(19) World Intellectual Property Organization
(10) International Publication Number
WO 2008/124469 A1

(51) International Patent Classification:
E21B 10/22 (2006.01)  E21B 10/25 (2006.01)

(21) International Application Number:
PCT/US2008/059218

(22) International Filing Date:
3 April 2008 (03.04.2008)

(25) Filing Language:
English

(26) Publication Language:
English

(30) Priority Data:
11/784,026 (05.04.2007) US

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(54) Title: SYSTEM, METHOD, AND APPARATUS FOR CONTOURED THRUST SURFACES BETWEEN THRUST WASHER AND HEAD FOR ROLLER CONE DRILL BIT

(57) Abstract: A thrust washer located between the thrust surfaces of the head and the cone of a drill bit allows for radial rotation between the cone, thrust washer, and head during drilling operations. The thrust washer also accommodates axial rotation between the cone and the head. The mating thrust surfaces between the thrust washer and the head are contoured to allow the thrust washer to rotate axially with the cone, and provide increased bearing contact between the thrust washer and the cone.
SYSTEM, METHOD, AND APPARATUS FOR CONTOURED THRUST SURFACES BETWEEN THRUST WASHER AND HEAD FOR ROLLER CONE DRILL BIT

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BACKGROUND OF THE INVENTION

1. Technical Field

[0001] The present invention relates in general to roller cone drill bits and, in particular, to an improved system, method, and apparatus for an earth boring bit having curved thrust faces between a thrust washer, bearing head and a cone.

2. Description of the Related Art

[0002] One type of earth boring bit for drilling oil and gas wells has a bit body with at least one roller cone. Each cone is mounted on a cylindrical bearing head that depends downward and inward from a bit leg of the bit body. Annular thrust faces are formed on the bearing head and in the cone cavity for reacting against downward thrust. The thrust face of the bearing head is in a plane that is perpendicular to an axis of the bearing head. Likewise, the thrust face of the cone is formed in a plane that is perpendicular to the rotational axis of the cone. Initially, the thrust faces are parallel to each other. Lubricant is supplied from a lubricant reservoir to the spaces between the bearing head and the cone.

[0003] While the bit is drilling, the thrust faces typically do not run precisely parallel to each other. The bearing head deflects slightly because it is cantilevered from the bit leg. Also, because of tolerances between the cylindrical portions of the cone and the bearing head, the cone...
can tilt slightly relative to the bearing head (i.e., axial rotation). This slight misalignment of the cone axis relative to the bearing head axis results in a circumferentially converging-diverging space between the thrust faces. This bearing misalignment concentrates thrust bearing contact loads, which is detrimental to the performance and life of the components. Thus, an improved solution that overcomes these problems would be desirable.
SUMMARY OF THE INVENTION

[0004] One embodiment of a system, method, and apparatus for a roller cone bit utilizes a thrust washer between the cone and the head. As the roller cone bit is drilling, there is radial rotation between the head and the cone. Due to clearance in the bearing and interaction between the cone and the earthen formation, there also can be slight axial rotation (i.e., cone tilting) between the head and cone with respect to the head axis.

[0005] A thrust washer constructed in accordance with the present invention and located between the thrust surfaces of the head and the cone allows for the required radial rotation between the cone and thrust washer during drilling operations. However, the thrust washer accommodates the axial rotation between the cone and the head. The mating thrust surfaces or faces between the thrust washer and the head are contoured to allow the thrust washer to rotate axially with the cone. For example, the head may comprise a concave thrust surface while the thrust surface of the thrust washer has a complementary convex shape. This configuration results in more bearing contact between the thrust washer and the cone. The thrust washer may be formed from a variety of bearing materials, or a combination of materials such as 440C, bronze, carbide, diamond, etc. The radial rotation between the thrust washer and head may be prevented with the use of a pin, dowel, etc., extending therebetween.

[0006] The foregoing and other objects and advantages of the present invention will be apparent to those skilled in the art, in view of the following detailed description of the present invention, taken in conjunction with the appended claims and the accompanying drawings.
BRIEF DESCRIPTION OF THE DRAWINGS

[0007] So that the manner in which the features and advantages of the present invention, which will become apparent, are attained and can be understood in more detail, more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof that are illustrated in the appended drawings which form a part of this specification. It is to be noted, however, that the drawings illustrate only some embodiments of the invention and therefore are not to be considered limiting of its scope as the invention may admit to other equally effective embodiments.

[0008] **Figure 1** is a quarter, vertical sectional view illustrating a portion of an earth boring bit constructed in accordance with the invention;

[0009] **Figure 2** is an enlarged side view of the bearing head of **Figure 1** and is constructed in accordance with the invention; and

[0010] **Figure 3** is an enlarged sectional side view of the bearing head of **Figure 1** and is constructed in accordance with the invention.
DETAILED DESCRIPTION OF THE INVENTION

[0011] Referring to Figure 1, one embodiment of a bit 11 has a body 13 with a threaded shank 15 on its upper end for connection to a drill string (not shown). Body 13 typically has three bit legs 17 (only one shown), and each leg 17 has a depending bearing head 19. Each bearing head 19 inclines downward and inward toward an axis 20 of rotation of body 13.

[0012] Each bearing head 19 has a cylindrical surface 21 that is concentric with a bearing head axis 23. In the illustrated embodiment, the radially inward end of bearing head 19 has a nose 25. Nose 25 also is cylindrical but has a smaller diameter than bearing surface 21. An annular bearing head thrust face 27 is formed on a shoulder that circumscribes nose 25. As shown in Figures 1 and 3, a roller cone 29 is mounted to each head 19 and has an axial cavity with a cylindrical portion 31 that fits around bearing surface 21 of head 19. Roller cone 29 rotates on head 19 about its roller cone axis, which may coincide with bearing head axis 23.

[0013] Each roller cone 29 has a plurality of cutting elements 35 on its exterior. Cutting elements 35 may be tungsten carbide inserts press-fitted into holes in the body of cone 29. Alternately, cutting elements 35 could be teeth milled into the exterior surface of the body of cone 29. Cone 29 is retained conventionally on bearing head 19, which in this example is by a plurality of balls 37. Balls 37 engage mating grooves formed in cone 29 and on bearing head 19. Lubricant passages 39 supply lubricant or grease to the spaces between cylindrical surfaces 21, 31 and between thrust faces 27 and 33. A pressure compensator 41 reduces the pressure differential between the lubricant within passages 39 and drilling fluid pressure on the exterior of bit 11.

[0014] As best shown in Figure 3, each roller cone 29 has an annular axial thrust face 33 within its cavity that faces upward and outward toward bearing head thrust face 27. A thrust washer 51 is located between and in dynamic engagement with the thrust faces 27, 33 of the bearing head 19 and the roller cone 29, respectively. In one embodiment, the thrust washer 51 has a thrust face 53 that is non-orthogonally contoured and complementary in shape to the thrust face 27 of
the bearing head 19. This increases bearing contact between the thrust washer 51 and the roller cone 29 during axial rotation between the head and cone.

[0015] The thrust washer 51 permits radial rotation (see arrow 55) between the cone 29 and the thrust washer 51, and accommodates axial rotation (see arrow 57) between the cone 29 and the head 19 with respect to the bearing head axis 23. The thrust washer 51 does not permit or restrict the axial rotation 57 between the head 19 and cone 29. If the thrust washer 51 is pinned 65 to the head 19 and there is a spherical radius 59 on the head 19 and thrust washer 51, the thrust washer 51 will stay aligned with the cone 29 and "tilt" relative to the head 19. The pin 65 restricts the thrust washer 51 from radial rotation 55 relative to the head 19. There is sufficient clearance between the pin 65 and hole in the thrust washer 51 to allow a limited amount of axial rotation 57. This allows the thrust washer 51 to rotate 57 and align with the cone thrust surface 33, maintaining maximum contact area.

[0016] In one embodiment, the thrust faces 53, 27 of the thrust washer 51 and the bearing head 19 are non-orthogonally contoured and complementary in shape. In another embodiment, the thrust faces 63, 33 of the thrust washer 51 and the roller cone 29 are non-orthogonally contoured and complementary in shape. In still other embodiments, both thrust faces 53, 63 of the thrust washer 51 and the thrust faces 27, 33 of both head 19 and roller cone 29 are non-orthogonally contoured and complementary in shape. In any of these embodiments, the contoured thrust faces that are selected may be formed on a spherical radius 59 such as the one illustrated in Figure 3.

[0017] In one embodiment, the thrust face 53 of the thrust washer 51 is convex, and the thrust face 27 of the bearing head 19 is concave (see, e.g., Figures 2 and 3, which are exaggerated). Alternatively, the thrust face 53 of the thrust washer 51 may be concave, and the thrust face 27 of the bearing head 19 may be convex. In the illustrated embodiment, the thrust face 63 of thrust washer 51 is flat and parallel to the thrust face 33 of the roller cone 29, which is orthogonal relative to bearing head axis 23.
[0018] In still other embodiments, the thrust washer 51 may be formed from one of a variety of bearing materials, or a combination of materials such as 440C, other stainless steel materials, bronze, carbide, carbide-containing materials, diamond, etc. Radial rotation between the thrust washer 51 and head 19 or cone 29 may be prevented with the use of a pin 65, dowel, etc., extending therebetween.

[0019] While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention.
CLAIMS

What is claimed is:

1. An earth boring bit, comprising:
   a bit body having a bit leg;
   a bearing head on the bit leg, the bearing head having a bearing head axis, a thrust face, and a cylindrical bearing surface concentric with the bearing head axis;
   a roller cone having a cone axis and mounted to the bearing head for rotation relative to the bearing head, the roller cone having a thrust face; and
   a thrust washer located between and in dynamic engagement with the thrust faces of the bearing head and roller cone, the thrust washer having a thrust face that is non-orthogonally contoured and complementary in shape to the thrust face of one of the bearing head and the roller cone to increase bearing contact between the thrust washer and the roller cone.

2. A earth boring bit according to Claim 1, wherein the thrust faces of the thrust washer and bearing head are formed on a spherical radius.

3. A earth boring bit according to Claim 1, wherein the thrust faces of the thrust washer and the bearing head are complementary in shape.

4. A earth boring bit according to Claim 1, wherein the thrust faces of the thrust washer and the roller cone are complementary in shape.
5. A earth boring bit according to Claim 1, wherein the thrust face of the thrust washer is convex, and the thrust face of the bearing head is concave.

6. A earth boring bit according to Claim 1, wherein the thrust face of the thrust washer is concave, and the thrust face of the bearing head is convex.

7. A earth boring bit according to Claim 1, wherein the thrust washer has a second thrust face that is flat and parallel to the thrust face of the other of the bearing head and the roller cone.

8. A earth boring bit according to Claim 1, wherein the thrust washer permits radial rotation between the roller cone and the thrust washer, and accommodates axial rotation between the roller cone and the bearing head with respect to the bearing head axis.

9. A earth boring bit according to Claim 1, wherein the thrust washer is formed from a material selected from the group consisting of stainless steel, bronze, carbide-containing materials, and diamond.

10. A earth boring bit according to Claim 1, further comprising a pin mounted to and extending between the thrust washer and one of the bearing head and the roller cone for preventing radial rotation therebetween.
11. An earth boring bit, comprising:

a bit body having a plurality of bit legs;

a bearing head on each of the bit legs to define a plurality of bearing heads, each bearing head having a bearing head axis, a thrust face, and a cylindrical bearing surface concentric with the bearing head axis;

a roller cone having a cone axis and mounted to each of the bearing heads to define a plurality of roller cones for rotation relative to the bearing heads, each roller cone having a thrust face; and

a thrust washer located between respective ones of the bearing heads and roller cones to define a plurality of thrust washers, the thrust washers being in dynamic engagement with the thrust faces of respective ones of the bearing heads and roller cones, and each thrust washer having a thrust face that is non-orthogonally contoured and complementary in shape to the thrust face of a respective one of the bearing heads to increase bearing contact between the thrust washer and the roller cone, such that the thrust washers permit radial rotation between the roller cones and the thrust washers, and accommodate axial rotation between the roller cones and the bearing heads with respect to the bearing head axes.

12. A earth boring bit according to Claim 11, wherein the thrust faces of the thrust washers and bearing heads are formed on a spherical radius.

13. A earth boring bit according to Claim 11, wherein the thrust faces of the thrust washers are convex, and the thrust faces of the bearing heads are concave.

14. A earth boring bit according to Claim 11, wherein the thrust faces of the thrust washers are concave, and the thrust faces of the bearing heads are convex.
15. A earth boring bit according to Claim 11, wherein the thrust washers have second thrust faces that are flat and parallel to the thrust faces of respective ones of the roller cones.

16. A earth boring bit according to Claim 11, wherein the thrust washers are formed from a material selected from the group consisting of stainless steel, bronze, carbide-containing materials, and diamond.

17. A earth boring bit according to Claim 11, further comprising a pin mounted to and extending between each of the thrust washers and respective ones of the bearing heads to define a plurality of pins for preventing radial rotation between respective ones of the thrust washers and bearing heads.
18. An earth boring bit, comprising:
   a bit body having a plurality of bit legs;
   a bearing head on each of the bit legs to define a plurality of bearing heads, each bearing head having a bearing head axis, a thrust face that is concave in shape, and a cylindrical bearing surface concentric with the bearing head axis;
   a roller cone having a cone axis and mounted to each of the bearing heads to define a plurality of roller cones for rotation relative to the bearing heads, each roller cone having a thrust face; and
   a thrust washer located between respective ones of the bearing heads and roller cones to define a plurality of thrust washers, the thrust washers being in dynamic engagement with the thrust faces of respective ones of the bearing heads and roller cones, and each thrust washer having a thrust face that is convex and complementary in shape to the thrust face of a respective one of the bearing heads to increase bearing contact between the thrust washer and the roller cone, such that the thrust washers permit radial rotation between the roller cones and the thrust washers, and accommodate axial rotation between the roller cones and the bearing heads with respect to the bearing head axis.

19. A earth boring bit according to Claim 18, wherein the thrust faces of the thrust washers and bearing heads are formed on a spherical radius, and the thrust washers have second thrust faces that are flat and parallel to the thrust faces of respective ones of the roller cones.

20. A earth boring bit according to Claim 18, wherein the thrust washers are formed from a material selected from the group consisting of stainless steel, bronze, carbide-containing materials, and diamond; and further comprising a pin mounted to and extending between each of the thrust washers and respective ones of the bearing heads to define a plurality of pins for preventing radial rotation between respective ones of the thrust washers and bearing heads.
FIG. 2
A. CLASSIFICATION OF SUBJECT MATTER

According to International Patent Classification (IPC) or to both national classification and IPC:

INV. E21B10/22 E21B10/25

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols):

E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic database consulted during the international search (name of database and, where practical, search terms used):

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

Special categories of cited documents:

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Date of the actual completion of the international search: 12 August 2008

Date of mailing of the international search report: 29/08/2008

Name and mailing address of the ISA:

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Authorized officer:

Morris, Susan

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