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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 August 2011 (11.08.2011)

PCT

(10) International Publication Number
WO 2011/097575 A4

(51) International Patent Classification:
E21B 10/54 (2006.01) *E21B 10/56* (2006.01)
E21B 10/62 (2006.01)

(21) International Application Number:
PCT/US2011/023922

(22) International Filing Date:
7 February 2011 (07.02.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/301,946 5 February 2010 (05.02.2010) US

(71) Applicant *(for all designated States except US)*: **BAKER HUGHES INCORPORATED** [US/US]; P.O. Box 4740, Houston, TX 77210-4740 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **LYONS, Nicholas, J.** [US/US]; 808 Pecore Street, Houston, TX 77009 (US). **SCOTT, Danny, E.** [US/US]; 3015 Poe Drive, Montgomery, TX 77356 (US). **PESSIER, Rudolf, Carl** [US/US]; 8900 Research Park Drive, Apt. 621, Spring, TX 77381 (US). **GAVIA, David** [US/US]; 30 Silver Lute Place, The Woodlands, TX 77381 (US). **BILEN, Juan, Miguel** [AR/US]; 27 Willow Point Place, The Woodlands, TX 77382 (US).

(74) Agents: **WELBORN, Brian, S.** et al.; BAKER HUGHES INCORPORATED, Intellectual Property Counsel, P.O. Box 4740, Houston, TX 77210-4740 (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, 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, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, 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.

[Continued on next page]

(54) Title: SHAPED CUTTING ELEMENTS ON DRILL BITS AND OTHER EARTH-BORING TOOLS, AND METHODS OF FORMING SAME

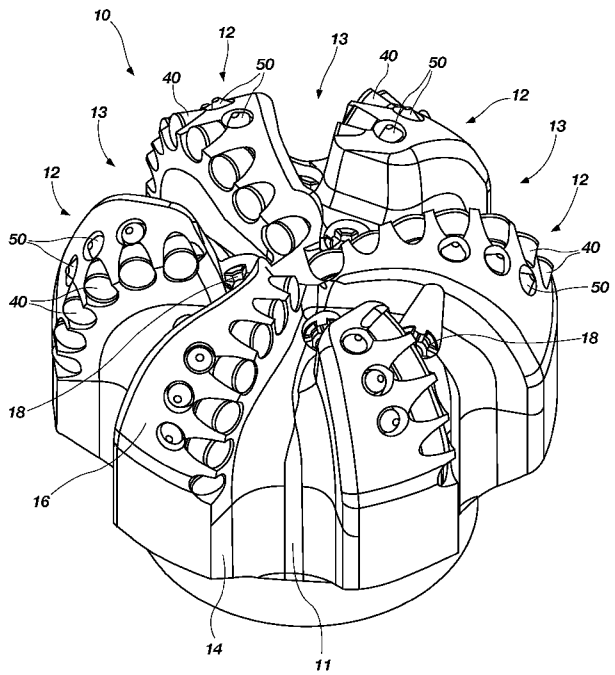

FIG. 1

(57) Abstract: Earth-boring tools include a body, one or more blades projecting outwardly from the body, and cutting elements carried by the blade. The cutting elements include at least one shearing cutting element and at least one gouging cutting element. Methods of forming an earth-boring tool include mounting a shearing cutting element comprising an at least substantially planar cutting face to a body of an earth-boring tool, and mounting a gouging cutting element comprising a non-planar cutting face to the body of the earth-boring tool. The gouging cutting element may be positioned on the body of the earth-boring tool such that the gouging cutting element will gouge formation material within a kerf cut in the formation material by the shearing cutting element, or between kerfs cut in the formation material by a plurality of shearing cutting elements.

WO 2011/097575 A4

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

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

— *with amended claims and statement (Art. 19(1))*

(88) Date of publication of the international search report: 10 November 2011

Date of publication of the amended claims and statement: 29 December 2011

AMENDED CLAIMS
received by the International Bureau on 7 November 2011 (07.11.2011)

1. An earth-boring tool, comprising:

a body;

at least one blade projecting outwardly from the body; and

a plurality of cutting elements carried by the at least one blade, the plurality of cutting elements comprising:

at least one shearing cutting element comprising an at least substantially planar cutting face positioned and oriented for shearing a subterranean formation when the earth-boring tool is rotated under applied force against the subterranean formation; and

at least one gouging cutting element located rotationally behind the at least one shearing cutting element on the at least one blade, the at least one gouging cutting element comprising a cutting face positioned and oriented with a forward rake angle for at least one of crushing and gouging the subterranean formation when the earth-boring tool is rotated under the applied force.

2. The earth-boring tool of claim 1, wherein the at least one shearing cutting element comprises a polycrystalline diamond material, and wherein the at least substantially planar cutting face of the at least one shearing cutting element comprises a surface of the polycrystalline diamond material.

3. The earth-boring tool of claim 1, wherein:

the at least one gouging cutting element comprises a polycrystalline diamond material;

the cutting face of the at least one gouging cutting element comprises a surface of the polycrystalline diamond material; and

the cutting face of the at least one gouging cutting element is non-planar.

4. The earth-boring tool of claim 3, wherein the cutting face of the at least one gouging cutting element is substantially dome-like in shape.

5. The earth-boring tool of claim 3, wherein the cutting face of the at least one gouging cutting element is substantially frustoconically shaped.

6. The earth-boring tool of any of claims 1 through 3, wherein the earth-boring tool comprises a fixed-cutter earth-boring rotary drill bit, and wherein each of the at least one shearing cutting element and the at least one gouging cutting element is located in a shoulder region, a nose region, or a cone region of the fixed-cutter earth-boring rotary drill bit.

7. The earth-boring tool of any of claims 1 through 3, wherein the at least one gouging cutting element is positioned to follow a path of the at least one shearing cutting element when the earth-boring tool is rotated under applied force.

8. The earth-boring tool of any of claims 1 through 3, wherein the at least one blade comprises a plurality of blades, each blade of the plurality of blades projecting outwardly from the body and carrying a row of cutting elements, each row of cutting elements comprising shearing cutting elements, each of the shearing cutting elements comprising a polycrystalline diamond material having an at least substantially planar cutting face positioned and oriented for shearing a subterranean formation when the earth-boring tool is rotated under applied force, and wherein each of at least two blades of the plurality of blades comprises at least two gouging cutting elements comprising a polycrystalline diamond material having a cutting face positioned and oriented for at least one of crushing and gouging a subterranean formation when the earth-boring tool is rotated under applied force.

9. The earth-boring tool of any of claims 1 through 3, wherein a shortest distance between a longitudinal axis of the earth-boring tool and a cutting surface of the at least one gouging cutting element is substantially equal to a shortest distance between the longitudinal axis of the earth-boring tool and a cutting surface of the at least one shearing cutting element.

10. The earth-boring tool of claim 9, wherein the at least one gouging cutting element exhibits an exposure greater than or equal to an exposure of the at least one shearing cutting element.

11. The earth-boring tool of claim 9, wherein the exposure of the at least one gouging cutting element is less than 2.54 mm greater than an exposure of the at least one shearing cutting element.

12. The earth-boring tool of any of claims 1 through 3, wherein a ratio of a shoulder height of the body to a diameter of the body is 0.10 or less.

13. The earth-boring tool of any of claims 1 through 3, wherein the at least one blade comprises at least one primary blade, and wherein the at least one gouging cutting element is disposed on the at least one primary blade.

14. A method of forming an earth-boring tool, comprising:

mounting a shearing cutting element comprising an at least substantially planar cutting face to a body of an earth-boring tool;

locating and orienting the shearing cutting element on the body of the earth-boring tool for shearing a subterranean formation when the earth-boring tool is used to form or enlarge a wellbore;

mounting a backup gouging cutting element comprising a non-planar cutting face to the body of the earth-boring tool;

locating and orienting the backup gouging cutting element on the body of the earth-boring tool for at least one of crushing and gouging a subterranean formation when the earth-boring tool is used to form or enlarge a wellbore; and

positioning the backup gouging cutting element on the body of the earth-boring tool to have a forward rake angle, such that the backup gouging cutting element will gouge formation material within a kerf cut in the formation material by the shearing cutting element.

15. The method of claim 14, wherein positioning the backup gouging cutting element on the body of the earth-boring tool comprises positioning the backup gouging cutting element on the body of the earth-boring tool such that a shortest distance between a longitudinal axis of the earth-boring tool and the at least one backup gouging cutting element is substantially equal to a shortest distance between the longitudinal axis of the earth-boring tool and the at least one shearing cutting element.

16. The method of claim 14 or claim 15, further comprising:
selecting the body of the earth-boring tool to comprise a bit body of a fixed-cutter earth-boring rotary drill bit comprising a plurality of blades; and
mounting each of the shearing cutting element and the backup gouging cutting element on a blade of the plurality of blades.

17. The method of claim 14 or claim 15, further comprising selecting the shearing cutting element to comprise a polycrystalline diamond material having a surface comprising the at least substantially planar cutting face.

18. The method of claim 17, further comprising selecting the backup gouging cutting element to comprise a polycrystalline diamond material having a surface comprising the non-planar cutting face.

19. The method of claim 14 or claim 15, further comprising mounting the backup gouging cutting element on the body of the earth-boring tool to have an exposure greater than an exposure of the shearing cutting element.

20. The method of claim 14 or claim 15, further comprising mounting the backup gouging cutting element on the body of the earth-boring tool to have an exposure less than an exposure of the shearing cutting element.

21. The earth-boring tool of any of claims 1 through 3, wherein the at least one gouging cutting element has a forward rake angle greater than approximately 15°.

22. The earth-boring tool of any of claims 1 through 3, wherein the at least one gouging cutting element is positioned to follow a path offset from a path of the at least one shearing cutting element when the earth-boring tool is rotated under applied force.

5

STATEMENT UNDER ARTICLE 19(1) (RULE 46.4)

Applicant has amended claims 1 and 14, and added new claims 21 and 22. The amendments have no impact on the description and the drawings. The amendments to claim 1 recite that the at least one gouging cutting element has a forward rake angle. The amendments to claim 14 recite positioning the backup gouging cutting element to have a forward rake angle. New claim 21 recites that the at least one gouging cutting element has a forward rake angle greater than approximately 15°. New claim 22 recites that the at least one gouging cutting element is positioned to follow a path offset from a path of the at least one shearing cutting element.