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BALL DIRECTOR FOR ROCK BITS

Filed May 23, 1962

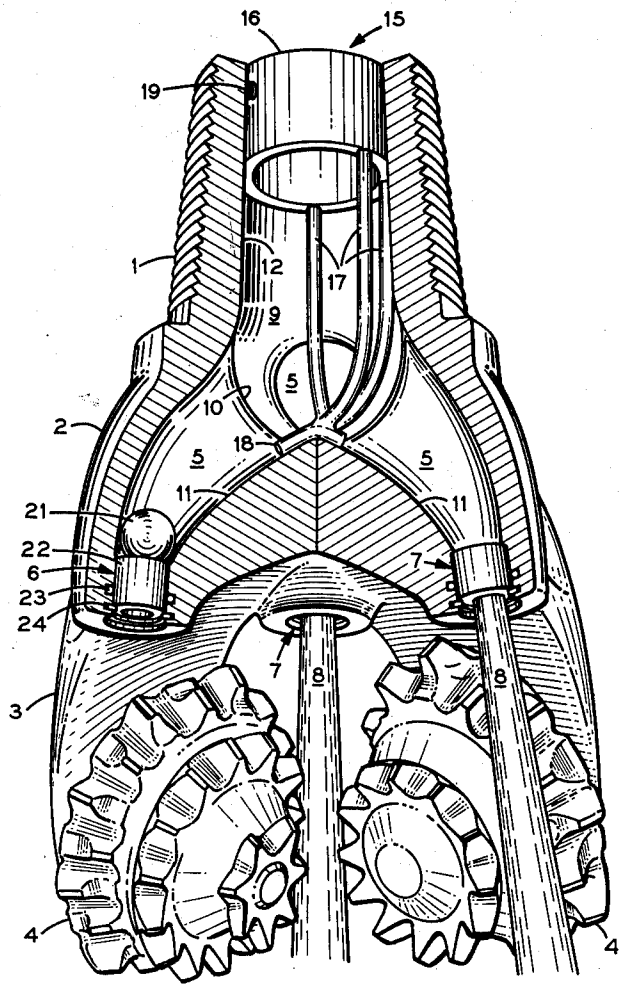


FIGURE 1

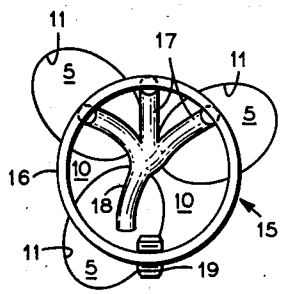


FIGURE 3

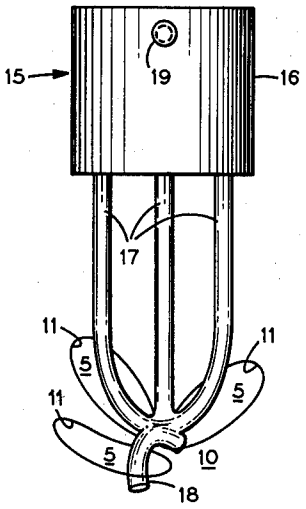


FIGURE 4

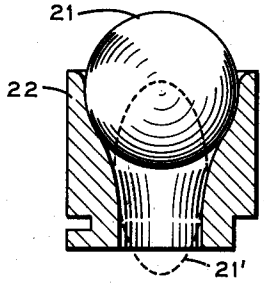


FIGURE 2

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BALL DIRECTOR FOR ROCK BITS

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The present invention lies in the field of auxiliary devices used with rotary rock bits, and more particularly in a method and device used to attain a measure of control over the flow of flushing fluid used in drilling with such bits. Such a bit is typically suspended from the lower end of a string of hollow drill pipe through which a flushing fluid or "mud" is circulated down to the bit and jetted therefrom through a number of nozzles or water-courses. This fluid is then circulated upwardly through the annulus between drill pipe and borewall, carrying the rock cuttings to the surface. Of course, the drill pipe also transmits the torque necessary to turn the bit against the resistance of the formation being drilled. A suitable downward force on the bit while keeping the drill string in tension is effected by using one or more drill collars as the drill string members just above the bit. A drill collar may be though of as a drill pipe with an extra thick wall, the extra thickness being achieved by using a larger outside diameter than that of the drill pipe. The weight on the bit is then controlled by adjusting the portion of the total drill string weight supported from the surface structure.

During the drilling of a well it is quite often necessary to halt actual drilling to "make a trip," i.e., raise the drill bit all the way to the surface, make some change or repair, and return the bit to bottom. During such trips, the mud pump is simply shut down, and the mud sits in the hole. If the bit is raised rapidly, as is desirable if "down" time is to be minimized, the so-called "piston effect" may be felt. This effect is one of turbulent motion and pressure surges in the mud, caused largely by the relative motion between the drill string and the mud but aggravated in part by the fact that the annulus between the borehole and the drill collars is relatively small and in part by the fact that the nozzle or water-course openings in the bit restrict the rate of flow therethrough so that the mud inside the drill string does not flow out as fast as the bit is being raised. It should also be noted that the bit is not raised from bottom to surface in one continuous step, but rather in a series of steps, at the end of each of which the crew on the drill rig floor must uncouple three or four drill stem sections as a unit and stack each unit at one side before again picking up and raising the string.

Even when the borehole is in the best condition, the piston effect produces certain undesirable results. In raising or "pulling" the bit, one such effect is that mud will drain from the string when a unit is uncoupled on the rig floor. The mess thus produced is not only unpleasant but dangerous as well, as it makes for treacherous footing, slippery tools, and, in cold weather, icing. In lowering or "running" the bit, the piston effect may cause "water hammer," which places an extra strain on equipment and is a suspected cause of the loss of nozzles from bits.

When the borehole passes through a "lost circulation" zone or reaches a depth such that the drilling fluid hydrostatic pressure must seal off the hole against the entry of formation fluids, the results of the pressure changes accompanying a rapid running or pulling of the bit can be even more devastating. Since pulling the bit causes a suction which reduces the mud pressure below the hydrostatic level, formation fluids may enter the borehole to

"cut" the mud and eventually cause a blowout. Running the bit, on the other hand, causes an increase in mud pressure over the hydrostatic value which may cause the mud to penetrate a highly porous formation, even though such formation had been previously sealed off to stop lost circulation by circulating with the mud materials found adaptable in plugging and patching such porous zones.

One practice which has been developed in an effort to avoid or minimize the results of the piston effect is that of using bits modified to have a larger nozzle flow area when the bit is being lowered than when it is "making hole." One method of doing this is to use only two nozzles while drilling and use a third nozzle which is open only when the bit is being lowered, the two nozzles used in drilling having a total cross-sectional area (orifice) equal to that of the three nozzles more commonly used for drilling. When the bit touches bottom, the third nozzle is plugged by dropping a ball from the surface. In the past steel balls have been used, with the result that a nozzle once plugged stayed plugged until the bit was raised to the surface.

There was thus no net gain in pulling the bit, although some advantage was gained in the running operation. Such steel balls were typically employed with jet bits having all three nozzles of the same orifice size, and it was immaterial which nozzle was plugged by the ball. With this arrangement there was a 50% increase in flow area during the running operation over that used in drilling.

The present invention was developed with the idea that the nozzle to be plugged could have a considerably larger orifice area than the unplugged, always open nozzles, thus providing more than a 50% increase in flow area. Such larger orifice area has the additional advantage of providing a considerably reduced likelihood of plugging all nozzles, a result sometimes occurring in the use of coarse lost circulation materials such as walnut hulls.

Since the prior art technique described above caused a permanent plugging of one nozzle and thus provided no improvement in the bit pulling operation, the present invention also contemplates remedying such defect by the use of balls of sufficient resiliency and of appropriate size so that they can be squeezed through the nozzle orifice by appropriate adjustments to the flushing fluid pressure just prior to raising the bit. Such a ball can also be ejected when the bit encounters a lost circulation zone and the mud mixture is reformulate to add lost circulation materials. Such reformulated mud is then circulated until the porous zone is sealed off, after which a second ball may be added to replug the nozzle. Thus the porous zone is plugged without coming off bottom with the bit, and drilling is resumed without loss of time for a "round trip."

To make such technique completely effective, it is necessary to use some means of directing the ball forced down the drill pipe into the proper nozzle. Accordingly, it is the object of the present invention to provide a device mounted inside a rock bit to direct a ball dropped down through the top of the bit into a predetermined nozzle. Stated in negative terms, such device prevents such a ball from entering any nozzle other than the oversize nozzle to be plugged.

Another and more general object is to provide a drilling method wherein the maximum cross sectional area of the nozzles in a drill bit is utilized during the steps of running the bit in a borehole and pulling such bit therefrom, and such area is reduced during the time the bit is being rotated to cut the formation.

A subsidiary object is to provide such a method in which such maximum area is also used when circulating

with the drilling fluid materials used to plug and/or patch a lost circulation zone.

The foregoing and other objects are achieved according to the present invention by using a conventional rock bit equipped with jet nozzles in which one nozzle is deliberately made oversize as to orifice area. As an example, if bit size, mud viscosity and other pertinent parameters called for drilling with three nozzles of 5/16 inch orifice diameter, the oversize nozzle is one having a 3/4 inch diameter while the other two are each of 3/8 inch diameter. (Note that the total area of the last two approximately equals the area of the three 5/16 inch nozzles.)

The rock bit thus equipped is attached to the lower end of a conventional drill string and is run into the hole through the mud therein with all three nozzles open. When the bit reaches bottom and other conditions are appropriate for drilling, a resilient ball of slightly larger diameter (e.g., 7/8 inch) than the oversize nozzle orifice is introduced and pumped down to the bit when the mud pump is turned on. The ball director of the present invention directs the ball into the oversize nozzle, in which it is seated and held by the pressure of the circulating mud. Closing of the oversize orifice causes the mud pressure and flow rate through the other two nozzles to adjust to the design values for drilling, and drilling may be commenced.

When it is necessary to pull the bit, or to circulate lost circulation materials without pulling the bit, the mud pump is stepped up to cause a transient high pressure surge which travels down the mud column inside the drill string to the bit. This temporary overpressure causes the ball to be squeezed into and through the nozzle orifice, after which it is carried up the annulus by circulation or flotation.

The present invention may be more readily appreciated by referring to the accompanying drawing for illustration.

In the drawing

FIGURE 1 is a perspective view of a conventional rock bit with a third portion cut away to show the ball director of the present invention disposed therein,

FIGURE 2 is a section of the oversize orifice nozzle of FIGURE 1 with the ball of that figure seated in sealing position therein, and also showing in phantom the contour of the ball as it is squeezed through the orifice by an overpressure,

FIGURE 3 is a top view of the ball director of FIGURE 1 with all of the bit removed except the concave bottom of the bit shank and the intersection therewith of the nozzle approach passageways, and

FIGURE 4 is a front view of the structure shown in FIGURE 3.

FIGURE 1 illustrates a conventional three cone jet rock bit from which a third of the shank **1** and a third of head **2**, together with one of the legs **3** and a cone **4** have been removed. The radial sectioning planes pass through a pair of three nozzle approach passageways **5**, located 120° apart, and all nozzle assemblies **6** and **7** have been left in place. These assemblies may be of any convenient type, but the removable type of Payne, U.S. Patent 2,855,182 or of Kistler, appl. S.N. 702,060, filed December 11, 1957, are preferred. The jet streams **8** emerging from the two nozzles **7** are used to indicate that these two nozzles are those used when drilling formation.

The ball director **15** is disposed in shank passageway **9** so that its sleeve portion **16** connecting rods or legs **17** abuts the inner wall **12** of shank **1** and rods **17** converge at their lower ends of about the center of the concave bottom wall **10** of the passageway. At such convergence rods **17** are conveniently welded to a seat **18** which is supported on the unrelieved part of bottom wall **10** with its ends projecting into a pair of passageways **5** in contact with the walls **11** thereof. Rods **17** are spaced to block the passage of a ball into either of the passageways **5** above the pair of nozzles **7** without blocking that above nozzle **6**, and are of small diameter to minimize any disturbance to the flow of flushing fluid. Sleeve portion **16**, which is likewise of minimum wall thickness, is secured to wall **12** of the shank **1** with a set screw **19**.

FIGURES 3 and 4 further illustrate the construction of ball director **15** and the manner in which it is supported in the bottom of shank passageway **9**. As therein indicated, the seat **18** which constitutes the bottom element of the ball director rests on a web of the bottom **10** defined between the intersection of the shank bottom **10** and a pair of the walls **11** defining nozzle approach passageways **5**. When thus seated, each of the two ends of seat **18**, which is simply a short piece of rod bent to conform to walls **11** of passageways **5** and the web of shank bottom **10** therebetween, extend into a pair of passageways **5** so that the ball director can not be rotated unless it is first raised. An undesired lifting is prevented by tightening set screw **19** against wall **12** of the shank. This engagement of set screw **19** with wall **12** also prevents rotation of the ball director.

When thus secured, the ball-blocking rods **17** are oriented to prevent a ball **21** from entering either nozzle approach passageway **5** above the pair of nozzles **7** and to direct it into the passagawey **5** above nozzles **6**. FIGURE 1 shows the ball **21** in its sealing position in nozzle assembly **6**. Such a nozzle assembly **6** typically consists of a tungsten carbide nozzle **22**, and O-ring **23** in grooves in one or both the nozzle and bit passageway, and a removable, contractable snap ring fastener **24** disposed in registering grooves in nozzle and passageway.

FIGURE 2 shows a ball **21** in a nozzle **22** in its normal, flow-preventing position. The phantom outlet **21'** shows the distorted shape of the ball as it is being squeezed through the nozzle orifice by an overpressure of drilling fluid. Ball **21** may be made of any of a variety of suitably resilient material. Nylon balls with a rubber covering, of the type commonly known as Halliburton "Frac" balls, have been used, but hard rubber and other materials such as plastics may be substituted.

It will be apparent, of course, that the embodiment shown in the drawing is capable of many variations without departing from the spirit of the invention. The embodiment illustrated is preferred because it is made of parts readily available, is quite simple to fabricate, and is very quickly installed and removed. Ready removability, of course, does not affect operation of the invention, but does make it possible to salvage the ball director for use in another bit.

The number of ball-blocking legs **17** may vary considerably with the type and size of bit in which the ball director is to be used, the important criterion being to have such number and spacing that a ball can not slip between adjacent legs nor between one leg and the shank bottom. In addition, the number of legs should not be so great as to seriously impede the flow of drilling fluid, though the legs should be close enough to direct balls of all expected sizes.

It is not absolutely essential that the legs **17** converge at the bottom of the ball director, nor even that they be joined together at their lower ends, though this arrangement does make for a convenient seat, a more rigid structure and insurance against rotation. So long as the legs are disposed to prevent a ball from entering predetermined nozzle approach passageways and not to prevent its entry into others, the action of the circulating drilling fluid will force the ball into one of the preselected nozzles for which it is destined.

Alternate techniques for securing the upper ends of the legs may vary all the way from welding individual legs to shank wall **12**, where neither replaceability or a unitized structure is deemed important to the use of a member similar to **16** which is of minimum size to link and integrate the legs but in itself is not readily securable to the bit shank. If, for instance, such member were a relatively

thin ring extending only betwen the tops of the legs, it could be secured to the shank by a snap ring fastener similar to those used in nozzle assemblies **6**. It is also believed to be apparent that various other devices can be used to prevent rotation and lifting, including a pin through registering grooves in the shank wall and member **16**.

The above examples in variations are pointed out merely by way of illustration and are not intended by way of limitation. Broadly, the present invention comprises a method of drill rig operation in which a bit is run or pulled with all nozzles unplugged and with one or more nozzles having orifice areas greater than those of the other nozzles and such bit is equipped with a ball director to prevent the entry of a ball circulating down the drill string from entering the approach passageways of the smaller orifice nozzles and allow entry into the others, in which balls are so circulated to block the larger orifice nozzles to prevent drilling mud circulation therethrough, in which formation drilling is accomplished with such nozzles plugged, and in which the mud pressure is temporarily raised to eject such balls prior to pulling the bit or at other desired times. In one of its more specific aspects, the present invention includes specific ball director means to accomplish the indicated ball directing function.

What is claimed is:

1. A method of utilizing a drill string having a continuous drilling fluid passageway from the surface to and through a drilling bit constituting the lowermost element of such drill string and having therein a multiplicity of nozzles defining the lower end of such passageway, such nozzles being divided into a first quantity having a total orifice area appropriate for a particular set of drilling conditions and a second quantity of at least one member each having an orifice area larger than that of each member of the first quantity, such bit also having secured therein means for blocking the entry of a ball into any of such first quantity of nozzles and directing it into such second quantity without seriously impeding the flow of flushing fluid through any of such nozzles comprising the steps of:

(1) running such bit into a bore hole which may contain flushing fluid with all such first and second nozzles unplugged,

(2) circulating at least one resilient ball of appropriate size down said drill string until it is seated in and seals such at least one member of the second quantity of nozzles against the flow of drilling fluid therethrough,

(3) drilling the formation as desired while circulating drilling fluid through such first quantity of nozzles, and

(4) causing a temporary overpressure behind said nozzles to push said ball into and through its associated nozzle orifice prior to pulling said bit or circulating lost circulation materials.

2. A ball director adaptable for disposition in the hollow shank of a rock bit or other earth penetrating tool having a multiplicity of fluid passageway each leading from said hollow shank to the bottom of said bit or tool and terminating thereat in a nozzle orifice, the number of said nozzle orifices being divided into a first quantity of one or more having a total cross-sectional area appropriate for drilling under a selected set of conditions and a second quantity of at least one orifice each having a cross-sectional area larger than that of each member of said first quantity, each said passageway above said second quantity of orifices being adapted to receive a resilient ball in flow-blocking relationship under pressures of drilling fluid used in drilling a formation, said ball and said passageway being of such size relative to said orifice that said ball may be squeezed into and ejected downwardly from said orifice by an increase in the pressure of a drilling fluid circulating thereabove, said ball director comprising a number of legs adapted to block the entry of such resilient ball into any of said passageways above said first quantity of nozzle orifice and to permit its entry into any passageway above said second quantity, said legs being of such cross-section and spacing as not to seriously impede the flow of flushing fluid, and means adaptable for securing said legs against rotation and axial movement relative to said shank.

3. A ball director of the type described in claim 2 adapted for use with the bit therein described in which said legs extend longitudinally downwardly and which includes a sleeve element joining the tops of said legs, said securing means comprising a member extending through said sleeve into the wall of said shank, said sleeve and legs approximately abutting said shank wall to prevent the passage of said balls therebetween.

4. A ball director of the type described in claim 3 adapted for use with the bit thereof in which said legs converge near their bottom ends and are joined together proximate the axis of said bit in a joint adapted for seating on the interior bottom surface of said shank between its intersection with said fluid passageways.

5. A ball director of the type described in claim 4 adapted for use with the bit thereof in which a seat element is secured to said legs at their common lower terminus, said seat being elongated generally traverse the bit and of shape conforming to the uncut bottom of the shank bore.

6. A ball director of the type described in claim 4 adapted for use with the bit thereof in which the ends of said seat are adapted to extend into a pair of said passageways in contact with the walls thereof to prevent rotation of said ball director relative to said shank.

7. In a drilling tool having an upstanding shank adapted for connection to a drill string in rotatable and fluid flow relationships therewith and having for such fluid flow a downwardly extending blind opening therein, a multiplicity of nozzle approach passageways extending from said blind opening adjacent its bottom through said tool, the lower ends of said passageways being adapted to receive replaceable nozzles of various orifice diameters: the combination of a ball director disposed in said blind opening, a first quantity of one or more nozzles of small orifice diameters and total cross section appropriate for drilling under a given set of conditions disposed in some of said passageways at the lower ends thereof to leave a balance of at least one passageway, and a second quantity of nozzles disposed in the lower ends of the balance of said passageways, said second quantity consisting of at least one nozzle which is of larger orifice diameter than that of said first quantity adaptable to receive a resilient ball in sealing and plugging relationship under ordinary pressures of drilling fluid and to pass said ball through its orifice under higher pressures, said ball director comprising a multiplicity of legs disposed to prevent the entry of said balls into the passageways above said first quantity of nozzles without preventing the entry thereof into the passageways above said second quantity and means to prevent the movement of said legs from such disposition, said legs being of such number and cross-section as not to seriously impede the flow of flushing fluid.

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