CUTTER ASSEMBLY FOR WELL TOOLS

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ABSTRACT OF THE DISCLOSURE

A cutter assembly adapted for use on a well drilling bit or the like and including a cutter member rotatably mounted on a support carried by the bit. The cutting assembly having a chamber formed therein that is substantially filled with a lubricant. The chamber also has a portion of the wall thereof formed by a flexible member that causes a response to pressure in the well to very the volume of the chamber whereby the lubricant in the chamber is maintained at a pressure substantially equal to the pressure surrounding the cutter assembly.

Background of the invention

This invention relates generally to improved cutter assemblies for drilling bits used in the drilling of oil or gas wells and the like. More particularly, but not by way of limitation, this invention relates to an improved sealed-bearing cutter assembly for use on a drill bit utilized to drill relatively large diameter well bores.

As is well known to those skilled in the art of drilling oil wells and the like, the life of the drill bit is an important factor in determining the speed and the cost of the well. Stated in another way, the cost of drilling the well is to a great extent dependent upon the efficiency of the drilling bit. The efficiency of the bit is determined by several factors, for example, the cutting structure of the bit and its effectiveness in penetrating and removing portions of the formation being drilled, the wear characteristic of the cutting structure, and the life of the bearings rotatably mounting the cutting member on the bit.

In recent years, there has been developed a bit incorporating a sealing structure that forms a chamber in which the bearings, journaling the cutting member are confined. Generally, the chamber is filled with a lubricant which serves the purpose of reducing the frictional engagement between the bearing members and the various rotating parts, and, of course, providing some cooling therefor.

Some problems have been encountered in the use of the sealed-bearing bit structures. For example, despite the lowering of friction in the bearings, friction and, consequently, heat is generated which expands and, perhaps, vaporizes some of the lubricant and forms a relatively high-pressure gas or vapor therein. Such pressure is occasionally of such magnitude that the seals are ruptured or damaged permitting deleterious materials in the environment surrounding the bit to enter the bearings. Once the deleterious materials have entered the bearings, the effectiveness and life of the bearings are drastically reduced.

Another example of the problems that have occurred is that the bit is, as the depth of the well progresses, exposed to relatively high ambient or environmental pressures which may be sudden but the deleterious material bypasses of force its way through the seals and enters the bearing structure. When this occurs, and as pointed out above, the bearing life and efficiency are drastically reduced.

Summary of the invention

This invention provides an improved cutter assembly adapted for use on a bit during the drilling of oil or gas wells and the like and includes: a cutter member; mount-
ranged to receive an enlarged end 34 of a sleeve or shaft member 36. Similarly, the leg portion 30 is provided with a semi-circular recess 38 that is sized and arranged to receive a second enlarged end 40 of the sleeve member 36. Aligned openings 42 and 44 extend transversely through the leg portions 28 and 39, respectively. The leg portion 28 is provided with an annular recess 45 in the opening 42 which mates with an annular recess 46 formed in a main pin 48 that extends through the aligned openings 42 and 44. The main pin 48 is received in the annular recesses 45 and 46, wherein the aligned openings are arranged to receive a retaining pin 50 that locks the main pin 48 in the saddle 24. With the main pin 48 extending through the sleeve member 36, the ends 34 and 40 engage the saddle 24 to prevent rotation therebetween. When the main pin 48 is removed, the cutting assembly 23 can be quickly and easily disassembled.

The sleeve member 36 has a counterbore 54 formed in one interior end thereof. An annular member 56 is located in the counterbore 54 with its interior disposed adjacent the pin 48. An annular recess 58 is formed in the medial exterior portion of the annular member 56 and a plurality of ports 60 extend therethrough, providing communication from the interior thereof with the annular recess 58. The annular member 56 is illustrated as being welded to the sleeve member 36 at 62, but any desired method can be utilized for connecting the members. An annular flexible member 64 encircles the recess 58 formed in the annular member 56. The flexible member 64 is secured to the annular member 56 in any suitable manner, such as by the bands 66 and 68 illustrated in FIG. 3. The flexible member 64 is of sufficient length to cover the ports 60 formed in the member 56 for reasons that will become more apparent hereinafter. Preferably, the flexible member 64 is constructed from a material that is both flexible and resilient and one that is compatible with the environmental conditions existing in the wellbore 12.

The sleeve member 36 is also provided with a roller race 70, a roller race 72 spaced from the roller race 70, and a ball race 74 located between the roller races 70 and 72. A ball passageway 76 extends from the counterbore 54 into the ball race 74. An exterior flange 78 encircles the sleeve member 36 retaining an annular seal 80 that is positioned between the sleeve member 36 and a shoulder 79 on the cutter member 26 forming a seal between the members 26 and 36. A plurality of roller bearings 82 are disposed in the roller race 70 between the cutter member 26 and the sleeve member 36 to journal the cutter member 26 thereon. Similarly, a plurality of roller bearings 84 are disposed in the roller race 72. After the cutter member 26 has been positioned on the sleeve member 36 with the roller bearings 82 and 84 in place, a plurality of ball bearings 86 are inserted through the counterbore 54 in the sleeve member 36 and through the passageway 76 substantially filling the ball bearing race 74. When the ball bearings 86 are in position, a ball plug 88 is positioned in the passageway 76. The annular member 56 with the flexible member 64 attached thereto is then inserted into the counterbore 54 and connected thereto as previously mentioned engaging and retaining the ball plug 88 in the passageway 76. To be certain that the counterbore 54 is sealed from well fluids, O-ring seals 90 and 92, which are carried by the annular member 56 near each end thereof, are arranged in sealing relationship between the annular member 56 and the sleeve member 36 in the counterbore 54 spanning the ball plug 88.

An annular seal 94 is positioned between an inwardly extending flange 95 on the cutter member 26 and the sleeve member 36 near the end 34 thereof forming a seal between the members 26 and 36. The seals 80 and 94 may be made of any material that will form a seal between the members 26 and 36. An internal lock ring 96 carried by the cutter member 26 is located between the seal 94 and the roller bearings 82 to prevent movement of the seal 94 in the sleeve member 36.

From the foregoing, it will be apparent that a chamber 98 is formed within the cutting assembly 23 by the flexible member 64, the seal 90, and the seal 94. To facilitate filling the chamber 98 with a lubricant, a passageway 100 is provided that extends from the end 34 of the sleeve member 36 into the roller race 70 which is within the chamber 98. A passageway 102 extends from the end 40 of the sleeve member 36 providing communication into the counterbore 54 outside the flexible member 64, but within the chamber 98 and also into the roller race 72 within the chamber 98. Plugs 104 and 106 are respectively located in the passageways 100 and 102, respectively, adjacent the outer ends thereof.

While the cutter member 26 is illustrated as having external cutting teeth 108, 110, and 112, it will of course be understood that various other cutter configurations can be utilized in a cutting assembly constructed in accordance with the invention. Also, the cutter member 26 is provided interiorly with the mating bearing surfaces 116, 118, and 120 for receiving the roller bearings 82 and 84 and the ball bearings 86, respectively.

After the cutter member 26 has been assembled on the sleeve member 36 with the bearings 82, 84, and 86 inserted therein and with the annular member 56 positioned in and connected to the sleeve member 36, lubricant is introduced into the chamber 98. To accomplish lubrication, the plugs 104 and 106 are removed from the respective passageways 100 and 102. A lubricant supply is then connected into the passageway 100 and a vacuum pump (not shown) is connected with the passageway 102. As the pressure is lowered in the chamber 98 by means of the vacuum pump, lubricant is induced through the passageway 100 into the chamber 98. After filling the chamber 98 with a lubricant, a small quantity of the lubricant is removed through the passageway 102 so that the chamber 98 is less than entirely full. It is desirable to leave the chamber 98 with some unfilled volume due to the change in volume of the lubricant when it becomes heated during operation of the bit 10.

After the chamber 98 has been filled with the quantity of lubricant desired, the plugs 104 and 106 are replaced in the passageways 100 and 102. The cutter member 26 and the assembled sleeve member 36 are then positioned in the recesses 32 and 38 of the saddle 24. The main pin 48 is inserted through the holes 42 and 44 in the leg portions 28 and 30 and through the sleeve member 36. After the retaining pin 50 is driven into the mating annular recesses 45 and 46, the cutting assembly 23 is arranged in the assembled condition as illustrated in FIG. 3.

Operation

With the cutting assemblies 23 assembled as previously described, and welded onto the bottom plate 18 substantially as illustrated in FIGS. 1 and 2, the bit 10 is connected with the lower end of the drill string 16 and lowered into the well bore 12 until the cutter member 26 engages the bottom of the well bore 12. Frequently, the well bore 12 is filled with a drilling fluid, commonly referred to as "mud." As the bit 10 progresses downwardly into the well bore 12, the hydrostatic head of the drilling mud increases. The flexible member 64 is subjected to the hydrostatic head or pressure through the ports 60 which extend through the annular member 56. The pressure deflects the flexible member 64 relatively away from the annular member 56, thereby exerting pressure on the lubricant in the chamber 98 to contribute to the hydrostatic pressure exerted on the seal 90 and 94 so that the pressure on the lubricant in the chamber 98 remains substantially equal to the hydrostatic pressure even though the hydro-
static pressure is constantly increasing as the bit 10 is lowered into the well bore 12. When the bit 10 has reached the bottom of the well bore 12, the drill pipe 16 is rotated, rotating the drill bit 10 therewith. As the teeth of the cutter members 26 engage the bottom of the well bore 12, the members 26 rotate about the bearings 82, 84, and 86, bringing the cutting teeth 106, 110, and 112 into engagement with the bottom of the well bore 12 and disintegrating the formation as is well known in the well drilling art.

Even though lubricant is present in the chamber 98 surrounding the bearings, some friction occurs therein which results in heating of the bearings and the surface area 88 is in a high thermal state so that the lubricant in the chamber 98 also becomes heated. As the temperature of the lubricant increases, the volume of the lubricant increases and exerts a pressure relatively outwardly on the seals 80 and 94 and the flexible member 64. The flexible member 64 is deflected relatively toward the annular member while the pressure increases the volume of the chamber 98. The volume of the chamber 98 increases sufficiently to maintain the pressure within the chamber 98 at a magnitude substantially equal to the hydrostatic pressure exerted by the drilling mud, thereby avoiding the possible destruction of or damage to the seals 80 and 94 by an uncontrolled differential pressure being exerted thereon. As the bit 10 rotates, some axial movement of the cutter member 26 relative to the sleeve member 36 can take place. Such movement may occur due to manufacturing tolerances and wear in the bearings and bearing races.

If the cutter member 26 moves to the left, as seen in FIG. 3, the volume of the chamber 98 increases slightly thereby lowering the pressure in the chamber 98. To compensate for the decrease in pressure and increase in chamber volume, the environmental pressure, acting through the ports 60, deflects the flexible member 64 away from the annular member 56, thus decreasing the chamber volume and maintaining the chamber pressure substantially equal to the environmental pressure.

If the cutter member 26 moves to the right, as seen in FIG. 3, the volume of the chamber 98 decreases with a consequent increase in chamber pressure. The flexible member 64 is moved toward the annular member 56 by the increase in chamber pressure, thereby increasing the chamber volume and reducing the chamber pressure to maintain the chamber pressure substantially equal to the environmental pressure.

As previously described, the ball plug 88 is spanned by the O-ring seals 90 and 92, and is therefore located within the chamber 98. With the plug 88 in the chamber 98, the plug 88 is in a balanced condition with respect to pressure forces exerted thereon and remains stationary within the ball passageway 76. The importance of such a feature can be appreciated when it is realized that ball plugs used in prior cutter assemblies were situated with one end adjacent the main pin and exposed to environmental pressure while the opposite end was in the lubricant chamber and exposed to chamber pressure. Differentials in pressure occurring between the environment and chamber resulted in movement of the ball plug which often caused damage to or excessive wear on the ball bearings as the cutter members rotate during drilling with such bits.

The flexible member 64 also provides an important function when the drill bit 10 is being removed from the well bore 12. As would be expected, the hydrostatic pressure constantly decreases as the bit 10 is pulled out of the well bore 12. As the pressure decreases, the flexible member 64 moves toward the annular member 56 providing more volume in the chamber 98 so that the pressure in the chamber 98 decreases as the hydrostatic pressure decreases. Obviously, if a relatively high hydrostatic pressure were trapped in the chamber 98 when the bit is near the bottom of the well bore 12, the decrease in hydrostatic pressure exteriorly of the chamber 98 would result in a high differential pressure across the seals 80 and 94 which could result in the rupture or extrusion of the seals which would at least require their replacement before the drill bit 10 can be returned into the well bore 12.

In summary, it can be seen that the provision of the variable volume chamber of relatively large capacity in the cutting assembly 23 provides a more efficient and longer life bit 10 since the seals are less susceptible to damage and thus the bearings are lubricated adequately even though the bit 10 is exposed to varying pressure conditions due to hydrostatic head changes, expansion or contraction of the lubricant resulting from heat generated during operation of the bit, and possibly, from axial movement of the cutter member during drilling.

It will also be appreciated that the structure described hereinbefore for providing the variable chamber is useful in various forms of relatively rotating members which must be lubricated and utilized in well bores and the like even though the foregoing description has related primarily to a cutter assembly for big-hole bits. Manifestly, such a structure can be utilized to advantage in reamer-type cutters and, if space is available, in other forms of bit cutter assemblies.

Having described but a single embodiment of the invention, it will be understood that it is presented by way of example only and that various changes and modifications can be made thereto without departing from the spirit of the invention or from the scope of the annexed claims.

What we claim is:
1. In a cutter assembly adapted for use on a bit during the drilling of oil or gas wells and the like:
   a. a cutter member;
   b. mounting means rotatably supporting said cutter member and adapted to mount said cutter assembly on the bit, said mounting means including annular flexible means responsive to pressure in the well; seal means located between said mounting means and cutter;
   c. member forming a chamber with said flexible means within said cutter assembly; and,
   d. a lubricant in said chamber, said lubricant being maintained at a pressure substantially equal to the ambient pressure on said cutter assembly due to the flexure of said flexible means in response to changes in the ambient pressure.
2. The cutter assembly of claim 1 also including:
   a. bearing means disposed between said cutter member and mounting means; and, wherein said seal means includes a pair of annular seal members, one of said seal members being located between one end of said cutter member and bearing means and the other seal member being located between said bearing means and the other end of said cutter member.
3. The cutter assembly of claim 1 wherein said mounting means also includes:
   a. an annular member having an interior exposed to the ambient pressure, an annular recess in the exterior thereof, and a port extending therethrough providing communication from the interior thereof into said recess;
   b. said annular flexible means encircling said recess and connected with said annular member covering said port, whereby said flexible means is exposed to the ambient pressure through said port; and,
   c. a sleeve member encompassing and connected to said annular member.
4. The cutter assembly of claim 3 and also including:
   a. bearing means located between said sleeve member and cutter member to permit relative rotation therebetween; and,
   b. said seal means includes a pair of annular seal members disposed between said cutter member and sleeve
member, one of said seal members being located between said bearing means and one end of said cutter member and the other seal member being located between said bearing means and the other end of said cutter member.

5. The cutter assembly of claim 4 wherein said sleeve member has:

a first passageway extending therethrough, into communication with said chamber, whereby said lubricant can be introduced therethrough; and, said sleeve member includes a ball passageway extending therethrough into communication with another portion of said chamber, whereby said sleeve member can be vented to permit substantially complete filling of said chamber with said lubricant; and, a second passageway extending therethrough into communication with another portion of said chamber, whereby said chamber can be vented to allow ball bearings to be inserted into said chamber and said sleeve member being exposed to ambient pressure.

6. In a cutter assembly adapted for use on a bit during the drilling of oil or gas wells and the like:

a main pin adapted to be mounted on the bit;
a mandrel assembly encircling a portion of said main pin and including

a substantially rigid annular member disposed on said shaft having an annular recess in the medial exterior portion thereof and at least one port extending through said medial portion into said recess, and,
a resilient tubular member encircling said recess and covering said port, said tubular member having end portions connected with said annular member and being exposed to ambient pressure on the cutter assembly through said port;
a sleeve member encompassing and connected to said mandrel assembly;
an annular cutter member disposed over said sleeve member;
bearing means located between said sleeve member and cutter member to permit relative rotation therebetween;

seal means located between said sleeve member and cutter member to prevent the entrance of deleterious material into said bearing members and forming a lubricant chamber with said tubular member in said cutter assembly; and,
a lubricant in said chamber, said lubricant being maintained at a pressure substantially equal to the ambient pressure due to the flexure of said resilient tubular member in response to changes in the ambient pressure.

7. The cutter assembly of claim 6 wherein:

said bearing means includes a plurality of ball bearings;
said sleeve member includes a ball passageway extending therethrough within said chamber to permit insertion of said ball bearings; and

said cutter assembly also includes a ball plug located in said ball passageway in engagement with said substantially rigid annular member, to retain said ball bearings in place, said ball plug being located within said chamber.

8. In a cutter sub-assembly adapted for use on a well drilling bit or the like, the bit including means supporting the cutter sub-assembly, said cutter sub-assembly including:

a cutter member;
a sleeve member journauling said cutter member and having a counterbore therein, said sleeve member being arranged to be connected with the means supporting the cutter sub-assembly on the bit;
an annular member located in said counterbore and having at least one port extending through the medial portion thereof;
an annular flexible means encircling and connected to said annular member covering said port, whereby said flexible means is exposed to ambient pressure through said port;

seal means located between said sleeve member and cutter member forming a chamber with said annular flexible means within said cutter sub-assembly; and,
a lubricant in said chamber, said lubricant being maintained at a pressure substantially equal to the ambient pressure on said cutter sub-assembly due to flexure of said flexible means.

9. The cutter sub-assembly of claim 8 and also including:

a plurality of ball bearings disposed between said cutter member and sleeve member;
a ball passageway extending through said sleeve member from said counterbore to permit insertion of said ball bearings;
a ball plug located in said ball passageway; and,
a pair of spaced seals between said annular member and sleeve member spanning said ball plug, whereby said ball plug is located within said chamber.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

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It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, lines 39 to 42, cancel:
"seal means located between said mounting means and cutter;
member forming a chamber with said flexible means within said cutter assembly;
and,"
and insert -- seal means located between said mounting means and cutter member forming a chamber with said flexible means within said cutter assembly; and, -

Signed and sealed this 14th day of April 1970.

(SEAL)

Attest:

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Commissioner of Patents