United States District Court,
E.D. Texas, Sherman Division.

HALIBURTON SERVICES,
Plaintiff.
v.
SMITH INTERNATIONAL INC,
Defendant.

No. 4:02-CV-269

Feb. 13, 2004.

Background: Suit was brought alleging infringement of patents for a new type of roller cone drill bit designed for use in oil and natural gas production.

Holdings: In construing disputed claim terms, the District Court, Davis, J., held that:
(1) term "per revolution of the drill bit" meant "as a function of the number of revolutions of the drill bit";
(2) term "during optimization," meant "during any process for optimizing the roller cone bit";
(3) term "as the engineer adjusts design parameters," could not be reduced to a more simple or clear construction based on the intrinsic evidence; and
(4) term "pattern of drilling," did not limit the patent to cover only those instances where the drill teeth created either "concentric circular arcs" or "rings" on the hole bottom.

Claims construed.

6,095,262, 6,213,225, 6,412,577. Construed.

Eric William Buether and Arthur Issac Navarro of Godwin Gruber, Dallas, TX, Michael Edwin Jones of Potter, Minton, Tyler, TX, for Plaintiff.

Alan David Rosenthal of Rosenthal & Osha, William C. Slusser of Slusser, Wilson & Partridge, Houston, TX, for Defendant.

MEMORANDUM OPINION

LEONARD DAVIS**, District Judge.**

This Claim Construction Opinion interprets disputed terms in United States Patents: 6,213,225 (the "225 Patent"); 6,095,262 (the "262 Patent"); and 6,412,577 (the "577 Patent").

BACKGROUND

This action is a patent infringement claim brought by Haliburton Services ("Haliburton") against Smith International Inc. ("Smith"). Haliburton designed a new type of roller cone drill bit for use in oil and natural gas production. Haliburton applied for and received United States Letters Patents for its new bits and methods for designing the bits, including the 225, 262 and 577 Patents. Upon information and belief, Haliburton sued Smith for making, using, and selling "Twist and Shout" drill bits that allegedly infringe the 225, 262, and 577 Patents. Haliburton also alleges that Smith infringes Haliburton's patents by using the "Integrated Dynamic Engineering Analysis System" ("IDEAS") process to design the infringing drill bits.

The drill bits in question are used for "down-hole" drilling. The three pieces of equipment used in down-hole drilling (and relevant to this case) are the drilling rig, the drill string and the drill bit. The drilling rig sits on the surface above the oil or gas well. One can visualize the drill string as a hanging metal rope that extends down from the drill rig and into the well. FN1 The drill bit is attached to the end of the drill string in the bottom of the well. When drilling, the drill rig twists the drill string, which in turn twists the drill bit at the well's bottom. It is the torque applied on the bit by the drill string's twisting action, combined with the weight pushing down on the bit ("weight on bit FN2") which crushes and/or scrapes material out of the well bottom. Drilling fluid pumped into the well then sweeps any material removed from the well bottom up and out of the well.

FN1. Although "hanging rope" allows one to easily visualize the drill string, the drill string is much more complicated than a simple piece of rope. Upon close inspection, a piece of the metal drill string may appear very hard and rigid. However, the drill string becomes very flexible when it is extended long distances into wells (sometimes over a mile deep). This flexibility, combined with the forces generated by the drill string's twisting motion and the drill bit's interaction with the well bottom, cause the drill string to oscillate in the well at frequencies near the rotary speed. When the drill string oscillates, it can reduce the drill bit's effectiveness by changing the way force is applied to the bit.

FN2. The terms "weight on bit" and "downforce" are used interchangeably in this Opinion. The parties agree that the terms have the same meaning and the Court switches between the two terms only to reflect relevant patent language.

The 225 Patent concerns "roller cone" type drill bits. A roller cone drill bit is a bit with a set of cones, usually three, attached to each of the bit's arms. The cones point inwards toward each other and have rows of "teeth" protruding from their faces. As the drill string rotates the bit, the cones roll along the surface and the teeth grind or scrape formation out of the well bottom.FN3 The cones may be unique from one another and are each individually designed to cut different surfaces in different ways. Furthermore, the 225 Patent teaches that the more equally downward force is applied to each of the cones, the more efficiently the bit will drill.FN4

FN3. The Court adopts the word "formation" from the submitted briefs to describe the material through which the well is dug. "Formation" is shorthand for the rock formation, dirt, or anything else that the drill bit would encounter.

FN4. The illustration labeled Fig. 12, infra, taken from the 225 Patent, depicts a roller cone bit with # 16 identifying the two visible roller cones and # 18 identifying one of the teeth. The illustration labeled Fig. 2 depicts an individual cone's cross section. The abbreviations in Fig. 2 are discussed infra.

Despite the advantages to equalizing downforce among the cones, roller cone bits are inherently difficult to balance because of their geometry and kinematics. Also, drill string oscillation may pull the drill bit off balance. Imbalanced drilling and string oscillation can cause drill bits to drill oversize or off center, and can cause them to wear out sooner than expected. To correct these expensive problems, the industry traditionally modified bit designs through trial and error. However, the trial and error technique was subjective and imprecise because of the different circumstances under which the bits were used.

Similarly, the drilling industry relied on trial and error to design the tooth formation on each roller cone. Generally, drills excavate soft formation with a scooping/slicing action and hard formation with a crushing action. Drill bit designers have traditionally lacked the ability to accurately predict or calculate the trajectory that roller cone teeth take through formation. Thus, they relied only on empirical evidence to design tooth orientation that best matched the consistency of formation to be drilled.

The patents at issue in this action purport to solve the problem of imbalanced drill bit design and inefficient tooth orientation. The 225 Patent purports to improve methods of designing roller cone bits and to improve the bits themselves by balancing both the force exerted on each of the cones ("force balancing") and the amount of volume each cone removes ("volume balancing"). Unlike the trial and error method, the 225 Patent is a design process which simulates drill interaction with various rock formations and provides information to drill designers. Additionally, the 262 and 577 Patents FN5 attempt to improve drilling efficiency by designing bits that balance the wear on cone teeth caused by drilling on hard formation against tooth penetration on soft formation. The 262 and 577 Patents claim a design process whereby a bit designer may input the bit geometry and formation type into a simulation which calculates the optimal tooth orientation on the roller cone drill bit based on the calculated tooth trajectory through the formation.

FN5. The 577 Patent is a continuation of the 262 Patent.

APPLICABLE LAW

In claim construction, courts examine the patent's intrinsic evidence to define the patented invention's scope. Bell Atlantic Network Services, Inc. v. Covad Communications Group, Inc., 262 F.3d 1258, 1267 (Fed.Cir.2001). First, courts give "claim terms their ordinary and accustomed meaning as understood by one of ordinary skill in the art." Alloc, Inc. v. International Trade Commission, 342 F.3d 1361, 1368 (Fed.Cir.2003); *Id*. Second, the court must determine whether it must deviate from the claim language's ordinary and accustomed meaning. Bell Atlantic Network Services, Inc., 262 F.3d at 1268. There is a "heavy presumption" that claim terms carry their ordinary and customary meaning which is only rebutted if the patent "expresses an intention to impart novel meaning to [them]." Sunrace Roots Enterprise Co., LTD. v. SRAM Corp., 336 F.3d 1298, 1302 (Fed.Cir.2003); *Id*. "This presumption is overcome: (1) where the patentee has chosen to be his own lexicographer, or (2) where a claim term deprives the claim of clarity such that there is no means by which the scope of the claim may be ascertained from the language used." Bell Atlantic Network Services, Inc., 262 F.3d at 1268. When a court attempts to define a term, it "immerses itself in the specification, the prior art, and other evidence, such as the understanding of skilled artisans at the time of the invention, to discern the context and normal usage of the words in the patent claim." Alloc, Inc., 342 F.3d at 1368.

The Federal Circuit has held that "among the intrinsic evidence, the specification is always highly relevant to the claim construction analysis. Usually, it is dispositive; it is the single best guide to the meaning of a disputed term." Teleflex, Inc. v. Ficosa North America Corp., 299 F.3d 1313, 1325 (Fed.Cir.2002). This is true because a patentee may define his own terms. Also, the specification may resolve ambiguous claim terms "where the ordinary and accustomed meaning of the words used in the claims lack sufficient clarity to permit the scope of the claim to be ascertained from the words alone." *Id*. However, the specification may not redefine particular claim terms away from their ordinary meaning unless the intrinsic evidence "clearly set[s] forth or clearly redefine[s] a claim term so as to put one reasonably skilled in the art on notice that the patentee intended to so redefine the claim term." Bell Atlantic Network Services, Inc., 262 F.3d at 1268 (internal quotations omitted). Thus, "although the specification may aid the court in interpreting the meaning of disputed claim language, particular embodiments and examples appearing in the specification will not generally be read into the claims." Comark Communications, Inc. v. Harris Corp., 156 F.3d 1182, 1187 (Fed.Cir.1998).

THE 225 PATENT

The parties dispute Claims 1, 2, 6, and 8 in the 225 Patent. The dispute over Claims 1 and 2 requires the Court to interpret the term "axial force." FN6 Claim 6 requires the Court to interpret the term "per revolution of the drill bit." Claim 8 includes both "axial force" and "per revolution of the drill bit." In relevant part, the 225 Patent claims:

FN6. The Court notes that any arguments and claim constructions it attributes to Smith or Haliburton in this Opinion are arguments asserted in the written briefing and supplemental Construction of Agreed and Disputed Terms submitted after the *Markman* hearing. Particularly in reference to the 262 and 577 Patents, Smith offered claim constructions at the *Markman* hearing that differed from the written briefing. As an example of the confusion that argument without briefing can create, during the *Markman* hearing, in many instances neither Haliburton, Smith, nor the Court could understand how Smith's new constructions differed from Haliburton's. Indeed, after Haliburton's argument regarding the term "in dependence on an expected trajectory of said tooth through formation material," Smith's counsel stated "I would only conclude by saying I'm not still clear where what they are saying has to be differs from what we have proposed the language [is]." Transcript at p. 131. Shortly thereafter, in response to the Court's question "are you changing your proposed construction from what you submitted with the proposed construction document," Smith's counsel replied "I believe that we have tried to simplify it ... yes." Id. at 134-35. Even though Smith's last minute changes have made claim construction more difficult, the Court gives Smith's later constructions all credence possible under the circumstances.

1. A roller cone drill bit comprising;
a plurality of arms;

rotatable cutting structures mounted on respective ones of said arms; and

a plurality of teeth located on each of said cutting structures, wherein the number and locations of said teeth are not identical between ones of said rotatable cutting structures;

wherein approximately the same axial force is acting on each of said cutting structure.

2. The roller cone drill bit of claim 1, wherein the axial force on each of said cutting structure is between thirty-one (31) percent and thirty-five (35) percent of the total of the axial force on the bit.

6. A method of designing a roller cone drill bit, comprising the steps of:

(a) calculating the volume of formation cut by each tooth on each cutting structure;

(b) calculating the volume of formation cut by each cutting structure per revolution of the drill bit;

(c) comparing the volume of formation cut by each of said cutting structures with the volume of formation cut by all others of said cutting structures of the bit;

(d) adjusting at least one geometric parameter on the design of at least one cutting structure; and

(e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit.

8. A method of designing a roller cone drill bit, the steps of comprising:

(a) calculating the axial force acting on each tooth on each cutting structure;

(b) calculating the axial force acting on each cutting structure per revolution of the drill bit;

(c) comparing the axial force acting on each of said cutting structures with the axial force on the other ones of said cutting structures of the bit;

(d) adjusting at least one geometric parameter on the design of at least one cutting structure;

(e) repeating steps (a) through (d) until approximately the same axial force is acting on each cutting structure.

Axial force
[1] First, the Court finds that a person of ordinary skill in the art would define "axial force" as used in the claim terms to mean the force acting parallel with an axis. The two words axial, meaning "of an axis," and "force" tell the reader that the term concerns some force exerted along or around an axis. Neither party suggests that axial force could be read as "torque" or the twisting force moving around an axis. Instead, despite their different proposed constructions, both parties agree that axial force is the force moving parallel to an axis. The only dispute is to what axis "axial force" refers.

The parties disagree over the meaning of "axial force" because the drill bit contemplated in the 225 Patent contains at least two types of axes. First, there is an axis theoretically perpendicular to the well bottom which travels up the drill string. The entire drill bit rotates around that axis, and any "axial force" generated along that axis presses straight down into the well bottom. Second, there is an axis around which each of the roller cones rotates. Axial forces that press down into the well bottom at an angle determined by the angle at which the roller cone intersects the drill bit act on those axes. *See* Figs. 2 and 12 *supra*.FN7 Third, Smith contends that there is a third type of axis through each tooth on the drill bit which creates axial force that presses down into the well bottom at the angle which the tooth intersects the formation. Essentially, Haliburton argues that axial force in the 225 Patent always means the type of axial force that is parallel to the bit's axis ("downforce"). In contrast, Smith argues that axial force in the 225 Patent never means downforce, and must instead mean the axial force along the roller cones' axes ("cone axial force") and along the teeth axes.

FN7. Fig. 2 illustrates the axial force of a roller cone with the variable Fz_i. The Fz_i arrow illustrates axial force pressing upward into the drill bit rather than down into the earth. This is nothing more than a recognition of the equal and opposite force that Newton's Third Law of Motion requires when the cone's axial force presses down into the formation. This effect has no bearing on the Court's analysis and for ease of reference the Court will continue to refer to axial forces as pressing down into the formation.

The Court finds that the language in Claim 1 could equally refer to downforce or cone axial force. Claim 1 only requires that the axial force acting on each cutting structure (roller cone) be approximately the same. Under Haliburton's construction, Claim 1 would mean that each roller cone took an approximately equal share of the downforce. Under Smith's construction, Claim 1 would mean that the cone axial forces were approximately the same. Based only on the claim language, Claim 1 does not assist proper construction of "axial force."

The Court finds that Claim 2's language suggests that "axial force" means downforce and not the cone axial forces. Claim 2 claims the drill bit described in Claim 1 where the axial force on each roller cone is roughly one third (between 31 and 35 percent) of "the total of the axial force on the bit." The phrase "the axial force" suggests that the drafter contemplated one axial force acting on the bit. Moreover, if the drafter had meant that phrase to mean "the sum of the axial forces acting on each of the cones" as Smith argues, the claim would say "the total of the axial force[s]" not "the total of the axial force." One cannot sum a single thing.

The Court finds that Claim 8, by its own terms can support either Haliburton's or Smith's interpretation. Claim 8 provides a method for designing a bit including a step of "calculating the axial force acting on each tooth on each cutting structure." If one of reasonable skill in the field were to define "axis" as a line around which an object rotates, then the Court would reject Smith's assertion that each tooth has an axis because the teeth do not rotate. In that case, Claim 8 would support Haliburton's construction. However, if a person of reasonable skill in the field defined "axis" as a line dividing an object into symmetrical halves, then Smith's interpretation would be feasible. The parties have provided the Court with no evidence regarding how one reasonably skilled in the field defines "axis." Therefore, the "tooth" language does not assist the Court's interpretation. Likewise, the Claim 8 language "axial force acting on each cutting structure per revolution of the drill bit" is inconclusive for the same reasons regarding Claim 1.

Examining intrinsic evidence other than the claims, the Court finds that the 225 Patent abstract defines "axial force" as downforce. *See* Pandrol USA, LP v. Airboss Ry. Products, Inc., 320 F.3d 1354, 1363 n. 1 (Fed.Cir.2003) (holding that the abstract is intrinsic evidence relevant to claim construction). The 225 Patent abstract states: "roller cone drilling wherein the bit optimization process equalizes the downforce (axial force) for the cones (as nearly as possible, subject to other design constraints). Bit performance is significantly enhanced by equalizing downforce." Even though the drafter did not use signals such as "hereafter" or "also called," the parenthetical "axial force" following the word "downforce" is strong evidence that the drafter intended "axial force" and "downforce" to have the same meaning. Members of all legal professions commonly use a parenthetical following a term to rename or provide an alternate name for the term. Thus, the Court finds that a person of ordinary skill in the field would read "downforce (axial force)" in a legal document like the 225 Patent to define "axial force" as "downforce."

However, the 225 Patent specification seemingly contradicts the abstract's "axial force" definition. Column 8 of the 225 Patent, lines 21-26, states: "there is a distinction between force balancing techniques and energy balancing. A force balanced bit uses multiple objective optimization technology, which considers weight on bit, axial force, and cone moment as separate optimization objectives." By describing "weight on bit" as a separate objective from "axial force," the specification seemingly contradicts the abstract's definition.FN8

FN8. The Court reminds the reader that "weight on bit" and "downforce" have the same meaning. *See* Fn. 2 *supra*.

However, the Court reads Column 8's distinction between "axial force" and "weight on bit" in light of mathematical formulas from the immediately preceding paragraph. The patent specification provides formulas describing three characteristics of each roller cone. First, WOB_i "is the weight on bit taken by cone i." Second, "Fz_i being the i-th cone axial force." And third, "Mz_i being the i-th cone moment in the direction perpendicular to the i-th cone axis." Fig. 2 *supra,* taken from the 225 Patent, illustrates WOB_i, Fz_i, and Mz_i on a roller cone. Because these three definitions immediately precede Column 8's distinction, are part of the same discussion as Column 8's distinction, and because the three variables (WOB_i, Fz_i, and Mz_i) parallel the three "objectives" noted in Column 8 (weight on bit, axial force, and cone moment), the Court reads the two statements together. Thus, Column 8 distinguishes "cone axial force" from "weight on bit" and does not distinguish "axial force" from "weight on bit."

Distinguishing the axial force of a cone from "weight on bit" is consistent with the abstract's assertion that "axial force" generally means "downforce." As noted above, by its terms "axial force" generally means the force parallel to an axis, and this invention has at least two types of axes. Moreover, it is unsurprising that the drafter would need to discuss both types of axes in the specification. Generally defining "axial force" as "downforce" in the abstract does not preclude the drafter from later discussing the axial force of a roller cone. Column 8 merely discusses a second type of axial force, and it does not attempt to redefine the abstract's axial force definition.

Finally, the abstract's "axial force" definition is consistent with the claim terms and teachings of the 225 patent. As discussed above, defining "axial force" as downforce is consistent with Claims 1 and 8, and is suggested by Claim 2. Moreover, the 225 patent identifies the importance of equalizing downforce on the roller cones in at least three different places: "the present application teaches that roller cone bit designs should have equal mechanical downforce on each of the cones," Col 4., lns. 49-51; "equalization of downforce per cone is a very important (and greatly underestimated) factor in roller cone performance," Col. 5, lns. 10-12; and "the improved performance of balanced-downforce cones may also be partly due to reduced oscillation of the drill string," Col 5, lns. 21-23. Thus, construing "axial force" as downforce is encouraged by the patent claims and teachings.

Therefore, the Court finds that "axial force" in the 225 Patent is synonymous with "downforce" and "weight on bit." The Court does not find that Column 8's distinction is clear enough to contradict the construction suggested by the abstract, claim language, and patent teachings. Consequently: (1) Claim 1's language "wherein approximately the same axial force is acting on each of said cutting structure" means "wherein nearly or exactly the same downforce parallel to the axis of the bit is taken by each cone;" (2) Claim 2's language "the total of the axial force on the bit" means "the weight on bit;" (3) Claim 8's language "the axial force acting on each tooth" means "the downforce parallel to the axis of the bit taken by each tooth;" and (4) Claim 8's language "the axial force acting on each cutting structure" means "downforce parallel to the axis of the bit taken by each cone."

Per revolution of the drill bit

[2] The Court next must determine whether the term "per revolution of the drill bit" found in Claims 6 and 8 measures only by complete drill bit revolutions. The relevant language from Claim 6 is "calculating the volume of formation cut by each cutting structure per revolution of the drill bit," and from Claim 8 is "calculating the axial force acting on each cutting structure per revolution of the drill bit." Relying on the American Heritage College Dictionary, Smith claims that the word "per" means "to, for, or by each; for every." Thus, Smith argues that the word "complete" is implicit in Claims 6 and 8, and"per revolution of the drill bit" means "for each complete 360 degree turn."

The Court finds that a person of skill in the engineering field would read the word "per" in Claims 6 and 8 as the English word for the mathematical function "divide." There is no question but that Claims 6 and 8 describe calculations because they begin with the word "calculating." When performing a calculation, a person of ordinary skill would convert English words into mathematical symbols whenever possible, and in math the English word "per" directly translates into "divide." Thus, "per revolution of the drill bit" means "divided by the drill bit revolutions."

Because the denominator in any mathematical formula may be a whole number or a fractional number, the Court finds that a person of skill in the relevant field would not limit the denominator in Claims 6 and 8 to a whole number. Haliburton's analogy to calculating an automobile's speed is appropriate. Miles per hour simply means the number of miles traveled divided by hours. Even though a car may have only driven for half of an hour, one may calculate the speed by dividing the miles traveled by .5 hours. Indeed, for every instant that a car moves, or does not move, one may calculate miles per hour, and no one would argue that the term "miles per hour" means "miles per complete hour." Therefore, the Court adopts Haliburton's construction and finds that "per revolution of the drill bit" in Claims 6 and 8 means: "as a function of the number of revolutions of the drill bit."

THE 262 PATENT

The parties dispute Claims 1 and 9 in the 262 Patent. Claim 1 includes two disputed terms: "in dependence on an expected trajectory of said tooth," and "during optimization." Claim 9 requires construction of "as the engineer adjusts design parameters ." In relevant part, the 262 Patent claims:

1. A method of designing a roller cone bit, comprising the steps of:

adjusting the orientation of at least one tooth on a cone, in dependence on an expected trajectory of said tooth through formation material at the cutting face, in dependence on an estimated ratio of cone rotation to bit rotation;

recalculating said ratio, if the location of any row of teeth on said cone changes during optimization;

recalculating the trajectory of said tooth in accordance with a recalculated value of said cone speed; and

adjusting the orientation of said tooth again, in accordance with a recalculated value of said tooth trajectory.

9. A method of designing a roller cone bit, comprising the steps of:

calculating the respective trajectories, of at least two non-axisymmetric teeth in different rows of a roller cone bit, through formation material at the cutting face; and

graphically displaying, to a design engineer, both said trajectories and also respective orientation vectors of said teeth, as the engineer adjusts design parameters.

In dependence on an expected trajectory of said tooth through formation material

[3] The Court finds that it can give Claim 1's term "in dependence on an expected trajectory of said tooth through formation material" its "ordinary and accustomed meaning as understood by one of ordinary skill in the art" FN9 by virtue of the claim language itself. No one disputes that a person of ordinary skill in bit engineering would interpret "expected trajectory" as an "expected path." Moreover, the claim clearly refers to the path that the drill tooth being adjusted ("said tooth") takes through the well bottom ("through formation material"). Thus, there is a heavy presumption that claim one means "based on the expected path the drill tooth being adjusted takes through the formation." Bell Atlantic Network Services, Inc., 262 F.3d at 1268. Because the claim term is capable of a clear construction and is unambiguous, the Court will only depart from this construction if the patentee has chosen to be its own lexicographer. *See id.*

FN9. *See* Alloc, Inc. v. International Trade Commission, 342 F.3d 1361, 1368 (Fed.Cir.2003); Bell Atlantic Network Services, Inc., 262 F.3d at 1267.

Smith contends that the patentee has defined the simple term "expected trajectory of said tooth" as "a calculated directed straight line segment extending from a calculated point of engagement of the tooth with the formation to a calculated point of disengagement of the tooth with the formation, wherein the points of engagement and disengagement are calculated from the centerline of the tooth." Thus, Smith argues that the intrinsic evidence "clearly set[s] forth or clearly redefine[s][the] claim term so as to put one reasonably skilled in the art on notice that the patentee intended to so redefine the claim term." *Id.* (internal quotations omitted). Smith argues that a paragraph in column 9, at lines 50-67, and figures 3A-3D of the 262 Patent require its construction.

The paragraph in column 9 discusses a calculation that may be performed using the expected tooth trajectory. The first sentence of the paragraph recognizes that "tooth trajectories" are the positions at which the teeth will actually encounter the formation by stating: "the tooth trajectories described above are projected on the hole bottom which is fixed in space." The paragraph then declares that the bit designer must determine the tooth orientation angle from the trajectory in order to properly align the teeth. The specification uses the actual projected points where individual teeth intersect the formation to determine the point at which a tooth will enter and subsequently leave the formation.FN10 From these entry and exit points, the patent "approximates" the tooth trajectory as a straight line.

FN10. The entry point P_1 is calculated by the formula: $P_1 = \{ x_1, y_1, z_1\}_c$. The exit point P_2 is calculated by the formula: $P_2 = \{x_2, y_2, z_2\}_c$.

The column 9 paragraph does not redefine "expected tooth trajectory." The paragraph describes optimizing tooth orientation by using the actual expected tooth trajectories to calculate an "approximate" tooth trajectory. It is only by first calculating the actual tooth trajectory that the specification allows for calculating an approximate tooth trajectory. Nonetheless, Smith would read the "approximate tooth trajectory" to redefine "tooth trajectory." The patentee chose to use "expected tooth trajectory" in Claim 1, not "approximate tooth trajectory." The paragraph in column 9, far from clearly redefining "expected tooth trajectory," distinguishes between the actual and approximate tooth trajectories. Although the "approximate tooth trajectory" may be necessary to optimize tooth orientation, it is not a part of the claim and the Court will not read it into Claim 1.

Likewise, figures 3A-3D (illustrated infra) do not indicate that the patentee clearly redefined or limited the term "expected tooth trajectory" to a straight line. The figures illustrate a curved anticipated tooth trajectory. Indeed, Smith concedes the point by its statement: "the actual trajectory of each tooth is curved, as shown by the staggered squares." Nonetheless, Smith argues that the straight line on Figures 3A-3D illustrate the "calculated trajectory" Smith gleaned from the column 9 paragraph (discussed supra). Even if the straight line does illustrate the approximate trajectory discussed in column 9, nothing in the illustration indicates any intention to redefine or limit Claim 1's "expected trajectory" to this "calculated trajectory." Without a clear expression of intent, the Court will not read such limitation into Claim 1. Id.

During optimization

[4] The Court also finds that the term "during optimization" in Claim 1 means "during any process for optimizing the roller cone bit." The plain language of "during optimization" means "during a process for making better." The Court finds no support for Smith's assertion FN11 that "during optimization" means "during the sequence of steps recited in the claim." Neither the claim, nor any other intrinsic evidence limits "optimization" to the steps recited in Claim 1. Moreover, the 262 Patent's specification provides that the 225 Patent's methods and optimizations "can be used ... in synergistic combination with the methods described in the present application." Col. 5, lns. 64-67. Thus, the specification contemplates other "optimization" steps than those included in the 262 Patent claims.

FN11. Smith's argument on this point in particular is unclear. In its response to Haliburton's claim construction brief, Smith argued that "during optimization" meant "during the sequence of steps recited in the claim." However, Smith changed its argument for presentation at the *Markman* hearing and in the supplemental Construction of Agreed and Disputed Terms document. Smith offers no briefing or explanation in support of its new construction, and, Smith's oral argument is unenlightening. *See* footnote 6 *supra*. In fact, the Court can only guess at how Smith's new construction ("during the process for optimizing the roller cone bit design") differs from Haliburton's proposed construction ("during a process for optimizing the roller cone bit"). Although Smith has arguably abandoned its prior position, the Court will consider Smith's briefed arguments in the interest of fairness.

As the engineer adjusts design parameters

[5] The Court finds that it cannot reduce the term "as the engineer adjusts design parameters" to a more simple or clear construction based on the intrinsic evidence. Haliburton proposes the construction "during any time while the design engineer is adjusting design parameters of the bit, either automatically or manually," and Smith proposes "automatically as the engineer adjusts design parameters." "As" relates to time in that it means "while" or "during," and it implies that two things happen close in time but not necessarily instantaneously. Additionally, "as" implies that one thing causes another. Haliburton's construction "during any time" would allow the two things to occur far apart in time, and Smith's construction "automatically as" seems to require the two things to occur instantaneously. Thus, the proposed constructions either improperly restrict or expand the time in which the graphic display would represent the engineer's adjustments. Also, Haliburton's "manually" would perhaps eliminate the causal relationship implied by "as," and Smith's "automatically" could place undue restrictions on the causal relationship. In sum, the word "as" is incapable of simplification or more precise definition, and the Court can only give the parties the guidelines announced here.

THE 577 PATENT

The parties dispute two terms in Claim 6 of the 577 Patent: "pattern of drilling" and "optimize the orientation." The 577 Patent provides in relevant part:

6. A method of designing a roller cone bit, comprising the steps of:

using respective coordinate systems for tooth, cone, bit and hole to define the location of a crest point of a tooth in three dimensional space;

using the locations of respective teeth on a bit to calculate pattern of drilling;

using said pattern of drilling to optimize the orientation of said teeth on said drill bit.

Pattern of drilling

[6] Although the parties generally agree that the term "pattern of drilling" means the "interactions the drill teeth would have on the formation bottom if the bit were drilling," Smith argues for limitations from the claim specification. Smith would limit the patent to cover only those instances where the drill teeth created either "concentric circular arcs" or "rings" on the hole bottom.FN12 The ordinary meaning of Claim 6's language does not include "concentric circular patterns" or "rings," and the Court will only find such limitations if the specification "clearly set[s] forth or clearly redefine [s] a claim term so as to put one reasonably skilled in the art on notice that the patentee intended to so redefine the claim term." Bell Atlantic Network Services, Inc., 262 F.3d at 1268. The only pieces of evidence Smith identified to support its contention are Figures 7A and 7B, which illustrate how the cones can leave uncut paths of material if the teeth from one cone are not designed in reference to the other cones. Illustrations 7A and 7B do not undertake to redefine "pattern of drilling" but rather illustrate one possible problem that pattern of drilling may create. Moreover, no other intrinsic evidence suggests that the "pattern of drilling" must be a ring or concentric circles. Therefore, the Court will not limit the patent claim.

FN12. This is another argument Smith altered after the *Markman* hearing. In briefing, Smith's proposed construction was "a pattern of concentric circular arcs resulting from cut and uncut ring widths," and in the

Construction of Agreed and Disputed terms it was "the pattern of cut and uncut rings on the hole bottom." Again, the Court gives Smith the benefit of the doubt and considers both arguments.

Optimize the orientation

[7] The Court finds that the phrase "optimize the orientation" means "to orient the teeth to achieve the desired design criteria using the information calculated in the previous step." The parties agree that "said pattern of drilling" incorporates the information calculated from the previous step in Claim 6, and the parties do not disagree on the meaning of "orientation." The only dispute is whether the "optimization" is limited to correcting uncut ring width, or whether it may address other issues. Again, Smith relies on Illustrations 7A and 7B to limit this claim's scope to ring width. As discussed above, 7A and 7B illustrate only one possible problem and do not demonstrate intent to limit the patent's scope. The specification declares "FIGS. 7A and 7B show how optimization of tooth orientation can perturb the width of uncut rings on the hole bottom. The width of uncut rings is *one of the design constraints* . ..." Col. 12, lns. 5-8 (emphasis added). Thus, the Court does not require "optimize the orientation" to only address uncut ring width.

CONCLUSION

For the foregoing reasons, the Court interprets the claim language at issue in this case in the manner set forth above.FN13

FN13. Attached as Appendix A, the Court has compiled a chart including the Court's interpretation of disputed terms. For ease of reference in this litigation, the Court has included constructions agreed on by the parties and not otherwise addressed in this Opinion. The agreed constructions are denoted by "**[AGREED]**".

APPENDIX A

{C1-4}U.S. Patent No. 6,213,225			
Claim	Claim Language (with language to be construed emphasized)	Term	Court's Construction
1	A roller cone drill bit comprising:		
	a plurality of arms;		
	rotatable cutting structures mounted on respective ones of said arms; and		
	a plurality of teeth located on each of said cutting structures, wherein the number and locations of said teeth are not identical between ones of said rotatable cutting structures;	the number and locations of said teeth are not identical between ones	[AGREED] for at least one of the cones, the number and locations of the teeth on that cone is different from the number and locations of the teeth on at least one of the other cones

	wherein approximately the same axial force is acting on each of said cutting structure.	approximately the same	[AGREED] nearly or exactly the same
		axial force is acting on each of said cutting structure* *There are two claim construction issues concerning this language: the first concerns "axial force"; the second concerns "is acting on"	downforce parallel to the axis of the bit is taken by each cone
2	The roller cone drill bit of claim 1,		
	wherein the axial force on each of said cutting structure is between thirty-one (31) percent and thirty-five (35) percent of the total of the axial force on the bit.	axial force on each of said cutting structure	Same as construction in claim 1 above
		the total of the axial force on the bit	the weight on bit
3	A roller cone drill bit comprising:		
	a plurality of arms;		
	rotatable cutting structures mounted on respective ones of said arms; and		
	a plurality of teeth located on each of said cutting structures, wherein the number and locations of said teeth are not identical between ones of said rotatable cutting structures;	not identical between ones	Same as construction in claim 1 above
	wherein a substantially equal volume of formation is drilled by each said cutting structure.	substantially equal	[AGREED] nearly or exactly the same
		volume of formation is drilled by	[AGREED] amount of formation i s removed by
4	The roller cone drill bit of claim 3,		
	wherein the volume of formation drilled by each of said cutting structures is between thirty-one (31) percent and thirty-five (35) percent of the total volume drilled by the drill bit.	volume of formation drilled by	Same as construction in claim 3 above
		axial force is acting on each of said cutting structure	Same as construction in claim 1 above

6	A method of designing a roller cone drill bit, comprising the steps of:		
	(a) calculating the volume of formation cut by each tooth on each cutting structure;	volume of formation cut by	[AGREED] amount of formation removed by
	(b) calculating the volume of formation cut by each cutting structure per revolution of the drill bit;	... per revolution of the drill bit	as a function of the number of revolutions of the drill bit
	(c) comparing the volume of formation cut by each of said cutting structures with the volume of formation cut by all others of said cutting structures of the bit;		
	(d) adjusting at least one geometric parameter on the design of at least one cutting structure; and	geometric parameter	[AGREED] A physical characteristic of a cone used in the design of the drill bit
	(e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit.	substantially the same	[AGREED] nearly or exactly the same
8	A method of designing a roller cone drill bit, the steps of comprising;		
	(a) calculating the axial force acting on each tooth on each cutting structure;	axial force acting on each tooth	the downforce parallel to the axis of the bit taken by each tooth
	(b) calculating the axial force acting on each cutting structure per revolution of the drill bit;	axial force acting on each cutting structure	downforce parallel to the axis of the bit taken by each cone
	(c) comparing the axial force acting on each of said cutting structures with the axial force on the other ones of said cutting structures of the bit;		
	(d) adjusting at least one geometric parameter on the design of at least one cutting structure;		
	(e) repeating steps (a) through (d) until approximately the same axial force is acting on each cutting structure.		
11	A method of using a roller cone drill bit which has at least two roller cones which are not identical to each other, comprising the step of rotating said roller cone drill bit such that substantially the same volume of formation is cut by each roller cone of said bit.	volume of formation cut by	same construction as in claim 6 above

12	A method of using a roller cone drill bit which has at least two roller cones which are not identical to each other, comprising the step of rotating said roller cone drill bit such that substantially the same axial force is acting on each roller cone of said bit.	substantially the same	same construction as in claim 6 above
		axial force is acting on each roller cone of said bit	same construction as in claim 1 above

{C1-4}U.S. Patent No. 6,095,262

Claim	Claim Language (with language to be construed emphasized)	Term	Court's Construction
1	A method of designing a roller cone bit, comprising the steps of:		
	adjusting the orientation of at least one tooth on a cone, in dependence on an expected trajectory of said tooth through formation material at the cutting face, in dependence on an estimated ratio of cone rotation to bit rotation;	in dependence on an expected trajectory of said tooth	based on the expected path the drill tooth being adjusted takes through the formation
	recalculating said ratio, if the location of any row of teeth on said cone changes during optimization;	row of teeth	[AGREED] a plurality of teeth circumscribing the cone for which the centerlines of the teeth are located at essentially the same point along the axis of the cone
		the location of any row of teeth on said cone changes	[AGREED] the "location of the row of teeth is the point along the axis of the cone associated with the centerline of the teeth for that row. The location changes if this point along the axis of the cone changes for the row
		during optimization	during any process for optimizing the roller cone bit
	recalculating the trajectory of said tooth in accordance with a recalculated value of said cone speed; and		
	adjusting the orientation of said tooth again, in accordance with a		

	recalculated value of said tooth trajectory.		
9	A method of designing a roller cone bit, comprising the steps of:		
	calculating the respective trajectories, of at least two nonaxisymmetric teeth in different rows of a roller cone bit, through formation material at the cutting face; and	at least two nonaxisymmetric teeth in different rows	[AGREED] at least two non-axisymmetric teeth with at least one of such teeth being in one row and at least another one of such teeth being in a different row
	graphically displaying, to a design engineer, both said trajectories and also respective orientation vectors of said teeth, as the engineer adjusts design parameters.	a design engineer	[AGREED] a person involved in the adjustment of the design parameters of a bit; not necessarily a person with an engineering degree
		as the engineer adjusts design parameters	as the engineer adjust s design parameters

{C1-4}U.S. Patent No. 6,412,577

Claim	Claim Language (with language to be construed emphasized)	Term	Court's Construction
1	A method of designing a roller cone bit, comprising the steps of:		
	inputting initial bit geometry, rock properties, and bit operational parameters;	rock properties	[AGREED] the physical or mechanical properties of rock or formation the bit is designed to drill
	stepping through a sequence of time intervals and, at each of said time intervals,	at each of said time intervals	[AGREED] at each of the time intervals in the sequence of time intervals specified in the claims
	mapping the locations of teeth which are cutting at a given time, and	mapping the locations	[AGREED] determining the positions in three dimensional space relative to the bottom of the hole
	calculating cutting area, volume and forces for each of said teeth which is cutting at said given time, using the results of said mapping step;	calculating cutting area	[AGREED] calculating, at a given time, the area of the hole bottom contacted by each of the teeth which is cutting
		calculating ... volume	[AGREED] calculating, at a given time, the amount of formation removed by each of the teeth which is cutting

		calculating ... forces	[AGREED] calculating, at a given time, the forces acting on each of the teeth which is cutting
	adjusting the orientation of said teeth, in accordance with the results of said calculating step.	in accordance with	[AGREED] in conformity with the results of the calculations
6	A method of designing a roller cone bit, comprising the steps of:		
	using respective coordinate systems for tooth, cone, bit and hole to define the location of a crest point of a tooth in three dimensional space;	using respective coordinate systems for tooth, cone, bit and hole	[AGREED] using separate coordinate systems for tooth, cone, bit, and hole
		crest point of a tooth	[AGREED] the point on the crest that is a t the tooth's center
	using the locations of respective teeth on a bit to calculate [a] pattern of drilling;	a pattern of drilling	interactions the drill teeth would have on the formation bottom if the bit were drilling
	using said pattern of drilling to optimize the orientation of said teeth on said drill bit.	optimize the orientation	to orient the teeth to achieve the desired design criteria using the information calculated in the previous step

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