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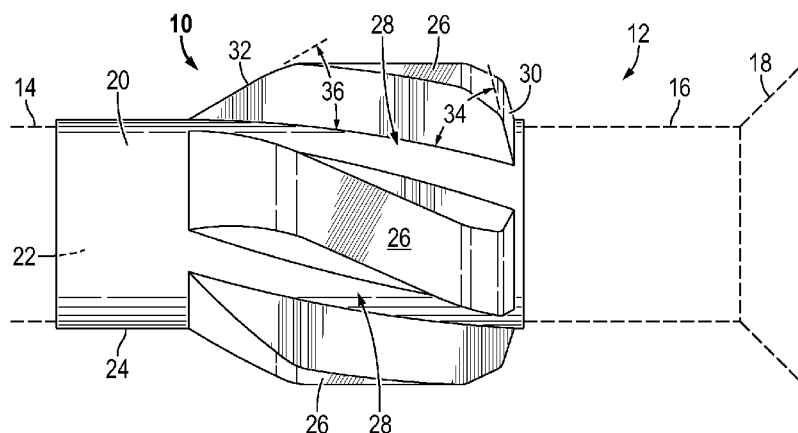
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[Continued on next page]

(54) Title: SYSTEM AND METHODOLOGY FOR USE IN BOREHOLE APPLICATIONS

FIG. 1



(57) Abstract: A technique facilitates the dependable, long-lasting use of a downhole component coupled into a drill string. In some applications, the downhole component comprises a stabilizer having a plurality of blades extending outwardly from a body, e.g. sleeve. Various features of the downhole component enhance the usefulness and dependability of the downhole component. Examples of such features comprise uniquely shaped surfaces; materials with a desired hardness, toughness, and impact strength; and/or wear protection elements incorporated into the downhole component.



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SYSTEM AND METHODOLOGY FOR USE IN BOREHOLE APPLICATIONS

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present document is based on and claims priority to U.S. Provisional Application Serial No.: 61/970864, filed March 26, 2014, and U.S. Provisional Application Serial No.: 62/036572, filed August 12, 2014, and U.S. Non-Provisional Application Serial No.: 14/663419, filed March 19, 2015, which are incorporated herein by reference in their entirety.

BACKGROUND

[0002] In many hydrocarbon well applications, wellbores are drilled into a desired hydrocarbon-bearing formation via a variety of drilling systems. For example, drilling operations may be performed with drill strings including a variety of bottom hole assemblies constructed to drill a desired wellbore. In some applications, rotary steerable drilling systems may be used to control the trajectory of the wellbore being drilled. This facilitates the drilling of deviated, e.g. horizontal, wellbores. During drilling, stabilizers and other drilling components of the bottom hole assembly may be subjected to

substantial abrasion. This abrasion can be detrimental to the life of the stabilizer or other bottom hole assembly components. Depending on the application, stabilizers may be used with steerable drilling systems to provide contact points with the wellbore wall to facilitate steering. Additionally, stabilizers known as string stabilizers may be used farther up the bottom hole assembly of the drill string to support tools, to reduce shock and vibration, and to reduce stick-slip.

SUMMARY

[0003] In general, a system and methodology are provided to facilitate the dependable, long-lasting use of a downhole component coupled into a drill string. In some embodiments, the downhole component may comprise a stabilizer having a plurality of blades extending outwardly from a body, e.g. sleeve. Various features of the downhole component enhance the usefulness and dependability of the downhole component. Examples of such features comprise uniquely shaped surfaces; materials with a desired hardness, toughness, and impact strength; and/or wear protection elements incorporated into the downhole component.

[0004] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0006] Figure 1 is a side view of an example of a stabilizer, e.g. an abrasion resistant stabilizer, mounted in a drill string, according to an embodiment of the disclosure;

[0007] Figure 2 is a cross-sectional view of an example of a stabilizer to illustrate mounting of the stabilizer on a collar of a drill string, according to an embodiment of the disclosure;

[0008] Figure 3 is a side view of another example of a stabilizer, according to an embodiment of the disclosure;

[0009] Figure 4 is a graphical representation illustrating plots of pull force versus taper angle for varying hole inclinations, according to an embodiment of the disclosure;

[0010] Figure 5 is a side view of another example of a stabilizer, according to an embodiment of the disclosure;

[0011] Figure 6 is an orthogonal view of an abrasion resistant sleeve which may be used with a variety of downhole components, including stabilizers, according to an embodiment of the disclosure;

[0012] Figure 7 is an illustration of a drill string having a plurality of downhole components protected with abrasion resistant sleeves and/or other abrasion resistant features, according to an embodiment of the disclosure;

[0013] Figure 8 is an illustration of another example of an abrasion resistant component in the form of a rotary valve system, according to an embodiment of the disclosure; and

[0014] Figure 9 is an illustration of another example of an abrasion resistant component in the form of an impeller which may be used in a variety of downhole components, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0015] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0016] With respect to certain embodiments of the present disclosure, a system and methodology are described for facilitating a drilling operation which employs a stabilizer or stabilizers on a drill string. The stabilizer (or stabilizers) comprises an end face or end faces having shallower slopes instead of steep slopes. Steep slopes can sometimes cause the bottom hole assembly to get stuck on a ledge or other obstruction along the wellbore. In some applications, shallower slopes may be employed on both leading and trailing faces. In other applications, a shallower slope may be employed on one of the faces. For example, the shallower slope may be located on a trailing face of the stabilizer to reduce the risk of hanging-up the bottom hole assembly on a ledge or other obstruction while tripping out of the hole. It should be noted the shallower slopes and/or the relatively shallower slope on the trailing face may be employed on a variety of parts, components or entire tools.

[0017] In some applications, the stabilizer may be constructed with a shallow sloped trailing face and a leading face having a steeper slope. The steeper leading face moves the crown (contact point) of the stabilizer forward toward the drill bit. By moving the crown of the stabilizer toward the drill bit, the dogleg capability of the drilling system may be substantially increased.

[0018] Referring generally to Figure 1, an example of a downhole component 10 in the form of a stabilizer mounted in a drilling system 12 is illustrated. However, downhole component 10 may comprise a variety of parts, components or entire tools. In this embodiment, drilling system 12 comprises a drill string 14 having a drill string collar 16 and a drill bit 18. The stabilizer 10 is mounted on drill string collar 16 and comprises a body 20, e.g. a tubular body, having an interior surface 22 and an exterior surface 24. The interior surface 22 faces inwardly toward the drill string collar 16 and the exterior surface 24 faces in a radially outward direction. The stabilizer 10 further comprises a plurality of blades 26 which extend outwardly from exterior surface 24. The blades 26 extend along at least a portion of the longitudinal length of body 20 and are separated circumferentially by flow channels 28. In some applications, the blades 26 are arranged helically and thus provide generally helical flow channels 28 therebetween. The flow channels 28 allow flows of fluid to move longitudinally past the stabilizer 10 along drill string 14.

[0019] The longitudinal ends of blades 26 establish a leading face 30 and a trailing face 32. Generally, the leading face 30 is on the downhole end toward drill bit 18 and the trailing face 32 is on the uphole end of blades 26. The leading face 30 is oriented at a leading end angle 34 with respect to exterior surface 24, and trailing face 32 is oriented at a trailing end angle 36 with respect to exterior surface 24. Depending on the application, the leading face 30 and/or trailing face 32 may have a shallow slope in the form of a relatively small leading end angle 34 and/or trailing end angle 36, respectively. In the embodiment illustrated in Figure 1, the leading face 30 has a relatively steep taper, e.g. a leading end angle 34 of 70° or greater. In this embodiment, the trailing face 32 has a shallow taper, e.g. a trailing end angle 36 of 45° or less. In some applications, the shallow taper may comprise a trailing end angle 36 of 30° or less.

[0020] As illustrated, some embodiments may utilize a substantially shallower taper on the trailing face 32 relative to a steeper taper on the leading face 30. Additionally, the leading face 30 and/or trailing face 32 may be constructed with the

leading end angle 34 and the trailing end angle 36, respectively, formed as compound angles. In other words, one or both of the leading end angle 34 and/or trailing end angle 36 may be formed with a plurality of differently angled slopes.

[0021] The stabilizer 10 may be mounted on drill string collar 16 of drilling system 12 via a variety of structures and techniques. An example of such a structure and technique is illustrated in Figure 2. In this embodiment, the interior surface 22 has an internal diameter profile 38, e.g. an abutment, located to facilitate construction of a lengthened stabilizer body 20. The profile 38 is oriented for engagement with a shoulder 40 of drill string collar 16. Additionally, the stabilizer 10 may be threadably engaged with and tightened against shoulder 40 via a threaded region 42 on collar 16 and a corresponding threaded region 44 along the interior of body 20. In this example, the drill string collar also may comprise a bit box 46 for engagement with drill bit 18. The overall arrangement facilitates construction of a longer stabilizer 10 to accommodate the longer, shallower slopes of the face or faces 30, 32. For example, profile 38 acts against the collar shoulder 40 at an internal location which allows the stabilizer to be lengthened by enabling the blades 26 to extend over this internal location.

[0022] Referring generally to Figure 3, another embodiment of the stabilizer 10 is illustrated. In this embodiment, the leading face 30 and the trailing face 32 of blades 26 both have a relatively shallow slope. In other words, the leading end angle 34 and the trailing end angle 36 are relatively small. For example, the shallow slope of the leading face 30 and the trailing face 32 may have leading end angle 34 and trailing end angle 36, respectively, of 45° or less. In some applications, the shallow taper may comprise both a leading end angle 34 and a trailing end angle 36 of 30° or less. In some applications, a shallower taper on the leading face 30 can limit steerability and dogleg capability. To increase dogleg capability, the slope taper at the leading face 30 may be steeper and the slope taper at the trailing face 32 may be relatively shallower.

[0023] As illustrated by the graph of Figure 4, the face taper angle has an effect on the force applied to the drill string, e.g. the pull force, to overcome friction associated

with an obstruction, e.g. a ledge. Figure 4 illustrates examples of pull force used to overcome friction for a variety of borehole inclinations and face taper angles. As illustrated, the pull force used to move stabilizer 10 past the obstruction decreases as the face taper angle decreases. Figure 4 provides a graphical overview of this relationship for a variety of wellbore types.

[0024] Referring generally to Figure 5, another embodiment of the stabilizer 10 is illustrated. In this embodiment, cutting features 48 are added along the slopes, e.g. the shallow slopes, of leading face 30 and/or trailing face 32. The cutting features 48 may comprise cutters, such as polycrystalline diamond (PDC) cutters, formed of hard material and positioned along the sloped faces 30 and/or 32. The cutting features may be oriented to cut away obstructions, such as ledges resulting from washouts, encountered along the wellbore. In some applications, the cutting features may be applied to a non-magnetic stainless steel substrate.

[0025] According to other and/or additional aspects of the present disclosure, various downhole components 10, e.g. stabilizers, other components, or entire tools, may be constructed in a manner providing resistance to abrasion in well related applications and non-well related applications. For example, the technique may provide increased abrasion resistance in a downhole component deployed in a drilling bottom hole assembly. In some applications, a sleeve is mounted to or constructed as part of the downhole component. The sleeve is formed of materials having suitable hardness, toughness and impact strength, such as materials comprising a tungsten carbide matrix. By way of example, the tungsten carbide matrix may comprise tungsten carbide particles in a suitable matrix, e.g. cobalt, and processed according to appropriate powder metallurgy techniques to form a metal matrix composite referred to herein as tungsten carbide matrix. In some applications, the sleeve may be formed primarily of tungsten carbide matrix.

[0026] In other applications, the sleeve may be formed of a suitable composite material with portions comprising the tungsten carbide mixture. By way of example, the

portions of hard tungsten carbide mixture may be bonded to steel or to another material having suitable toughness and impact strength. However, various other materials and material combinations may be used to form the sleeve. The composition of the tungsten carbide matrix also may be adjusted to accommodate various loading effects, thermal effects, and/or other effects likely to be experienced by the sleeve in a given application. The sleeve also may employ a plurality of wear protection elements. Depending on the application, the wear protection elements may be used with or incorporated into a variety of other components. It should be noted the suitable composite material and the plurality of wear protection elements may be used in a variety of parts, components or entire tools.

[0027] In some embodiments, the abrasion resistant components facilitate drilling operations and may be in the form of a stabilizer (or stabilizers) having an abrasion resistant sleeve. One or more of the stabilizers may be employed at various positions along a drill string and in combination with various types of drill string components, such as bottom hole assembly components. In addition to their usefulness in stabilizers, the abrasion resistant sleeves and/or other abrasion resistant features may be used in combination with directional drilling components, measurement-while-drilling components, and logging-while-drilling components. However, the abrasion resistant sleeves and/or other abrasion resistant features also may be used with a variety of other components, such as bottom hole assembly components. Examples include wear bands, kicker plates, filters and screens, telemetry modulators, impellers, turbine blades, cutter blocks for hole enlargement tools, stabilizer blocks for variable gauge stabilizers, and/or other downhole components.

[0028] Depending on the parameters of a given application, the abrasion resistant sleeves may comprise a suitable material or materials, e.g. a composite material having portions formed of tungsten carbide matrix. In some applications, the entire abrasion resistant sleeve may be made of tungsten carbide matrix. The sleeve also may be provided with additional wear protection elements, such as polycrystalline diamond compacts and thermally stable polycrystalline components. The polycrystalline diamond compacts and the thermally stable polycrystalline components can be constructed in a

variety of different shapes to provide additional, high abrasion resistance with respect to the sleeves or other components. The additional wear protection elements also may be positioned in optimized patterns or arrangements to help reduce the erosion and abrasive wear.

[0029] Referring again to Figure 1, the component 10, e.g. stabilizer 10, may be formed as an abrasion resistant component 10. The abrasion resistant stabilizer 10 (or other component 10) may similarly be mounted on drill string collar 16. As with embodiments described above, the abrasion resistant stabilizer 10 may comprise the plurality of blades 26 which extend outwardly from exterior surface 24. Also, the abrasion resistant stabilizer 10 may be used in combination with drill bit 18 and/or in combination with other drill string components.

[0030] As illustrated in Figure 6, the abrasion resistant stabilizer 10 may comprise an abrasion resistant sleeve 50. The abrasion resistant sleeve 50 may be constructed as the entire abrasion resistant stabilizer 10, or the abrasion resistant sleeve 50 may be mounted to or incorporated into the stabilizer 10. In this example, the abrasion resistant sleeve 50 is formed at least in part from tungsten carbide matrix and comprises a plurality of additional wear protection elements 52. By way of example, the additional wear protection elements 52 may comprise polycrystalline diamond compacts and/or thermally stable polycrystalline components.

[0031] In this stabilizer example, sleeve 50 may be formed with stabilizer blades 26 and the wear protection elements 52 may be mounted on or incorporated into the stabilizer blades 26. By way of example, the wear protection elements 52 may comprise polycrystalline diamond compact elements 54 and/or thermally stable polycrystalline elements 56. The wear protection elements 52 may be mounted along a lead edge 58 progressing up along each stabilizer blade 26 and in an arrangement which reduces wear on the lead edge 58. Additionally, the wear protection elements 52 may be arranged to reduce transversal wear patterns.

[0032] In the embodiment illustrated, the wear protection elements 52 comprise polycrystalline diamond compact elements 54 constructed as high rake cutters provided along the leading edges 58. In some applications, the polycrystalline diamond compact elements 54 are arranged in rows along the leading edge 58. In this example, the blades 26 also comprise thermally stable polycrystalline elements 56 positioned to provide additional wear protection. It should be noted, however, the wear protection elements 52 may be formed from a variety of hardened materials. The wear protection elements 52 also may have various shapes and may be arranged in different patterns depending on the environment, the application, and/or the type of abrasion resistant component 10, e.g. stabilizer 10. In some applications, sleeve 50 may comprise threaded regions 59 (or other suitable connector mechanisms) at its longitudinal ends to facilitate attachment to adjacent well string components.

[0033] Referring generally to Figure 7, other embodiments of abrasion resistant components 10 are illustrated. In this example, the abrasion resistant components 10 are assembled into drill string 14 deployed in a wellbore 60. The abrasion resistant components 10 incorporate abrasion resistant sleeves 50 which provide the components with high abrasion resistance. Again, the abrasion resistant sleeves 50 may be formed in whole or in part of tungsten carbide matrix. In some applications, the abrasion resistant sleeves 50 may be used to protect antennas 62 of, for example, measurement-while-drilling components and/or logging-while-drilling components. The abrasion resistant sleeves 50 also may be used in conjunction with, e.g. as part of, stabilizers to form abrasion resistant stabilizer components 10 as described above. The abrasion resistant sleeves 50 in these embodiments may again comprise or be combined with a variety of the wear protection elements 52 formed of various hard materials. The wear protection elements 52 may be attached to sleeve 50 via suitable attachment mechanisms, such as threaded attachment mechanisms, weldments, independent fasteners, and/or other suitable attachment mechanisms.

[0034] As illustrated in Figure 8, the abrasion resistant component 10 also may comprise a variety of rotary valves 64 in which hardened, wear protection elements 52

are combined with various components of the valve 64. In some downhole applications, the rotary valve 64 is combined with a torque impeller 66, and the wear protection elements 52 may be mounted on or formed with impeller blades and/or other system components to provide a high resistance to abrasion from, for example, sand and other particulates.

[0035] As illustrated in Figure 9, for example, a variety of impellers 66 may incorporate wear protection elements 52 along impeller blades 68 and/or at other portions of the impeller 66 to provide resistance to abrasion. As discussed above, however, the abrasion resistant sleeves 50 and/or wear protection elements 52 may be used with many types of components to construct abrasion resistant components 10. The abrasion resistant sleeves 50 and/or wear protection elements 52 may be combined with wear bands, kicker plates, filters and screens, telemetry modulators, turbine blades, cutter blocks for hole enlargement tools, stabilizer blocks for variable gauge stabilizers, and/or other downhole components.

[0036] Depending on the application, the wear resistant components 10 may have a variety of configurations comprising other and/or additional components. For example, the wear resistant components 10 may comprise a variety of rotary steerable system components such as pads, e.g. actuator pads, or kickers. In stabilizer applications, the shape and structure of the stabilizer body and stabilizer blades may vary in size and configuration depending on the parameters of a given application and environment. Similarly, a variety of materials may be used to construct the wear protection elements 52. Additionally, the wear protection elements 52 may be combined with many types of abrasion resistant sleeves 50 and/or other types of abrasion resistant components in well applications and non-well applications. In some applications, the sleeve 50 may utilize features, e.g. tongue and groove features, to facilitate making-up the connection with adjacent components.

[0037] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many

modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

- 1 1. A system for stabilizing a drilling string, comprising:
2
3 a drill string having a collar and a stabilizer mounted on the collar, the
4 stabilizer comprising:
5 a body having an interior surface and an exterior surface; and
6 a plurality of blades extending outwardly from the exterior surface
7 of the body, the plurality of blades being separated by flow channels, the
8 plurality of blades establishing a leading face and a trailing face, at least
9 one of the leading face and the trailing face having a shallow slope of 45°
10 or less relative to the exterior surface.
- 1 2. The system as recited in claim 1, wherein the body has the structure of a sleeve,
2 the sleeve being formed of a material comprising a tungsten carbide matrix, a
3 plurality of wear protection elements being mounted on the sleeve.
- 1 3. The system as recited in claim 1, wherein the trailing face has the shallow slope
2 and the leading face has a relatively steeper slope.
- 1 4. The system as recited in claim 1, wherein both the trailing face and the leading
2 face have the shallow slope.
- 1 5. The system as recited in claim 1, wherein the shallow slope is less than 30°.
- 1 6. The system as recited in claim 1, wherein the interior surface comprises an
2 internal profile which abuts against a corresponding shoulder of the collar when
3 the stabilizer is mounted on the collar.

- 1 7. The system as recited in claim 2, wherein the plurality of wear protection
2 elements comprises polycrystalline diamond compacts.
- 1 8. The system as recited in claim 2, wherein the plurality of wear protection
2 elements comprises thermally stable polycrystalline components.
- 1 9. The system as recited in claim 3, wherein the shallow slope is no greater than 45°
2 and the relatively steeper slope is no less than 70°.
- 1 10. A system, comprising:
2
3 a downhole component deployed in a drill string;
4 a sleeve coupled to the downhole component and formed of a material
5 comprising a tungsten carbide matrix, the sleeve employing a plurality of wear
6 protection elements.
- 1 11. The system as recited in claim 10, wherein the plurality of wear protection
2 elements comprises polycrystalline diamond compacts mounted on the sleeve.
- 1 12. The system as recited in claim 10, wherein the plurality of wear protection
2 elements comprises thermally stable polycrystalline components mounted on the
3 sleeve.
- 1 13. The system as recited in claim 10, wherein the downhole component comprises a
2 stabilizer.
- 1 14. The system as recited in claim 10, wherein the downhole component comprises a
2 measurement-while-drilling tool.
- 1 15. The system as recited in claim 10, wherein the downhole component comprises a
2 logging-while-drilling tool.

- 1 16. The system as recited in claim 10, wherein the downhole component comprises an
2 impeller.
1
- 1 17. The system as recited in claim 10, wherein the downhole component comprises a
2 rotary valve.
1
- 1 18. A method of drilling a wellbore, comprising:
2
3 providing a stabilizer having: a body with an interior surface and an
4 exterior surface, and a plurality of blades extending outwardly from the exterior
5 surface of the body;
6 forming the blades to establish a leading face and a trailing face with at
7 least one of the leading face and the trailing face having a shallow slope relative
8 to the exterior surface; and
9 mounting the stabilizer on a drill string collar of a drill string.
1
- 1 19. The method as recited in claim 18, wherein providing comprises forming the body
2 with a sleeve constructed of a material comprising a tungsten carbide matrix, a
3 plurality of wear protection elements being mounted on the sleeve.
- 1 20. The method as recited in claim 19, wherein providing comprises forming the
2 plurality of wear protection elements as polycrystalline diamond compacts.

FIG. 1

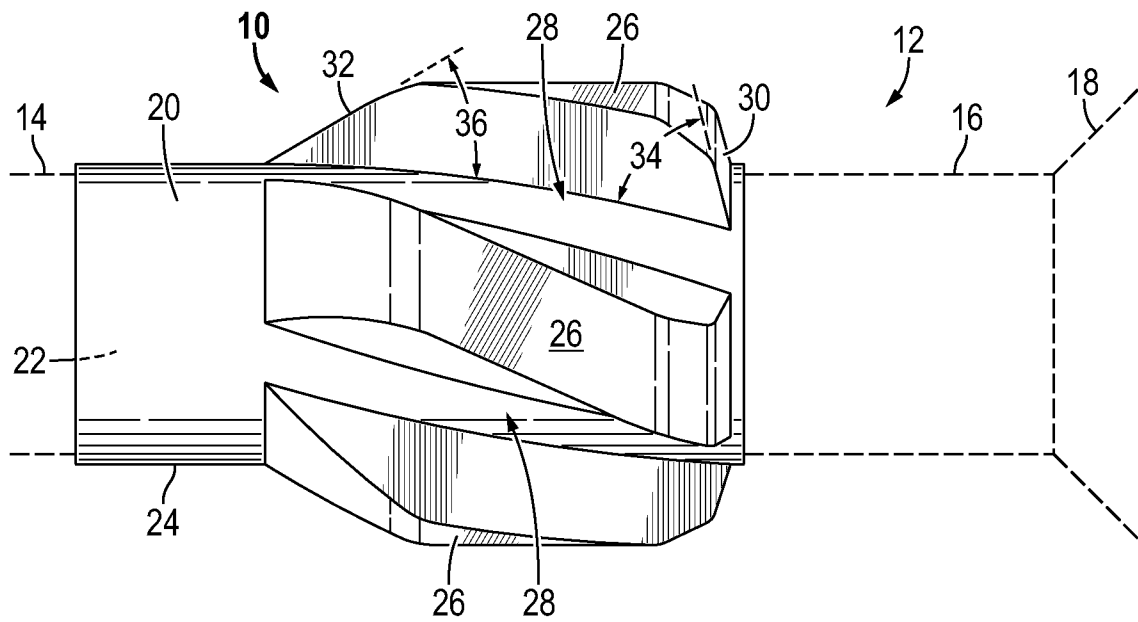


FIG. 2

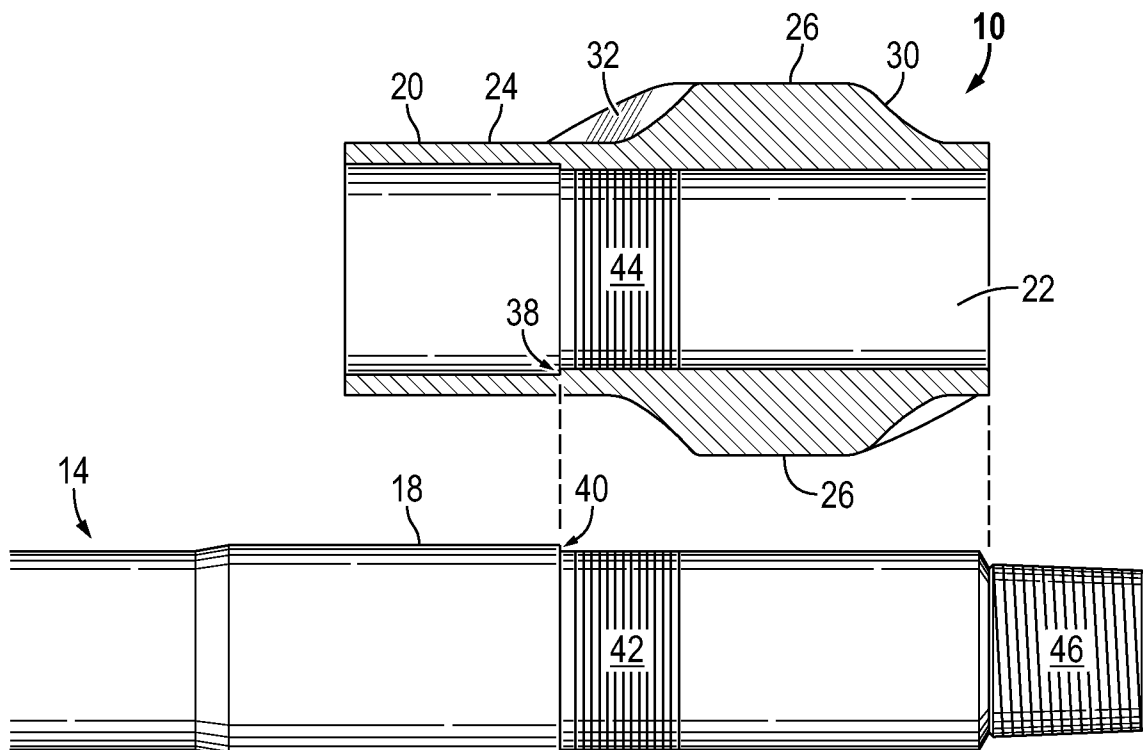


FIG. 3

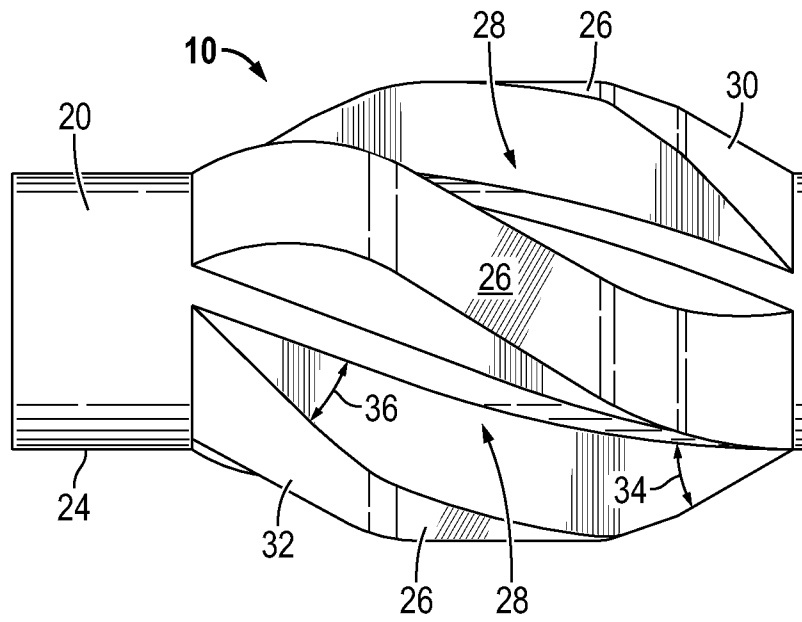


FIG. 5

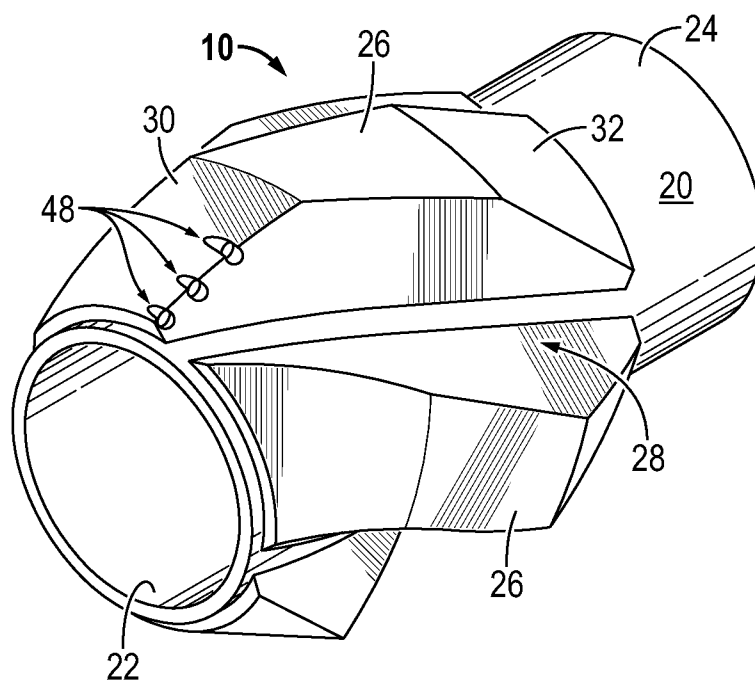


FIG. 4

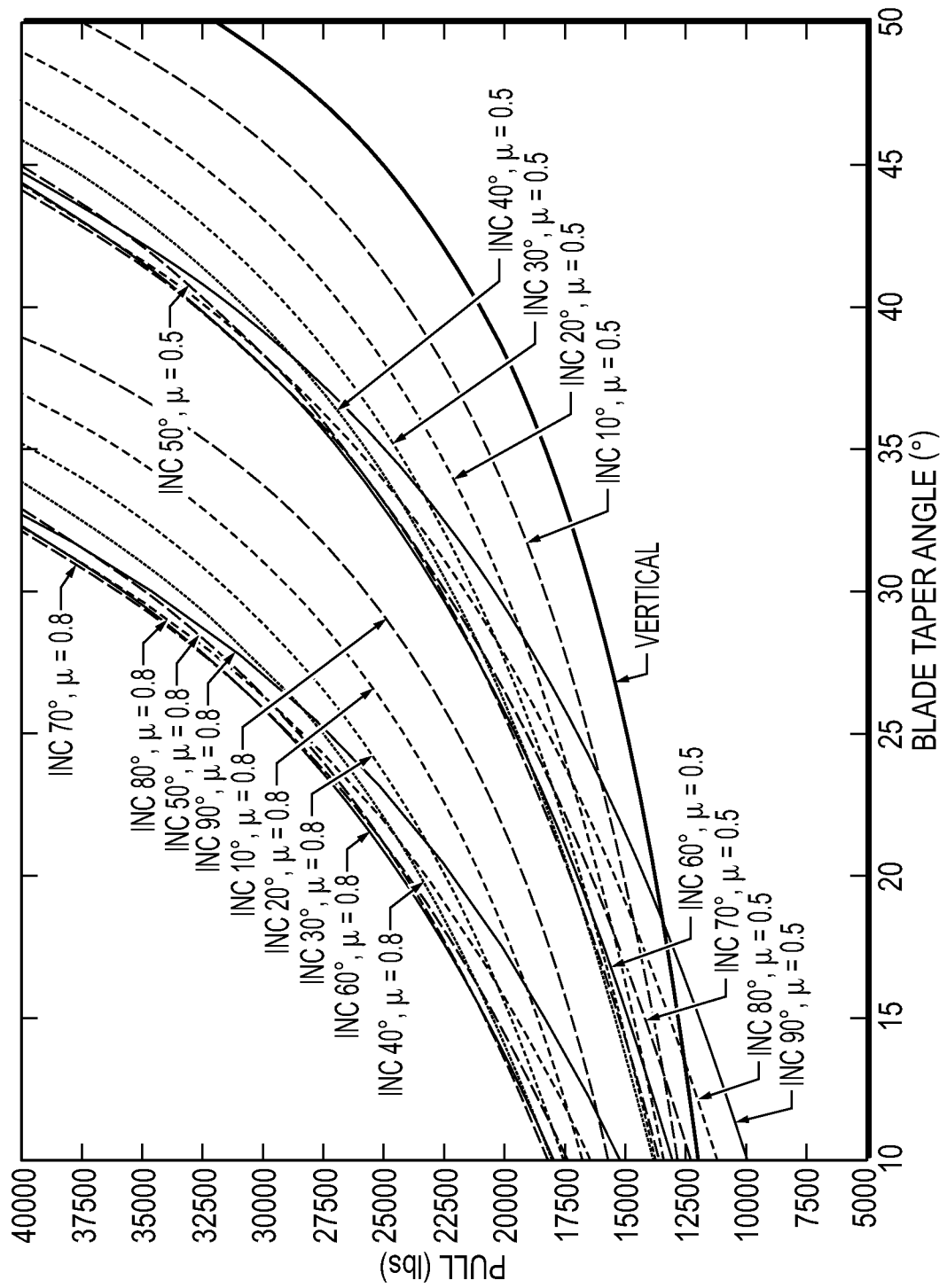


FIG. 6

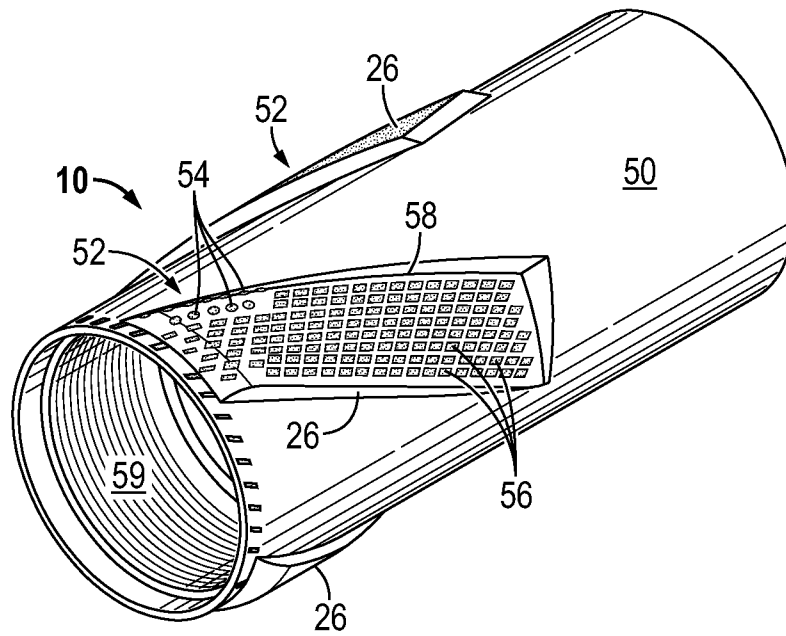


FIG. 7

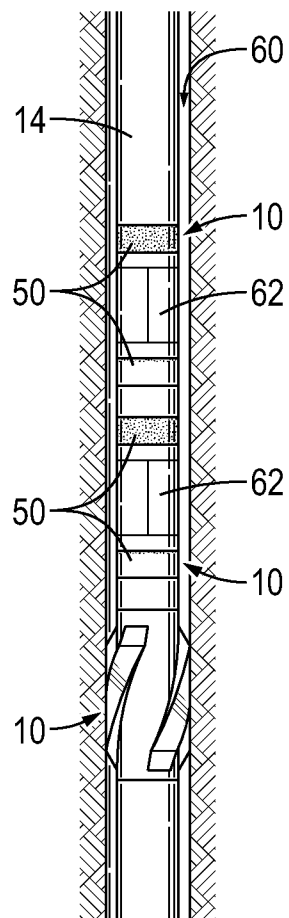


FIG. 8

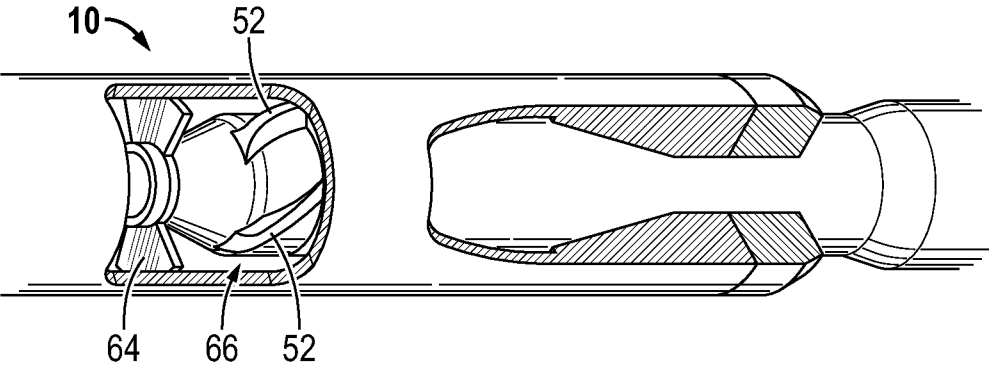
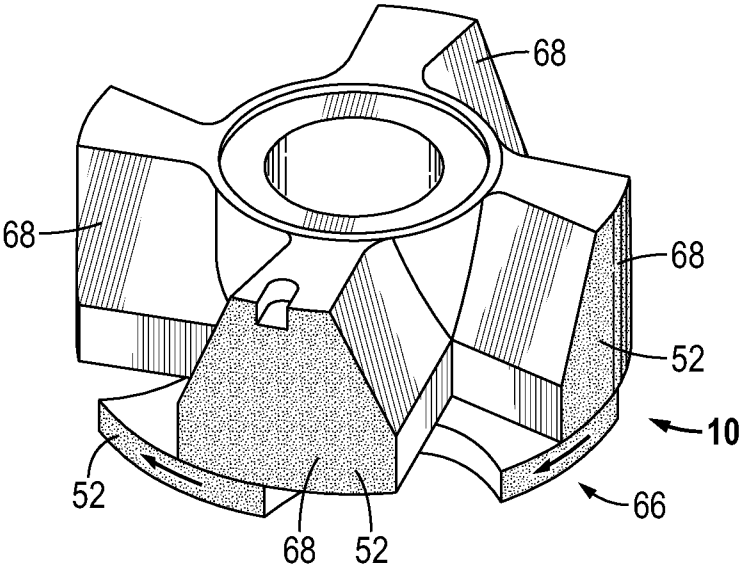


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/021639**A. CLASSIFICATION OF SUBJECT MATTER****E21B 17/10(2006.01)i, E21B 17/22(2006.01)i, E21B 7/00(2006.01)i**

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 17/10; E21B 7/00; F16C 1/26; E21B 10/32; E21C 9/00; E21B 11/00; E21B 17/22

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: stabilizer, drill string, collar, thread, blade, flow channel, wear resistant, tungsten carbide, polycrystalline and diamond

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010-0122851 A1 (WILDE, DAVID et al.) 20 May 2010 See paragraphs [0016]–[0027] and figures 1, 5–6.	1–20
A	US 4081203 A (FULLER, JOHN MICHAEL) 28 March 1978 See claims 1–16 and figures 3–5.	1–20
A	US 2013-0146361 A1 (MAKKAR et al.) 13 June 2013 See paragraphs [0034]–[0048] and figures 1A–4.	1–20
A	US 3978933 A (OLSON et al.) 07 September 1976 See claims 1–14 and figures 1–4.	1–20
A	US 4304311 A (SHINN, KIM E. et al.) 08 December 1981 See column 3, lines 12–68 and figure 1.	1–20

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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/021639

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US 3978933 A	07/09/1976	None	
US 4304311 A	08/12/1981	None	