BL O/080/11

25 February 2011

PATENTS ACT 1977

APPLICANT Halliburton Energy Services Inc

ISSUE Whether patent applications GB 0523735.9, GB 0802299.8, and GB 0802300.4 comply with Section 1(2)

HEARING OFFICER Phil Thorpe

DECISION

Introduction

1 This decision concerns whether the inventions defined in three patent applications relate to excluded matter. All three applications have been filed by the same applicant, Halliburton Energy Services Ltd ("Halliburton") and all relate to methods of designing drill bits.

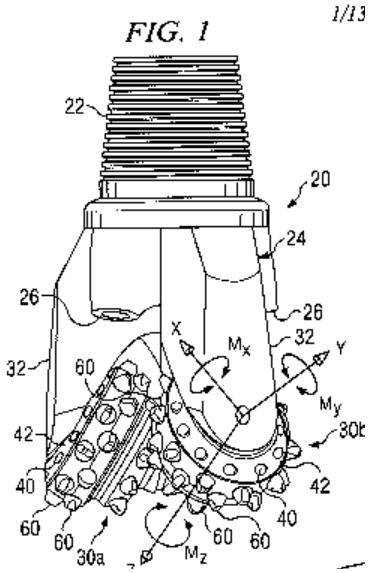
2 A similar objection has been raised that the invention claimed in each of these three applications is excluded from patentability as a mental act under section 1(2)(c) of the Patents Act 1977. The applicant has not been able to overcome these objections, despite amendments to the applications.

3 The matter subsequently came before me at a hearing on 29 November 2010 at which Mr Richard Davis instructed by Hoffman Eitle appeared as counsel for the applicant. The arguments advanced by Mr Davis at the hearing apply to all three applications however to hopefully avoid unnecessary duplication I will address these arguments firstly to just one of the applications, GB 0523735.9 and then consider afterwards how they apply to the other two applications.

GB 0523735.9

4 GB 0523735.9 was filed on 22 November 2005. It was published as GB 2420433 A on 24 May 2006.

5 The invention set out in this application relates to a method of designing roller cone drill bits of the type shown in the figure below. These drill bits are used to form wellbores in subterranean formations.



6 The invention is concerned with improving the design of drill bits so as to increase their drilling efficiency and their operational life. The invention uses a computer simulation of the interaction of the drill bit with the material being drilled to optimise various design features of the drill bits. The use of computer simulation reduces or eliminates extensive field testing.

7 The design method can be explained with reference to the following flow diagram taken from the description.

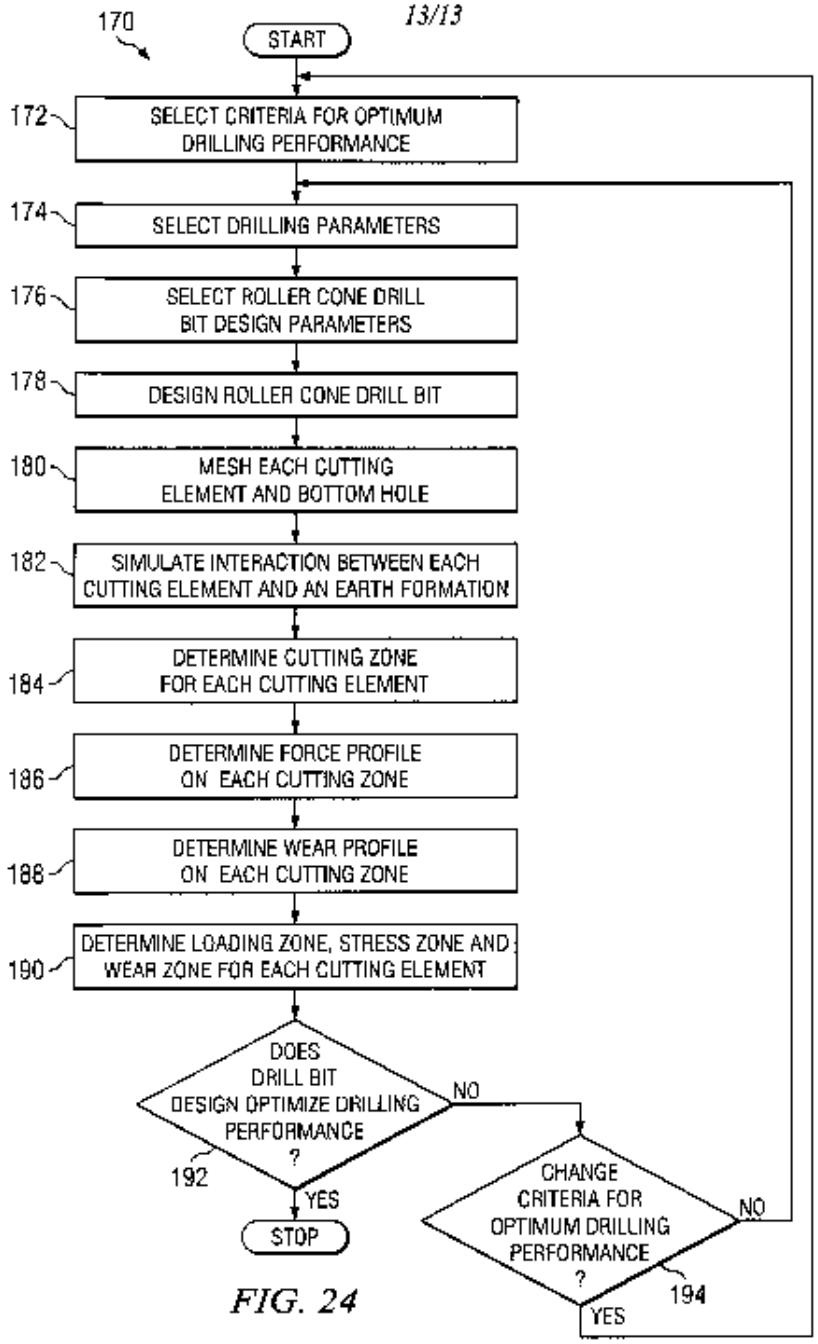
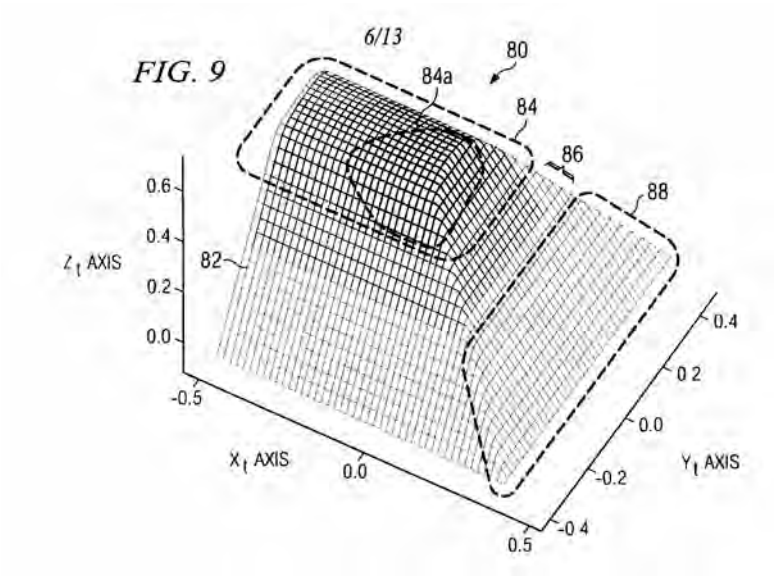


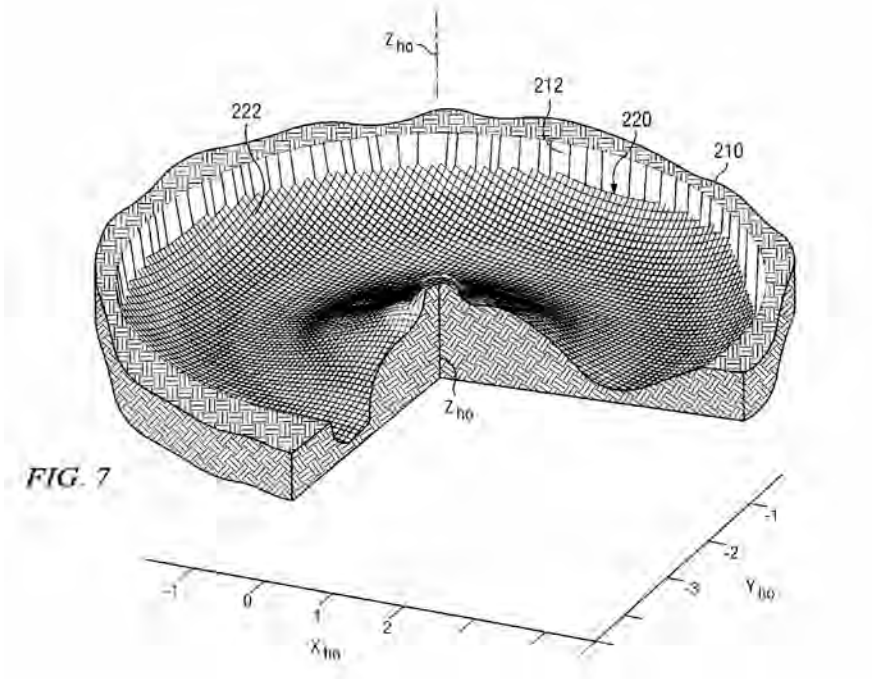
FIG. 24

8 The first step is to select one or more drilling performance criteria that the designer is seeking to optimise. This might for example be the drilling life of the drill bit. Various drilling parameters are then selected (step 174). These may include for example diameter of the wellbore, speed of rotation of the drill bit, type of material being drilled. Various roller cone drill bit design

parameters such as size, number and configuration of the cutting elements are then selected (step 176). An initial design for a roller cone drill bit is then produced (step 178).

9 Three dimensional mesh representations of the cutting elements and a three dimensional mesh representation of the downhole formation are produced (step 180). Examples of mesh representations of a generally chisel shaped cutting element as well as a downhole formation are shown respectively in figures 9 and figures 7 of the application (reproduced below)





10 The mesh analysis enables the interactions of each cutting element with the downhole formation to be simulated (step 182). From this simulation it is possible to identify the mesh segments of the cutting element that will contact the formation during any discrete drilling period. This represents

the cutting zone of the element (area indicated as 84 in figure 9). The core cutting zone is those segments of the mesh that contact the formation most of the time (shown as 84a).

11 The average force acting on each mesh segment within the cutting zone can then be determined. This forms the force profile (step 186). Those segments that are subjected to average forces greater than a selected minimum value form a “core loading zone” for the cutting element. Finite element analysis can then be performed to determine the stress distribution and wear zones for each cutting element (steps 188 and 190).

12 The results of the simulation may be evaluated at step 192 to determine if the initial drill bit design optimises drilling performance based on the criteria selected at step 172. If the answer is no, a change may be made to the optimum drilling performance criteria and then steps 174 through 190 may be repeated until a subsequent drill bit design provides optimum drilling performance. The process is intended according to Mr Davis to be performed wholly within the computer once the initial criteria have been chosen by the designer.

13 Having described the invention I turn now to the claims. The applicant has requested that I should base this decision on the amended claim set filed on 18 November 2010. These include independent claims 1, 2, 7 and 8.

14 Claim 1 as amended reads:

> A method to design a roller cone drill bit with optimum drill design parameters to form a wellbore in an earth formation, comprising:
>
> initially designing the drill bit using a respective cone profile for each roller cone and at least one drill bit design parameter selected from the group consisting of type of cutting element, size, configuration and number of cutting elements, respective offset of each roller cone, number of roller cones, number of rows of cutting elements in each roller cone, number of cutting elements in each row, location of each cutting element and orientation: of each cutting element;
>
> simulating drilling portions of the earth formation with the initial drill bit design including the respective cone profile for each roller cone and at least one drilling parameter selected from the group consisting of weight on bit, rate of penetration, rate of drill bit rotation, depth of borehole, bottom hole temperature, bottom hole pressure, deviation of the wellbore from vertical, distance from an associated well surface, type of formation, hardness of formation and diameter of the wellbore;
>
> modifying the at least one drill bit design parameter for the drill bit;
>
> simulating drilling portions of the earth formation with the modified drill bit design parameter and the at least one drilling parameter;
>
> comparing simulated drilling performance of the drill bit design prior to modifying the at least one drill bit design parameter with simulated drilling performance of the drill bit design after modifying the at least one drill bit design parameter; and
>
> outputting to a resource the results of the method;
>
> wherein simulating drilling portions of the earth formation with the initial drill bit design and with the modified drill bit design parameter each comprise

calculating a three dimensional mesh for each cutting element;

calculating a three dimensional mesh for each portion of the earth formation used in the simulated drilling;

simulating interaction of each cutting element with each portion of the earth formation for a selected drilling time interval;

determining contacts between each mesh segment of each cutting element and mesh segments of the earth formation during the selected drilling time interval;

calculating forces acting upon each mesh segment of each cutting element during the selected drilling time interval; and

determining the cutting zone and respective force profile for each cutting element.

15 The other independent claims of this application together with the independent claims of the other two applications in issue are appended to this decision.

The Law

16 The examiner has raised an objection under section 1(2)(c) of the Patents Act 1977 that the invention is not patentable because it relates to a method for performing a mental act as such; the relevant provisions of this section of the Act are shown in bold below:

1(2) It is hereby declared that the following (amongst other things) are not inventions for the purpose of the Act, that is to say, anything which consists of –

(a) …..
(b) …..
(c) a scheme, rule, or ***method for performing a mental act****, playing a game or doing business, or a program for a computer;*
(d) …..

but the foregoing provisions shall prevent anything from being treated as an invention for the purposes of the Act only to the extent that a patent or application for a patent relates to that thing as such.

17 As explained in the notice published by the UK Intellectual Property Office on 8 December 2008[1], the starting point for determining whether an invention falls within the exclusions of section 1(2) is the judgment of the Court of Appeal in *Aerotel/Macrossan*[2].

18 The interpretation of section 1(2) has been considered by the Court of Appeal in *Symbian Ltd's Application*[3]. *Symbian* arose under the computer program exclusion, but as with its previous decision in *Aerotel,* the Court gave general guidance on section 1(2). Although the Court approached the question of excluded matter primarily on the basis of whether there was

[1] http://www.ipo.gov.uk/pro-types/pro-patent/p-law/p-pn/p-pn-computer.htm
[2] *Aerotel Ltd v Telco Holdings Ltd* and *Macrossan's Application* [2006] EWCA Civ 1371; [2007] RPC 7
[3] *Symbian Ltd v Comptroller-General of Patents*, [2009] RPC 1

a technical contribution, it nevertheless (at paragraph 59) considered its conclusion in the light of the *Aerotel* approach. The Court was quite clear (see paragraphs 8-15) that the structured four-step approach to the question in *Aerotel* was never intended to be a new departure in domestic law; that it remained bound by its previous decisions, particularly *Merrill Lynch*[4] which rested on whether the contribution was technical; and that any differences in the two approaches should affect neither the applicable principles nor the outcome in any particular case.

19 Subject to the clarification provided by *Symbian*, it is therefore still appropriate for me to proceed on the basis of the four-step approach explained at paragraphs 40-48 of *Aerotel* namely:

1) Properly construe the claim

2) Identify the actual contribution (although at the application stage this might have to be the alleged contribution).

3) Ask whether it falls solely within the excluded matter, which (see paragraph 45) is merely an expression of the "as such" qualification of section 1(2).

4) If the third step has not covered it, check whether the actual or alleged contribution is actually technical.

20 Mr Davis accepted that this is the right approach to take.

Properly Construe the Claims

21 At the hearing Mr Davis accepted that the invention is required to be implemented using a computer and that should it be necessary the applicant is content to amend the claims to more clearly bring this out. No other issues of claim construction arise.

Identify the actual contribution

Substance over form

22 Mr Davis was keen to impress on me, for reasons that will become clear later, that when identifying the actual contribution I need to look at the substance of the claims rather than their form. He kindly took me through the relevant authorities referring first to the judgment of the Court of Appeal in *Aerotel.* There Jacob LJ. noted:

> "The second step—identify the contribution—is said to be more problematical. How do you assess the contribution? Mr Birss submits the test is workable—it is an exercise in judgment probably involving the problem said to be solved, how the invention works, what its advantages are. What has the inventor really added to

[4] *Merrill Lynch's Application* [1989] RPC 561

> human knowledge perhaps best sums up the exercise. The formulation involves looking at substance not form—which is surely what the legislator intended."

23 Mr Davis then took me to *Astron Clinica*[5] where Kitchen J. noted:

> "... in the case of a computer related invention which produces a substantive technical contribution, the application of step ii) will identify that contribution and the application of step iii) will lead to the answer that it does not fall wholly within excluded matter. Any computer related invention which passes step iii) but does not involve a substantive technical contribution will fail step iv). The answer to these questions will be the same irrespective of whether the invention is claimed in the form of a programmed computer, a method involving the use of that programmed computer or the program itself. Aerotel/Macrossan requires the analysis to be carried out as a matter of substance not form, just as did Genentech, Merrill Lynch, Gale and Fujitsu. True it is that the first step requires the scope of the monopoly to be determined and, in the case of a program, that will necessarily be limited. However the contribution of that monopoly must still be assessed by reference to the process it will cause a computer to perform."

24 Mr Davis noted that the *ratio decidendi* of *Astron Clinica is* that the assessment *of* contribution for the purposes *of Aerotel* step 2 is not strictly limited to that which is claimed. He referred me to paragraph 25 where Kitchen J. notes:

> "The case of Fujitsu concerned a computer programmed to model synthetic crystal structures. In dismissing the appeal and finding that the invention related to a computer program as such, the Court of Appeal reaffirmed the principle that a technical contribution must be found and that the issue was one of substance not form—it was not sufficient to look at the words of the claimed monopoly."

25 To the extent that Mr Davis is arguing that it is the substance of the claimed invention that matters rather than the precise wording or form of the claim then I wholly agree. Indeed this is a point made clear by Kitchen shortly after the paragraph referred to above when he notes:

> "However, for the purposes of the present appeal it is also important to note a number of further matters. First, they established that claims to computer related inventions must be considered as a matter of substance not form. A computer program as such is excluded from patentability irrespective of whether the claim is directed to the program on a carrier, a computer containing the program or a method performed using the programmed computer."

26 Given the weight of authority it is not surprising that I am entirely with Mr

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[5] *Astron Clinica* [2008] RPC14

Davis on this point. In identifying the contribution, I need to consider the substance rather than the form of the claimed invention.

Identifying the Contribution in this instance

27 Mr Davis argues that the contribution in this instance as a matter of substance is how one can provide a system to simulate the performance of various drill bit design parameters namely by calculating a three dimensional mesh for each cutting element and for the earth formation, the convolution of the two so as to calculate the contacting regions between these mesh segments, calculating forces acting of each mesh segment, determining a force profile of each cutting element.

28 For completeness I should note that Mr Davis also argues insofar as it is relevant that the contribution also includes outputting the results of the design method to a resource.

29 I will leave for a moment the issue of whether outputting the results to a resource adds to the contribution. For the moment I am happy to proceed on the basis of a slightly broader interpretation of what Mr Davis has proposed. The contribution of the claimed invention is in my view, as a matter of substance:

> A method of designing drill bits that includes simulation of the performance of the drill bit based on calculating a three dimensional mesh for each cutting element and for the earth formation and using that to determine the forces acting on each mesh segment of the cutting element and then the forces and stresses acting on each cutting element.

30 Having identified the contribution, as a matter of substance, I need to decide whether it falls solely within excluded matter.

Does the contribution fall solely within excluded matter

Scheme or Method of performing a Mental Act

31 The examiner has maintained an objection that the application relates to a scheme, rule or method for performing a mental act. The examiner has relied principally on the decision of Pumfrey J. in *Halliburton Energy Services, Inc. v Smith International (North Sea) Ltd & Ors* [6] *("Smith").*

32 This decision covers a number of issues in relation to two patents owned by the same proprietor as this case. On the issue of patentability Pumfrey J. found no material distinction between the two patents. Mr Davis also did not distinguish between the two patents hence in seeking to draw out anything from this decision; I can focus on just one of the two patents. I will choose EP1112433, referred to in the decision as the "Force Balancing Patent", simply because that was the first considered by Pumfrey J.

[6] *Halliburton Energy Services, Inc. v Smith International (North Sea) Ltd & Ors* [2005] EWHC 1623 (Pat) (21 July 2005) [2005] EWHC 1623 (Pat), [2006] RPC 2

33 The Force Balancing Patent is entitled “Roller cone drill bit, method of designing the same and rotary drilling system” and relates, as with the application in issue here, to the use of simulation in a method of designing drill bits.

34 At the heart of the invention is the realisation that designing drill bits in such a way as to balance the mechanical downforces on each of the cutting cones improves the performance of the drill bit. The invention also recognises that equalizing the amount of material removed by each cone can produce in most cases force balancing of the cones. The cones are the parts of the drill bit that carry the sets of cutting elements. The drill bit shown above has three cones (only two of which, 30a & 30b, are clearly visible).

35 The invention as claimed therefore covers a method of design involving adopting a particular criterion for the design of the bit (force balancing as equated by volume of material removed). At least one of the geometric design parameters of the drill bit is then adjusted until a calculation of the volume of rock cut by the teeth on each cone (cutting structure) shows that the volumes cut are equal for each cone. The process, as with the process here is iterative in that if the volumes cut are not equal, the parameter is adjusted, further simulations run etc until the volumes are equal.

36 Claim 1 of the force balancing patent reads:

> A method of designing 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 on each of said cutting structures, the method comprising the steps of:
>
> (a) calculating the volume of formation cut by each tooth on each cutting structure (16) of the roller cone drill bit (10);
>
> (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 of the cutting structures; 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 (10) when the drill bit is drilling into a formation.

37 Paragraphs 215-218 of the decision set out Pumfrey’s J. reasoning on the question of whether the Force Balancing Patent relates to excluded matter. These read:

> “215 I am very reluctant to examine a large number of decided cases on this question, since for my purposes I think the law is, as I have indicated, clear, albeit difficult to apply: the contribution the inventor makes must lie in a technical effect, and not merely in excluded subject matter. But it is suggested that this case is on all

fours with T 0453/91 IBM/Method for physical VLSI-chip design. In this case, the Technical Board of Appeal considered the VICOM case (above) and evidently felt unease with its distinction between a method of processing resulting in an image transformed in a defined way (not allowable) with a method of processing physical data corresponding to a physical entity (allowable). The case was concerned with a claim to a method that delivered "a mere 'design' in form of an image of something which does not exist in the real world and which may or may not become a real object". The object in question was a Very Large Scale Integrated circuit, so there was no doubt that the claim was to a stage in manufacturing the chip, but the Board considered the claim rightly rejected. They allowed a claim to a method of making a chip in which the only features were the excluded method and the words "and materially producing the chip so designed".

216 I have great sympathy with this approach. An untethered method claim may well cover activities which have nothing to do with any industrial activity, but, if the claim is tied down to the industrial activity it becomes a valuable invention restricted to its proper sphere. What cannot be plausibly suggested is that the method is not freighted with the technical effect that is needed for patentability: but the scope of the claim should be restricted to its technical field.

217 In the present case, claims 1 and 3 are directed purely to the intellectual content of a design process, and the criteria according to which decisions on the way to a design are made. They are not limited in terms to a computer program, although no doubt are so limited as a matter of reality. They are thus firmly within the forbidden region as schemes for performing a mental act. So I think that these claims are bad because they are too broad, but an amendment of the type described in T 0453/91 should dispose of the problem.

218 It might be supposed that such amendment does not affect the position "as a matter of substance", but I think this is quite wrong. The objection, in my view, is to width of claim alone when the method has potential industrial utility, that is, a potential technical effect. The objection to the claims in this case are to the form of the claim, not to the substance of the invention."

38 So what should I take from this decision and how should I apply that to the facts of this case?

39 Unsurprisingly the bulk of the hearing was taken up with these questions. Mr Davis' arguments have two basic strands: the first is that the invention here can be distinguished from that in *Smith.* More specifically he argues that:

a) The invention claimed in *Smith* was the mere implementation of a design method in part of an automated process. In this case

the claims specify how technically the method is implemented and

b) the claims in this case have an output step which although different to the manufacturing step discussed by Pumfrey J. still causes a comparable real world effect.

40 Mr Davis' second strand focuses on the weight that I should give to *Smith*. In particular he argues that:

a) *Smith* relies on an overly broad consideration of the mental act exclusion which has been subsequently been doubted by the Court of Appeal.

b) The comments of Pumfrey J. regarding tethering are obiter and are quite clearly wrong in view of the *ratio* of *Astron Clinica*, which is a more recent decision of the Patents Court, and also *Aerotel*. More particular, Pumfrey J. has wrongly considered the contribution as a matter of form rather than substance.

c) The EPO decision on which Pumfrey J. principally relied in *Smith* is itself no longer good law having been disapproved by a later Board of Appeal.

Are the facts in this case sufficiently different to those in *Smith* to result in a different outcome?

41 I have already identified the contribution here. I have also described the invention (or at least one of the inventions) in *Smith.*

42 Mr Davis argues that the contribution in *Smith* was simply the mere implementation of a design method which Pumfrey J. subsequently described as "purely the intellectual content of a design process and the criteria according to which decisions on the way to a design are made". And according to Mr Davis this added nothing to the font of human knowledge over and above excluded matter (mental act).

43 He contrasts that with the contribution here which is as he puts it "how technically" the method of design is implemented. I take this to mean that the contribution here lies in providing the detail that was found lacking in *Smith* into how the method steps, in particular the simulation, is performed. Specifically it is the use of the three dimensional mapping as part of the simulation. In contrast in *Smith* the contribution so far as was sufficiently disclosed lay in recognizing the desirability of designing drill bits using simulation such that a particular result was achieved. In the case of EP 1112433 this was force balancing.

44 I am prepared to accept that the contribution in this case does differ from that in *Smith* in that it goes to also how the simulation is to be performed and subsequently how that is used in the design process. However

notwithstanding that, the invention here is still a method of designing a drill bit, based on certain selected criteria, which uses simulation. The inclusion of the additional detail, most notably the three dimensional mapping, may make it a better method of design and clearly a more sufficiently disclosed method than in *Smith*, but it does not to my mind provide the technical contribution found lacking in *Smith*.

45 In other words if I follow the reasoning in *Smith* that a method of designing a drill bit that uses simulation does not involve a technical contribution then I must also find that the method here, albeit which includes possibly a better method, and certainly a better described method of simulation, also does not involve a technical contribution. And as in *Smith* I must find that the invention here falls within the forbidden region as a scheme for performing a mental act.

46 I need to say something about the question of whether including the step of outputting the results to a resource changes anything. Mr Davis argues that having this output causes a real world effect and that in *Smith*, Pumfrey J. was not saying that the tethering to the claim to include the actual manufacture of a drill bit was the only way in which patentability could be conferred. He was merely saying that it was one way. This Mr Davis argues was re-emphasised by Pumfrey J. in *Bloomberg*[7] where he notes:

> "But standing alone, I would respectfully suggest that an algorithm capable of being performed by a human being mentally, and complete (so far as the claim is concerned) when the algorithm terminates, is, as a matter of literal meaning, a scheme ... for performing a mental act. If the physical article resulting from this design process becomes a feature of the claim, it cannot, in my judgment, be objectionable. But it is objectionable, in my view, unless "tethered" to that result. I do not, of course, say that every result must be a physical article before the claim is allowable. But if I revert for a moment to the four stage test, there is no contribution lying outside excluded matter until the claim also covers the physical result of performing the claimed algorithm."

47 I note first that the method of design set out in the Force Balancing Patent must have an output step. I accept that this is not explicitly mentioned in the main claims of that patent or actually in the body of patent itself. But it is difficult to see how any method of design does not involve an output step. That output step may in the Force Balancing Patent be just that the iteration has finished and that substantially the same volume of formation is calculated as being cut by each of the cutting structures of the bit.

48 Interestingly in paragraph 94 of *Smith*, Pumfrey J. notes that:

> "The result of the performance of the claimed method is, if I am right on the question of construction, a CAD file containing a design of bit balanced under design conditions."

[7] Bloomberg LLP's Application [2007] EWHC 476 (Pat) F.S.R. 26

49 In this instance the output step is more explicit. It is the output of the "results" to a resource. Mr Davis confirmed that the term resource is broad and covers for example, a printer, a display or a communications network. I take the results to be presumably details of the optimised designed drill bit. This could be a simple graphical representation of the optimised design features or it could be the sort of file mentioned by Pumfrey J. in respect of the Force Balancing patent. But whatever form the results take, I simply cannot see how outputting those to, for example, a display or printer comes anywhere near the sort of non-excluded contribution suggested by Pumfrey J. If a method of designing a drill bit that includes simulation is excluded then so, as a matter of substance, in my view is such a method that in addition merely displays on a computer screen the design resulting from that method. I should add also that I have reservations, as I discuss later about whether including an actual manufacturing step is sufficient in this respect. However even without those doubts I would have still reached the same conclusion that the addition of the sort of output step set out in the claim does not move the contribution out of the excluded areas.

50 Having considered carefully all the arguments I conclude that the invention claimed here is not sufficiently distinguished from those in *Smith* that would lead to a different outcome. Hence, if *Smith* is good law, then I must find that the invention here is similarly excluded as a method or scheme of performing a mental act.

Is *Smith* binding on me?

51 I turn now to issue of whether I should follow *Smith*.

52 It is perhaps useful at this point just to clarify the role of precedents so far as the comptroller is concerned. This is clearly set out in the IPO's Hearings Manual[8] in paragraphs 1.80 to 1.88. These read so far as I consider relevant to the issues here as follows:

> 1.82 Judgments of the House of Lords and "courts of record" (eg the Court of Appeal and Patents Court) are binding on all inferior courts and tribunals. It is thus not open to the hearing officer to depart from a precedent of a court of record which is on all fours with the case in suit as regards any point at issue. Where, however, the hearing officer is satisfied that the case in issue is distinguished from an earlier case cited as a precedent on the facts or that the precedent did not in fact decide the point in issue, the decision of the court in the earlier case need not be followed
>
> 1.86…; where a decision of a High Court judge has been fully considered but not followed by another judge of the High Court, the second decision should be considered as having settled the point. See *Colchester Estates (Cardiff) v Carlton Industries plc* [1986] 1 Ch 80; and *obiter dicta* should not be confused with binding precedent (the *ratio decidendi*). The essential point is that while a judge's view will always be significant, *obiter* comments cannot be binding for the simple reason that the parties almost certainly had not been given the opportunity of making full and considered representations on the point in question. Thus, a close reading of a report will often be necessary in order to decide whether or not any particular aspect pronounced upon is *obiter*…..

[8] http://www.ipo.gov.uk/pro-types/pro-patent/p-law/p-manual/p-manual-hearing.htm

> 1.88 Decisions of (a) the Boards of Appeal and Enlarged Board of Appeal of the European Patent Office and (b) the courts and tribunals of the member countries of the EU are not binding by themselves unless approved and adopted by a court of record. Nevertheless, such decisions, particularly those of the Boards of Appeal of the European Patent Office, should be regarded as persuasive and should normally be followed. The Court of Appeal in *Actavis UK Limited v Merck & Co Inc* [2008] EWCA Civ 444 found that it was free (but not bound) to depart from the *ratio decidendi* of an earlier Court of Appeal decision if it was satisfied that the EPO Boards of Appeal had formed a settled view of European Patent law which was inconsistent with that earlier decision.

53 With that guidance firmly to the fore of my mind, I can turn now to consider the particular arguments advanced by Mr Davis.

Timing of Smith

54 I should say a little first about a further observation made by Mr Davis. This was that the decision in *Smith* was issued before *Aerotel* and that consequently Pumfrey J. was not addressing his mind along the lines of the approach now required. That may indeed be the case however as was made clear by the Court of Appeal in *Aerotel* and subsequently in *Symbian*, the approach set out in *Aerotel* was not a new departure in domestic law. The structured approach was considered to be consistent with what had previously been decided by the Court, including in cases that predated *Smith* and which Pumfrey J. was bound to follow.

55 This was touched on by Kitchen J. in *Crawford's Application*[9] when he noted:

> "For my part I do not detect any difference in substance between this approach [CFPH] and the conclusion expressed by Pumfrey J. in *Halliburton*. Nor do I believe it to be inconsistent with the decision of the Court of Appeal in *Fujitsu*. At the heart of all of these decisions is the consistent principle that an inventor must make a contribution to the art (that is to say the invention must be new and not obvious) and that contribution must be of a technical nature (susceptible of industrial application and not within one of the areas excluded by Art.52(2))."

56 Also as recognised by Mr Davis, Pumfrey J. revisited to some extent his decision in *Smith* in *Bloomberg* which post dated *Aeortel*. In *Bloomberg* he notes at §8

> "That case [ie. *Smith*] was a case of a claim to a method of design, in which certain calculations were to be carried out recursively, modifying the results each time until a particular criterion was satisfied. Obviously, such a method was particularly susceptible to performance by a computer, but as a matter of principle the claim was not so limited. Nor was the claim limited to the employment of such a method in the production of a physical article. It would have been infringed had the person employing the method stopped at the

[9] Crawford's Application [2005] EWHC 2417 (Pat) [2006] R.P.C. 11

> end of the necessary calculations. Such a case, in my view, can be saved [from the mental act exclusion] by limiting it to a method of manufacture of the resulting article. I do not think it can then be objectionable. But standing alone, I would respectfully suggest that an algorithm capable of being performed by a human being mentally, and complete (so far as the claim is concerned) when the algorithm terminates, is, as a matter of literal meaning, a scheme ... for performing a mental act. If the physical article resulting from this design process becomes a feature of the claim, it cannot, in my judgment, be objectionable. But it is objectionable, in my view, unless "tethered" to that result. I do not, of course, say that every result must be a physical article before the claim is allowable. But if I revert for a moment to the four stage test, there is no contribution lying outside excluded matter until the claim also covers the physical result of performing the claimed algorithm."

57 Leaving aside the issue of “tethering” which I will come on to shortly, Pumfrey J. is saying in *Bloomberg* that the invention in *Smith* would still be excluded under the four stage Aerotel test as a scheme or method for performing a mental act. Consequently I do not think Mr Davis’ point on the timing of *Smith* gets him anywhere.

Scope of the mental act exclusion

58 I turn now to the issue of whether *Smith* provides useful guidance on the scope of the mental act exclusion. Mr Davis argues that is does not and consequently I should not follow it. He argues that he has support for this from most notably the comments of Jacob LJ. in *Aerotel* :

> “We return to the first instance jurisprudence of this country. In *Halliburton v Smith* [2005] EWHC 1623 (Pat) Pumfrey J. held that claims to a method of designing a drill bit were to methods of performing a mental act even though they could be carried out by computer program. They were curable by amendment to a process of manufacturing a bit using the design process. As we have said we have doubts as to whether the mental act exclusion is that wide.”

59 The earlier comments referred to by Jacob LJ. can be found in paragraphs 96-98 of the decision. These read:

> “96 One of the reasons Mann J. gave for refusing Mr Macrossan's application was that it was to a method of performing a mental act.Mr Birss said the Comptroller supported Mr Macrossan on the question of mental act, if we got that far. However the question only arose if we were in favour of Mr Macrossan on the issues of computer program and business method and we ought to rule against him on at least one of these grounds.
>
> 97 The Comptroller's reasons for objecting to the wide meaning of

> "mental act" (which so far as we can see he once espoused) are that it goes too wide and would cover cases not caught by the computer program as such exclusion. For ultimately every computer program could be said to be the sort of thing that could have been done by a notional mental act.
>
> 98 We are not sure this submission is right, or that if it is, it has any consequence other than that the mental act exclusion also covers the computer program exclusion. However, since we reject Mr Macrossan's appeal on the other grounds it is unnecessary to go into this further other than to say that we are by no means convinced that Aldous L.J.'s provisional view is correct. There is no particular reason to suppose that "mental act" was intended to exclude things wider than, for instance, methods of doing mental arithmetic (every now and then someone comes up with a trick for this, for instance Trachtenberg's system) or remembering things (e.g. in its day, Pelmanism)."

60 Notwithstanding that these doubts are expressed by such a senior and distinguished judge in this field, they are obiter and do not amount to a clear overturning of the *ratio* in *Smith*.

Tethering

61 Mr Davis' next point is that that Pumfrey J. was wrong to suggest that adding a manufacturing step to the claim would make an otherwise unallowable claim allowable. This he asserts is wrong because it puts the form of the claim over its substance.

62 I find some force in this argument. As I have discussed at some length above it is clear that the contribution of a claimed invention is to be determined as a matter of substance rather than form.

63 But what does that mean here? Let us assume for example that claim 1 in this application was amended so that it was directed to a method of manufacturing a drill bit including the method of design currently claimed as well as a step of "and materially producing the drill bit so designed". The breadth of the claim will have changed. So would have the scope of protection that is being sought and what would constitute direct infringement. The output of the invention claimed is now a real entity – the optimised drill bit – rather than simply the optimised design for that drill bit. But has the contribution according to step 2 of Aerotel really changed? Has anything further been added to the pool of human knowledge?

64 In Bloomberg Pumfrey J. appears to answer this question in part where he notes :

> "But if I revert for a moment to the four stage test, there is no contribution lying outside excluded matter until the claim also covers the physical result of performing the claimed algorithm."

65 So Pumfrey J. is saying that the contribution is more with this

manufacturing step though he does not actually identify what this additional contribution is. To me it seems that the only thing added is the transformation of a design, which could conceivably be represented as a three dimensional computer generated image, into a three dimensional physical item. I find it hard to follow how that in itself can, as a matter of substance, take something outside of excluded matter. It also begs the question of whether a method of design which involved physically producing and testing prototype designs, but yet does not include the step of manufacturing the final design would also be allowable. This is often how designers produced their final designs before computer simulated testing became possible. If such claimed inventions are allowable, as would seem to be suggested by *Smith*, then it would seem odd to exclude improvements on such methods that replace the need to make and test prototype designs with computer simulations as in the case in issue here.

66 Fortunately I do not need to decide on these points since there are no amendments before me that add any manufacturing steps. The possibility of amending the claims in this application in this way was discussed during the examination process. The examiner indicated that at least as regards excluded matter, a claim amended in this way would be considered allowable. The applicant, mindful of avoiding possible claim conflict with a divisional application decided not to so amend. At the hearing Mr Davis confirmed that they did not wish me to consider a claim including a manufacturing step.

67 What Mr Davis has asked me to consider is whether the suggestion in *Smith* of a possible saving amendment is at odds with *Aerotel* and the later *Astron Clinica* decisions, both of which espoused substance over form. Even if it is at odds, and I am struggling to see how it could not be, I'm not sure it really helps the applicant in this case. This is because the comments of Pumfrey J. on the issue of tethering are obiter.

68 When faced with possibly conflicting *ratio*, that has been doubted but not disapproved, and obiter comments then I must follow the *ratio*. Doing so does not put me at odds with *Aerotel* or *Astron Clinica*. That would only happen (let us assume for a moment that there is conflict) if I were now to go on and allow claims including an amendment of the sort discussed in *Smith*. But as I have said there is no proposal before me for such an amendment. If there were then in all likelihood I would have followed the *ratio* in *Smith* on mental act and the principle of substance over form and not allowed the amendment. But as I have said, that is not something that I need to decide.

Decisions of the EPO Boards of Appeal

69 Mr Davis also argues that *Smith* is no longer good law because the EPO decision upon which Pumfrey J. principally relied is itself no longer good law. As is clear from the extracts from the judgment in *Smith* reproduced above, Pumfrey J. clearly expresses considerable sympathy for the approach of the EPO Board of Appeal in decision T 453/91- Method for

physical VLSI-chip design/IBM. This decision Mr Davis claims is no longer good law in light of the more recent decision of the Board of Appeal in T 1227/05 - Infineon Technologies AG[10].

70 It is perhaps useful to reproduce the discussion of the T 453/91 in T 1227/05 which can be found in paragraph 3.4:

> "3.4 Distinction from earlier T 453/91
>
> 3.4.1 In 453/91 - Method for physical VLSI-chip design/IBM of 31 May 1994 (not published in OJ EPO), the board (in a different composition) held a semiconductor chip design method to be a non-invention because the design delivered a mere image of something which did not and possibly never would exist in the real world; thus the result of the claimed method was not necessarily a physical entity. The only contributions the design steps made were in excluded fields, such as mental acts and their implementation by computer programs (Reasons 5.2). Only methods involving an extra step for actually manufacturing the designed semiconductor chips were to be regarded as technical overall (Reasons 5.3).
>
> 3.4.2 The board in its present composition is persuaded that a circuit design method is not necessarily to be equated with a simulation method for testing a designed circuit under noise influences. Be that as it may, with regard to the general statements in T 453/91, and especially its demand for the inclusion of a manufacturing step, it must be noted that the importance and assessment of industrial simulation methods are changing. For the reasons discussed in point 3.2 above, for an increasing number of fields in the engineering sciences "the application of numerical simulation is becoming a cost-effective alternative to expensive, experimental investigations consuming significant time and personnel resources. In many industrial branches numerical simulation has already evolved to a key technology" (to quote for example from the website of the Computational Engineering faculty of Darmstadt Technical University, http://www.ce.tu-darmstadt.de/res/gk-mso.en.php?language=en). Even today, in some situations, technological progress demands developments whose performance and reliable operation can only be tested by simulation, where the real application environment is not directly available to the tester, as is the case for example with space travel.
>
> To that extent, specific technical applications of computer-implemented simulation methods are themselves to be regarded as modern technical methods which form an essential part of the fabrication process and precede actual production, mostly as an intermediate step. In view of this development it must be assumed that the outlay for implementing a technical product will increasingly shift to the numerical simulation phase, while final implementation of the simulation result in the actual manufacture of the product will entail no or only comparatively little extra innovation effort. In that light, such simulation methods cannot be denied a technical effect merely on the ground that they do not yet incorporate the physical end product (in effect the German Federal Court of Justice ruled in the same way in its decision of 13 December 1999, X ZB 11/98 - *Logikverifikation*; Reasons II.4(h)).
>
> A further fundamental change is to be found in the fact that development and production are increasingly separated, materially and geographically, in a globally distributed industry. In that light, too, the board considers specific patent protection to be appropriate for numerical development tools designed for a technical purpose."

71 I will leave completely the question of whether the increasing use and importance of simulation in industrial processes should in itself lead to a

[10] http://legal.european-patent-office.org/dg3/biblio/t051227ep1.htm

change in the interpretation of the law. The question before me is whether this later decision of the Board of Appeal alters in any way the weight that I should put on *Smith*. As noted in the IPO's Hearings Manual decisions of the EPO are not binding on me though they can be persuasive. The Courts in the UK have also repeatedly emphasised the desirability of the UK being consistent with decisions of the EPO. That said however, and notwithstanding any further doubts that this EPO decision may raise about the decision in *Smith*, I am still bound by that decision.

Indirect infringement

72 The increasing separation of design and manufacture and the implications of this on the scope of protection required by patentees was raised as a separate point by Mr Davis. He observes that:

> "It must be recalled that the reason that the claims are not limited by the addition of a manufacturing step is so as to provide the patentee with a commercially useful scope of protection. Whilst the patentee could add the additional drill bit production step (and indeed the examiner has indicated that such a claim would be permissible) a competitor carrying out the claimed process terminating in, for example, the production of computer numerical control (CNC) drill bit production data would not infringe unless that competitor fell within the double jurisdiction requirements of contributory infringement.
>
> This double jurisdiction requirement of section 60(2), which requires both the contributing act to be performed in the United Kingdom and the method to be put into effect in the United Kingdom, was a key reason why Kitchin J. permitted the computer product claims in *Astron Clinca.* The instant case is a comparable situation - ie. one in which it is agreed that the applicant's invention is patentable and in respect of which all the applicant seeks is a commercially useful scope of protection.
>
> It should also be recalled that the computer product claims of *Astron Clinica* are patentable by reason of what they potentially do. Moreover, it cannot be right to permit the claiming of a program which would control a computer coupled to drill bit manufacturing means but not permit a claim to the processing method of that computer.

73 Again these may well be valid points though clearly I disagree with the assertion that the invention here is patentable. In addition I do not necessarily agree that considerations about section 60(2) were key to the decision in *Astron Clinica*. But even if all of these points were right and if I accept as I do that the EPO decision referred to in *Smith* no longer reflects the position in the EPO, then that still would not enable me to go against the *ratio* in *Smith*.

74 Summarising my findings in respect of the third step of Aerotel, I find the contribution in the invention claimed to fall solely within excluded subject matter.

Check whether the contribution is actually technical in nature

75 The final step under *Aerotel* is to check whether the contribution is actually technical in nature. I have already in effect considered this.

76 I turn now to the other two applications. Both of these are at an earlier stage of the examination process than GB. I indicated prior to the hearing that my consideration of these cases in this decision would extend only to the issue of patentability.

GB 0802299.8

77 GB 0802299.8 is derived from PCT/U2006/030830 which was filed on 7 August 2006. It was published initially as WO2007/019483 and subsequently on entering the national phase as GB 2443125 A.

78 The invention relates to a method of designing rotary drill used to form wellbores in subterranean formations. More specifically the invention is concerned with designing drill bits that have optimised bit walk characteristics. Bit walk is the tendency of the drill bit to move away from the direction of drilling. For example arrow 177 in the figure below represents a walk force tending to move the drill bit 100 away from the drilling plane 170. The invention uses simulation to predict the walk rate of the drill bit and in turn uses that to optimise characteristics of the drill bit to produce a desired walk rate.

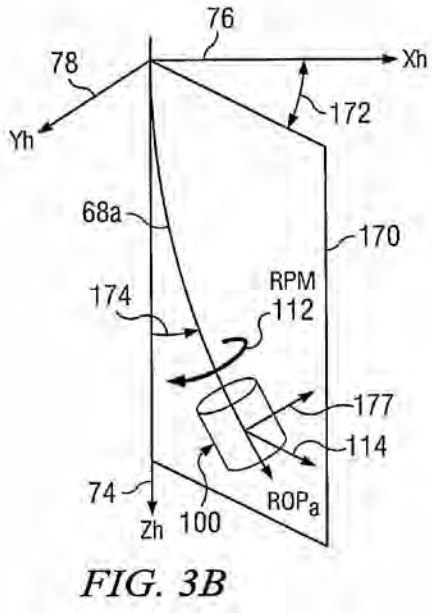

FIG. 3B

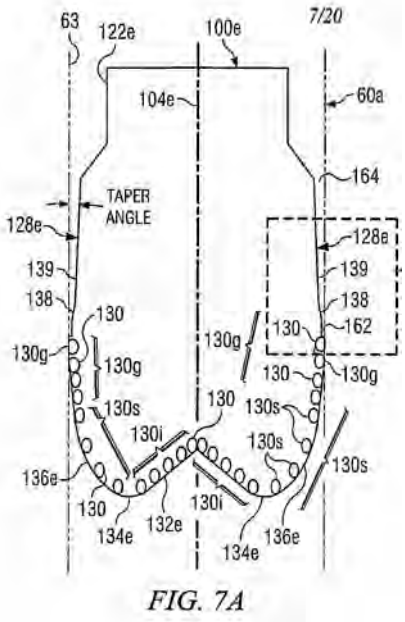

FIG. 7A

79 The design method subdivides the drill bit into inner and shoulder cutting zones (130i and 130s in figure 7A shown above) and also active and

passive gauge zones (138 and 139). If the overall drill bit walk rate does not correspond with the desired walk rate then the walk rate for each of these zones is calculated and that is used to determine what aspects of the drill bit design should be altered. The process is repeated until the desired overall walk rate is achieved.

80 The claims that I have been asked to consider are those filed on 22 October 2010. These consist of three independent claims, claims 1, 7 and 12. These are appended to this decision.

81 I shall again apply the 4 step procedure set out in *Areotel.*

Construction and identifying the contribution

82 Construction causes no problems. According to Mr Davis the contribution in this application is

> "how one optimises a simulator / drill bit design processor so as to permit the manufacture of a bit having a desired walk rate index, namely by the division of the modelling of the bit body into defined zones and by separate calculation of the walk rate of various of those zones. Insofar as it is relevant the contribution includes the output of that bit design to a resource."

83 I am generally prepared to accept that this is what the claimed invention has added to human knowledge. I would however repackage it slightly to:

> A method of designing a drill bit with a desired walk rate index using simulation that divides the modeling of the bit body into defined zones and by separately calculating the walk rate of various of those zones.

84 As I have discussed above at some length I do not think outputting the results to a device adds anything as a matter of substance.

Does the contribution fall solely within excluded matter

85 I can be brief. The contribution here lies, like in GB 0523735.9, in a method of designing a drill bit that uses simulation. The method here differs in that rather than using a three dimensional mesh, it relies on subdividing the drill bit into zones for the purpose of optimizing the design. It also focuses on a specific drilling performance characteristic, the walk rate. But these are not differences that would in my view take the invention outside of excluded matter. Therefore I find that the contribution here also lies wholly in excluded matter. In particular it relates to a scheme or method for performing a mental act.

Check whether the contribution is actually technical in nature

86 I have already in effect considered this.

GB0802300.4

87 I turn now to GB0802300.4. This was a PCT application filed on 7 August 2006 and published as WO2007/019471. It entered the national phase and was republished as GB 2443127 A on 23 April 2008. The invention in this application differs from that in GB 0802299.8 in that it optimises the design on the basis of steerability difficulty index rather than walk rate. The steerability difficulty index is the *ratio* of the steer forces to the tilt rate. The tilt rate is the rate of change in degrees of the wellbore from vertical (angle 174 in figure 3a above). The steer forces are the side forces applied to the drill bit by an associated drill bit steering unit in order to steer the drill bit (shown as force 114 in figure 3a).

88 More specifically the invention provides for the evaluation of the steerability difficulty index for a number of discrete zones of the drill bit. By comparing the steering difficulty index of each zone, a bit designer may more easily identify which zone or zones are more difficult to steer and design modifications may be focused on the difficult zone or zones. The calculation of steerability index for each zone may be repeated and design changes made until the calculation of steerability for each zone is satisfactory and/or the steerability index for the overall drill bit design is satisfactory.

89 The claims that I have been asked to consider were filed on 22 October 2010 and consist of two independent claims, claims 1 and 8. These are appended to this decision.

Construction and identifying the contribution

90 Again applying the four stage test, I have no difficulty with construction.

91 Mr Davis suggests the contribution is:

> " how one optimises a simulator / drill bit design processor so as to permit the manufacture of a bit having a desired bit steerability index, namely by the division of the modelling of the bit body into defined zones and by separate calculation of the bit steerability of various of those zones. Insofar as it is relevant the contribution includes the output of that bit design to a resource."

92 I am again generally prepared to accept that this is what the claimed invention has added to human knowledge. I would however repackage it slightly to:

> A method of designing a drill bit with a desired steerability index using simulation that divides the modeling of the bit body into defined zones and by separately calculating the bit steerability of various of those zones.

93 As before, I do not think outputting the results to a device adds anything as a matter of substance.

Does the contribution fall solely within excluded matter

94 I can again be brief. The contribution here lies, like in GB 0523735.9, in a method of designing a drill bit which uses simulation. The method here differs in that rather than using a three dimensional mesh, it relies on subdividing the drill bit into zones for the purpose of optimizing the design. It also focuses on a specific drilling performance characteristic, the steerability index. But these are not differences that would in my view take the invention outside of excluded matter. Therefore I find that the contribution here also lies wholly in excluded matter. In particular it relates to a scheme or method for performing a mental act.

Check whether the contribution is actually technical in nature

95 I have already in effect considered this

Are the inventions claimed also excluded as computer programs?

96 The examiner has in his examination report suggested that the inventions in GB 0802299.8 and GB0802300.4 are also excluded as programs for a computer and as mathematical methods. Neither of these objections was discussed at any length at the hearing so it would be unfair to the applicant for me to go into them in any detail here. Also having found the invention to be excluded as a scheme or method for performing a mental act it is not strictly necessary to consider other possible categories of excluded matter. I will nevertheless make some observations.

97 The first is that I do not believe that the inventions as claimed are excluded as mathematical methods.

98 Secondly it is not disputed that the inventions in issue here, like those in *Smith*, are intended to be implemented on a computer. In *Smith*, Pumfrey J. recognised that the inventions there were as a matter of reality limited to computer programs but did not exclude them on that basis relying instead on the mental act exclusion. That does not necessarily mean that he did not think that they were computer programs.

99 Interestingly in *Fujistsu,* Aldous LJ. observes somewhat generally that:

> "The fact that a patent application consists of a program for a computer does not mean that it does not also consist of a method of performing a mental act. The contrary is not true."

which might be construed as suggesting that if, as I have found here, the invention consists of a method for performing a mental act then it cannot also be a computer program. I do not think that was the intent behind these words and as Aldous LJ. and others elsewhere make clear it is necessary to consider each case on its facts.

100 What ultimately determines the issue is whether as, I have discussed at some length, the claimed inventions, as a matter of substance make a contribution that falls squarely within the computer program exclusion.

101 Mr Davis says the inventions here clearly do not. In particular they go beyond programs for a computer since they concern not the mere computerisation of an otherwise known design method but how technically such methods are to be implemented on a computer. This is essentially the same argument as he deployed unsuccessfully in relation to the mental act exclusion. This is not surprising since the two issues are to a greater extent linked. And since I found nothing technical that would take the claimed method outside of the mental act exclusion, it follows that if the tool for enabling the method to be performed is a computer program, as it is here, then the method must also fall within the computer program exclusion.

Other issues

I indicated that I would limit my consideration of GB 0802299.8 and GB0802300.4 to the question of patentability. Mr Davis did however raise a further issue in his skeleton which I can deal with quite quickly. Mr Davis notes that the examiner has raised an objection in respect of the use of the term `desired' in the preamble to the independent claims of tese two applications. Mr Davis argues that the term "desired" in this context is no different from, for example "predetermined". It merely relates to the given target output characteristic sought, the method steps being repeated until the desired characteristic is reached. Whilst in some cases terms like “desired” and “predetermined” can cause uncertainty (see for example the comments of Jacob LJ. in *Nikken Kosakusho Works v Pioneer Trading Company* [11]*),* I do not believe it is the case here.

Conclusions and findings

102 I find the invention in GB 0523735.9 to be excluded from patentability as a scheme or method for performing a mental act. Having read the specification I do not think that any saving amendment is possible. I therefore refuse the application under section 18(3).

103 I find the invention in GB 0802299.8 to be excluded from patentability as a scheme or method for performing a mental act and as a computer program. Having read the specification I do not think that any saving amendment is possible. I therefore refuse the application under section 18(3).

104 I find the invention in GB 0802300.4 to be excluded from patentability as a scheme or method for performing a mental act and as a computer program. Having read the specification I do not think that any saving amendment is possible. I therefore refuse the application under section 18(3).

Appeal

[11] *Nikken Kosakusho Works v Pioneer Trading Company) [2005] EWCA Civ 906*

105 Under the Practice Direction to Part 52 of the Civil Procedure Rules, any Appeal must be lodged within 28 days.

P Thorpe
Deputy Director acting for the Comptroller

ANNEX 1: INDEPENDENT CLAIMS CONSIDERED BY THIS DECISION

GB 0523735.9

1. (This is set out in the body of the decision.)

2. A method to design a roller cone drill bit with optimum drill bit design parameters to form a wellbore in an earth formation, comprising:

initially designing the drill bit using a respective cone profile for each roller cone and at least one drill bit design parameter selected from the group consisting of type of cutting element, size, configuration and number of cutting elements, respective offset of each roller cone, number of roller cones, number of rows of cutting elements or. each roller cone, number of cutting elements in each row, location of each cutting element and orientation of each cutting element;

simulating drilling portions of the earth formation with the initial drill bit design including the respective cone profile for each roller cone and at least one drilling parameter selected from the group consisting of weight on bit, rate of penetration, rate of drill bit rotation, depth of borehole, bottom hole temperature, bottom hole pressure, deviation of the wellbore from vertical, distance from an associated well surface, type of formation, hardness of formation and diameter of the wellbore;

determining at least one characteristic for each cutting element selected from the group consisting of cutting zone, loading zone, stress zone and wear zone based on the drilling simulation with the Initial drill bit design parameter and the at least one drilling parameter;

modifying the at least, one drill bit design parameter for the drill bit;

simulating drilling portions of the earth formation with the modified drill bit design parameter and the at least one drilling parameter;

comparing simulated drilling performance of the drill bit design prior to modifying the at least one drill hit design parameter with simulated drilling performance of the drill bit design after modifying the at least one drill bit design parameter; and

outputting to a resource the results of the method;

wherein simulating drilling portions of the earth formation with the initial drill bit design and with the modified drill bit design parameter each comprise

calculating a three dimensional mesh with a large number of small segments for each cutting element;

determining the mesh segments of each cutting element which cut into adjacent portions of the earth formation during a simulated drilling time interval;

determining the cutting zone for each cutting element based on the number of mesh segments having contact with respective portions of the earth formation during the simulated drilling time interval;

determining the location of each mesh segment which interacts with portions of the earth formation for additional simulated drilling time intervals; and

determining a core cutting area for each cutting element by determining the mesh segments of each cutting element which engage portions of the earth formation during each drilling time interval without regard to changes in downhole drilling parameters.

7. A method for designing a roller cone drill bit to form a wellbore in an earth formation, comprising:

determining a cone profile for each roller cone projected onto a vertical plane passing through an associated cone rotational axis;

initially designing the roller cone drill bit with the cone profile for each roller cone and at least one roller cone drill bit design parameter selected from the group consisting of type of cutting element, size, configuration and number of cutting elements, respective offset of each roller cone, respective roller cone profile, number of roller cones, number of rows of cutting elements on each roller cone and number of cutting elements in each row, the roller cone drill bit being also initially designed

using the location of each cutting element and orientation of each cutting element on each roller cone;

simulating drilling a portion of the earth formation with the initial at least one roller cone drill bit design parameter and at least one drilling parameter selected from the group consisting of weight on bit, rate of penetration, rate of drill bit rotation, depth of borehole, bottom hole temperature, bottom hole pressure, deviation of the wellbore from vertical, distance from an associated well surface, type of formation, hardness of formation and diameter of the wellbore; and

outputting to a resource the results of the method;

wherein simulating drilling a portion of the earth formation with the initial at least one roller cone drill bit design parameter comprises the steps:

calculating a three dimensional mesh for each cutting element;

calculating a three dimensional mesh for portions of the earth formation used in the simulated drilling;

simulating interaction of each cutting element with portions of the earth formation for a selected drilling time interval;

determining contacts between each mesh segment of each cutting element and mesh segments of the earth formation during the selected drilling time interval;

calculating forces acting upon each mesh segment of each cutting element during the selected drilling time interval; and

determining the cutting zone and respective force profile for each cutting element.

8. A method for designing a roller cone drill bit to form a wellbore in an earth formation, comprising:

determining a cone profile for each roller cone projected onto a vertical plane passing through an associated cone rotational axis;

initially designing the roller cone drill bit with the cone profile for each roller cone and at least one roller cone drill bit design parameter selected from the group consisting of type of cutting element, size, configuration and number of cutting elements, respective offset of each roller cone, respective roller cone profile, number roller cones, number of rows of cutting elements on each roller cone and number of cutting elements in each row, the roller cone drill bit being also initially designed using the location of each cutting element and orientation of each cutting element on each roller cone;

simulating drilling a portion of the earth formation with the initial at least one roller cone drill bit design parameter and at least one drilling parameter selected from the group consisting of weight on bit, rate of penetration, rate of drill bit rotation, depth of borehole, bottom hole temperature, bottom hole pressure, deviation of the wellbore from vertical, distance from an associated well surface, type of formation, hardness of formation and diameter of the weilbore; and

outputting to a resource the results of the method;
wherein simulating drilling a portion of the earth formation with the initial at least one roller cone drill bit design parameter comprises the steps:

calculating a three dimensional mesh with a large number of small segments for each cutting element;

determining the mesh segments of each cutting element which cut into portions of the earth formation during a selected simulated drilling time interval;

determining the cutting zone for each cutting element based on the number of mesh segments having contact with portions of the earth formation during the selected simulated drilling time interval;

determining the location of each mesh segment which interacts with portions of the earth formation for additional simulated drilling time intervals; and

determining a core cutting area for each cutting element by determining the mesh segments of each cutting element which engage portions of the earth formation during each simulated drilling time interval without regard to changes in downhole drilling parameters.

GB 0802299.8

1. A method to design a rotary drill bit with a desired bit walk rate comprising:

(a) determining the drilling conditions and the formation characteristics to be drilled by the bit;

(b) simulating drilling at least one portion of a wellbore using the drilling conditions;

(c) calculating the average bit walk rate;

(d) comparing the calculated bit walk rate to the desired walk rate;

(e) if the calculated bit walk rate does not approximately equal the desired walk rate, performing the following steps:

(f) dividing the bit body into at least inner zone, shoulder zone, gage zone, active gauge zone and passive gauge zone ;

(g) calculating the walk rate of each zone;

(h) calculating the walk rate of combined inner zone and shoulder zone to get walk rate of face cutters;

(i) calculating the walk rate of active gauge and passive gauge to get walk rate of the gauge;

(j) modifying the structure within one zone, or one combined zone which has the maximal magnitude of walk rate or has the minimal magnitude of the walk rate;

(k) repeating steps (b) through (j) until the calculated walk rate approximately equals the desired walk rate; and

(l) outputting to a resource the results of the method.

7. A method for designing a rotary drill bit having a gauge comprising:

(a) determining formation properties such as transition layer strength and inclination angle for use in simulating drilling with the rotary drill bit;

(b) determining drilling conditions for use in simulating drilling with the rotary drill bit;

(c) determining if the rotary drill bit will be used with a point-the-bit or push-the-bit drilling system;

(d) simulating applying a steering motion, a relative shorter bent length, axial penetration and rotation forces to the rotary drill bit when used with a point-the-bit drilling system;

(e) simulating applying steering motion, a relative longer bent length, axial penetration and rotation forces to the rotary drill bit when izsed with a push-the-bit drilling system;

(f) calculating a walk rate based on the simulated drilling;

(g) comparing the calculated walk rate with a desired walk rate;

(h) if the calculated walk rate is not approximately equal to the desired walk rate, changing a bit geometry such as bit profile, cutter locations and orientations, cutter density or changing a geometric parameter of the gauge such as gauge length, gauge radius, gauge taper angle and gauge blade spiral angle;

(i) repeating steps (c) to (h) until the calculated walk rate approximately equals the desired walk rate; and

(j) outputting to a resource the results of the method.

12. A method to design a rotary drill bit with a desired bit walk rate comprising:

(a) determining the drilling conditions and the formation characteristics to be drilled by the bit;

(b) simulating drilling at least one portion of a wellbore using the drilling conditions;

(c) calculating the average bit walk rate;

(d) comparing the calculated bit walk rate to the desired walk rate;

(e) if the calculated walk rate does not approximately equal the desired walk rate, modifying at least one bit geometry of the rotary drill bit selected from the group consisting of bit profile, cutter location, cutter orientation, cutter density, gauge length, gage diameter;

(f) repeating steps (a) through (e) until the calculated walk rate approximately equals the desired walk rate; and

(g) outputting to a resource the results of the method.

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1. A method to design a rotary drill bit with a desired bit steering difficulty index comprising:

(a) determining the drilling conditions and the formation characteristics to be drilled by the bit;

(b) simulating drilling at least one portion of a wellbore using the drilling conditions;

(c) calculating a bit steering difficulty index;

(d) comparing the calculated bit steering difficulty index to desired bit steer difficulty index;

(e) if the calculated bit steering difficulty index does not approximately equal the desired bit steering difficulty index, performing the following steps:

(f) dividing the bit body into zones selected from the group consisting of inner zone, shoulder zone, gage cutter zone, active gage zone and passive gage zone;

(g) calculating the bit steering difficulty index of each zone;

(h) adding the bit steering difficulty index of inner zone and shoulder zone to get a face cutter steering difficulty index;

(i) adding the steering difficulty index of the active gage zone and the passive gage zone to get a gage steer difficulty index;

(j) comparing the steering difficulty index of each zone ;

(k) modifying the structure within a selected zone beginning with the zone which has the largest steering difficulty index;

(l) repeating steps (b) through (k) until the calculated bit steering difficulty index approximately equals the desired Sit steering difficulty index; and

(m) outputting to a resource the results of the method.

8. A method to design a rotary drill bit, comprising:

(a) choosing an existing rotary drill bit design (design A) which was previously used in a steerable drilling system;

(b) simulating applying tilting motion, axial penetration and rotation forces to design A for selected formation properties of transition layer strength and inclination angle;

(c) calculating steerability for design A;

(d) designing a new rotary drill bit (design B) to be more steerable than design A under the same set of drilling conditions;

(e) simulating applying the same tilting motion, axial penetration and rotation forces to design B for the selected formation properties of transition layer strength and inclination angle;

(f) calculating steerability for design B;

(g) if design B has a value of steerability lower than the value of steerability for design A, modifying design B by adjusting at least one feature associated inner and outer cutting structures of design B;

(h) repeating steps (e) through (g) until the calculated steerability of design B is greater than the calculated steerability of design A; and

(i) outputting to a resource the results of the method.