(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 November 2015 (12.11.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/171199 A1

(51) International Patent Classification: *E21B 10/42* (2006.01)

(21) International Application Number: PCT/US2015/019959

(22) International Filing Date: 11 March 2015 (11.03.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 61/951,225 11 March 2014 (11.03.2014) US

(71) Applicant: **VAREL INTERNATIONAL IND., L.P.** [US/US]; 1625 W. Crosby, Suite 124, Carrollton, TX 75006 (US).

(72) Inventors: **THIGPEN, Gary Michael**; 1007 Rosemeadow Drive, Houston, TX 77094 (US). **BELLIN, Federico**; 39 Butternut Grove Place, Tomball, TX 77375 (US). **DE REYNAL, Michel, Jr.**; 34, Route du Cagnes, 64370 Arthez De Bearn (FR). **AMUNDSEN, Marvin Windsor**; 16646 Greenbriar Point Lane, Houston, TX 77095 (US). **JOHNSON, Charles Daniel**; 21301 Timber Bluff Ct., Porter, TX 77365 (US).

(74) Agents: **MCCOY, Michael, S.** et al.; King & Spalding LLP, 1100 Louisiana St., Houston, TX 77002 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: SHORT MATRIX DRILL BITS AND METHODOLOGIES FOR MANUFACTURING SHORT MATRIX DRILL BITS

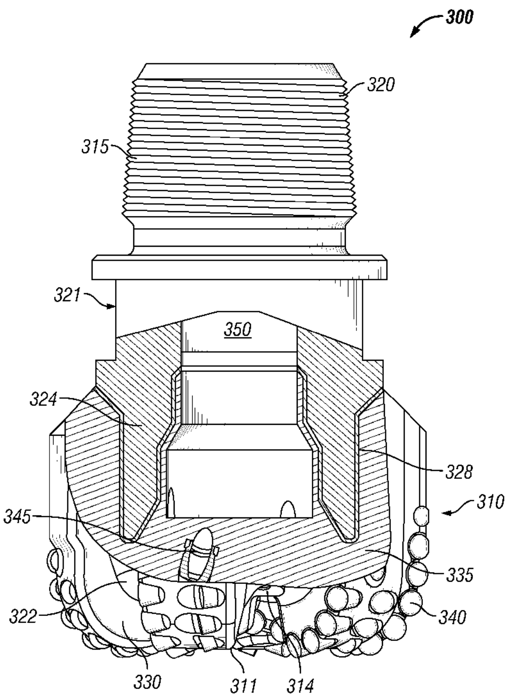

FIG. 3

(57) Abstract: A short matrix drill bit is disclosed along with methods of manufacturing the same. The Short drill matrix bit includes a combination shank/blank bonded to a matrix. The combination shank/blank includes a blank portion and a shank portion, which are formed as a unitary component. The combination shank and blank may also include an outer layer formed along at least a portion of the combination shank/blank. In some instances, the outer layer is nickel plating, or some other suitable material, which facilitates wetting of the binder material used to form the matrix.

WO 2015/171199 A1

Published:

— *with international search report (Art. 21(3))*

SHORT MATRIX DRILL BITS AND METHODOLOGIES FOR MANUFACTURING SHORT MATRIX DRILL BITS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This present application claims priority to U. S. Provisional Patent Application No. 61/951,225, entitled "Methodologies For Manufacturing Short Matrix Bits," filed March 11, 2014, the disclosure of which is incorporated herein.

BACKGROUND

[0001] This invention relates generally to drill bits used in downhole drilling. More particularly, this invention relates to a matrix drill bit, such as a tungsten carbide matrix drill bit, having an overall reduced bit height and the methods for manufacturing the same.

[0002] Underground drilling, such as gas, oil, or mining, generally involves drilling a borehole through a formation deep in the earth. Such boreholes are formed by connecting a drill bit to long sections of pipe, referred to as a "drill pipe," so as to form an assembly commonly referred to as a "drill string." The drill string extends from the surface, to the bottom of the borehole. The drill string is rotated, which causes the drill bit to be rotated. As the drill bit rotates, it advances into the earth, thereby forming the borehole. Oftentimes, the trajectory of borehole is directed by steering the drill bit either towards a target or away from an area where the drilling conditions are difficult. The process of drilling a borehole which is directed is referred to as "directional drilling." A directional drilling tool generally sits behind a drill bit and forward of measurement tools. The directional drilling tool facilitates guiding the direction at which the drill bit proceeds as it moves further within the earth. Drilling operators have been trying to increase the ease and control of drill bit steerability, oftentimes with respect to changes or improvements being made to the directional drilling tool.

[0003] Figure 1 shows a perspective view of a matrix drill bit 100 in accordance with the prior art. Referring to Figure 1, the matrix drill bit 100, or drill bit, includes a bit body 110 that is coupled to a shank 115, or an upper section. The shank 115 includes a threaded connection 116 at one end 120 of the matrix drill bit

100. The threaded connection 116 couples to a drill string (not shown) or some other equipment that is coupled to the drill string. The threaded connection 116 is shown to be positioned on the exterior surface of the one end 120. This positioning assumes that the matrix drill bit 100 is coupled to a corresponding threaded connection located on the interior surface of a drill string. However, the threaded connection 116 at the one end 120 is alternatively positioned on the interior surface of the one end 120 if the corresponding threaded connection of the drill string is positioned on its exterior surface in other exemplary embodiments. A bore (not shown) is formed longitudinally through the shank 115 and the bit body 110 for communicating drilling fluid from within the drill string to a drill bit face 111 via one or more nozzles 114 formed in the drill bit face 111 during drilling operations.

[0004] The bit body 110 includes a plurality of blades 130 extending from the drill bit face 111 of the bit body 110 towards the threaded connection 116. The drill bit face 111 is positioned at one end of the bit body 110 furthest away from the shank 115. The plurality of blades 130 form the cutting surface of the matrix drill bit 100. One or more of these plurality of blades 130 are either coupled to the bit body 110 or are integrally formed with the bit body 110. A junk slot 122 is formed between each consecutive blade 130, which allows for cuttings and drilling fluid to return to the surface of the wellbore (not shown) once the drilling fluid is discharged from the nozzles 114. A plurality of cutters 140 are coupled to each of the blades 130 and extend outwardly from the surface of the blades 130 to cut through earth formations when the matrix drill bit 100 is rotated during drilling. The cutters 140 and portions of the bit body 110 deform the earth formation by scraping and/or shearing. The cutters 140 and portions of the bit body 110 are subjected to extreme forces and stresses during drilling which causes surface of the cutters 140 and the bit body 110 to eventually wear. Although one example of the matrix drill bit has been described, other matrix drill bits known to people having ordinary skill in the art are applicable to present invention described below.

[0005] Figure 2 shows a side view and a partial cross-sectional view of the matrix drill bit 100 illustrating the internal components of the bit body 110 and the coupling between the bit body 110 and the shank 115 in accordance with the prior art. Referring to Figures 1 and 2, the bit body 110 further includes a blank 224 and a matrix 235 bonded to the blank 224. The matrix 235 defines a bore 240 therein and a plurality of passageways 245 extending from the bore 240 to the respective nozzle

114 in the drill bit face 111. The bore 240 of the bit body 110 is fluidly communicable with the bore of the shank 115 once the shank 115 is coupled to the bit body 110.

[0006] The blank 224 is a cylindrical steel casting mandrel that extends into the matrix 235. A portion of the blank 224 is positioned external to the matrix 235 while a remaining portion of the blank 224 extends centrally and longitudinally into the matrix 235 and surrounds the bore 240 formed within the matrix 235. According to the prior art, the blank 224 is fabricated from AISI 1020 steel or AISI 1018 steel. The blank 224, according to at least some of the prior art, includes a first portion 225, a second portion 226, a third portion 227, and a fourth portion 228. The first portion 225 is positioned external to the matrix 235 and includes threads 220 formed along the outer perimeter. However, in some alternative embodiments, the threads 220 are formed internally of the first portion 225. The second portion 226 also is positioned external to the matrix 235 and immediately adjacent to the matrix 235 between the first portion 225 and the matrix 235. The internal diameter of the first and second portions 225, 226 are similar while the outer diameter of the second portion 226 is greater than the outer diameter of the first portion 225. A top end of the second portion 226 is formed with a half-U shaped groove 231, via machining or in a mold. The third portion 227 is disposed within the matrix 225 and is positioned adjacent the second portion 226. The third portion 227 has an internal diameter similar to the internal diameters of the first and second portions 225, 226; however, the external diameter of the third portion 227 is variable as it transitions from the outer diameter of the second portion 226 to the outer diameter of the fourth portion 228. The fourth portion 228 is disposed within the matrix 235 and extends from the third portion 227 towards the bit face 111. The outer diameter of the fourth portion 228 is smaller than the outer diameter of the second portion 226 but larger than the outer diameter of the first portion 225. Further, the inner diameter of the fourth portion 228 is larger than the internal diameter of the first, second, and third portions 225, 226, 227.

[0007] The matrix 235 is formed from a sintering process and is fabricated from tungsten carbide powder and a binder material, such as cobalt, copper, cobalt alloy, copper alloy, or any other known material, such as a nickel, nickel alloy, or MF 53 braze filler material. Although tungsten carbide powder is used to form the matrix 235, other carbide powders can be used in lieu of or in conjunction with the tungsten carbide powder. The matrix 235 bonds to the blank 224 during a sintering process and surrounds the third and fourth portions 227, 228 of the blank 225.

[0008] The shank 115 further includes a second end 260 positioned distally away from the one end 120 of the matrix drill bit 100 and a plurality of bit breaker slots 270 formed at opposite sides thereof between the one end 120 and the second end 260. The second end 260 includes threads 262 formed internally therein and extending from the second end 260 towards the one end 120. The threads 262 are configured to be coupled threadedly with the threads 220 of the blank 224. The second end 260 is formed with a half-U shaped groove 261, via machining or molding, such that a U-shaped groove 265 is formed between the shank 115 and the blank 224 when the shank 115 is threadedly coupled to the blank 224 and the half U-shaped groove 231 of the blank 224 is positioned adjacent the half U-shaped groove 261 of the shank 115. The U-shaped groove 265 is formed with a 0.200 inch radius and a fifteen (15) degree angle; however, these dimensions may vary on other examples. According to the prior art, the shank 115 is generally fabricated from AISI 4140 steel.

[0009] In the prior art, the AISI 4140 shank 115 is welded by submerged arc welding ("SAW") to the AISI 1020 blank 224 forming a U-groove joint 267 within the U-shaped groove 265. The U-shaped groove 265 allows access to the root of the weld when performing welding using the SAW weld technique, which is known to people having ordinary skill in the art and is not repeated herein for the sake of brevity. The U-shaped groove 265 is filled with multiple passes using the SAW weld technique, thereby forming the U-groove joint 267. The SAW welding technique makes use of a 0.062 inch diameter wire, Lincolnweld L61 consumable electrode material immersed in a protective layer of Lincoln 860 Flux. Since the U-groove joint 267 is a wide joint, the overall bit height of the matrix drill bit 100 becomes longer. A longer overall matrix bit height causes steerability of the matrix drill bit 100 to be more difficult and/or less efficient than if a shorter overall bit height were to be used. The shank 115 and the blank 224 are fabricated as two distinct components using different materials of construction because the blank 224 needs less carbon therein to better bond with the matrix 235, while the shank 115 needs more carbon for higher strength.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing and other features and aspects of the invention will be best understood with reference to the following description of certain exemplary embodiments of the invention, when read in conjunction with the accompanying drawings, wherein:

[0011] Figure 1 shows a perspective view of a matrix drill bit in accordance with the prior art;

[0012] Figure 2 shows a side view and a partial cross-sectional view of the matrix drill bit of Figure 1 illustrating the internal components of the bit body and the coupling between the bit body and the shank in accordance with the prior art; and

[0013] Figure 3 shows a side view and a partial cross-sectional view of a matrix drill bit illustrating the internal components therein and the coupling between a bit body and a combination shank/blank in accordance with an exemplary embodiment of the present invention.

[0014] The drawings illustrate only exemplary embodiments of the invention and are therefore not to be considered limiting of its scope, as the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0015] This invention relates generally to drill bits used in downhole drilling. More particularly, this invention relates to a matrix drill bit, such as a tungsten carbide matrix drill bit, having a reduced bit height and the methods for manufacturing the same. A matrix drill bit having a reduced distance from the cutters to the bend and/or from the cutters to the operative portion of the steering tool allows easier steering of the bit through a formation. Although the description provided below is related to a matrix drill bit, exemplary embodiments of the invention relate to any downhole tool including, but not limited to, rotary bits and shear bits, that benefit from having a reduced overall height.

[0016] Figure 3 shows a side view and a partial cross-sectional view of a matrix drill bit 300 illustrating the internal components therein and the coupling between the bit body 310 and a combination shank/blank 321 in accordance with an exemplary embodiment of the present invention. Referring to Figure 3, the matrix drill bit 300 is similar to matrix drill bit 100 (Figures 1 and 2), except that the shank 115 (Figure 1) and the blank 224 (Figure 2) of drill bit 100 (Figures 1 and 2) are replaced with a combination shank/blank 321, which includes a shank portion 315, or upper section, and a blank portion 324. According to exemplary embodiments, the shank portion 315 and the blank portion 324 are fabricated as a single component, i.e. a unitary construction component, using the same fabrication material and forms the combination shank/blank 321. Hence, there is no weld or other coupling occurring between the shank portion 315 and the blank portion 324, thereby allowing the fabrication length of the drill bit 300 to be shorter than those of the prior art with respect to equivalent size drill bits. The remaining features of the matrix drill bit 300 are similar to those corresponding features of the matrix drill bit 100 (Figure 1).

[0017] The matrix drill bit 300 includes the bit body 310 that is coupled to the combination shank/blank 321. The shank portion 315 includes a threaded connection at one end 320 of the matrix drill bit 300. The threaded connection couples to a drill string (not shown) or some other equipment that is coupled to the drill string. The threaded connection is positioned on the exterior surface of the one end 320 according to some exemplary embodiments. This positioning assumes that the matrix drill bit 300 is coupled to a corresponding threaded connection located on the interior surface of a drill string. However, the threaded connection at the one end 320 is alternatively positioned on the interior surface of the one end 320 if the corresponding threaded connection of the drill string is positioned on its exterior surface in other exemplary embodiments. A bore 350 is formed longitudinally through the combination shank/blank 321 and the bit body 310 for communicating drilling fluid from within the drill string to a drill bit face 311 via one or more nozzles 314 formed in the drill bit face 311 during drilling operations.

[0018] As previously mentioned, the combination shank/blank 321 includes the blank portion 324 and the shank portion 315, which are formed as a unitary component with the same fabrication material. The blank portion 324 is similar to the blank 224 (Figure 2) and the shank portion 315 is similar to the shank 11 (Figure 1). According to some exemplary embodiments, an outer layer 328 is optionally formed on at least a portion of the surface of the combination shank/blank 321. According to Figure 3, this outer layer is formed along a portion of the surface of the blank portion 324; however, this outer layer may be formed along a lesser portion of the surface of the blank portion 324, a greater portion of the surface of the blank portion 324, or at least a portion of the combination shank/blank 321 that also includes the shank portion 315. This outer layer 328 may be formed along the surface of the combination shank/blank 321 by treating the surface of the combination shank/blank 321 and/or applying a material to coat the surface of the combination shank/blank 321 according to certain exemplary embodiments. Some of these exemplary embodiments are discussed in further detail below.

[0019] The bit body 310 includes a matrix 335 bonded to the blank portion 324 of the combination shank/blank 321. The matrix 335 defines a portion of the bore 350 therein, which also extends into the shank portion 315, and a plurality of passageways 345 extending from the bore 350 to the respective nozzle 314 in the drill bit face 311. The matrix 335 forms a plurality of blades 330 extending from the drill bit face 311 of the bit body 310 towards the threaded connection at the one end 320. The drill bit face 311 is positioned at one end of the bit body 310 furthest away from the shank portion 315. The plurality of blades 330 form the cutting surface of the matrix drill bit 300. One or more of these plurality of blades 330 are either coupled to the bit body 310 or are integrally formed with the bit body 310. A junk slot 322 is formed between each consecutive blade 330, which allows for cuttings and drilling fluid to return to the surface of the wellbore (not shown) once the drilling fluid is discharged from the nozzles 314. A plurality of cutters 340 are coupled to each of the blades 330 and extend outwardly from the surface of the blades 330 to cut through earth formations when the matrix drill bit 300 is rotated during drilling. The cutters 340 and portions of the bit body 310 deform the earth formation by scraping and/or shearing. The cutters 340 and portions of the bit body 310 are subjected to extreme forces and stresses during drilling which causes surface of the cutters 340 and the bit body 310 to eventually wear.

[0020] The matrix 335 is formed from a sintering process and is fabricated from tungsten carbide powder and a binder material, such as cobalt, copper, cobalt alloy, copper alloy, or any other known material, such as a nickel, nickel alloy, or MF 53 braze filler material. Although tungsten carbide powder is used to form the matrix 335, other carbide powders or non-carbide powders can be used in lieu of or in conjunction with the tungsten carbide powder. The matrix 335 bonds to the blank portion 324 and/or the optional outer layer 328 during the sintering process, which is known to people having ordinary skill in the art having the benefit of the present disclosure.

[0021] According to some exemplary embodiments, the combination shank/blank 321, which includes the shank portion 315 and the blank portion 324, is fabricated as a single component using AISI 4140 machined component. There is no welded, brazed, or threaded joint of any kind coupling the shank portion 315 to the blank portion 324. In certain exemplary embodiments, the optional outer layer 328 is applied onto the surface of at least a portion of the combination shank/blank 321, that portion which bonds to the matrix 335. This optional outer layer 328 is nickel plating, or some other suitable material, according to some exemplary embodiments, which facilitates wetting of the binder material, such as MF 53 braze filler metal, with the surface of the AISI 4140 material upon infiltration. The brazing (infiltration process) would suffice to austenitize the AISI 4140 base metal given that it is performed at a temperature of 2150 °F, well above the austenitizing temperature currently used in the hardening operation for AISI 4140. Thus, this optional outer layer 328 is applied onto at least a portion of the surface of the combination shank/blank 321 prior to infiltration. In certain exemplary embodiments, this optional outer layer 328 is a 0.0005 inch thick layer of electrolytic nickel that is applied.

[0022] According to some other exemplary embodiments, the combination shank/blank 321, which includes the shank portion 315 and the blank portion 324, is fabricated as a single component using AISI 4140 machined component. There is no welded, brazed, or threaded joint of any kind coupling the shank portion 315 to the blank portion 324. According to this exemplary embodiment, the optional outer layer 328 is applied onto the surface of at least a portion of the combination shank/blank 321, that portion which bonds to the matrix 335. This optional outer layer 328 is a low carbon steel layer, or some other suitable material, that is welded onto the surface of the combination shank/blank 321, which facilitates the bonding between the matrix 335 and the blank portion 324 of the combination shank/blank 321. Thus, this optional outer layer 328 is applied onto at least a portion of the surface of the combination shank/blank 321 prior to infiltration in this exemplary embodiment. In certain exemplary embodiments, this optional outer layer 328 is applied by using a low carbon steel rod. Also, according to certain exemplary embodiments, the optional outer layer 328 has a thickness ranging between 1/16 of an inch to 1/8 of an inch; however, this range can have a lower end less than 1/16 of an inch or a higher end greater than 1/8 of an inch in other exemplary embodiments.

[0023] According to some other exemplary embodiments, the combination shank/blank 321, which includes the shank portion 315 and the blank portion 324, is fabricated as a single component using AISI 4140 machined component. There is no welded, brazed, or threaded joint of any kind coupling the shank portion 315 to the blank portion 324. According to this exemplary embodiment, the optional outer layer 328 is formed by treating the surface of at least a portion of the combination shank/blank 321, that portion which bonds to the matrix 335. This optional outer layer 328 is formed by decarburizing at least that portion of the surface of the combination shank/blank 321 that bonds to the matrix 335, i.e. removing carbon form the mentioned surface. This allows the matrix 335 to better bond to the combination shank/blank 321. This decarburizing process is performed prior to the infiltration step. This decarburizing process is known to people having ordinary skill in the art having the benefit of the present disclosure and is therefore not repeated herein for the sake of brevity.

[0024] According to some other exemplary embodiments, the combination shank/blank 321, which includes the shank portion 315 and the blank portion 324, is fabricated as a single component using precipitation hardening steel. There is no welded, brazed, or threaded joint of any kind coupling the shank portion 315 to the blank portion 324. Some examples of the precipitation hardening steel includes, but is not limited to, 17-4 PH and 17-22 PH. Precipitation hardening, also called age hardening, is a heat treatment technique used to increase the yield strength of malleable materials, such as stainless steels. Precipitation hardening relies on changes in solid solubility with temperature to produce fine particles of an impurity phase, which impede the movement of dislocations, or defects in a crystal's lattice. Since dislocations are often the dominant carriers of plasticity, this serves to harden the material. Unlike ordinary tempering, alloys must be kept at elevated temperature for hours to allow precipitation to take place. After infiltration, the precipitation hardening steel is heat treated to achieve API Spec 7 properties. According to one exemplary embodiment, this post-infiltration heat treatment is at 1150 °F for four hours, which is a typical heat treatment for 17-4 PH material. The temperature and time may vary depending upon the material used and the properties desired, which would be known to people having ordinary skill in the art having the benefit of the present disclosure. According to this exemplary embodiment, the optional outer layer 328 is not used.

[0025] According to some other exemplary embodiments, the combination shank/blank 321, which includes the shank portion 315 and the blank portion 324, is fabricated as a single component using maraging steel. There is no welded, brazed, or threaded joint of any kind coupling the shank portion 315 to the blank portion 324. Maraging steels are steels which are known for possessing superior strength and toughness without losing malleability. These steels are a special class of low-carbon ultra-high-strength steels which derive their strength not from carbon, but from precipitation of inter-metallic compounds. After infiltration, the maraging steel is heat treated to achieve API Spec 7 properties. The temperature and time may vary depending upon the material used and the properties desired, which would be known to people having ordinary skill in the art having the benefit of the present disclosure. According to this exemplary embodiment, the optional outer layer 328 is not used.

[0026] Although the invention has been described with reference to specific embodiments, these descriptions are not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the invention will become apparent to persons skilled in the art upon reference to the description of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. It is therefore, contemplated that the claims will cover any such modifications or embodiments that fall within the scope of the invention.

CLAIMS

WHAT IS CLAIMED IS:

1. A downhole tool, comprising:

a combination shank/blank comprising a shank portion and a blank portion, the shank portion comprising a threaded portion at one end, the blank portion forming a bore extending centrally therethrough; and

a bit body comprising a matrix bonded to and surrounding at least a portion of the blank portion, the matrix forming one or more blades extending outwardly in a direction away from the blank,

wherein the combination shank/blank is fabricated as a unitary construction component using the same material.

2. The downhole tool of Claim 1, further comprising a coating formed along at least a portion of a surface of the blank portion that bonds with the matrix.

3. The downhole tool of Claim 2, wherein the coating comprises a thickness ranging from about 1/16 inch to 1/8 inch.

4. The downhole tool of Claim 2, wherein the coating comprises a thickness ranging from about 0.0005 inch to 1/8 inch.

5. The downhole tool of Claim 1, wherein the combination shank/blank is manufactured using AISI 4140.

6. The downhole tool of Claim 5, further comprising a coating formed along at least a portion of a surface of the blank portion that bonds with the matrix.

7. The downhole tool of Claim 6, wherein the coating comprises a nickel coating.

8. The downhole tool of Claim 6, wherein the coating comprises a low carbon steel layer welded onto at least a portion of the surface of the blank portion.

9. The downhole tool of Claim 6, wherein the coating is formed by decarburizing at least a portion of the surface of the blank portion prior to an infiltration process performed in forming the downhole tool.

10. The downhole tool of Claim 1, wherein the combination shank/blank is manufactured using precipitation hardening steel.

11. The downhole tool of Claim 1, wherein the combination shank/blank is manufactured using maraging steel.

12. A method for forming a matrix downhole tool having a reduced overall height, comprising:

obtaining a combination shank/blank comprising a shank portion and a blank portion, the shank portion comprising a threaded portion at one end, the blank portion forming a bore extending centrally therethrough; and

bonding a matrix to and surrounding at least a portion of the blank portion, the matrix forming one or more blades extending outwardly in a direction away from the blank,

wherein the combination shank/blank is fabricated as a unitary construction component using the same material.

13. The method of Claim 12, further comprising forming a coating along at least a portion of a surface of the blank portion that bonds with the matrix.

14. The method of Claim 13, wherein the coating comprises a thickness ranging from about 1/16 inch to 1/8 inch.

15. The method of Claim 13, wherein the coating comprises a thickness ranging from about 0.0005 inch to 1/8 inch.

16. The method of Claim 12, wherein the combination shank/blank is manufactured using AISI 4140.

17. The method of Claim 16, further comprising forming a coating along at least a portion of a surface of the blank portion that bonds with the matrix.

18. The method of Claim 17, wherein the coating comprises a nickel coating.

19. The method of Claim 17, wherein the coating comprises a low carbon steel layer welded onto at least a portion of the surface of the blank portion.

20. The method of Claim 17, wherein the coating is formed by decarburizing at least a portion of the surface of the blank portion prior to an infiltration process performed in forming the downhole tool.

21. The method of Claim 12, wherein the combination shank/blank is manufactured using precipitation hardening steel.

22. The method of Claim 12, wherein the combination shank/blank is manufactured using maraging steel.

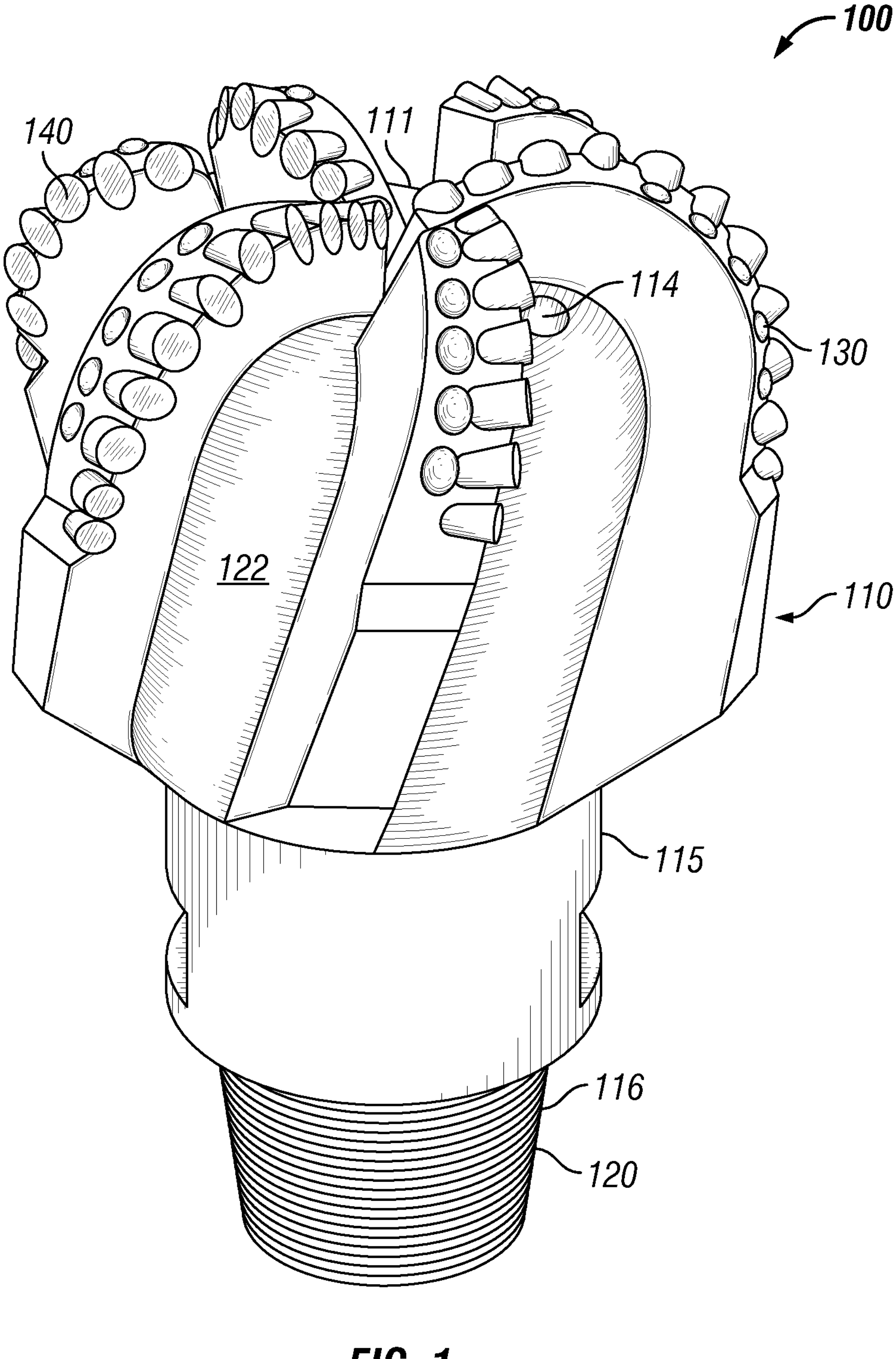

FIG. 1
(Prior Art)

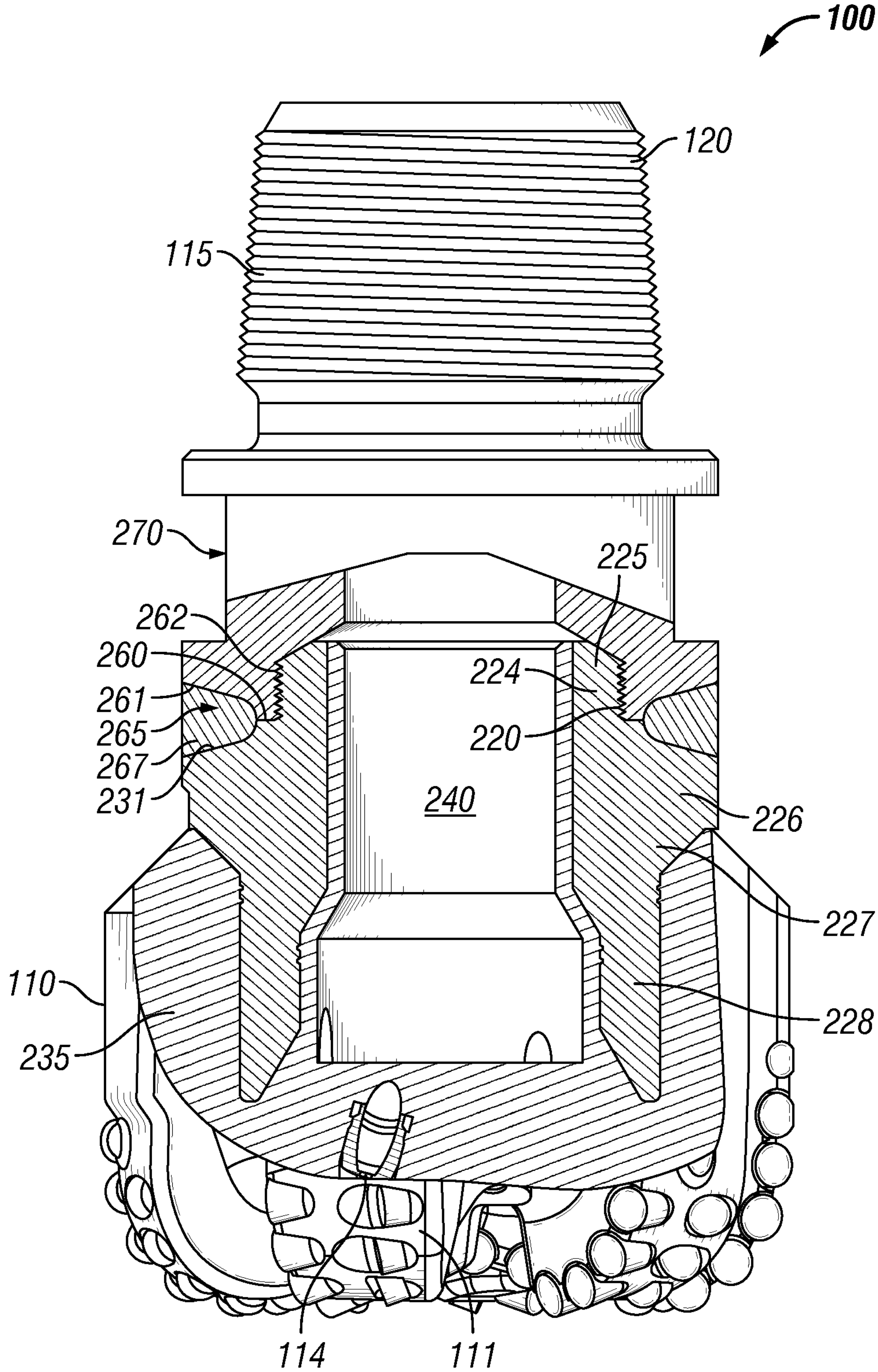

FIG. 2
(Prior Art)

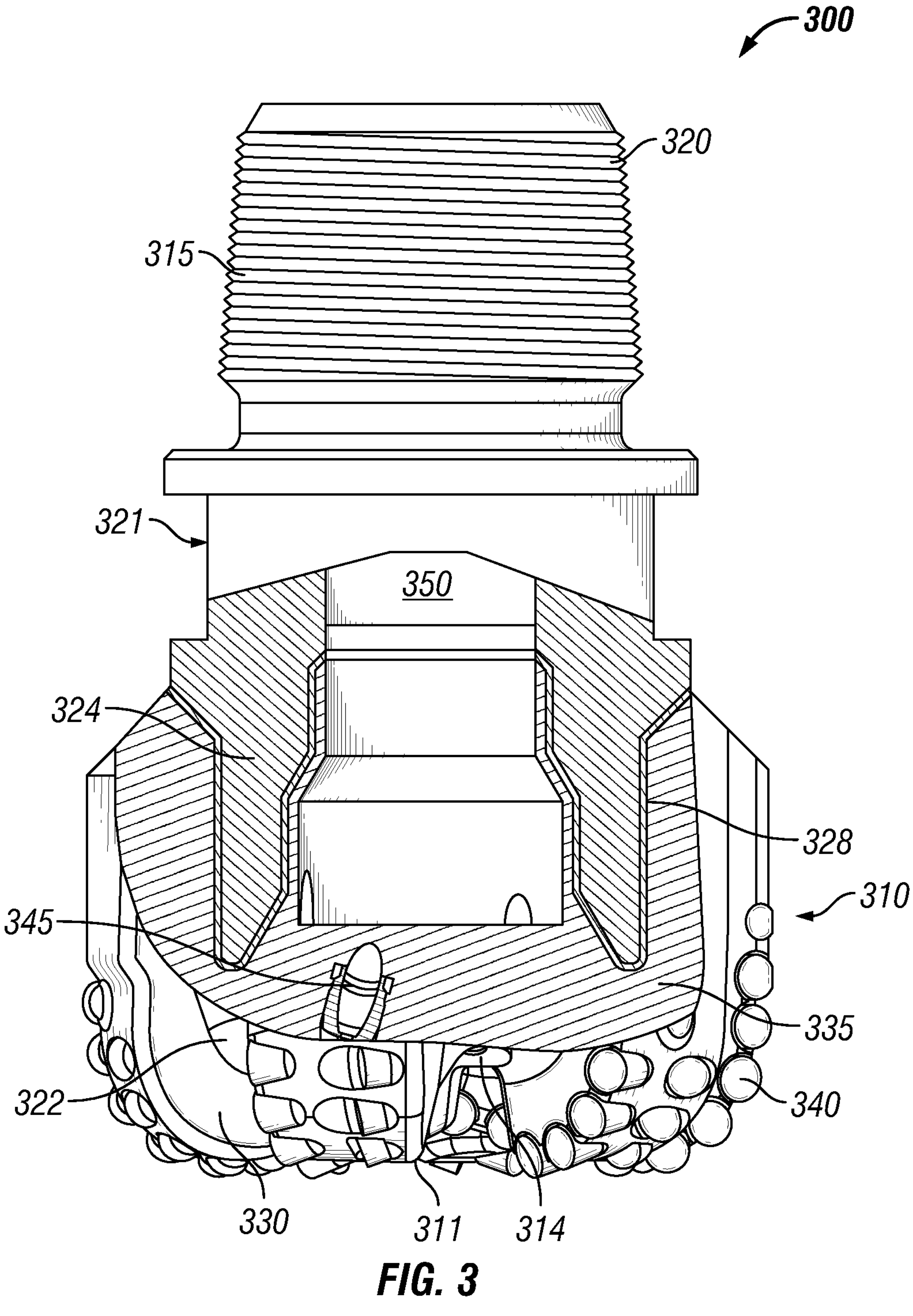

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/019959

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 10/42 (2015.01)
CPC - E21B 10/42 (2015.05)
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)
IPC(8) - E21B 10/00, 10/08, 10/36, 10/42, 10/46, 10/54, 10/55, 10/56, 10/567 (2015.01)
CPC - B22F 2005/001; E21B 10/00, 10/42, 10/46, 10/54, 10/55, 10/567 (2015.05)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 76/108.2; 175/374, 425, 426, 428, 431, 434 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google, Google Scholar, YouTube.
Search terms used: varel, unitary, shank, blank, bit, drill, combination

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,351,401 A (FIELDER) 28 September 1982 (28.09.1982) entire document	1, 12 --- 2-7, 10, 11, 13-18, 21, 22
Y	US 2012/0298425 A1 (DE MAINDREVILLE et al) 29 November 2012 (29.11.2012) entire document	2-4, 6, 7, 13-15, 17, 18
Y	US 2006/0213693 A1 (ZAHRADNIK et al) 28 September 2006 (28.09.2006) entire document	5-7, 16-18
Y	US 2013/0146366 A1 (CHENG et al) 13 June 2013 (13.06.2013) entire document	10, 11, 21, 22

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2015	11 JUN 2015

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774