

Please type a plus sign (+) inside this box → ☐

PTO/SB/05 (03-01)

Approved for use through 10/31/2002. OMB 0651-0032  
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. 1.53(b))

Attorney Docket No. 1684-4578.2US (484-09454-US-C2)

First Inventor Dykstra et al.

Title DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Express Mail Label No. EV325774472US

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

## ADDRESS TO:

Mail Stop Patent Application  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

1. ☒ Fee Transmittal Form (e.g., PTO/SB/17)  
(Submit an original and a duplicate for fee processing)
2. ☐ Applicant claims small entity status.  
See 37 CFR 1.27.
3. ☒ Specification [Total Pages 51]  
(preferred arrangement set forth below)
  - Descriptive title of the invention
  - Cross Reference to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to sequence listing, a table, or a computer program listing appendix
  - Background of the invention
  - Brief Summary of the invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
4. ☒ Drawing(s) (35 U.S.C. 113) [Total Sheets 22]
5. ☐ Oath or Declaration [Total Pages 4]
  - a. ☐ Newly executed (original or copy)
  - b. ☒ Copy from a prior application (37 CFR 1.63 (d))  
(for a continuation/divisional with Box 18 completed)
  - i. ☐ **DELETION OF INVENTOR(S)**  
Signed statement attached deleting inventor(s)  
named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. ☐ Application Data Sheet. See 37 CFR 1.76

7. ☐ CD-ROM or CD-R in duplicate, large table or Computer Program (Appendix)
8. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
  - a. ☐ Computer Readable Form (CRF)
  - b. Specification Sequence Listing on:
    - i. ☐ CD-ROM or CD-R (2 copies); or
    - ii. ☐ paper
  - c. ☐ Statements verifying identity of above copies

## ACCOMPANYING APPLICATIONS PARTS

9. ☐ Assignment Papers (cover sheet & document(s))
10. ☐ 37 C.F.R. §3.73(b) Statement ☐ Power of Attorney  
(when there is an assignee)
11. ☐ English Translation Document (if applicable)
12. ☒ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
13. ☐ Preliminary Amendment
14. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
15. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
16. ☐ Nonpublication Request under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. ☒ Other: Associate Power of Attorney

18. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP)

of prior application No: 10 / 266,534  
Group / Art Unit: 3672

Prior application information: Examiner Frank Tsay  
For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

## 19. CORRESPONDENCE ADDRESS

☒ Customer Number

24247

or ☐ Correspondence address below

Name

Address

City

State

Zip Code

Country

Telephone

Fax

Name (Print/Type)

Trent N. Butcher, P.E.

Registration No. (Attorney/Agent)

51,518

Signature

*Trent N. Butcher*

Date

June 4, 2004

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop Patent Application, Commissioner of Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

*Effective 10/01/2003. Patent fees are subject to annual revision.*

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT	(\$)	842
-------------------------	------	-----

**Complete if Known**

Application Number	To be assigned
Filing Date	June 4, 2004
First Named Inventor	Dykstra et al.
Examiner Name	To be assigned
Art Unit	To be assigned
Attorney Docket No.	1684-4578.2US (484-09454-US-C2)

**METHOD OF PAYMENT** (check all that apply)

☐ Check    ☐ Credit card    ☐ Money Order    ☐ Other    ☐ None☒ Deposit Account:

Deposit Account Number	02-0429
------------------------------	---------

Deposit Account Name	Baker Hughes Incorporated
----------------------------	---------------------------

**The Director is authorized to: (check all that apply)**

☒ Charge fee(s) indicated below    ☐ Credit any overpayments  
☒ Charge any additional fee(s) during the pendency of this application  
☐ Charge fee(s) indicated below, **except for the filing fee**  
 to the above-identified deposit account.

### FEE CALCULATION

**1. BASIC FILING FEE**

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
1001	770	2001	385	Utility filing fee	770
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

<b>SUBTOTAL (1)</b>	<b>(\$)</b> 770
---------------------	-----------------

## 2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims	24	-20 **	= 4	X	18	=	72
Independent Claims	3	-3 **	= 0	X	86	=	0
Multiple Dependent	0			X		=	0

Large Entity		Small Entity		Fee Description
Fee Code	Fee (\$)	Fee Code	Fee (\$)	
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

<b>SUBTOTAL (2)</b>	<b>(\$)</b> 72
---------------------	----------------

**\*\*or number previously paid, if greater; For Reissues, see above**

**FEE CALCULATION (continued)**


### 3. ADDITIONAL FEES

Large Entity		Small Entity		Fee Description	Fee Paid
Fee Code	Fee (\$)	Fee Code	Fee (\$)		
1051	130	2051	65	Surcharge - late filing fee or oath	
1052	50	2052	25	Surcharge - late provisional filing fee or cover sheet.	
1053	130	2053	130	Non-English specification	
1812	2,520	2012	2,520	For filing a request for reexamination	
1804	920*	2004	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	2005	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	2451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,330	2453	665	Petition to revive – unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	2460	130	Petitions to the Commissioner	
1807	50	2807	50	Processing fee under 37 CFR 1.17 (q)	
1806	180	2806	180	Submission of Information Disclosure Stmt	
8021	40	2021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR § 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37 CFR § 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	2802	900	Request for expedited examination of a design application	

Other fee (specify) \_\_\_\_\_

*Reduced by Basic Filing Fee Paid	<b>SUBTOTAL (3)</b>	<b>(\$)</b> 0
-----------------------------------	---------------------	---------------

## SUBMITTED BY

Name (Print/Type)	Trent N. Butcher, P.E.	Registration No. (Attorney/Agent)	51,518	Telephone	801-531-1922
Signature				Date	June 4, 2004

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

This collection of information is required by 37 CFR 1.17 and 1.27. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. **DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing this form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.

PATENT  
Attorney Docket 4578.2US (484-09454-US-C2)

NOTICE OF EXPRESS MAILING

Express Mail Mailing Label Number: EV 325774472 US  
Date of Deposit with USPS: June 4, 2004  
Person mailing Deposit: Christopher Haughton

APPLICATION FOR LETTERS PATENT

for

**DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS**

Inventors:

Mark W. Dykstra  
William Heuser  
Michael L. Doster  
Theodore E. Zaleski, Jr.  
Jack T. Oldham  
Terry D. Watts  
Daniel E. Ruff  
Rodney B. Walzel  
Christopher C. Beuershausen

Attorneys:

Joseph A. Walkowski  
Registration No. 28,765  
Trent N. Butcher  
Registration No. 51,518  
TRASKBRITT, PC  
P.O. Box 2550  
Salt Lake City, Utah 84110  
(801) 532-1922

## TITLE OF THE INVENTION

### DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a continuation of application Serial No.10/266,534, filed October 7, 2002, pending, which is a continuation of application Serial No. 09/738,687, filed December 15, 2000, now U.S. Patent 6,460,631, issued October 8, 2002, which is a continuation-in-part of application Serial No. 09/383,228, filed August 26, 1999, now U.S. Patent No. 6,298,930, issued October 9, 2001, entitled Drill Bits with Controlled Cutter Loading and Depth of Cut.

## BACKGROUND OF THE INVENTION

**[0002]** Field of the Invention: The present invention relates to rotary drag bits for drilling subterranean formations and their operation. More specifically, the present invention relates to the design of such bits for optimum performance in the context of controlling cutter loading and depth-of-cut without generating an excessive amount of torque-on-bit should the weight-on-bit be increased to a level which exceeds the optimal weight-on-bit for the current rate-of-penetration of the bit.

**[0003]** State of the Art: Rotary drag bits employing polycrystalline diamond compact (PDC) cutters have been employed for several decades. PDC cutters are typically comprised of a disc-shaped diamond "table" formed on and bonded under high-pressure and high-temperature conditions to a supporting substrate such as cemented tungsten carbide (WC), although other configurations are known. Bits carrying PDC cutters, which for example, may be brazed into pockets in the bit face, pockets in blades extending from the face, or mounted to studs inserted into the bit body, have proven very effective in achieving high rates of penetration (ROP) in drilling subterranean formations exhibiting low to medium compressive strengths. Recent improvements in the design of hydraulic flow regimes about the face of bits, cutter design, and drilling fluid formulation have reduced prior, notable tendencies of such bits to "ball" by



increasing the volume of formation material which may be cut before exceeding the ability of the bit and its associated drilling fluid flow to clear the formation cuttings from the bit face.

**[0004]** Even in view of such improvements, however, PDC cutters still suffer from what might simply be termed “overloading” even at low weight-on-bit (WOB) applied to the drill string to which the bit carrying such cutters is mounted, especially if aggressive cutting structures are employed. The relationship of torque to WOB may be employed as an indicator of aggressivity for cutters, so the higher the torque to WOB ratio, the more aggressive the cutter. This problem is particularly significant in low compressive strength formations where an unduly great depth of cut (DOC) may be achieved at extremely low WOB. The problem may also be aggravated by drill string bounce, wherein the elasticity of the drill string may cause erratic application of WOB to the drill bit, with consequent overloading. Moreover, operating PDC cutters at an excessively high DOC may generate more formation cuttings than can be consistently cleared from the bit face and back up the bore hole via the junk slots on the face of the bit by even the aforementioned improved, state-of-the-art bit hydraulics, leading to the aforementioned bit balling phenomenon.

**[0005]** Another, separate problem involves drilling from a zone or stratum of higher formation compressive strength to a “softer” zone of lower strength. As the bit drills into the softer formation without changing the applied WOB (or before the WOB can be changed by the directional driller), the penetration of the PDC cutters, and thus the resulting torque on the bit (TOB), increase almost instantaneously and by a substantial magnitude. The abruptly higher torque, in turn, may cause damage to the cutters and/or the bit body itself. In directional drilling, such a change causes the tool face orientation of the directional (measuring-while-drilling, or MWD, or a steering tool) assembly to fluctuate, making it more difficult for the directional driller to follow the planned directional path for the bit. Thus, it may be necessary for the directional driller to back off the bit from the bottom of the borehole to reset or reorient the tool face. In addition, a downhole motor, such as drilling fluid-driven Moineau-type motors commonly employed in directional drilling operations in combination with a steerable bottomhole assembly, may completely stall under a sudden torque increase. That is, the bit may stop rotating thereby stopping the drilling operation and again necessitating backing off the bit from the borehole

bottom to re-establish drilling fluid flow and motor output. Such interruptions in the drilling of a well can be time consuming and quite costly.

[0006] Numerous attempts using varying approaches have been made over the years to protect the integrity of diamond cutters and their mounting structures and to limit cutter penetration into a formation being drilled. For example, from a period even before the advent of commercial use of PDC cutters, U.S. Patent 3,709,308 discloses the use of trailing, round natural diamonds on the bit body to limit the penetration of cubic diamonds employed to cut a formation. U.S. Patent 4,351,401 discloses the use of surface set natural diamonds at or near the gage of the bit as penetration limiters to control the depth-of-cut of PDC cutters on the bit face. The following other patents disclose the use of a variety of structures immediately trailing PDC cutters (with respect to the intended direction of bit rotation) to protect the cutters or their mounting structures: U.S. Patents 4,889,017; 4,991,670; 5,244,039 and 5,303,785. U.S. Patent 5,314,033 discloses, *inter alia*, the use of cooperating positive and negative or neutral backrake cutters to limit penetration of the positive rake cutters into the formation. Another approach to limiting cutting element penetration is to employ structures or features on the bit body rotationally preceding (rather than trailing) PDC cutters, as disclosed in U.S. Patents 3,153,458; 4,554,986; 5,199,511 and 5,595,252.

[0007] In another context, that of so-called “anti-whirl” drilling structures, it has been asserted in U.S. Patent 5,402,856 to one of the inventors herein that a bearing surface aligned with a resultant radial force generated by an anti-whirl underreamer should be sized so that force per area applied to the borehole sidewall will not exceed the compressive strength of the formation being underreamed. See also U.S. Patents 4,982,802; 5,010,789; 5,042,596; 5,111,892 and 5,131,478.

[0008] While some of the foregoing patents recognize the desirability to limit cutter penetration, or DOC, or otherwise limit forces applied to a borehole surface, the disclosed approaches are somewhat generalized in nature and fail to accommodate or implement an engineered approach to achieving a target ROP in combination with more stable, predictable bit performance. Furthermore, the disclosed approaches do not provide a bit or method of drilling which is generally tolerant to being axially loaded with an amount of weight-on-bit over and in

excess what would be optimum for the current rate-of-penetration for the particular formation being drilled and which would not generate high amounts of potentially bit-stopping or bit-damaging torque-on-bit should the bit nonetheless be subjected to such excessive amounts of weight-on-bit.

#### BRIEF SUMMARY OF THE INVENTION

**[0009]** The present invention addresses the foregoing needs by providing a well-reasoned, easily implementable bit design particularly suitable for PDC cutter-bearing drag bits, which bit design may be tailored to specific formation compressive strengths or strength ranges to provide DOC control in terms of both maximum DOC and limitation of DOC variability. As a result, continuously achievable ROP may be optimized and torque controlled even under high WOB, while destructive loading of the PDC cutters is largely prevented.

**[0010]** The bit design of the present invention employs depth of cut control (DOCC) features which reduce, or limit, the extent in which PDC cutters, or other types of cutters or cutting elements, are exposed on the bit face, on bladed structures, or as otherwise positioned on the bit. The DOCC features of the present invention provide substantial area on which the bit may ride while the PDC cutters of the bit are engaged with the formation to their design DOC, which may be defined as the distance the PDC cutters are effectively exposed below the DOCC features. Stated another way, the cutter standoff is substantially controlled by the effective amount of exposure of the cutters above the surface, or surfaces, surrounding each cutter. Thus, by constructing the bit so as to limit the exposure of at least some of the cutters on the bit, such limited exposure of the cutters in combination with the bit providing ample surface area to serve as a "bearing surface" in which the bit rides as the cutters engage the formation at their respective design DOC enables a relatively greater DOC (and thus ROP for a given bit rotational speed) than with a conventional bit design without the adverse consequences usually attendant thereto. Therefore the DOCC features of the present invention preclude a greater DOC than that designed for by distributing the load attributable to WOB over a sufficient surface area on the bit face, blades or other bit body structure contacting the formation face at the borehole bottom so that the

compressive strength of the formation will not be exceeded by the DOCC features. As a result, the bit does not substantially indent, or fail, the formation rock.

[0011] Stated another way, the present invention limits the unit volume of formation material (rock) removed per bit rotation to prevent the bit from over-cutting the formation material and balling the bit or damaging the cutters. If the bit is employed in a directional drilling operation, tool face loss or motor stalling is also avoided.

[0012] In one embodiment, a rotary drag bit preferably includes a plurality of circumferentially spaced blade structures extending along the leading end or formation engaging portion of the bit generally from the cone region approximate the longitudinal axis, or centerline, of the bit, upwardly to the gage region, or maximum drill diameter of bit. The bit further includes a plurality of superabrasive cutting elements, or cutters such as PDC cutters, preferably disposed on radially outward facing surfaces of preferably each of the blade structures. In accordance with the DOCC aspect of the present invention, each cutter positioned in at least the cone region of the bit, e.g., those cutters which are most radially proximate the longitudinal centerline and thus are generally positioned radially inward of a shoulder portion of the bit, are disposed in their respective blade structures in such a manner that each of such cutters is exposed only to a limited extent above the radially outwardly facing surface of the blade structures in which the cutters are associatively disposed. That is, each of such cutters exhibit a limited amount of exposure generally perpendicular to the selected portion of the formation-facing surface in which the superabrasive cutter is secured to control the effective depth-of-cut of at least one superabrasive cutter into a formation when the bit is rotatably engaging a formation such as during drilling. By so limiting the amount of exposure of such cutters by, for example, the cutters being secured within and substantially encompassed by cutter-receiving pockets, or cavities, the DOC of such cutters into the formation is effectively and individually controlled. Thus, regardless of the amount of WOB placed, or applied, on the bit, even if the WOB exceeds what would be considered an optimum amount for the hardness of the formation being drilled and the ROP in which the drill bit is currently providing, the resulting torque, or TOB, will be controlled or modulated. Thus, because such cutters have a reduced amount of exposure above the respective formation-facing surface in which it is installed, especially as compared to prior art

cutter installation arrangements, the resultant TOB generated by the bit will be limited to a maximum, acceptable value. This beneficial result is attributable to the DOCC features, or characteristic, of the present invention effectively preventing at least a sufficient number of the total number of cutters from over-engaging the formation and potentially causing the rotation of the bit to slow or stall due to an unacceptably high amount of torque being generated.

Furthermore, the DOCC features of the present invention are essentially unaffected by excessive amounts of WOB, as there will preferably be a sufficient amount or size of bearing surface area devoid of cutters on at least the leading end of the bit in which the bit may “ride” upon the formation to inhibit or prevent a torque-induced bit stall from occurring.

[0013] Optionally, bits employing the DOCC aspects of the present invention may have reduced exposure cutters positioned radially more distant than those cutters proximate to the longitudinal centerline of the bit such as in the cone region. To elaborate, cutters having reduced exposure may be positioned in other regions of a drill bit embodying the DOCC aspects of the present invention. For example, reduced exposure cutters positioned on the comparatively more radially distant nose, shoulder, flank, and gage portions of a drill bit will exhibit a limited amount of cutter exposure generally perpendicular to the selected portion of the radially outwardly facing surface to which each of the reduced exposure cutters are respectively secured. Thus, the surfaces carrying and proximately surrounding each of the additional reduced exposure cutters will be available to contribute to the total combined bearing surface area on which the bit will be able to ride upon the formation as the respective maximum depth-of-cut for each additional reduced exposure cutter is achieved depending upon the instant WOB and the hardness of the formation being drilled.

[0014] By providing DOCC features having a cumulative surface area sufficient to support a given WOB on a given rock formation preferably without substantial indentation or failure of same, WOB may be dramatically increased, if desired, over that usable in drilling with conventional bits without the PDC cutters experiencing any additional effective WOB after the DOCC features are in full contact with the formation. Thus, the PDC cutters are protected from damage and, equally significant, the PDC cutters are prevented from engaging the formation to a

greater depth of cut and consequently generating excessive torque which might stall a motor or cause loss of tool face orientation.

[0015] The ability to dramatically increase WOB without adversely affecting the PDC cutters also permits the use of WOB substantially above and beyond the magnitude applicable without the adverse effects associated with conventional bits to maintain the bit in contact with the formation, reduce vibration and enhance the consistency and depth of cutter engagement with the formation. In addition, drill string vibration as well as dynamic axial effects, commonly termed “bounce,” of the drill string under applied torque and WOB may be damped so as to maintain the design DOC for the PDC cutters. Again, in the context of directional drilling, this capability ensures maintenance of tool face and stall-free operation of an associated downhole motor driving the bit.

[0016] It is specifically contemplated that the DOCC features according to the present invention may be applied to coring bits as well as full bore drill bits. As used herein, the term “bit” encompasses core bits and other special purpose bits. Such usage may be, by way of example only, particularly beneficial when coring from a floating drilling rig, or platform, where WOB is difficult to control because of surface water wave-action-induced rig heave. When using the present invention, a WOB in excess of that normally required for coring may be applied to the drill string to keep the core bit on bottom and maintain core integrity and orientation.

[0017] It is also specifically contemplated that the DOCC attributes of the present invention have particular utility in controlling, and specifically reducing, torque required to rotate rotary drag bits as WOB is increased. While relative torque may be reduced in comparison to that required by conventional bits for a given WOB by employing the DOCC features at any radius or radii range from the bit centerline, variation in placement of DOCC features with respect to the bit centerline may be a useful technique for further limiting torque since the axial loading on the bit from applied WOB is more heavily emphasized toward the centerline and the frictional component of the torque is related to such axial loading. Accordingly, the present invention optionally includes providing a bit in which the extent of exposure of the cutters vary with respect to the cutters respective positions on the face of the bit. As an example, one or more of the cutters positioned in the cone, or the region of the bit proximate the centerline of the bit,

are exposed to a first extent, or amount, to provide a first DOC and one or more cutters positioned in the more radially distant nose and shoulder regions of the bit are exposed at a second extent, or amount, to provide a second DOC. Thus, a specifically engineered DOC profile may be incorporated into the design of a bit embodying the present invention to customize, or tailor, the bit's operational characteristics in order to achieve a maximum ROP while minimizing and/or modulating the TOB at the current WOB, even if the WOB is higher than what would otherwise be desired for the ROP and the specific hardness of the formation then being drilled.

**[0018]** Furthermore, bits embodying the present invention may include blade structures in which the extent of exposure of each cutter positioned on each blade structure has a particular and optionally individually unique DOC, as well as individually selected and possibly unique effective backrake angles, thus resulting in each blade of the bit having a preselected DOC cross-sectional profile as taken longitudinally parallel to the centerline of the bit and taken radially to the outermost gage portion of each blade. Moreover, a bit incorporating the DOCC features of the present invention need not have cutters installed on, or carried by, blade structures, as cutters having a limited amount of exposure perpendicular to the exterior of the bit in which each cutter is disposed may be incorporated on regions of bits in which no blade structures are present. That is, bits incorporating the present invention may be completely devoid of blade structures entirely, such as, for example, a coring bit.

**[0019]** A method of constructing a drill bit in accordance with the present invention is additionally disclosed herein. The method includes providing at least a portion of the drill bit with at least one cutting element-accommodating pocket, or cavity, on a surface which will ultimately face and engage a formation upon the drill bit being placed in operation. The method of constructing a bit for drilling subterranean formations includes disposing within at least one cutter-receiving pocket a cutter exhibiting a limited amount of exposure perpendicular to the formation-facing surface proximate the cutter upon the cutter being secured therein. Optionally, the formation-facing surface may be built up by a hard facing, a weld, a weldment, or other material being disposed upon the surface surrounding the cutter so as to provide a bearing surface of a sufficient size while also limiting the amount of cutter exposure within a preselected range to

effectively control the depth of cut that the cutter may achieve upon a certain WOB being exceeded and/or upon a formation of a particular compressive strength being encountered.

[0020] A yet further option is to provide wear knots, or structures, formed of a suitable material which extend outwardly and generally perpendicularly from the face of the bit in general proximity of at least one or more of the reduced exposure cutters. Such wear knots may be positioned rotationally behind, or trailing, each provided reduced exposure cutter so as to augment the DOCC aspects provided by the bearing surface respectively carrying and proximately surrounding a significant portion of each reduced exposure cutter. Thus, the optional wear knots, or wear bosses, provide a bearing surface area in which the drill bit may ride on the formation upon the maximum DOC of that cutter being obtained for the present formation hardness and then current WOB. Such wear knots, or bosses, may comprise hard facing material, structure provided when casting or molding the bit body or, in the case of steel-bodied bits, may comprise weldments, structures secured to the bit body by methods known within the art of subterranean drill bit construction, or by surface welds in the shape of one or more weld-beads or other configurations or geometries.

[0021] A method of drilling a subterranean formation is further disclosed. The method for drilling includes engaging a formation with at least one cutter and preferably a plurality of cutters in which one or more of the cutters each exhibit a limited amount of exposure perpendicular to a surface in which each cutter is secured. In one embodiment, several of the plurality of limited exposure cutters are positioned on a formation-facing surface of at least one portion, or region, of at least one blade structure to render a cutter spacing and cutter exposure profile for that blade and preferably for a plurality of blades that will enable the bit to engage the formation within a wide range of WOB without generating an excessive amount of TOB, even at elevated WOBs, for the instant ROP in which the bit is providing. The method further includes an alternative embodiment in which the drilling is conducted with primarily only the reduced exposure cutters engaging a relatively hard formation within a selected range of WOB and upon a softer formation being encountered and/or an increased amount of WOB being applied, at least one bearing surface surrounding at least one reduced, or limited, exposure cutter, and preferably a plurality of sufficiently sized bearing surfaces respectively surrounding a plurality of reduced



exposure cutters, contacts the formation and thus limits the DOC of each reduced, or limited, exposure cutter while allowing the bit to ride on the bearing surface, or bearing surfaces, against the formation regardless of the WOB being applied to the bit and without generating an unacceptably high, potentially bit damaging TOB for the current ROP.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

**[0022]** FIG. 1 is a bottom elevation looking upward at the face of one embodiment of a drill bit including the DOCC features according to the invention;

**[0023]** FIG. 2 is a bottom elevation looking upward at the face of another embodiment of a drill bit including the DOCC features according to the invention;

**[0024]** FIG. 2A is a side sectional elevation of the profile of the bit of FIG. 2;

**[0025]** FIG. 3 is a graph depicting mathematically predicted torque versus WOB for conventional bit designs employing cutters at different backrakes versus a similar bit according to the present invention;

**[0026]** FIG. 4 is a schematic side elevation, not to scale, comparing prior art placement of a depth-of-cut limiting structure closely behind a cutter at the same radius, taken along a 360° rotational path, versus placement according to the present invention preceding the cutter and at the same radius;

**[0027]** FIG. 5 is a schematic side elevation of a two-step DOCC feature and associated trailing PDC cutter;

**[0028]** FIGS. 6A and 6B are, respectively, schematics of single-angle bearing surface and multi-angle bearing surface DOCC feature;

**[0029]** FIGS. 7 and 7A are, respectively, a schematic side partial sectional elevation of an embodiment of a pivotable DOCC feature and associated trailing PDC cutter, and an elevation looking forward at the pivotable DOCC feature from the location of the associated PDC cutter;

**[0030]** FIGS. 8 and 8A are, respectively, a schematic side partial sectional elevation of an embodiment of a roller-type DOCC feature and associated trailing cutter, and a transverse partial cross-sectional view of the mounting of the roller-type DOCC features to the bit;

[0031] FIGS. 9A-9D depict additional schematic partial sectional elevations of further pivotable DOCC features according to the invention;

[0032] FIGS. 10A and 10B are schematic side partial sectional elevations of variations of a combination cutter carrier and DOCC features according to the present invention;

[0033] FIG. 11 is a frontal elevation of an annular channel-type DOCC feature in combination with associated trailing PDC cutters;

[0034] FIGS. 12 and 12A are, respectively, a schematic side partial sectional elevation of a fluid bearing pad-type DOCC feature according to the present invention and an associated trailing PDC cutter and an elevation looking upward at the bearing surface of the pad;

[0035] FIGS. 13A, 13B and 13C are transverse sections of various cross-sectional configurations for the DOCC features according to the invention;

[0036] FIG. 14A is a perspective view of the face of one embodiment of a drill bit having eight blade structures including reduced exposure cutters disposed on at least some of the blades in accordance with the present invention;

[0037] FIG. 14B is a bottom view of the face of the exemplary drill bit of FIG. 14A;

[0038] FIG. 14C is a photographic bottom view of the face of another exemplary drill bit embodying the present invention having six blade structures and a different cutter profile than the cutter profile of the exemplary bit illustrated in FIGS. 14A and 14B;

[0039] FIG. 15A is a schematic side partial sectional view showing the cutter profile and radial spacing of adjacently positioned cutters along a single, representative blade of a drill bit embodying the present invention;

[0040] FIG. 15B is a schematic side partial sectional view showing the combined cutter profile, including cutter-to-cutter overlap of the cutters positioned along all the blades, as superimposed upon a single, representative blade;

[0041] FIG. 15C is a schematic side partial sectional view showing the extent of cutter exposure along the cutter profile as illustrated in FIGS. 15A and 15B with the cutters removed for clarity and further shows a representative, optional wear knot, or wear cloud, profile;

[0042] FIG. 16 is an enlarged, isolated schematic side partial sectional view illustrating an exemplary superimposed cutter profile having a relative low amount of cutter overlap in accordance with the present invention;

[0043] FIG. 17 is an enlarged, isolated schematic side partial sectional view illustrating an exemplary superimposed cutter profile having a relative high amount of cutter overlap in accordance with the present invention;

[0044] FIG. 18A is an isolated, schematic, frontal view of three representative cutters positioned in the cone region of a representative blade structure of a representative bit, each cutter is exposed at a preselected amount so as to limit the DOC of the cutters, while also providing individual kerf regions between cutters in the bearing surface of the blade in which the cutters are secured contributing to the bit's ability to ride, or rub, upon the formation when a bit embodying the present invention is in operation;

[0045] FIG. 18B is a schematic, partial side cross-sectional view of one of the cutters depicted in FIG. 18A as the cutter engages a relatively hard formation and/or engages a formation at a relatively low WOB resulting in a first, less than maximum DOC;

[0046] FIG. 18C is a schematic, partial side cross-sectional view of the cutter depicted in FIG. 18A as the cutter engages a relatively soft formation and/or engages a formation at relatively high WOB resulting in a second, essentially maximum DOC;

[0047] FIG. 19 is a graph depicting laboratory test results of Aggressiveness versus DOC for a representative prior art steerable bit (STR bit), a conventional, or standard, general purpose bit (STD bit) and two exemplary bits embodying the present invention (RE-W and RE-S) as tested in a Carthage limestone formation at atmospheric pressure;

[0048] FIG. 20 is a graph depicting laboratory test results of WOB versus ROP for the tested bits;

[0049] FIG. 21 is a graph depicting laboratory test results of TOB versus ROP for the tested bits; and

[0050] FIG. 22 is a graph depicting laboratory test results of TOB versus WOB for the tested bits.

## DETAILED DESCRIPTION OF THE INVENTION

[0051] FIG. 1 of the drawings depicts a rotary drag bit 10 looking upwardly at its face or leading end 12 as if the viewer were positioned at the bottom of a borehole. Bit 10 includes a plurality of PDC cutters 14 bonded by their substrates (diamond tables and substrates not shown separately for clarity), as by brazing, into pockets 16 in blades 18 extending above the face 12, as is known in the art with respect to the fabrication of so-called “matrix” type bits. Such bits include a mass of metal powder, such as tungsten carbide, infiltrated with a molten, subsequently hardenable binder, such as a copper-based alloy. It should be understood, however, that the present invention is not limited to matrix-type bits, and that steel body bits and bits of other manufacture may also be configured according to the present invention.

[0052] Fluid courses 20 lie between blades 18 and are provided with drilling fluid by nozzles 22 secured in nozzle orifices 24, orifices 24 being at the end of passages leading from a plenum extending into the bit body from a tubular shank at the upper, or trailing, end of the bit (see FIG. 2A in conjunction with the accompanying text for a description of these features). Fluid courses 20 extend to junk slots 26 extending upwardly along the side of bit 10 between blades 18. Gage pads 19 comprise longitudinally upward extensions of blades 18 and may have wear-resistant inserts or coatings on radially outer surfaces 21 thereof as known in the art. Formation cuttings are swept away from PDC cutters 14 by drilling fluid F emanating from nozzle orifices 24 which moves generally radially outwardly through fluid courses 20 and then upwardly through junk slots 26 to an annulus between the drill string from which the bit 10 is suspended and on to the surface.

[0053] A plurality of the DOCC features, each comprising an arcuate bearing segment 30a through 30f, reside on, and in some instances bridge between, blades 18. Specifically, bearing segments 30b and 30e each reside partially on an adjacent blade 18 and extend therebetween. The arcuate bearing segments 30a through 30f, each of which lies along substantially the same radius from the bit centerline as a PDC cutter 14 rotationally trailing that bearing segment 30, together provide sufficient surface area to withstand the axial or longitudinal WOB without exceeding the compressive strength of the formation being drilled, so that the rock does not indent or fail and the penetration of PDC cutters 14 into the rock is substantially

controlled. As can be seen in FIG. 1, wear-resistant elements or inserts 32, in the form of tungsten carbide bricks or discs, diamond grit, diamond film, natural or synthetic diamond (PDC or TSP), or cubic boron nitride, may be added to the exterior bearing surfaces of bearing segments 30 to reduce the abrasive wear thereof by contact with the formation under WOB as the bit 10 rotates under applied torque. In lieu of inserts, the bearing surfaces may be comprised of, or completely covered with, a wear-resistant material. The significance of wear characteristics of the DOCC features will be explained in more detail below.

[0054] FIGS. 2 and 2A depict another embodiment of a rotary drill bit 100 according to the present invention, and features and elements in FIGS. 2 and 2A corresponding to those identified with respect to bit 10 of FIG. 1 are identified with the same reference numerals. FIG. 2 depicts a rotary drill bit 100 looking upwardly at its face 12 as if the viewer were positioned at the bottom of a borehole. Bit 100 also includes a plurality of PDC cutters 14 bonded by their substrates (diamond tables and substrates not shown separately for clarity), as by brazing, into pockets 16 in blades 18 extending above the face 12 of bit 100.

[0055] Fluid courses 20 lie between blades 18 and are provided with drilling fluid F by nozzles 22 secured in nozzle orifices 24, orifices 24 being at the end of passages 36 leading from a plenum 38 extending into bit body 40 from a tubular shank 42 threaded (not shown) on its exterior surface 44 as known in the art at the upper end of the bit (see FIG. 2A). Fluid courses 20 extend to junk slots 26 extending upwardly along the side of bit 10 between blades 18. Gage pads 19 comprise longitudinally upward extensions of blades 18 and may have wear-resistant inserts or coatings on radially outer surfaces 21 thereof as known in the art.

[0056] A plurality of the DOCC features, each comprising an arcuate bearing segment 30a through 30f, reside on, and in some instances bridge between, blades 18. Specifically, bearing 30b and 30e each reside partially on an adjacent blade 18 and extend therebetween. The arcuate bearing segments 30a through 30f, each of which lies substantially along the same radius from the bit centerline as a PDC cutter 14 rotationally trailing that bearing segment 30, together provide sufficient surface area to withstand the axial or longitudinal WOB without exceeding the compressive strength of the formation being drilled, so that the rock does

not unduly indent or fail and the penetration of PDC cutters 14 into the rock is substantially controlled.

[0057] By way of example only, the total DOCC features surface area for an 8.5 inch diameter bit generally configured as shown in FIGS. 1 and 2 may be about 12 square inches. If, for example, the unconfined compressive strength of a relatively soft formation to be drilled by either bit 10 or 100 is 2,000 pounds per square inch (psi), then at least about 24,000 lbs. WOB may be applied without failing or indenting the formation. Such WOB is far in excess of the WOB which may normally be applied to a bit in such formations (for example, as little as 1,000 to 3,000 lbs., up to about 5,000 lbs.) without incurring bit balling from excessive DOC and the consequent cuttings volume which overwhelms the bit's hydraulic ability to clear them. In harder formations, with, for example, 20,000 to 40,000 psi compressive strengths, the total DOCC features surface area may be significantly reduced while still accommodating substantial WOB applied to keep the bit firmly on the borehole bottom. When older, less sophisticated, drill rigs are employed or during directional drilling, both of which render it difficult to control WOB with any substantial precision, the ability to overload WOB without adverse consequences further distinguishes the superior performance of bits embodying the present invention. It should be noted at this juncture that the use of an unconfined compressive strength of formation rock provides a significant margin for calculation of the required bearing area of the DOCC features for a bit, as the in situ, confined, compressive strength of a subterranean formation being drilled is substantially higher. Thus, if desired, confined compressive strength values of selected formations may be employed in designing the total DOCC features as well as the total bearing area of a bit to yield a smaller required area, but which still advisedly provides for an adequate "margin" of excess bearing area in recognition of variations in continued compressive strengths of the formation to preclude substantial indentation and failure of the formation downhole.

[0058] While bit 100 is notably similar to bit 10, the viewer will recognize and appreciate that wear inserts 32 are omitted from bearing segments on bit 100, such an arrangement being suitable for less abrasive formations where wear is of lesser concern and the tungsten carbide of the bit matrix (or applied hard facing in the case of a steel body bit) is sufficient to resist abrasive wear for a desired life of the bit. As shown in FIG. 13A, the DOCC

features (bearing segments 30) of either bit 10 or bit 100, or of any bit according to the invention, may be of arcuate cross-section, taken transverse to the arc followed as the bit rotates, to provide an arcuate bearing surface 31a mimicking the cutting edge arc of an unworn, associated PDC cutter following a DOCC feature. Alternatively, as shown in FIG. 13B, a DOCC feature (bearing segment 30) may exhibit a flat bearing surface 31f to the formation, or may be otherwise configured. It is also contemplated, as shown in FIG. 13C, that a DOCC feature (bearing segment 30) may be cross-sectionally configured and comprised of a material so as to intentionally and relatively quickly (in comparison to the wear rate of a PDC cutter) wear from a smaller initial bearing surface 31i providing a relatively small  $DOC_1$  with respect to the point or line of contact C with the formation traveled by the cutting edge of a trailing, associated PDC cutter while drilling a first, hard formation interval to a larger, secondary bearing surface 31s which also provides a much smaller  $DOC_2$  for a second, lower, much softer (and lower compressive strength) formation interval. Alternatively, the head 33 of the DOCC structure (bearing segment 30) may be made controllably shearable from the base 35 (as with frangible connections like a shear pin, one shear pin 37 shown in broken lines).

**[0059]** For reference purposes, bits 10 and 100 as illustrated may be said to be symmetrical or concentric about their centerlines or longitudinal axes L, although this is not necessarily a requirement of the invention.

**[0060]** Both bits 10 and 100 are unconventional in comparison to state of the art bits in that PDC cutters 14 on bits 10 and 100 are disposed at far lesser backrakes, in the range of, for example,  $7^\circ$  to  $15^\circ$  with respect to the intended direction of rotation generally perpendicular to the surface of the formation being engaged. In comparison, many conventional bits are equipped with cutters at a  $30^\circ$  backrake, and a  $20^\circ$  backrake is regarded as somewhat "aggressive" in the art. The presence of the DOCC feature permits the use of substantially more aggressive backrakes, as the DOCC features preclude the aggressively raked PDC cutters from penetrating the formation to too great a depth, as would be the case in a bit without the DOCC features.

**[0061]** In the cases of both bit 10 and bit 100, the rotationally leading DOCC features (bearing segments 30) are configured and placed to substantially exactly match the pattern drilled in the bottom of the borehole when drilling at an ROP of 100 feet per hour (fph) at 120 rotations

per minute (rpm) of the bit. This results in a DOC of about 0.166 inch per revolution. Due to the presence of the DOCC features (bearing segments 30), after sufficient WOB has been applied to drill 100 fph, any additional WOB is transferred from the body 40 of the bit 10 or 100 through the DOCC features to the formation. Thus, the cutters 14 are not exposed to any substantial additional weight, unless and until a WOB sufficient to fail the formation being drilled would be applied, which application may be substantially controlled by the driller, since the DOCC features may be engineered to provide a large margin of error with respect to any given sequence of formations which might be encountered when drilling an interval.

[0062] As a further consequence of the present invention, the DOCC features would, as noted above, preclude cutters 14 from excessively penetrating or “gouging” the formation, a major advantage when drilling with a downhole motor where it is often difficult to control WOB and WOB inducing such excessive penetration can result in the motor stalling, with consequent loss of tool face and possible damage to motor components as well as to the bit itself. While the addition of WOB beyond that required to achieve the desired ROP will require additional torque to rotate the bit due to frictional resistance to rotation of the DOCC features over the formation, such additional torque is a lesser component of the overall torque.

[0063] The benefit of DOCC features in controlling torque can readily be appreciated by a review of FIG. 3 of the drawings, which is a mathematical model of performance of a 3 3/4 inch diameter, four-bladed, Hughes Christensen R324XL PDC bit showing various torque versus WOB curves for varying cutter backrakes in drilling Mancos shale. Curve A represents the bit with a 10° cutter backrake, curve B, the bit with a 20° cutter backrake, curve C, the bit with a 30° cutter backrake, and curve D, the bit using cutters disposed at a 20° backrake and including the DOCC features according to the present invention. The model assumes a bit design according to the invention for an ROP of 50 fph at 100 rpm, which provides 0.1 inch per revolution penetration of a formation being drilled. As can readily be seen, regardless of cutter backrake, curves A through C clearly indicate that, absent the DOCC features according to the present invention, required torque on the bit continues to increase continuously and substantially linearly with applied WOB, regardless of how much WOB is applied. On the other hand, curve D indicates that, after WOB approaches about 8,000 lbs. on the bit including the DOCC



features, the torque curve flattens significantly and increases in a substantially linear manner only slightly from about 670 ft-lb. to just over 800 ft-lb. even as WOB approaches 25,000 lbs. As noted above, this relatively small increase in the torque after the DOCC features engage the formation is frictionally related, and is also somewhat predictable. As graphically depicted in FIG. 3, this additional torque load increases substantially linearly as a function of WOB times the coefficient of friction between the bit and the formation.

[0064] Referring now to FIG. 4 (which is not to scale) of the drawings, a further appreciation of the operation and benefits of the DOCC features according to the present invention may be obtained. Assuming a bit designed for an ROP of 120 fph at 120 rpm, this requires an average DOC of 0.20 inch. The DOCC features or DOC limiters would thus be designed to first contact the subterranean formation surface FS to provide a 0.20 inch DOC. It is assumed for the purposes of FIG. 4 that DOCC features or DOC limiters are sized so that compressive strength of the formation being drilled is not exceeded under applied WOB. As noted previously, the compressive strength of concern would typically be the in situ compressive strength of the formation rock resident in the formation being drilled (plus some safety factor), rather than unconfined compressive strength of a rock sample. In FIG. 4, an exemplary PDC cutter 14 is shown, for convenience, moving linearly right to left on the page. One complete revolution of the bit 10 or 100 on which PDC cutter 14 is mounted has been “unscrolled” and laid out flat in FIG. 4. Thus, as shown, PDC cutter 14 has progressed downwardly (i.e., along the longitudinal axis of the bit 10 or 100 on which it is mounted) 0.20 inch in 360° of rotation of the bit 10 or 100. As shown in FIG. 4, a structure or element to be used as a DOC limiter 50 is located conventionally, closely rotationally “behind” PDC cutter 14, as only 22.5° behind PDC cutter 14, the outermost tip 50a must be recessed upwardly 0.0125 inch ( $0.20 \text{ inch DOC} \times 22.5^\circ/360^\circ$ ) from the outermost tip 14a of PDC cutter 14 to achieve an initial 0.20 inch DOC. However, when DOC limiter 50 wears during drilling, for example by a mere 0.010 inch relative to the tip 14a of PDC cutter 14, the vertical offset distance between the tip 50a of DOC limiter 50 and tip 14a of PDC cutter 14 is increased to 0.0225 inch. Thus, DOC will be substantially increased, in fact, almost doubled, to 0.36 inch. Potential ROP would consequently equal 216 fph due to the increase in vertical standoff provided PDC cutter 14 by worn DOC limiter 50, but

the DOC increase may damage PDC cutter 14 or ball the bit 10 or 100 by generating a volume of formation cuttings which overwhelms the bit's ability to clear them hydraulically. Similarly, if PDC cutter tip 14a wore at a relatively faster rate than DOC limiter 50 by, for example, 0.010 inch, the vertical offset distance is decreased to 0.0025 inch, DOC is reduced to 0.04 inch and ROP, to 24 fph. Thus, excessive wear or vertical misplacement of either PDC cutter 14 or DOC limiter 50 to the other may result in a wide range of possible ROPs for a given rotational speed. On the other hand, if an exemplary DOCC feature 60 is placed, according to the present invention, 45° rotationally in front of (or 315° rotationally behind) PDC cutter tip 14a, the outermost tip 60a would initially be recessed upwardly 0.175 inch ( $0.20 \text{ inch DOC} \times 315^\circ/360^\circ$ ) relative to PDC cutter tip 14a to provide the initial 0.20 inch DOC. FIG. 4 shows the same DOCC feature 60 twice, both rotationally in front of and behind PDC cutter 14, for clarity, it being, of course, understood that the path of PDC cutter 14 is circular throughout a 360° arc in accordance with rotation of bit 10 or 100. When DOCC feature 60 wears 0.010 inch relative to PDC cutter tip 14a, the vertical offset distance between tip 60a of DOCC feature 60 and tip 14a of PDC cutter 14 is only increased from 0.175 inch to 0.185 inch. However, due to the placement of DOCC feature 60 relative to PDC cutter 14, DOC will be only slightly increased to about 0.211 inch. As a consequence, ROP would only increase to about 127 fph. Likewise, if PDC cutter 14 wears 0.010 inch relative to DOCC feature 60, vertical offset of DOCC feature 60 is only reduced to 0.165 inch and DOC is only reduced to about 0.189 inch, with an attendant ROP of about 113 fph. Thus, it can readily be seen how rotational placement of a DOCC feature can significantly affect ROP as the limiter or the cutter wears with respect to the other, or if one such component has been misplaced or incorrectly sized to protrude incorrectly even slightly upwardly or downwardly of its ideal, or "design," position relative to the other, associated component when the bit is fabricated. Similarly, mismatches in wear between a cutter and a cutter-trailing DOC limiter are magnified in the prior art, while being significantly reduced when DOCC features sized and placed in cutter-leading positions according to the present invention are employed. Further, if a DOC limiter trailing, rather than leading, a given cutter is employed, it will be appreciated that shock or impact loading of the cutter is more probable as, by the time the DOC limiter contacts the formation, the cutter tip will have already contacted the formation.

Leading DOCC features, on the other hand, by being located in advance of a given cutter along the downward helical path the cutter travels as it cuts the formation and the bit advances along its longitudinal axis, tend to engage the formation before the cutter. The terms “leading” and “trailing” the cutter may be easily understood as being preferably respectively associated with DOCC features positions up to 180° rotationally preceding a cutter versus positions up to 180° rotationally trailing a cutter. While some portion of, for example, an elongated, arcuate leading DOCC feature according to the present invention may extend so far rotationally forward of an associated cutter so as to approach a trailing position, the substantial majority of the arcuate length of such a DOCC feature would preferably reside in a leading position. As may be appreciated by further reference to FIGS. 1 and 2, there may be a significant rotational spacing between a PDC cutter 14 and an associated bearing segment 30 of a DOCC feature, as across a fluid course 20 and its associated junk slot 26, while still rotationally leading the PDC cutter 14. More preferably, at least some portion of a DOCC feature according to the invention will lie within about 90° rotationally preceding the face of an associated cutter.

[0065] One might question why limitation of ROP would be desirable, as bits according to the present invention using DOCC features may not, in fact, drill at as great an ROP as conventional bits not so equipped. However, as noted above, by using DOCC features to achieve a predictable and substantially sustainable DOC in conjunction with a known ability of a bit's hydraulics to clear formation cuttings from the bit at a given maximum volumetric rate, a sustainable (rather than only peak) maximum ROP may be achieved without the bit balling and with reduced cutter wear and substantial elimination of cutter damage and breakage from excessive DOC, as well as impact-induced damage and breakage. Motor stalling and loss of tool face may also be eliminated. In soft or ultra-soft formations very susceptible to balling, limiting the unit volume of rock removed from the formation per unit time prevents a bit from “over cutting” the formation. In harder formations, the ability to apply additional WOB in excess of what is needed to achieve a design DOC for the bit may be used to suppress unwanted vibration normally induced by the PDC cutters and their cutting action, as well as unwanted drill string vibration in the form of bounce, manifested on the bit by an excessive DOC. In such harder formations, the DOCC features may also be characterized as “load arresters” used in conjunction

with “excess” WOB to protect the PDC cutters from vibration-induced damage, the DOCC features again being sized so that the compressive strength of the formation is not exceeded. In harder formations, the ability to damp out vibrations and bounce by maintaining the bit in constant contact with the formation is highly beneficial in terms of bit stability and longevity, while in steerable applications the invention precludes loss of tool face.

[0066] FIG. 5 depicts one exemplary variation of a DOCC feature according to the present invention, which may be termed a “stepped” DOCC feature 130 comprising an elongated, arcuate bearing segment. Such a configuration, shown for purposes of illustration preceding a PDC cutter 14 on a bit 100 (by way of example only), includes a lower, rotationally leading first step 132 and a higher, rotationally trailing second step 134. As tip 14a of PDC cutter 14 follows its downward helical path generally indicated by line 140 (the path, as with FIG. 4, being unscrolled on the page), the surface area of first step 132 may be used to limit DOC in a harder formation with a greater compressive strength, the bit “riding” high on the formation with cutter 14 taking a minimal  $DOC_1$  in the formation surface, shown by the lower dashed line. However, as bit 100 enters a much softer formation with a far lesser compressive strength, the surface area of first step 132 will be insufficient to prevent indentation and failure of the formation, and so first step 132 will indent the formation until the surface of second step 134 encounters the formation material, increasing DOC by cutter 14. At that point, the total surface area of first and second steps 132 and 134 (in combination with other first and second steps respectively associated with other cutters 14) will be sufficient to prevent further indentation of the formation and the deeper  $DOC_2$  in the surface of the softer formation (shown by the upper dashed line) will be maintained until the bit 100 once again encounters a harder formation. When this occurs, the bit 100 will ride up on the first step 132, which will take any impact from the encounter before cutter 14 encounters the formation, and the DOC will be reduced to its previous DOC level, avoiding excessive torque and motor stalling.

[0067] As shown in FIGS. 1 and 2, one or more DOCC features of a bit according to an invention may comprise elongated arcuate bearing segments 30 disposed at substantially the same radius about the bit longitudinal axis or centerline as a cutter preceded by that DOCC feature. In such an instance, and as depicted in FIG. 6A with exemplary arcuate bearing

segment 30 unscrolled to lie flat on the page, it is preferred that the outer bearing surface S of a segment 30 be sloped at an angle  $\alpha$  to a plane P transverse to the centerline L of the bit substantially the same as the angle  $\beta$  of the (helical path 140) traveled by associated PDC cutter 14 as the bit drills the borehole. By so orienting the outer bearing surface S, the full potential surface, or bearing area of bearing segment 30 contacts and remains in contact with the formation as the PDC cutter 14 rotates. As shown in FIG. 6B, the outer surface S of an arcuate segment may also be sloped at a variable angle to accommodate maximum and minimum design ROP for a bit. Thus, if a bit is designed to drill between 110 and 130 fph, the rotationally leading portion LS of surface S may be at one, relatively shallower angle  $\gamma$ , while the rotationally trailing portion TS of surface S (all of surface S still rotationally leading PDC cutter 14) may be at another, relatively steeper angle  $\delta$ , (both angles shown in exaggerated magnitude for clarity) the remainder of surface S gradually transitioning in an angle therebetween. In this manner, and since DOC must necessarily increase for ROP to increase, given a substantially constant rotational speed, at a first, shallower helix angle 140a corresponding to a lower ROP, the leading portion LS of surface S will be in contact with the formation being drilled, while at a higher ROP the helix angle will steepen, as shown (exaggerated for clarity) by helix angle 140b and leading portion LS will no longer contact the formation, the contact area being transitioned to more steeply angled trailing portion TS. Of course, at an ROP intermediate the upper and lower limits of the design range, a portion of surface S intermediate leading portion LS and trailing portion TS (or portions of both LS and TS) would act as the bearing surface. A configuration as shown in FIG. 6B is readily suitable for high compressive strength formations at varying ROP's within a design range, since bearing surface area requirements for the DOCC features are nominal. For bits used in drilling softer formations, it may be necessary to provide excess surface area for each DOCC feature to prevent formation failure and indentation, as only a portion of each DOCC feature will be in contact with the formation at any one time when drilling over a design range of ROPs. Conversely, for bits used in drilling harder formations, providing excess surface area for each DOCC feature to prevent formation failure and indentation may not be necessary as the respective portions of each DOCC feature may, when taken in combination, provide enough total

bearing surface area, or total size, for the bit to ride on the formation over a design range of ROPs.

[0068] Another consideration in the design of bits according to the present invention is the abrasivity of the formation being drilled, and relative wear rates of the DOCC features and the PDC cutters. In non-abrasive formations this is not of major concern, as neither the DOCC feature nor the PDC cutter will wear appreciably. However, in more abrasive formations, it may be necessary to provide wear inserts 32 (see FIG. 1) or otherwise protect the DOCC features against excessive (i.e., premature) wear in relation to the cutters with which they are associated to prevent reduction in DOC. For example, if the bit is a matrix-type bit, a layer of diamond grit may be embedded in the outer surfaces of the DOCC features. Alternatively, preformed cemented tungsten carbide slugs cast into the bit face may be used as DOCC features. A diamond film may be formed on selected portions of the bit face using known chemical vapor deposition techniques as known in the art, or diamond films formed on substrates which are then cast into or brazed or otherwise bonded to the bit body. Natural diamonds, thermally stable PDCs (commonly termed TSPs) or even PDCs with their faces substantially parallel to the helix angle of the cutter path (so that what would normally be the cutting face of the PDC acts as a bearing surface), or cubic boron nitride structures similar to the aforementioned diamond structures may also be employed on, or as, bearing surfaces of the DOCC features, as desired or required, for example when drilling in limestones and dolomites. In order to reduce frictional forces between a DOCC bearing surface and the formation, a very low roughness, so-called "polished" diamond surface may be employed in accordance with U.S. Patents 5,447,208 and 5,653,300, assigned to the assignee of the present invention and hereby incorporated herein by this reference. Ideally, and taking into account wear of the diamond table and supporting substrate in comparison to wear of the DOCC features, the wear characteristics and volumes of materials taking the wear for the DOCC features may be adjusted so that the wear rate of the DOCC features may be substantially matched to the wear rate of the PDC cutters to maintain a substantially constant DOC. This approach will result in the ability to use the PDC cutter to its maximum potential life. It is, of course, understood that the DOCC features may be configured as abbreviated "knots," "bosses," or large "mesas" as well as the aforementioned arcuate

segments or may be of any other configuration suitable for the formation to be drilled to prevent failure thereof by the DOCC features under expected or planned WOB.

[0069] As an alternative to a fixed, or passive, DOCC feature, it is also contemplated that active DOCC features or bearing segments may be employed to various ends. For example, rollers may be disposed in front of the cutters to provide reduced-friction DOCC features, or a fluid bearing comprising an aperture surrounded by a pad or mesa on the bit face may be employed to provide a standoff for the cutters with attendant low friction. Movable DOCC features, for example pivotable structures, might also be used to accommodate variations in ROP within a given range by tilting the bearing surfaces of the DOCC features so that the surfaces are oriented at the same angle as the helical path of the associated cutters.

[0070] Referring now to FIGS. 7 through 12 of the drawings, various DOCC features (which may also be referred to as bearing segments) according to the invention are disclosed.

[0071] Referring to FIGS. 7 and 7A, exemplary bit 150 having PDC cutter 14 secured thereto rotationally trailing fluid course 20 includes pivotable DOCC feature 160 comprised of an arcuate-surfaced body 162 (which may comprise a hemisphere for rotation about several axes or merely an arcuate surface extending transverse to the plane of the page for rotation about an axis transverse to the page) secured in socket 164 and having an optional wear-resistant feature 166 on the bearing surface 168 thereof. Wear-resistant feature 166 may merely be an exposed portion of the material of body 162 if the latter is formed of, for example, WC. Alternatively, wear-resistant feature 166 may comprise a WC tip, insert or cladding on bearing surface 168 of body 162, diamond grit embedded in body 162 at bearing surface 168, or a synthetic or natural diamond surface treatment of bearing surface 168, including specifically and without limitation, a diamond film deposited thereon or bonded thereto. It should be noted that the area of the bearing surface 168 of the DOCC feature 160 which will ride on the formation being drilled, as well as the DOC for PDC cutter 14, may be easily adjusted for a given bit design by using bodies 162 exhibiting different exposures (heights) of the bearing surface 168 and different widths, lengths or cross-sectional configurations, all as shown in broken lines. Thus, different formation compressive strengths may be accommodated. The use of a pivotable DOCC feature 160 permits the DOCC feature to automatically adjust to different ROPs within a given range of cutter helix

angles. While DOC may be affected by pivoting of the DOCC feature 160, variation within a given range of ROPs will usually be nominal.

[0072] FIGS. 8 and 8A depict exemplary bit 150 having PDC cutter 14 secured thereto rotationally trailing fluid course 20, wherein bit 150 in this instance includes DOCC feature 170 including roller 172 rotationally mounted by shaft 174 to bearings 176 carried by bit 150 on each side of cavity 178 in which roller 172 is partially received. In this embodiment, it should be noted that the exposure and bearing surface area of DOCC feature 170 may be easily adjusted for a given bit design by using different diameter rollers 172 exhibiting different widths and/or cross-sectional configurations.

[0073] FIGS. 9A, 9B, 9C and 9D respectively depict alternative pivotable DOCC features 190, 200, 210 and 220. DOCC feature 190 includes a head 192 partially received in a cavity 194 in a bit 150 and mounted through a ball and socket connection 196 to a stud 180 press-fit into aperture 198 at the top of cavity 194. DOCC features 200, wherein elements similar to those of DOCC feature 190 are identified by the same reference numerals, is a variation of DOCC feature 190. DOCC feature 210 employs a head 212 which is partially received in a cavity 214 in a bit 150 and secured thereto by a resilient or ductile connecting element 216 which extends into aperture 218 at the top of cavity 214. Connecting element 216 may comprise, for example, an elastomeric block, a coil spring, a belleville spring, a leaf spring, or a block of ductile metal, such as steel or bronze. Thus, connecting element 216, as with the ball and socket connections 196 and heads 192, permits head 212 to automatically adjust to, or compensate for, varying ROPs defining different cutter helix angles. DOCC feature 220 employs a yoke 222 rotationally disposed and partially received within cavity 224, yoke 222 supported on protrusion 226 of bit 150. Stops 228, of resilient or ductile materials (such as elastomers, steel, lead, etc.) and which may be permanent or replaceable, permit yoke 222 to accommodate various helix angles. Yoke 222 may be secured within cavity 224 by any conventional means. Since helix angles vary even for a given, specific ROP as distance of each cutter from the bit centerline, affording such automatic adjustment or compensation may be preferable to trying to form DOCC features with bearing surfaces at different angles at different locations over the bit face.



[0074] FIGS. 10A and 10B respectively depict different DOCC features and PDC cutter combinations. In each instance, a PDC cutter 14 is secured to a combined cutter carrier and DOC limiter 240, the carrier 240 being received within a cavity 242 in the face (or on a blade) of an exemplary bit 150 and secured therein as by brazing, welding, mechanical fastening, or otherwise as known in the art. DOC limiter 240 includes a protrusion 244 exhibiting a bearing surface 246. As shown and by way of example only, bearing surface 246 may be substantially flat (FIG. 10A) or hemispherical (FIG. 10B). By selecting an appropriate cutter carrier and DOC limiter 240, the DOC of PDC cutter 14 may be varied and the surface area of bearing surface 246 adjusted to accommodate a target formation's compressive strength.

[0075] It should be noted that the DOCC features of FIGS. 7 through 10, in addition to accommodating different formation compressive strengths as well as optimizing DOC and permitting minimization of friction-causing bearing surface area while preventing formation failure under WOB, also facilitate field repair and replacement of DOCC features due to drilling damage or to accommodate different formations to be drilled in adjacent formations, or intervals, to be penetrated by the same borehole.

[0076] FIG. 11 depicts a DOCC feature 250 comprised of an annular cavity or channel 252 in the face of an exemplary bit 150. Radially adjacent PDC cutters 14 flanking annular channel 252 cut the formation 254 but for uncut annular segment 256, which protrudes into annular cavity 252. At the top 260 of annular channel 252, a flat-edged PDC cutter 258 (or preferably a plurality of rotationally spaced cutters 258) truncates annular segment 256 in a controlled manner so that the height of annular segment 256 remains substantially constant and limits the DOC of flanking PDC cutters 14. In this instance, the bearing surface of the DOCC feature 250 comprises the top 260 of annular channel 252, and the sides 262 of channel 252 prevent collapse of annular segment 256. Of course, it is understood that multiple annular channels 252 with flanking PDC cutters 14 may be employed, and that a source of drilling fluid, such as aperture 264, would be provided to lubricate channel 252 and flush formation cuttings from cutter 258.

[0077] FIGS. 12 and 12A depict a low-friction, hydraulically enhanced DOCC feature 270 comprised of a DOCC pad 272 rotationally leading a PDC cutter 14 across fluid

course 20 on exemplary bit 150, pad 272 being provided with drilling fluid through passage 274 leading to the bearing surface 276 of pad 272 from a plenum 278 inside the body of bit 150. As shown in FIG. 12A, a plurality of channels 282 may be formed on bearing surface 276 to facilitate distribution of drilling fluid from the mouth 280 of passage 274 across bearing surface 276. By diverting a small portion of drilling fluid flow to the bit 150 from its normal path leading to nozzles associated with the cutters, it is believed that the increased friction normally attendant with WOB increases after the bearing surface 276 of DOCC pad 272 contacts the formation may be at least somewhat alleviated, and in some instances substantially avoided, reducing or eliminating torque increases responsive to increases of WOB. Of course, passages 274 may be sized to provide appropriate flow, or pads 272 sized with appropriately dimensioned mouths 280. Pads 272 may, of course, be configured for replaceability.

[0078] As has been mentioned above, backrakes of the PDC cutters employed in a bit equipped with DOCC features according to the invention may be more aggressive, that is to say, less negative, than with conventional bits. It is also contemplated that extremely aggressive cutter rakes, including neutral rakes and even positive (forward) rakes of the cutters may be successfully employed consistent with the cutters' inherent strength to withstand the loading thereon as a consequence of such rakes, since the DOCC features will prevent such aggressive cutters from engaging the formation to too great a depth.

[0079] It is also contemplated that two different heights, or exposures, of bearing segments may be employed on a bit, a set of higher bearing segments providing a first bearing surface area supporting the bit on harder, higher compressive strength formations providing a relatively shallow DOC for the PDC cutters of the bit, while a set of lower bearing segments remains out of contact with the formation while drilling until a softer, lower compressive stress formation is encountered. At that juncture, the higher or more exposed bearing segments will be of insufficient surface area to prevent indentation (failure) of the formation rock under applied WOB. Thus, the higher bearing segments will indent the formation until the second set of bearing segments comes in contact therewith, whereupon the combined surface area of the two sets of bearing segments will support the bit on the softer formation, but at a greater DOC to permit the cutters to remove a greater volume of formation material per rotation of the bit and

thus generate a higher ROP for a given bit rotational speed. This approach differs from the approach illustrated in FIG. 5 in that, unlike stepped DOCC features (bearing segment 130), bearing segments of differing heights or exposures are associated with different cutters. Thus, this aspect of the invention may be effected, for example, in the bits 10 and 100 of FIGS. 1 and 2 by fabricating selected arcuate bearing segments to a greater height or exposure than others. Thus, bearing segments 30b and 30e of bits 10 and 100 may exhibit a greater exposure than segments 30a, 30c, 30d and 30f, or vice versa.

[0080] Cutters employed with bits 10 and 100, as well as other bits disclosed that will be discussed subsequently herein, are depicted as having PDC cutters 14, but it will be recognized and appreciated by those of ordinary skill in the art that the invention may also be practiced on bits carrying other types of superabrasive cutters, such as thermally stable polycrystalline diamond compacts, or TSPs, for example arranged into a mosaic pattern as known in the art to simulate the cutting face of a PDC. Diamond film cutters may also be employed, as well as cubic boron nitride compacts.

[0081] Another embodiment of the present invention, as exemplified by rotary drill bit 300 and 300', is depicted in FIGS. 14A - 20. Rotary drill bits such as drill bits 300 and 300', according to the present invention, may include many features and elements which correspond to those identified with respect to previously described and illustrated bits 10 and 100.

[0082] Representative rotary drill bit 300 shown in FIGS. 14A and 14B, includes a bit body 301 having a leading end 302 and a trailing end 304. Connection 306 may comprise a pin-end connection having tapered threads for connecting bit 300 to a bottom hole assembly of a conventional rotating drill string, or alternatively for connection to a downhole motor assembly such as a drilling fluid powered Moineau-type downhole motor, as described earlier. Leading end, or drill bit face, 302 includes a plurality of blade structures 308 generally extending radially outwardly and longitudinally toward trailing end 304. Exemplary bit 300 comprises eight blade structures, or blades, 308 spaced circumferentially about the bit. However, a fewer number of blades may be provided on a bit such as provided on bit body 301' of bit 300' shown in FIG. 14C which has six blades. A greater number of blade structures of a variety of geometries may be utilized as determined to be optimum for a particular drill bit. Furthermore, blades 308 need not

be equidistantly spaced about the circumference of drill bit 300 as shown, but may be spaced about the circumference, or periphery, of a bit in any suitable fashion including a non-equidistant arrangement or an arrangement wherein some of the blades are spaced circumferentially equidistantly from each other and wherein some of the blades are irregularly, non-equidistantly spaced from each other. Moreover, blades 308 need not be specifically configured in the manner as shown in FIGS. 14A and 14B, but may be configured to include other profiles, sizes, and combinations than those shown.

[0083] Generally, a bit, such as bit 300, includes a cone region 310, a nose region 312, a flank region 314, a shoulder region 316, and a gage region 322. Frequently, a specific distinction between flank region 314 and shoulder region 316 may not be made. Thus, the term “shoulder,” as used in the art, will often incorporate the “flank” region within the “shoulder” region. Fluid ports 318 are disposed about the face of the bit and are in fluid communication with at least one interior passage provided in the interior of bit body 301 in a manner such as illustrated in FIG. 2A of the drawings and for the purposes described previously herein. Preferably, but not necessarily, fluid ports 318 include nozzles 338 disposed therein to better control the expulsion of drilling fluid from bit body 301 into fluid courses 344 and junk slots 340 in order to facilitate the cooling of cutters on bit 300 and the flushing of formation cuttings up the borehole toward the surface when bit 300 is in operation.

[0084] Blades 308 preferably comprise, in addition to gage region 322 of blades 308, a radially outward facing bearing surface 320, a rotationally leading surface 324, and a rotationally trailing surface 326. That is, as the bit is rotated in a subterranean formation to create a borehole, leading surface 324 will be facing the intended direction of bit rotation while trailing surface 326 will be facing opposite, or backwards from, the intended direction of bit rotation. A plurality of cutting elements, or cutters, 328 are preferably disposed along and partially within blades 308. Specifically, cutters 328 are positioned so as to have a superabrasive cutting face, or table, 330 generally facing in the same direction as leading surface 324 as well as to be exposed to a certain extent beyond bearing surface 320 of the respective blade in which each cutter is positioned. Cutters 328 are preferably superabrasive cutting elements known within the art, such as the exemplary PDC cutters described previously herein, and are physically

secured in pockets 342 by installation and securement techniques known in the art. The preferred amount of exposure of cutters 328 in accordance with the present invention will be described in further detail hereinbelow.

[0085] Optional wear knots, wear clouds, or built-up wear-resistant areas 334, collectively referred to as wear knots 334 herein, may be disposed upon, or otherwise provided on bearing surfaces 320 of blades 308 with wear knots 334 preferably being positioned so as to rotationally follow cutters 328 positioned on respective blades or other surfaces in which cutters 328 are disposed. Wear knots 334 may be originally molded into bit 300 or may be added to selected portions of bearing surface 320. As described earlier herein, bearing surfaces 320 of blades 308 may be provided with other wear-resistant features or characteristics such as embedded diamonds, TSPs, PDCs, hard facing, weldings, and weldments for example. As will become apparent, such wear-resistant features can be employed to further enhance and augment the DOCC aspect as well as other beneficial aspects of the present invention.

[0086] FIGS. 15A-15C highlight the extent in which cutters 328 are exposed with respect to the surface immediately surrounding cutters 328 and particularly cutters 328C located within the radially innermost region of the leading end of a bit proximate the longitudinal centerline of the bit. FIG. 15A provides a schematic representation of a representative group of cutters provided on a bit as the bit rotatably engages a formation with the cutter profile taken in cross-section and projected onto a single, representative vertical plane (i.e., the drawing sheet). Cutters 328 are generally radially, or laterally, positioned along the face of the leading end of a bit, such as representative bit 300, so as to provide a selected center-to-center radial, or lateral spacing between cutters referred to as center-to-center cutter spacing  $R_s$ . Thus, if a bit is provided with a blade structure, such as blade 308, the cutter profile of 15A represents the cutters positioned on a single representative blade 308. As exaggeratedly illustrated in FIG. 15A, cutters 328C located in cone region 310 are preferably disposed into blade 308 so as to have a cutter exposure  $H_c$  generally perpendicular to the outwardly face bearing surface 320 of blade 308 by a selected amount. As can be seen in FIG. 15A, cutter exposure  $H_c$  is of a preferably relative small amount of standoff, or exposure, distance in cone region 310 of bit 300. Preferably, cutter exposure  $H_c$  generally differs for each of the cutters or groups of cutters

positioned more radially distant from centerline L. For example cutter exposure  $H_c$  is generally greater for cutters 328 in nose region 312 than it is for cutters 328 located in cone region 310 and cutter exposure  $H_c$  is preferably at a maximum in flank/shoulder regions 314/316. Cutter exposure  $H_c$  preferably diminishes slightly radially toward gage region 322, and radially outermost cutters 328 positioned longitudinally proximate gage pad surface 354 of gage region 322 may incorporate cutting faces of smaller cross-sectional diameters as illustrated. Gage line 352 (see FIGS. 16 and 17) defines the maximum outside diameter of bit 300.

[0087] The cross-sectional profile of optional wear knots, wear clouds, hard facing, or surface welds 334 have been omitted for clarity in FIG. 15A. However, FIG. 15C depicts the rotational cross-sectional profile, as superimposed upon a single, representative vertical plane, of representative optional wear knots, wear clouds, hard facing, surface welds, or other wear knot structures 334. FIG. 15C further illustrates an exemplary cross-sectional wear knot height  $H_{wk}$  measured generally perpendicular to outwardly face bearing surface 320. There may or may not be a generally radial dimensional difference, or relief,  $\Delta H_{c-wk}$ , between wear knot height  $H_{wk}$ , which generally corresponds to a radially outermost surface of a given wear knot or structure, and respective cutter exposure  $H_c$ , which generally corresponds to the radially outermost portion of the rotationally associated cutter, to further provide a DOCC feature in accordance with the present invention. Conceptually, these differences in exposures can be regarded as analogous to the distance of cutter 14 and rotationally trailing DOC limiter 50 as measured from the dashed reference line illustrated in FIG. 4 and as described earlier. Furthermore, instead of referring to the distance in which the radially outermost surface of a given wear knot structure is positioned radially outward from a bearing surface or blade structure in which a particular wear knot structure is disposed upon, it may be helpful to alternatively refer to a preselected distance in which the radially outermost surface of a given wear knot structure is radially/longitudinally inset, or relieved from the outermost portion of the exposed portion of a rotationally associated superabrasive cutter as denoted as  $\Delta H_{c-wk}$  in FIG. 15C. Thus, in addition to controlling the DOC with at least certain cutters, and perhaps every cutter, by selecting an appropriate cutter exposure height  $H_c$  as defined and illustrated herein, the present invention further encompasses optionally providing drill bits with wear knots, or other similar cutter depth limiting structures, to

complement, or augment, the control of the DOCs of respectively rotationally associated cutters wherein such optionally provided wear knots are disposed on the bit so as to have a wear knot surface that is positioned, or relieved, a preselected distance  $\Delta H_{c-wk}$  as measured from the outermost exposed portion of the cutter in which a wear knot is rotationally associated to the wear knot surface.

[0088] The superimposed cross-sectional cutter profile of a representative drill bit such as bit 300 in FIG. 15B depicts the combined profile of all cutters installed on each of a plurality of blades 308 so as to have a selected center-to-center radial cutter spacing  $R_s$ . Thus, the cutter profile illustrated in FIG. 15B is the result of all of the cutters provided on a plurality of blades and rotated about the centerline of the bit to be superimposed upon a single, representative blade 308. In some embodiments, there will likely be several cutter redundancies at identical radial locations between various cutters positioned on respective, circumferentially spaced blades, and, for clarity, such profiles which are perfectly, or absolutely, redundant are typically not illustrated. As can be seen in FIG. 15B, there will be a lateral, or radial, overlap between respective cutter paths as the variously provided cutters rotationally progress generally tangential to longitudinal axis L as the bit 300 rotates so as to result in a uniform cutting action being achieved as the drill bit rotatingly engages a formation under a selected WOB. Additionally, it can be seen in FIG. 15B that the lateral, or radial, spacing between individual cutter profiles need not be of the same, uniform distance with respect to the radial, or lateral, position of each cutter. This non-uniform spacing with respect to the radial, or lateral, positioning of each cutter is more clearly illustrated in FIGS. 16 and 17.

[0089] FIGS. 16 and 17 are enlarged, isolated partial cross-sectional cutter profile views to which all of the cutters located on a bit are superimposed as if on a single cross-sectional portion of a bit body 301 or cutters 328 of a bit such as bit 300. The cutter profiles of FIGS. 16 and 17 are illustrated as being to the right of longitudinal centerline L of a representative bit such as bit 300 instead of the left as illustrated in FIGS. 15A - 15C. As described the leading end of bit 300 includes cone region 310 which includes cutters 328C, nose region 312 which includes cutters 328N, flank region 314 which includes cutters 328F, shoulder region 316 which includes cutters 328S, and gage region 322 which includes cutters 328G

wherein the cutters in each region may be referred to collectively as cutters 328. FIG. 16 illustrates a cutter profile exhibiting a high degree, or amount, of cutter overlap 356. That is, cutters 328 as illustrated in FIG. 17 are provided in sufficient quantity and are positioned sufficiently close to each other laterally, or radially, so as to provide a high degree of cutter redundancy as the bit rotates and engages the formation. In contrast, the representative cutter profile illustrated in FIG. 17 exhibits a relatively lower degree, or amount, of cutter overlap 356. That is, the total number of cutters 328 is less in quantity and are spaced further apart with respect to the radial, or lateral, distance between individual, rotationally adjacent cutter profiles. Kerf regions 348, shown in phantom, in FIGS. 16 and 17 reveal a relatively small height for kerf regions 348 of FIG. 16 wherein kerf regions of FIGS. 17 are significantly higher. To aid in the illustration of the respective differences in individual kerf region height  $K_H$ , which, as a practical matter, is directly related to cutter exposure height  $H_C$ , as well as individual kerf region widths  $K_w$ , which are directly influenced by the extent of radial overlap of cutters respectively positioned on different blades, a scaled reference grid of a plurality of parallel spaced lines is provided in FIGS. 16 and 17 to highlight the cutter exposure height and kerf region widths. The spacing between the grid lines in FIGS. 16 and 17 are scaled to represent approximately .125 of an inch. However, such a .125, or 1/8 inch, scale grid is merely exemplary, as dimensionally greater as well as dimensionally smaller cutter exposure heights, kerf region heights, and kerf region widths may be used in accordance with the present invention. The superimposed cutter profile of cutters 328 is illustrated with each of the represented cutters 328 being generally equidistantly spaced along the face of the bit from centerline L toward gage region 322; however, such need not be the case. For example, cutters 328C may have a cutter profile exhibiting more cutter overlap 356 resulting in a small kerf widths in cone region 310 as compared to a cutter profile of cutters 328N, 328F, and 328S respectively located in nose region 312, flank region 314, and shoulder region 316 wherein such more radially outward positioned cutters would have less overlap resulting in larger kerf widths therein, or vice versa. Thus, by selectively incorporating the amount of cutter overlap 356 to be provided in each region of a bit, the depth of cut of the cutters in combination with selecting the degree or amount of cutter exposure height of each cutter located in each particular region may be utilized to specifically and precisely control the



depth of cut in each region as well as to design into the bit the amount of available bearing surface surrounding the cutters to which the bit may ride upon the formation. Stated differently, the wider the kerf width  $K_w$  between the collective, superimposed, individual cutter profiles of all the cutters on all of the blades, or alternatively all the cutters radially and circumferentially spaced about a bit, such as cutters 328 provided on a bit such as shown in FIG. 17, a greater proportion of the total applied WOB will be dispersed upon the formation allowing the bit to "ride" on the formation than would be the case if a greater quantity of cutters were provided having a smaller kerf width  $K_w$  therebetween as shown in FIG. 16.

[0090] Therefore, the cutter profile illustrated in FIG. 17 would result in a considerable portion of the WOB being applied to bit 300 to be dispersed over the wide kerfs and thereby allowing bit 300 to be supported by the formation as cutters 328 engage the formation. This feature of selecting both the total number of kerfs and the widths of the individual kerf widths  $K_w$  allows for a precise control of the individual depth-of-cuts of the cutters adjacent the kerfs, as well as the total collective depth-of-cut of bit 300 into a formation of a given hardness. Upon a great enough, or amount of, WOB being applied on the bit when drilling in a given relatively hard formation the kerf regions 348 would come to ride upon the formation, thereby limiting, or arresting, the DOC of cutters 328. If yet further WOB were to be applied, the DOC would not increase as the kerf regions 348, as well as portions of the outwardly facing surface of the blade surrounding each cutter 328 provided with a reduced amount of exposure in accordance with the present invention, would, in combination, provide a total amount of bearing surface to support the bit in the relative hard formation, notwithstanding an excessive amount of WOB being applied to the bit in light of the current ROP.

[0091] Contrastingly, in a bit provided with a cutter profile exhibiting dimensionally small cutter-to-cutter spacings by incorporating a relatively high quantity of cutters 328 with a small kerf region  $K_w$  between mutually radially, or laterally, overlapped cutters such as illustrated in FIG. 16, each individual cutter would engage the formation with a lesser amount of DOC per cutter at a given WOB. Because each cutter would engage the formation at a lesser DOC as compared with the cutter profile of FIG. 17, with all other variables being held constant, the cutters of the cutter profile of FIG. 16 would tend to be better suited for engaging a relative hard

formation where a large DOC is not needed, and is in fact not preferred, for engaging and cutting a hard formation efficiently. Upon a requisite, or excessive amount of WOB further being applied on a bit having the cutter profile of FIG. 16 in light of the current ROP being afforded by the bit, kerf regions 348 would come to ride upon the formation, as well as other portions of the outwardly facing blade surface surround each cutter 328 exhibiting a reduced amount of exposure in accordance with the present invention to limit the DOC of each cutter by providing a total amount of bearing surface to disperse the WOB onto the formation being drilled. In general, larger kerfs will promote dynamic stability over formation cutting efficiency, while smaller kerfs will promote formation cutting efficiency over dynamic stability.

[0092] Furthermore, the amount of cutter exposure that each cutter is designed to have will influence how quickly, or easily, the bearing surfaces will come into contact and ride upon the formation to axially disperse the WOB being applied to the bit. That is, a relatively small amount of cutter exposure will allow the surrounding bearing surface to come into contact with the formation at a lower WOB while a relatively greater amount of cutter exposure will delay the contact of the surrounding bearing surface with the formation until a higher WOB is applied to the bit. Thus, individual cutter exposures, as well as the mean kerf widths and kerf heights may be manipulated to control the DOC of not only each cutter, but the collective DOC per revolution of the entire bit as it rotatingly engages a formation of a given hardness and confining pressure at given WOB.

[0093] Therefore, FIG. 16 illustrates an exemplary cutter profile particularly suitable for, but not limited to, a “hard formation,” while FIG. 17 illustrates an exemplary cutter profile particularly suitable for, but not limited to, a “soft formation.” Although the quantity of cutters provided on a bit will significantly influence the amount of kerf provided between radially adjacent cutters, it should be kept in mind that both the size, or diameter, of the cutting surfaces of the cutters may also be selected to alter the cutter profile to be more suitable for either a harder or softer formation. For example, cutters having larger diameter superabrasive tables may be utilized to provide a cutter profile including dimensionally larger kerf heights and dimensionally larger kerf widths to enhance soft formation cutting characteristics. Conversely, a bit may be provided with cutters having smaller diameter superabrasive tables to provide a cutter profile

exhibiting dimensionally smaller kerf heights and dimensionally smaller kerf widths to enhance hard formation cutting characteristics of a bit in accordance with the teachings herein.

[0094] Additionally, the full-gage diameter that a bit is to have will also influence the overall cutter profile of the bit with respect to kerf heights and kerf widths, as there will be a greater total amount of bearing surface potentially available to support larger diameter bits on a formation unless the bit is provided with a proportionately greater number of reduced exposure cutters and, if desired, conventional cutters, so as to effectively reduce the total amount of potential bearing surface area of the bit.

[0095] FIG. 18A of the drawings is an isolated, schematic, frontal view of three representative cutters 328C positioned in cone region 310 of a representative blade structure 308. Each of the representative cutters exhibits a preselected amount of cutter exposure so as to limit the DOC of the cutters while also providing individual kerf regions 348 between cutters 328 (in this particular illustration, kerf width  $K_w$  represents the kerf width between cutters which are located on the same blade and exhibit a selected radial spacing  $R_s$ ) and to which the bearing surface of the blade to which the cutters are secured (surface 320C) provides a bearing surface, including kerf regions 348 for the bit to ride, or rub, upon the formation, not currently being cut by this particular blade 308, upon the design WOB being exceeded for a given ROP in a formation 350 of certain hardness, or compressive strength. As can be seen in FIG. 18A, this particular view shows a rotationally leading blade surface 324 advancing toward the viewer and shows superabrasive cutting face or tables 330 of cutters 328C engaging and creating a formation cutting, or chip, 350' as the cutters engage the formation at a given DOC.

[0096] FIG. 18B provides an isolated, side view of a representative reduced exposure cutter, such as cutter 328C located in cone region 310. Cutter 328C is shown as being secured in a blade 308 at a preselected backrake angle  $\theta_{br}$  and exhibits a selected exposed cutter height  $H_c$ . As can be seen in FIG. 18B, cutter 328C is provided with an optional, peripherally extending chamfered region 321 exhibiting a preselected chamfer width  $C_w$ . The arrow represents the intended direction of bit rotation when the bit in which the cutter is installed is placed in operation. A gap referenced as  $G_1$  can be seen rotationally rearwardly of cutter 328C. Cutter exposure height  $H_c$  allows a sufficient amount of cutter 328C to be exposed to allow cutter 328C

to engage formation 350 at a particular DOC1, which is well within the maximum DOC that cutter 328C is capable of engaging formation 350, to create a formation cutting 350' at this particular DOC1. Thus, in accordance with the present invention, the WOB now being applied to the bit in which cutter 328C is installed, is at a value less than the design WOB for the instant ROP and the compressive strength of formation 350.

[0097] In contrast to FIG. 18B, FIG. 18C provides essentially the same side view of cutter 328C upon the design WOB for the bit being exceeded for the instant ROP and the compressive strength of formation 350. As can be seen in FIG. 18C, reduced exposure cutter 328C is now engaging formation 350 at a DOC2 which happens to be the maximum DOC that this particular cutter 328C should be allowed to cut. This is because formation 350 is now riding upon outwardly facing bearing surface 320C which generally surrounds the exposed portion of cutter 328C. That is, gap  $G_2$  is essentially nil in that surface 320C and formation 350 are contacting each other and surface 320C is sliding upon formation 350 as the bit to which representative reduced exposure cutter 320C is rotated in the direction of the reference arrow. Thus, especially in the absence of optional wear knots 334, DOC2 is essentially limited to the amount of cutter exposure height  $H_c$  at the presently applied WOB in light of the compressive strength of the formation being engaged at the instant ROP. Even if the amount of WOB applied to the bit to which cutter 328C is installed is increased further, DOC2 will not increase as bearing surface 320C, in addition to other face bearing surfaces 320 on the bit accommodating reduced exposure cutter 328, will prevent DOC2 from increasing beyond the maximum amount shown. Thus, bearing surface(s) 320C surrounding at least the exposed portion of cutter 328, taken collectively with other bearing surfaces, will prevent DOC2 from increasing dimensionally to an extent which could cause an unwanted, potentially bit damaging TOB being generated due to cutter 328 overengaging formation 350. That is, a maximum-sized formation cutting 350" associated with a reduced exposure cutter engaging the formation at a respective maximum DOC2, taken in combination with other reduced exposure cutters engaging the formation at a respective maximum DOC2, will not generate as taken in combination, a total, excessive amount of TOB which would stall the bit when the design WOB for the bit is met or exceeded for the particular compressive strength of the formation being engaged at the current ROP. Thus, the

DOCC aspects of this particular embodiment is achieved by preferably ensuring that there is sufficient area surrounding each reduced exposure cutter 328, such as representative reduced exposure cutter 328C, so that not only is the DOC2 for this particular cutter not exceeded, regardless of the WOB being applied, but preferably the DOC of a sufficient number of other cutters provided along the face of a bit encompassing the present invention is limited to an extent which prevents an unwanted, potentially damaging TOB from being generated. Therefore, it is not necessary that each and every cutter provided on a drill bit exhibit a reduced exposure cutter height so as to effectively limit the DOC of each and every cutter, but it is preferred that at least a sufficient quantity of cutters of the total quantity of cutters provided on a bit be provided with at least one of the DOCC features disclosed herein to preclude a bit, and the cutters thereon, from being exposed to a potentially damaging TOB in light of the ROP for the particular formation being drilled. For example, limiting the amount of cutter exposure of each cutter positioned in the cone region of a drill bit may be sufficient to prevent an unwanted amount of TOB should the WOB exceed the design WOB when drilling through a formation of a particular hardness at a particular ROP.

[0098] FIGS. 19 - 22 are graphical portrayals of laboratory test results of four different bladed-style drill bits incorporating PDC cutters on the blades thereof. Drill bits "RE-S" and "RE-W" each had selectively reduced cutter exposures in accordance with the present invention as previously described and illustrated in FIGS. 14A - 18C. However, bit "RE-S" was provided with a cutter profile exhibiting small kerfs and "RE-W" was provided with a cutter profile exhibiting wide kerfs. The bits having reduced exposure cutters are graphically contrasted with the laboratory test results of a prior art steerable bit "STR" featuring approximately .50 inch diameter cutters with each cutter including a superabrasive table having a peripheral edge chamfer exhibiting a width of approximately .050 inches and angled toward the longitudinal axis of the cutter by approximately 45°. Conventional, or standard, general purpose drill bit "STD" featured approximately .50 inch diameter cutters backraked at approximately 20° and exhibiting chamfers that were approximately 0.016 inches in width and angled approximately 45° with respect to the longitudinal axis of the cutter. All bits had a gage diameter of approximately 12.25 inches and were rotated at 120 RPM during testing. With

respect to all of the tested bits, the PDC cutters installed in the cone, nose, flank, and shoulder of the bits had cutter backrake angles of approximately 20° and the PDC cutters installed generally within the gage region had a cutter backrake angle of approximately 30°. The cutter exposure heights of the RE-S and RE-W bits were approximately .120 inches for the cutters positioned in the cone region, approximately .150 inches in the nose region, approximately .100 inches in the flank region, approximately .063 inches in the shoulder region, and the cutters in the gage region were generally ground flush with the gage for both of these bits embodying the present invention. The PDC cutters of the RE-S and RE-W bits were approximately .75 inches in diameter (with the exception of PDC cutters located in the gage region which were smaller diameter and ground flush with the gage) and were provided with a chamfer on the peripheral edge of the superabrasive cutting table of the cutter. The chamfers exhibited a width of approximately .019 inches and were angled toward the longitudinal axes of the cutters by approximately 45°. The mean kerf width of the RE-S bit was approximately 0.3 of an inch and the mean kerf width of the RE-W bit was approximately 0.2 an inch.

**[0099]** FIG. 19 depicts test results of Aggressiveness ( $\mu$ ) vs. DOC (in/rev) of the four different drill bits. Aggressiveness ( $\mu$ ), which is defined as Torque / (Bit Diameter x Thrust), can be expressed as:

$$\mu = 36 \text{Torque (ft-lbs)} / \text{WOB(lbs)} \cdot \text{Bit Diameter(inches)}$$

The values of DOC depicted FIG. 19 represent the DOC measured in inches of penetration per revolution that the test bits made in the test formation of Carthage limestone. The confining pressure of the formation in which the bits were tested was at atmospheric, or in other words 0 psig.

**[00100]** Of significance is the encircled region “D” of the graph of FIG. 19. The plot of bit RE-S prior to encircled region D is very similar in slope to prior art steerable bit STR but upon the DOC reaching about .120 inches, the respective aggressiveness of the RE-S bit falls rather dramatically compared to the plot of the STR bit proximate and within encircled region D. This is attributable to the bearing surfaces of the RE-S bit taking on and axially dispersing the elevated WOB upon the formation axially underlying the bit associated with the larger DOCs, such as the DOCs exceeding approximately .120 inches in accordance with the present invention.

[00101] FIG. 20 graphically portrays the test results with respect to WOB in pounds versus ROP in feet per hour with a drill bit rotation of 120 revolutions per minute. Of general importance in the graph of FIG. 20 is that all of the plots tend to have the same flat curve as WOB and ROP increases indicating that at lower WOBs and lower ROPs of the RE-S and RE-W bits embodying the present invention exhibit generally the same behavior as the STR and STD bits. However, as WOB was increased, the RE-S bit in particular required an extremely high amount of WOB in order to increase the ROP for the bit due to the bearing surfaces of the bit taking on and dispersing the axial loading of the bit. This is evidenced by the plot of the reduced cutter exposure bit in the vicinity of region "E" of the graph exhibiting a dramatic upward slope. Thus, in order to increase the ROP of the subject inventive bit at ROP values exceeding about 75 ft/hr, a very significant increase of WOB was required for WOB values above approximately 20,000 lbs as the load on the subject bit was successfully dispersed on the formation axially underlying the bit. The fact that a WOB of approximately 40,000 lbs was applied without the RE-S bit stalling provides very strong evidence of the effectiveness of incorporating reduced exposure cutters to modulate and control TOB in accordance with the present invention as will become even more apparent in yet to be discussed FIG. 22.

[00102] FIG. 21 is a graphical portrayal of the test results in terms of TOB in the units of pounds-foot versus ROP in the units of feet per hour. As can be seen in the graph of FIG. 21 the various plots of the tested bits generally tracked the same, moderate and linear slope throughout the respective extent of each plot. Even in region "F" of the graph, where ROP was over 80 ft/hr, the TOB curve of the bit having reduced exposure cutters exhibited only slightly more TOB as compared to the prior art steerable and standard, general purpose bit notwithstanding the corresponding highly elevated WOB being applied to the subject inventive bit as shown in FIG. 20.

[00103] FIG. 22 is a graphical portrayal of the test results in terms of TOB in the units of foot-pounds versus WOB in the units of pounds. Of particular significance with respect to the graphical data presented in FIG. 22 is that the STD bit provides a high degree of aggressivity at the expense of generating a relatively high amount of TOB at lower WOBs. Thus, if a generally non-steerable, standard bit were to suddenly "break through" a relative hard formation into a

relatively soft formation, or if WOB were suddenly increased for some reason, the attendant high TOB generated by the highly aggressive nature of such a conventional bit would potentially stall and/or damage the bit.

[00104] The representative prior art steerable bit generally has an efficient TOB/WOB slope at WOB's below approximately 20,000 lbs but at WOBs exceeding approximately 20,000 lbs, the attendant TOB is unacceptably high and could lead to unwanted bit stalling and/or damage. The RE-W bit incorporating the reduced exposure cutters in accordance with the present invention, which also incorporated a cutter profile having large kerf widths so that the onset of the bearing surfaces of the bit contacting the formation occurs at relatively low values of WOB. However, the bit having such an "always rubbing the formation" characteristic via the bearing surfaces, such as formation facing surfaces 320 of blades 308 as previously discussed and illustrated herein, coming into contact and axially dispersing the applied WOB upon the formation at relatively low WOBs, may provide acceptable ROPs in soft formations, but such a bit would lack the amount of aggressivity needed to provide suitable ROPs in harder, firmer formations and thus could be generally considered to exhibit an inefficient TOB versus WOB curve.

[00105] The representative RE-S bit incorporating reduced exposure cutters of the present invention and exhibiting relatively small kerf widths effectively delayed the bearing surfaces (for example, including but not limited to surface 320 of blades 308 as previously discussed and illustrated herein) surrounding the cutters from contacting the formation until relatively higher WOBs were applied to the bit. This particularly desirable characteristic is evidenced by the plot for the RE-S bit at WOB values greater than approximately 20,000 lbs exhibits a relatively flat and linear slope as the WOB is approximately doubled to 40,000 lbs with the resulting TOB only increasing by about 25% from a value of about 3,250 ft-lbs to a value of approximately 4,500 ft-lbs. Thus, considering the entire plot for the subject inventive bit over the depicted range of WOB, the RE-S bit is aggressive enough to efficiently penetrate firmer formations at a relatively high ROP, but if WOB should be increased, such as by loss of control of the applied WOB, or upon breaking through from a hard formation into a softer formation, the bearing surfaces of the bit contact the formation in accordance with the present



invention to limit the DOC of the bit as well as to modulate the resulting TOB so as to prevent stalling of the bit. Because stalling of the bit is prevented, the unwanted occurrence of losing tool face control or worse, damage to the bit is minimized if not entirely prevented in many situations.

**[00106]** It can now be appreciated that the present invention is particularly suitable for applications involving extended reach or horizontal drilling where control of WOB becomes very problematic due to friction-induced drag on the bit, downhole motor if being utilized, and at least a portion of the drill string, particularly that portion of the drill string within the extended reach, or horizontal, section of the borehole being drilled. In the case of conventional, general purpose fixed cutter bits, or even when using prior art bits designed to have enhanced steerability, which exhibit high efficiency, that is, the ability to provide a high ROP at a relatively low WOB, the bit will be especially prone to large magnitudes of WOB fluctuation, which can vary from 10 to 20 klbs (10,000 to 20,000 pounds) or more, as the bit lurches forward after overcoming a particularly troublesome amount of frictional drag. The accompanying spikes in TOB resulting from the sudden increase in WOB may in many cases be enough to stall a downhole motor or damage a high efficient drill bit and or attached drill string when using a conventional drill string driven by a less sophisticated conventional drilling rig. If a bit exhibiting a low efficiency is used, that is, a bit that requires a relatively high WOB is applied to render a suitable ROP, the bit may not be able to provide a fast enough ROP when drilling harder, firmer formations. Therefore, when practicing the present invention of providing a bit having a limited amount of cutter exposure above the surrounding bearing surface of the bit and selecting a cutter profile which will provide a suitable kerf width and kerf height, a bit embodying the present invention will optimally have a high enough efficiency to drill hard formations at low depths-of-cut but exhibit a torque ceiling that will not be exceeded in soft formations when WOB surges.

**[00107]** While the present invention has been described herein with respect to certain preferred embodiments, those of ordinary skill in the art will recognize and appreciate that it is not so limited and many additions, deletions, and modifications to the preferred embodiments may be made without departing from the scope of the invention as claimed. In addition, features from one embodiment may be combined with features of another embodiment while still being

encompassed within the scope of the invention. Further, the invention has utility in both full bore bits and core bits, and with different and various bit profiles as well as cutter types, configurations and mounting approaches.

## CLAIMS

What is claimed is:

1. A drill bit for subterranean drilling, comprising:  
a bit body including a longitudinal centerline, a leading end having a face for contacting a subterranean formation during drilling, and a trailing end having a structure associated therewith for connecting the bit body to a drill string, the face of the leading end including a bearing surface sized and configured to transfer a range of weight-on-bit from the body of the bit through the bearing surface to the subterranean formation, wherein the range of weight-on-bit comprises any weight-on-bit which results in the bearing surface contacting the subterranean formation without substantial indentation of the bearing surface thereinto;  
wherein the bearing surface area is structured so that the bearing surface area in contact with the subterranean formation remains substantially constant within the range of weight-on-bit;  
and  
at least one superabrasive cutter secured to a selected portion of the face of the leading end of the bit body and configured for engaging the subterranean formation during drilling.
2. The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a plurality of superabrasive cutters and the face of the leading end comprises a plurality of blade structures protruding from the bit body, at least some of the plurality of blade structures carrying at least one of the plurality of superabrasive cutters and the blade structures exhibiting in total a combined bearing surface area of sufficient size to substantially prevent indentation of the combined bearing surface into the subterranean formation.

3. The drill bit of claim 2, wherein the at least some of the plurality of blade structures each extend from a respective point generally proximate the longitudinal centerline of the bit body generally radially outward toward a gage of the bit body and longitudinally toward the trailing end of the bit body.

4. The drill bit of claim 3, wherein the at least some of the plurality of blade structures each carry several of the plurality of superabrasive cutters and exhibit at least one bearing surface, and wherein each of the plurality of blade structures generally encompasses each of the several of the plurality of superabrasive cutters carried thereon with a limited portion of each of the several superabrasive cutters exposed by a preselected extent perpendicular from the respective at least one bearing surface proximate each of the several superabrasive cutters so as to control a respective depth-of-cut for each of the several superabrasive cutters.

5. The drill bit of claim 2, wherein the bit body comprises at least one of steel and a metal matrix.

6. The drill bit of claim 4, wherein at least a portion of the at least one bearing surface of at least one of the plurality of blade structures includes a wear-resistant exterior.

7. The drill bit of claim 6, wherein the wear-resistant exterior comprises at least one of the group consisting of carbide, tungsten carbide, synthetic diamond, natural diamond, polycrystalline diamond, thermally stable polycrystalline diamond, cubic boron nitride, and hard facing material.

8. The drill bit of claim 2, wherein at least one bearing surface of at least one of the plurality of blade structures comprises a wear-resistant exterior.

9. The drill bit of claim 1, wherein the face of the leading end of the bit body comprises cone, nose, flank, shoulder, and gage regions.

10. The drill bit of claim 9, wherein the portion of the bearing surface area positioned in the cone region exhibits a greater amount of bearing surface area than the portion of bearing surface area positioned in the nose region.

11. The drill bit of claim 10, wherein the portion of the bearing surface area positioned in the nose region exhibits a greater amount of bearing surface area than the portion of bearing surface area positioned in the flank region.

12. The drill bit of claim 9, wherein portion of the bearing surface area positioned in the cone region exhibits a greater amount of bearing surface area than the portion of the bearing surface area positioned in the shoulder region.

13. The drill bit of claim 2, wherein at least one superabrasive cutter of the plurality comprises a chamfered region extending at least partially about a circumferential periphery thereof.

14. The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a chamfered peripheral edge portion of a preselected width and chamfer angle.

15. The drill bit claim 1, comprising at least another bearing surface configured to transfer another weight-on-bit from the body of the bit through the another bearing surface to the subterranean formation at a weight-on-bit above which results in the another bearing surface contacting the subterranean formation without substantial indentation of the another bearing surface thereinto.

16. A method of drilling a subterranean formation without generating an excessive amount of torque-on-bit, comprising:  
engaging the subterranean formation with at least one cutter of a drill bit within a selected depth-of-cut range;  
applying a weight-on-bit within a range of weight-on-bit in excess of that required for the at least one cutter to penetrate the subterranean formation and above which results in a bearing surface contacting the subterranean formation;  
wherein the area of the bearing surface contacting the subterranean formation remains substantially constant over the range of excess weight-on-bit; and  
transferring the excess weight-on-bit from the body of the bit through a bearing surface to the subterranean formation without substantial indentation of the bearing surface into the subterranean formation.

17. The method of claim 16, wherein transferring the excess weight-on-bit from the body of the bit through a bearing surface to the subterranean formation comprises transferring the excess weight-on-bit to at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter.

18. The method of claim 17, wherein transferring the excess weight-on-bit to at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a plurality of wear knots on the formation-facing bearing surfaces.

19. The method of claim 17, wherein transferring the excess weight-on-bit to at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a hard facing material affixed to a selected portion of the respective at least one formation-facing bearing surface proximate at least one of the superabrasive cutters.

20. The method of claim 16, further comprising:  
applying an additional weight-on-bit in excess of the excess weight-on-bit required for the bearing surface to contact the subterranean formation and above which results in the bearing surface and another bearing surface contacting the subterranean formation; and transferring the additional excess weight-on-bit from the body of the bit through the another bearing surface to the subterranean formation without substantial indentation of the another bearing surface thereinto.

21. A method of designing a drill bit for drilling a subterranean formation, the drill bit under design including a plurality of superabrasive cutters disposed about the formation-engaging leading end of the drill bit, the method comprising:  
selecting a maximum depth-of-cut for the at least some of the plurality of superabrasive cutters;  
selecting a cutter profile arrangement to which the at least some of the plurality of superabrasive cutters are to be radially and longitudinally positioned on the leading end of the drill bit;  
and  
configuring within the design of the drill bit a sufficient total amount of formation-facing bearing surface area structured for axially supporting the drill bit without substantially indenting the subterranean formation should the drill bit be subjected to a weight-on-bit exceeding a weight-on-bit which would cause the bearing surface area to contact the subterranean formation, wherein the bearing surface area is sized and configured to remain substantially constant over a range of excess weight-on-bit.

22. The method of claim 21, further comprising including within the drill bit under design a plurality of kerf regions of a preselected width positioned laterally intermediate of selected rotationally adjacently positioned superabrasive cutters.

23. The method of claim 21, wherein configuring within the design of the drill bit a sufficient total amount of formation-facing bearing surface area comprises selecting an amount of hard facing to be disposed on at least a portion of the at least one respective formation-facing bearing surface at least partially surrounding the at least some of the plurality of superabrasive cutters.

24. The method of claim 21, further comprising:  
including within the design of the drill bit another formation-facing bearing surface area structured for axially supporting the drill bit without substantially indenting the subterranean formation therewith should the drill bit be subjected to an additional excess weight-on-bit exceeding the excess weight-on-bit.

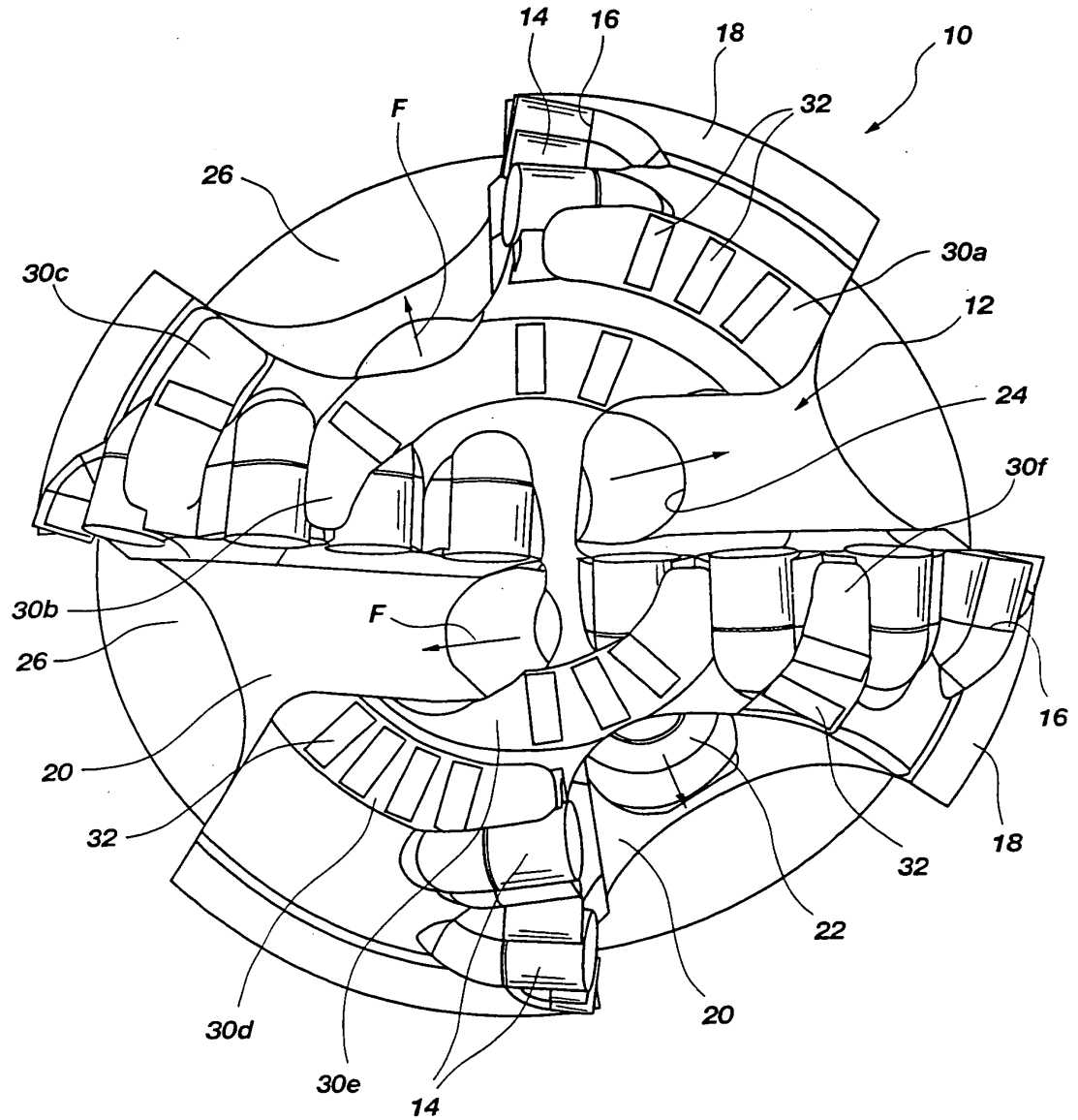


## ABSTRACT OF THE DISCLOSURE

A rotary drag bit and method for drilling subterranean formations including a bit body being provided with at least one cutter thereon exhibiting reduced, or limited, exposure to the formation so as to control the depth-of-cut of the at least one cutter, so as to control the volume of formation material cut per bit rotation, as well as to control the amount of torque experienced by the bit and an optionally associated bottomhole assembly regardless of the effective weight-on-bit. The exterior of the bit preferably includes a plurality of blade structures carrying at least one such cutter thereon and including a sufficient amount of bearing surface area to contact the formation so as to generally distribute an additional weight applied to the bit against the bottom of the borehole without exceeding the compressive strength of the formation rock.

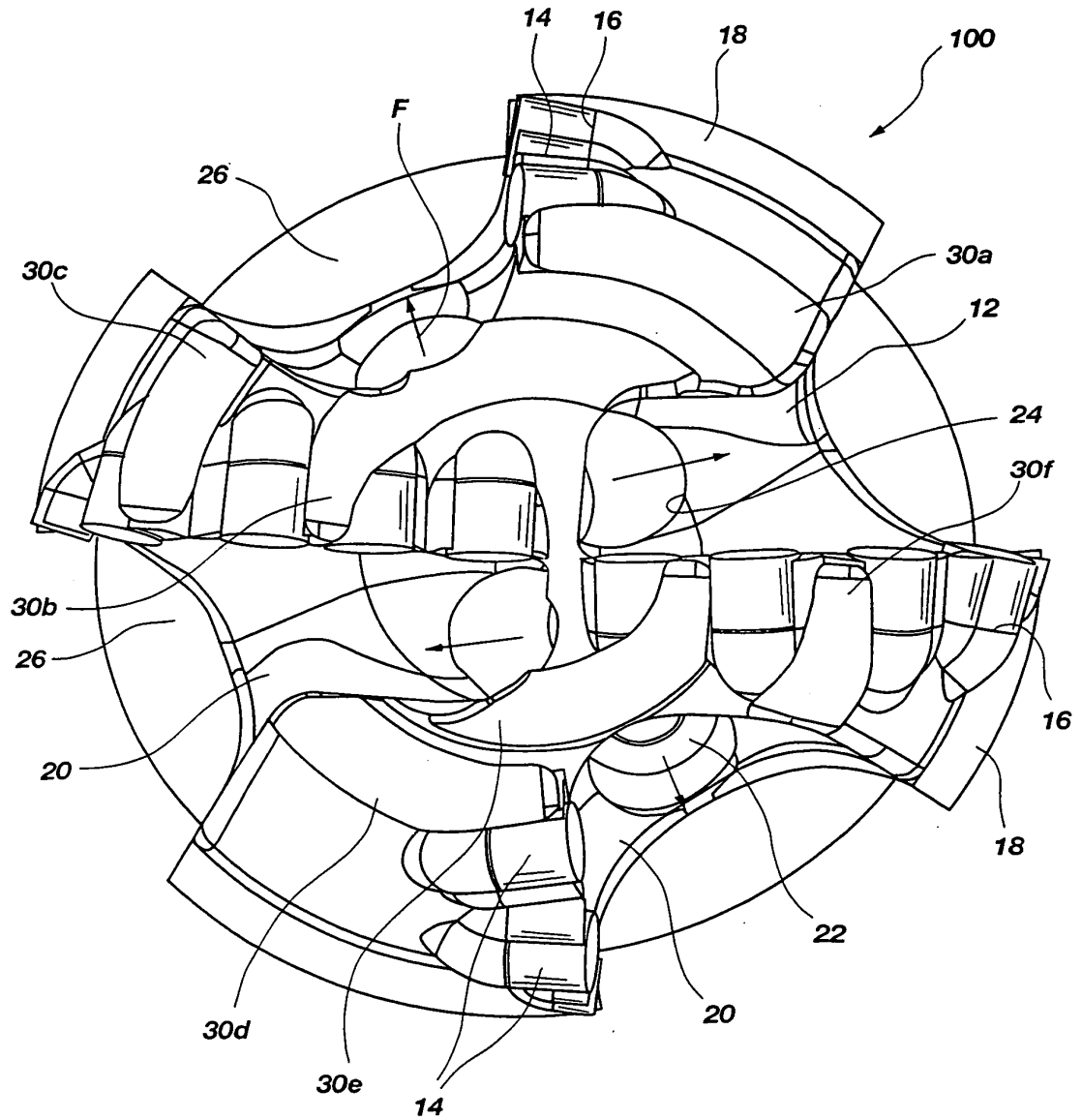
NA16844578.2(CONT.PAT.APP.DOC 06/03/04

1/22



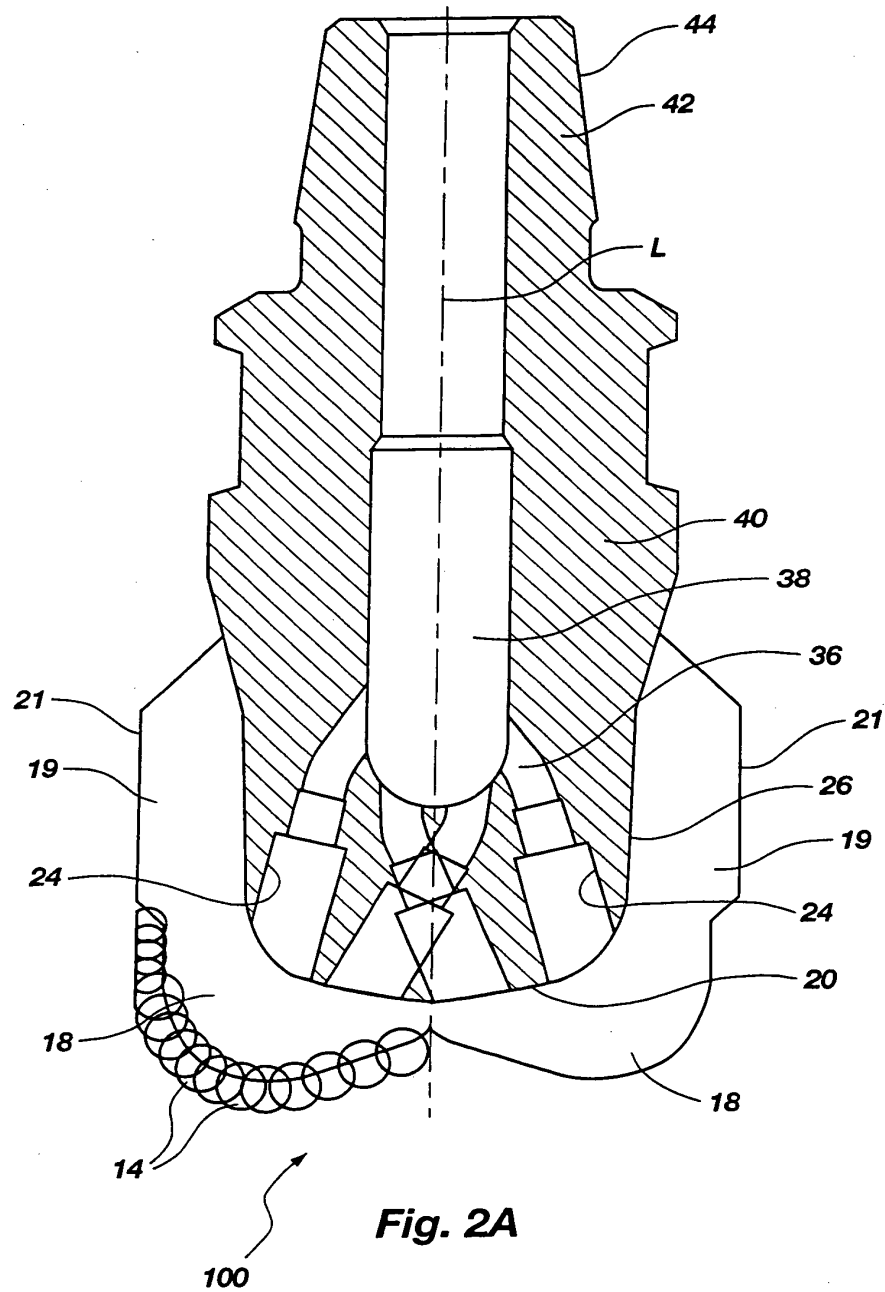
**Fig. 1**

2/22



**Fig. 2**

3/22



TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS  
 Inventor: Mark W. Dykstra et al.  
 Serial No.: Not Yet Assigned  
 Docket No.: 4578.2US

4/22

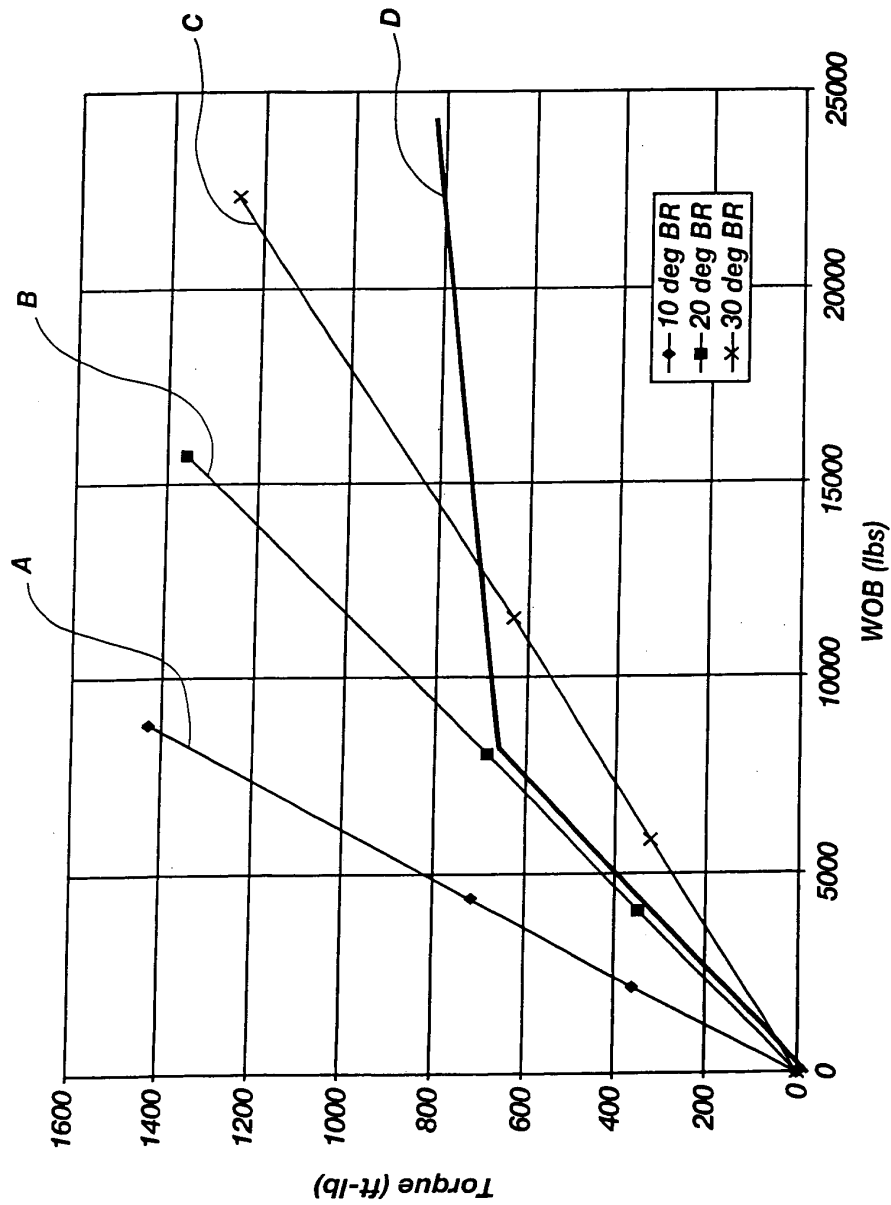


Fig. 3

5/22

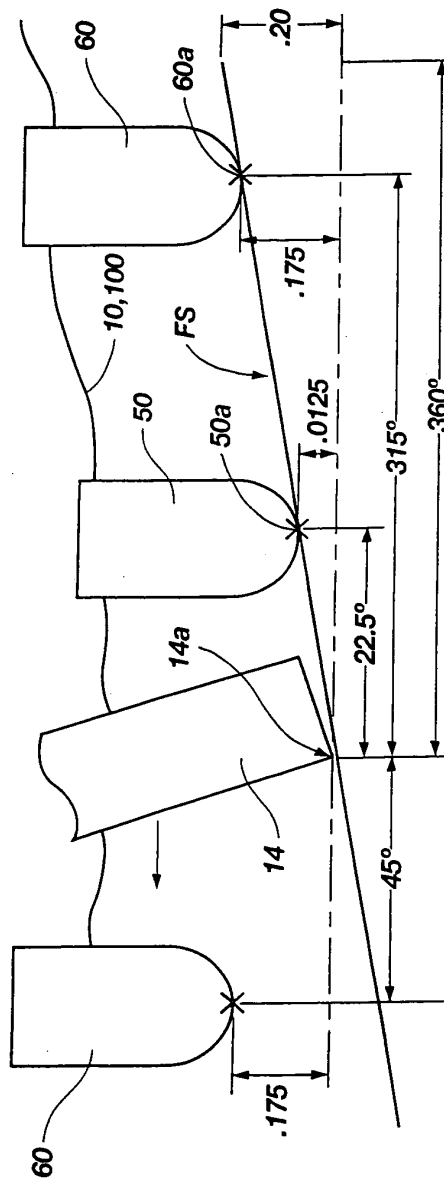


Fig. 4

TITLE: DRILL BITS WITH REDUCED EXPOSURE OF  
CUTTERS

Inventor: Mark W. Dykstra et al.

Serial No.: Not Yet Assigned

Docket No.: 4578.2US

6/22

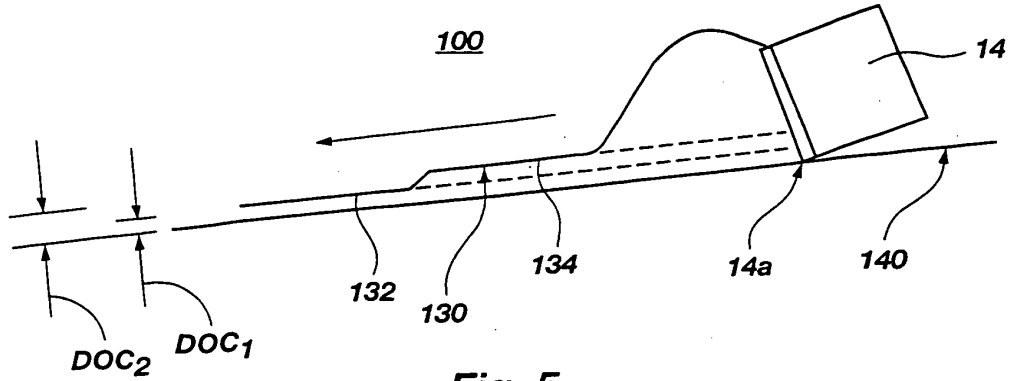


Fig. 5

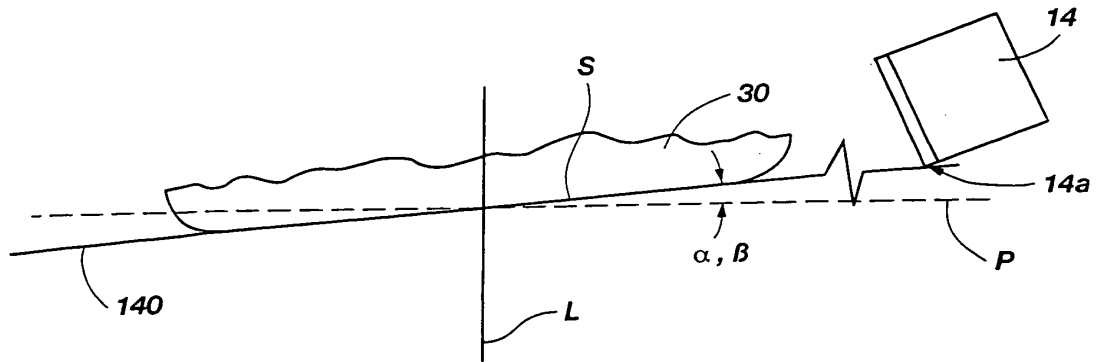


Fig. 6A

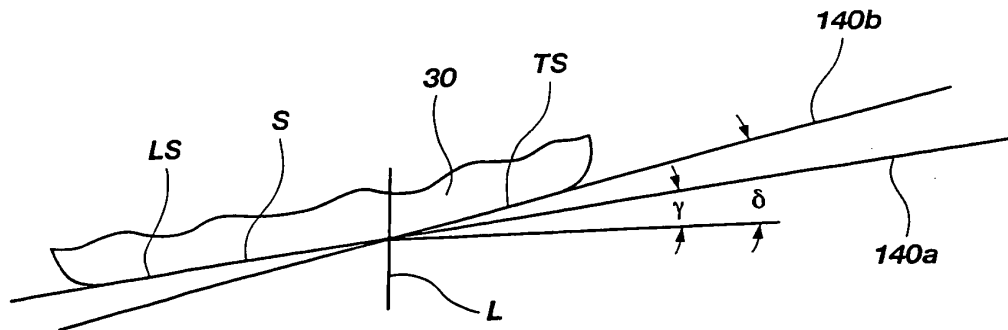
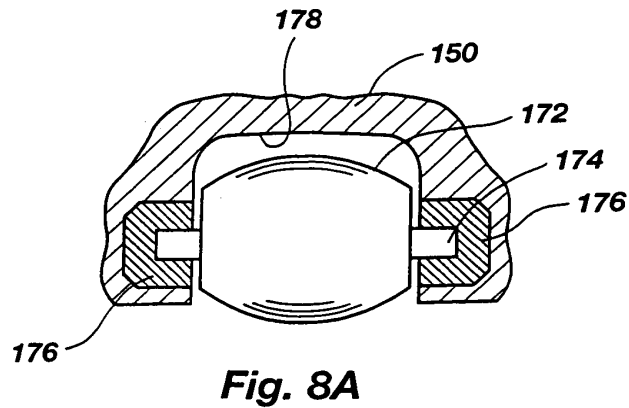
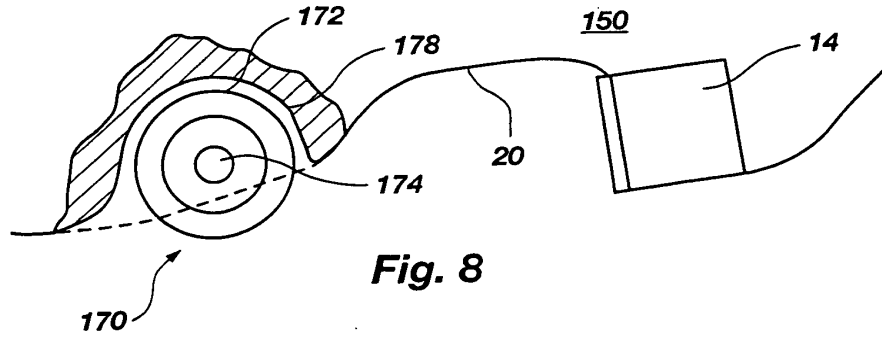
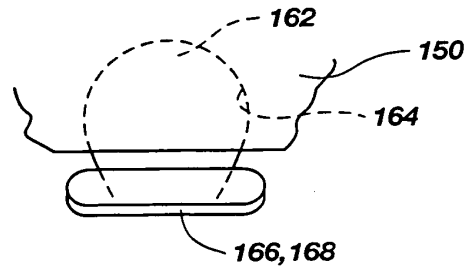
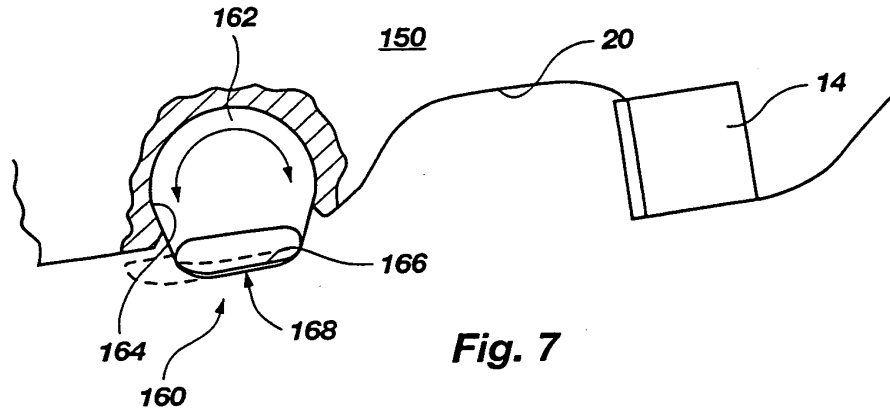


Fig. 6B

TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.  
Serial No.: Not Yet Assigned  
Docket No.: 4578.2US

7/22





TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.  
Serial No.: Not Yet Assigned  
Docket No.: 4578.2US

8/22

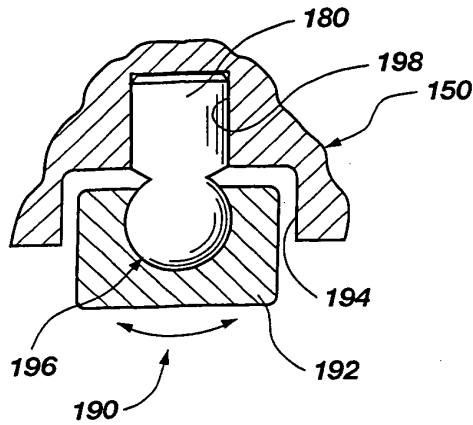


Fig. 9A

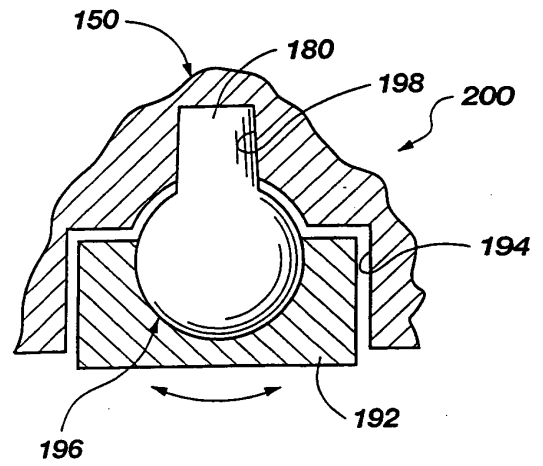


Fig. 9B

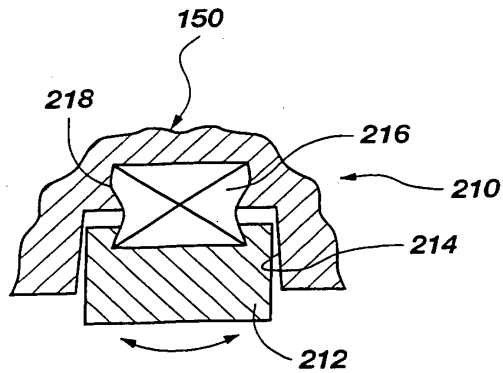


Fig. 9C

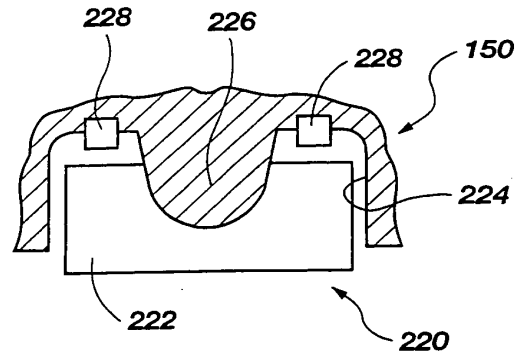


Fig. 9D

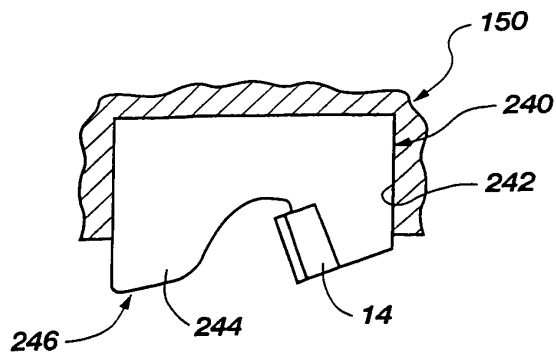


Fig. 10A

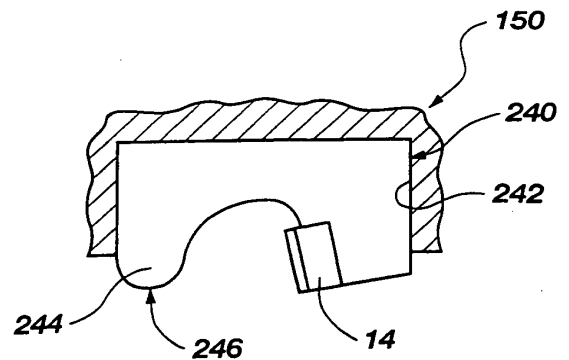
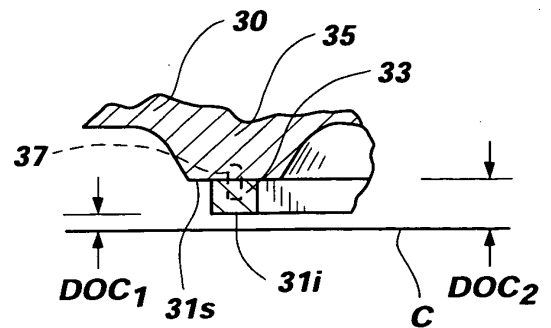
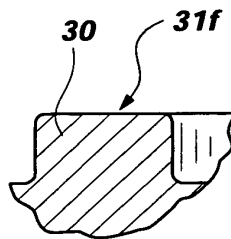
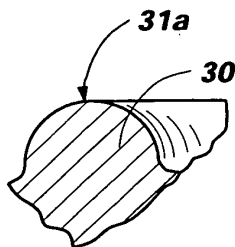
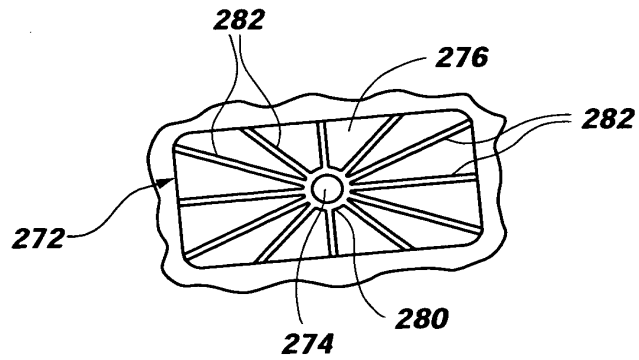
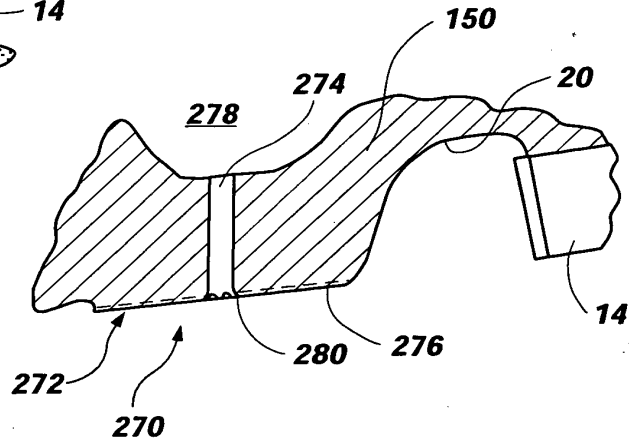
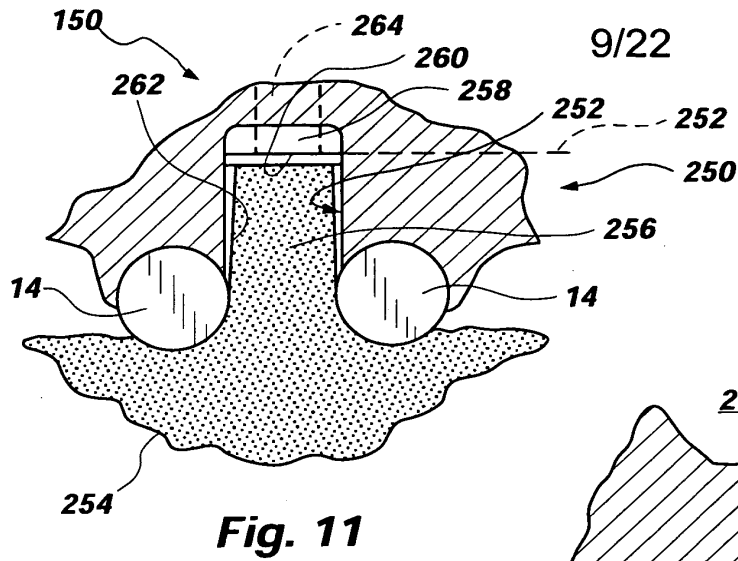


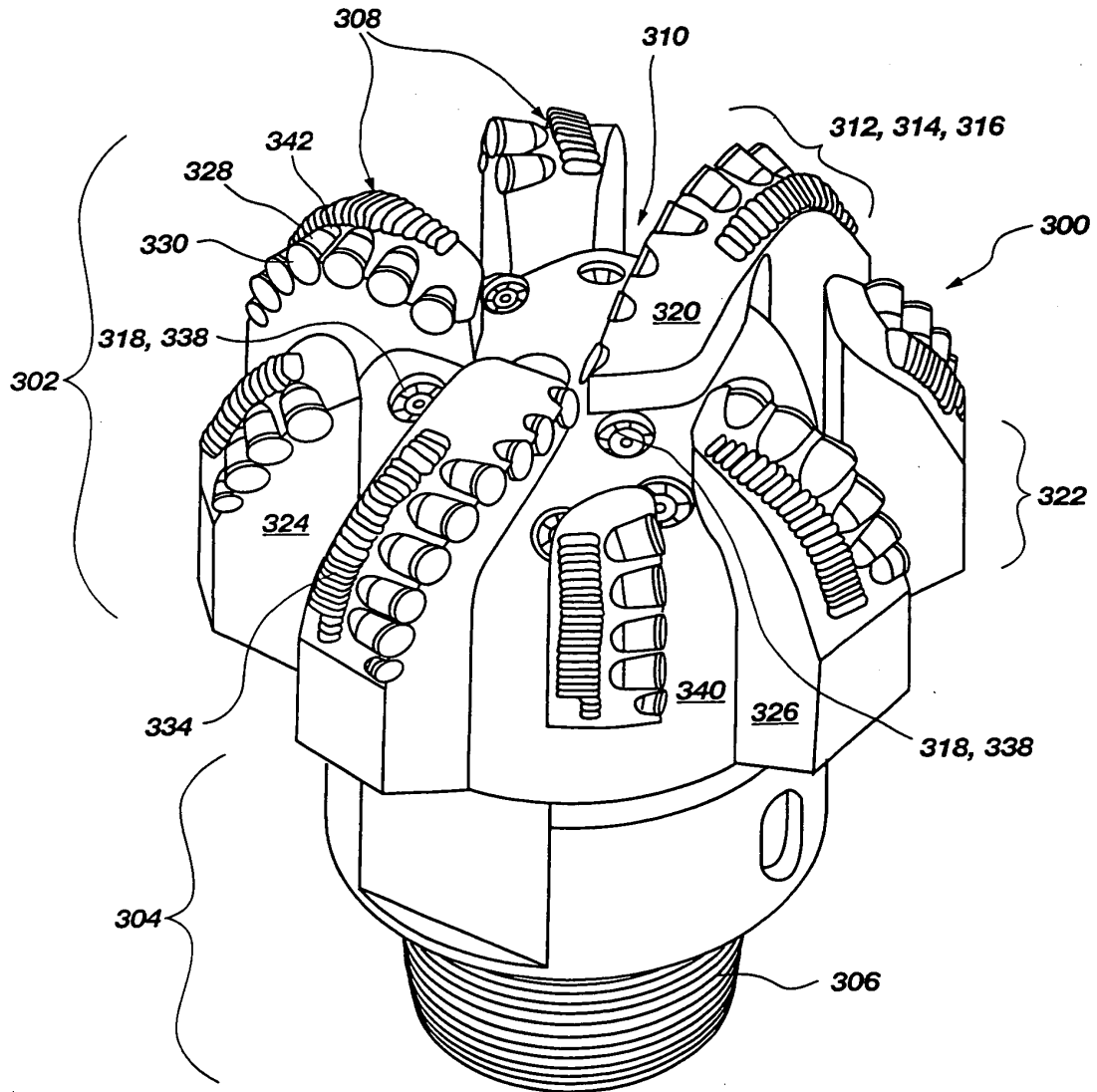
Fig. 10B

TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.  
Serial No.: Not Yet Assigned  
Docket No.: 4578.2US

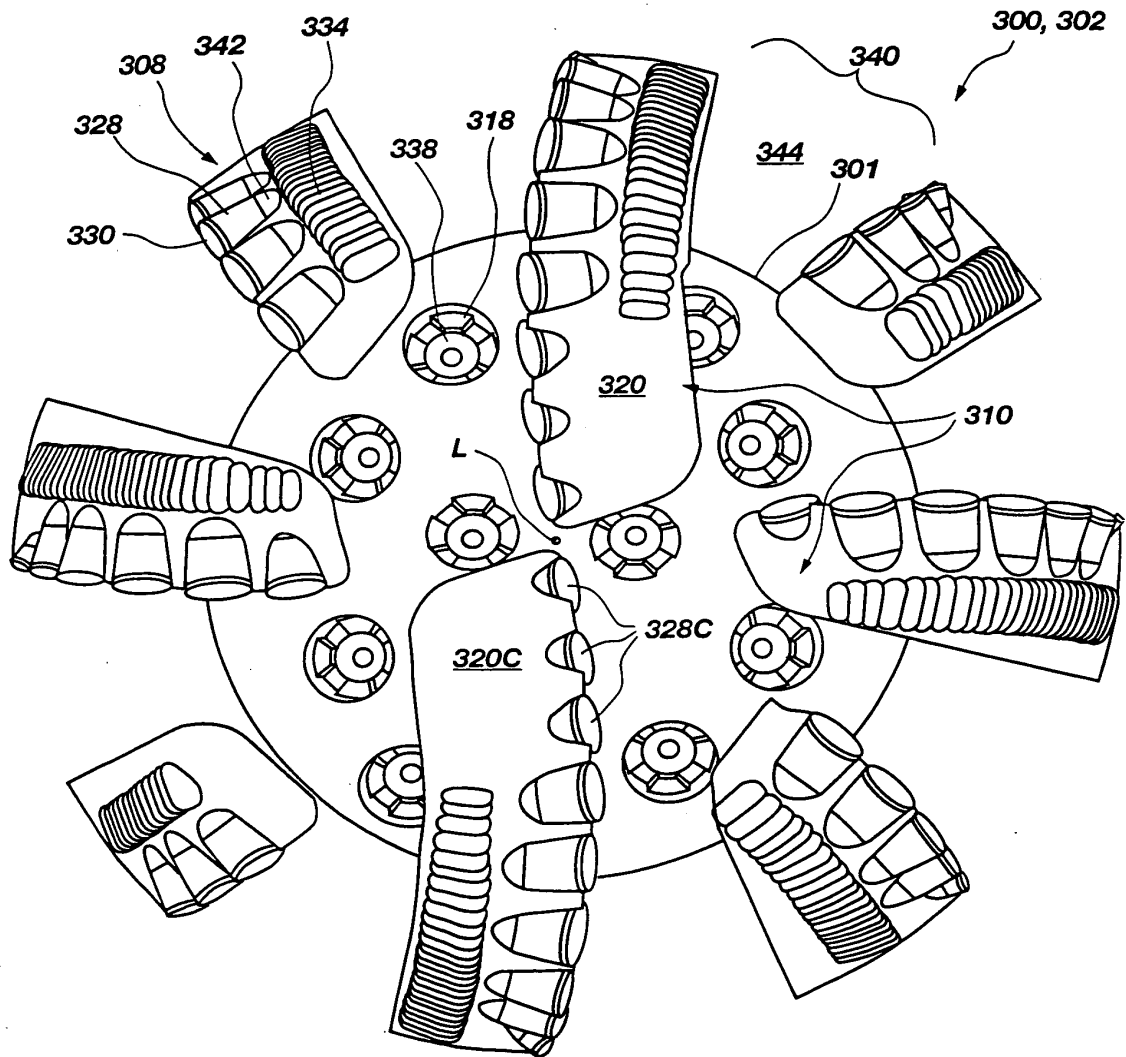


10/22



**Fig. 14A**

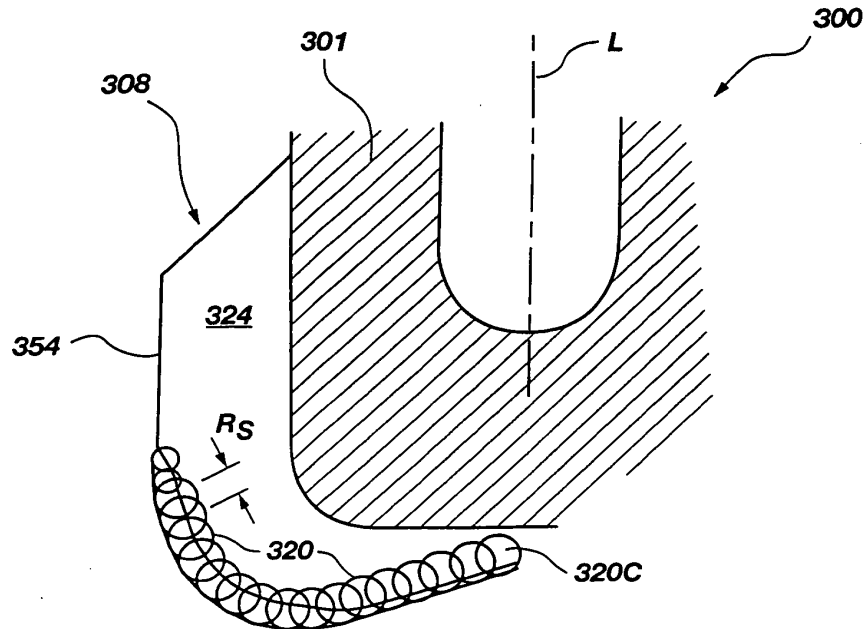
11/22



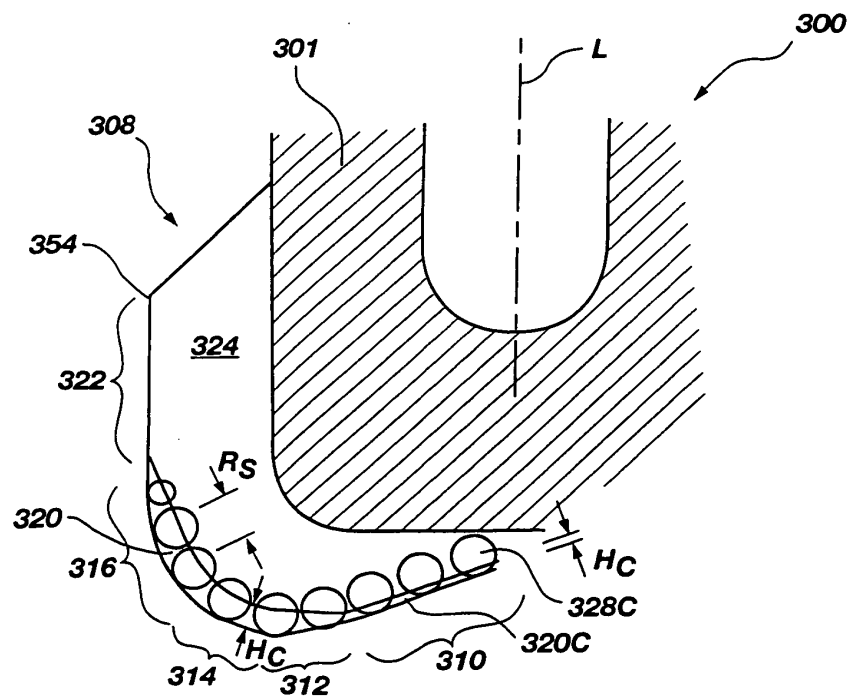
**Fig. 14B**



13/22



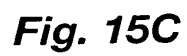
**Fig. 15B**



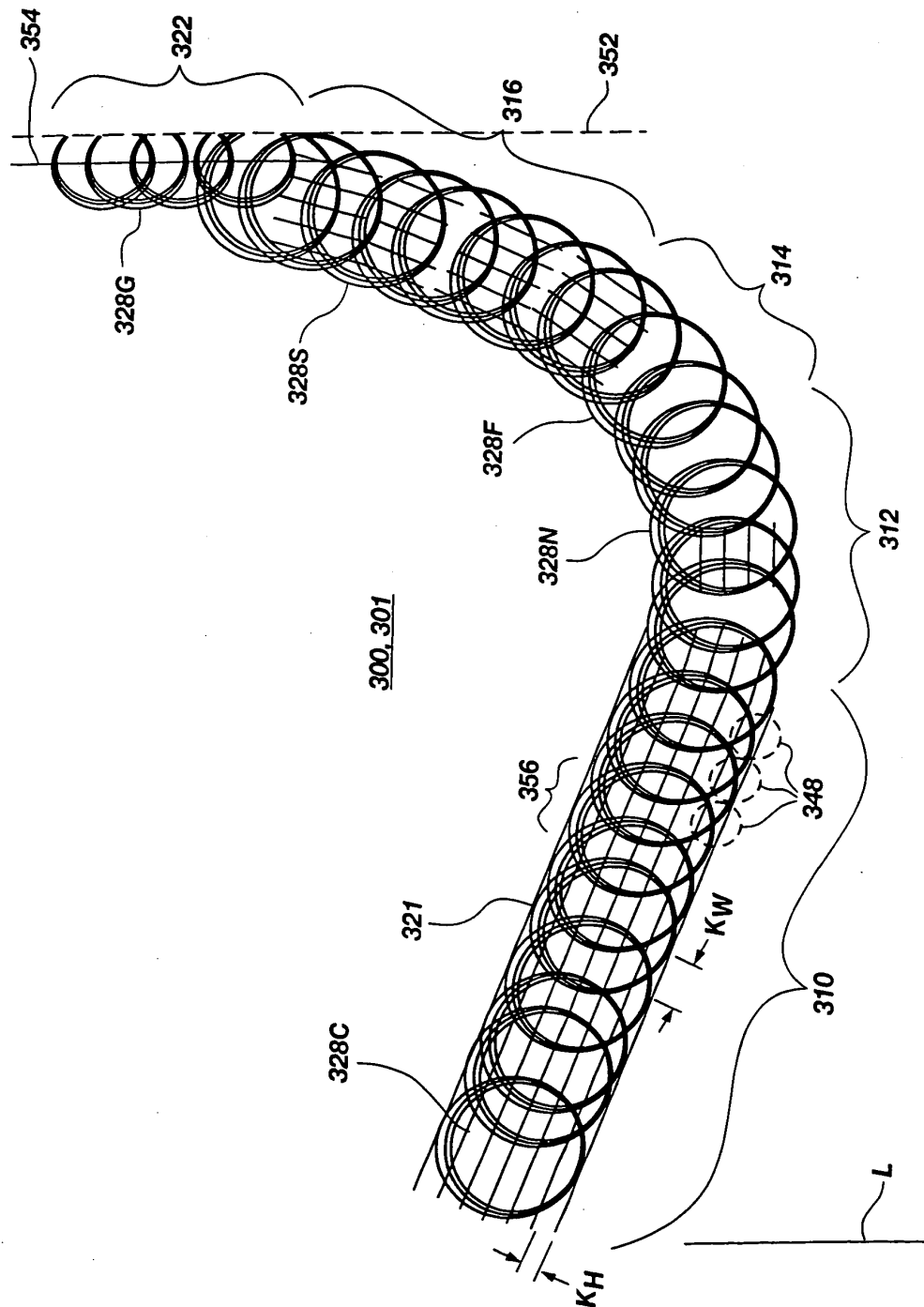
**Fig. 15A**

• •

14/22



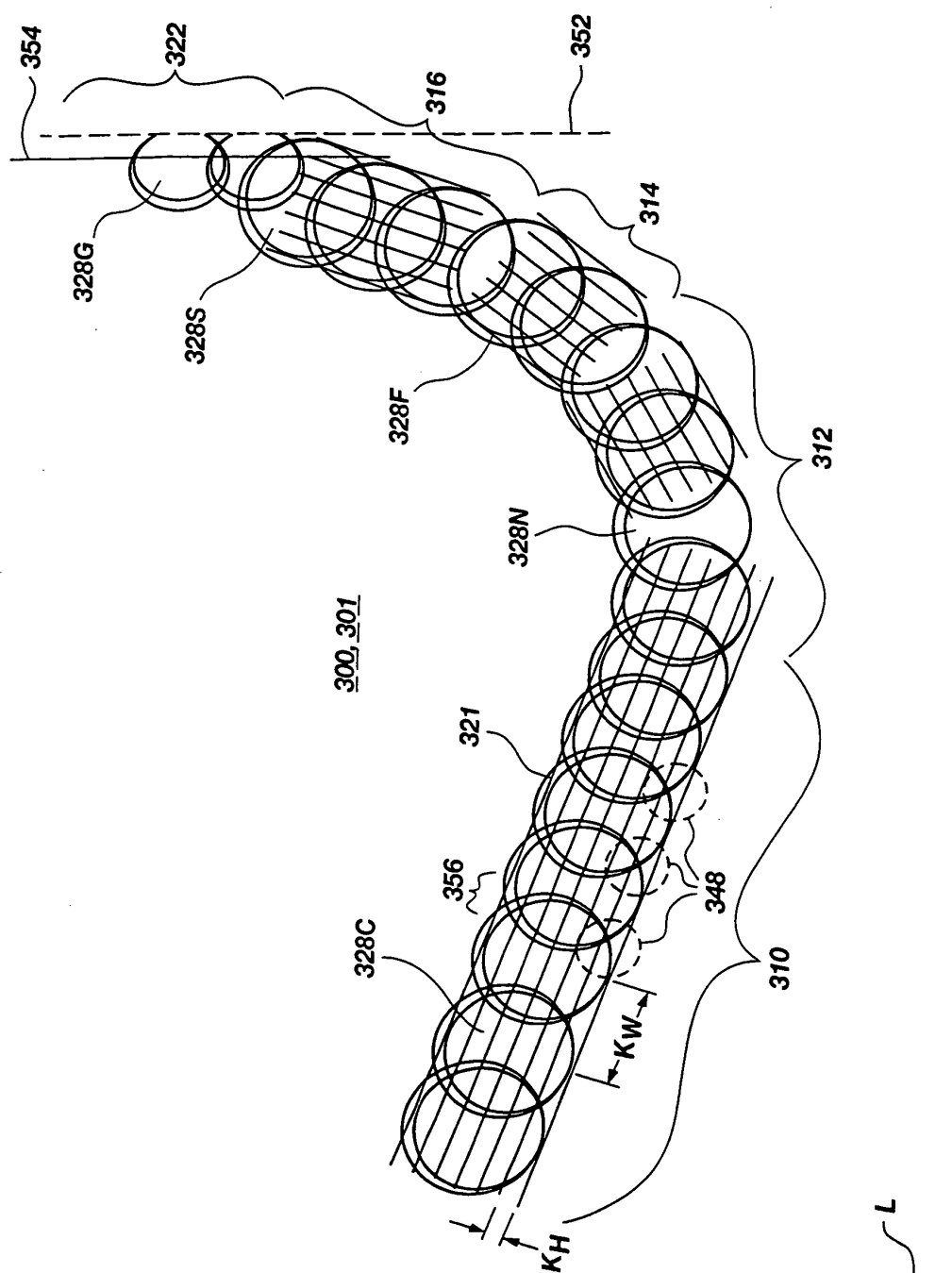
15/22



**Fig. 16**



16/22



**Fig. 17**

TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.  
Serial No.: Not Yet Assigned  
Docket No.: 4578.2US

17/22

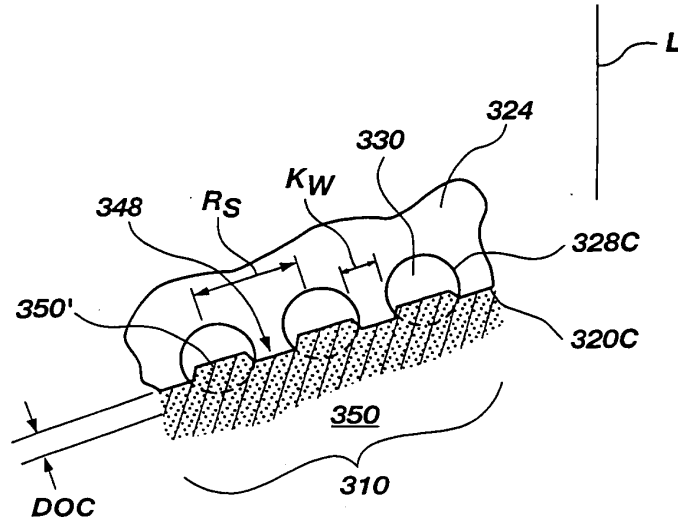


Fig. 18A

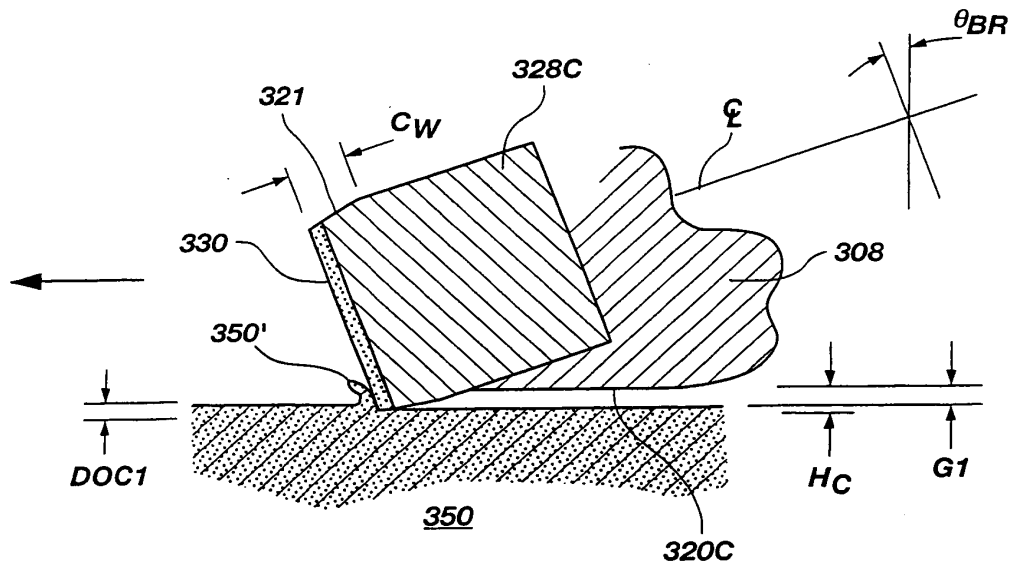
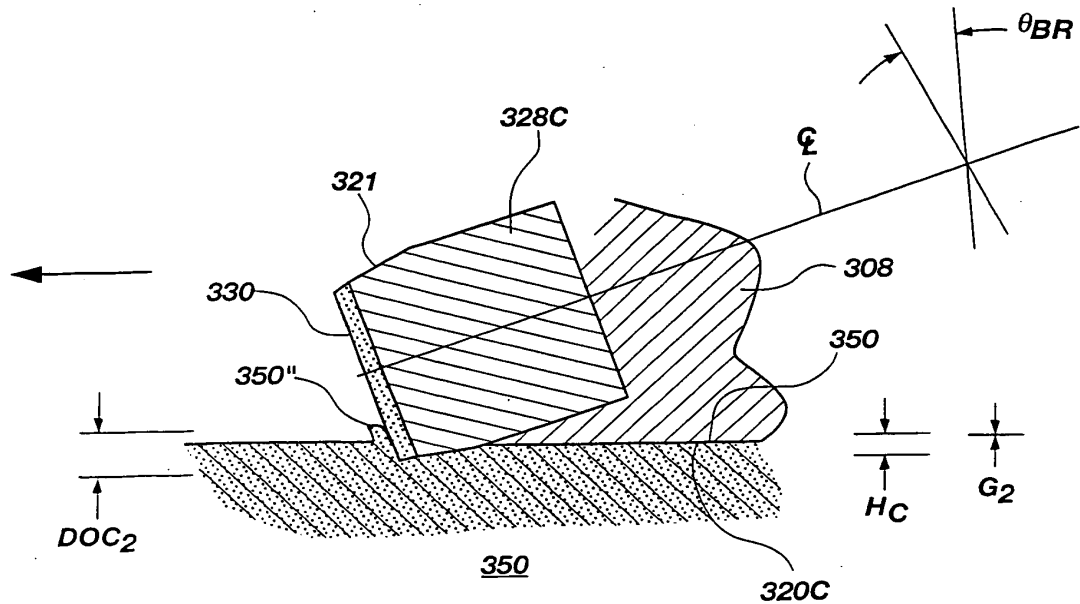


Fig. 18B

18/22



**Fig. 18C**

19/22

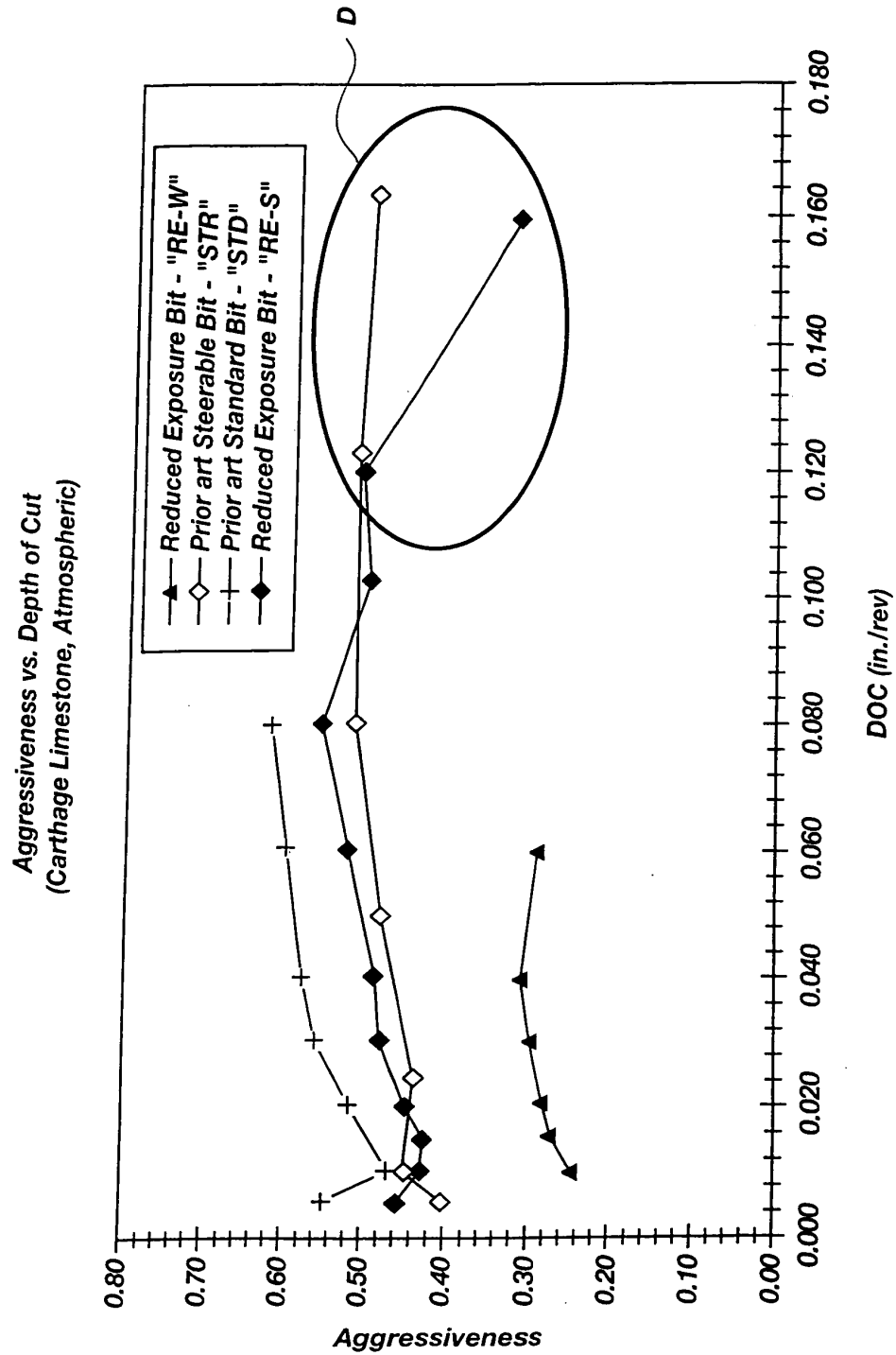


Fig. 19

TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.

Serial No.: Not Yet Assigned

Docket No.: 4578.2US

20/22

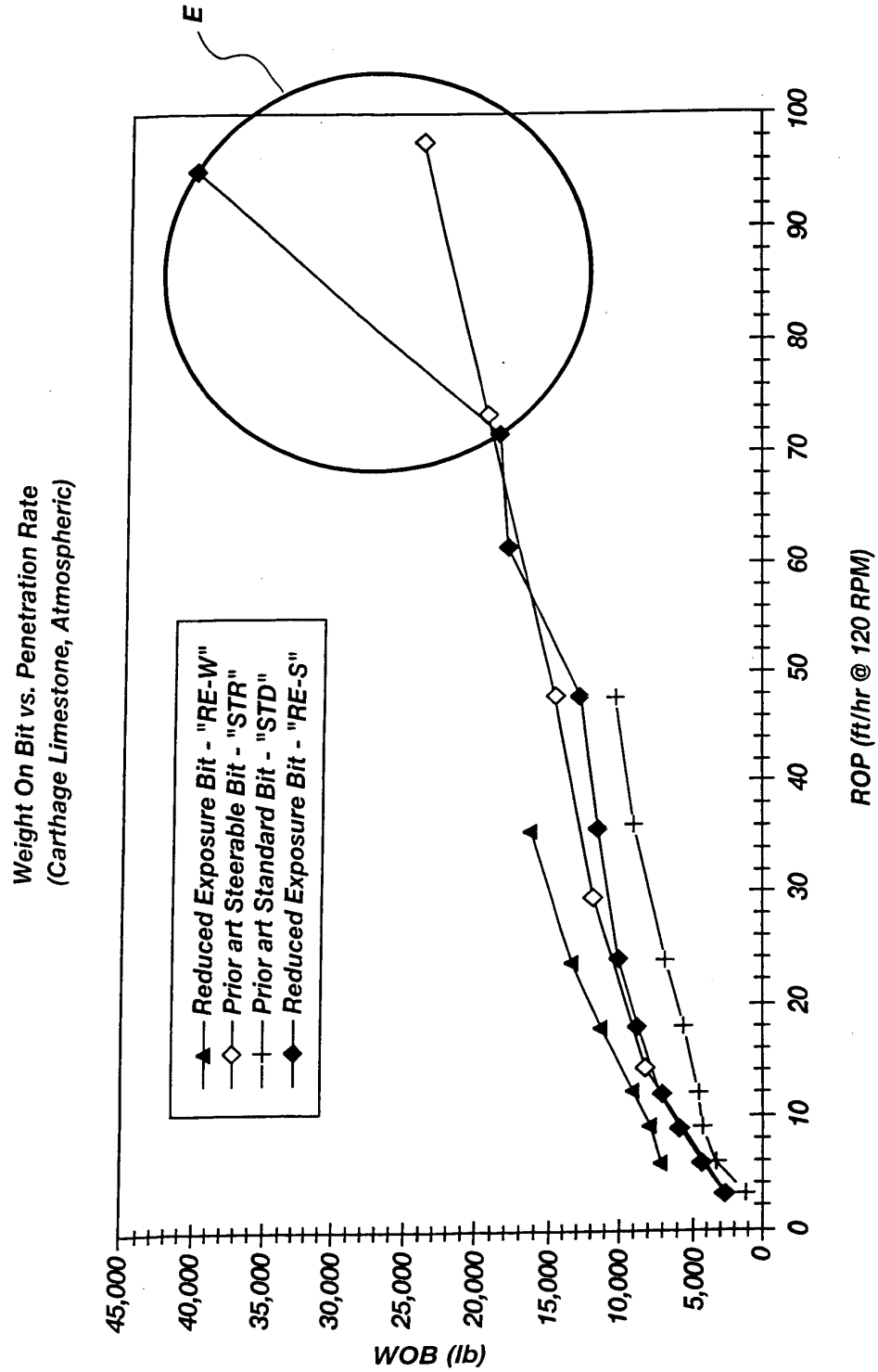


Fig. 20

# TITLE: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor: Mark W. Dykstra et al.

Serial No.: Not Yet Assigned

Docket No.: 4578.2US

21/22

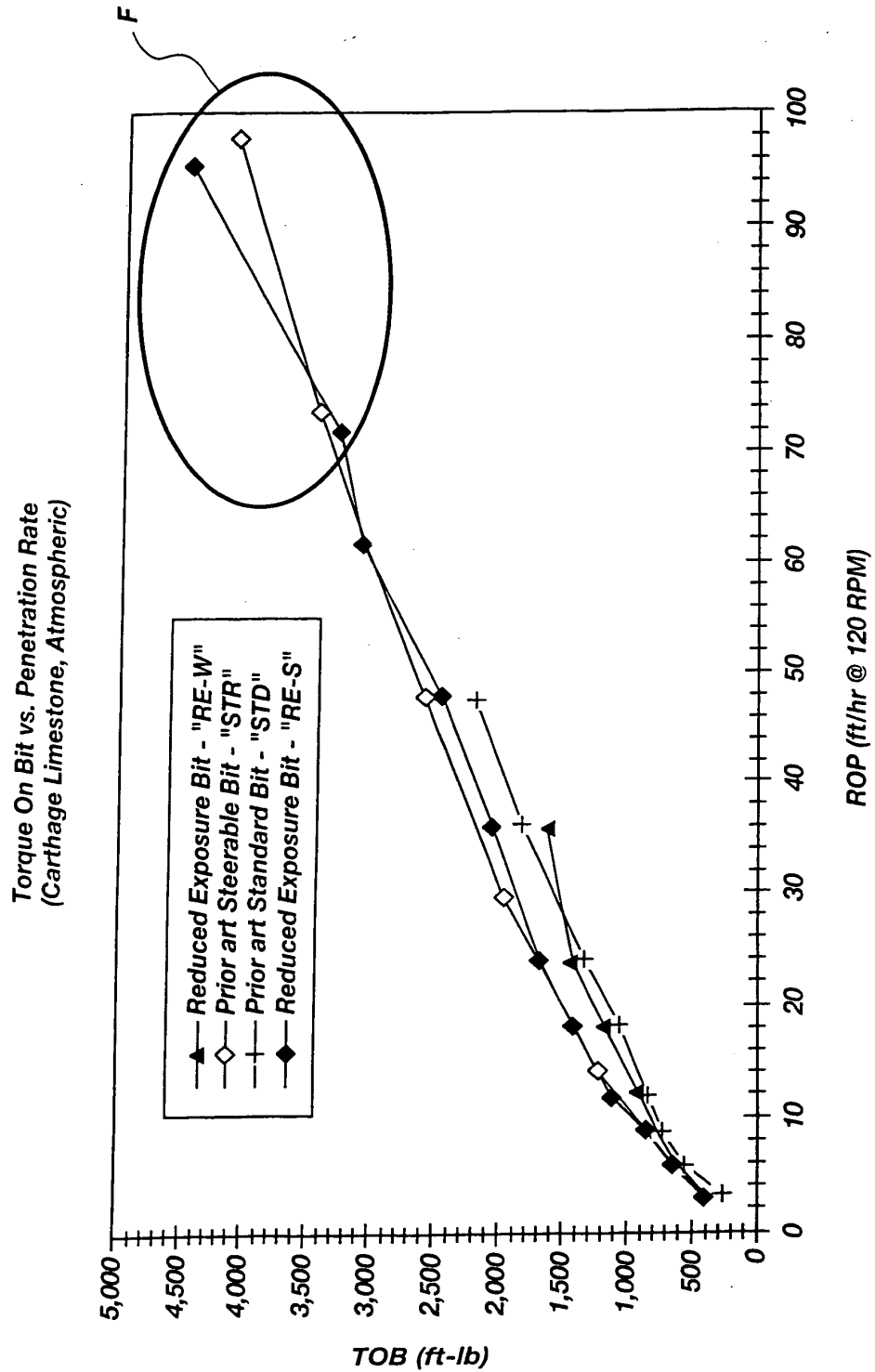


Fig. 21

22/22

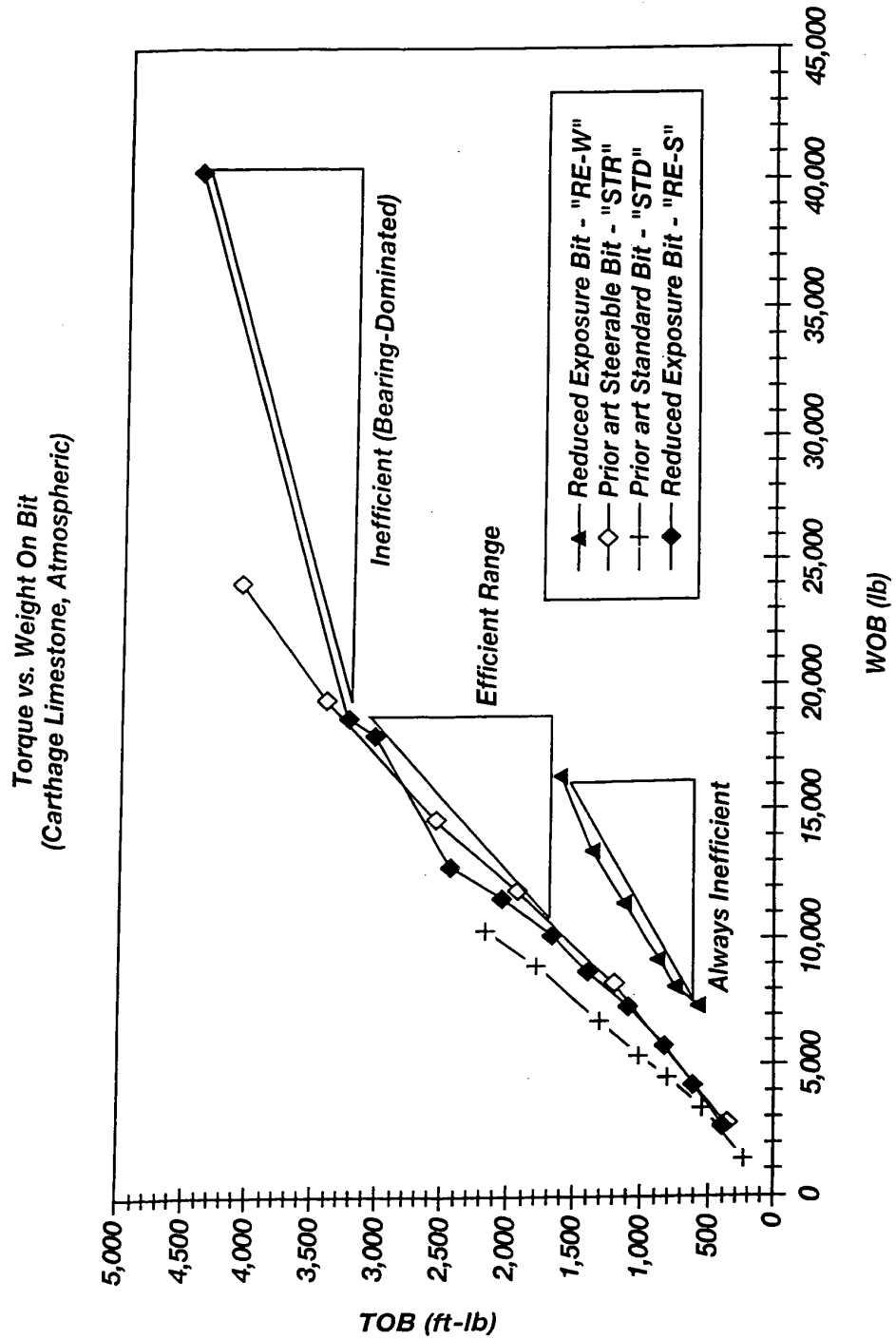


Fig. 22

# DECLARATION FOR PATENT APPLICATION (WITH POWER OF ATTORNEY)

As an inventor named below or on any attached continuation page, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS, the specification of which (check one):

- ☐ is attached hereto.
- ☒ was filed on December 15, 2000 as United States application serial no. 09/738,687 and was amended on \_\_\_\_\_.
- ☐ was filed on \_\_\_\_\_ as PCT international application no. \_\_\_\_\_ and was amended under PCT Article 19 on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability of the subject matter claimed in this application, as "materiality" is defined in Title 37, Code of Federal Regulations § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT international application(s) designating at least one country other than the United States of America listed below and on any attached continuation page and have also identified below and on any attached continuation page any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America having a filing date before that of the application(s) on which priority is claimed.

Prior foreign/PCT application(s):

			Priority Claimed	
(number)	(country)	(day/month/year filed)	Yes	No
_____	_____	_____	_____	_____
(number)	(country)	(day/month/year filed)	Yes	No
_____	_____	_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or § 365(c) of PCT international application(s) designating the United States of America listed below and on any attached continuation page and, insofar as the subject matter of each of the claims of this application is not disclosed in any such prior application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56 which became available between the filing date of such prior application and the national or PCT international filing date of this application:

09/383,228  
(application serial no.)

August 26, 1999  
(filing date)

pending  
(status - pending, patented or abandoned)

(application serial no.)

(filing date)

(status - pending, patented or abandoned)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

(provisional application no.)

(filing date)

I hereby appoint the following Registered Practitioners to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

David V. Trask, Reg. No. 22,012  
Joseph A. Walkowski, Reg. No. 28,765  
Edgar R. Cataxinos, Reg. No. 39,931  
Brick G. Power, Reg. No. 38,581  
Devin R. Jensen, Reg. No. 44,805  
David L. Stott, Reg. No. 43,937  
Matt W. Carson, Reg. No. 33,662

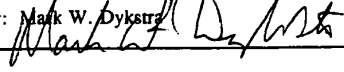
William S. Britt, Reg. No. 20,969  
James R. Duzan, Reg. No. 28,393  
Kent S. Burningham, Reg. No. 30,453  
Kenneth B. Ludwig, Reg. No. 42,814  
Eleanor V. Goodall, Reg. No. 35,162  
Bradley B. Jensen, Reg. No. 46,801  
J. Albert Riddle IV, Reg. No. 33,445

Laurence B. Bond, Reg. No. 30,549  
Allen C. Turner, Reg. No. 33,041  
Stephen R. Christian, Reg. No. 32,687  
Paul C. Oestreich, Reg. No. 44,983  
Samuel E. Webb, Reg. No. 44,394  
Stephen A. Littlefield, Reg. No. 27,923

Address all correspondence to:

Joseph A. Walkowski, telephone no. (801) 532-1922.  
TRASK BRITT  
P.O. BOX 2550  
Salt Lake City, Utah 84110

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first joint inventor: Mark W. Dykstra  
Inventor's signature:   
Residence: Kingwood, Texas  
Citizenship: U.S.A.  
Post Office Address: 3623 Oak Lake Drive, Kingwood, Texas 77339-5511

Date: 4-18-2001



DECLARATION FOR PATENT APPLICATION  
(continuation page)

Invention title: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor name(s) appearing on first declaration page: Mark W. Dykstra

☒ Additional original, first and joint inventor(s):

Full name of second joint inventor: William Heuser

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: The Woodlands, Texas

Citizenship: U.S.A.

Post Office Address: 6 N. Brook Pebble Court, The Woodlands, Texas 77380

Full name of third joint inventor: Michele L. Doster

Inventor's signature \_\_\_\_\_ Date 4-18-2001

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 1327 Chesterpoint Drive, Spring, Texas 77386

Full name of fourth joint inventor: Theodore B. Zaleski Jr.

Inventor's signature \_\_\_\_\_ Date 4-18-2001

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 6115 River Mill, Spring, Texas 77379

Full name of fifth joint inventor: Jack T. Olham

Inventor's signature \_\_\_\_\_ Date 4-18-2001

Residence: Willis, Texas

Citizenship: U.S.A.

Post Office Address: 115184 Paradise Point Drive, Willis, Texas 77318

Full name of sixth joint inventor: Terry D. Watts

Inventor's signature \_\_\_\_\_ Date 4-24-2001

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 16726 Bonnie Sean, Spring, Texas 77379

Full name of seventh joint inventor: Daniel E. Ruff

Inventor's signature \_\_\_\_\_ Date 4-24-2001

Residence: Kingwood, Texas

Citizenship: U.S.A.

Post Office Address: 5202 Manner Glen, Kingwood, Texas 77345

Full name of eighth joint inventor: Rodney B. Walzel

Inventor's signature \_\_\_\_\_ Date 4-27-2001

Residence: Conroe, Texas

Citizenship: U.S.A.

Post Office Address: 2407 Coachman, Conroe, Texas 77384

Full name of ninth joint inventor: Christopher A. Beuershausen

Inventor's signature \_\_\_\_\_ Date 21 Feb 2001

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 1714 Ashton Village Drive, Spring, Texas 77386

## DECLARATION FOR PATENT APPLICATION (WITH POWER OF ATTORNEY)

As an inventor named below or on any attached continuation page, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS, the specification of which (check one):

- ☐ is attached hereto.  
☒ was filed on December 15, 2000 as United States application serial no. 09/738,687 and was amended on .  
☐ was filed on \_\_\_\_\_ as PCT international application no. \_\_\_\_\_ and was amended under PCT Article 19 on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability of the subject matter claimed in this application, as "materiality" is defined in Title 37, Code of Federal Regulations § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate or § 365(a) of any PCT international application(s) designating at least one country other than the United States of America listed below and on any attached continuation page and have also identified below and on any attached continuation page any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America having a filing date before that of the application(s) on which priority is claimed.

Prior foreign/PCT application(s):

(number)	(country)	(day/month/year filed)	Priority Claimed	
			Yes	No
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or § 365(c) of PCT international application(s) designating the United States of America listed below and on any attached continuation page and, insofar as the subject matter of each of the claims of this application is not disclosed in any such prior application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations § 1.56 which became available between the filing date of such prior application and the national or PCT international filing date of this application:

09/383,228 (application serial no.)	August 26, 1999 (filing date)	pending (status - pending, patented or abandoned)
_____	_____	_____

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

_____	_____
(provisional application no.)	(filing date)

I hereby appoint the following Registered Practitioners to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

David V. Trask, Reg. No. 22,012  
 Joseph A. Walkowski, Reg. No. 28,765  
 Edgar R. Cataxinos, Reg. No. 39,931  
 Brick G. Power, Reg. No. 38,581  
 Devin R. Jensen, Reg. No. 44,805  
 David L. Stott, Reg. No. 43,937  
 Matt W. Carson, Reg. No. 33,662

William S. Britt, Reg. No. 20,969  
 James R. Duzan, Reg. No. 28,393  
 Kent S. Birmingham, Reg. No. 30,453  
 Kenneth B. Ludwig, Reg. No. 42,814  
 Eleanor V. Goodall, Reg. No. 35,162  
 Bradley B. Jensen, Reg. No. 46,801  
 J. Albert Riddle IV, Reg. No. 33,445

Laurence B. Bond, Reg. No. 30,549  
 Allen C. Turner, Reg. No. 33,041  
 Stephen R. Christian, Reg. No. 32,687  
 Paul C. Oestreich, Reg. No. 44,983  
 Samuel E. Webb, Reg. No. 44,394  
 Stephen A. Littlefield, Reg. No. 27,923

Address all correspondence to: Joseph A. Walkowski, telephone no. (801) 532-1922.  
**TRASK BRITT**  
 P.O. BOX 2550  
 Salt Lake City, Utah 84110

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first joint inventor: Mark W. Dykstra

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_  
 Residence: Kingwood, Texas  
 Citizenship: U.S.A.  
 Post Office Address: 3623 Oak Lake Drive, Kingwood, Texas 77339-5511

Full name of second joint inventor: William H. Hays  
 Inventor's signature William H. Hays Date 08 MAY 2001  
 Residence: The Woodlands, Texas  
 Citizenship: U.S.A.  
 Post Office Address: 6 N. Brook Pebble Court, The Woodlands, Texas 77380

DECLARATION FOR PATENT APPLICATION  
(continuation page)

Invention title: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

Inventor name(s) appearing on first declaration page: Mark W. Dykstra

☒ Additional original, first and joint inventor(s):

Full name of third joint inventor: Michael L. Doster

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 1327 Chesterpoint Drive, Spring, Texas 77386

Full name of fourth joint inventor: Theodore E. Zaleski, Jr.

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 6115 River Mill, Spring, Texas 77379

Full name of fifth joint inventor: Jack T. Oldham

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Willis, Texas

Citizenship: U.S.A.

Post Office Address: 115184 Paradise Point Drive, Willis, Texas 77318

Full name of sixth joint inventor: Terry D. Watts

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 16726 Bonnie Sean, Spring, Texas 77379

Full name of seventh joint inventor: Daniel E. Ruff

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Kingwood, Texas

Citizenship: U.S.A.

Post Office Address: 5202 Manner Glen, Kingwood, Texas 77345

Full name of eighth joint inventor: Rodney B. Walzel

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Conroe, Texas

Citizenship: U.S.A.

Post Office Address: 2407 Coachman, Conroe, Texas 77384

Full name of ninth joint inventor: Christopher C. Beuershausen

Inventor's signature \_\_\_\_\_ Date \_\_\_\_\_

Residence: Spring, Texas

Citizenship: U.S.A.

Post Office Address: 1714 Ashton Village Drive, Spring, Texas 77386

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**In re Application of:** Dykstra et al.

**Serial No.:** Not Yet Assigned

**Filed:** June 4, 2004

**For:** DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

**Confirmation No.:** Unknown

**Examiner:** Unknown

**Group Art Unit:** Unknown

**Attorney Docket No.:** 1684-4578.2US  
(484-09454-US-C2 )

**NOTICE OF EXPRESS MAILING**

Express Mail Mailing Label Number: EV324774472US

Date of Deposit with USPS: June 4, 2004

Person making Deposit: Christopher Haughton

**ASSOCIATE POWER OF ATTORNEY**

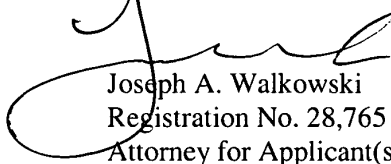
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

In accordance with 37 C.F.R. § 1.34(b), please recognize the following individual as an associate agent/attorney herein in connection with the above-identified patent application, and with all continuing and divisional applications hereof:

Trent N. Butcher, P.E., Reg. No. 51,518

Respectfully submitted,



Joseph A. Walkowski  
Registration No. 28,765  
Attorney for Applicant(s)

TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: June 4, 2004  
TNB/ps:ljb  
Document in ProLaw

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**In re Application of:**

Dykstra et al.

**Serial No.:** Not Yet Assigned

**Filed:** June 4, 2004

**For:** DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

**Confirmation No.:** Unknown

**Examiner:** Unknown

**Group Art Unit:** Unknown

**Attorney Docket No.:** 1684-4578.2US  
(484-09454-US-C2)

**NOTICE OF EXPRESS MAILING**

Express Mail Mailing Label Number: EV324774472US

Date of Deposit with USPS: June 4, 2004

Person making Deposit: Christopher Haughton

**INFORMATION DISCLOSURE STATEMENT**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

The present application is a continuation of application Serial No.10/266,534, filed October 7, 2002, pending, which is a continuation of application Serial No. 09/738,687, filed December 15, 2000, now U.S. Patent 6,460,631, issued October 8, 2002, which is a continuation-in-part of application Serial No. 09/383,228, filed August 26, 1999, now U.S. Patent No. 6,298,930, issued October 9, 2001, entitled Drill Bits with Controlled Cutter Loading and Depth of Cut.

Pursuant to M.P.E.P. 2001.06(b), the Examiner is respectfully requested to consider the information of record in the prior applications, and to confirm in the first Office Action on the

**Attorney Docket No.: 1684-4578.2US**

merits that such art has in fact been reviewed. A PTO-1449 form listing all of the information of record in the prior applications is enclosed herewith.

This Information Disclosure Statement is filed within three (3) months of the filing date of the above-identified application, and no certification pursuant to 37 C.F.R. § 1.97(c) or a fee pursuant to 37 C.F.R. 1.17(p) is required.

Respectfully submitted,



Trent N. Butcher, P.E.  
Registration No. 51,518  
Attorney for Applicant(s)  
TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: June 4, 2004  
TNB/ps:ljb

Enclosures: Form PTO-1449  
Document in ProLaw

Form PTO-1449  <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b>  <i>(Use several sheets if necessary)</i>			Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <b>Not Yet Assigned</b>	
			Applicant <b>Dykstra et al.</b>			
			Filing Date <b>June 4, 2004</b>		Group Art Unit <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	1,805,678	05/1931	Smith			
	2,198,849	04/1940	Waxler			
	2,563,515	08/1951	Brown			
	2,624,549	01/1953	Wallace			
	2,684,835	07/1954	Moore			
	2,776,817	01/1957	Gregory et al.			
	3,153,458	10/1964	Short			
	3,303,894	02/1967	Varney			
	3,709,308	01/1973	Rowley et al.			
	3,779,323	12/1973	Horten et al.			
	3,915,246	10/1975	Sheshtawy			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	APPLICANT	CLASS	SUBCLASS	Translation	
						YES	NO
	EP 0 169 683 A2	01/1986	NL Petroleum				
	GB 2 273 946 A	07/1994	Camco Drilling				
	EP 0 874 128 A2	10/1998	Camco International				
	GB 2 326 659 A	12/1998	Camco International				
	GB 2 329 203 A	03/1999	Baker Hughes				

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
		1995 Hughes Christensen Drill Bit Catalog, page 31.
		Hughes Christensen Bit Drawing dated 29 May 1997 - HC Part No. CC201918.
		Hughes Christensen Bit Drawing dated 18 September 1996 - HC Part No. CW 210655.

EXAMINER	DATE CONSIDERED
----------	-----------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

<b>Form PTO-1449</b>  <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b>  <i>(Use several sheets if necessary)</i>			Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <b>Not Yet Assigned</b>	
			Applicant <b>Dykstra et al.</b>			
			Filing Date <b>June 4, 2004</b>		Group Art Unit <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	3,938,599	02/1976	Horn			
	4,351,401	09/1982	Fielder			
	4,386,669	06/1983	Evans			
	4,499,958	02/1985	Radtke et al.			
	4,554,986	11/1985	Jones			
	4,718,505	01/1988	Fuller			
	4,763,737	08/1988	Hellnick			
	4,889,017	12/1989	Fuller et al.			
	4,932,484	06/1990	Warren et al.			
	4,981,184	01/1991	Knowlton et al.			
	4,982,802	01/1991	Warren et al.			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
		Hughes Christensen Bit Drawing dated 18 September 1996 - HC Part No. CS205023.
		Hughes Christensen Bit Drawing dated 9 September 1996 - HC Part No. CC201718.
		Search Report of the UK Patent Office, dated December 7, 2000, for Application No. GB0020134.3.
EXAMINER		DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.



<b>Form PTO-1449</b> <b>INFORMATION DISCLOSURE CITATION</b> <b>IN AN APPLICATION</b> <i>(Use several sheets if necessary)</i>			Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <b>Not Yet Assigned</b>	
			Applicant <b>Dykstra et al.</b>			
			Filing Date <b>June 4, 2004</b>		Group Art Unit <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	4,991,670	02/1991	Fuller et al.			
	5,010,789	04/1991	Brett et al.			
	5,042,596	08/1991	Brett et al.			
	5,090,492	02/1992	Keith			
	5,111,892	05/1992	Sinor et al.			
	5,131,478	07/1992	Brett et al.			
	5,199,511	04/1993	Tibbitts et al.			
	5,244,039	09/1993	Newton, Jr. et al.			
	5,265,685	11/1993	Keith et al.			
	5,303,785	04/1994	Duke			
	5,314,033	05/1994	Tibbitts			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
		Search Report of the Belgian Patent Office, dated August 14, 2001, for Application No. BE20000528.

EXAMINER	DATE CONSIDERED
----------	-----------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

<b>Form PTO-1449</b>  <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b>  <i>(Use several sheets if necessary)</i>				Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <b>Not Yet Assigned</b>	
				Applicant <b>Dykstra et al.</b>			
				Filing Date <b>June 4, 2004</b>		Group Art Unit <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	5,388,649	02/1995	Ilomäki			
	5,402,856	04/1995	Warren et al.			
	5,447,208	09/1995	Lund et al.			
	5,531,281	07/1996	Murdock			
	5,549,171	08/1996	Mensa-Wilmot et al.			
	5,558,170	09/1996	Thigpen et al.			
	5,582,258	12/1996	Tibbitts et al.			
	5,595,252	01/1997	O'Hanlon			
	5,653,300	08/1997	Lund et al.			
	5,663,512	09/1997	Schader et al.			
	5,730,234	03/1998	Putot			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER	DATE CONSIDERED
----------	-----------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

**PATENT APPLICATION FEE DETERMINATION RECORD**  
Effective October 1, 2003

Application or Docket Number

10861129

**CLAIMS AS FILED - PART I**

	(Column 1)	(Column 2)
TOTAL CLAIMS	24	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	24 minus 20 =	4
INDEPENDENT CLAIMS	3 minus 3 =	-
MULTIPLE DEPENDENT CLAIM PRESENT <input type="checkbox"/>		

\* If the difference in column 1 is less than zero, enter "0" in column 2

**CLAIMS AS AMENDED - PART II**

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT C	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

\* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

\*\* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."

\*\*\* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

**SMALL ENTITY TYPE** ☐ OR

**OTHER THAN SMALL ENTITY**

RATE	FEE
BASIC FEE	385.00
X\$ 9=	
X43=	
+145=	
TOTAL	

RATE	FEE
BASIC FEE	770.00
X\$18=	72
X86=	
+290=	
TOTAL	842

**SMALL ENTITY** OR

**OTHER THAN SMALL ENTITY**

RATE	ADDITIONAL FEE
X\$ 9=	
X43=	
+145=	
TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE
X\$18=	
X86=	
+290=	
TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE
X\$ 9=	
X43=	
+145=	
TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE
X\$18=	
X86=	
+290=	
TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE
X\$ 9=	
X43=	
+145=	
TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE
X\$18=	
X86=	
+290=	
TOTAL ADDIT. FEE	

PATENT APPLICATION SERIAL NO. \_\_\_\_\_

U.S. DEPARTMENT OF COMMERCE  
PATENT AND TRADEMARK OFFICE  
FEE RECORD SHEET

06/09/2004 EHAILE1 00000014 020429 10861129

01 FC:1001	770.00 DA
02 FC:1202	72.00 DA

PTO-1556  
(5/87)

\*U.S. Government Printing Office: 2002 — 489-257/89033



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060
24247	7590	11/10/2004	EXAMINER	
TRASK BRITT P.O. BOX 2550 SALT LAKE CITY, UT 84110			TSAY, FRANK	
			ART UNIT	PAPER NUMBER
			3672	

DATE MAILED: 11/10/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

<b>Office Action Summary</b>	Application No. 10/861,129	Applicant(s) DYKSTRA ET AL.	
	Examiner Frank S Tsay	Art Unit 3672	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1) ☒ Responsive to communication(s) filed on 04 June 2004.

2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.

3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4) ☒ Claim(s) 1-24 is/are pending in the application.

4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.

5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.

6) ☒ Claim(s) 1-24 is/are rejected.

7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.

8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

9) ☐ The specification is objected to by the Examiner.

10) ☒ The drawing(s) filed on 04 June 2004 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
     Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
     Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
     a) ☐ All    b) ☐ Some \* c) ☐ None of:  
         1. ☐ Certified copies of the priority documents have been received.  
         2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
         3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) <input type="checkbox"/> Notice of References Cited (PTO-892) 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.	4) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s)/Mail Date. _____. 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) 6) <input type="checkbox"/> Other: _____.
---	--

## DETAILED ACTION

### ***Double Patenting***

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. See *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); and, *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) may be used to overcome an actual or provisional rejection based on a nonstatutory double patenting ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 CFR 1.130(b).

Effective January 1, 1994, a registered attorney or agent of record may sign a terminal disclaimer. A terminal disclaimer signed by the assignee must fully comply with 37 CFR 3.73(b).

Claims 1-24 are rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-41 of U.S. Patent No. 6,779,613. Although the conflicting claims are not identical, they are not patentably distinct from each other because a perusal of the instant claims clearly indicates that the subject matter thereof is fully disclosed by the claims of said patent (see e.g., claim 1 ) and/or that portion of the patent disclosure which provides support for such claims [see *In re Vogel*, 422 F.2d 438; 164 USPQ 619 (CCPA 1970)], more specifically, the language such as "without substantial indentation of the bearing surface" in the application is considered an obvious consequence when "the bearing surface contacting the formation at a stress of less than the compressive strength of the formation" recited in respective claims of US 6,779,613. Therefore, it is axiomatic that the instant claims

are nothing more than obvious variations of the inventions disclosed and claimed in said patent and cannot properly issue in the absence of a terminal disclaimer. Furthermore, it is also clear that the inventors could have included the instant claims in said patent and that if the instant application were to issue without a terminal disclaimer protection of the previously patent inventions would be improperly extended until the expiration of the instant claims since the utilization of such inventions would infringe the instant claims.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Frank S Tsay whose telephone number is (703) 308-2170. The examiner can normally be reached on Monday thru Friday, 7:30am-5:00 pm, 2nd Friday off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David J Bagnell can be reached on (703)308-2151. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Frank S Tsay  
Primary Examiner  
Art Unit 3672

11/04/04



# Index of Claims



Application No.

10/861,129

Examiner

Frank S Tsay

Applicant(s)

DYKSTRA ET AL.

Art Unit

3672

✓	Rejected
=	Allowed

—	(Through numeral) Cancelled
+	Restricted

N	Non-Elected
I	Interference

A	Appeal
O	Objected

Claim		Date											
Final	Original												
	11												
	12												
	13												
	14												
	15												
	16												
	17												
	18												
	19												
	20												
	21												
	22												
	23												
	24												
	25												
	26												
	27												
	28												
	29												
	30												
	31												
	32												
	33												
	34												
	35												
	36												
	37												
	38												
	39												
	40												
	41												
	42												
	43												
	44												
	45												
	46												
	47												
	48												
	49												
	50												

Claim		Date											
Final	Original												
	51												
	52												
	53												
	54												
	55												
	56												
	57												
	58												
	59												
	60												
	61												
	62												
	63												
	64												
	65												
	66												
	67												
	68												
	69												
	70												
	71												
	72												
	73												
	74												
	75												
	76												
	77												
	78												
	79												
	80												
	81												
	82												
	83												
	84												
	85												
	86												
	87												
	88												
	89												
	90												
	91												
	92												
	93												
	94												
	95												
	96												
	97												
	98												
	99												
	100												

Claim		Date											
Final	Original												
	101												
	102												
	103												
	104												
	105												
	106												
	107												
	108												
	109												
	110												
	111												
	112												
	113												
	114												
	115												
	116												
	117												
	118												
	119												
	120												
	121												
	122												
	123												
	124												
	125												
	126												
	127												
	128												
	129												
	130												
	131												
	132												
	133												
	134												
	135												
	136												
	137												
	138												
	139												
	140												
	141												
	142												
	143												
	144												
	145												
	146												
	147												
	148												
	149												
	150												

**Search Notes**

Application No.

10/861,129

Examiner

Frank S Tsay

Applicant(s)

DYKSTRA ET AL.

Art Unit

3672

**SEARCHED**

Class	Subclass	Date	Examiner
175	428		
	429		
	431		
	57		
	363		
	376		
	378		
	398		
	432	11/4/04	

**INTERFERENCE SEARCHED**

Class	Subclass	Date	Examiner

**SEARCH NOTES  
(INCLUDING SEARCH STRATEGY)**

	DATE	EXMR



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
 United States Patent and Trademark Office  
 Address: COMMISSIONER FOR PATENTS  
 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

## \*BIBDATASHEET\*

Bib Data Sheet

CONFIRMATION NO. 1060

SERIAL NUMBER 10/861,129	FILING DATE 06/04/2004  RULE	CLASS 175	GROUP ART UNIT 3672	ATTORNEY DOCKET NO. 1684-4578.2US (484-09454-
-----------------------------	---------------------------------------	--------------	------------------------	--

## APPLICANTS

Mark W. Dykstra, Kingwood, TX;

William Heuser, The Woodlands, TX;

Michael L. Doster, Spring, TX; Theodore E. Zaleski JR., Spring, TX;

Jack T. Oldham, Willis, TX;

Terry D. Watts, Spring, TX;

Daniel E. Ruff, Kingwood, TX;

Rodney B. Walzel, Conroe, TX;

Christopher C. Beuershausen, Spring, TX;

## \*\* CONTINUING DATA \*\*\*\*\*

This application is a CON of 10/266,534 10/07/2002 PAT 6,779,613  
 which is a CON of 09/738,687 12/15/2000 PAT 6,460,631  
 which is a CIP of 09/383,228 08/26/1999 PAT 6,298,930

OK

## \*\* FOREIGN APPLICATIONS \*\*\*\*\*

None

IF REQUIRED, FOREIGN FILING LICENSE GRANTED

\*\* 07/29/2004

Foreign Priority claimed 35 USC 119 (a-d) conditions met	<input type="checkbox"/> yes <input checked="" type="checkbox"/> no <input type="checkbox"/> yes <input checked="" type="checkbox"/> no <input type="checkbox"/> Met after Allowance	STATE OR COUNTRY TX	SHEETS DRAWING 22	TOTAL CLAIMS 24	INDEPENDENT CLAIMS 3
Verified and Acknowledged	Examiner's Signature <i>[Signature]</i> Initials <i>[Initials]</i>				

## ADDRESS

24247

TRASK BRITT

P.O. BOX 2550

SALT LAKE CITY, UT

84110

## TITLE

Drill bits with reduced exposure of cutters

☐ All Fees



**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**In re Application of:**

Dykstra et al.

**Serial No.:** 10/861,129

**Filed:** June 4, 2004

**For:** DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

**Confirmation No.:** 1060

**Examiner:** F. Tsay

**Group Art Unit:** 3672

**Attorney Docket No.:** 1684-4578.2US  
(484-09454-US-C2)

**CERTIFICATE OF MAILING**

I hereby certify that this correspondence along with any attachments referred to or identified as being attached or enclosed is being deposited with the United States Postal Service as First Class Mail on the date of deposit shown below with sufficient postage and in an envelope addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

1/14/2005  
Date

Signature

Leah J. Barrow  
Name (Type/Print)

**AMENDMENT**

Mail Stop Amendment  
Commissioner for Patents  
PO Box 1450  
Alexandria, VA 22313-1450

Sir:

The following amendments and remarks are filed in response to the Examiner's remarks in the Office Action mailed November 10, 2004, the three-month shortened statutory period for response to which expires on February 10, 2005.

**Amendments to the Specification** begin on page 3 of this paper.

**Amendments to the Abstract** appear on page 39 of this paper.

**Amendments to the Claims** are reflected in the listing which begins on page 40 of this paper.

**Serial No. 10/861,129**

**Amendments to the Drawings** appear on page 46 of this paper and include both an attached replacement sheet and an annotated sheet showing changes.

**Remarks** begin on page 47 of this paper.

An **Appendix** including amended drawing figures is attached following page 48 of this paper.

**Amendments to the Specification:**

Please amend paragraph number [0001] as follows:

[0001] This application is a continuation of application Serial ~~No.~~ No. 10/266,534, filed October 7, 2002, pending, which is a continuation of application Serial No. 09/738,687, filed December 15, 2000, now U.S. Patent 6,460,631, issued October 8, 2002, which is a continuation-in-part of application Serial No. 09/383,228, filed August 26, 1999, now U.S. Patent No. 6,298,930, issued October 9, 2001, entitled Drill Bits with Controlled Cutter Loading and Depth of Cut.

Please amend paragraph number [0003] as follows:

[0003] State of the Art: Rotary drag bits employing polycrystalline diamond compact (PDC) cutters have been employed for several decades. PDC cutters are typically comprised of a disc-shaped diamond “table” formed on and bonded under high-pressure and high-temperature conditions to a supporting-~~substrate~~ substrate, such as cemented tungsten carbide (WC), although other configurations are known in the art. Bits carrying PDC cutters, which for example, may be brazed into pockets in the bit face, pockets in blades extending from the face, or mounted to studs inserted into the bit body, have proven very effective in achieving high rates of penetration (ROP) in drilling subterranean formations exhibiting low to medium compressive strengths. Recent improvements in the design of hydraulic flow regimes about the face of bits, cutter design, and drilling fluid formulation have reduced prior, notable tendencies of such bits to “ball” by increasing the volume of formation material which may be cut before exceeding the ability of the bit and its associated drilling fluid flow to clear the formation cuttings from the bit face.

Please amend paragraph number [0006] as follows:

[0006] Numerous attempts using ~~varying~~ various approaches have been made over the years to protect the integrity of diamond cutters and their mounting structures and to limit cutter penetration into a formation being drilled. For example, from a period even before the advent of commercial use of PDC cutters, U.S. Patent 3,709,308 discloses the use of trailing, round natural

diamonds on the bit body to limit the penetration of cubic diamonds employed to cut a formation.

U.S. Patent 4,351,401 discloses the use of surface set natural diamonds at or near the gage of the bit as penetration limiters to control the depth-of-cut of PDC cutters on the bit face. The following other patents disclose the use of a variety of structures immediately trailing PDC cutters (with respect to the intended direction of bit rotation) to protect the cutters or their mounting structures: U.S. Patents 4,889,017; 4,991,670; 5,244,039 and 5,303,785. U.S. Patent 5,314,033 discloses, *inter alia*, the use of cooperating positive and negative or neutral backrake cutters to limit penetration of the positive rake cutters into the formation. Another approach to limiting cutting element penetration is to employ structures or features on the bit body rotationally preceding (rather than trailing) PDC cutters, as disclosed in U.S. Patents 3,153,458; 4,554,986; 5,199,511 and 5,595,252.

Please amend paragraph number [0008] as follows:

[0008] While some of the foregoing patents recognize the desirability to limit cutter penetration, or DOC, or otherwise limit forces applied to a borehole surface, the disclosed approaches are somewhat generalized in nature and fail to accommodate or implement an engineered approach to achieving a target ROP in combination with more stable, predictable bit performance. Furthermore, the disclosed approaches do not provide a bit or method of drilling which is generally tolerant to being axially loaded with an amount of weight-on-bit over and in excess what would be optimum for the current rate-of-penetration for the particular formation being drilled and which would not generate high amounts of potentially bit-stopping or bit-damaging ~~torque-on-bit~~ torque-on-bit, should the bit nonetheless be subjected to such excessive amounts of weight-on-bit.

Please amend paragraph number [0010] as follows:

[0010] The bit design of the present invention employs depth of cut control (DOCC) ~~features~~ features, which reduce, or limit, the extent in which PDC ~~cutters~~, cutters or other types of cutters or cutting ~~elements~~, elements are exposed on the bit face, on bladed structures, or as otherwise positioned on the bit. The DOCC features of the present invention provide substantial area on which the bit may ride while the PDC cutters of the bit are engaged with the formation to their design DOC, which may be defined as the distance the PDC cutters are effectively exposed below the DOCC features. Stated another way, the cutter standoff is substantially controlled by the effective amount of exposure of the cutters above the surface, or surfaces, surrounding each cutter. Thus, by constructing the bit so as to limit the exposure of at least some of the cutters on the bit, such limited exposure of the cutters in combination with the bit providing ample surface area to serve as a “~~bearing-surface~~” surface,” in which the bit rides as the cutters engage the formation at their respective design DOC enables a relatively greater DOC (and thus ROP for a given bit rotational speed) than with a conventional bit design without the adverse consequences usually attendant thereto. Therefore the DOCC features of the present invention preclude a greater DOC than that designed for by distributing the load attributable to WOB over a sufficient surface area on the bit face, blades or other bit body structure contacting the formation face at the borehole bottom so that the compressive strength of the formation will not be exceeded by the DOCC features. As a result, the bit does not substantially indent, or fail, the formation rock.

Please amend paragraph number [0012] as follows:

[0012] In one embodiment, a rotary drag bit preferably includes a plurality of circumferentially spaced blade structures extending along the leading end or formation engaging portion of the bit generally from the cone region approximate the longitudinal axis, or centerline, of the bit, upwardly to the gage region, or maximum drill diameter of bit. The bit further includes a plurality of superabrasive cutting elements, or ~~cutters~~ cutters, such as PDC cutters, preferably disposed on radially outward facing surfaces of preferably each of the blade structures. In accordance with the DOCC aspect of the present invention, each cutter positioned in at least the cone region of the bit, e.g., those cutters which are most radially proximate the longitudinal



centerline and thus are generally positioned radially inward of a shoulder portion of the bit, are disposed in their respective blade structures in such a manner that each of such cutters is exposed only to a limited extent above the radially outwardly facing surface of the blade structures in which the cutters are associatively disposed. That is, each of such cutters exhibit a limited amount of exposure generally perpendicular to the selected portion of the formation-facing ~~surface~~ surface, in which the superabrasive cutter is secured to control the effective depth-of-cut of at least one superabrasive cutter into a formation when the bit is rotatably engaging a ~~formation~~ formation, such as during drilling. By so limiting the amount of exposure of such cutters by, for example, the cutters being secured within and substantially encompassed by cutter-receiving pockets, or cavities, the DOC of such cutters into the formation is effectively and individually controlled. Thus, regardless of the amount of WOB ~~placed~~, placed or ~~applied~~, applied on the bit, even if the WOB exceeds what would be considered an optimum amount for the hardness of the formation being drilled and the ROP in which the drill bit is currently providing, the resulting torque, or TOB, will be controlled or modulated. Thus, because such cutters have a reduced amount of exposure above the respective formation-facing surface in which it is installed, especially as compared to prior art cutter installation arrangements, the resultant TOB generated by the bit will be limited to a maximum, acceptable value. This beneficial result is attributable to the DOCC features, or ~~characteristic~~, characteristics, of the present invention effectively preventing at least a sufficient number of the total number of cutters from over-engaging the formation and potentially causing the rotation of the bit to slow or stall due to an unacceptably high amount of torque being generated. Furthermore, the DOCC features of the present invention are essentially unaffected by excessive amounts of WOB, as there will preferably be a sufficient amount or size of bearing surface area devoid of cutters on at least the leading end of the bit in which the bit may “ride” upon the formation to inhibit or prevent a torque-induced bit stall from occurring.

Please amend paragraph number [0013] as follows:

[0013] Optionally, bits employing the DOCC aspects of the present invention may have reduced exposure cutters positioned radially more distant than those cutters proximate to the longitudinal centerline of the ~~bit~~ bit, such as in the cone region. To elaborate, cutters having reduced exposure may be positioned in other regions of a drill bit embodying the DOCC aspects of the present invention. For example, reduced exposure cutters positioned on the comparatively more radially distant nose, shoulder, flank, and gage portions of a drill bit will exhibit a limited amount of cutter exposure generally perpendicular to the selected portion of the radially outwardly facing surface to which each of the reduced exposure cutters are respectively secured. Thus, the surfaces carrying and proximately surrounding each of the additional reduced exposure cutters will be available to contribute to the total combined bearing surface area on which the bit will be able to ride upon the formation as the respective maximum depth-of-cut for each additional reduced exposure cutter is achieved depending upon the instant WOB and the hardness of the formation being drilled.

Please amend paragraph number [0014] as follows:

[0014] By providing DOCC features having a cumulative surface area sufficient to support a given WOB on a given rock ~~formation~~ formation, preferably without substantial indentation or failure of same, WOB may be dramatically increased, if desired, over that usable in drilling with conventional bits without the PDC cutters experiencing any additional effective WOB after the DOCC features are in full contact with the formation. Thus, the PDC cutters are protected from damage and, equally significant, the PDC cutters are prevented from engaging the formation to a greater depth of cut and consequently generating excessive torque ~~which might~~ may stall a motor or cause loss of tool face orientation.

Please amend paragraph number [0015] as follows:

[0015] The ability to dramatically increase WOB without adversely affecting the PDC cutters also permits the use of WOB substantially above and beyond the magnitude applicable without the adverse effects associated with conventional bits to maintain the bit in contact with

the formation, reduce vibration and enhance the consistency and depth of cutter engagement with the formation. In addition, drill string ~~vibration~~, as well as dynamic axial effects, commonly termed "~~bounce~~," "bounce" of the drill string under applied torque and WOB may be damped so as to maintain the design DOC for the PDC cutters. Again, in the context of directional drilling, this capability ensures maintenance of tool face and stall-free operation of an associated downhole motor driving the bit.

Please amend paragraph number [0017] as follows:

[0017] It is also specifically contemplated that the DOCC attributes of the present invention have particular utility in ~~controlling~~, controlling and specifically ~~reducing~~, reducing torque required to rotate rotary drag bits as WOB is increased. While relative torque may be reduced in comparison to that required by conventional bits for a given WOB by employing the DOCC features at any radius or radii range from the bit centerline, variation in placement of DOCC features with respect to the bit centerline may be a useful technique for further limiting torque since the axial loading on the bit from applied WOB is more heavily emphasized toward the centerline and the frictional component of the torque is related to such axial loading. Accordingly, the present invention optionally includes providing a bit in which the extent of exposure of the cutters vary with respect to the ~~cutters~~ cutters' respective positions on the face of the bit. As an example, one or more of the cutters positioned in the cone, or the region of the bit proximate the centerline of the bit, are exposed to a first extent, or amount, to provide a first DOC and one or more cutters positioned in the more radially distant nose and shoulder regions of the bit are exposed at a second extent, or amount, to provide a second DOC. Thus, a specifically engineered DOC profile may be incorporated into the design of a bit embodying the present invention to customize, or tailor, the bit's operational characteristics in order to achieve a maximum ROP while minimizing and/or modulating the TOB at the current WOB, even if the WOB is higher than what would otherwise be desired for the ROP and the specific hardness of the formation then being drilled.

Please amend paragraph number [0018] as follows:

[0018] Furthermore, bits embodying the present invention may include blade structures in which the extent of exposure of each cutter positioned on each blade structure has a particular and optionally individually unique DOC, as well as individually selected and possibly unique effective backrake angles, thus resulting in each blade of the bit having a preselected DOC cross-sectional profile as taken longitudinally parallel to the centerline of the bit and taken radially to the outermost gage portion of each blade. Moreover, a bit incorporating the DOCC features of the present invention need not have cutters installed on, or carried by, blade structures, as cutters having a limited amount of exposure perpendicular to the exterior of the bit in which each cutter is ~~disposed~~ disposed, may be incorporated on regions of bits in which no blade structures are present. That is, bits incorporating the present invention may be completely devoid of blade structures entirely, such as, for example, a coring bit.

Please amend paragraph number [0021] as follows:

[0021] A method of drilling a subterranean formation is further disclosed. The method for drilling includes engaging a formation with at least one cutter and preferably a plurality of cutters in which one or more of the cutters each exhibit a limited amount of exposure perpendicular to a surface in which each cutter is secured. In one embodiment, several of the plurality of limited exposure cutters are positioned on a formation-facing surface of at least one portion, or region, of at least one ~~blade-structure~~ structure, to render a cutter spacing and cutter exposure profile for that blade and preferably for a plurality of blades ~~that~~ which will enable the bit to engage the formation within a wide range of WOB without generating an excessive amount of TOB, even at elevated WOBs, for the instant ROP in which the bit is providing. The method further includes an alternative embodiment in which the drilling is conducted with primarily only the reduced exposure cutters engaging a relatively hard formation within a selected range of WOB and upon a softer formation being encountered and/or an increased amount of WOB being applied, at least one bearing surface surrounding at least one reduced, or limited, exposure cutter, and preferably a plurality of sufficiently sized bearing surfaces respectively surrounding a plurality of reduced exposure cutters, contacts the formation and thus limits the DOC of each reduced, or limited, exposure cutter while allowing the bit to ride on the bearing surface, or

bearing surfaces, against the formation regardless of the WOB being applied to the bit and without generating an unacceptably high, potentially bit damaging TOB for the current ROP.

Please amend paragraph number [0035] as follows:

[0035] FIGS. ~~13A, 13B and 13C~~ 13A-13C are transverse sections of various cross-sectional configurations for the DOCC features according to the invention;

Please amend paragraph number [0045] as follows:

[0045] FIG. 18B is a schematic, partial side cross-sectional view of one of the cutters depicted in FIG. 18A as the cutter engages a relatively hard formation and/or engages a formation at a relatively low-~~WOB~~ WOB, resulting in a first, less than maximum DOC;

Please amend paragraph number [0046] as follows:

[0046] FIG. 18C is a schematic, partial side cross-sectional view of the cutter depicted in FIG. 18A as the cutter engages a relatively soft formation and/or engages a formation at relatively high-~~WOB~~ WOB resulting in a second, essentially maximum DOC;

Please amend paragraph number [0052] as follows:

[0052] Fluid courses 20 lie between blades 18 and are provided with drilling fluid by nozzles 22 secured in nozzle orifices 24, orifices 24 being at the end of passages leading from a plenum extending into the bit body from a tubular shank at the upper, or trailing, end of the bit (see FIG. 2A in conjunction with the accompanying text for a description of these features). Fluid courses 20 extend to junk slots 26 extending upwardly along the side of bit 10 between blades 18. Gage pads 19 comprise longitudinally upward extensions of blades 18 and may have wear-resistant inserts or coatings on radially outer surfaces 21 thereof as known in the art. Formation cuttings are swept away from PDC cutters 14 by drilling fluid F emanating from nozzle orifices-~~24~~ 24, ~~which moves the fluid moving~~ generally radially outwardly through fluid courses 20 and then upwardly through junk slots 26 to an annulus between the drill string from which the bit 10 is suspended and on to the surface.

Please amend paragraph number [0054] as follows:

[0054] FIGS. 2 and 2A depict another embodiment of a rotary drill bit 100 according to the present invention, ~~and~~ For clarity, features and elements in FIGS. 2 and 2A corresponding to those identified with respect to bit 10 of FIG. 1 are identified with the same reference numerals. FIG. 2 depicts a rotary drill bit 100 looking upwardly at its face 12 as if the viewer were positioned at the bottom of a borehole. Bit 100 also includes a plurality of PDC cutters 14 bonded by their substrates (diamond tables and substrates not shown separately for clarity), as by brazing, into pockets 16 in blades 18 extending above the face 12 of bit 100.

Please amend paragraph number [0055] as follows:

[0055] Fluid courses 20 lie between blades 18 and are provided with drilling fluid F by nozzles 22 secured in nozzle orifices 24, orifices 24 being at the end of passages 36 leading from a plenum 38 extending into bit body 40 from a tubular shank 42 threaded (not shown) on its exterior surface 44 as known in the art at the upper end of the ~~bit~~ bit 100 (see FIG. 2A). Fluid courses 20 extend to junk slots 26 extending upwardly along the side of bit 10 between blades 18. Gage pads 19 comprise longitudinally upward extensions of blades 18 and may have wear-resistant inserts or coatings on radially outer surfaces 21 thereof as known in the art.

Please amend paragraph number [0056] as follows:

[0056] ~~A~~Referring again to FIG. 2, a plurality of the DOCC features, each comprising an arcuate bearing segment 30a through 30f, reside on, and in some instances bridge between, blades 18. Specifically, bearing 30b and 30e each reside partially on an adjacent blade 18 and extend therebetween. The arcuate bearing segments 30a through 30f, each of which lies substantially along the same radius from the bit centerline as a PDC cutter 14 rotationally trailing that bearing segment 30, together provide sufficient surface area to withstand the axial or longitudinal WOB without exceeding the compressive strength of the formation being drilled, so that the rock does not unduly indent or fail and the penetration of PDC cutters 14 into the rock is substantially controlled.

Please amend paragraph number [0058] as follows:

[0058] While bit 100 is notably similar to bit 10, the viewer will recognize and appreciate that wear inserts 32 are omitted from bearing segments 30a through 30f on bit 100, such an arrangement being suitable for less abrasive formations where wear is of lesser concern and the tungsten carbide of the bit matrix (or applied hard facing in the case of a steel body bit) is sufficient to resist abrasive wear for a desired life of the bit. As shown in FIG. 13A, the DOCC features (bearing segments 30) of either bit 10 or bit 100, or of any bit according to the invention, may be of arcuate cross-section, taken transverse to the arc followed as the bit rotates, to provide an arcuate bearing surface 31a mimicking the cutting edge arc of an unworn, associated PDC cutter following a DOCC feature. Alternatively, as shown in FIG. 13B, a DOCC feature (bearing segment 30) may exhibit a flat bearing surface 31f to the formation, or may be otherwise configured. It is also contemplated, as shown in FIG. 13C, that a DOCC feature (bearing segment 30) may be cross-sectionally configured and comprised of a material so as to intentionally and relatively quickly (in comparison to the wear rate of a PDC cutter) wear from a smaller initial bearing surface 31i providing a relatively small  $DOC_1$  with respect to the point or line of contact C with the formation traveled by the cutting edge of a trailing, associated PDC cutter while drilling a first, hard formation interval to a larger, secondary bearing surface ~~31s~~ 31s, which also provides a much smaller  $DOC_2$  for a second, lower, much softer (and lower compressive strength) formation interval. Alternatively, the head 33 of the DOCC structure (bearing segment 30) may be made controllably shearable from the base 35 (as with frangible connections like a shear pin, one shear pin 37 shown in broken lines).

Please amend paragraph number [0059] as follows:

[0059] For reference purposes, bits 10 and 100 as ~~illustrated~~ illustrated, may be said to be symmetrical or concentric about their centerlines or longitudinal axes L, although this is not necessarily a requirement of the invention.

Please amend paragraph number [0060] as follows:

[0060] Both bits 10 and 100 are unconventional in comparison to state of the art bits in that PDC cutters 14 on bits 10 and 100 are disposed at far lesser backrakes, in the range of, for example, 7° to 15° with respect to the intended direction of rotation generally perpendicular to the surface of the formation being engaged. In comparison, many conventional bits are equipped with cutters at a 30° ~~backrake~~, backrake and a 20° backrake is regarded as somewhat “aggressive” in the art. The presence of the DOCC feature permits the use of substantially more aggressive backrakes, as the DOCC features preclude the ~~aggressively~~ aggressively-raked PDC cutters from penetrating the formation to too great a depth, as would be the case in a bit without the DOCC features.

Please amend paragraph number [0061] as follows:

[0061] In the cases of both bit 10 and bit 100, the rotationally leading DOCC features (bearing segments 30) are configured and placed to substantially exactly match the pattern drilled in the bottom of the borehole when drilling at an ROP of 100 feet per hour (fph) at 120 rotations per minute (rpm) of the bit. This results in a DOC of about 0.166 inch per revolution. Due to the presence of the DOCC features (bearing segments 30), after sufficient WOB has been applied to drill 100 fph, any additional WOB is transferred from the ~~body bit body~~ 40 of the bit 10 or 100 through the DOCC features to the formation. Thus, the cutters 14 are not exposed to any substantial additional weight, unless and until a WOB sufficient to fail the formation being drilled would be applied, which application may be substantially controlled by the driller, since the DOCC features may be engineered to provide a large margin of error with respect to any given sequence of formations which might be encountered when drilling an interval.

Please amend paragraph number [0062] as follows:

[0062] As a further consequence of the present invention, the DOCC features would, as noted above, preclude cutters 14 from excessively penetrating or “gouging” the formation, a major advantage when drilling with a downhole motor where it is often difficult to control WOB and WOB-~~inducing~~ inducing, such excessive penetration can result in the motor stalling, with consequent loss of tool face and possible damage to motor ~~components~~ components, as well as to



the bit itself. While the addition of WOB beyond that required to achieve the desired ROP will require additional torque to rotate the bit due to frictional resistance to rotation of the DOCC features over the formation, such additional torque is a lesser component of the overall torque.

Please amend paragraph number [0063] as follows:

[0063] The benefit of DOCC features in controlling torque can readily be appreciated by a review of FIG. 3 of the drawings, which is a mathematical model of performance of a 3 3/4 inch diameter, four-bladed, Hughes Christensen R324XL PDC bit showing various torque versus WOB curves for varying cutter backrakes in drilling Mancos shale. Curve A represents the bit with a 10° cutter backrake, curve B, the bit with a 20° cutter backrake, curve C, the bit with a 30° cutter backrake, and curve D, the bit using cutters disposed at a 20° backrake and including the DOCC features according to the present invention. The model assumes a bit design according to the invention for an ROP of 50 fph at 100 rpm, which provides 0.1 inch per revolution penetration of a formation being drilled. As can readily be seen, regardless of cutter backrake, curves A through C clearly indicate that, absent the DOCC features according to the present invention, required torque on the bit continues to increase continuously and substantially linearly with applied WOB, regardless of how much WOB is applied. On the other hand, curve D indicates that, after WOB approaches about 8,000 lbs. on the ~~bit~~ bit, including the DOCC features, the torque curve flattens significantly and increases in a substantially linear manner only slightly from about 670 ft-lb. to just over 800 ft-lb. even as WOB approaches 25,000 lbs. As noted above, this relatively small increase in the torque after the DOCC features engage the formation is frictionally related, and is also somewhat predictable. As graphically depicted in FIG. 3, this additional torque load increases substantially linearly as a function of WOB times the coefficient of friction between the bit and the formation.

Please amend paragraph number [0064] as follows:

[0064] Referring now to FIG. 4 (which is not to scale) of the drawings, a further appreciation of the operation and benefits of the DOCC features according to the present invention may be obtained. Assuming a bit designed for an ROP of 120 fph at 120 rpm, this

requires an average DOC of 0.20 inch. The DOCC features or DOC limiters would thus be designed to first contact the subterranean formation surface FS to provide a 0.20 inch DOC. It is assumed for the purposes of FIG. 4 that DOCC features or DOC limiters are sized so that compressive strength of the formation being drilled is not exceeded under applied WOB. As noted previously, the compressive strength of concern would typically be the in situ compressive strength of the formation rock resident in the formation being drilled (plus some safety factor), rather than unconfined compressive strength of a rock sample. In FIG. 4, an exemplary PDC cutter 14 is shown, for convenience, moving linearly right to left on the page. One complete revolution of the bit 10 or 100 on which PDC cutter 14 is mounted has been “unscrolled” and laid out flat in FIG. 4. Thus, as shown, PDC cutter 14 has progressed downwardly (i.e., along the longitudinal axis of the bit 10 or 100 on which it is mounted) 0.20 inch in  $360^\circ$  of rotation of the bit 10 or 100. As shown in FIG. 4, a structure or element to be used as a DOC limiter 50 is located conventionally, closely rotationally “behind” PDC cutter 14, as only  $22.5^\circ$  behind PDC cutter 14, the outermost tip 50a must be recessed upwardly 0.0125 inch ( $0.20 \text{ inch DOC} \times 22.5^\circ/360^\circ$ ) from the outermost tip 14a of PDC cutter 14 to achieve an initial 0.20 inch DOC. However, when DOC limiter 50 wears during drilling, ~~for example~~ example, by a mere 0.010 inch relative to the tip 14a of PDC cutter 14, the vertical offset distance between the tip 50a of DOC limiter 50 and tip 14a of PDC cutter 14 is increased to 0.0225 inch. Thus, DOC will be substantially increased, in fact, almost doubled, to 0.36 inch. Potential ROP would consequently equal 216 fph due to the increase in vertical standoff provided PDC cutter 14 by worn DOC limiter 50, but the DOC increase may damage PDC cutter 14 or ball the bit 10 or 100 by generating a volume of formation cuttings which overwhelms the bit's ability to clear them hydraulically. Similarly, if PDC cutter tip 14a wore at a relatively faster rate than DOC limiter 50 by, for example, 0.010 inch, the vertical offset distance is decreased to 0.0025 inch, DOC is reduced to 0.04 inch and ~~ROP,~~ ROP to 24 fph. Thus, excessive wear or vertical misplacement of either PDC cutter 14 or DOC limiter 50 to the other may result in a wide range of possible ROPs for a given rotational speed. On the other hand, if an exemplary DOCC feature 60 is placed, according to the present invention,  $45^\circ$  rotationally in front of (or  $315^\circ$  rotationally behind) PDC cutter tip 14a, the outermost tip 60a would initially be recessed upwardly 0.175 inch ( $0.20 \text{ inch DOC} \times 315^\circ/360^\circ$ ) relative to PDC cutter tip 14a to provide the

initial 0.20 inch DOC. FIG. 4 shows the same DOCC feature 60 twice, both rotationally in front of and behind PDC cutter 14, for clarity, it being, of course, understood that the path of PDC cutter 14 is circular throughout a 360° arc in accordance with rotation of bit 10 or 100.

When DOCC feature 60 wears 0.010 inch relative to PDC cutter tip 14a, the vertical offset distance between tip 60a of DOCC feature 60 and tip 14a of PDC cutter 14 is only increased from 0.175 inch to 0.185 inch. However, due to the placement of DOCC feature 60 relative to PDC cutter 14, DOC will be only slightly increased to about 0.211 inch. As a consequence, ROP would only increase to about 127 fph. Likewise, if PDC cutter 14 wears 0.010 inch relative to DOCC feature 60, vertical offset of DOCC feature 60 is only reduced to 0.165 inch and DOC is only reduced to about 0.189 inch, with an attendant ROP of about 113 fph. Thus, it can readily be seen how rotational placement of a DOCC feature can significantly affect ROP as the limiter or the cutter wears with respect to the other, or if one such component has been misplaced or incorrectly sized to protrude incorrectly even slightly upwardly or downwardly of its ideal, or “design,” position relative to the other, associated component when the bit is fabricated. Similarly, mismatches in wear between a cutter and a cutter-trailing DOC limiter are magnified in the prior art, while being significantly reduced when DOCC features sized and placed in cutter-leading positions according to the present invention are employed. Further, if a DOC limiter trailing, rather than leading, a given cutter is employed, it will be appreciated that shock or impact loading of the cutter is more probable as, by the time the DOC limiter contacts the formation, the cutter tip will have already contacted the formation. Leading DOCC ~~features~~, features on the other hand, by being located in advance of a given cutter along the downward helical ~~path~~ path, the cutter travels as it cuts the formation and the bit advances along its longitudinal axis, tend to engage the formation before the cutter. The terms “leading” and “trailing” the cutter may be easily understood as being preferably respectively associated with DOCC ~~features~~ positions positioned up to 180° rotationally preceding a cutter versus DOCC features ~~positions~~ positioned up to 180° rotationally trailing a cutter. While some portion of, for example, an elongated, arcuate leading DOCC feature according to the present invention may extend so far rotationally forward of an associated cutter so as to approach a trailing position, the substantial majority of the arcuate length of such a DOCC feature would preferably reside in a leading position. As may be appreciated by further reference to FIGS. 1

and 2, there may be a significant rotational spacing between a PDC cutter 14 and an associated bearing segment 30 of a DOCC feature, as across a fluid course 20 and its associated junk slot 26, while still rotationally leading the PDC cutter 14. More preferably, at least some portion of a DOCC feature according to the invention will lie within about 90° rotationally preceding the face of an associated cutter.

Please amend paragraph number [0067] as follows:

[0067] As shown in FIGS. 1 and 2, one or more DOCC features of a bit according to an invention may comprise elongated arcuate bearing segments 30 disposed at substantially the same radius about the bit longitudinal axis or centerline as a cutter preceded by that DOCC feature. In such an instance, and as depicted in FIG. 6A with exemplary arcuate bearing segment 30 unscrolled to lie flat on the page, it is preferred that the outer bearing surface S of a segment 30 be sloped at an angle  $\alpha$  to a plane P transverse to the centerline L of the bit substantially the same as the angle  $\beta$  of the (of the helical path 140) traveled by associated PDC cutter 14 as the bit drills the borehole. By so orienting the outer bearing surface S, the full potential surface, or bearing area of bearing segment 30 contacts and remains in contact with the formation as the PDC cutter 14 rotates. As shown in FIG. 6B, the outer surface S of an arcuate ~~segment~~ segment 30 may also be sloped at a variable angle to accommodate maximum and minimum design ROP for a bit. Thus, if a bit is designed to drill between 110 and 130 fph, the rotationally leading portion LS of surface S may be at one, relatively shallower angle  $\gamma$ , while the rotationally trailing portion TS of surface S (all of surface S still rotationally leading PDC cutter 14) may be at another, relatively steeper angle  $\delta$ , (both angles shown in exaggerated magnitude for clarity) the remainder of surface S gradually transitioning in an angle therebetween. In this manner, and since DOC must necessarily increase for ROP to increase, given a substantially constant rotational speed, at a first, shallower helix angle 140a corresponding to a lower ROP, the leading portion LS of surface S will be in contact with the formation being drilled, while at a higher ROP the helix angle will steepen, as shown (exaggerated for clarity) by comparatively steeper helix angle 140b and leading portion LS will no longer contact the formation, the contact area being transitioned to more steeply angled trailing portion TS. Of course, at an ROP intermediate the upper and lower limits of the design

range, a portion of surface S intermediate leading portion LS and trailing portion TS (or portions of both LS and TS) would act as the bearing surface. A configuration as shown in FIG. 6B is readily suitable for high compressive strength formations at varying ROP's within a design range, since bearing surface area requirements for the DOCC features are nominal. For bits used in drilling softer formations, it may be necessary to provide excess surface area for each DOCC feature to prevent formation failure and indentation, as only a portion of each DOCC feature will be in contact with the formation at any one time when drilling over a design range of ROPs. Conversely, for bits used in drilling harder formations, providing excess surface area for each DOCC feature to prevent formation failure and indentation may not be necessary as the respective portions of each DOCC feature may, when taken in combination, provide enough total bearing surface area, or total size, for the bit to ride on the formation over a design range of ROPs.

Please amend paragraph number [0068] as follows:

[0068] Another consideration in the design of bits according to the present invention is the abrasivity of the formation being drilled, and relative wear rates of the DOCC features and the PDC cutters. In non-abrasive formations this is not of major concern, as neither the DOCC feature nor the PDC cutter will wear appreciably. However, in more abrasive formations, it may be necessary to provide wear inserts 32 (see FIG. 1) or otherwise protect the DOCC features against excessive (i.e., premature) wear in relation to the cutters with which they are associated to prevent reduction in DOC. For example, if the bit is a matrix-type bit, a layer of diamond grit may be embedded in the outer surfaces of the DOCC features. Alternatively, preformed cemented tungsten carbide slugs cast into the bit face may be used as DOCC features. A diamond film may be formed on selected portions of the bit face using known chemical vapor deposition techniques as known in the art, or diamond films formed on substrates which are then cast into or brazed or otherwise bonded to the bit body. Natural diamonds, thermally stable PDCs (commonly termed TSPs) or even PDCs with ~~their~~ faces thereon substantially parallel to the helix angle of the cutter path (so that what would normally be the cutting face of the PDC acts as a bearing surface), or cubic boron nitride structures similar to the aforementioned diamond structures may also be employed on, or as, bearing surfaces of

the DOCC features, as desired or required, for example when drilling in limestones and dolomites. In order to reduce frictional forces between a DOCC bearing surface and the formation, a very low roughness, so-called "polished" diamond surface may be employed in accordance with U.S. Patents 5,447,208 and 5,653,300, assigned to the assignee of the present invention and hereby incorporated herein by this reference. Ideally, and taking into account wear of the diamond table and supporting substrate in comparison to wear of the DOCC features, the wear characteristics and volumes of materials taking the wear for the DOCC features may be adjusted so that the wear rate of the DOCC features may be substantially matched to the wear rate of the PDC cutters to maintain a substantially constant DOC. This approach will result in the ability to use the PDC cutter to its maximum potential life. It is, of course, understood that the DOCC features may be configured as abbreviated "knots," "bosses," or large "~~mesas~~" "mesas," as well as the aforementioned arcuate segments or may be of any other configuration suitable for the formation to be drilled to prevent failure thereof by the DOCC features under expected or planned WOB.

Please amend paragraph number [0073] as follows:

[0073] FIGS. 9A, 9B, 9C and 9D respectively depict alternative pivotable DOCC features 190, 200, 210 and 220. DOCC feature 190 includes a head 192 partially received in a cavity 194 in a bit 150 and mounted through a ball and socket connection 196 to a stud 180 press-fit into aperture 198 at the top of cavity 194. ~~DOCC features~~ feature 200, wherein elements similar to those of DOCC feature 190 are identified by the same reference numerals, is a variation of DOCC feature 190. DOCC feature 210 employs a head ~~212~~ 212, which is partially received in a cavity 214 in a bit 150 and secured thereto by a resilient or ductile connecting element 216 which extends into aperture 218 at the top of cavity 214. Connecting element 216 may comprise, for example, an elastomeric block, a coil spring, a belleville spring, a leaf spring, or a block of ductile metal, such as steel or bronze. Thus, connecting element 216, as with the ball and socket connections 196 and heads 192, permits head 212 to automatically adjust to, or compensate for, varying ROPs defining different cutter helix angles. DOCC feature 220 employs a yoke 222 rotationally disposed and partially received within cavity 224, yoke 222 supported on protrusion 226 of bit 150. Stops 228, of resilient or ductile materials (such as elastomers, steel,

lead, etc.) and which may be permanent or replaceable, permit yoke 222 to accommodate various helix angles. Yoke 222 may be secured within cavity 224 by any conventional means. Since helix angles vary even for a given, specific ROP as distance of each cutter from the bit centerline, affording such automatic adjustment or compensation may be preferable to trying to form DOCC features with bearing surfaces at different angles at different locations over the bit face.

Please amend paragraph number [0074] as follows:

[0074] FIGS. 10A and 10B respectively depict different DOCC features and PDC cutter combinations. In each instance, a PDC cutter 14 is secured to a combined cutter carrier and DOC limiter 240, the cutter carrier and DOC limiter 240 being received within a cavity 242 in the face (or on a blade) of an exemplary bit 150 and secured therein as by brazing, welding, mechanical fastening, or otherwise as known in the art. The cutter carrier and DOC limiter 240 includes a protrusion 244 exhibiting a bearing surface 246. As shown and by way of example only, bearing surface 246 may be substantially flat (FIG. 10A) or hemispherical (FIG. 10B). By selecting an appropriate cutter carrier and DOC limiter 240, the DOC of PDC cutter 14 may be varied and the surface area of bearing surface 246 adjusted to accommodate a target formation's compressive strength.

Please amend paragraph number [0075] as follows:

[0075] It should be noted that the DOCC features of FIGS. 7 through 10, in addition to accommodating different formation compressive ~~strengths~~ strengths, as well as optimizing DOC and permitting minimization of friction-causing bearing surface area while preventing formation failure under WOB, also facilitate field repair and replacement of DOCC features due to drilling damage or to accommodate different formations to be drilled in adjacent formations, or intervals, to be penetrated by the same borehole.

Please amend paragraph number [0076] as follows:

[0076] FIG. 11 depicts a DOCC feature 250 comprised of an annular cavity or channel 252 in the face of an exemplary bit 150. Radially adjacent PDC cutters 14 flanking

annular channel 252 cut the formation 254 but ~~for use~~ do not cut annular segment 256, which protrudes into annular cavity 252. At the top 260 of annular channel 252, a flat-edged PDC cutter 258 (or preferably a plurality of rotationally spaced cutters 258) truncates annular segment 256 in a controlled manner so that the height of annular segment 256 remains substantially constant and limits the DOC of flanking PDC cutters 14. In this instance, the bearing surface of the DOCC feature 250 comprises the top 260 of annular channel 252, and the sides 262 of channel 252 prevent collapse of annular segment 256. Of course, it is understood that multiple annular channels 252 with flanking PDC cutters 14 may be ~~employed~~, employed and that a source of drilling fluid, such as aperture 264, would be provided to lubricate channel 252 and flush formation cuttings from cutter 258.

Please amend paragraph number [0077] as follows:

[0077] FIGS. 12 and 12A depict a low-friction, hydraulically enhanced DOCC feature 270 comprised of a DOCC pad 272 rotationally leading a PDC cutter 14 across fluid course 20 on exemplary bit 150, pad 272 being provided with drilling fluid through passage 274 leading to the bearing surface 276 of pad 272 from a plenum 278 inside the body of bit 150. As shown in FIG. 12A, a plurality of channels 282 may be formed on bearing surface 276 to facilitate distribution of drilling fluid from the mouth 280 of passage 274 across bearing surface 276. By diverting a small portion of drilling fluid flow to the bit 150 from its normal path leading to nozzles associated with the cutters, it is believed that the increased friction normally attendant with WOB increases after the bearing surface 276 of DOCC pad 272 contacts the formation may be at least somewhat ~~alleviated, and alleviated or~~, in some ~~instances~~ instances, substantially avoided, ~~reducing which may reduce or eliminating~~ eliminate torque increases responsive to increases of WOB. Of course, passages 274 may be sized to provide appropriate flow, or pads 272 sized with appropriately dimensioned mouths 280. Pads 272 may, of course, be configured for replaceability.



Please amend paragraph number [0078] as follows:

[0078] As has been mentioned above, backrakes of the PDC cutters employed in a bit equipped with DOCC features according to the invention may be more aggressive, that is to say, less negative, than with conventional bits. It is also contemplated that extremely aggressive cutter rakes, including neutral rakes and even positive (forward) rakes of the ~~cutters~~ cutters, may be successfully employed consistent with the cutters' inherent strength to withstand the loading thereon as a consequence of such rakes, since the DOCC features will prevent such aggressive cutters from engaging the formation to too great a depth.

Please amend paragraph number [0079] as follows:

[0079] It is also contemplated that two different heights, or exposures, of bearing segments may be employed on a bit, a set of higher bearing segments providing a first bearing surface area supporting the bit on harder, higher compressive strength formations providing a relatively shallow DOC for the PDC cutters of the bit, while a set of lower bearing segments remains out of contact with the formation while drilling until a softer, lower compressive stress formation is encountered. At that juncture, the higher or more exposed bearing segments will be of insufficient surface area to prevent indentation (failure) of the formation rock under applied WOB. Thus, the higher bearing segments will indent the formation until the second set of bearing segments comes in contact therewith, whereupon the combined surface area of the two sets of bearing segments will support the bit on the softer formation, but at a greater DOC to permit the cutters to remove a greater volume of formation material per rotation of the bit and thus generate a higher ROP for a given bit rotational speed. This approach differs from the approach illustrated in FIG. ~~5~~ 5, in that, unlike stepped DOCC features (bearing segment 130), bearing segments of differing heights or exposures are associated with different cutters. Thus, this aspect of the invention may be effected, for example, in the bits 10 and 100 of FIGS. 1 and 2 by fabricating selected arcuate bearing segments to a greater height or exposure than others. Thus, bearing segments 30b and 30e of bits 10 and 100 may exhibit a greater exposure than segments 30a, 30c, 30d and 30f, or vice versa.

Please amend paragraph number [0080] as follows:

[0080] Cutters employed with bits 10 and 100, as well as other bits disclosed that will be discussed subsequently herein, are depicted as having PDC cutters 14, but it will be recognized and appreciated by those of ordinary skill in the art that the invention may also be practiced on bits carrying other types of superabrasive cutters, such as thermally stable polycrystalline diamond compacts, or TSPs, for ~~example~~ example, arranged into a mosaic pattern as known in the art to simulate the cutting face of a PDC. Diamond film cutters may also be employed, as well as cubic boron nitride compacts.

Please amend paragraph number [0081] as follows:

[0081] Another embodiment of the present invention, as exemplified by rotary drill bit 300 and 300', is depicted in FIGS. ~~14A-20~~, 14A-20. Rotary drill ~~bits~~ bits, such as drill bits 300 and 300', according to the present invention, may include many features and elements which correspond to those identified with respect to previously described and illustrated bits 10 and 100.

Please amend paragraph number [0082] as follows:

[0082] Representative rotary drill bit 300 shown in FIGS. 14A and 14B, includes a bit body 301 having a leading end 302 and a trailing end 304. Connection 306 may comprise a pin-end connection having tapered threads for connecting bit 300 to a bottom hole assembly of a conventional rotating drill string, or ~~alternatively~~ alternatively, for connection to a downhole motor ~~assembly~~ assembly, such as a drilling fluid powered Moineau-type downhole motor, as described earlier. Leading end 302, or drill bit face, ~~302~~ includes a plurality of blade structures 308 generally extending radially outwardly and longitudinally toward trailing end 304. Exemplary bit 300 comprises eight blade structures 308, or blades, ~~308~~ spaced circumferentially about the bit. However, a fewer number of blades may be provided on a bit such as provided on bit body 301' of bit 300' shown in FIG. 14C which has six blades. A greater number of blade structures of a variety of geometries may be utilized as determined to be optimum for a particular drill bit. Furthermore, ~~blades~~ blade structures 308 need not be equidistantly spaced about the

circumference of drill bit 300 as shown, but may be spaced about the circumference, or periphery, of a bit in any suitable ~~fashion~~ fashion, including a non-equidistant arrangement or an arrangement wherein some of the blades are spaced circumferentially equidistantly from each other and ~~wherein some of the blades are~~ irregularly, non-equidistantly spaced from each other. Moreover, ~~blades~~ blade structures 308 need not be specifically configured in the manner as shown in FIGS. 14A and 14B, but may be configured to include other profiles, sizes, and combinations than those shown.

Please amend paragraph number [0084] as follows:

[0084] ~~Blades~~ Blade structures 308 preferably comprise, in addition to gage region 322 of ~~blades~~ blade structures 308, a radially outward facing bearing surface 320, a rotationally leading surface 324, and a rotationally trailing surface 326. That is, as the bit 300 is rotated in a subterranean formation to create a borehole, leading surface 324 will be facing the intended direction of bit rotation while trailing surface 326 will be facing opposite, or backwards from, the intended direction of bit rotation. A plurality of cutting elements, or ~~cutters, 328~~ cutters 328, are preferably disposed along and partially within ~~blades~~ blade structures 308. Specifically, cutters 328 are positioned so as to have a superabrasive cutting face, or ~~table, 330~~ table 330, generally facing in the same direction as leading surface ~~324~~ 324, as well as to be exposed to a certain extent beyond bearing surface 320 of the respective blade in which each cutter is positioned. Cutters 328 are preferably superabrasive cutting elements known within the art, such as the exemplary PDC cutters described previously herein, and are physically secured in pockets 342 by installation and securement techniques known in the art. The preferred amount of exposure of cutters 328 in accordance with the present invention will be described in further detail hereinbelow.

Please amend paragraph number [0085] as follows:

[0085] Optional wear knots, wear clouds, or built-up wear-resistant areas ~~334~~, collectively referred to as wear knots 334 herein, may be disposed upon, or otherwise provided on bearing surfaces 320 of ~~blades~~ blade structures 308 with wear knots 334 preferably being

positioned so as to rotationally follow cutters 328 positioned on respective blades or other surfaces in which cutters 328 are disposed. Wear knots 334 may be originally molded into bit 300 or may be added to selected portions of bearing surface 320. As described earlier herein, bearing surfaces 320 of ~~blades~~ blade structures 308 may be provided with other wear-resistant features or ~~characteristics~~ characteristics, such as embedded diamonds, TSPs, PDCs, hard facing, weldings, and weldments for example. As will become apparent, such wear-resistant features can be employed to further enhance and augment the DOCC aspect as well as other beneficial aspects of the present invention.

Please amend paragraph number [0086] as follows:

[0086] FIGS. 15A-15C highlight the extent in which cutters 328 are exposed with respect to the surface immediately surrounding cutters 328 and particularly cutters 328C located within the radially innermost region of the leading end of a bit proximate the longitudinal centerline of the bit. FIG. 15A provides a schematic representation of a representative group of cutters provided on a bit as the bit rotatingly engages a formation with the cutter profile taken in cross-section and projected onto a single, representative vertical plane (i.e., the drawing sheet). Cutters 328 are generally radially, or laterally, positioned along the face of the leading end of a bit, such as representative bit 300, so as to provide a selected center-to-center radial, or lateral spacing between cutters referred to as center-to-center cutter spacing  $R_s$ . Thus, if a bit is provided with a blade structure, such as blade structures 308, the cutter profile of 15A represents the cutters positioned on a single representative blade structures 308. As exaggeratedly illustrated in FIG. 15A, cutters 328C located in cone region 310 are preferably disposed into blade structures 308 so as to have a cutter exposure  $H_c$  generally perpendicular to the outwardly face bearing surface 320 of blade structures 308 by a selected amount. As can be seen in ~~FIG. 15A,~~ FIG. 15A, cutter exposure  $H_c$  is of a preferably relative small amount of standoff, or exposure, distance in cone region 310 of bit 300. Preferably, cutter exposure  $H_c$  generally differs for each of the cutters or groups of cutters positioned more radially distant from centerline L. For example cutter exposure  $H_c$  is generally greater for cutters 328 in nose region 312 than it is for cutters 328 located in cone region 310 and cutter exposure  $H_c$  is preferably at a maximum in flank/shoulder regions 314/316. Cutter exposure  $H_c$  preferably diminishes slightly radially

toward gage region 322, and radially outermost cutters 328 positioned longitudinally proximate gage pad surface 354 of gage region 322 may incorporate cutting faces of smaller cross-sectional diameters as illustrated. Gage line 352 (see FIGS. 16 and 17) defines the maximum outside diameter of bit 300.

Please amend paragraph number [0087] as follows:

[0087] The cross-sectional profile of optional wear knots 334, wear clouds, hard facing, or surface welds ~~334~~ have been omitted for clarity in FIG. 15A. However, FIG. 15C depicts the rotational cross-sectional profile, as superimposed upon a single, representative vertical ~~plane~~, plane of representative optional wear knots 334, wear clouds, hard facing, surface welds, or other wear knot structures ~~334~~. FIG. 15C further illustrates an exemplary cross-sectional wear knot height  $H_{wk}$  measured generally perpendicular to outwardly face bearing surface 320. There may or may not be a generally radial dimensional difference, or relief,  $\Delta H_{c-wk}$ , between wear knot height  $H_{wk}$ , which generally corresponds to a radially outermost surface of a given wear knot or structure, and respective cutter exposure  $H_c$ , which generally corresponds to the radially outermost portion of the rotationally associated cutter, to further provide a DOCC feature in accordance with the present invention. Conceptually, these differences in exposures can be regarded as analogous to the distance of cutter 14 and rotationally trailing DOC limiter 50 as measured from the dashed reference line illustrated in FIG. 4 and as described earlier. Furthermore, instead of referring to the distance in which the radially outermost surface of a given wear knot structure is positioned radially outward from a bearing surface or blade structure in which a particular wear knot structure is disposed upon, it may be helpful to alternatively refer to a preselected distance in which the radially outermost surface of a given wear knot structure is radially/longitudinally inset, or relieved from the outermost portion of the exposed portion of a rotationally associated superabrasive cutter as denoted as  $\Delta H_{c-wk}$  in FIG. 15C. Thus, in addition to controlling the DOC with at least certain cutters, and perhaps every cutter, by selecting an appropriate cutter exposure height  $H_c$  as defined and illustrated herein, the present invention further encompasses optionally providing drill bits with wear knots, or other similar cutter depth limiting structures, to complement, or augment, the control of the DOCs of respectively rotationally associated ~~cutters~~ cutters, wherein such optionally provided wear knots are disposed

on the bit so as to have a wear knot surface that is positioned, or relieved, a preselected distance  $\Delta H_{c-wk}$  as measured from the outermost exposed portion of the cutter in which a wear knot is rotationally associated to the wear knot surface.

Please amend paragraph number [0088] as follows:

[0088] The superimposed cross-sectional cutter profile of a representative drill bit such as bit 300 in FIG. 15B depicts the combined profile of all cutters installed on each of a plurality of ~~blades~~ blade structures 308 so as to have a selected center-to-center radial cutter spacing  $R_s$ . Thus, the cutter profile illustrated in FIG. 15B is the result of all of the cutters provided on a plurality of blades and rotated about the centerline of the bit to be superimposed upon a single, representative blade structures 308. In some embodiments, there will likely be several cutter redundancies at identical radial locations between various cutters positioned on respective, circumferentially spaced blades, and, for clarity, such profiles which are perfectly, or absolutely, redundant are typically not illustrated. As can be seen in FIG. 15B, there will be a lateral, or radial, overlap between respective cutter paths as the variously provided cutters rotationally progress generally tangential to longitudinal axis L as the bit 300 rotates so as to result in a uniform cutting action being achieved as the drill bit rotatingly engages a formation under a selected WOB. Additionally, it can be seen in FIG. 15B that the lateral, or radial, spacing between individual cutter profiles need not be of the same, uniform distance with respect to the radial, or lateral, position of each cutter. This non-uniform spacing with respect to the radial, or lateral, positioning of each cutter is more clearly illustrated in FIGS. 16 and 17.

Please amend paragraph number [0089] as follows:

[0089] FIGS. 16 and 17 are enlarged, isolated partial cross-sectional cutter profile views to which all of the cutters located on a bit are superimposed as if on a single cross-sectional portion of a bit body 301 or cutters 328 of a ~~bit~~ bit, such as bit 300. The cutter profiles of FIGS. 16 and 17 are illustrated as being to the right of longitudinal centerline L of a representative ~~bit~~ bit, such as bit ~~300~~ 300, instead of the ~~left~~ left, as illustrated in ~~FIGS. 15A-15C.~~ 15A-15C. As ~~described~~ described, the leading end of bit 300 includes cone

region ~~310~~ 310, which includes cutters ~~328C~~, 328C; nose region ~~312~~ 312, which includes cutters ~~328N~~, 328N; flank region ~~314~~ 314, which includes cutters ~~328F~~, 328F; shoulder region ~~316~~ 316, which includes cutters ~~328S~~, 328S; and gage region ~~322~~ 322, which includes cutters ~~328G~~ 328G; wherein the cutters in each region may be referred to collectively as cutters 328. FIG. 16 illustrates a cutter profile exhibiting a high degree, or amount, of cutter overlap 356. That is, cutters 328 as illustrated in FIG. 17 are provided in sufficient quantity and are positioned sufficiently close to each other laterally, or radially, so as to provide a high degree of cutter redundancy as the bit rotates and engages the formation. In contrast, the representative cutter profile illustrated in ~~FIG. 17~~ FIG. 17 exhibits a relatively lower degree, or amount, of cutter overlap 356. That is, the total number of cutters 328 is less in quantity and are spaced further apart with respect to the radial, or lateral, distance between individual, rotationally adjacent cutter profiles. Kerf regions 348, shown in phantom, in FIGS. 16 and 17 reveal a relatively small height for kerf regions 348 of FIG. 16 wherein kerf regions of ~~FIGS. 17~~ FIG. 17 are significantly higher. To aid in the illustration of the respective differences in individual kerf region height  $K_H$ , which, as a practical matter, is directly related to cutter exposure height  $H_C$ , as well as individual kerf region widths  $K_w$ , which are directly influenced by the extent of radial overlap of cutters respectively positioned on different blades, a scaled reference grid of a plurality of parallel spaced lines is provided in FIGS. 16 and 17 to highlight the cutter exposure height and kerf region widths. The spacing between the grid lines in FIGS. 16 and 17 are scaled to represent approximately .125 of an inch. However, such a .125, or 1/8 inch, scale grid is merely exemplary, as dimensionally greater as well as dimensionally smaller cutter exposure heights, kerf region heights, and kerf region widths may be used in accordance with the present invention. The superimposed cutter profile of cutters 328 is illustrated with each of the represented cutters 328 being generally equidistantly spaced along the face of the bit from centerline L toward gage region ~~322~~, 322, however, such need not be the case. For example, cutters 328C may have a cutter profile exhibiting more cutter overlap 356 resulting in a in small kerf widths in cone region 310 as compared to a cutter profile of cutters 328N, 328F, and 328S respectively located in nose region 312, flank region 314, and shoulder region ~~316~~ 316, wherein such more radially outward positioned cutters would have less overlap resulting in larger kerf widths therein, or vice versa. Thus, by selectively incorporating the amount of cutter overlap 356 to be

provided in each region of a bit, the depth of cut of the cutters in combination with selecting the degree or amount of cutter exposure height of each cutter located in each particular region may be utilized to specifically and precisely control the depth of cut in each ~~region~~ region, as well as to design into the bit the amount of available bearing surface surrounding the cutters to which the bit may ride upon the formation. Stated differently, the wider the kerf width  $K_w$  between the collective, superimposed, individual cutter profiles of all the cutters on all of the blades, or ~~alternatively~~ alternatively, all the cutters radially and circumferentially spaced about a bit, such as cutters 328 provided on a bit ~~such as~~ as shown in FIG. 17, a greater proportion of the total applied WOB will be dispersed upon the formation allowing the bit to “ride” on the formation than would be the case if a greater quantity of cutters were provided having a smaller kerf width  $K_w$  ~~therebetween~~ therebetween, as shown in FIG. 16.

Please amend paragraph number [0090] as follows:

[0090] Therefore, the cutter profile illustrated in FIG. 17 would result in a considerable portion of the WOB being applied to bit 300 to be dispersed over the wide kerfs and thereby allowing bit 300 to be supported by the formation as cutters 328 engage the formation. This feature of selecting both the total number of kerfs and the widths of the individual kerf widths  $K_w$  allows for a precise control of the individual depth-of-cuts of the cutters adjacent the kerfs, as well as the total collective depth-of-cut of bit 300 into a formation of a given hardness. Upon a great enough, or amount of, WOB being applied on the bit when drilling in a given relatively ~~hard-formation~~ formation, the kerf regions 348 would come to ride upon the formation, thereby limiting, or arresting, the DOC of cutters 328. If yet further WOB were to be applied, the DOC would not increase as the kerf regions 348, as well as portions of the outwardly facing surface of the blade surrounding each cutter 328 provided with a reduced amount of exposure in accordance with the present invention, would, in combination, provide a total amount of bearing surface to support the bit in the relative hard formation, notwithstanding an excessive amount of WOB being applied to the bit in light of the current ROP.



Please amend paragraph number [0091] as follows:

[0091] Contrastingly, in a bit provided with a cutter profile exhibiting dimensionally small cutter-to-cutter spacings by incorporating a relatively high quantity of cutters 328 with a small kerf region  $K_w$  between mutually radially, or laterally, overlapped-cutters cutters, such as illustrated in FIG. 16, each individual cutter would engage the formation with a lesser amount of DOC per cutter at a given WOB. Because each cutter would engage the formation at a lesser DOC as compared with the cutter profile of FIG. 17, with all other variables being held constant, the cutters of the cutter profile of FIG. 16 would tend to be better suited for engaging a relative hard formation where a large DOC is not needed, and ~~is~~ is, in-fact fact, not ~~preferred~~, preferred for engaging and cutting a hard formation efficiently. Upon a requisite, or excessive amount of WOB further being applied on a bit having the cutter profile of FIG. 16 in light of the current ROP being afforded by the bit, kerf regions 348 would come to ride upon the formation, as well as other portions of the outwardly facing blade surface surround each cutter 328 exhibiting a reduced amount of exposure in accordance with the present invention to limit the DOC of each cutter by providing a total amount of bearing surface to disperse the WOB onto the formation being drilled. In general, larger kerfs will promote dynamic stability over formation cutting efficiency, while smaller kerfs will promote formation cutting efficiency over dynamic stability.

Please amend paragraph number [0093] as follows:

[0093] Therefore, FIG. 16 illustrates an exemplary cutter profile particularly suitable for, but not limited to, a “hard formation,” while FIG. 17 illustrates an exemplary cutter profile particularly suitable for, but not limited to, a “soft formation.” Although the quantity of cutters provided on a bit will significantly influence the amount of kerf provided between radially adjacent cutters, it should be kept in mind that both the size, or diameter, of the cutting surfaces of the cutters may also be selected to alter the cutter profile to be more suitable for either a harder or softer formation. For example, cutters having larger diameter superabrasive tables may be utilized to provide a cutter ~~profile~~ profile, including dimensionally larger kerf heights and dimensionally larger kerf widths to enhance soft formation cutting characteristics. Conversely, a

bit may be provided with cutters having smaller diameter superabrasive tables to provide a cutter profile exhibiting dimensionally smaller kerf heights and dimensionally smaller kerf widths to enhance hard formation cutting characteristics of a bit in accordance with the teachings herein.

Please amend paragraph number [0094] as follows:

[0094] Additionally, the full-gage diameter that a bit is to have will also influence the overall cutter profile of the bit with respect to kerf heights and kerf widths, as there will be a greater total amount of bearing surface potentially available to support larger diameter bits on a ~~formation~~ formation, unless the bit is provided with a proportionately greater number of reduced exposure cutters and, if desired, conventional cutters, so as to effectively reduce the total amount of potential bearing surface area of the bit.

Please amend paragraph number [0095] as follows:

[0095] FIG. 18A of the drawings is an isolated, schematic, frontal view of three representative cutters 328C positioned in cone region 310 of a representative blade-~~structure~~ structures 308. Each of the representative cutters exhibits a preselected amount of cutter exposure so as to limit the DOC of the cutters while also providing individual kerf regions 348 between cutters 328 (in this particular illustration, kerf width  $K_w$  represents the kerf width between cutters which are located on the same blade and exhibit a selected radial spacing  $R_s$ ) and to which the bearing surface of the blade to which the cutters are secured (surface 320C) provides a bearing surface, including kerf regions 348 for the bit to ride, or rub, upon the formation, not currently being cut by this particular blade structures 308, upon the design WOB being exceeded for a given ROP in a formation 350 of certain hardness, or compressive strength. As can be seen in FIG. 18A, this particular view shows a rotationally leading ~~blade-surface~~ 324 advancing toward the viewer and shows superabrasive cutting face or tables 330 of cutters 328C engaging and creating a formation cutting 350', or chip, ~~350'~~ as the cutters engage the formation at a given DOC.

Please amend paragraph number [0096] as follows:

[0096] FIG. 18B provides an isolated, side view of a representative reduced exposure cutter, such as cutter 328C located in cone region 310. Cutter 328C is shown as being secured in a blade structures 308 at a preselected backrake angle  $\theta_{br}$  and exhibits a selected exposed cutter height  $H_c$ . As can be seen in FIG. 18B, cutter 328C is provided with an optional, peripherally extending chamfered region 321 exhibiting a preselected chamfer width  $C_w$ . The arrow represents the intended direction of bit rotation when the bit in which the cutter is installed is placed in operation. A gap referenced as  $G_1$  can be seen rotationally rearwardly of cutter 328C. Cutter exposure height  $H_c$  allows a sufficient amount of cutter 328C to be exposed to allow cutter 328C to engage formation 350 at a particular DOC1, which is well within the maximum DOC that cutter 328C is capable of engaging formation 350, to create a formation cutting 350' at this particular DOC1. Thus, in accordance with the present invention, the WOB now being applied to the bit in which cutter 328C is installed, is at a value less than the design WOB for the instant ROP and the compressive strength of formation 350.

Please amend paragraph number [0097] as follows:

[0097] In contrast to FIG. 18B, FIG. 18C provides essentially the same side view of cutter 328C upon the design WOB for the bit being exceeded for the instant ROP and the compressive strength of formation 350. As can be seen in FIG. 18C, reduced exposure cutter 328C is now engaging formation 350 at a ~~DOC2~~ DOC2, which happens to be the maximum DOC that this particular cutter 328C should be allowed to cut. This is because formation 350 is now riding upon outwardly facing bearing surface ~~320C~~ 320C, which generally surrounds the exposed portion of cutter 328C. That is, gap  $G_2$  is essentially nil in that surface 320C and formation 350 are contacting each other and surface 320C is sliding upon formation 350 as the bit to which representative reduced exposure cutter ~~320C~~ 328C is rotated in the direction of the reference arrow. Thus, especially in the absence of optional wear knots 334 (FIG. 14A), DOC2 is essentially limited to the amount of cutter exposure height  $H_c$  at the presently applied WOB in light of the compressive strength of the formation being engaged at the instant ROP. Even if the amount of WOB applied to the bit to which cutter 328C is installed is

increased further, DOC2 will not increase as bearing surface 320C, in addition to other face bearing surfaces 320 on the bit accommodating reduced ~~exposure~~ exposure of cutter-328, 328C will prevent DOC2 from increasing beyond the maximum amount shown. Thus, bearing surface(s) 320C surrounding at least the exposed portion of cutter-~~328, 328C~~, taken collectively with other bearing surfaces, will prevent DOC2 from increasing dimensionally to an extent which could cause an unwanted, potentially bit damaging TOB being generated due to cutter-~~328, 328C~~ overengaging formation 350. That is, a maximum-sized formation cutting 350" associated with a reduced exposure cutter engaging the formation at a respective maximum DOC2, taken in combination with other reduced exposure cutters engaging the formation at a respective maximum DOC2, will not generate as taken in combination, a total, excessive amount of TOB which would stall the bit when the design WOB for the bit is met or exceeded for the particular compressive strength of the formation being engaged at the current ROP. Thus, the DOCC aspects of this particular embodiment ~~is~~ are achieved by preferably ensuring that there is sufficient area surrounding each reduced exposure cutter 328, such as representative reduced exposure cutter 328C, so that not only is the DOC2 for this particular cutter not exceeded, regardless of the WOB being applied, but preferably the DOC of a sufficient number of other cutters provided along the face of a bit encompassing the present invention is limited to an extent which prevents an unwanted, potentially damaging TOB from being generated. Therefore, it is not necessary that each and every cutter provided on a drill bit exhibit a reduced exposure cutter height so as to effectively limit the DOC of each and every cutter, but it is preferred that at least a sufficient quantity of cutters of the total quantity of cutters provided on a bit be provided with at least one of the DOCC features disclosed herein to preclude a bit, and the cutters thereon, from being exposed to a potentially damaging TOB in light of the ROP for the particular formation being drilled. For example, limiting the amount of cutter exposure of each cutter positioned in the cone region of a drill bit may be sufficient to prevent an unwanted amount of TOB should the WOB exceed the design WOB when drilling through a formation of a particular hardness at a particular ROP.

Please amend paragraph number [0098] as follows:

[0098] ~~FIGS. 19-22~~ FIGS. 19-22 are graphical portrayals of laboratory test results of four different bladed-style drill bits incorporating PDC cutters on the blades thereof. Drill bits labeled "RE-S" and "RE-W" each had selectively reduced cutter exposures in accordance with the present invention as previously described and illustrated in ~~FIGS. 14A-18C~~ 14A-18C. However, ~~drill bit labeled "RE-S" was~~ "RE-S" was provided with a cutter profile exhibiting small kerfs and drill bit labeled "RE-W" was provided with a cutter profile exhibiting wide kerfs. The bits having reduced exposure cutters are graphically contrasted with the laboratory test results of a prior art steerable bit ~~labeled "STR" featuring~~ "STR" including approximately .50 inch diameter cutters with each cutter including a superabrasive table having a peripheral edge chamfer exhibiting a width of approximately .050 inches and angled toward the longitudinal axis of the cutter by approximately 45°. Conventional, or standard, general purpose drill bit labeled "STD" ~~featured~~ included approximately .50 inch diameter cutters backraked at approximately 20° and exhibiting chamfers ~~that were of~~ approximately 0.016 inches in width and angled approximately 45° with respect to the longitudinal axis of the cutter. All bits had a gage diameter of approximately 12.25 inches and were rotated at 120 RPM during testing. With respect to all of the tested bits, the PDC cutters installed in the cone, nose, flank, and shoulder of the bits had cutter backrake angles of approximately 20° and the PDC cutters installed generally within the gage region had a cutter backrake angle of approximately 30°. The cutter exposure heights of the RE-S and RE-W bits were approximately .120 inches for the cutters positioned in the cone region, approximately .150 inches in the nose region, approximately .100 inches in the flank region, approximately .063 inches in the shoulder region, and the cutters in the gage region were generally ground flush with the gage for both of these bits embodying the present invention. The PDC cutters of the RE-S and RE-W bits were approximately .75 inches in diameter (with the exception of PDC cutters located in the ~~gage region~~ region, which were ~~smaller~~ smaller in diameter and ground flush with the gage) and were provided with a chamfer on the peripheral edge of the superabrasive cutting table of the cutter. The chamfers exhibited a width of approximately .019 inches and were angled toward the longitudinal axes of the cutters by

approximately 45°. The mean kerf width of the RE-S bit was approximately 0.3 ~~of an inch~~ inches and the mean kerf width of the RE-W bit was approximately 0.2 ~~an inch~~ inches.

Please amend paragraph number [0099] as follows:

[0099] FIG. 19 depicts test results of Aggressiveness ( $\mu$ ) vs. DOC (in/rev) of the four different drill bits. Aggressiveness ( $\mu$ ), which is defined as ~~Torque / (Bit Torque / (Bit Diameter~~ x Thrust), can be expressed as:

$$\mu = 36 \text{Torque (ft-lbs)} / \text{WOB(lbs)} \cdot \text{Bit Diameter(inches)}$$

The values of DOC depicted FIG. 19 represent the DOC measured in inches of penetration per revolution that the test bits made in the test formation of Carthage limestone. The confining pressure of the formation in which the bits were tested was at atmospheric, or ~~in other words~~ 0 psig.

Please amend paragraph number [0100] as follows:

[0100] Of significance is the encircled region labeled "D" ~~of as shown in~~ the graph of FIG. 19. The plot of bit RE-S prior to encircled region D is very similar in slope to prior art steerable bit STR but upon the DOC reaching about .120 inches, the respective aggressiveness of the RE-S bit falls rather dramatically compared to the plot of the STR bit proximate and within encircled region D. This is attributable to the bearing surfaces of the RE-S bit taking on and axially dispersing the elevated WOB upon the formation axially underlying the bit associated with the larger DOCs, such as the DOCs exceeding approximately .120 inches in accordance with the present invention.

Please amend paragraph number [0101] as follows:

[0101] FIG. 20 graphically portrays the test results with respect to WOB in pounds versus ROP in feet per hour with a drill bit rotation of 120 revolutions per minute. Of general importance in the graph of FIG. 20 is that all of the plots tend to have the same flat curve as WOB and ROP initially ~~increases indicating that~~. Thus, at lower WOBs and lower ~~ROPs~~ ROPs, of the RE-S and RE-W bits embodying the present invention exhibit generally the same

behavior as the STR and STD bits. However, as WOB was increased, the RE-S bit in particular required an extremely high amount of WOB in order to increase the ROP for the bit due to the bearing surfaces of the bit taking on and dispersing the axial loading of the bit. This is evidenced by the plot of the reduced cutter exposure bit in the vicinity of region labeled "E" of the graph exhibiting a dramatic upward slope. Thus, in order to increase the ROP of the subject inventive bit at ROP values exceeding about 75 ft/hr, a very significant increase of WOB was required for WOB values above approximately 20,000 lbs as the load on the subject bit was successfully dispersed on the formation axially underlying the bit. The fact that a WOB of approximately 40,000 lbs was applied without the RE-S bit stalling provides very strong evidence of the effectiveness of incorporating reduced exposure cutters to modulate and control TOB in accordance with the present invention as will become even more apparent in yet to be discussed FIG. 22.

Please amend paragraph number [0102] as follows:

[0102] FIG. 21 is a graphical portrayal of the test results in terms of TOB in the units of pounds-foot versus ROP in the units of feet per hour. As can be seen in the graph of FIG. ~~21~~ 21, the various plots of the tested bits generally tracked the same, moderate and linear slope throughout the respective extent of each plot. Even in region labeled "F" of the graph, where ROP was over 80 ft/hr, the TOB curve of the bit having reduced exposure cutters exhibited only slightly more TOB as compared to the prior art steerable and standard, general purpose bit notwithstanding the corresponding highly elevated WOB being applied to the subject inventive bit as shown in FIG. 20.

Please amend paragraph number [0104] as follows:

[0104] The representative prior art steerable bit generally has an efficient TOB/WOB slope at ~~WOB's~~ WOBs below approximately 20,000 ~~lbs~~ lbs, but at WOBs exceeding approximately 20,000 lbs, the attendant TOB is unacceptably high and could lead to unwanted bit stalling and/or damage. The RE-W bit incorporating the reduced exposure cutters in accordance with the present invention, which also incorporated a cutter profile having large kerf widths so

that the onset of the bearing surfaces of the bit contacting the formation occurs at relatively low values of WOB. However, the bit having such an “always rubbing the formation” characteristic via the bearing surfaces, such as formation facing bearing surfaces 320 of blades blade structures 308 as previously discussed and illustrated herein, coming into contact and axially dispersing the applied WOB upon the formation at relatively low WOBs, may provide acceptable ROPs in soft formations, but such a bit would lack the amount of aggressivity needed to provide suitable ROPs in harder, firmer formations and thus could be generally considered to exhibit an inefficient TOB versus WOB curve.

Please amend paragraph number [0105] as follows:

[0105] The representative RE-S bit incorporating reduced exposure cutters of the present invention and exhibiting relatively small kerf widths effectively delayed the bearing surfaces (for example, including but not limited to bearing surface 320 of blades blade structures 308 as previously discussed and illustrated herein) surrounding the cutters from contacting the formation until relatively higher WOBs were applied to the bit. This particularly desirable characteristic is evidenced by the plot for the RE-S bit at WOB values greater than approximately 20,000 ~~lbs~~ lbs and exhibits a relatively flat and linear slope as the WOB is approximately doubled to 40,000 lbs with the resulting TOB only increasing by about 25% from a value of about 3,250 ft-lbs to a value of approximately 4,500 ft-lbs. Thus, considering the entire plot for the subject inventive bit over the depicted range of WOB, the RE-S bit is aggressive enough to efficiently penetrate firmer formations at a relatively high ROP, but if WOB should be increased, such as by loss of control of the applied WOB, or upon breaking through from a hard formation into a softer formation, the bearing surfaces of the bit contact the formation in accordance with the present invention to limit the DOC of the bit as well as to modulate the resulting TOB so as to prevent stalling of the bit. Because stalling of the bit is prevented, the unwanted occurrence of losing tool face control or worse, damage to the ~~bit~~ bit, is minimized if not entirely prevented in many situations.



Please amend paragraph number [0106] as follows:

[0106] It can now be appreciated that the present invention is particularly suitable for applications involving extended reach or horizontal drilling where control of WOB becomes very problematic due to friction-induced drag on the bit, downhole motor if being utilized, and at least a portion of the drill string, particularly that portion of the drill string within the extended reach, or horizontal, section of the borehole being drilled. In the case of conventional, general purpose fixed cutter bits, or even when using prior art bits designed to have enhanced steerability, which exhibit high efficiency, that is, the ability to provide a high ROP at a relatively low WOB, the bit will be especially prone to large magnitudes of WOB fluctuation, which can vary from 10 to 20 klbs (10,000 to 20,000 pounds) or more, as the bit lurches forward after overcoming a particularly troublesome amount of frictional drag. The accompanying spikes in TOB resulting from the sudden increase in WOB may in many cases be enough to stall a downhole motor or damage a high efficient drill bit and or attached drill string when using a conventional drill string driven by a less sophisticated conventional drilling rig. If a bit exhibiting a low efficiency is used, that is, a bit that requires a relatively high WOB is applied to render a suitable ROP, the bit may not be able to provide a fast enough ROP when drilling harder, firmer formations. Therefore, when practicing the present invention of providing a bit having a limited amount of cutter exposure above the surrounding bearing surface of the bit and selecting a cutter profile which will provide a suitable kerf width and kerf height, a bit embodying the present invention will optimally have a high enough efficiency to drill hard formations at low ~~depths-of-cut~~ depths-of-cut, but exhibit a torque ceiling that will not be exceeded in soft formations when WOB surges.

AMENDMENTS TO THE ABSTRACT:

Please amend the Abstract originally appearing on page 51 of the application with the following amended paragraph:

ABSTRACT OF THE DISCLOSURE

A rotary drag bit and method for drilling subterranean ~~formations~~ formations, including a bit body being provided with at least one cutter thereon exhibiting reduced, or limited, exposure to the ~~formation~~ formation, so as to control the depth-of-cut of the at least one cutter, so as to control the volume of formation material cut per bit rotation, as well as to control the amount of torque experienced by the bit and an optionally associated bottomhole assembly regardless of the effective weight-on-bit are all disclosed. The exterior of the bit preferably includes a plurality of blade structures carrying at least one such cutter thereon and including a sufficient amount of bearing surface area to contact the formation so as to generally distribute an additional weight applied to the bit against the bottom of the borehole without exceeding the compressive strength of the formation rock.

**Amendments to the Claims:**

Claims 1, 2, 4, 10-13, 15-19, 21-24 have been amended herein. Please note that all claims currently pending and under consideration in the referenced application are shown below. Please enter these claims as amended. This listing of claims will replace all prior versions and listings of claims in the application.

**Listing of Claims:**

1. (Currently Amended) A drill bit for subterranean drilling, comprising:  
a bit body including a longitudinal centerline, a leading end having a face for contacting a subterranean formation during drilling, and a trailing end having a structure associated therewith for connecting the bit body to a drill string, the face of the leading end including a bearing surface sized and configured to transfer a range of weight-on-bit from ~~the body of the bit~~ body through the bearing surface to the subterranean formation, wherein the range of weight-on-bit comprises any weight-on-bit which results in the bearing surface contacting the subterranean formation without substantial indentation of the bearing surface thereinto;  
wherein the bearing surface ~~area~~ is structured so that an area of the bearing surface ~~area~~ in contact with the subterranean formation remains substantially constant within the range of weight-on-bit; and  
at least one superabrasive cutter secured to a selected portion of the face of the leading end of the bit body and configured for engaging the subterranean formation during drilling.

2. (Currently Amended) The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a plurality of superabrasive cutters and the face of the leading end comprises a plurality of blade structures protruding from the bit body, at least some of the plurality of blade structures carrying at least one of the plurality of superabrasive cutters and the blade structures exhibiting in total a combined bearing surface area of sufficient size to substantially prevent indentation of the combined bearing surface area into the subterranean formation.

3. (Original) The drill bit of claim 2, wherein the at least some of the plurality of blade structures each extend from a respective point generally proximate the longitudinal centerline of the bit body generally radially outward toward a gage of the bit body and longitudinally toward the trailing end of the bit body.

4. (Currently Amended) The drill bit of claim 3, wherein the at least some of the plurality of blade structures each carry several of the plurality of superabrasive cutters and exhibit at least one bearing surface, and wherein each of the plurality of blade structures generally encompasses each of the several of the plurality of superabrasive cutters carried thereon with a limited portion of each of the several of the plurality of superabrasive cutters exposed by a preselected extent perpendicular from the respective at least one bearing surface proximate each of the several of the plurality of superabrasive cutters so as to control a respective depth-of-cut for each of the several of the plurality of superabrasive cutters.

5. (Original) The drill bit of claim 2, wherein the bit body comprises at least one of steel and a metal matrix.

6. (Original) The drill bit of claim 4, wherein at least a portion of the at least one bearing surface of at least one of the plurality of blade structures includes a wear-resistant exterior.

7. (Original) The drill bit of claim 6, wherein the wear-resistant exterior comprises at least one of the group consisting of carbide, tungsten carbide, synthetic diamond, natural diamond, polycrystalline diamond, thermally stable polycrystalline diamond, cubic boron nitride, and hard facing material.

8. (Original) The drill bit of claim 2, wherein at least one bearing surface of at least one of the plurality of blade structures comprises a wear-resistant exterior.

9. (Original) The drill bit of claim 1, wherein the face of the leading end of the bit body comprises cone, nose, flank, shoulder, and gage regions.

10. (Currently Amended) The drill bit of claim 9, wherein ~~the~~ a portion of the bearing surface ~~area~~ positioned in the cone region exhibits a greater amount of bearing surface area than ~~the~~ a portion ~~of~~ of the bearing surface ~~area~~ positioned in the nose region.

11. (Currently Amended) The drill bit of claim 10, wherein the portion of the bearing surface ~~area~~ positioned in the nose region exhibits a greater amount of bearing surface area than ~~the~~ a portion ~~of~~ of the bearing surface ~~area~~ positioned in the flank region.

12. (Currently Amended) The drill bit of claim 9, ~~wherein~~ wherein a portion of the bearing surface ~~area~~ positioned in the cone region exhibits a greater amount of bearing surface area than ~~the~~ a portion of the bearing surface ~~area~~ positioned in the shoulder region.

13. (Currently Amended) The drill bit of claim 2, wherein the at least one superabrasive cutter of the plurality of superabrasive cutters comprises a chamfered region extending at least partially about a circumferential periphery thereof.

14. (Original) The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a chamfered peripheral edge portion of a preselected width and chamfer angle.

15. (Currently Amended) The drill ~~bit~~ bit of claim 1, comprising at least another bearing surface configured to transfer another weight-on-bit from ~~the body of the bit~~ body through the another bearing surface to the subterranean formation at a weight-on-bit above which results in the another bearing surface contacting the subterranean formation without substantial indentation of the another bearing surface thereinto.

16. (Currently Amended) A method of drilling a subterranean formation without generating an excessive amount of torque-on-bit, comprising:

engaging the subterranean formation with at least one cutter of a drill bit within a selected

depth-of-cut range;

applying a weight-on-bit within a range of weight-on-bit in excess of that required for the at least

one cutter to penetrate the subterranean formation and above which results in a bearing

surface contacting the subterranean formation;

~~wherein the area of the bearing surface contacting the subterranean formation remains~~

~~substantially constant over the range of excess weight-on-bit; and~~

transferring the excess weight-on-bit from the ~~body of the drill~~ bit through ~~a the~~ bearing surface

to the subterranean formation without substantial indentation of the bearing surface into

the subterranean formation; ~~and~~

wherein an area of the bearing surface contacting the subterranean formation remains

substantially constant over the range of excess weight-on-bit.

17. (Currently Amended) The method of claim 16, wherein transferring the excess weight-on-bit from the body of the bit through ~~a the~~ bearing surface to the subterranean formation comprises transferring the excess weight-on-bit to at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter.

18. (Currently Amended) The method of claim 17, wherein transferring the excess weight-on-bit ~~to the~~ to the at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a plurality of wear knots on the at least one formation-facing bearing ~~surfaces~~ surface.

19. (Currently Amended) The method of claim 17, wherein transferring the excess weight-on-bit ~~to the~~ to the at least one formation-facing bearing surface on the drill bit generally surrounding ~~at the~~ at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a hard facing material affixed to a selected portion of the ~~respective~~ at least one formation-facing bearing surface proximate at least one of the superabrasive cutters.

20. (Original) The method of claim 16, further comprising:  
applying an additional weight-on-bit in excess of the excess weight-on-bit required for the bearing surface to contact the subterranean formation and above which results in the bearing surface and another bearing surface contacting the subterranean formation; and transferring the additional excess weight-on-bit from the body of the bit through the another bearing surface to the subterranean formation without substantial indentation of the another bearing surface thereinto.

21. (Currently Amended) A method of designing a drill bit for drilling a subterranean formation, the drill bit under design including a plurality of superabrasive cutters disposed about ~~the~~ a formation-engaging leading end of the drill bit, the method comprising:  
selecting a maximum depth-of-cut for ~~the~~ at at least some of the plurality of superabrasive cutters;  
selecting a cutter profile arrangement to which the at least some of the plurality of superabrasive cutters are to be radially and longitudinally positioned on the formation-engaging leading end of the drill bit; and  
configuring within the design of the drill bit a sufficient total amount of formation-facing bearing surface area structured for axially supporting the drill bit without substantially indenting the subterranean formation should the drill bit be subjected to a weight-on-bit exceeding a weight-on-bit which would cause the formation-facing bearing surface area to contact the subterranean formation, wherein the formation-facing bearing surface area is sized and configured to remain substantially constant over a range of excess weight-on-bit.

22. (Currently Amended) The method of claim 21, further comprising including within the drill bit under design a plurality of kerf regions of a preselected width positioned laterally intermediate of ~~selected rotationally adjacently positioned~~ the at least some of the plurality of superabrasive cutters.

23. (Currently Amended) The method of claim 21, wherein configuring within the design of the drill bit a sufficient total amount ~~of~~ of the formation-facing bearing surface area

comprises selecting an amount of hard facing to be disposed on at least a portion of the ~~at least one respective~~ formation-facing bearing surface at least partially surrounding the at least some of the plurality of superabrasive cutters.

24. (Currently Amended) The method of claim 21, further comprising:  
including within the design of the drill bit another formation-facing bearing surface area structured for axially supporting the drill bit without substantially indenting the subterranean formation therewith should the drill bit be subjected to an additional excess weight-on-bit exceeding ~~the~~ an excess weight-on-bit.



**REMARKS**

Applicants note the filing of an Information Disclosure Statement herein on June 4, 2004 and note that no copy of the PTO-1449 was returned with the outstanding Office Action. Applicants respectfully request that the information cited on the PTO-1449 (which is the same as that of record to that date in the parent application hereto) be made of record herein.

The Office Action mailed November 10, 2004, has been received and reviewed. Claims 1 through 24 are currently pending in the application. Claims 1 through 24 stand rejected. Applicants have amended claims 1, 2, 4, 10-13, 15-19, 21-24 and respectfully request reconsideration of the application as amended herein.

**Double Patenting Rejection Based on U.S. Patent No. 6,779,613**

Claims 1 through 24 stand rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 through 41 of U.S. Patent No. 6,779,613. In order to avoid further expenses and time delay, Applicants elect to expedite the prosecution of the present application by filing a terminal disclaimer to obviate the double patenting rejections in compliance with 37 CFR 1.321 (b) and (c). Applicants' filing of the terminal disclaimer should not be construed as acquiescence in the Examiner's double patenting or obviousness-type double patenting rejections. Attached is the Terminal Disclaimer. The Commissioner is authorized to charge the fee to Baker Hughes Incorporated, Deposit Account No. 02-0429.

**ENTRY OF AMENDMENTS**

The amendments to claims 1, 2, 4, 10-13, 15-19, 21-24 above should be entered by the Examiner because the amendments are supported by the as-filed specification and drawings. The amendments to claims 1, 2, 4, 10-13, 15-19, 21-24 are for improving antecedent basis and phraseology. Further, the amendments do not raise new issues or require a further search.

**CONCLUSION**

Claims 1-24 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain which might be resolved by a telephone conference, he is respectfully invited to contact Applicants' undersigned attorney.

Respectfully submitted,



Trent N. Butcher  
Registration No. 51,518  
Attorney for Applicants  
TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: January 14, 2005

TNB/dlm:ljb

Enclosures: Replacement Sheet  
Annotated Sheet Showing Changes

Document in ProLaw

**Amendments to the Drawings:**

The attached sheet of drawings includes a change to FIG. 18A. This sheet, which includes FIG. 18A, replaces the original sheet including FIGS. 18A and 18B.

FIG. 18A has been amended herein. Specifically, FIG. 18A has been revised to add the reference numeral --308-- with appropriate lead line. No new matter has been added.

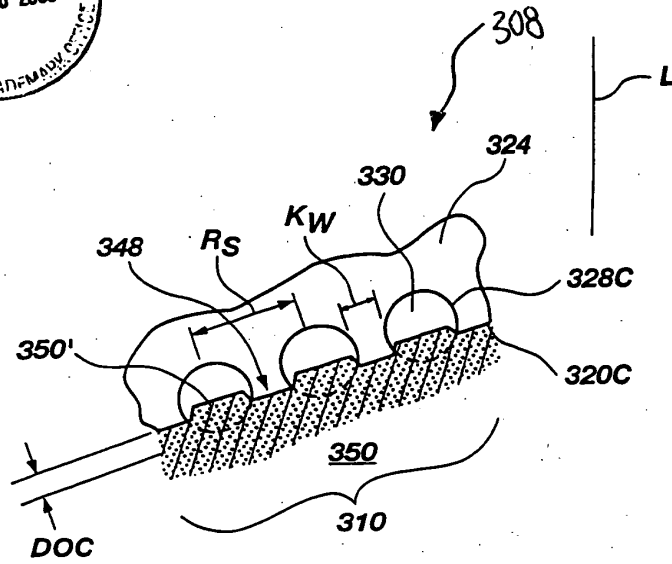
# **APPENDIX**

**(ANNOTATED SHEET SHOWING CHANGES OF FIG. 18A  
AND REPLACEMENT SHEET)**

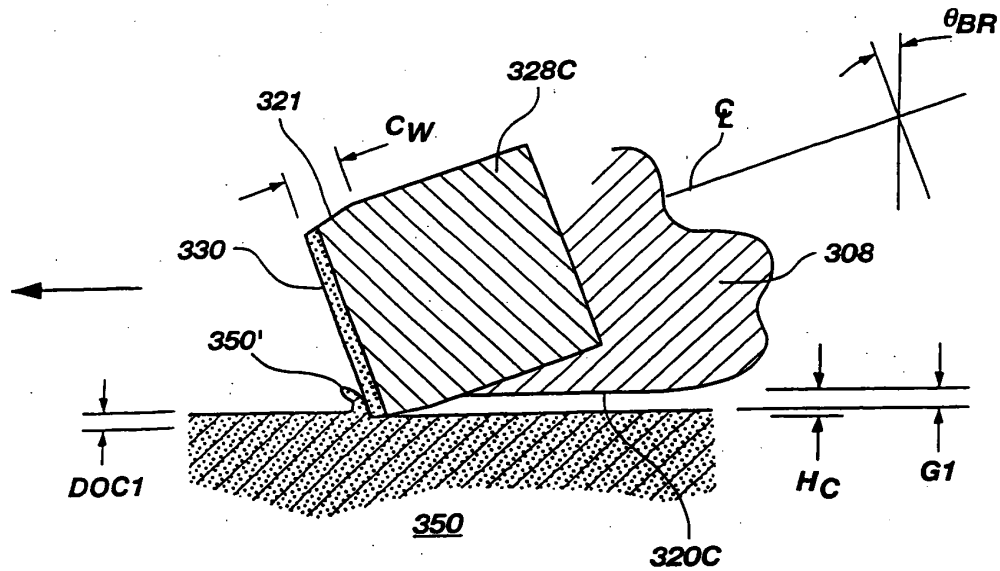
**(Serial No. 10/861,129)**



17/22



**Fig. 18A**



**Fig. 18B**

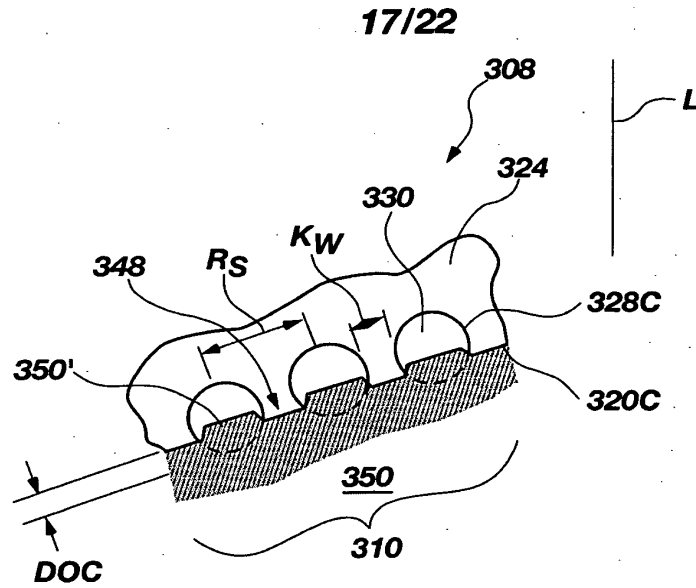


Fig. 18A

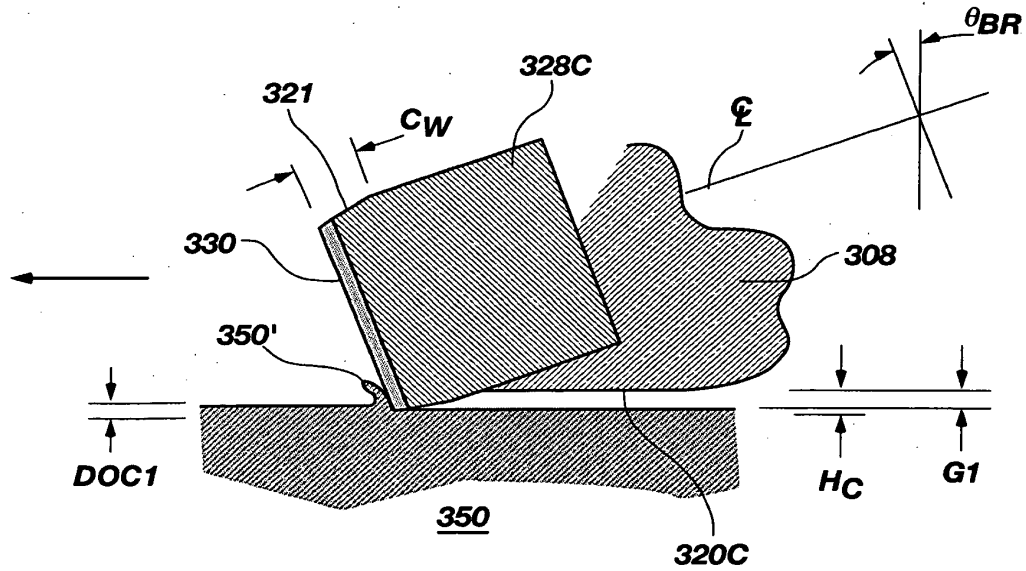


Fig. 18B

**REMARKS**

Applicants note the filing of an Information Disclosure Statement herein on June 4, 2004 and note that no copy of the PTO-1449 was returned with the outstanding Office Action. Applicants respectfully request that the information cited on the PTO-1449 (which is the same as that of record to that date in the parent application hereto) be made of record herein.

The Office Action mailed November 10, 2004, has been received and reviewed. Claims 1 through 24 are currently pending in the application. Claims 1 through 24 stand rejected. Applicants have amended claims 1, 2, 4, 10-13, 15-19, 21-24 and respectfully request reconsideration of the application as amended herein.

**Double Patenting Rejection Based on U.S. Patent No. 6,779,613**

Claims 1 through 24 stand rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 through 41 of U.S. Patent No. 6,779,613. In order to avoid further expenses and time delay, Applicants elect to expedite the prosecution of the present application by filing a terminal disclaimer to obviate the double patenting rejections in compliance with 37 CFR 1.321 (b) and (c). Applicants' filing of the terminal disclaimer should not be construed as acquiescence in the Examiner's double patenting or obviousness-type double patenting rejections. Attached is the Terminal Disclaimer. The Commissioner is authorized to charge the fee to Baker Hughes Incorporated, Deposit Account No. 02-0429.

**ENTRY OF AMENDMENTS**

The amendments to claims 1, 2, 4, 10-13, 15-19, 21-24 above should be entered by the Examiner because the amendments are supported by the as-filed specification and drawings. The amendments to claims 1, 2, 4, 10-13, 15-19, 21-24 are for improving antecedent basis and phraseology. Further, the amendments do not raise new issues or require a further search.

**CONCLUSION**

Claims 1-24 are believed to be in condition for allowance, and an early notice thereof is respectfully solicited. Should the Examiner determine that additional issues remain which might be resolved by a telephone conference, he is respectfully invited to contact Applicants' undersigned attorney.

Respectfully submitted,



Trent N. Butcher  
Registration No. 51,518  
Attorney for Applicants  
TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: January 14, 2005

TNB/dlm:ljb

Enclosures: Replacement Sheet  
Annotated Sheet Showing Changes

Document in ProLaw



**Amendments to the Drawings:**

The attached sheet of drawings includes a change to FIG. 18A. This sheet, which includes FIG. 18A, replaces the original sheet including FIGS. 18A and 18B.

FIG. 18A has been amended herein. Specifically, FIG. 18A has been revised to add the reference numeral --308-- with appropriate lead line. No new matter has been added.

# **APPENDIX**

**(ANNOTATED SHEET SHOWING CHANGES OF FIG. 18A  
AND REPLACEMENT SHEET)**

**(Serial No. 10/861,129)**

[illegible]

**Fig. 18B**

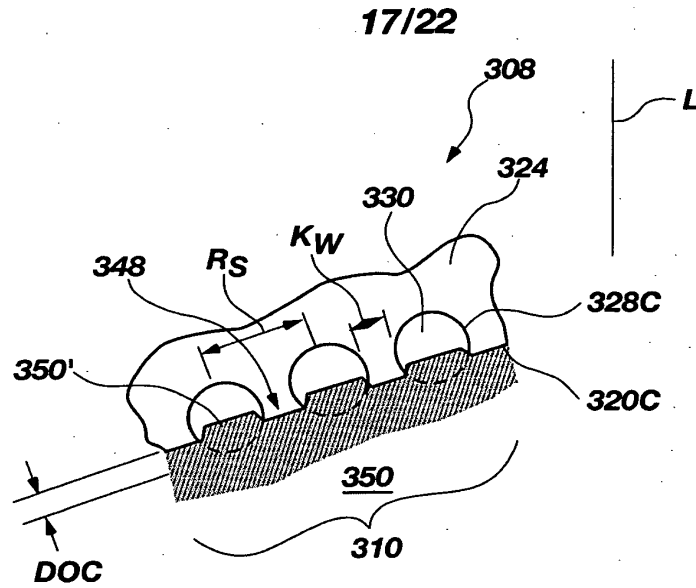


Fig. 18A

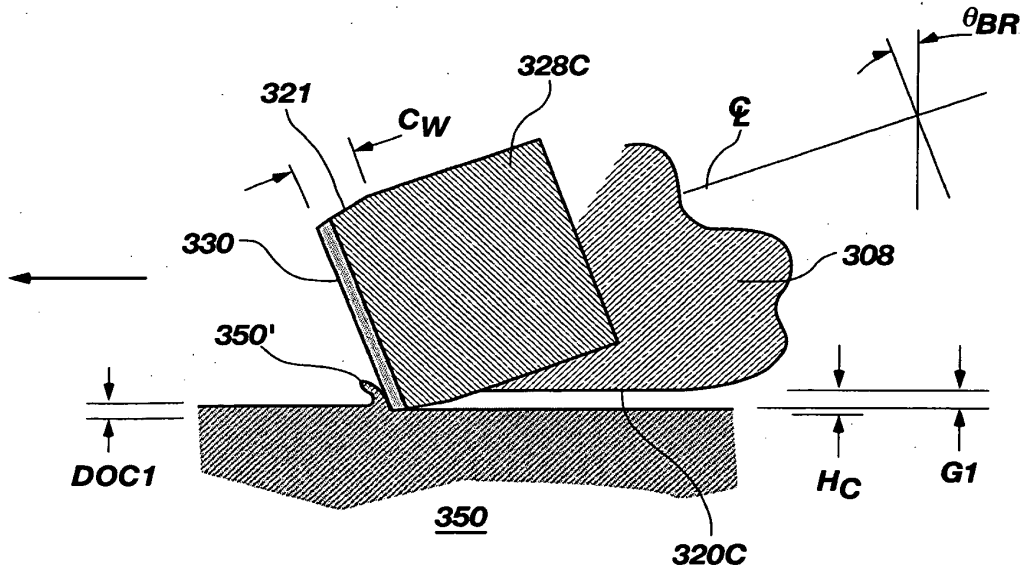


Fig. 18B



PTO/SB/26 (10-00)  
Approved for use through 10/31/2002. OMB 0651-0031  
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE  
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**TERMINAL DISCLAIMER TO OBIATE A DOUBLE PATENTING  
REJECTION OVER A PRIOR PATENT**

Docket Number (Optional)  
1684-4578.2US (484-09454-  
US-C2)

In re Application of: Dykstra et al.

Application No.: 10/861,129

Filed: June 4, 2004

For: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

The owner\*, Baker Hughes Incorporated of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application, which would extend beyond the expiration date of the full statutory term defined in 35 U.S.C. 154 to 156 and 173, as presently shortened by any terminal disclaimer, of prior Patent No. 6,779,613. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 to 156 and 173 of the prior patent, as presently shortened by any terminal disclaimer, in the event that it later: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims cancelled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of an organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney of record.

Signature

JAN 14, 2005

Date

Trent N. Butcher

Typed or printed name

Reg. No. 51,518

- ☒ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

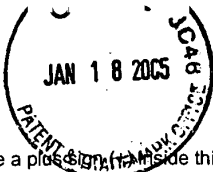
**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

\*Certification under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).  
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

01/24/2005 ERIUBAK1 00000137 020429 10861129

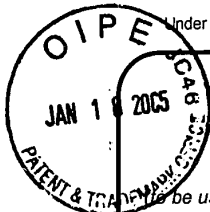
01 FC:1814 130.00 DA



ITW

Please type a plus sign (+) inside this box → ☐

PTO/SB/21 (08-00)  
Approved for use through 10/31/2002. OMB 0651-0031  
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE  
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



## TRANSMITTAL FORM

Use this form for all correspondence after initial filing)

Application Number	10/861,129
Filing Date	June 4, 2004
First Named Inventor	Dykstra et al.
Group Art Unit	3672
Examiner Name	F. Tsay
Attorney Docket Number	1684-4578.2US (484-09454-US-C2)

### ENCLOSURES (check all that apply)

<input checked="" type="checkbox"/> Postcard receipt acknowledgment (attached to the front of this transmittal)	<input type="checkbox"/> Information Disclosure Statement, PTO/SB/08A (08-00); <input type="checkbox"/> copy of cited references	<input checked="" type="checkbox"/> Terminal Disclaimer
<input checked="" type="checkbox"/> Duplicate copy of this transmittal sheet in the event that additional filing fees are required under 37 C.F.R. § 1.16	<input type="checkbox"/> Supplemental Information Disclosure Statement; PTO/SB/08A (08-00); copy of cited references and Check No. in the amount of \$180.00	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Preliminary Amendment	<input type="checkbox"/> Associate Power of Attorney	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Response to Restriction Requirement/Election of Species Requirement dated	<input type="checkbox"/> Petition for Extension of Time and Check No. in the amount of \$	
<input checked="" type="checkbox"/> Amendment in response to office action dated November 10, 2004 with Appendix attaching Replacement Drawing Sheet and Annotated Drawing Sheet Showing Changes	<input type="checkbox"/> Petition	
<input type="checkbox"/> Amendment under 37 C.F.R. § 1.116 in response to final office action dated	<input type="checkbox"/> Fee Transmittal Form	<input type="checkbox"/> Other Enclosure(s) (please identify below):
<input type="checkbox"/> Additional claims fee - Check No. in the amount of \$	<input type="checkbox"/> Certified Copy of Priority Document(s)	
<input type="checkbox"/> Letter to Chief Draftsman and copy of FIGS. with changes made in red	<input type="checkbox"/> Assignment Papers (for an Application)	
<input type="checkbox"/> Transmittal of Formal Drawings	Remarks	
<input type="checkbox"/> Formal Drawings ( sheets)	The Commissioner is authorized to charge any additional fees required but not submitted with any document or request requiring fee payment under 37 C.F.R. §§ 1.16 and 1.17 to Deposit Account 02-0429 during pendency of this application.	

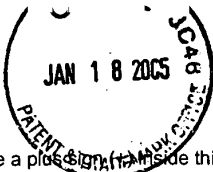
### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Trent N. Butcher	Registration No. 51,518
Signature		
Date	January 14, 2005	

### CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below.			
Typed or printed name	Leah J. Barrow		
Signature		Date	January 14, 2005

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.



ITW

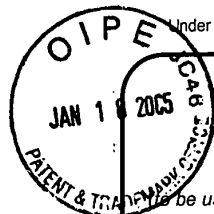
Please type a plus sign (+) inside this box → ☒

PTO/SB/21 (08-00)

Approved for use through 10/31/2002. OMB 0651-0031

U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



## TRANSMITTAL FORM

Use this form for all correspondence after initial filing)

Application Number	10/861,129
Filing Date	June 4, 2004
First Named Inventor	Dykstra et al.
Group Art Unit	3672
Examiner Name	F. Tsay
Attorney Docket Number	1684-4578.2US (484-09454-US-C2)

### ENCLOSURES (check all that apply)

<input checked="" type="checkbox"/> Postcard receipt acknowledgment (attached to the front of this transmittal)	<input type="checkbox"/> Information Disclosure Statement, PTO/SB/08A (08-00); <input type="checkbox"/> copy of cited references	<input checked="" type="checkbox"/> Terminal Disclaimer
<input checked="" type="checkbox"/> Duplicate copy of this transmittal sheet in the event that additional filing fees are required under 37 C.F.R. § 1.16	<input type="checkbox"/> Supplemental Information Disclosure Statement; PTO/SB/08A (08-00); copy of cited references and Check No. in the amount of \$180.00	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Preliminary Amendment	<input type="checkbox"/> Associate Power of Attorney	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Response to Restriction Requirement/Election of Species Requirement dated	<input type="checkbox"/> Petition for Extension of Time and Check No. in the amount of \$	
<input checked="" type="checkbox"/> Amendment in response to office action dated November 10, 2004 with Appendix attaching Replacement Drawing Sheet and Annotated Drawing Sheet Showing Changes	<input type="checkbox"/> Petition	
<input type="checkbox"/> Amendment under 37 C.F.R. § 1.116 in response to final office action dated	<input type="checkbox"/> Fee Transmittal Form	<input type="checkbox"/> Other Enclosure(s) (please identify below):
<input type="checkbox"/> Additional claims fee - Check No. in the amount of \$	<input type="checkbox"/> Certified Copy of Priority Document(s)	
<input type="checkbox"/> Letter to Chief Draftsman and copy of FIGS. with changes made in red	<input type="checkbox"/> Assignment Papers (for an Application)	
<input type="checkbox"/> Transmittal of Formal Drawings	Remarks	
<input type="checkbox"/> Formal Drawings ( sheets)	The Commissioner is authorized to charge any additional fees required but not submitted with any document or request requiring fee payment under 37 C.F.R. §§ 1.16 and 1.17 to Deposit Account 02-0429 during pendency of this application.	

### SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Trent N. Butcher	Registration No. 51,518
Signature		
Date	January 14, 2005	

### CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on the date shown below.			
Typed or printed name	Leah J. Barrow		
Signature		Date	January 14, 2005

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

# PATENT APPLICATION FEE DETERMINATION RECORD

Effective October 1, 2003

Application or Docket Number:

10861129

## CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	24	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	24 minus 20 =	4
INDEPENDENT CLAIMS	3 minus 3 =	-
MULTIPLE DEPENDENT CLAIM PRESENT <input type="checkbox"/>		

\* If the difference in column 1 is less than zero, enter "0" in column 2

## CLAIMS AS AMENDED - PART II

1.18.05

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	24	Minus	24
Independent	3	Minus	3
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

1, 16, 21

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total		Minus	
Independent		Minus	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT C	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total		Minus	
Independent		Minus	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM <input type="checkbox"/>			

\* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.  
 \* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."  
 \* If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."  
 The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

### SMALL ENTITY TYPE ☐

### OTHER THAN SMALL ENTITY

RATE	FEE	RATE	FEE
BASIC FEE	385.00	BASIC FEE	770.00
XS 9=		XS 18=	77
X43=		X86=	
+145=		+290=	
TOTAL		TOTAL	842

### SMALL ENTITY TYPE ☐

### OTHER THAN SMALL ENTITY

RATE	ADDITIONAL FEE	RATE	ADDITIONAL FEE
XS 9=		XS 18=	
X43=		X86=	
+145=		+290=	
TOTAL ADDIT. FEE		TOTAL ADDIT. FEE	

RATE	ADDITIONAL FEE	RATE	ADDITIONAL FEE
XS 9=		XS 18=	
X43=		X86=	
+145=		+290=	
TOTAL ADDIT. FEE		TOTAL ADDIT. FEE	


RATE	ADDITIONAL FEE	RATE	ADDITIONAL FEE
XS 9=		XS 18=	
X43=		X86=	
+145=		+290=	
TOTAL ADDIT. FEE		TOTAL ADDIT. FEE	

RM PTO-873 (Rev 10/03)

Patents and Trademarks Office, U.S. DEPARTMENT OF COMMERCE

Best Available Copy



<b>Application Number</b> 	<b>Application/Control No.</b> 10/861,129	<b>Applicant(s)/Patent under Reexamination</b> DYKSTRA ET AL.	
<b>Document Code - DISQ</b>		<b>Internal Document – DO NOT MAIL</b>	

<b>TERMINAL DISCLAIMER</b>	<input checked="" type="checkbox"/> <b>APPROVED</b>	<input type="checkbox"/> <b>DISAPPROVED</b>
Date Filed : 18 JAN 05	This patent is subject to a Terminal Disclaimer	

<b>Approved/Disapproved by:</b>
SHANETTE BROWN

U.S. Patent and Trademark Office



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

## NOTICE OF ALLOWANCE AND FEE(S) DUE

24247 7590 03/08/2005  
TRASK BRITT  
P.O. BOX 2550  
SALT LAKE CITY, UT 84110

EXAMINER

TSAY, FRANK

ART UNIT

PAPER NUMBER

3672

DATE MAILED: 03/08/2005

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
-----------------	-------------	----------------------	---------------------	------------------

10/861,129

06/04/2004

Mark W. Dykstra

1684-4578.2US

1060

(484-09454-

TITLE OF INVENTION: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	06/08/2005

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN **THREE MONTHS** FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. **THIS STATUTORY PERIOD CANNOT BE EXTENDED.** SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

### HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER:** Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

# **PART B - FEE(S) TRANSMITTAL**

Complete and send this form, together with applicable fee(s), to: **Mail** **Mail Stop ISSUE FEE**  
**Commissioner for Patents**  
**P.O. Box 1450**  
**Alexandria, Virginia 22313-1450**  
**or Fax (703) 746-4000**

**INSTRUCTIONS:** This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

24247 7590 03/08/2005

TRASK BRITT  
P.O. BOX 2550  
SALT LAKE CITY, UT 84110

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

## **Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (703) 746-4000, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060

TITLE OF INVENTION: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	06/08/2005

EXAMINER	ART UNIT	CLASS-SUBCLASS
TSAY, FRANK	3672	175-057000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).  
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.  
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list  
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,  
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 \_\_\_\_\_  
2 \_\_\_\_\_  
3 \_\_\_\_\_

## **3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)**

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☐ Corporation or other private group entity ☐ Government

## **4a. The following fee(s) are enclosed:**

- ☐ Issue Fee  
☐ Publication Fee (No small entity discount permitted)  
☐ Advance Order - # of Copies \_\_\_\_\_

## **4b. Payment of Fee(s):**

- ☐ A check in the amount of the fee(s) is enclosed.  
☐ Payment by credit card. Form PTO-2038 is attached.  
☐ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number \_\_\_\_\_ (enclose an extra copy of this form).

## **5. Change in Entity Status (from status indicated above)**

- ☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27. ☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above. NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature \_\_\_\_\_

Date \_\_\_\_\_

Typed or printed name \_\_\_\_\_

Registration No. \_\_\_\_\_

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
[www.uspto.gov](http://www.uspto.gov)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060
24247	7590	03/08/2005	EXAMINER	
TRASK BRITT P.O. BOX 2550 SALT LAKE CITY, UT 84110			TSAY, FRANK	
			ART UNIT	PAPER NUMBER
			3672	

DATE MAILED: 03/08/2005


## Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (<http://pair.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571) 272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

 <b>Notice of Allowability</b>	<b>Application No.</b> 10/861,129		<b>Applicant(s)</b> DYKSTRA ET AL.	
	<b>Examiner</b> Frank S Tsay		<b>Art Unit</b> 3672	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to amendment and terminal disclaimer filed on 1/14/05.
2. ☒ The allowed claim(s) is/are 1-24.
3. ☒ The drawings filed on 1/18/05 are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
  - a) ☐ All    b) ☐ Some\*    c) ☐ None    of the:
  1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
  - (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
    - 1) ☐ hereto or 2) ☐ to Paper No./Mail Date \_\_\_\_\_.
  - (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. <input type="checkbox"/> Notice of References Cited (PTO-892) 2. <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) 3. <input type="checkbox"/> Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____ 4. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material	5. <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) 6. <input type="checkbox"/> Interview Summary (PTO-413), Paper No./Mail Date _____ 7. <input type="checkbox"/> Examiner's Amendment/Comment 8. <input type="checkbox"/> Examiner's Statement of Reasons for Allowance 9. <input type="checkbox"/> Other _____
---	--

**DETAILED ACTION**

***Response to Amendment***

The amendment filed on January 14, 2005 regarding to the specification and the claims have been entered. Amendment to Fig. 18A, has also been approved for entry.


Claims 1-24 are allowed.


Any inquiry concerning this communication or earlier communications from the examiner should be directed to Frank S Tsay whose telephone number is (703) 308-2170. The examiner can normally be reached on Monday thru Friday, 7:30am-5:00 pm, 2nd Friday off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David J Bagnell can be reached on (703)308-2151. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

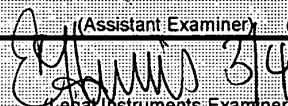


Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

2/18/05

  
Frank S Tsay  
Primary Examiner  
Art Unit 3672

<b>Issue Classification</b> 	Application No.	Applicant(s)	
	10/861,129	DYKSTRA ET AL.	
	Examiner	Art Unit	
	Frank S Tsay	3672	

ISSUE CLASSIFICATION													
ORIGINAL				CROSS REFERENCE(S)									
CLASS		SUBCLASS		CLASS		SUBCLASS (ONE SUBCLASS PER BLOCK)							
175		57		175		428		431					
INTERNATIONAL CLASSIFICATION													
E21		B 10146											
		/											
		/											
		/											
		/											

 (Assistant Examiner) (Date)		 <b>FRANK TSAY</b> <b>PRIMARY EXAMINER</b> (Primary Examiner) (Date)		Total Claims Allowed: 24	
 (Legal Instruments Examiner) (Date)				O.G. Print Claim(s) /	
				O.G. Print Fig. 18A-0	

<input checked="" type="checkbox"/> Claims renumbered in the same order as presented by applicant						<input type="checkbox"/> CPA		<input type="checkbox"/> T.D.		<input type="checkbox"/> R.1.47	
Final	Original		Final	Original		Final	Original		Final	Original	
	1		31		61		91		121		181
	2		32		62		92		122		182
	3		33		63		93		123		183
	4		34		64		94		124		184
	5		35		65		95		125		185
	6		36		66		96		126		186
	7		37		67		97		127		187
	8		38		68		98		128		188
	9		39		69		99		129		189
	10		40		70		100		130		190
	11		41		71		101		131		191
	12		42		72		102		132		192
	13		43		73		103		133		193
	14		44		74		104		134		194
	15		45		75		105		135		195
	16		46		76		106		136		196
	17		47		77		107		137		197
	18		48		78		108		138		198
	19		49		79		109		139		199
	20		50		80		110		140		200
	21		51		81		111		141		201
	22		52		82		112		142		202
	23		53		83		113		143		203
	24		54		84		114		144		204
	25		55		85		115		145		205
	26		56		86		116		146		206
	27		57		87		117		147		207
	28		58		88		118		148		208
	29		59		89		119		149		209
	30		60		90		120		150		210



## UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

**\*BIBDATASHEET\***

Bib Data Sheet

CONFIRMATION NO. 1060

SERIAL NUMBER 10/861,129	FILING DATE 06/04/2004  RULE	CLASS 175	GROUP ART UNIT 3672	ATTORNEY DOCKET NO. 1684-4578.2US (484-09454-
-----------------------------	---------------------------------------	--------------	------------------------	--

APPLICANTS

Mark W. Dykstra, Kingwood, TX;

William Heuser, The Woodlands, TX;  
Michael L. Doster, Spring, TX; Theodore E. Zaleski JR., Spring, TX;  
Jack T. Oldham, Willis, TX;  
Terry D. Watts, Spring, TX;  
Daniel E. Ruff, Kingwood, TX;  
Rodney B. Walzel, Conroe, TX;  
Christopher C. Beuershausen, Spring, TX;

\*\* CONTINUING DATA \*\*\*\*\*

This application is a CON of 10/266,534 10/07/2002 PAT 6,779,613  
which is a CON of 09/738,687 12/15/2000 PAT 6,460,631  
which is a CIP of 09/383,228 08/26/1999 PAT 6,298,930 *OK*

\*\* FOREIGN APPLICATIONS \*\*\*\*\* *None*

IF REQUIRED, FOREIGN FILING LICENSE GRANTED  
\*\* 07/29/2004

Foreign Priority claimed <input type="checkbox"/> yes <input checked="" type="checkbox"/> no	STATE OR COUNTRY TX	SHEETS DRAWING 22	TOTAL CLAIMS 24	INDEPENDENT CLAIMS 3
35 USC 119 (a-d) conditions met <input type="checkbox"/> yes <input checked="" type="checkbox"/> no <input type="checkbox"/> Met after Allowance				
Verified and Acknowledged Examiner's Signature <i>[Signature]</i> Initials <i>[Initials]</i>				


ADDRESS  
24247  
TRASK BRITT  
P.O. BOX 2550  
SALT LAKE CITY, UT  
84110

TITLE  
Drill bits with reduced exposure of cutters

☐ All Fees

<http://neo:8000/PrexServlet/PrexAction?serviceName=BibDataSheet&Action=display&browserType=IE&...> 11/2/04



<b>Application Number</b> 	<b>Application No.</b> 10/861,129	<b>Applicant(s)</b> DYKSTRA ET AL.	

<b>TERMINAL DISCLAIMER</b>	<input checked="" type="checkbox"/> <b>APPROVED</b>	<input type="checkbox"/> <b>DISAPPROVED</b>
Document Code - DISQ	This patent is subject to a Terminal Disclaimer	
<b>INTERNAL DOCUMENT – DO NOT MAIL</b>		

U.S. Patent and Trademark Office

# ● PRINTER RUSH ●

(PTO ASSISTANCE)

Application : <u>101861129</u>	Examiner : <u>Tsay</u>	GAU : <u>3672</u>
From: <u>J. Blach</u>	Location: <u>IDC</u> FMF FDC	Date: <u>4/26/05</u>
Tracking #: <u>06093081</u>		Week Date: <u>4/11/05</u>

DOC CODE	DOC DATE	MISCELLANEOUS
<input type="checkbox"/> 1449		<input type="checkbox"/> Continuing Data
<input checked="" type="checkbox"/> IDS	<u>6/4/04</u>	<input type="checkbox"/> Foreign Priority
<input type="checkbox"/> CLM		<input type="checkbox"/> Document Legibility
<input type="checkbox"/> IIFW		<input type="checkbox"/> Fees
<input type="checkbox"/> SRFW		<input type="checkbox"/> Other
<input type="checkbox"/> DRW		
<input type="checkbox"/> OATH		
<input type="checkbox"/> 312		
<input type="checkbox"/> SPEC		

**[RUSH] MESSAGE:**

Please initial line through Citations.

Thank you!

**[XRUSH] RESPONSE:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

**INITIALS:**

NOTE: This form will be included as part of the official USPTO record, with the Response document coded as XRUSH.  
REV 10/04



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060
24247	7590	05/06/2005	EXAMINER	
TRASK BRITT P.O. BOX 2550 SALT LAKE CITY, UT 84110			TSAY, FRANK	
			ART UNIT	PAPER NUMBER
			3672	

DATE MAILED: 05/06/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

<b>Supplemental Notice of Allowability</b>	Application No.	Applicant(s)	
	10/861,129	DYKSTRA ET AL.	
	Examiner	Art Unit	
	Frank S Tsay	3672	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to IDS filed 6/4/04.
2. ☒ The allowed claim(s) is/are 1-24.
3. ☒ The drawings filed on 1/18/05 are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
  - a) ☐ All    b) ☐ Some\*    c) ☐ None    of the:
  1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
  - (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
    - 1) ☐ hereto or 2) ☐ to Paper No./Mail Date \_\_\_\_\_.
  - (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08),  
Paper No./Mail Date 6/4/04
4. ☐ Examiner's Comment Regarding Requirement for Deposit  
of Biological Material

5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413),  
Paper No./Mail Date \_\_\_\_\_.
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other \_\_\_\_\_

**Frank S. Tsay**  
Primary Examiner

*HL*

6/4/04

(2-92)

Sheet 1 of 4

<b>Form PTO-1449</b> <b>INFORMATION DISCLOSURE CITATION</b> <b>IN AN APPLICATION</b> <i>(Use several sheets if necessary)</i>		Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <b>Not Yet Assigned</b> <b>10/061,129</b>	
		Applicant <b>Dykstra et al.</b>			
		Filing Date <b>June 4, 2004</b>		Group Art Unit <b>3672</b> <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
7	1,805,678	05/1931	Smith			
	2,198,849	04/1940	Waxler			
	2,563,515	08/1951	Brown			
	2,624,549	01/1953	Wallace			
	2,684,835	07/1954	Moore			
	2,776,817	01/1957	Gregory et al.			
	3,153,458	10/1964	Short			
	3,303,894	02/1967	Varney			
	3,709,308	01/1973	Rowley et al.			
	3,779,323	12/1973	Horten et al.			
7	3,915,246	10/1975	Sheshtawy			

FOREIGN PATENT DOCUMENTS							
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	APPLICANT	CLASS	SUBCLASS	Translation	
						YES	NO
7	EP 0 169 683 A2	01/1986	NL Petroleum				
	GB 2 273 946 A	07/1994	Camco Drilling				
	EP 0 874 128 A2	10/1998	Camco International				
	GB 2 326 659 A	12/1998	Camco International				
	GB 2 329 203 A	03/1999	Baker Hughes				

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
7		1995 Hughes Christensen Drill Bit Catalog, page 31.
7		Hughes Christensen Bit Drawing dated 29 May 1997 - HC Part No. CC201918.
7		Hughes Christensen Bit Drawing dated 18 September 1996 - HC Part No. CW 210655.

EXAMINER <i>Frank T. Song</i>	DATE CONSIDERED <b>4/7/05</b>
----------------------------------	----------------------------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

(2-92)

Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Form PTO-1449  <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b>  <i>(Use several sheets if necessary)</i>		Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <del>Not Yet Assigned</del> <b>10/861,129</b>	
Applicant <b>Dykstra et al.</b>		Filing Date <b>June 4, 2004</b>		Group Art Unit <b>Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
77	3,938,599	02/1976	Horn			
	4,351,401	09/1982	Fielder			
	4,386,669	06/1983	Evans			
	4,499,958	02/1985	Radtke et al.			
	4,554,986	11/1985	Jones			
77	4,718,505	01/1988	Fuller			
	4,763,737	08/1988	Hellnick			
	4,889,017	12/1989	Fuller et al.			
	4,932,484	06/1990	Warren et al.			
	4,981,184	01/1991	Knowlton et al.			
	4,982,802	01/1991	Warren et al.			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
77		Hughes Christensen Bit Drawing dated 18 September 1996 - HC Part No. CS205023.
77		Hughes Christensen Bit Drawing dated 9 September 1996 - HC Part No. CC201718.
77		Search Report of the UK Patent Office, dated December 7, 2000, for Application No. GB0020134.3.

EXAMINER <i>Frederick</i>	DATE CONSIDERED <i>4/7/05</i>
---------------------------	-------------------------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Form PTO-1449  <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b>  <i>(Use several sheets if necessary)</i>		Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <del>Not Yet Assigned</del> <b>10/861,129</b>	
		Applicant <b>Dykstra et al.</b>			
		Filing Date <b>June 4, 2004</b>		Group Art Unit <b>3672</b> <del>Unknown</del>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
7	4,991,670	02/1991	Fuller et al.			
	5,010,789	04/1991	Brett et al.			
	5,042,596	08/1991	Brett et al.			
	5,090,492	02/1992	Keith			
	5,111,892	05/1992	Sinor et al.			
7	5,131,478	07/1992	Brett et al.			
	5,199,511	04/1993	Tibbitts et al.			
	5,244,039	09/1993	Newton, Jr. et al.			
	5,265,685	11/1993	Keith et al.			
	5,303,785	04/1994	Duke			
	5,314,033	05/1994	Tibbitts			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS		(Including Author, Title, Date, Pertinent Pages, Etc.)
7		Search Report of the Belgian Patent Office, dated August 14, 2001, for Application No. BE20000528.

EXAMINER <i>Free/50</i>	DATE CONSIDERED <b>4/7/05</b>
----------------------------	----------------------------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Form PTO-1449 <b>INFORMATION DISCLOSURE CITATION IN AN APPLICATION</b> <i>(Use several sheets if necessary)</i>		Docket Number (Optional) <b>4578.2US</b> <b>(484-09454-US-CP2)</b>		Application Number <del>Not Yet Assigned</del> <b>10/03/01, 129</b>	
		Applicant <b>Dykstra et al.</b>			
		Filing Date <b>June 4, 2004</b>		Group and Unit <b>3670 Unknown</b>	

U.S. PATENT DOCUMENTS						
EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
77	5,388,649	02/1995	Ilomäki			
	5,402,856	04/1995	Warren et al.			
	5,447,208	09/1995	Lund et al.			
	5,531,281	07/1996	Murdock			
	5,549,171	08/1996	Mensa-Wilmot et al.			
	5,558,170	09/1996	Thigpen et al.			
	5,582,258	12/1996	Tibbitts et al.			
77	5,595,252	01/1997	O'Hanlon			
	5,653,300	08/1997	Lund et al.			
	5,663,512	09/1997	Schader et al.			
	5,730,234	03/1998	Putot			

FOREIGN PATENT DOCUMENTS							
	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	Translation	
						YES	NO

OTHER DOCUMENTS			(Including Author, Title, Date, Pertinent Pages, Etc.)

EXAMINER <b>Fred [Signature]</b>	DATE CONSIDERED <b>4/17/05</b>
----------------------------------	--------------------------------

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.



# ● PRINTER RUSH ●

(PTO ASSISTANCE)

Application : <u>10/86/129</u>	Examiner : <u>Tsay</u>	GAU : <u>3672</u>
From: <u>J. Blach</u>	Location: <u>IDC</u> FMF FDC	Date: <u>4/26/05</u>
Tracking #: <u>06093081</u>		Week Date: <u>4/11/05</u>

DOC CODE	DOC DATE	MISCELLANEOUS
<input type="checkbox"/> 1449		<input type="checkbox"/> Continuing Data
<input checked="" type="checkbox"/> IDS	<u>6/4/04</u>	<input type="checkbox"/> Foreign Priority
<input type="checkbox"/> CLM		<input type="checkbox"/> Document Legibility
<input type="checkbox"/> IIFW		<input type="checkbox"/> Fees
<input type="checkbox"/> SRFW		<input type="checkbox"/> Other
<input type="checkbox"/> DRW		
<input type="checkbox"/> OATH		
<input type="checkbox"/> 312		
<input type="checkbox"/> SPEC		

**[RUSH] MESSAGE:**

Please initial/line through Citations

Thank you!

**[XRUSH] RESPONSE:** IDS considered and initial copy  
of 1449 sent to applicant in NOA (5/6/05)

RB  
**INITIALS:**

NOTE: This form will be included as part of the official USPTO record, with the Response document coded as XRUSH.  
 REV 10/04

DAVID BAGNELL  
 SUPERVISORY PATENT EXAMINER  
 TECHNOLOGY CENTER 3600

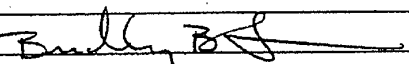
Please type a plus sign (+) inside this box → ☐

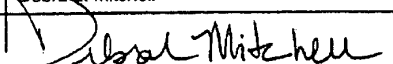
PTO/SB/21 (08-00)  
Approved for use through 10/31/2002. OMB 0651-0031  
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

<b>TRANSMITTAL FORM</b> <i>(to be used for all correspondence after initial filing)</i>	Application Number	10/861,129
	Filing Date	June 4, 2004
	First Named Inventor	Dykstra et al.
	Group Art Unit	3672
	Examiner Name	F. Tsay
Attorney Docket Number		1684-4578.2US (484-09454-US-C2)

<b>ENCLOSURES (check all that apply)</b>		
<input type="checkbox"/> Postcard receipt acknowledgment (attached to the front of this transmittal)	<input type="checkbox"/> Information Disclosure Statement, PTO/SB/08A (08-00); <input type="checkbox"/> copy of cited references	<input checked="" type="checkbox"/> Terminal Disclaimer U.S. Patent No. 6,460,631
<input checked="" type="checkbox"/> Duplicate copy of this transmittal sheet in the event that additional filing fees are required under 37 C.F.R. § 1.16	<input type="checkbox"/> Supplemental Information Disclosure Statement; PTO/SB/08A (08-00); copy of cited references and Check No. in the amount of \$180.00	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Preliminary Amendment	<input type="checkbox"/> Associate Power of Attorney	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> Response to Restriction Requirement/Election of Species Requirement dated	<input type="checkbox"/> Petition for Extension of Time and Check No. in the amount of \$	
<input type="checkbox"/> Amendment in response to office action dated	<input type="checkbox"/> Petition	
<input type="checkbox"/> Amendment under 37 C.F.R. § 1.116 in response to final office action dated	<input type="checkbox"/> Fee Transmittal Form	<input type="checkbox"/> Other Enclosure(s) (please identify below):
<input type="checkbox"/> Additional claims fee - Check No. in the amount of \$	<input type="checkbox"/> Certified Copy of Priority Document(s)	
<input type="checkbox"/> Letter to Chief Draftsman and copy of FIGS. with changes made in red	<input type="checkbox"/> Assignment Papers (for an Application)	
<input type="checkbox"/> Transmittal of Formal Drawings	Remarks	
<input type="checkbox"/> Formal Drawings ( sheets)	<b>The Commissioner is authorized to charge the terminal disclaimer fee of \$130.00 plus any additional fees required but not submitted with any document or request requiring fee payment under 37 C.F.R. §§ 1.16 and 1.17 to Deposit Account 20-1469 during pendency of this application.</b>	

<b>SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT</b>		
Firm or Individual name	Bradley B. Jensen	Registration No. 46,801
Signature		
Date	June 2, 2005	

<b>CERTIFICATE OF TRANSMISSION</b>			
I hereby certify that this correspondence is being transmitted electronically to the Commissioner for Patents to <a href="mailto:frank.tsay@uspto.gov">frank.tsay@uspto.gov</a> on the date shown below.			
Typed or printed name	Petra L. Mitchell		
Signature		Date	June 2, 2005

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

**TERMINAL DISCLAIMER TO OBTAIN A DOUBLE PATENTING  
REJECTION OVER A PRIOR PATENT**Docket Number (Optional)  
1684-4578.2US (484-09454-  
US-C2)

In re Application of: Dykstra et al.

Application No.: 10/861,129

Filed: June 4, 2004

For: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

The owner, Baker Hughes Incorporated of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application, which would extend beyond the expiration date of the full statutory term defined in 35 U.S.C. 154 to 156 and 173, as presently shortened by any terminal disclaimer, of prior Patent No. 6,460,631. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

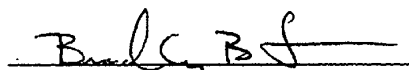
In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 to 156 and 173 of the prior patent, as presently shortened by any terminal disclaimer, in the event that it later: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims cancelled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of an organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney of record.

 6/2/2005  
Signature Date

Bradley B. Jensen

Typed or printed name  
Reg. No. 46,801

- ☒ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

\*Certification under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).  
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

**Burden Hour Statement:** This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

**TERMINAL DISCLAIMER TO OBTAIN A DOUBLE PATENTING  
REJECTION OVER A PRIOR PATENT**

Docket Number (Optional)  
1684-4578.2US (484-09454-  
US-C2)

In re Application of: Dykstra et al.

Application No.: 10/861,129

Filed: June 4, 2004

For: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

The owner\*, Baker Hughes Incorporated of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application, which would extend beyond the expiration date of the full statutory term defined in 35 U.S.C. 154 to 156 and 173, as presently shortened by any terminal disclaimer, of prior Patent No. 6,460,631. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.


In making the above disclaimer, the owner does not disclaim the terminal part of any patent granted on the instant application that would extend to the expiration date of the full statutory term as defined in 35 U.S.C. 154 to 156 and 173 of the prior patent, as presently shortened by any terminal disclaimer, in the event that it later: expires for failure to pay a maintenance fee, is held unenforceable, is found invalid by a court of competent jurisdiction, is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321, has all claims cancelled by a reexamination certificate, is reissued, or is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ For submissions on behalf of an organization (e.g., corporation, partnership, university, government agency, etc.), the undersigned is empowered to act on behalf of the organization.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

2. ☒ The undersigned is an attorney of record.

  
Signature

6/2/2005  
Date

Bradley B. Jensen


Typed or printed name  
Reg. No. 46,801

- ☒ Terminal disclaimer fee under 37 CFR 1.20(d) is included.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

\*Certification under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).  
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

<b>Application Number</b> 	<b>Application/Control No.</b> 10/861,129	<b>Applicant(s)/Patent under Reexamination</b> DYKSTRA ET AL.	
<b>Document Code - DISQ</b>		<b>Internal Document – DO NOT MAIL</b>	

<b>TERMINAL DISCLAIMER</b>	<input checked="" type="checkbox"/> <b>APPROVED</b>	<input type="checkbox"/> <b>DISAPPROVED</b>
Date Filed : 6/2/05	This patent is subject to a Terminal Disclaimer	

<b>Approved/Disapproved by:</b>
Approved D. Wildermuth 6/13/05

U.S. Patent and Trademark Office

06-07-05  
PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail**

**Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
(703) 746-4000**

or **Fax**

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence, including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

24247 7590 03/08/2005

TRASK BRITT  
P.O. BOX 2550  
SALT LAKE CITY, UT 84110

NOTICE OF EXPRESS MAILING

Express Mail Mailing Label Number: EL994822926US

Date of Deposit with USPS: June 6, 2005

Person making Deposit: Steve Wong

06/08/2005 HGUTEM2 00000010 020429 10861129

01 FC:1501 1400.00 DA  
02 FC:1504 300.00 DA

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
-----------------	-------------	----------------------	---------------------	------------------

10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060
------------	------------	-----------------	------------------------------	------

TITLE OF INVENTION: DRILL BITS WITH REDUCED EXPOSURE OF CUTTERS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	06/08/2005

EXAMINER	ART UNIT	CLASS-SUBCLASS
TSAY, FRANK	3672	175-057000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☒ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1. TraskBritt

2. \_\_\_\_\_

3. \_\_\_\_\_

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

BAKER HUGHES INCORPORATED

Houston, Texas

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are enclosed:

- ☒ Issue Fee  
☒ Publication Fee (No small entity discount permitted)  
☐ Advance Order - # of Copies \_\_\_\_\_

4b. Payment of Fee(s):

- ☐ A check in the amount of the fee(s) is enclosed.  
☐ Payment by credit card. Form PTO-2038 is attached.  
☒ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 02-0429 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above. NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature \_\_\_\_\_

Date 6/6/05

Typed or printed name

Joseph A. Walkowski

Registration No. 28,765

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



**PATENT**

**THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**In re Application of:**

Dykstra et al.

**Serial No.:** 10/861,129

**Filed:** June 4, 2004

**For:** DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

**Confirmation No.:** 1060

**Examiner:** F. Tsay

**Group Art Unit:** 3672

**Attorney Docket No.:** 1684-4578.2US  
(484-09454-US-C2)

**Notice of Allowance Mailed:**

March 8, 2005

**NOTICE OF EXPRESS MAILING**

Express Mail Mailing Label Number: EL994822926US

Date of Deposit with USPS: June 6, 2005

Person making Deposit: Steve Wong

**TRANSMITTAL LETTER**

Mail Stop Issue Fee  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

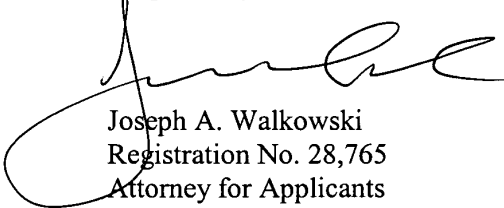
Applicants submit herewith Part B - Fee(s) Transmittal for the above-captioned application. Also enclosed are Amendment Pursuant to 37 C.F.R. § 1.312(a) and Fee Addressee for Receipt of PTO Notices Relating to Maintenance Fees.

The Commissioner is authorized to charge the issue fee(s) to Baker Hughes Incorporated, Deposit Account No. 02-0429. Applicant understands that no additional fees are required.

Serial No. 10/861,129

However, if the Office determines that any comparison fees or other additional fees are required, the Commissioner is authorized to charge any such fees to Baker Hughes Incorporated, Deposit Acct. No. 02-0429. A copy of this Transmittal Letter is enclosed for deposit account charging purposes.

Respectfully submitted,



Joseph A. Walkowski  
Registration No. 28,765  
Attorney for Applicants

TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: June 6, 2005

JAW/dlm:slm

Enclosures: Part B - Issue Fee Transmittal

Copy of Transmittal Letter

Amendment Pursuant to 37 C.F.R. § 1.312(a) (19 pages)

Fee Addressee for Receipt of PTO Notices Relating to Maintenance Fees (2 pages)

Document in ProLaw





**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**In re Application of:**

Dykstra et al.

**Serial No.:** 10/861,129

**Filed:** June 4, 2004

**For:** DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

**Confirmation No.:** 1060

**Examiner:** F. Tsay

**Group Art Unit:** 3672

**Attorney Docket No.:** 1684-4578.2US

**Notice of Allowance Mailed:**

March 8, 2005

**NOTICE OF EXPRESS MAILING**

Express Mail Mailing Label Number: EL994822926US

Date of Deposit with USPS: June 6, 2005

Person making Deposit: Steve Wong

**AMENDMENT PURSUANT TO 37 C.F.R. § 1.312(a)**

Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

Sir:

Please amend the above-referenced application as follows:

**Amendments to the Specification** begin on page 3 of this paper.

**Amendments to the Abstract** appear on page 11 of this paper.

**Serial No. 10/861,129**

**Amendments to the Claims** are reflected in the listing of claims which begins on page 12 of this paper.

**Remarks** begin on page 19 of this paper.

IN THE SPECIFICATION:

Please amend paragraph number [0001] as follows:

[0001] This application is a continuation of application Serial No. 10/266,534, filed October 7, 2002, pending, which is a continuation of application Serial No. 09/738,687, filed December 15, 2000, now U.S. Patent 6,460,631, issued October 8, 2002, which is a ~~continuation-in-part~~ continuation-in-part of application Serial No. 09/383,228, filed August 26, 1999, now U.S. Patent No. 6,298,930, issued October 9, 2001, entitled Drill Bits with Controlled Cutter Loading and Depth of Cut.

Please amend paragraph number [0008] as follows:

[0008] While some of the foregoing patents recognize the desirability to limit cutter penetration, or DOC, or otherwise limit forces applied to a borehole surface, the disclosed approaches are somewhat generalized in nature and fail to accommodate or implement an engineered approach to achieving a target ROP in combination with more stable, predictable bit performance. Furthermore, the disclosed approaches do not provide a bit or method of drilling which is generally tolerant to being axially loaded with an amount of weight-on-bit over and in excess what would be optimum for the current rate-of-penetration for the particular formation being drilled and which would not generate high amounts of potentially bit-stopping or ~~bit-damaging~~ bit-damaging torque-on-bit, should the bit nonetheless be subjected to such excessive amounts of weight-on-bit.

Please amend paragraph number [0009] as follows:

[0009] The present invention addresses the foregoing needs by providing a ~~well-reasoned,~~ well-reasoned, easily implementable bit design particularly suitable for PDC cutter-bearing drag bits, which bit design may be tailored to specific formation compressive strengths or strength ranges to provide DOC control in terms of both maximum DOC and limitation of DOC variability. As a result, continuously achievable ROP may be optimized and

torque controlled even under high WOB, while destructive loading of the PDC cutters is largely prevented.

Please amend paragraph number [0057] as follows:

[0057] By way of example only, the total DOCC features surface area for an ~~8.5-inch~~ 8.5-inch diameter bit generally configured as shown in FIGS. 1 and 2 may be about 12 square inches. If, for example, the unconfined compressive strength of a relatively soft formation to be drilled by either bit 10 or 100 is 2,000 pounds per square inch (psi), then at least about 24,000 lbs. WOB may be applied without failing or indenting the formation. Such WOB is far in excess of the WOB which may normally be applied to a bit in such formations (for example, as little as 1,000 to 3,000 lbs., up to about 5,000 lbs.) without incurring bit balling from excessive DOC and the consequent cuttings volume which overwhelms the bit's hydraulic ability to clear them. In harder formations, with, for example, 20,000 to 40,000 psi compressive strengths, the total DOCC features surface area may be significantly reduced while still accommodating substantial WOB applied to keep the bit firmly on the borehole bottom. When older, less sophisticated, drill rigs are employed or during directional drilling, both of which render it difficult to control WOB with any substantial precision, the ability to overload WOB without adverse consequences further distinguishes the superior performance of bits embodying the present invention. It should be noted at this juncture that the use of an unconfined compressive strength of formation rock provides a significant margin for calculation of the required bearing area of the DOCC features for a bit, as the in situ, confined, compressive strength of a subterranean formation being drilled is substantially higher. Thus, if desired, confined compressive strength values of selected formations may be employed in designing the total DOCC features as well as the total bearing area of a bit to yield a smaller required area, but which still advisedly provides for an adequate "margin" of excess bearing area in recognition of variations in continued compressive strengths of the formation to preclude substantial indentation and failure of the formation downhole.

Please amend paragraph number [0061] as follows:

[0061] ~~n the~~ In the cases of both bit 10 and bit 100, the rotationally leading DOCC features (bearing segments 30) are configured and placed to substantially exactly match the pattern drilled in the bottom of the borehole when drilling at an ROP of 100 feet per hour (fph) at 120 rotations per minute (rpm) of the bit. This results in a DOC of about 0.166 inch per revolution. Due to the presence of the DOCC features (bearing segments 30), after sufficient WOB has been applied to drill 100 fph, any additional WOB is transferred from the bit body 40 of the bit 10 or 100 through the DOCC features to the formation. Thus, the cutters 14 are not exposed to any substantial additional weight, unless and until a WOB sufficient to fail the formation being drilled would be applied, which application may be substantially controlled by the driller, since the DOCC features may be engineered to provide a large margin of error with respect to any given sequence of formations which might be encountered when drilling an interval.

Please amend paragraph number [0063] as follows:

[0063] The benefit of DOCC features in controlling torque can readily be appreciated by a review of FIG. 3 of the drawings, which is a mathematical model of performance of a ~~3-3/4 inch~~ 3 3/4 inch diameter, four-bladed, Hughes Christensen R324XL PDC bit showing various torque versus WOB curves for varying cutter backrakes in drilling Mancos shale. Curve A represents the bit with a 10° cutter backrake, curve B, the bit with a 20° cutter backrake, curve C, the bit with a 30° cutter backrake, and curve D, the bit using cutters disposed at a 20° backrake and including the DOCC features according to the present invention. The model assumes a bit design according to the invention for an ROP of 50 fph at 100 rpm, which provides 0.1 inch per revolution penetration of a formation being drilled. As can readily be seen, regardless of cutter backrake, curves A through C clearly indicate that, absent the DOCC features according to the present invention, required torque on the bit continues to increase continuously and substantially linearly with applied WOB, regardless of how much WOB is applied. On the

other hand, curve D indicates that, after WOB approaches about 8,000 lbs. on the bit, including the DOCC features, the torque curve flattens significantly and increases in a substantially linear manner only slightly from about 670 ft-lb. to just over 800 ft-lb. even as WOB approaches 25,000 lbs. As noted above, this relatively small increase in the torque after the DOCC features engage the formation is frictionally related, and is also somewhat predictable. As graphically depicted in FIG. 3, this additional torque load increases substantially linearly as a function of WOB times the coefficient of friction between the bit and the formation.

Please amend paragraph number [0071] as follows:

[0071] Referring to FIGS. 7 and 7A, exemplary bit 150 having PDC cutter 14 secured thereto rotationally trailing fluid course 20 includes pivotable DOCC feature 160 comprised of an arcuate-surfaced body 162 (which may comprise a hemisphere for rotation about several axes or merely an arcuate surface extending transverse to the plane of the page for rotation about an axis transverse to the page) secured in socket 164 and having an optional wear-resistant feature 166 on the bearing surface 168 thereof. Wear-resistant feature 166 may merely be an exposed portion of the material of body 162 if the latter is formed of, for example, WC. Alternatively, ~~wear-resistant~~ wear-resistant feature 166 may comprise a WC tip, insert or cladding on bearing surface 168 of body 162, diamond grit embedded in body 162 at bearing surface 168, or a synthetic or natural diamond surface treatment of bearing surface 168, including specifically and without limitation, a diamond film deposited thereon or bonded thereto. It should be noted that the area of the bearing surface 168 of the DOCC feature 160 which will ride on the formation being drilled, as well as the DOC for PDC cutter 14, may be easily adjusted for a given bit design by using bodies 162 exhibiting different exposures (heights) of the bearing surface 168 and different widths, lengths or cross-sectional configurations, all as shown in broken lines. Thus, different formation compressive strengths may be accommodated. The use of a pivotable DOCC feature 160 permits the DOCC feature to automatically adjust to different ROPs within a given range of cutter helix angles. While DOC may be affected by pivoting of the DOCC feature 160, variation within a given range of ROPs will usually be nominal.

Please amend paragraph number [0082] as follows:

[0082] Representative rotary drill bit 300 shown in FIGS. 14A and 14B, includes a bit body 301 having a leading end 302 and a trailing end 304. Connection 306 may comprise a ~~pin-end~~ pin-end connection having tapered threads for connecting bit 300 to a bottom hole assembly of a conventional rotating drill string, or alternatively, for connection to a downhole motor assembly, such as a drilling fluid powered Moineau-type downhole motor, as described earlier. Leading end 302, or drill bit face, includes a plurality of blade structures 308 generally extending radially outwardly and longitudinally toward trailing end 304. Exemplary bit 300 comprises eight blade structures 308, or blades, spaced circumferentially about the bit. However, a fewer number of blades may be provided on a bit such as provided on bit body 301' of bit 300' shown in FIG. 14C which has six blades. A greater number of blade structures of a variety of geometries may be utilized as determined to be optimum for a particular drill bit. Furthermore, blade structures 308 need not be equidistantly spaced about the circumference of drill bit 300 as shown, but may be spaced about the circumference, or periphery, of a bit in any suitable fashion, including a non-equidistant arrangement or an arrangement wherein some of the blades are spaced circumferentially equidistantly from each other and some are irregularly, non-equidistantly spaced from each other. Moreover, blade structures 308 need not be specifically configured in the manner as shown in FIGS. 14A and 14B, but may be configured to include other profiles, sizes, and combinations than those shown.

Please amend paragraph number [0089] as follows:

[0089] FIGS. 16 and 17 are enlarged, isolated partial cross-sectional cutter profile views to which all of the cutters located on a bit are superimposed as if on a single ~~cross-sectional~~ cross-sectional portion of a bit body 301 or cutters 328 of a bit, such as bit 300. The cutter profiles of FIGS. 16 and 17 are illustrated as being to the right of longitudinal centerline L of a representative bit, such as bit 300, instead of the left, as illustrated in FIGS. 15A-15C. As

described, the leading end of bit 300 includes cone region 310, which includes cutters 328C; nose region 312, which includes cutters 328N; flank region 314, which includes cutters 328F; shoulder region 316, which includes cutters 328S; and gage region 322, which includes cutters 328G; wherein the cutters in each region may be referred to collectively as cutters 328.

FIG. 16 illustrates a cutter profile exhibiting a high degree, or amount, of cutter overlap 356.

That is, cutters 328 as illustrated in FIG. 17 are provided in sufficient quantity and are positioned sufficiently close to each other laterally, or radially, so as to provide a high degree of cutter redundancy as the bit rotates and engages the formation. In contrast, the representative cutter profile illustrated in FIG. 17 exhibits a relatively lower degree, or amount, of cutter overlap 356.

That is, the total number of cutters 328 is less in quantity and are spaced further apart with respect to the radial, or lateral, distance between individual, rotationally adjacent cutter profiles.

Kerf regions 348, shown in phantom, in FIGS. 16 and 17 reveal a relatively small height for kerf regions 348 of FIG. 16 wherein kerf regions of FIG. 17 are significantly higher. To aid in the illustration of the respective differences in individual kerf region height  $K_H$ , which, as a practical matter, is directly related to cutter exposure height  $H_C$ , as well as individual kerf region

widths  $K_w$ , which are directly influenced by the extent of radial overlap of cutters respectively positioned on different blades, a scaled reference grid of a plurality of parallel spaced lines is provided in FIGS. 16 and 17 to highlight the cutter exposure height and kerf region widths. The spacing between the grid lines in FIGS. 16 and 17 are scaled to represent approximately .125 of an inch. However, such a .125, or 1/8 inch, scale grid is merely exemplary, as dimensionally greater as well as dimensionally smaller cutter exposure heights, kerf region heights, and kerf region widths may be used in accordance with the present invention. The superimposed cutter profile of cutters 328 is illustrated with each of the represented cutters 328 being generally equidistantly spaced along the face of the bit from centerline L toward gage region 322, however, such need not be the case. For example, cutters 328C may have a cutter profile exhibiting more cutter overlap 356 resulting in small kerf widths in cone region 310 as compared to a cutter profile of cutters 328N, 328F, and 328S respectively located in nose region 312, flank region 314, and shoulder region 316, wherein such more radially outward positioned cutters



would have less overlap resulting in larger kerf widths therein, or vice versa. Thus, by selectively incorporating the amount of cutter overlap 356 to be provided in each region of a bit, the depth of cut of the cutters in combination with selecting the degree or amount of cutter exposure height of each cutter located in each particular region may be utilized to specifically and precisely control the depth of cut in each region, as well as to design into the bit the amount of available bearing surface surrounding the cutters to which the bit may ride upon the formation. Stated differently, the wider the kerf width  $K_w$  between the collective, superimposed, individual cutter profiles of all the cutters on all of the blades, or alternatively, all the cutters radially and circumferentially spaced about a bit, such as cutters 328 provided on a bit as shown in FIG. 17, a greater proportion of the total applied WOB will be dispersed upon the formation allowing the bit to “ride” on the formation than would be the case if a greater quantity of cutters were provided having a smaller kerf width  $K_w$  therebetween, as shown in FIG. 16.

Please amend paragraph number [0098] as follows:

[0098] FIGS. 19-22 are graphical portrayals of laboratory test results of four different bladed-style drill bits incorporating PDC cutters on the blades thereof. Drill bits labeled “RE-S” and “RE-W” each had selectively reduced cutter exposures in accordance with the present invention as previously described and illustrated in FIGS. 14A-18C. However, drill bit labeled “RE-S” was provided with a cutter profile exhibiting small kerfs and drill bit labeled “RE-W” was provided with a cutter profile exhibiting wide kerfs. The bits having reduced exposure cutters are graphically contrasted with the laboratory test results of a prior art steerable bit labeled “STR” including approximately ~~.50-inch~~ .50-inch diameter cutters with each cutter including a superabrasive table having a peripheral edge chamfer exhibiting a width of approximately ~~.050 inches~~ .050 inch and angled toward the longitudinal axis of the cutter by approximately 45°. Conventional, or standard, general purpose drill bit labeled “STD” included approximately ~~.50-inch~~ .50-inch diameter cutters backraked at approximately 20° and exhibiting chamfers of approximately ~~0.016 inches~~ 0.016 inch in width and angled approximately 45° with

respect to the longitudinal axis of the cutter. All bits had a gage diameter of approximately 12.25 inches and were rotated at 120 RPM during testing. With respect to all of the tested bits, the PDC cutters installed in the cone, nose, flank, and shoulder of the bits had cutter backrake angles of approximately 20° and the PDC cutters installed generally within the gage region had a cutter backrake angle of approximately 30°. The cutter exposure heights of the RE-S and RE-W bits were approximately ~~.120 inches~~ .120 inch for the cutters positioned in the cone region, approximately ~~.150 inches~~ .150 inch in the nose region, approximately ~~.100 inches~~ .100 inch in the flank region, approximately ~~.063 inches~~ .063 inch in the shoulder region, and the cutters in the gage region were generally ground flush with the gage for both of these bits embodying the present invention. The PDC cutters of the RE-S and RE-W bits were approximately ~~.75 inches~~ .75 inch in diameter (with the exception of PDC cutters located in the gage region, which were smaller in diameter and ground flush with the gage) and were provided with a chamfer on the peripheral edge of the superabrasive cutting table of the cutter. The chamfers exhibited a width of approximately ~~.019 inches~~ .019 inch and were angled toward the longitudinal axes of the cutters by approximately 45°. The mean kerf width of the RE-S bit was approximately ~~0.3 inches~~ 0.3 inch and the mean kerf width of the RE-W bit was approximately ~~0.2 inches~~ 0.2 inch.

Please amend paragraph number [00100] as follows:

[00100] Of significance is the encircled region labeled “D” as shown in the graph of FIG. 19. The plot of bit RE-S prior to encircled region D is very similar in slope to prior art steerable bit STR but upon the DOC reaching about ~~.120 inches~~ .120 inch, the respective aggressiveness of the RE-S bit falls rather dramatically compared to the plot of the STR bit proximate and within encircled region D. This is attributable to the bearing surfaces of the RE-S bit taking on and axially dispersing the elevated WOB upon the formation axially underlying the bit associated with the larger DOCs, such as the DOCs exceeding approximately ~~.120 inches~~ .120 inch in accordance with the present invention.

AMENDMENTS TO THE ABSTRACT:

Please amend the Abstract originally appearing on page 51 of the application as follows:

ABSTRACT OF THE DISCLOSURE

A rotary drag bit and method for drilling subterranean formations, including a bit body being provided with at least one cutter thereon exhibiting reduced, or limited, exposure to the formation, so as to control the depth-of-cut of the at least one cutter, so as to control the volume of formation material cut per bit rotation, as well as to control the amount of torque experienced by the bit and an optionally associated bottomhole assembly regardless of the effective-weight-on-bit ~~on-bit~~ weight-on-bit are all disclosed. The exterior of the bit preferably includes a plurality of blade structures carrying at least one such cutter thereon and including a sufficient amount of bearing surface area to contact the formation so as to generally distribute an additional weight applied to the bit against the bottom of the borehole without exceeding the compressive strength of the formation rock.

IN THE CLAIMS:

Claims 4, 17, 19 and 20 have been amended herein. All of the pending claims 1 through 24 are presented below. This listing of claims will replace all prior versions and listings of claims in the application. Please enter these claims as amended.

**Listing of Claims:**

1. (Previously presented) A drill bit for subterranean drilling, comprising:  
a bit body including a longitudinal centerline, a leading end having a face for contacting a subterranean formation during drilling, and a trailing end having a structure associated therewith for connecting the bit body to a drill string, the face of the leading end including a bearing surface sized and configured to transfer a range of weight-on-bit from the bit body through the bearing surface to the subterranean formation, wherein the range of weight-on-bit comprises any weight-on-bit which results in the bearing surface contacting the subterranean formation without substantial indentation of the bearing surface thereinto;  
wherein the bearing surface is structured so that an area of the bearing surface in contact with the subterranean formation remains substantially constant within the range of weight-on-bit;  
and  
at least one superabrasive cutter secured to a selected portion of the face of the leading end of the bit body and configured for engaging the subterranean formation during drilling.

2. (Previously presented) The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a plurality of superabrasive cutters and the face of the leading end comprises a plurality of blade structures protruding from the bit body, at least some of the plurality of blade structures carrying at least one of the plurality of superabrasive cutters and the blade structures exhibiting in total a combined bearing surface area of sufficient size to substantially prevent indentation of the combined bearing surface area into the subterranean formation.

3. (Original) The drill bit of claim 2, wherein the at least some of the plurality of blade structures each extend from a respective point generally proximate the longitudinal centerline of the bit body generally radially outward toward a gage of the bit body and longitudinally toward the trailing end of the bit body.

4. (Currently amended) The drill bit of claim 3, wherein the at least some of the plurality of blade structures each carry several of the plurality of superabrasive cutters and exhibit at least one bearing surface, and wherein each of the plurality of blade structures generally encompasses each of the several of the plurality of superabrasive cutters carried thereon with a limited portion of each of the several of the plurality of superabrasive cutters exposed by a preselected extent perpendicular ~~from the~~ from a respective at least one bearing surface proximate each of the several of the plurality of superabrasive cutters so as to control a respective depth-of-cut for each of the several of the plurality of superabrasive cutters.

5. (Original) The drill bit of claim 2, wherein the bit body comprises at least one of steel and a metal matrix.

6. (Original) The drill bit of claim 4, wherein at least a portion of the at least one bearing surface of at least one of the plurality of blade structures includes a wear-resistant exterior.

7. (Original) The drill bit of claim 6, wherein the wear-resistant exterior comprises at least one of the group consisting of carbide, tungsten carbide, synthetic diamond, natural diamond, polycrystalline diamond, thermally stable polycrystalline diamond, cubic boron nitride, and hard facing material.

8. (Original) The drill bit of claim 2, wherein at least one bearing surface of at least one of the plurality of blade structures comprises a wear-resistant exterior.

9. (Original) The drill bit of claim 1, wherein the face of the leading end of the bit body comprises cone, nose, flank, shoulder, and gage regions.

10. (Previously presented) The drill bit of claim 9, wherein a portion of the bearing surface positioned in the cone region exhibits a greater amount of bearing surface area than a portion of the bearing surface positioned in the nose region.

11. (Previously presented) The drill bit of claim 10, wherein the portion of the bearing surface positioned in the nose region exhibits a greater amount of bearing surface area than a portion of the bearing surface positioned in the flank region.

12. (Previously presented) The drill bit of claim 9, wherein a portion of the bearing surface positioned in the cone region exhibits a greater amount of bearing surface area than a portion of the bearing surface positioned in the shoulder region.

13. (Previously presented) The drill bit of claim 2, wherein the at least one superabrasive cutter of the plurality of superabrasive cutters comprises a chamfered region extending at least partially about a circumferential periphery thereof.

14. (Original) The drill bit of claim 1, wherein the at least one superabrasive cutter comprises a chamfered peripheral edge portion of a preselected width and chamfer angle.

15. (Previously presented) The drill bit of claim 1, comprising at least another bearing surface configured to transfer another weight-on-bit from the bit body through the another bearing surface to the subterranean formation at a weight-on-bit above which results in the another bearing surface contacting the subterranean formation without substantial indentation of the another bearing surface thereinto.

16. (Previously presented) A method of drilling a subterranean formation without generating an excessive amount of torque-on-bit, comprising:  
engaging the subterranean formation with at least one cutter of a drill bit within a selected depth-of-cut range;  
applying a weight-on-bit within a range of weight-on-bit in excess of that required for the at least one cutter to penetrate the subterranean formation and above which results in a bearing surface contacting the subterranean formation;  
transferring the excess weight-on-bit from the drill bit through the bearing surface to the subterranean formation without substantial indentation of the bearing surface into the subterranean formation; and  
wherein an area of the bearing surface contacting the subterranean formation remains substantially constant over the range of excess weight-on-bit.

17. (Currently amended) The method of claim 16, wherein transferring the excess weight-on-bit from ~~the~~ a body of the drill bit through the bearing surface to the subterranean formation comprises transferring the excess weight-on-bit to at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter.

18. (Previously presented) The method of claim 17, wherein transferring the excess weight-on-bit to the at least one formation-facing bearing surface on the drill bit generally surrounding at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a plurality of wear knots on the at least one formation-facing bearing surface.

19. (Currently amended) The method of claim 17, wherein transferring the excess weight-on-bit to the at least one formation-facing bearing surface on the drill bit generally surrounding the at least a portion of the at least one cutter comprises transferring the excess weight-on-bit to a hard facing material affixed to a selected portion of the at least one formation-facing bearing surface proximate the at least one of the ~~superabrasive cutters~~ cutter.

20. (Currently amended) The method of claim 16, further comprising:  
applying an additional weight-on-bit in excess of the excess weight-on-bit required for the bearing surface to contact the subterranean formation and above which results in the bearing surface and another bearing surface contacting the subterranean formation; and transferring the additional excess weight-on-bit from ~~the~~ a body of the drill bit through the another bearing surface to the subterranean formation without substantial indentation of the another bearing surface thereinto.



21. (Previously presented) A method of designing a drill bit for drilling a subterranean formation, the drill bit under design including a plurality of superabrasive cutters disposed about a formation-engaging leading end of the drill bit, the method comprising: selecting a maximum depth-of-cut for at least some of the plurality of superabrasive cutters; selecting a cutter profile arrangement to which the at least some of the plurality of superabrasive cutters are to be radially and longitudinally positioned on the formation-engaging leading end of the drill bit; and configuring within the design of the drill bit a sufficient total amount of formation-facing bearing surface area structured for axially supporting the drill bit without substantially indenting the subterranean formation should the drill bit be subjected to a weight-on-bit exceeding a weight-on-bit which would cause the formation-facing bearing surface area to contact the subterranean formation, wherein the formation-facing bearing surface area is sized and configured to remain substantially constant over a range of excess weight-on-bit.

22. (Previously presented) The method of claim 21, further comprising including within the drill bit under design a plurality of kerf regions of a preselected width positioned laterally intermediate of the at least some of the plurality of superabrasive cutters.

23. (Previously presented) The method of claim 21, wherein configuring within the design of the drill bit a sufficient total amount of the formation-facing bearing surface area comprises selecting an amount of hard facing to be disposed on at least a portion of the formation-facing bearing surface at least partially surrounding the at least some of the plurality of superabrasive cutters.

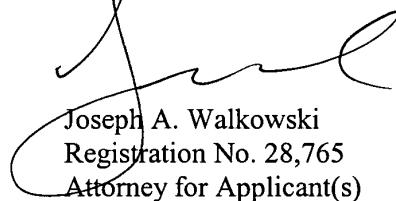
24. (Previously presented) The method of claim 21, further comprising:  
including within the design of the drill bit another formation-facing bearing surface area  
structured for axially supporting the drill bit without substantially indenting the  
subterranean formation therewith should the drill bit be subjected to an additional excess  
weight-on-bit exceeding an excess weight-on-bit.

REMARKS

This amendment corrects errors in the text. Entry is respectfully solicited.

This amendment is submitted prior to or concurrently with the payment of the issue fee and, therefore, no petition or fee is required. No new matter has been added.

Respectfully submitted,



Joseph A. Walkowski  
Registration No. 28,765  
Attorney for Applicant(s)

TRASKBRITT  
P.O. Box 2550  
Salt Lake City, Utah 84110-2550  
Telephone: 801-532-1922

Date: June 6, 2005  
JAW/csw

\\Traskbritt1\Shared\DOCS\1684-4578.2US\112322.doc



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/861,129	06/04/2004	Mark W. Dykstra	1684-4578.2US (484-09454-	1060
24247	7590	06/17/2005	EXAMINER	
TRASK BRITT P.O. BOX 2550 SALT LAKE CITY, UT 84110			TSAY, FRANK	
			ART UNIT	PAPER NUMBER
			3672	

DATE MAILED: 06/17/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

1/7

<b>Supplemental Notice of Allowability</b>	<b>Application No.</b> 10/861,129		<b>Applicant(s)</b> DYKSTRA ET AL.	
	<b>Examiner</b> Frank S. Tsay		<b>Art Unit</b> 3672	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--**

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to Amendment filed 6/6/05, and Terminal Disclaimer filed on 6/2/05.
2. ☒ The allowed claim(s) is/are 1-24.
3. ☒ The drawings filed on 18 January 2005 are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 

a) ☐ All    b) ☐ Some\*    c) ☐ None    of the:
 
  1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

\* Certified copies not received: \_\_\_\_\_.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.  
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS ( as "replacement sheets") must be submitted.
 

(a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review ( PTO-948) attached
 

1) ☐ hereto or 2) ☐ to Paper No./Mail Date \_\_\_\_\_.

 (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date \_\_\_\_\_.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. <input type="checkbox"/> Notice of References Cited (PTO-892) 2. <input type="checkbox"/> Notice of Draftperson's Patent Drawing Review (PTO-948) 3. <input type="checkbox"/> Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____ 4. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material	5. <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) 6. <input checked="" type="checkbox"/> Interview Summary (PTO-413), Paper No./Mail Date _____ 7. <input checked="" type="checkbox"/> Examiner's Amendment/Comment 8. <input type="checkbox"/> Examiner's Statement of Reasons for Allowance 9. <input type="checkbox"/> Other _____
--	--

### **EXAMINER'S AMENDMENT**

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it **MUST** be submitted no later than the payment of the issue fee.

The application has been amended as follows:

In the Specification, line 3, the language "pending" has been deleted, and replaced by: --- now US Patent No. 6,770,613-----

### ***Response to Amendment***

Applicant's amendment pursuant to 37 CFR 1.312(a) has been entered.

Claims 1-24 are allowed.


Any inquiry concerning this communication or earlier communications from the examiner should be directed to Frank S. Tsay whose telephone number is (517) 272-7038. The examiner can normally be reached on Monday thru Friday, 7:30am-5:00 pm, 2nd Friday off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, David J. Bagnell can be reached on (517)272-6999. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Application/Control Number: 10/861,129  
Art Unit: 3672

Page 3

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Frank S Tsay  
Primary Examiner  
Art Unit 3672

6/13/05



PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Dykstra et al.

Serial No.: 10/861,129

Filed: June 4, 2004

For: DRILL BITS WITH REDUCED  
EXPOSURE OF CUTTERS

Confirmation No.: 1060

Examiner: F. Tsay

Group Art Unit: 3672

Attorney Docket No.: 1684-4578.2US

Notice of Allowance Mailed:

March 8, 2005

NOTICE OF EXPRESS MAILING

Express Mail Mailing Label Number: EL994822926US

Date of Deposit with USPS: June 6, 2005

Person making Deposit: Steve Wong

*OK to  
enter  
Rule 312  
Amendment!  
7/6/13/05*

AMENDMENT PURSUANT TO 37 C.F.R. § 1.312(a)

Mail Stop ISSUE FEE  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450


Sir:

Please amend the above-referenced application as follows:

Amendments to the Specification begin on page 3 of this paper.

Amendments to the Abstract appear on page 11 of this paper.



<b>Application Number</b> 	<b>Application/Control No.</b> 10/861,129	<b>Applicant(s)/Patent under Reexamination</b> DYKSTRA ET AL.	
<b>Document Code - DISQ</b>		<b>Internal Document – DO NOT MAIL</b>	

<b>TERMINAL DISCLAIMER</b>	<input checked="" type="checkbox"/> <b>APPROVED</b>	<input type="checkbox"/> <b>DISAPPROVED</b>
Date Filed : 6/2/05	This patent is subject to a Terminal Disclaimer	

<b>Approved/Disapproved by:</b>

U.S. Patent and Trademark Office



<b>Response to Rule 312 Communication</b>	<b>Application No.</b>	<b>Applicant(s)</b>	
	10/861,129	DYKSTRA ET AL.	
	<b>Examiner</b>	<b>Art Unit</b>	
	Frank S. Tsay	3672	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

1. ☒ The amendment filed on 06 June 2005 under 37 CFR 1.312 has been considered, and has been:

a) ☐ entered.

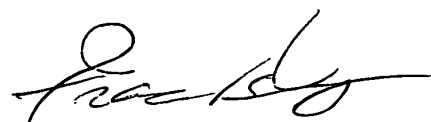
b) ☒ entered as directed to matters of form not affecting the scope of the invention.

c) ☐ disapproved because the amendment was filed after the payment of the issue fee.

Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

d) ☐ disapproved. See explanation below.

e) ☐ entered in part. See explanation below.



Frank S Tsay  
Primary Examiner  
Art Unit: 3672

## PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1  
 Stylesheet Version v1.2

EPAS ID: PAT4766287

<b>SUBMISSION TYPE:</b>	NEW ASSIGNMENT	
<b>NATURE OF CONVEYANCE:</b>	ENTITY CONVERSION	
<b>CONVEYING PARTY DATA</b>		
<b>Name</b>		<b>Execution Date</b>
BAKER HUGHES INCORPORATED		07/03/2017
<b>RECEIVING PARTY DATA</b>		
<b>Name:</b>	BAKER HUGHES, A GE COMPANY, LLC	
<b>Street Address:</b>	17021 ALDINE WESTFIELD	
<b>City:</b>	HOUSTON	
<b>State/Country:</b>	TEXAS	
<b>Postal Code:</b>	77073	
<b>PROPERTY NUMBERS Total: 11</b>		
<b>Property Type</b>	<b>Number</b>	
Patent Number:	6298930	
Patent Number:	6460631	
Patent Number:	6779613	
Patent Number:	6935441	
Patent Number:	7096978	
Patent Number:	7814990	
Patent Number:	8066084	
Patent Number:	8172008	
Patent Number:	6575256	
Patent Number:	7762355	
Patent Number:	7861809	
<b>CORRESPONDENCE DATA</b>		
<b>Fax Number:</b>	(281)582-4110	
<i>Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.</i>		
<b>Email:</b>	kimberly.gregg@bakerhughes.com	
<b>Correspondent Name:</b>	BAKER HUGHES, A GE COMPANY, LLC	
<b>Address Line 1:</b>	17021 ALDINE WESTFIELD	
<b>Address Line 4:</b>	HOUSTON, TEXAS 77073	
<b>ATTORNEY DOCKET NUMBER:</b>	ECC2-63818	

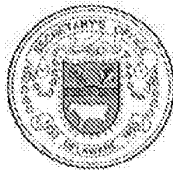
<b>NAME OF SUBMITTER:</b>	ANDRE PORTER
<b>SIGNATURE:</b>	/andre porter/
<b>DATE SIGNED:</b>	01/09/2018
	This document serves as an Oath/Declaration (37 CFR 1.63).
<b>Total Attachments: 6</b> source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page1.tif source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page2.tif source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page3.tif source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page4.tif source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page5.tif source=Baker Hughes a GE Company LLC.Cert of Conversion and Formation#page6.tif	

# Delaware

The First State

Page 1

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF DELAWARE, DO HEREBY CERTIFY THAT THE ATTACHED IS A TRUE AND CORRECT COPY OF THE CERTIFICATE OF CONVERSION OF A DELAWARE CORPORATION UNDER THE NAME OF "BAKER HUGHES INCORPORATED" TO A DELAWARE LIMITED LIABILITY COMPANY, CHANGING ITS NAME FROM "BAKER HUGHES INCORPORATED" TO "BAKER HUGHES, A GE COMPANY, LLC", FILED IN THIS OFFICE ON THE THIRD DAY OF JULY, A.D. 2017, AT 9:35 O'CLOCK A.M.



2106297 8100V  
SR# 20175062939

You may verify this certificate online at [corp.delaware.gov/authver.shtml](http://corp.delaware.gov/authver.shtml)

A handwritten signature in black ink, appearing to read "JBULLOCK", is written over a horizontal line. Below the line, the text "Jeffrey W. Bullock, Secretary of State" is printed in a small font.

Authentication: 202820609  
Date: 07-03-17

State of Delaware  
Secretary of State  
Division of Corporations  
Delivered 09:35 AM 07/03/2017  
FILED 09:35 AM 07/03/2017  
SR 20175062939 - File Number 2136297

**CERTIFICATE OF CONVERSION**

**CONVERTING**

**BAKER HUGHES INCORPORATED**

to

**BAKER HUGHES, A GE COMPANY, LLC**

This Certificate of Conversion is being filed for the purpose of converting Baker Hughes Incorporated, a Delaware corporation (the "Converting Corporation"), to a Delaware limited liability company to be named Baker Hughes, a GE company, LLC (the "Company") pursuant to Section 18-214 of the Delaware Limited Liability Company Act, 6 *Del. C.* §§ 18-101 *et seq.* (the "Delaware LLC Act"), and Section 266 of the General Corporation Law of the State of Delaware, 8 *Del. C.* §§ 101 *et seq.* (the "DGCL").

The undersigned, as authorized person for the Converting Corporation, does hereby certify as follows:

1. The Converting Corporation was first incorporated in Delaware on November 3, 1986.
2. The name of the Converting Corporation immediately prior to filing this Certificate is Baker Hughes Incorporated.
3. The name of the Company as set forth in the Certificate of Formation is Baker Hughes, a GE company, LLC.
4. The conversion effected by this Certificate of Conversion has been approved by the directors and the sole stockholder of the Converting Corporation in accordance with the provisions of Section 266 of the DGCL and Section 18-214 of the Delaware LLC Act.

IN WITNESS WHEREOF, the undersigned has executed this Certificate of Conversion  
on July 3, 2017.

BAKER HUGHES INCORPORATED

By: Lee Whitley

Name: Lee Whitley

Title: Vice President

*[Signature Page to Baker Hughes Certificate of Conversion]*



# Delaware

The First State

Page 1

I, JEFFREY W. BULLOCK, SECRETARY OF STATE OF THE STATE OF  
DELAWARE DO HEREBY CERTIFY THAT THE ATTACHED IS A TRUE AND  
CORRECT COPY OF THE CERTIFICATE OF FORMATION OF "BAKER HUGHES,  
A GE COMPANY, LLC" FILED IN THIS OFFICE ON THE THIRD DAY OF  
JULY, A.D. 2017, AT 9:35 O'CLOCK A.M.



2106297 8100V  
SR# 20175062939

You may verify this certificate online at [corp.delaware.gov/authver.shtml](http://corp.delaware.gov/authver.shtml)

A handwritten signature in black ink, appearing to read "JB", is written over a horizontal line. Below the line, the text "Jeffrey W. Bullock, Secretary of State" is printed in a small font.

Authentication: 202820609  
Date: 07-03-17

State of Delaware  
Secretary of State  
Division of Corporations  
Delivered 09:35 AM 07/03/2017  
FILED 09:35 AM 07/03/2017  
SR 20175052939 - File Number 2106297

**BAKER HUGHES, A GE COMPANY, LLC**

**CERTIFICATE OF FORMATION**

This Certificate of Formation is being filed pursuant to Section 18-214(b) of the Delaware Limited Liability Company Act, 6 *Del. C. §§ 18-101 et seq.*, in connection with the conversion of Baker Hughes Incorporated, a Delaware corporation, to a Delaware limited liability company.

The undersigned, as an authorized person, does hereby certify as follows:

1. The name of the limited liability company is Baker Hughes, a GE company, LLC (the "Company").
2. The Company's registered office in the State of Delaware is located at Corporation Trust Center, 1209 Orange Street, in the City of Wilmington, County of New Castle, Delaware 19801. The registered agent of the Company for service of process at such address is The Corporation Trust Company.

IN WITNESS WHEREOF, the undersigned has executed this Certificate of Formation on  
July 3, 2017.



Lee Whitley, Authorized Person

*[Signature Page to Certificate of Formation (BHGE, LLC Conversion)]*