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CHECK VALVE

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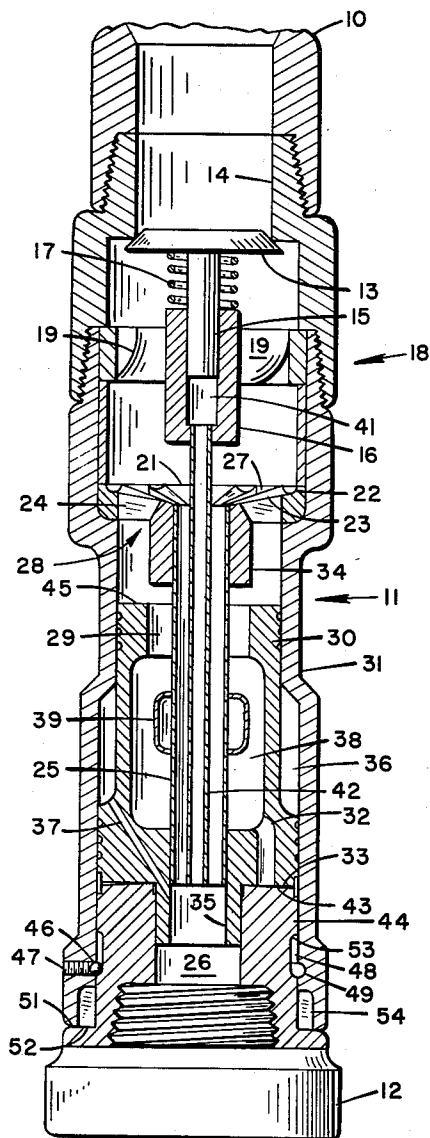


FIG. 1

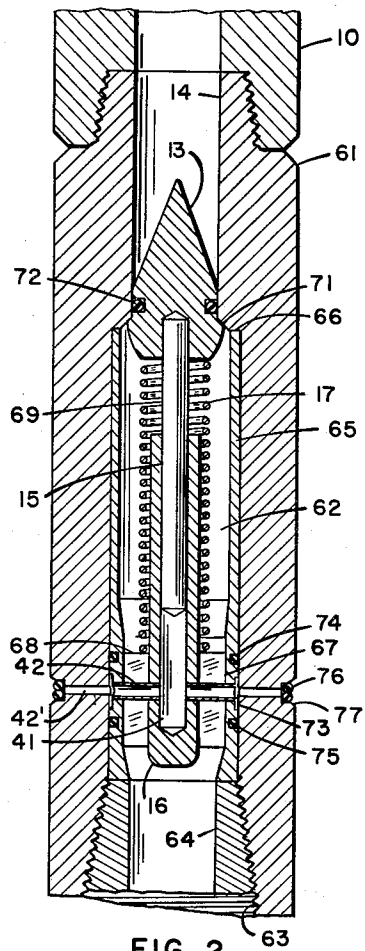


FIG. 2

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CHECK VALVE

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This invention relates to a check valve. More particularly, this invention relates to a well drilling apparatus wherein a check valve is combined with a vibratory drilling apparatus.

Check valves which are placed in a string of drill pipe and oriented to pass fluid downwardly through the drill pipe and to close upwardly are often referred to as drill pipe float valves. These valves are used for a number of purposes including floating the drill pipe into a well to relieve the load on the drill rig, preventing blowouts through the drill pipe, and avoiding flow of the drilling fluid upwardly through the drill pipe as the drill pipe is being run. Check valves of this type have been used for many years without any particular difficulty in ordinary drilling apparatus. I have found, however, that the standard drill pipe float valve is impractical when used in combination with a fluid actuated vibratory drilling apparatus.

It is an object of this invention to provide an improved drill pipe float valve. It is a more specific object of this invention to provide a check valve for use in combination with a rotary percussion drilling apparatus. It is still a more specific object of this invention to provide a combination check valve and fluid actuated vibratory motor for use in drilling, particularly rotary percussion drilling. Other objects of this invention will become apparent from the following description. In this description, reference will be made to the accompanying drawing in which:

FIGURE 1 is a cross-sectional view of a rotary percussion drilling apparatus employing my combined check valve and fluid actuated percussion motor; and

FIGURE 2 is a cross-sectional view of a preferred type of check valve which is particularly adapted for use with a fluid actuated vibratory drilling apparatus.

This invention may be described in brief as a check valve—fluid actuated percussion motor combination in which the check valve is held open by the pressure drop across the motor. Referring now, first, to FIGURE 1 for a more detailed description of the construction and operation of this apparatus, the drilling apparatus at the surface which is not shown includes, as usual, the drilling rig and drilling fluid compressors for rotating the drill pipe 10 and circulating drilling fluid through a vibratory motor such as the percussion motor 11 and through drill bit 12, both of which are located below the surface in a well. A drill pipe float valve which is merely a unidirectional valve such as a check valve 13, is located between the drill pipe and percussion motor preferably adjacent to or in the fluid inlet 14 to the percussion motor. This valve forms a seat with the inlet which prevents flow of fluid upwardly through the drill pipe but permits fluid to be pumped down the drill pipe and into the subjacent percussion motor. The valve stem, which forms a plunger 15 in cylinder 16, is urged upwardly so that the valve is normally in a closed position by a compression spring 17. Drilling fluid passing downwardly through this valve enters a phase separator 18 comprising angular whirler vanes 19 and a dense component collector 21 located downstream from the whirler vanes. The whirler vanes cause the drilling fluid to rotate at high velocity and thus separate the dense component centrifugally on the wall of the separator. The dense component then flows downwardly along the separator wall and into the circumferential trough 22 and the lighter component flows down-

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wardly at the center of the separator. This dense component, which is usually liquid and/or solid, flows along radial troughs 23 in the top of radial ribs 24 into the top of a motor bypass conduit 25 to the motor exhaust port 26 and thence through the drill bit ports (not shown) out into the well and are circulated to the surface in the well annulus with the drill bit cuttings. The lighter component of the drilling fluid, e.g., the clean gas, flows downwardly through the central openings 27 between the radial ribs 24 in the motor head 28. This drilling fluid then passes downwardly through the axial opening 29 in the annular free-piston-type hammer 30 which reciprocates longitudinally in housing 31. The hammer forms a fluid seal with the concentric bypass conduit 25 so that the power fluid passes through the port 32 in the lower end of the hammer and builds up pressure underneath the hammer striking face 33 to lift the hammer from its bottom position, as shown, to its upper position. As the hammer moves up, the upper finger valve 34 closes the opening 29 in the upper end of the hammer and substantially simultaneously opens the lower finger valve 35 to exhaust the high pressure gas from beneath the hammer striking face 33. During this return stroke of the hammer, the fluid in the annular recess 36 is displaced through port 37 and intermingled with the exhaust from the motor in the exhaust port 26. The amount of power fluid passing through the motor per cycle depends upon the internal volume of the hammer less the volume of the bypass tube within the hammer, i.e., the volume of chamber 38. This volume may be varied to change the operating characteristics, i.e., the frequency of the hammer by varying the internal diameter of either the opening or the bypass conduit. A preferred means involves placing an enlargement 39 on the motor bypass conduit 25. The outside diameter of the enlargement is less than the diameter of opening 29.

A variable volume chamber 41 for controlling the position of valve member 13 is formed by the plunger 15 in cylinder 16. The connection between the plunger and the valve member or dart is such that the volume of this chamber decreases when the valve opens and increases when the valve closes. A pressure equalizing tube or conduit 42 extends from the chamber down into or preferably through the motor bypass conduit 25 to equalize the pressure within the variable volume chamber with the motor exhaust pressure or some pressure lower than the motor inlet pressure. The valve is thus held open by the differential pressure which exists between the inlet pressure acting downwardly on the plunger 15 and the motor exhaust pressure which acts upwardly on the plunger. That is, the valve is not only held open by the flow of fluid when fluid is moving downwardly to the motor, but is held open by the pressure drop of the drilling fluid as it passes through and gives up its energy to the percussion motor. We have found that whereas customary drill pipe float valves are closed cyclically on the return cycle of the hammer when the flow of power fluid is temporarily halted, in a check valve actuated by the differential pressure across the motor, the valve is held open continuously while the motor is operating. When the motor is stopped, the pressure differential across the motor decreases rapidly and in many cases even reverses closing valve 13 rapidly and preventing the contaminated drilling fluid from backing up into the percussion motor.

On the return stroke, after the hammer is raised to a point at which the upper finger valve closes the opening 29 in the upper end of the hammer, the inertia of the hammer carries it up around the upper finger valve for a distance sufficient to open the lower valve 35 and exhaust the high pressure gas within the hammer and between the hammer and the upper face 43 of the anvil 44. With the high pressure gas in the hammer exhausted, i.e., reduced

to bottom hole pressure, the pressure of the drilling fluid on the upper annular area 45 of the hammer then forces the hammer down on the power stroke at rapid rate causing it to strike the anvil at high velocity and produce an impact on the drill bit 12 which is attached to the lower end of the anvil. The anvil is held in the lower end of the housing 31 by a number of retaining balls 46 which are inserted through an opening 47 in the housing and lodged midway between the housing and the anvil with one-half in the wide groove 48 on the anvil and with the other half in the circumferential, semi-circular groove 49 within the housing. When the bottom 51 of the housing rests on the shoulder 52 of the drill bit, the balls are in the bottom of the elongated groove 48. When the drill pipe is raised, the anvil drops until the upper shoulder 53 strikes the balls 46 so that the anvil and bit can be recovered or lifted with the drill pipe. This provides a flexible longitudinal connection between the housing and the anvil so that when the hammer strikes the anvil, the impact is not transmitted to the housing. Mating splines 54 on the anvil and housing transmit torsional force from the drill pipe 10 and housing 31 to the drill bit so that the bit can be rotated during vibratory drilling.

Referring now more specifically to FIGURE 2 of the drawings for a detailed description of a preferred embodiment of the check valve per se, a valve housing 61 is connected to the drill pipe 10 with the fluid inlet 14 of the valve in fluid communication with the drill pipe. There is a central fluid passage 62 through the valve housing terminating at the lower end in a valve outlet 63 which is threaded for insertion of a pin 64 and attachment to a drill pipe, drill collars or, preferably, to the top of a fluid actuated vibratory drill motor. A valve cage 65 is inserted in the fluid passage and held in place between an upper shoulder 66 and the pin 64 of the subjacent drilling apparatus. A spider 67 within this housing has circumferentially spaced ribs 68 connected at the center to the cylinder 16 and at the outer end to the housing so that the cylinder is held substantially concentrically in the valve housing and the fluid passage through the valve is not materially obstructed. A variable volume chamber 41 is formed within this cylinder by a movable wall or plunger 15. The plunger is connected to or forms a part of the valve stem 69. Valve member 13, which is connected to this plunger via the valve stem, seats against an upper shoulder 71 and forms a valve seal with the valve housing 61 to prevent upward flow through the valve. In some cases an O-ring gasket seal 72 may be incorporated to provide a more positive seal. One or more pressure equalizing conduits 42 are attached at one end to the chamber 16 and at the other end to the cage 65 to provide a fluid connection between the variable volume chamber and the circumferential recess 73 in the periphery of the valve cage. Upper and lower gaskets 74 and 75, respectively, provide a seal between the valve cage and housing 61 so that, together with the conduit extension 42' comprising a radial hole in the valve housing, the pressure equalizing tube or conduit extends from the variable volume chamber 41 to the outside of the housing. This space is typically the annulus surrounding the drill pipe in a well. A screen or other protective device such as a pair of O-rings 76 may be placed in circumferential groove 77 to prevent foreign matter from entering and plugging the conduit. The valve member will obviously be forced down by the downward flow of fluid and forced up to a closed position as shown when the fluid tends to flow upwardly, i.e., by reverse circulation in the drill pipe. Generally, the valve member is biased to a closed position by a compression spring 17 which is placed between the base of the valve member and the spider 67.

In operation, as indicated above, the valve housing 61 is placed in a string of drill pipe, preferably immediately above a vibratory drilling apparatus such as a fluid actuated percussion motor, and lowered into drilling position at the bottom of a well. During drilling, the power or

drilling fluid injected through the drill pipe flows by direct circulation downwardly through the drill pipe and the check valve to the motor 11. This flow overcomes the bias of spring 17 and opens the valve to the flow of fluid downwardly. While in standard rotary drilling, the flow of drilling fluid by direct circulation is continuous and the check valve remains open; in vibratory drilling such as that using a single acting percussion motor, the flow of fluid is interrupted cyclically each time the motor piston makes a return stroke repeatedly closing the check valve. This rapid and continuous closing of the valve has been found to destroy the valve member and seat of a drill pipe float valve after only a few minutes of operation. In my apparatus, on the other hand, even though the flow of power fluid to the motor is periodically interrupted, the pressure drop across the subjacent percussion motor remains substantially constant so that the pressure on the downstream side of the motor as reflected at the outlet end of pressure equalizing conduit 42 is always lower than the pressure in the drill pipe and in fluid passage 62. Consequently, during operation when the power fluid is giving up its energy to the motor, the pressure on the upper end of plunger 15 is greater than the pressure on its lower end in variable volume chamber 41 and the valve member is held down.

From the foregoing, it can be seen that we have provided an apparatus whereby power or drilling fluid contaminants, particularly liquids and solids in a gaseous drilling fluid, can be removed from the component of that drilling fluid which passes through a percussion motor at the lower end of the drill pipe and that by this means, the operating life of the motor components can be substantially extended. It will also be apparent that whereas in this description reference has been made to a preferred embodiment, the invention should not be construed to be limited to that embodiment, but should instead be construed to be limited only by the scope of the appended claims.

I claim:

1. A check valve including a housing, a fluid passage through said housing, a valve seat in said passage, a valve member adapted to form a fluid seal with said seat and permit flow in only one direction through said passage, conduit means between said fluid passage and the outside of said housing, piston means in said conduit, and means connecting said piston means to said valve member so that as the pressure inside said housing becomes greater than the pressure outside said housing said piston means tend to move said valve member to open said passage.

2. A check valve including a housing, a fluid passage through said housing, a valve seat in said housing, a valve member adapted to form a fluid seal with said seat, means including a moveable wall forming a variable volume chamber which is within and is fixed to said housing, means to connect said moveable wall to said valve member, and a pressure equalizing conduit extending from said chamber to a position outside said housing where the pressure is normally less than the pressure inside said housing.

3. A drill pipe check valve including an elongated tubular housing having a flow passage therethrough, means to connect said housing to a drill pipe so that fluid flowing through said drill pipe passes through said flow passage, a valve seat formed in said passage, a valve member adapted to form a fluid seal with said seat and prevent flow of fluid upwardly through said passage, means including a moveable wall forming a variable volume chamber which is within and is fixed to said housing, means connecting said moveable wall to said valve member so that the volume of said chamber decreases as said valve opens and increases as said valve closes, and a conduit extending from said chamber to a position outside said housing where the pressure is normally lower than the pressure in said housing, whereby said check valve is held open by a pressure in said housing that is greater than the pressure outside said housing,

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4. A check valve for use with a subsurface fluid actuated vibratory drilling motor in a drill string comprising an elongated tubular housing having a flow passage therethrough, means to connect said housing in said drill string above said motor so that drilling fluid flowing from said drill pipe to said motor passes through said flow passage, a valve seat in the periphery of said flow passage, a valve member adapted to form a fluid seal with said seat and prevent flow of said drilling fluid upwardly through said flow passage, means including a moveable wall forming a variable volume chamber which is fixed to said housing, means connecting said moveable wall to said valve member so that the volume of said chamber decreases as said valve opens and increases as said valve closes, and a conduit extending from said chamber to a position downstream of said motor where during operation of said motor the pressure is lower than the pressure in said housing and said valve is held open.

5. A float valve according to claim 4 including resilient means urging said valve member to a closed position.

6. A combination check valve and subsurface fluid actuated vibratory drilling motor for driving a drill bit at the lower end of a drill string comprising an elongated tubular housing having a flow passage therethrough, means to connect said housing in said drill string above said motor so that drilling fluid flowing from said drill string to said motor passes through said flow passage, a valve seat in said flow passage, a valve member adapted to form a fluid seal with said seat and prevent flow of said drilling fluid upwardly through said flow passage, conduit means between said housing and the downstream side of said motor, piston means in said conduit, and means connecting said piston means to said valve member so that as the pressure in said housing becomes greater than the pressure on said downstream side of said motor, said piston means tend to move said valve member and open said flow passage, whereby said check valve is held open when said motor is operating and is closed by fluid flow in the opposite direction.

7. A combination as set out in claim 6 including spring means acting on said valve member so that said valve member is normally held in a closed position.

8. A check valve including a tubular housing, a fluid inlet and a fluid outlet in said housing, a fluid passage through said housing between said inlet and said outlet, a valve seat in said passage, a valve member adapted to form a seal with said seat and prevent flow through said passage, a valve cage in said passage, means including a piston forming a variable volume chamber which is fixed to said cage, means connecting said piston to said valve member so that as said check valve closes the volume of said chamber increases, and a conduit extending from said chamber through said housing, whereby a pressure inside said housing greater than the pressure outside said

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housing tends to hold said check valve in an open position.

9. A check valve according to claim 8 including a spring acting on said valve member to hold said check valve in a normally closed position.

10. In a percussion drilling apparatus which includes a vibratory fluid-actuated motor having a tubular housing and a hammer adapted to oscillate longitudinally within said housing, the improvement comprising a unidirectional valve having a valve member in the fluid inlet to said motor adapted to admit power fluid to said motor, means fixed to said valve member and to said housing which form a variable-volume chamber that expands when said valve closes said fluid inlet and an unobstructed pressure-equalizing conduit extending from said variable-volume chamber to a position at which the pressure is substantially less than the pressure at said inlet so that said valve is held open when said motor is operating.

11. The apparatus of claim 10 wherein said pressure-equalizing conduit extends axially through said motor.

12. In a percussion drilling tool having a fluid-actuated motor and a float valve in the power fluid conductor upstream from said motor, the improvement comprising means to immobilize said float valve during the operation of said motor whereby the wear on said valve is substantially eliminated, said means including a variable-volume chamber connected to said float valve and positioned upstream from said motor whereby the pressure of said power fluid tends to decrease the volume of said chamber and open said valve, a pressure-equalizing line between said variable-volume chamber and a position downstream from said chamber where the pressure of said power fluid is substantially less than the pressure at said chamber whereby the pressure drop across said variable-volume chamber effectively immobilizes said float valve.

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