Lubricant is circulated from a lubricant reservoir to the bearings of a rock bit and back to the lubricant reservoir by a lubricant pump that is operated by periodic fluid pressure variations. A pumping chamber is located in the bit body. A movable pumping element is positioned in the pumping chamber. A first side of the pumping element is exposed to the pressure of the drilling fluid. Passages are provided to channel the lubricant from the lubricant reservoir to the bearing systems and back to the lubricant reservoir. The second side of the pumping element is exposed to lubricant in the passages. Check valves in the passages provide one-way flow of lubricant. Periodic pressure variations in the drilling fluid create a reciprocating motion of the pumping element causing the lubricant to be circulated through the passages.

23 Claims, 5 Drawing Figures
HYDROSTATIC ROCK BIT LUBRICATION SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to the earth boring art and more particularly to a lubrication system for a rotary rock bit.

A rotary rock bit must operate under very severe environmental conditions and the geometry of the bit is restricted by the operating characteristics. At the same time, the economics of petroleum production demand a longer lifetime and improved performance from the bit. In attempting to provide an improved bit, new and improved materials have been developed for the cutting structure of the cones, thereby providing a longer useful lifetime for the cones. This has resulted in the bearing system being the first to fail during the drilling operation. Consequently, a need clearly exists for a system that will extend the useful lifetime of the bearing systems of the bit.

DESCRIPTION OF PRIOR ART

In U.S. Pat No. 3,244,451 to J. E. Ortloff, patented Apr. 5, 1966, a lubricating system for extending the life of the bearings of a roller cone type bit is shown. Sealing means are provided to effectively separate or close off the clearance between the journal of the roller cone and the outer bearing surface. A special pump means is provided to circulate the lubricating fluid under high pressure through this sealed-off clearance space. The pump means is actuated by the rotation of the roller cone element on the shaft.

In U.S. Pat. No. 3,251,634 to W. D. Dareing, patented May 17, 1966, a lubricating system for extending the life of the bearings of a roller cone type bit is shown. Sealing means are provided to effectively separate or close off the clearance or space between the journal of the roller cone and the outer bearing surface.

SUMMARY OF THE INVENTION

Periodic pressure variations are produced in the drilling fluid during the drilling of an oil well. During drilling, joints of pipe must be added to the drill string for progressively deeper penetration. This may mean that fifty or sixty joints of pipe are added to the drill string during the normal life of a sealed bearing rotary rock bit. In order to add a joint of pipe, which is usually 30 feet in length, rotation of the pipe must be stopped and the entire string of pipe, including the bit, must be raised high enough to allow the Kelly to clear the rotary table. (35–50 feet). The pumps that circulate fluid through the drill pipe and borehole during the drilling operation are shut down during the raising and lowering of the bit. The pumps are started again after the joint of pipe is added. Periodic pressure variations are therefore produced in the drilling fluid each time a section of pipe is added to the drill string.

In order to extend the useful lifetime of the rock bit bearing system, the present invention provides a system for circulating lubricant from a lubricant reservoir to the bearing system and back to the lubricant reservoir utilizing the periodic pressure variations in the drilling fluid. The bit includes a surface exposed to the drilling fluid. Rotatable cutters are mounted upon bearing pins extending from the bit body and bearing systems between the cutters and the bearing pins promote rotation of the cutters. A lubricant reservoir is provided in the bit body and passage means channel lubricant from the lubricant reservoir to the bearing systems and from the bearing systems back to the lubricant reservoir. A pumping chamber is located in the bit body. A movable pumping element is positioned in the pumping chamber and the movable pumping element responds to the periodic pressure variations in the drilling fluid to pump lubricant through the passages. Check valve means ensure one-way flow of lubricant in the passages. The above and other features and advantages of the present invention will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a three cone sealed bearing rotary rock bit constructed in accordance with the present invention.

FIG. 2 is a sectional view of one arm of the bit of FIG. 1, showing the lubricant circulation system.

FIG. 3 is a schematic diagram of the lubricant circulation system of the present invention.

FIG. 4 illustrates a second embodiment of the present invention.

FIG. 5 illustrates a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and to FIG. 1 in particular, shown therein and generally designated by the reference number 10 is a three cone sealed bearing rotary rock bit. As illustrated, the bit 10 includes a bit body 11, including an upper threaded portion 12. The threaded portion 12 allows the bit 10 to be connected to the lower end of a rotary drill string (not shown). Depending from the bit body 11 are three substantially identical arms with two of the arms 13 and 15 being shown in FIG. 1. The lower end of each of the arms is provided with an extended journal portion and the details of this journal portion will be discussed subsequently. Three rotary cone cutters 14, 14' and 14'' are rotatably positioned on three bearing pins extending from the arms. Each of the cutters 14, 14' and 14'' includes cutting structure 15, 15' and 15'' on its outer surface adapted to disintegrate formations as the bit 10 is rotated and moved through the formations. The cutting structure 15, 15', 15'' is shown in the form of tungsten carbide inserts. However, it is to be understood that other cutting structures such as steel teeth may be used as the cutting structure on the cone cutters.

The bit 10 includes a central passageway 16 extending along the central axis of body 11 to allow drilling fluid to enter from the upper section of the drill string (not shown) immediately above and pass downward through three jet nozzles, one nozzle 17 being shown in FIG. 1, past the cutting structure 15, 15' and 15'' of the cone cutters 14, 14' and 14''. In use, the bit 10 is connected as the lower member of a rotary drill string (not shown) and lowered into the well bore until the cone cutters engage the bottom of the well bore. Upon engagement with the bottom of the well bore, the drill string is rotated, rotating bit 10 therewith. Drilling fluid is forced down through the interior passage of the ro-
tary drill string by mud pumps located at the surface. The drilling fluid continues through the central pas-
sageway 16 of bit 10, passing through the nozzles past the cutting structure of the cutters to the bottom of the well bore, thence upward in the annulus between the rotary drill string and the wall of the well bore, carrying with it the cuttings and debris from the drilling opera-
tion.

Periodic pressure variations are produced in the borehole fluid during the drilling operation. During drilling, joints of pipe must be added to the drill string for progressively deeper penetration. This may mean that 50 or 60 joints of pipe are added to the drill string during the normal life of a rotary rock bit. In order to add a joint of pipe which is usually 30 feet in length, rota-
tion of the bit must be stopped and the entire string of pipe, including the bit, must be raised high enough to allow the Kelly to clear the rotary table (35–50 feet). The mud pumps are stopped during the addition of a joint of pipe thereby reducing the pressure of the borehole fluid acting on the bit. After the joint of pipe is added to the drill string, the mud pumps are started thereby increasing the pressure of the borehole fluid acting on the bit.

Since operating costs of oil well drilling rig are quite high, the time that the bit is off bottom and not drilling must be kept to a minimum. Therefore, the addition of a joint of pipe must be accomplished quickly and the drill string must be raised and lowered as rapidly as possible. This raising and lowering of the drill string also creates pressure variation because of the hydrostatic pressure of the fluid in the well bore. As the drill string is elevated in the well bore, the bit acts in much the same manner as a piston in a cylinder. The enlarged di-
diameter of the bit body exerts a force on the column of fluid above it due to the velocity of the bit traveling up the well bore. The aforementioned periodic pressure variations are utilized to pump lubricant from a lubri-
cant reservoir in the bit body to the bearings and from the bearings to the lubricant reservoir.

Referring now to FIG. 2, a sectional view of one arm 13 of the bit 10 is shown. The cutter 14 is rotatably po-

tioned on the journal portion of the arm 13 and adapted to disintegrate earth formations as the bit is ro-
tated. The journal portion of the arm 13 consists of a bearing pin 18 on which the cutter 14 is mounted. A plurality of bearing systems are located in the bearing area between the cutter 14 and the bearing pin 18. The bearing systems in the bearing area include an outer friction bearing 19, a series of ball bearings 20, an inner friction bearing 21, and a thrust button 22. An O-ring seal 23 is positioned between the cutter 14 and the bearing pin 18. This seal retains lubricant in the bearing area around the bearing systems and prevents any ma-
terials in the well bore from entering the bearing area. The O-ring seal 23 prevents fluid flow in either direc-
tion. A passageway 24 allows the balls that make up the ball bearing system 20 to be inserted into position after the cone cutter 14 is placed on the bearing pin 18. The series of ball bearings 20 serves toロック the cone cutter 14 on bearing pin 18. After the balls are in place, a plug 25 is inserted into the passageway 24 and welded therein by weld 26. Plug 25 has a reduced diameter throughout the major portion of its length to allow lu-

A cylindrical reservoir chamber 26 is located in the bit body 11. A lubricant reservoir 27 containing a suit-
able lubricant is positioned in the lubricant reservoir chamber 26. The lubricant reservoir 27 consists of a lu-

bricant reservoir canister 28 with a flexible diaphragm 29 attached. A vent passage 30 allows the pressure of the fluid in the borehole to be transmitted to the outside of the flexible diaphragm 29. A bore 31 is located in the bit body 11. The bore 31 provides a piston cham-
ber. A movable piston 32 is positioned in the bore 31. The area above piston 32 provides a pumping chamber 98. A passage 99 connects the pumping chamber 98 and the central passageway 16. A passage connects the lubricant reservoir 27 and the bore 31 containing the movable piston 32. A passage 33 extends from the bore 31 to the bearing area between the cutter 14 and the bearing pin 18. A return passage 34 extends from the passage 24 to the lubricant reservoir 27. Lubricant in the bearing area between the cutter 14 and the bearing pin 18 can flow through the passage 24 into the passage 34 back to the lubricant reservoir 27. A check valve 35 insures that there will be only one-way flow in passage 34 by preventing flow from the lubricant reservoir 27 toward the bearing area.

Referring now to FIG. 3, a schematic diagram of the lubrication circulation system of FIGS. 1 and 2 is shown. Lubricant in the lubricant reservoir 27 is transmitted through a passage 36 into the bore 31. A check valve 37 insures one-way flow in passage 36 by preventing flow from bore 31 into lubricant reservoir 27. A spring 38 tends to force movable piston 32 toward the pumping chamber 98 in section 39 of bit 10. The pressure of fluid in the passage 16 will act on the movable piston 32 compressing spring 38 and forcing lubricant in the bore 31 through the passage 33 into the bearing area between the cutter 14 and bearing pin 18. Lubricant in the bearing area between the cutter 14 and the bearing pin 18 will be forced through passages 24 and 34 through check valve 35 back to lubricant reservoir 27. The pressure variations in the drilling fluid in the central passage 16 will create periodic oscillations of the movable piston 32, thereby circulating lubricant from the lubricant reservoir 27 through the passages 36 and 33 to the bearing area between the cutter 14 and the bearing pin 18 and from the bearing area through passages 24 and 34 back to the lubricant reservoir 27.

Referring now to FIG. 4, another embodiment of the present invention is illustrated. A sectional view of one arm 40 of a rotary rock bit generally designated by the reference number 41 is shown. A cutter 42 is rotatably po-

tioned on the journal portion of the arm 40 and adapted to disintegrate earth formations as the bit is ro-
tated. The journal portion of the arm 40 consists of a bearing pin 43 on which cutter 42 is mounted. A plurality of bearing systems are located in the bearing area between the cutter 42 and the bearing pin 43. The bearing systems in the bearing area include an outer friction bearing 44, a series of ball bearings 45, an inner friction bearing 46, and a thrust button 47. An O-ring seal 48 is positioned between the cutter 42 and the bearing pin 43. This seal retains lubricant in the bearing area around the bearing system and prevents any ma-
terials in the well bore from entering the bearing area. The O-ring seal 48 prevents fluid flow in either direc-
tion. Cutting structure 49 extends from the outer sur-
face of the cutter 42 to disintegrate the formations as the bit 41 is rotated and moved downward. The cutting structure 49 is shown in the form of tungsten carbide
inserts. However, it is to be understood that the other cutting structures such as steel teeth may be used as the cutting structure on cutter 42. A cylindrical reservoir chamber 50 is located in the bit 41. A lubricant reservoir 51 for containing a suitable lubricant is positioned in the lubricant reservoir chamber 58. The lubricant reservoir 51 consists of a lubricant reservoir canister 52 with a flexible diaphragm attached. The lubricant reservoir canister 52 is locked in the lubricant reservoir chamber 50 by a snap ring 54 that fits within a groove in the lubricant reservoir chamber 50. An O-ring seal 55 provides a fluid seal between the lubricant reservoir canister 52 and the lubricant reservoir chamber 50. A vent passage 56 allows the pressure of the fluid in the borehole to be transmitted to the outside of the flexible diaphragm 53.

A passage 57 extends from the lubricant reservoir 51 to the bearing area between the cutter 42 and the bearing pin 43. A return passage 58 extends from the bearing area between the cutter 42 and the bearing pin 43 to the lubricant reservoir 51. Check valves 59 and 60 insure one way-flow of the lubricant in the passages 57 and 58. A pumping chamber 61 is located in the arm 40 of the bit 41. The pumping chamber 61 is positioned in the passage 57 by a passage 62. A canister 63 is positioned in the pumping chamber 61 and locked therein by a snap ring 64. A flexible diaphragm 65 is positioned in the canister 63 and divides the canister into an air space 66 and a lubricant space 67. The diaphragm 65 completely seals the air chamber 66.

The structural details of a second embodiment of the present invention having been described, the operation of the lubricant circulation system shown in bit 41 will be considered. The pressure of the fluid in the well bore is transmitted through the vent passage 56 to the outside of the flexible diaphragm 53. The flexible diaphragm 53 transmits the fluid pressure directly to the lubricant in the lubricant reservoir 51. Periodic pressure variations are produced in the borehole fluid during the drilling operation. During drilling joints of pipe must be added to the drill string for progressively deeper penetration. This may mean that 50 or 60 joints of pipe are added to the drill string during the normal life of a rotary rock bit. In order to add a joint of pipe, the mud pumps are stopped and the entire string of pipe is raised high enough to allow the Kelly to clear the rotary table. The section of pipe is added to the drill string and the drill string is lowered into the borehole. The mud pumps are started again and the drilling operation continues. The starting and stopping of the mud pumps creates periodic pressure variations in the borehole fluid. The periodic pressure variations in the borehole fluid surrounding the bit 41 will cause the trapped air in air chamber 66 to compress and expand, thereby moving the flexible diaphragm 65 and creating a pumping action in the lubricant. The check valve 60 prevents the lubricant from being forced back into the lubricant reservoir 51 and the lubricant is forced out through check valve 59 to the bearing area between the cutter 42 and the bearing pin 43. The lubricant is returned to the lubricant reservoir 51 through the return passage 58.

Referring now to FIG. 5, a third embodiment of the present invention is shown. One arm 68 of a rotary rock bit generally designated by the reference number 69 is shown in cross section. A cutter 70 is rotatably positioned on the journal portion of the arm 68 and adapted to disintegrate earth formations as the bit is rotated. The journal portion of the arm 68 consists of a bearing pin 71 on which the cutter 70 is mounted. A plurality of bearing systems are located in the bearing area between the cutter 70 and the bearing pin 71. Bearing systems in the bearing area include an outer friction bearing 72, a series of ball bearings area 73, an inner friction bearing 74, and a thrust button 75. An O-ring seal 76 is positioned between the cutter 70 and the bearing pin 71. This seal retains lubricant in the bearing area around the bearing systems and prevents any materials in the well bore from entering the bearing area. The O-ring seal 76 prevents fluid flow in either direction. Cutting structure 77 extends from the surface of cutter 70 to disintegrate formations as bit 69 is rotated and moved downward. The cutting structure 77 is shown in the form of tungsten carbide inserts. However, it is to be understood that other cutting structures such as steel teeth may be used as the cutting structure on the cone cutter 70.

A cylindrical reservoir chamber 78 is located in the bit 69. A lubricant reservoir 79 containing a suitable lubricant is positioned in the lubricant reservoir chamber 78. The lubricant reservoir 79 consists of a lubricant reservoir canister 80 with a flexible diaphragm 81 attached. A vent passage 82 allows the pressure of the fluid in the borehole to be transmitted to the outside of the flexible diaphragm 81. A pumping chamber 83 is located in the bit 69. A passage 84 extends from the lubricant reservoir 79 to the pumping chamber 83. A passage 85 extends from the pumping chamber 83 to the bearing area between the cutter 70 and the bearing pin 71. A return passage 86 extends from the bearing area to the lubricant reservoir 79.

The pumping chamber 83 is completely sealed from the fluid in the borehole by a plug 87 that is positioned in the upper end of the pumping chamber 83 and welded therein by weld 88. A movable piston 89 is positioned in the pumping chamber 83. An O-ring seal 90 insures a fluid seal between the walls of the pumping chamber 83 and the movable piston 89. A spring 91 is positioned below the movable piston 89. A bleed passage 92 extends from the lubricant reservoir 79 to the bottom of the pumping chamber 83 below the movable piston 89. An orifice 93 in the bleed passage 92 restricts flow through the bleed passage 92. Check valves 94 and 95 in passages 84 and 85 respectively insure one-way flow of lubricant through the lubricant circulation system.

The structural details of a third embodiment of the present invention having been described the operation of the lubrication system in bit 69 will now be considered. The space in the pumping chamber 83 below the movable piston 89 is divided into a lubricant portion 96 and a gaseous portion 97 immediately above the lubricant portion 96. Periodic pressure variations are produced in the borehole fluid during the drilling operation and these periodic pressure variations create a reciprocating motion of movable piston 89, thereby pumping lubricant from the lubricant reservoir 79 through the passages 84 and 85 to the bearing area between the cutter 70 and the bearing pin 71 and from the bearing area through passage 86 back to the lubricant reservoir 79. The check valves 94 and 95 insure continued circulation of the lubricant by providing one-way flow of the lubricant through the circulation system.
During drilling, joints of pipe must be added to the drill string for progressively deeper penetration. This may mean that 50 or 60 joints of pipe are added to the drill string during the normal life of a rotary rock bit. In order to add a joint of pipe, the mud pumps that circulate drilling fluid through the borehole are stopped, and the entire string of pipe including the bit is raised high enough to allow the Kelly to clear the rotary table. Once the joint of pipe has been added to the drill string the drill string is lowered into the borehole, the mud pumps are started and the drilling operation continues. This starting and stopping of the mud pumps creates periodic pressure variations in the borehole fluid surrounding the bit 69. The borehole fluid enters the reservoir chamber through vent passage 82 and the pressure of the fluid in the borehole is transmitted to the lubricant in the lubricant reservoir 79 through the flexible diaphragm 81.

When the mud pumps are started the pressure of fluid in the borehole will be increased. This pressure increase is transmitted to the lubricant in the lubricant reservoir 79 and through the lubricant in the passage 84 to the lubricant in the pumping chamber 83. This increase in pressure will cause the movable piston 89 to move toward the bottom of the pumping chamber 83, thereby compressing the spring 91 and compressing the trapped gas in the gaseous portion 97 of the pumping chamber 83. Lubricant in the lubricant reservoir 79 will flow through check valve 94 and passage 84 into pumping chamber 83. Flow of lubricant through the bleed passage 92 into the lubricant portion 96 is slow because of the orifice 93 that restricts flow. Once the movable piston 89 reaches its lowest position in pumping chamber 83, the force of the compressed spring 91 plus the force of the compressed gas in the gaseous portion 97 acting on movable piston 89 will equal the force of lubricant in the pumping chamber above the movable piston acting on the piston. Lubricant will slowly flow from the lubricant reservoir 79 through the bleed passage 92 into the lubricant portion 96 to equalize the pressure of the compressed gas in the gaseous portion 97 acting on movable piston 89 and the pressure of lubricant above movable piston 89 acting on piston 89. As lubricant flows into the lubricant portion 96 and the pressures equalize the force of spring 91 will move the movable piston 89 upward thereby pumping lubricant through passage 85 past check valve 95 into the bearing area and through passage 86 back to the lubricant reservoir 79. When the mud pumps are stopped, the pressure of fluid in the borehole will decrease. Lubricant will flow from lubricant portion 96 through bleed passage 92 in the lubricant reservoir 79 until the pressure of gas in gaseous portion 97 equals the pressure of fluid in the borehole. When the mud pumps are started the operation described above is repeated.

The embodiments of the invention in which an exclusive property of privilege are claimed are described as follows:

1. In an earth boring bit that operates in a fluid filled borehole wherein said fluid is subjected to periodic pressure variations, said earth boring bit including a bit body, a rotatable cutter, bearing means for promoting rotation of said cutter and a seal between said rotatable cutter and said bit body, a lubricant circulation system, comprising:
   a lubricant reservoir in said bit body;
   passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
   one-way valve means in said passage means for providing one-way flow of lubricant in said passage means;
   a pumping chamber in said bit body;
   pumping means for pumping lubricant through said passage means, said pumping means including a movable pumping element positioned in said pumping chamber, said movable pumping element responsive to said periodic pressure variations; and
   means for allowing said periodic pressure variations to be transmitted to said movable pumping element.

2. The system of claim 1 wherein said movable pumping element is a sliding piston positioned in said pumping chamber.

3. The system of claim 1 wherein said movable pumping element is a flexible diaphragm positioned in said pumping chamber.

4. In an earth boring bit including a bit body with an external surface, a bearing pin extending from said bit body, a rotatable cutter mounted upon said bearing pin, and bearing means between said bearing pin and said cutter, a lubricant circulation system, comprising:
   a lubricant reservoir in said bit body;
   passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
   a pumping chamber in said bit body;
   pump means for pumping lubricant through said passage means, said pump means including a movable pumping element positioned in said pumping chamber; and
   means for allowing said periodic pressure variations to be transmitted to said movable pumping element.

5. The earth boring bit of claim 4 including a seal between said rotatable cutter and said bit body.

6. The earth boring bit of claim 5 including check valve means for providing one-way flow of lubricant in said passage means.

7. The earth boring bit of claim 6 including force means for biasing said movable pumping element toward said external surface.

8. The earth boring bit of claim 7 wherein said means for biasing said movable pumping element toward said external surface is a spring.

9. A rotary rock bit for drilling in a borehole filled with fluid with said fluid being subjected to periodic pressure variations, comprising:
   a bit body, said bit body including an exterior surface exposed to said fluid;
   at least one bearing pin extending from said bit body;
   a rotatable cutter mounted upon said bearing pin;
   a seal between said cutter and said bit body;
   bearing means between said bearing pin and said cutter for promoting rotation of said rotatable cutter;
   a lubricant reservoir in said bit body, said lubricant reservoir containing lubricant;
passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
valve means for providing one-way flow of lubricant in said passage means;
a pumping chamber in said bit body;
pumping means responsive to said periodic pressure variations in said fluid, said pumping means including a movable pumping element positioned in said pumping chamber; and
means for allowing said periodic pressure variations to be transmitted to said movable pumping element.
10. The rotary rock bit of claim 9 wherein said pumping element is a movable piston positioned in said pumping chamber.
11. The rotary rock bit of claim 10 including a vent passage extending from said pumping chamber to the exterior surface of said bit.
12. In an earth boring bit including a bit body with an external surface, a bearing pin extending from said bit body, a rotatable cutter mounted upon said bearing pin, and bearing means between said bearing pin and said rotatable cutter for promoting rotation of said cutter, a lubricant circulation system, comprising:
a lubricant reservoir in said bit body;
passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
a piston chamber extending into said bit body from the external surface of said bit body; and
pump means for pumping lubricant through said passage means, said pump means including a movable piston positioned in said piston chamber.
13. The earth boring bit of claim 12 including force means for biasing said movable piston toward said external surface.
14. The earth boring bit of claim 13 wherein said means for biasing said movable piston toward said external surface is a spring.
15. The earth boring bit of claim 14 including a seal between said rotatable cutter and said bit body.
16. The earth boring bit of claim 15 including check valve means for providing one-way flow of lubricant in said passage means.
17. A rotary rock bit for drilling in a borehole filled with fluid, comprising:
a bit body, said bit body including an interior passageway exposed to said fluid;
at least one bearing pin extending from said bit body;
a rotatable cutter mounted upon said bearing pin;
bearing means between said bearing pin and said cutter for promoting rotation of said rotatable cutter;
a lubricant reservoir in said bit body, said lubricant reservoir containing lubricant;
passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
a piston cylinder in said bit body, said piston cylinder in communication with said interior passage and said passage means; and
pump means for pumping lubricant through said passage means, said pump means including a movable piston positioned in said piston cylinder.
18. The rotary rock bit of claim 17 including check valve means for providing one-way flow of lubricant in said passage means.
19. The rotary rock bit of claim 18 including force means for biasing said movable piston toward said exterior surface.
20. The rotary rock bit of claim 19 wherein said means for biasing said movable piston toward said exterior surface is a spring.
21. The rotary rock bit of claim 20 including a seal between said rotatable cutter and said bit body.
22. In an earth boring bit that operates in a fluid filled borehole wherein said fluid is subjected to periodic pressure variations, said earth boring bit including a bit body, a rotatable cutter, bearing means for promoting rotation of said cutter and a seal between said rotatable cutter and said bit body, a lubricant circulation system, comprising:
a lubricant reservoir in said bit body;
passage means for channeling lubricant from said lubricant reservoir to said bearing means and from said bearing means to said lubricant reservoir;
one-way valve means in said passage means for providing one-way flow of lubricant in said passage means;
a piston chamber in said bit body;
pump means for pumping lubricant through said passage means, said pump means including a movable piston positioned in said piston chamber, said movable piston responsive to said periodic pressure variations; and
means for allowing said periodic pressure variations to be transmitted to said movable pumping element.
23. The system of claim 22 wherein said pump means includes a spring positioned between said movable piston and said bit body.
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