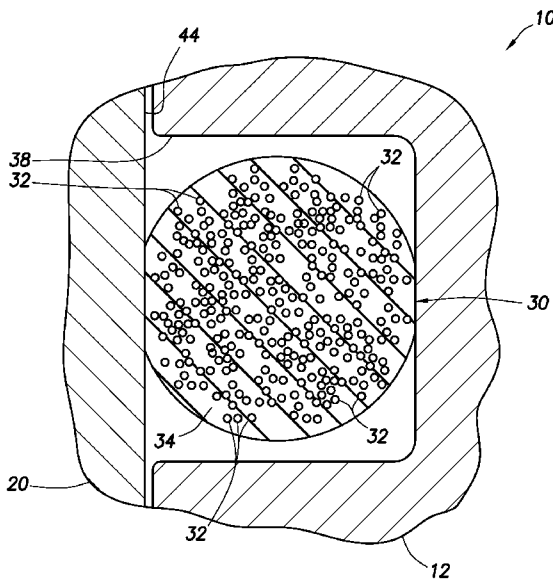




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[Continued on nextpage]

(54) **Title:** DRILL BIT WITH SEAL HAVING SPHERES IN A MATRFX SEAL MATERIAL



(57) **Abstract:** A drill bit can include a seal which seals against a drill bit surface, the seal including a matrix seal material and a plurality of hollow spheres in the matrix seal material. Another drill bit can include a seal with a matrix seal material, spheres being more dense in a portion of the matrix seal material as compared to in the matrix seal material outside of the portion, and the portion of the matrix seal material being in dynamic sealing contact with a drill bit surface during operation. A drill bit can include a seal between a cone and a journal, the seal comprising a matrix seal material and a plurality of spheres in the matrix seal material, the matrix seal material comprising nitrile.



SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). **Published:**

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- *of inventorship (Rule 4.17(iv))*

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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**DRILL BIT WITH SEAL HAVING SPHERES
IN A MATRIX SEAL MATERIAL**

10

TECHNICAL FIELD

This disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in one example described below, more particularly provides a drill bit with a seal having spheres in a matrix seal material of the seal.

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BACKGROUND

Drill bits used to drill wellbores have to operate in an extremely hostile environment. As a result, such drill bits are highly specialized for their purpose. One such drill bit is of the type known as a roller cone bit, in which cutting elements are mounted on cones which rotate as the drill bit is rotated downhole to drill a wellbore.

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To facilitate rotation of the cones, bearings are provided between the cones and a body of the bit, and lubricant is provided for the bearings. To prevent external debris from damaging the bearings or otherwise causing excessive wear in the rotating cones, and to prevent escape of the lubricant, seals are also provided in such bits.

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Unfortunately, in the harsh downhole environment, seals in drill bits tend to fail (e.g., permit excessive wear, no longer exclude debris, fail to contain the lubricant, etc.) sooner than is desired. Drilling operations could be made
5 much more economical and expeditious if drill bit seals had longer lives.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative elevational view of a drill
10 bit embodying principles of this disclosure.

FIG. 2 is a representative cross-sectional view through one arm of the drill bit of FIG. 1.

FIG. 3 is a representative enlarged scale cross-sectional view through a seal which can embody principles of
15 this disclosure.

FIG. 4 is a representative graph of sealing force over time for two seal examples .

FIG. 5 is a representative cross-sectional view of another configuration of the seal.

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DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a drill bit
10 which can embody principles of this disclosure. The drill bit 10 is of the type known to those skilled in the art as a roller cone bit or a tri-cone bit, due to its use of
25 multiple generally conical shaped rollers or cones 12 having earth-engaging cutting elements 14 thereon.

Each of the cones 12 is rotatably secured to a respective arm 16 extending downwardly (as depicted in FIG.

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1) from a main body 18 of the bit 10. In this example, there are three each of the cones 12 and arms 16.

However, it should be clearly understood that the principles of this disclosure may be incorporated into drill bits having other numbers of cones and arms, and other types of drill bits and drill bit configurations. The drill bit 10 depicted in FIG. 1 is merely one example of a wide variety of drill bits which can utilize the principles described herein .

Referring additionally now to FIG. 2, a cross-sectional view of one of the arms 16 is representatively illustrated. In this view it may be seen that the cone 12 rotates about a journal 20 of the arm 16. Retaining balls 22 are used between the cone 12 and the journal 20 to secure the cone on the arm.

Lubricant is supplied to the interface between the cone 12 and the journal 20 from a chamber 24 via a passage 26. A pressure equalizing device 28 ensures that the lubricant is at substantially the same pressure as the downhole environment when the drill bit 10 is being used to drill a wellbore .

A seal 30 is used to prevent debris and well fluids from entering the interface between the cone 12 and the journal 20, and to prevent escape of the lubricant from the interface area. As the cone 12 rotates about the journal 20, the seal 30 preferably rotates with the cone and seals against an outer surface of the journal, as described more fully below. However, in other examples, the seal could remain stationary on the journal 20, with the cone 12 rotating relative to the journal and seal.

Referring additionally now to FIG. 3, an enlarged scale cross-sectional view of the seal 30 is representatively

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illustrated, along with a seal groove or gland 38 in which the seal is retained, and an adjacent surface 44 of the drill bit 10 against which the seal seals. In this example, the seal gland 38 is formed in the cone 12, and the surface 44 is formed on the journal 20, but in other examples the seal 30 could be otherwise retained and could seal against other surfaces.

Note that the seal 30 rotates with the cone 12 about the journal 20 during operation, so the seal dynamically contacts the surface 44 (e.g., there is relative displacement between the seal and the surface while the seal sealingly contacts the surface). However, in other examples, the seal 30 could dynamically contact the cone 12 (e.g., the gland 38 could be formed on the journal 20, and the surface 44 could be formed in an interior of the cone, etc.).

This dynamic contact coupled with abrasive particles in the environment surrounding the drill bit 10 (for example, in drilling mud circulated through a drill string and wellbore during a drilling operation) can result in rapid wear of the seal 30, particularly where it contacts the surface 44.

However, the seal 30 depicted in FIG. 3 comprises many spheres 32 distributed in a matrix seal material 34. The spheres 32 enhance the wear resistance of the seal 30.

In this example, the spheres 32 comprise hollow glass microspheres. Suitable hollow glass microspheres are marketed by Dyneon LLC of Oakdale, Minnesota USA (e.g., Product No. iM30K), and manufactured by 3M of St. Paul, Minnesota USA.

In other examples, the spheres 32 may not be hollow, glass or micrometer-sized (e.g., approximately 1 to 1000 micrometers). The spheres 32 could instead be solid, made of

- 5 -

another material and/or nanometer-sized, or otherwise dimensioned or configured.

The spheres 32 may have a hardness which is less than that of the journal 20, or at least less than that of the surface 44. In this manner, the spheres 32 will not significantly abrade the surface 44 during operation. However, the spheres 32 can have a hardness greater than that of the matrix seal material 34, so that the spheres do not wear away as quickly as the seal material, thereby reducing the total wear of the seal 30.

The matrix seal material 34 in this example comprises an elastomer--more particularly, a nitrile material (e.g., NBR). The nitrile material may be hydrogenated (e.g., HNBR or HSN). However, other materials (such as, fluorocarbon seal materials, EPDM, AFLAS(TM), FKM(TM), etc.) may be used in keeping with the scope of this disclosure.

The inventors have discovered that hollow glass microspheres can desirably share a compressive load in the seal 30 with the matrix seal material 34. This results in reduced contact pressure between the seal 30 and the surface 44, which reduces wear. In tests, solid spheres do not share the compressive load as desirably, perhaps because of the greater mismatch between the compressibility of the matrix seal material 34 and the compressibility of the solid spheres.

However, as representatively depicted in FIG. 4, less sealing force is available over time from a compressed seal 30 with the spheres 32 therein (as indicated by curve 36 in FIG. 4), as compared to a compressed seal without the spheres therein (as indicated by curve 40 in FIG. 4). This unexpected result can be compensated for by increasing the initial compression of the seal 30 with the spheres 32

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therein, so that it retains a desired sealing force over a desired period of time. This increase in initial compression can help to exclude debris and abrasive particles from the journal 20 and bearings 22, and wear effects due to the increased compression can be more than offset by the increased wear resistance of the seal 30 with the spheres 32 therein .

Referring additionally now to FIG. 5, another configuration of the seal 30 is representatively illustrated. In this configuration, the spheres 32 are predominately in a portion 42 of the matrix seal material 34 which sealingly and dynamically contacts the drill bit 10 surface 44.

The spheres 32 may, in some examples, be exclusively confined to only the portion 42 of the matrix seal material 34. In other examples, the spheres 32 may be more dense in the portion 42 of the seal material 34, as compared to in the remainder of the seal material.

As depicted in FIG. 5, the portion 42 comprises an inner diameter portion of the seal 30 which contacts the journal 20. In other examples, the portion 42 could comprise an outer diameter portion of the seal 30, the portion 42 could be in sealing contact with the cone 12 or another drill bit surface, etc.

Furthermore, the portion 42 could comprise an entire outer surface portion of the seal 30 (e.g., the seal having a core of the matrix seal material 34 with none, or at least less density, of the spheres 32 in the core), so that any surface contacted by the seal also contacts the portion 42. Thus, it will be appreciated that the principles of this disclosure are not limited to the specific details of the

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seal 30 examples described above, or to any specific positioning of the spheres 32 in the seal.

It may now be fully appreciated that this disclosure provides significant advancements to the art of constructing
5 drill bits with seals therein. In examples described above, the wear resistance of a seal 30 can be substantially increased by incorporating spheres 32 into at least a portion 42 of a matrix seal material 34.

In one example, a drill bit 10 can include a seal 30
10 which seals against a drill bit surface 44. The seal 30 comprises a matrix seal material 34 and a plurality of hollow spheres 32 in the matrix seal material 34.

The hollow spheres 32 may comprise hollow microspheres and/or hollow glass spheres.

15 The hollow spheres 32 may be are confined to a portion 42 of the matrix seal material 34. The portion 42 of the matrix seal material 34 may contact a journal 20 and/or a cone 12 of the drill bit 10. The portion 42 of the matrix seal material 34 may be in dynamic contact with at least one
20 of a journal 20 of the drill bit 10 and a cone 12 of the drill bit 10 during operation.

The matrix seal material 34 can include at least one of nitrile and hydrogenated nitrile.

25 The hollow spheres 32 may have a hardness less than a hardness of a journal 20 of the drill bit 10.

Also described above is a drill bit 10 which, in one example, comprises a seal 30 including a matrix seal material 34. A portion 42 of the matrix seal material 34 has a greater density of spheres 32 therein, as compared to
30 outside of the portion 42. The portion 42 of the matrix seal

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material 34 is in dynamic sealing contact with a drill bit surface 44 during operation.

The above disclosure also describes an example of a drill bit 10 which comprises a journal 20, a cone 12 which rotates about the journal 20, and a seal 30 between the cone 12 and the journal 20. The seal 30 comprises a matrix seal material 34 and a plurality of spheres 32 in the matrix seal material 34. The matrix seal material 34 comprises nitrile.

Although various examples have been described above, with each example having certain features, it should be understood that it is not necessary for a particular feature of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope of this disclosure encompasses any combination of any of the features .

Although each example described above includes a certain combination of features, it should be understood that it is not necessary for all features of an example to be used. Instead, any of the features described above can be used, without any other particular feature or features also being used.

It should be understood that the various embodiments described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of this disclosure. The embodiments are described merely as examples of useful applications of the principles

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of the disclosure, which is not limited to any specific details of these embodiments.

In the above description of the representative examples, directional terms (such as "above," "below," "upper," "lower," etc.) are used for convenience in referring to the accompanying drawings. However, it should be clearly understood that the scope of this disclosure is not limited to any particular directions described herein.

The terms "including," "includes," "comprising," "comprises," and similar terms are used in a non-limiting sense in this specification. For example, if a system, method, apparatus, device, etc., is described as "including" a certain feature or element, the system, method, apparatus, device, etc., can include that feature or element, and can also include other features or elements. Similarly, the term "comprises" is considered to mean "comprises, but is not limited to."

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many modifications, additions, substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of this disclosure. Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the invention being limited solely by the appended claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A drill bit, comprising:

5 a seal which seals against a drill bit surface, the seal comprising a matrix seal material and a plurality of hollow spheres in the matrix seal material.

2. The drill bit of claim 1, wherein the hollow spheres comprise hollow microspheres.

10

3. The drill bit of claim 1, wherein the hollow spheres comprise hollow glass spheres.

4. The drill bit of claim 1, wherein the hollow spheres are more dense in a portion of the matrix seal material, as compared to in the matrix seal material outside of the portion.

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5. The drill bit of claim 4, wherein the portion of the matrix seal material contacts a journal of the drill bit.

20

6. The drill bit of claim 4, wherein the portion of the matrix seal material contacts a cone of the drill bit.

25

7. The drill bit of claim 4, wherein the portion of the matrix seal material is in dynamic contact with at least one of a journal of the drill bit and a cone of the drill bit during operation.

8. The drill bit of claim 1, wherein the matrix seal material comprises at least one of nitrile and hydrogenated nitrile.

5

9. The drill bit of claim 1, wherein the hollow spheres have a hardness less than a hardness of at least one of a journal of the drill bit and a cone of the drill bit.

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10. A drill bit, comprising:

a seal including a matrix seal material, spheres being more dense in a portion of the matrix seal material as compared to in the matrix seal material outside of the
5 portion, and the portion of the matrix seal material being in dynamic sealing contact with a drill bit surface during operation .

11. The drill bit of claim 10, wherein the spheres
10 comprise hollow spheres.

12. The drill bit of claim 10, wherein the portion of the matrix seal material contacts a journal of the drill bit.
15

13. The drill bit of claim 10, wherein the portion of the matrix seal material contacts a cone of the drill bit.

14. The drill bit of claim 10, wherein the matrix seal
20 material comprises at least one of nitrile and hydrogenated nitrile .

15. The drill bit of claim 10, wherein the spheres have a hardness less than a hardness of the drill bit
25 surface .

16. The drill bit of claim 10, wherein the seal seals between a cone and a journal of the drill bit.

17. The drill bit of claim 16, wherein the portion of the matrix seal material is in dynamic contact with at least one of the journal and the cone during operation.

5 18. The drill bit of claim 10, wherein the spheres comprise hollow microspheres.

19. The drill bit of claim 10, wherein the spheres comprise hollow glass spheres.

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20. A drill bit, comprising:

a journal;

a cone which rotates about the journal; and

a seal between the cone and the journal, the seal
5 comprising a matrix seal material and a plurality of spheres
in the matrix seal material, the matrix seal material
comprising nitrile.

21. The drill bit of claim 20, wherein the spheres
10 comprise hollow microspheres.

22. The drill bit of claim 20, wherein the spheres
comprise hollow glass spheres.

15 23. The drill bit of claim 20, wherein the spheres are
confined to a portion of the matrix seal material.

24. The drill bit of claim 23, wherein the portion of
the matrix seal material contacts the journal.

20

25. The drill bit of claim 23, wherein the portion of
the matrix seal material contacts the cone.

26. The drill bit of claim 23, wherein the portion of
25 the matrix seal material is in dynamic contact with at least
one of the journal and the cone during operation.

- 15 -

27. The drill bit of claim 20, wherein the nitrile comprises hydrogenated nitrile.

28. The drill bit of claim 20, wherein the spheres
5 have a hardness less than a hardness of at least one of a journal of the drill bit and a cone of the drill bit.

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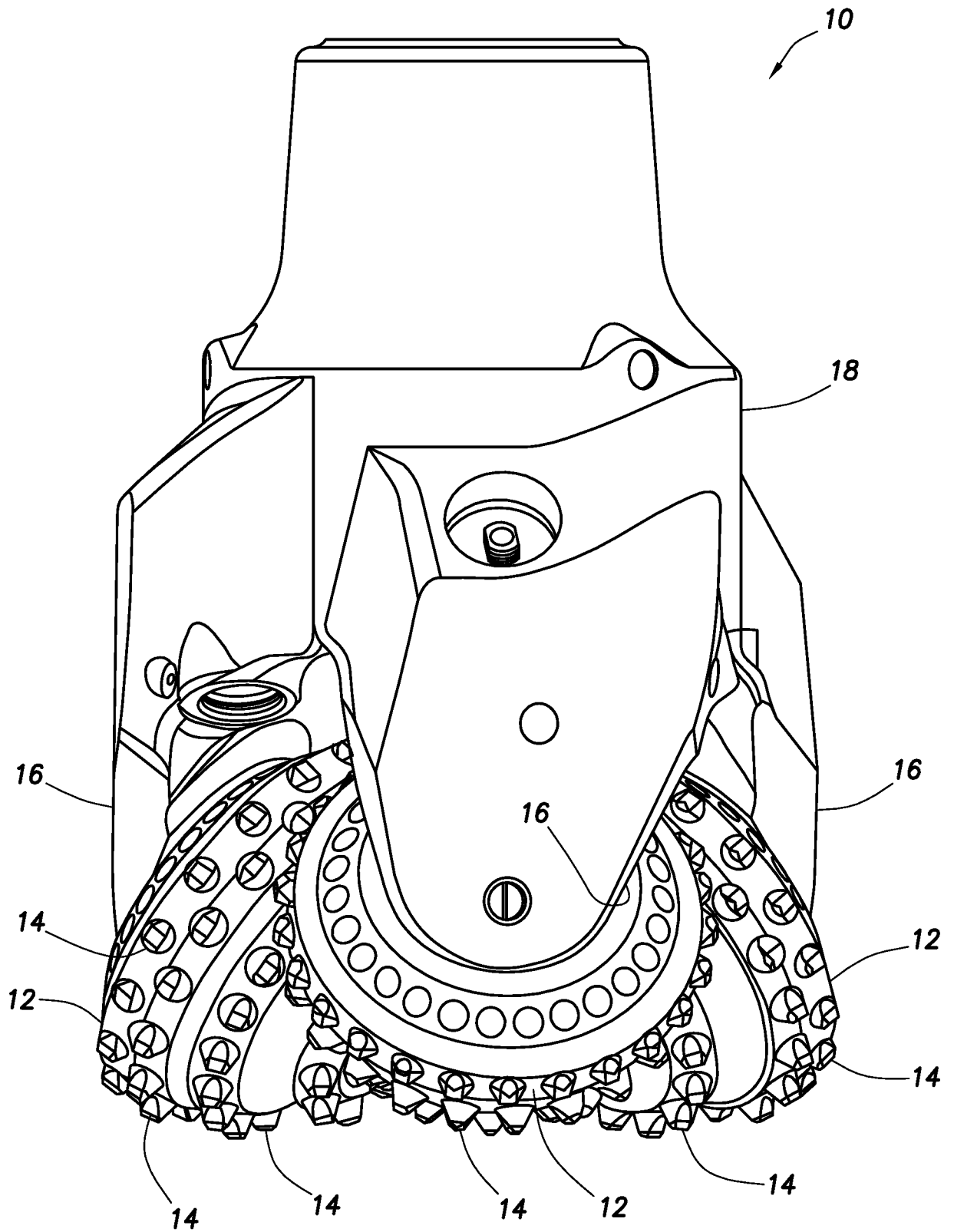


FIG. 1

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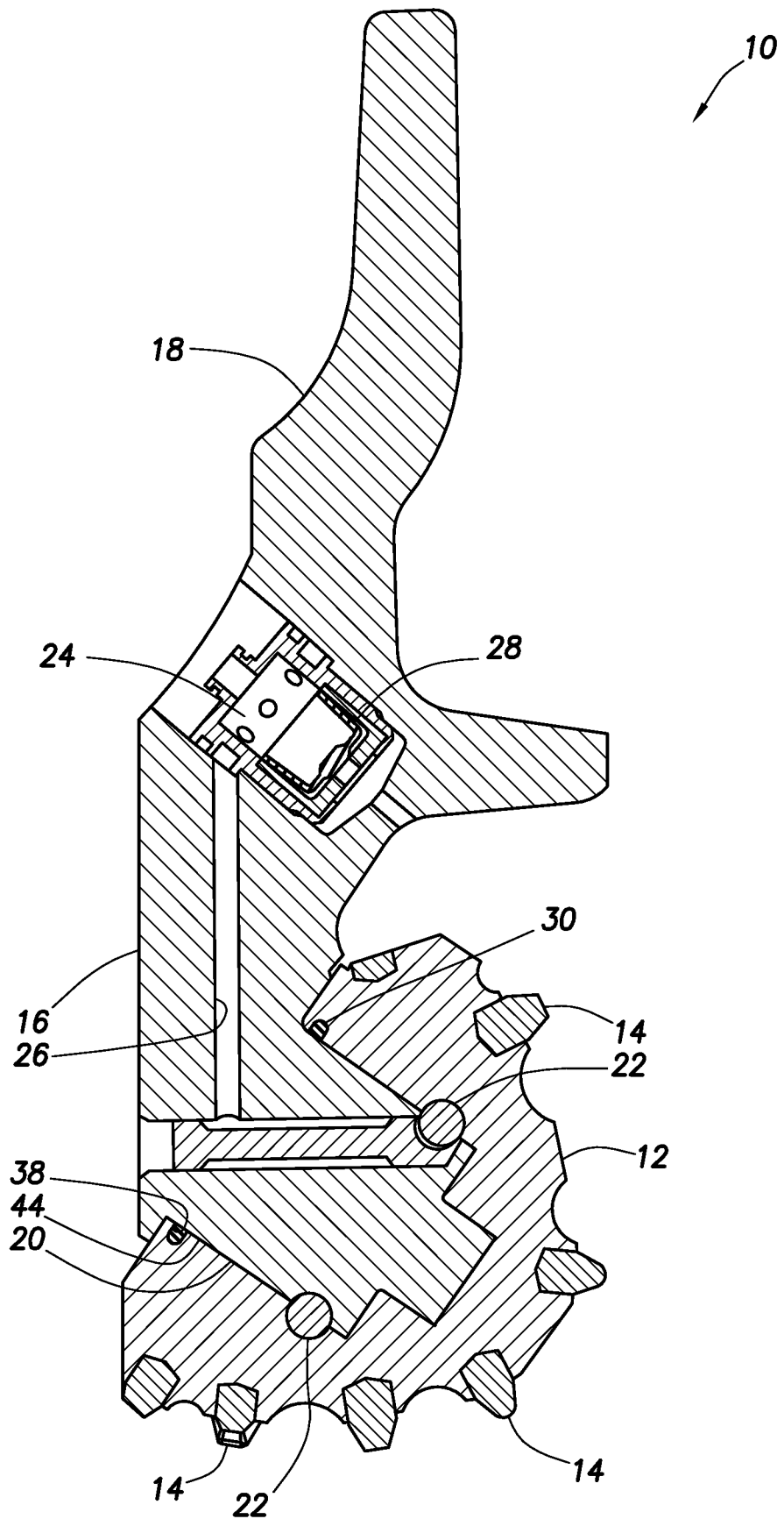


FIG. 2

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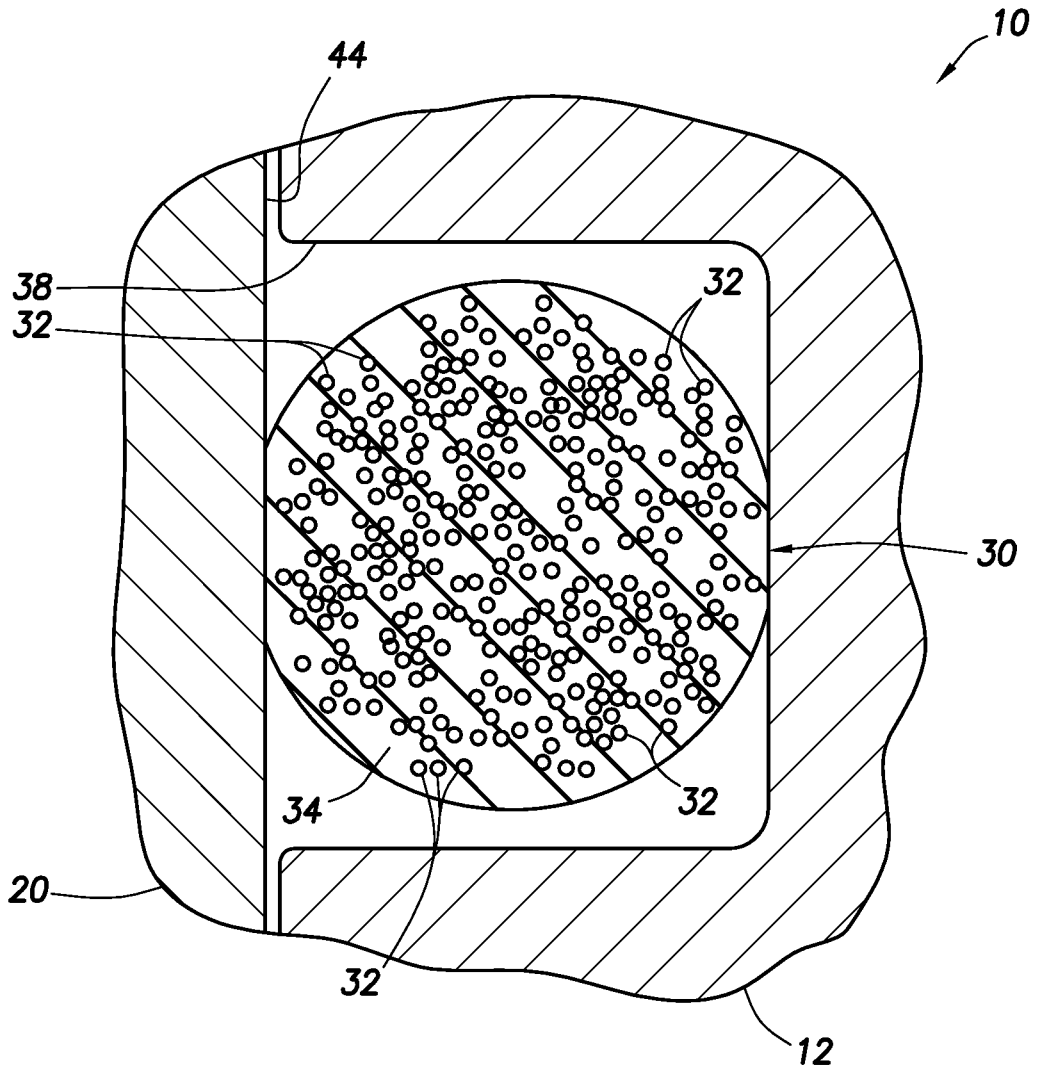


FIG. 3

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FIG. 4

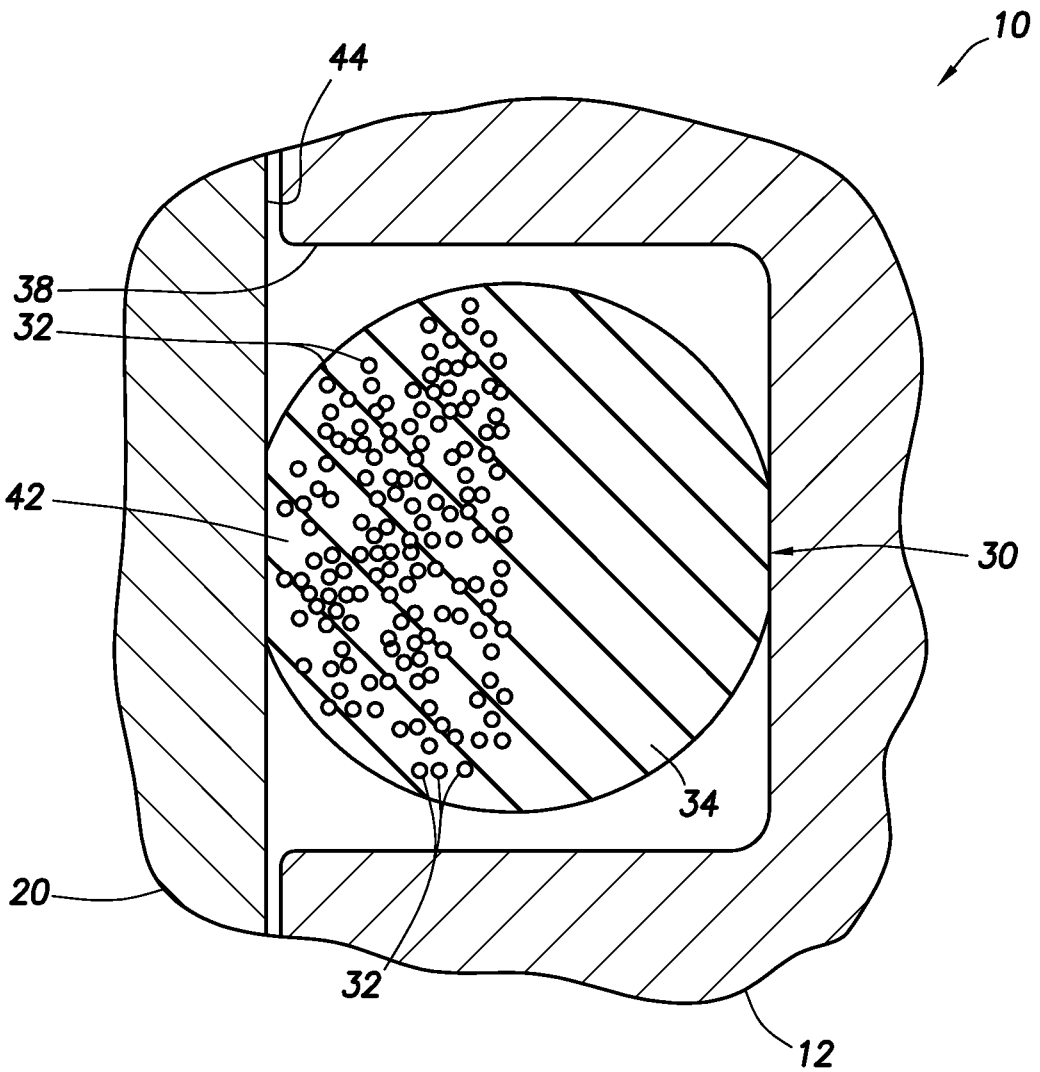
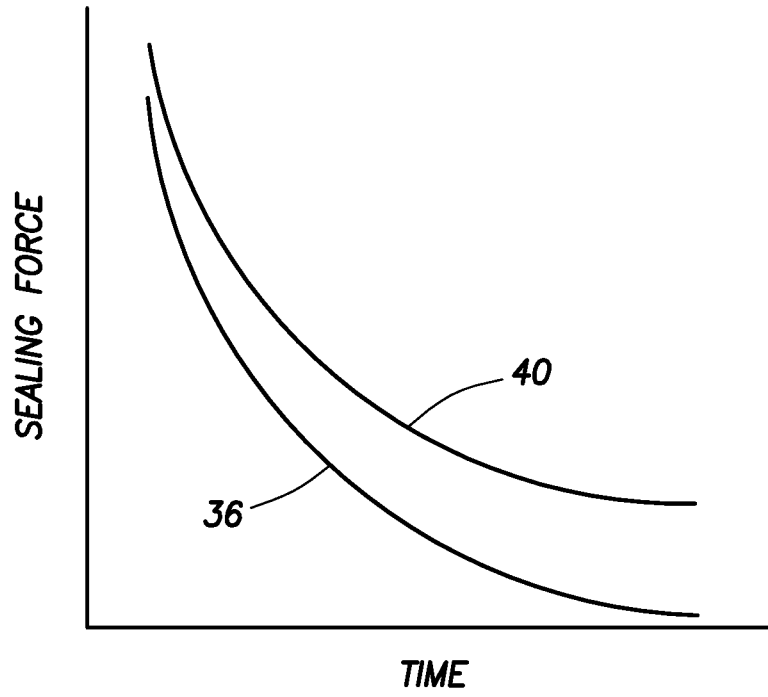


FIG. 5

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/062654**A. CLASSIFICATION OF SUBJECT MATTER*****E21B 10/573(2006.01)i, E21B 12/00(2006.01)1***

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B 10/573; B32B 9/00; F16J 15/02; E21B 10/25; B32B 5/16; C04B 35/447; F16L 17/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: seal, drill bit, wear resistance, hollow sphere, bead and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2009-0038858 A1 (GRIFFO, ANTHONY et al.) 12 February 2009 See abstract, paragraphs 0022,0023,0026,0033 and figure 2.	1-3,8,20-22,27 4-7,9-19,23-26,28
Y	US 5962076 A (MASON, STEPHEN et al.) 5 October 1999 See abstract, column 3 lines 42 - 53 and figure 3.	1-3,8,20-22,27
A	US 4580794 A (GIBBONS, ROBERT M.) 8 April 1986 See abstract and column 2 lines 42 - 55.	1-28
A	US 6543780 B1 (KOGLER, MARKUS et al.) 8 April 2003 See abstract, column 2 lines 55 - 63 and claim 4.	1-28

 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

26 March 2013 (26.03.2013)

Date of mailing of the international search report

27 March 2013 (27.03.2013)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/062654

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