate spaces between the upper stop lugs 35 into the string of drill pipe.

During the performance of the drilling operation, the drill string is rotated and drilling mud pumped down through the string of drill pipe. The pressure of the drilling fluid will force the ball member 30 against its upper valve seat 28 and then squeeze it through the throat 27 to its lowermost position in engagement with the lower stop elements 31, the drilling mud then being free to pass through the throat 27, around the ball valve element 30, through the arcuate spaces between the lower stop elements 31 into the drill pipe section 15, or drill bit therebelow, discharging from the drill bit to carry the cuttings upwardly around the drill pipe to the top of the hole.

As drilling proceeds, the kelly at the top of the hole must be disconnected, to permit the connection of an additional stand of drill pipe. Whenever the kelly is dis-

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connected at the top of the hole, the heavier fluid in the well bore around the drill pipe cannot force the drilling fluid back up through the drill string, inasmuch as the tendency of the fluid to flow upwardly in the drill pipe is prevented by the upward movement of the ball valve element 30 into engagement with the lower seat 29. Ordinarily, the pressure differential externally of the drill pipe is insufficient to force the ball valve element 30 through the throat 27 to its upper position in the apparatus. After the stand of drill pipe has been added at the top of the hole and the kelly connected to such added stand, drilling can proceed, the drilling mud again being pumped down through the drill pipe and moving the ball valve element 30 away from its seat 29 to its lower position against the lower stop elements 31, the fluid then flowing freely through the apparatus and into the lower portions 15 of the string of drill pipe and the drill bit.

In the event the drill pipe is to be withdrawn from the hole, it is elevated in the usual manner, the ball valve element 30 moving downwardly from its lower seat 29 to permit the fluid to drain from the drill pipe into the well bore. Here again, should there be any tendency for the fluid in the well bore externally of the drill pipe to flow into and proceed upwardly through the drill pipe, such tendency is precluded by the upward seating of the ball valve element 30 against the lower tapered valve seat 29. As a result, the drill pipe can be disconnected at the top of the well bore without fear of the well bore fluid flowing from the annulus around the drill pipe to its lower end and then upwardly therethrough, spilling over at the top of the well bore and wetting the working area and the personnel, thereby creating a hazardous condition. As elevation of the drill pipe continues, the ball valve element 30 will move down away from its lower seat 29 and will permit fluid to drain from the drill pipe through its lower end into the well bore.

It is, accordingly, apparent that a control valve apparatus for drill pipes has been provided which will permit the string of drill pipe to fill automatically with the fluid in the well bore as it is being lowered therewithin. Fluid can also be pumped freely down through the drill pipe during the usual drilling or circulating operation performed in the well bore. Moreover, fluid will drain from the drill pipe while the latter is being removed from the well bore. Despite such freedom of movement of the drilling fluid into and out of the drill pipe, the fluid is prevented from flowing from the annulus surrounding the drill pipe into and up through the drill pipe whenever the drill pipe connection at the top of the well bore is broken, either to add a stand of drill pipe or to disconnect a stand of drill pipe. When a stand of drill pipe is to be added, the valve element is in its lower position, since it has been disposed in such position as the result of downward pumping of the drilling fluid through the drill pipe. Similarly, when a section or stand of drill pipe is to be disconnected at the top of the hole, such disconnection usually occurs immediately after the cessation of the drilling operation, the rubber ball valve element again being in its lower position. In fact, the rubber ball valve element 30 is ordinarily in its lower position in the apparatus except during the initial lowering of the drill pipe through the fluid in the well bore. The valve element is made of a pliant, elastic material, such as rubber or rubber-like materials, and can be forced or extruded through the restricted throat 27 from one side of the intermediate valve cage portion 18 to the other side without permanently deforming the valve element.

The inventor claims:

1. In apparatus of the character described: a tubular drilling string lowered through fluid in a well bore and extending to the top of the well bore; a body member in a lower portion of said drilling string while said drilling string is lowered in the well bore and having a passage

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fluid leakage around the exterior of said body member; a valve member in said body member having a cross-section initially greater than said passage and disposed initially below said passage and movable upwardly into engagement with said body member to prevent upward flow of well bore fluid through said passage during initial lowering of said drilling string through the well bore fluid, said valve member being of pliant, elastic material to permit said valve member to be forced by fluid pressure through said passage, upon further lowering of said drilling string, from a position below said passage to a position above said passage and from a position above said passage to a position below said passage upon being subjected to fluid pressure in said drilling string above said valve mem-

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ber; said body member having a lower stop means adapted to be engaged by said valve member to limit downward movement of said valve member from said passage; said body member having an upper stop means adapted to be engaged by said valve member for limiting upward movement of said valve member from said passage.

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