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(54) **ROTARY DRAG BIT**

DREHWIDERSTANDSBIT

OUTIL BILAME ROTATIF

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Description

PRIORITY CLAIM

[0001] This application claims priority to and the benefit of U.S. Provisional Patent Application No. 60/889,403, which was filed on February 12, 2007, incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates in general to rotary drag bits and, in particular, to an improved system, method, and apparatus for a rotary drag bit having gauge cutting elements configured at large back rake angles.

BACKGROUND

[0003] Earth-boring bits of the fixed cutter variety, commonly referred to as drag bits, have no moving parts and employ an array of hard inserts to scrape and shear formation material as the bit is rotated in the borehole. Inserts on prior art fixed cutter bits are typically aligned such that the inserts scrape the material from the borehole bottom. For scraping to take place, the longitudinal axis of the insert is typically at a small acute angle (e.g., 0° to 30°) relative to the bit face. Such an alignment places the cutting face of a cylindrically-shaped insert nearly perpendicular to the borehole bottom. The contact area between the cutting element and the formation starts out very small but increases rapidly as penetration or depth of cut becomes deeper.

[0004] High impact side-loading of drill bits during operation results in non-compressive loading of the interface between the diamond and tungsten carbide components on PDC cutters. This leads to broken and/or chipped cutters in the upper shoulder and gauge areas of the bit profile. High residual stresses are inherent in this interface area as a result of varying planar and non-planar geometries and the cutter manufacturing process. An improved solution that overcomes these problems would be desirable.

[0005] EP 1 134 355 A2 is considered the closest prior art document and discloses a fixed cutter rotary drill bit having a bit body with a bit axis and a cutting profile defined about the bit axis, the cutting profile including a cone extending from the bit axis, a nose adjacent the cone, a shoulder adjacent the nose, and a gauge adjacent the shoulder, the gauge being on an outermost portion of the bit body relative to the bit axis and being adapted to engage a side wall of a bore hole during drilling operations, a plurality of cutting elements extending from the cone, nose, shoulder and gauge of the cutting profile. The cutting elements extending from the gauge have a back rake angle of 20°.

[0006] EP 1 091 083 A1 discloses a bi-center bit comprising a bit body defining a pilot bit and an intermediate reamer section. The reamer section defines leading and trailing upsets such that cutting elements positioned about said leading and trailing upsets and extending to the pass-through gauge define an effective back-rake angle of between 45° to 85°.

[0007] WO 03/031763 discloses a drill bit used for percussion drilling and having a bit body provided with a plurality of cutters mutually spaced along the bottom face of the drill bit. The cutters are fixed to the bit body at a back-rake angle of about 70°. However, no cutters are fixed at the gauge region of the drill bit.

[0008] The object of the invention is to provide a fixed cutter rotary drill bit which helps to ensure cutter loading in the gauge region when side impact forces are higher.

[0009] This object is achieved by a fixed cutter rotary drill bit comprising the features of claim 1. Preferred embodiments of the fixed cutter rotary drill bit of the present invention are claimed in claims 2 to 9.

[0010] Embodiments of a system, method, and apparatus for a fixed cutter rotary drill bit having gauge cutting elements at large back rake angles are disclosed. The gauge is located at the outer diameter side wall portion of the bit that extends from the cutting end. The gauge and its cutting components contact the side wall of the bore hole during drilling operations.

[0011] In accordance with the invention, the gauge cutting elements may be configured at a back rake angle in a range of about 40° to 70°. For applications where cutter damage is a concern and side-cutting aggressiveness is a low priority, a very high back rake angle helps ensure compressive cutter loading when side impact forces are higher.

[0012] The foregoing and other objects and advantages of the present invention will be apparent to those skilled in the art, in view of the following detailed description of the present invention, taken in conjunction with the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] So that the manner in which the features and advantages of the present invention are attained and can be understood in more detail, a more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof that are illustrated in the appended drawings. However, the drawings illustrate only some embodiments of the invention and therefore are not to be considered limiting of its scope as the invention may admit to other equally effective embodiments.

FIG. 1 is an isometric view of one embodiment of drill bit constructed in accordance with the present invention;

FIG. 2 is a schematic representation of half of a cutting profile of the drill bit of FIG. 1 and is constructed in accordance with the present invention;

FIG. 3 is an illustration of cutter element manipulation;

FIG. 4 is a side view of a cutting element showing a conventional back rake angle;

FIG. 5 is a side view of one embodiment of a cutting element showing a back rake angle constructed in accordance with the present invention; and

FIG. 6 is a side view of another embodiment of a cutting element showing a back rake angle constructed in accordance with the present invention.

MODE(S) FOR CARRYING OUT THE INVENTION

[0014] Referring to FIG. 1, one embodiment of a fixed cutter rotary drill bit 11 is shown. Bit 11 has a bit axis 12 and a threaded end 13 for connection into a drill string.

[0015] A cutting end 15 at a generally opposite end of the bit 11 is provided with a plurality of hard cutting elements 17 (e.g., polycrystalline diamond cutters, etc.) arranged about cutting end 15 to effect efficient disintegration of formation material as bit 11 is rotated in a bore hole.

[0016] As shown in the embodiment of FIG. 5, each cutting element 17 has a cylindrical base 19 with an axis 20, and is secured in a preformed pocket 21 provided on cutting end 15 and a cutting face 23 that engages the formation material. As illustrated, cutting element 17 may comprise a frustoconical cutting end that forms a beveled edge adjacent the face 23. Cutting element 17 acts somewhat like a plow that generally directs a high percentage of the material of the formation up its flat face.

[0017] Referring now to FIGS. 1 and 2, the arrangement of cutting elements 17 on bit 11 is configured in an overall cutting profile 25 (approximately half of which is shown in FIG. 2) about bit axis 12. Starting at axis 12 at the inner diameter of bit 11 and moving toward the outer diameter of bit 11 (right to left in FIG. 2), profile 25 comprises various areas, including a cone 27, a nose 29, a shoulder 31, and a gauge or gauge pad or surface 33. The gauge 33 is on a radially outermost portion of the bit body relative to the bit axis 12.

[0018] The gauge 33 essentially defines the flat, outer diameter side wall portion of bit 11 that extends from cutting end 15 (FIG. 1). The gauge 33 and its cutting components are proximal to and contact the side wall 34 (see FIG. 3) of the bore hole during drilling operations with bit 11. As shown in FIG. 1, a plurality of channels or grooves 35 (e.g., junk slots) extend from cutting end 15 through gauge 33 to provide a clearance area for the removal of cuttings and chips formed by cutting elements 17.

[0019] As shown in FIG. 1, a plurality of cutting elements 17 are provided on gauge 33 of bit 11. Active, gauge cutting elements 17 on gauge 33 provide the ability to actively cut formation material at the side wall 34 (FIG. 3) of the bore hole to provide dynamic stability and improved gauge-holding ability in earth-boring bits of the fixed cutter variety. As FIG. 1 illustrates, at least some of the gauge cutting elements 17 on gauge 33 may be ground flat at the outer diameter of bit 11 for some types of applications. Bit 11 is illustrated as a polycrystalline diamond cutter (PDC) bit, but cutting elements 17 are equally useful in other fixed cutter or drag bits that include a gauge or gauge surface for engagement with the side wall of the bore hole. Examples include impregnated and natural diamond bit cutting elements.

[0020] Referring now to FIG. 4, one type of prior art cutting element 117 for cutting formation is shown. Cutting element 117 is a conventional PDC cutting element and is cylindrical in shape. Cutting element 117 has an axis 120 and a diamond table on its face 123 with an essentially circular cross-section. Cutting element 117 has a cutter back rake angle 140 of 20°. However, conventional cutter back rake angles of 5° to 30° also are known.

[0021] As shown in FIG. 3, the circle 23 represents the face of cutting element 17 on the gauge 33. A back rake axis 42 is shown as vertical in the drawing, and parallel to the gauge 33, bit axis 12, and the bore side wall 34. A side rake axis 44 is perpendicular to axis 42, gauge 33, the bit axis 12, and the bore side wall 34.

[0022] In a "nominal" position on the gauge 33, both the back rake angle and the side rake angle of element 17 are zero. Thus, in one embodiment of the nominal position, face 23 extends in the plane defined by axes 42, 44, such that it is perpendicular to the gauge 33 and bore sidewall, and face 23 is parallel to axes 12, 42 and 44. Rotating the face 23 about axis 42 results in a modification to the back rake angle. In the gauge area 33, a positive back rake angle inclines the cutting face 23 away from the bit axis 12 and toward the borehole 34. Rotating the face 23 about axis 44 results in a modification to the side rake angle. A positive side rake angle includes the cutting face 23 away from the drill string and toward the bottom of the bore hole.

[0023] Referring again to FIG. 5, one embodiment of cutting element 17 in accordance with the invention is shown with a relatively large positive back rake angle 42 of 40°, and a 0° side rake angle. In FIG. 6, another embodiment of cutting element 17 is shown at a 65° back rake angle 42, and a 0° side rake angle. The invention may comprise back rake angles of approximately 40° to 70°.

[0024] For applications where cutter damage is a concern and side-cutting (e.g., cutting with the gauge 33 of the cutting profile 25) aggressiveness is a low priority, a very high back rake angle help ensures compressive cutter loading when side impact forces are higher. This is accomplished by lowering the y-component force (see, e.g., FIGS. 5 and 6) that results from side loads.

[0025] For example, comparing FIGS. 4 and 5, lower back rake angles result in higher loading in the y-direction, as depicted by the vectors F_y. This is detrimental to cutter integrity with respect to the diamond/tungsten carbide interface where residual stresses are high. Although the direction of overall force, F_f (which is normal to the bore side wall 34), will vary slightly with dynamic events, the invention enhances the cutter integrity and dynamic stability of fixed cutter drill bits.

[0026] While the invention has been shown or described in only some of its forms, it should be apparent to those skilled in the art that it is not so limited, but is susceptible to various changes without departing from the scope of the invention.

Claims

1. A fixed cutter rotary drill bit (11) having a bit body with a bit axis (12) and a cutting profile (25) defined about the bit axis (12), the cutting profile (25) including a cone (27) extending from the bit axis (12), a nose (29) adjacent the cone (27), a shoulder (31) adjacent the nose (29), and a gauge (33) adjacent the shoulder (31), the gauge (33) being on an outermost portion of the bit body relative to the bit axis (12) and being adapted to engage a side wall (34) of a bore hole during drilling operations, a plurality of cutting elements (17) extending from the cone (27), nose (29), shoulder (31) and gauge (33) of the cutting profile (25), **characterized in that** at least one of the cutting elements (17) extending from the gauge (33) has a back rake angle (42) in a range of 40° to 70°.

2. The fixed cutter rotary drill bit (11) of Claim 1, wherein the cutting elements (17) are selected from the group consisting of polycrystalline diamond cutters (PDC), and impregnated and natural diamond bit cutting elements.

3. The fixed cutter rotary drill bit (11) of Claim 1, wherein at least some of the cutting elements (17) extending from the gauge (33) are ground flat at an outer diameter of the bit body.

4. The fixed cutter rotary drill bit (11) of Claim 1, wherein each cutting element (17) has a cylindrical base (19) that is secured in a pocket (21) in the bit body, a cutting element axis (20), and a cutting face (23) with a beveled edge.

5. The fixed cutter rotary drill bit (11) of Claim 4, wherein the cutting face (23) extends in a plane defining a back rake axis (42) and a side rake axis (44) that is perpendicular to the back rake axis, with both the back rake and side rake axes extending through the cutting element axis (20), and the back rake axis being parallel to a surface of the gauge (33) and the bit axis (12), such that a positive back rake angle at the gauge inclines the cutting face away from the bit axis.

6. The fixed cutter rotary drill bit (11) of Claim 5, wherein the back rake angle (42) is 40°.

7. The fixed cutter rotary drill bit (11) of Claim 5, wherein the back rake angle (42) is 65°.

8. The fixed cutter rotary drill bit (11) of Claim 1, further comprising a threaded end (13) for connection into a drill string, and
wherein the cutting elements (17) extend from a cutting end (15) in the cone (27), nose (29), shoulder (31), and gauge (33) of the cutting profile (25), the cutting end opposite the threaded end, and the gauge on a radially outermost portion of the bit body relative to the bit axis (12).

9. The fixed cutter rotary drill bit (11) of Claim 8, wherein the plurality of cutting elements (17) extend from the cutting end (15) in the cone (27), nose (29), shoulder (31), and gauge (33) of the cutting profile (25), each cutting element having a cylindrical base (19), a cutting element axis (20), and a cutting face (23), wherein the cutting face extends in a plane defining a back rake axis (42) and a side rake axis (44) that is perpendicular to the back rake axis, with both the back rake and side rake axes extending through the cutting element axis, and the back rake axis being parallel to a surface of the gauge and the bit axis, such that a positive back rake angle at the gauge inclines the cutting face away from the bit axis (12).

Patentansprüche

1. Drehbohrmeißel (11) mit feststehender Schneideinrichtung, der einen Meißelkörper mit einer Meißelachse (12) und ein um die Meißelachse (12) gebildetes Schneidprofil (25) aufweist, wobei das Schneidprofil (25) einen sich von der Meißelachse (12) erstreckenden Konus (27), eine an den Konus (27) angrenzende Nase (29), eine an die Nase (29) angrenzende Schulter (31) und ein an die Schulter (31) anschließendes Kaliber (33) einschließt, wobei das Kaliber (33) sich auf einem äußersten Abschnitt des Meißelkörpers relativ zur Meißelachse (12) befindet und für ein Angreifen an einer Seitenwand (34) eines Bohrlochs während Bohrvorgängen angepasst ist, wobei sich eine Vielzahl von Schneidelementen (17) von dem Konus (27), der Nase (29), der Schulter (31) und dem Kaliber (33) des Schneidprofils (25) erstreckt,
dadurch gekennzeichnet, dass wenigstens eines der sich von dem Kaliber (33) erstreckenden Schneidelemente (17) einen Rückspanwinkel (42) in einem Bereich von 40° bis 70° aufweist.

2. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 1, wobei die Schneidelemente (17) aus der Gruppe ausgewählt sind, die aus Polykristallindiamant-Schneideinrichtungen (PDC) und Meißelschneidelementen aus imprägniertem und natürlichem Diamant besteht.

3. Drehbohrmeißel (11) mit feststehender Schneidein-

richtung nach Anspruch 1, wobei wenigstens einige der sich von dem Kaliber (33) erstreckenden Schneidelemente (17) an einem Außendurchmesser des Meißelkörpers flach geschliffen sind.

4. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 1, wobei jedes Schneidelement (17) eine in einer Tasche (21) in dem Meißelkörper befestigte zylindrische Basis (19), eine Schneidelementachse (20) und eine Schneidfläche (23) mit einer abgeschrägten Kante aufweist.

5. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 4, wobei sich die Schneidfläche (23) in einer Ebene erstreckt, die eine Rückspanachse (42) und eine zu der Rückspanachse senkrecht verlaufende Seitenspanachse (44) definiert, wobei sich sowohl die Rückspan- als auch die Seitenspanachse durch die Schneidelementachse (20) erstreckt und die Rückspanachse parallel zu einer Oberfläche des Kalibers (33) und der Meißelachse (12) ist, so dass ein positiver Rückspanwinkel an dem Kaliber die Schneidfläche weg von der Meißelachse neigt.

6. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 5, wobei der Rückspanwinkel (42) 40° beträgt.

7. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 5, wobei der Rückspanwinkel (42) 65° beträgt.

8. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 1, der weiterhin ein mit einem Gewinde versehenes Ende (13) zur Verbindung in einen Bohrstrang umfasst und

- wobei die Schneidelemente (17) sich von einem Schneidende (15) in dem Konus (27), der Nase (29), der Schulter (31) und dem Kaliber (33) des Schneidprofils (25) erstrecken, das Schneidende gegenüber dem mit einem Gewinde versehenen Ende angeordnet ist und das Kaliber sich auf einem radial äußersten Abschnitt des Meißelkörpers relativ zur Meißelachse (12) befindet.

9. Drehbohrmeißel (11) mit feststehender Schneideinrichtung nach Anspruch 8, wobei die Vielzahl der Schneidelemente (17) sich von dem Schneidende (15) in dem Konus (27), der Nase (29), der Schulter (31) und dem Kaliber (33) des Schneidprofils (25) erstreckt, wobei jedes Schneidelemente eine zylindrische Basis (19), eine Schneidelementachse (20) und eine Schneidfläche (23) aufweist, wobei sich die Schneidfläche in einer Ebene erstreckt, die eine Rückspanachse (42) und eine zu der Rückspanachse senkrecht verlaufende Seitenspanachse (44) definiert, wobei sich sowohl die Rückspan- als auch die Seitenspanachse durch die Schneidelementachse (20) erstreckt und die Rückspanachse parallel zu einer Oberfläche des Kalibers (33) und der Meißelachse (12) ist, so dass ein positiver Rückspanwinkel an dem Kaliber die Schneidfläche weg von der Meißelachse (12) neigt.

Revendications

1. Trépan rotatif à outil de coupe fixe (11) ayant un corps de trépan avec un axe de trépan (12) et un profil de coupe (25) défini autour de l'axe de trépan (12), le profil de coupe (25) incluant un cône (27) s'étendant à partir de l'axe de trépan (12), un nez (29) adjacent au cône (27), un talon (31) adjacent au nez (29), et un calibre (33) adjacent au talon (31), le calibre (33) étant sur une partie la plus extérieure du corps de trépan par rapport à l'axe de trépan (12) et étant adapté à engager une paroi latérale (34) d'un puits de forage lors d'opérations de forage, une pluralité d'éléments de coupe (17) s'étendant à partir du cône (27), du nez (29), du talon (31) et du calibre (33) du profil de coupe (25), **caractérisé en ce qu'**au moins un des éléments de coupe (17) s'étendant à partir du calibre (33) a un angle de coupe vers l'arrière dans une plage de 40° à 70°.

2. Trépan rotatif à outil de coupe fixe (11) selon la revendication 1, dans lequel les éléments de coupe (17) sont choisis parmi le groupe consistant en des outils de coupe au diamant polycristallin (PDC), et des éléments de coupe de trépan au diamant imprégné et naturel.

3. Trépan rotatif à outil de coupe fixe (11) selon la revendication 1, dans lequel au moins certains des éléments de coupe (17) s'étendant à partir du calibre (33) sont aplatis par rectification à un diamètre extérieur du corps de trépan.

4. Trépan rotatif à outil de coupe fixe (11) selon la revendication 1, dans lequel chaque élément de coupe (17) a une base cylindrique (19) qui est fixée dans une poche (21) dans le corps de trépan, un axe d'élément de coupe (20), et une face de coupe (23) avec un bord biseauté.

5. Trépan rotatif à outil de coupe fixe (11) selon la revendication 4, dans lequel la face de coupe (23) s'étend dans un plan définissant un axe de coupe vers l'arrière (42) et un axe de coupe latérale (44) qui est perpendiculaire à l'axe de coupe vers l'arrière, les deux axes de coupe vers l'arrière et de coupe latérale s'étendant à travers l'axe d'élément de coupe (20), et l'axe de coupe vers l'arrière étant parallèle à une surface du calibre (33) et à l'axe de trépan (12), de telle manière qu'un angle de coupe vers l'arrière positif au niveau du calibre incline la face de coupe à l'opposé de l'axe de trépan.

6. Trépan rotatif à outil de coupe fixe (11) selon la revendication 5, dans lequel l'angle de coupe vers l'arrière (42) est 40°.

7. Trépan rotatif à outil de coupe fixe (11) selon la revendication 5, dans lequel l'angle de coupe vers l'arrière (42) est 65°.

8. Trépan rotatif à outil de coupe fixe (11) selon la revendication 1, comprenant en outre une extrémité filetée (13) pour un raccordement dans un train de tiges, et
dans lequel les éléments de coupe (17) s'étendent à partir d'une extrémité de coupe (15) dans le cône (27), le nez (29), le talon (31), et le calibre (33) du profil de coupe (25), l'extrémité de coupe opposée à l'extrémité filetée, et le calibre sur une partie radialement la plus extérieure du corps de trépan par rapport à l'axe de trépan (12).

9. Trépan rotatif à outil de coupe fixe (11) selon la revendication 8, dans lequel la pluralité d'éléments de coupe (17) s'étendent à partir de l'extrémité de coupe (15) dans le cône (27), le nez (29), le talon (31), et le calibre (33) du profil de coupe (25), chaque élément de coupe ayant une base cylindrique (19), un axe d'élément de coupe (20), et une face de coupe (23), dans lequel la face de coupe s'étend dans un plan définissant un axe de coupe vers l'arrière (42) et un axe de coupe latérale (44) qui est perpendiculaire à l'axe de coupe vers l'arrière, les deux axes de coupe vers l'arrière et de coupe latérale s'étendant à travers l'axe d'élément de coupe, et l'axe de coupe vers l'arrière étant parallèle à une surface du calibre et à l'axe de trépan, de telle manière qu'un angle de coupe vers l'arrière positif au niveau du calibre incline la face de coupe à l'opposé de l'axe de trépan (12).

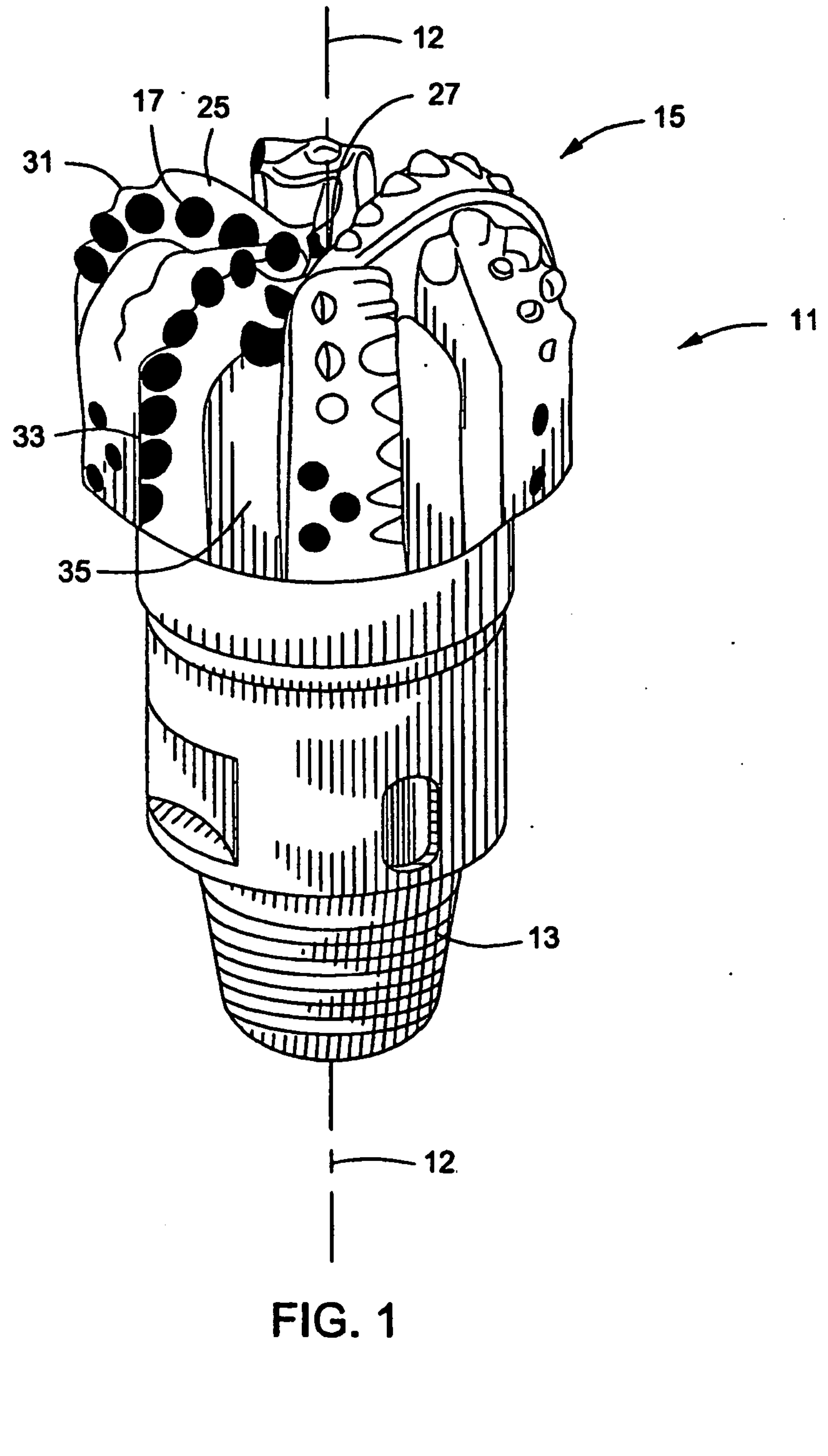

FIG. 1

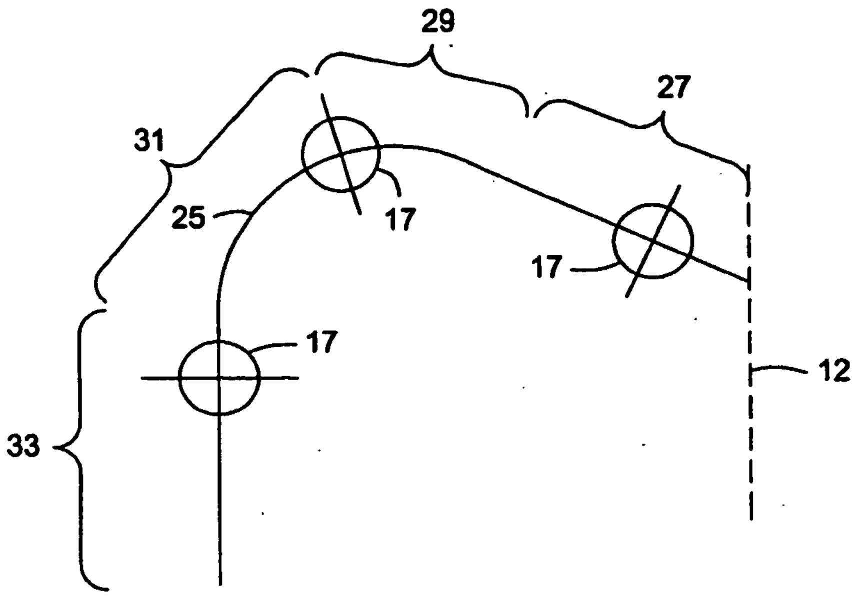

FIG. 2

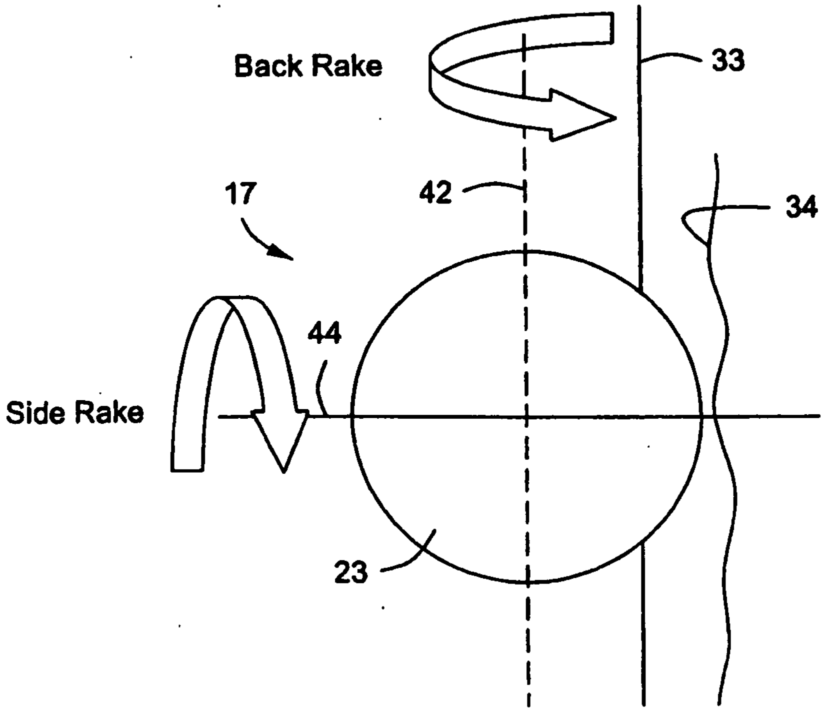

FIG. 3

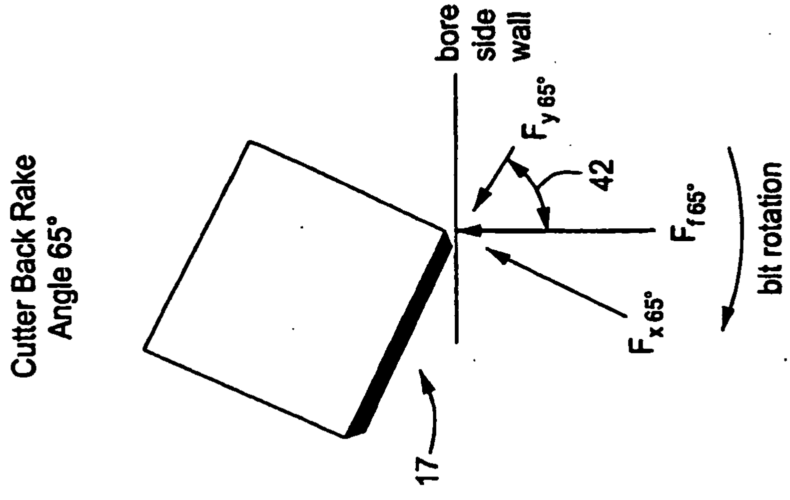

FIG. 6

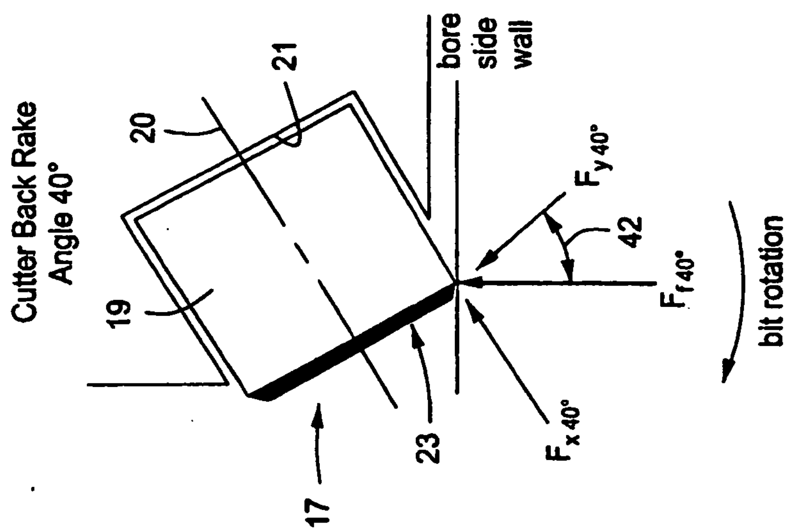

FIG. 5

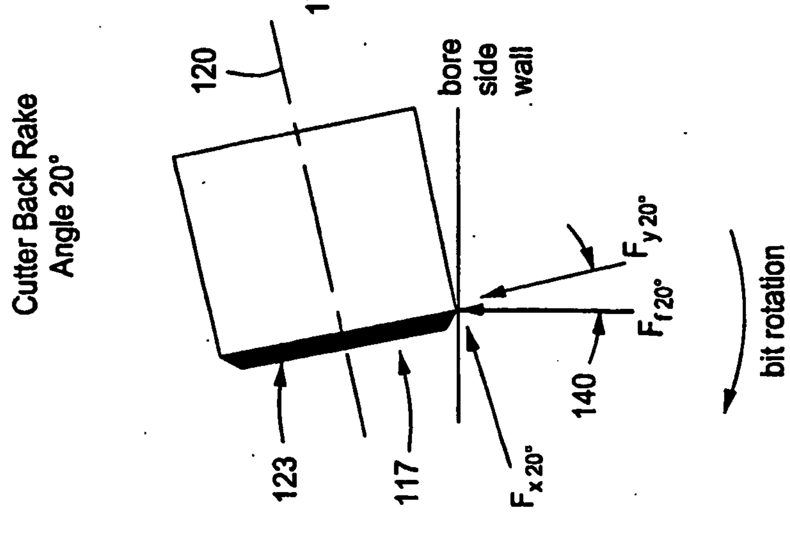

FIG. 4
(PRIOR ART)

REFERENCES CITED IN THE DESCRIPTION

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