Intellectual Property Office

BL O/130/22

15 February 2022

PATENTS ACT 1977

APPLICANT	River Lane Research Ltd.
ISSUE	Whether patent application GB2011051.6 complies with section 1(2)
HEARING OFFICER	B Micklewright

DECISION

Introduction

1 Patent application GB2011051.6, titled 'Estimating an energy level of a physical system', is the national phase application based on PCT application number PCT/GB2019/051345, filed in the name of River Lane Research Limited on 16 May 2019 with a declared priority date of 16 May 2018. The international application was published as WO 2019/220122 A1 and was assigned the UK publication number GB 2582534 A.

2 In an initial examination report, issued on 13 August 2020, the examiner raised objections that the application was excluded from patentability as a computer program as such and a mathematical method as such. Further objections relating to added matter and clarity were also raised, with further examination, including the updating of the search, being deferred until such time as the initial objections were overcome.

3 A number of rounds of amendment and further examination followed and, while the issue of added matter was resolved, the examiner has maintained that the invention is excluded from patentability. A hearing was suggested by the examiner in their letter of 16 March 2021, and subsequently requested by the applicant in their response of 16 July 2021. The matter came before me at a video hearing on 30 November 2021 with the applicant being represented by Dr James Auger, Mr Peter Finnie and Dr Michael Linehan of Potter Clarkson LLP, with Dr James Cruise of River Lane Research Limited also attending.

4 I am grateful for the skeleton arguments which were provided before the hearing. I can confirm that I have taken account of these in reaching my decision. I have also reviewed the correspondence on file.

The Invention

5 The invention relates to a method of determining at least one unknown energy level of a physical system utilising a quantum computer. The application states that being able to determine the possible eigenstates and energies of physical systems such as molecules or atoms has applications in numerous areas from determining the rates of reactions in chemistry through to determining charge and energy transfer processes in photovoltaic materials and the design of new pharmaceuticals and catalysts.

6 The method set out in the application as filed involves performing an iterative optimisation procedure on a quantum computer in which a first ansatz trial state, which has a first state energy which is dependent on a trial state variable, is prepared using a first arrangement of quantum gates. An energy estimation routine is performed to determine a value associated with an estimate for the first ansatz trial state energy, after which an overlap estimation routine is used to determine the degree of overlap between a first prepared state corresponding with or based on the first ansatz trial state and a second prepared state corresponding with or based on a known state. The value of an optimisation function based on the output of the energy estimation routine and the overlap estimation routine is determined, which is then used to update the trial state variable. The process is then performed iteratively until a stopping criterion is reached, at which point a value for the at least one unknown energy level can be determined.

7 The exact features of the claimed invention have subsequently been narrowed through amendment, as per the claim below. Notably, the physical system is now limited to a physical system which comprises one or more atoms and the overlap estimation routine now comprises either a Variational Quantum Deflection algorithm or a destructive SWAP test.

The Claims

8 The application contains a single primary independent claim which states:

> 1. A computer-implemented method for determining at least one unknown energy level of a physical system, wherein the physical system comprises one or more atoms that can be in any one of a plurality of eigenstates, each respective eigenstate of the physical system having a corresponding energy level, the method comprising an iterative optimisation procedure, wherein each iteration of the optimisation procedure comprises:
>
> on a quantum computer:
>
> preparing a first ansatz state using a first arrangement of quantum gates, the first ansatz trial state having a first state energy which is dependent on a trial state variable,
>
> performing an energy estimation routine to determine and output a plurality of expectation value estimates associated with the first ansatz trial state, *each expectation value estimate associated with a term in a Hamiltonian of the physical system*;
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> performing an overlap estimation routine to determine and output a degree of overlap between a first prepared state corresponding with or based on the first ansatz trial state, and a second prepared state corresponding with or based on a known state *of the physical system*, the overlap estimation routine comprising:
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> either (i) a Variational Quantum Deflation algorithm;
>
> or (ii) a destructive swap test, and

using a classical computer or the quantum computer:

determining an estimate for the first ansatz trial state energy by summing the plurality of expectation value estimates associated with the first ansatz trial state;

determining the value of an optimisation function based on the estimate for the first ansatz trial energy state and the output of the overlap estimation routine; and

updating the trial state variable based on the value of the optimisation function;

the method further comprising performing the iterative optimisation procedure until a stopping criterion is reached, and outputting a value for the at least one unknown energy level, wherein the value for the at least one unknown energy level is based on the estimate for the first ansatz trial state energy determined by a last iteration of the iterative optimisation procedure.

9 The portions of the claim underlined and in italics are additional text added by amendment prior to the hearing, such that they were not considered by the examiner. I am happy to proceed on the basis of these amended claims.

10 The application does contain a further notional independent claim at claim 17, which reads:

> 17. A computer readable medium comprising computer-executable instructions which, when executed on a processor, cause the processor to perform the method of any preceding claim.

11 While I do not believe that this claim has any bearing or impact on the patentability of the claimed invention, I would note that the references in the claim to 'a processor' is potentially unclear given that the method of claim 1 potentially utilises both a quantum computer and a classical computer.

The Law

12 Section 1(2) of the Act states:

> *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-*
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> *(a) A discovery, scientific theory or mathematical method;*
> *(b) A literary, a dramatic, musical or artistic work or any other aesthetic creation whatsoever;*
> *(c) A scheme, rule, or method for performing a mental act, playing a game or doing business, or a program for a computer;*
> *(d) The presentation of information;*
>
> *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 things as such.*

13 The provisions of Section 1(2) were considered by the Court of Appeal in *Aerotel Ltd v Telco Holdings Ltd and Macrossan's Application*[1] where a four-step test was set out to decide whether a claimed invention was excluded from patent protection:

(1) Properly construe the claim;
(2) Identify the actual contribution;
(3) Ask whether it falls solely within the excluded subject matter;
(4) Check whether the actual or alleged contribution is actually technical in nature.

14 It was stated by Jacob LJ in *Aerotel* that the test is a re-formulation of and is consistent with the previous 'technical effect approach with rider' test established in previous UK case law. Kitchen LJ noted in *HTC v Apple*[2] that the *Aerotel* test is followed in order to address whether the invention makes a technical contribution to the art, with the rider that novel or inventive purely excluded matter does not count as a 'technical contribution'.

15 Lewison J in *AT&T/CVON*[3] set out five signposts that he considered to be helpful when considering whether a computer program makes a technical contribution. Lewison LJ reformulated the signposts in *HTC v Apple* in light of the decision in *Gemstar*[4]. The signposts are:

i) Whether the claimed technical effect has a technical effect on a process which is carried on outside the computer.

ii) Whether the claimed technical effect operates at the level of the architecture of the computer; that is to say whether the effect is produced irrespective of the data being processed or the applications being run.

iii) Whether the claimed technical effect results in the computer being made to operate in a new way.

iv) Whether the program makes the computer a better computer in the sense of running more efficiently and effectively as a computer.

v) Whether the perceived problem is overcome by the claimed invention as opposed to merely being circumvented.

Analysis

16 To determine whether the claimed invention can be considered more than a computer program and/or a mathematical method as such, I am required to follow the approach set out by the Courts in *Aerotel*.

(1) Properly construe the claim

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[1] *Aerotel Ltd. v Telco Holdings and Macrossan's Application* [2006] EWCA Civ 1371
[2] *HTC Europe Co Ltd v Apple Inc* [2013] EWCA Civ 451
[3] *AT&T Knowledge Venture/CVON Innovations v Comptroller General of Patents* [2009] EWHC 343 (Pat)
[4] *Gemstar-TV Guide International v Virgin Media Ltd* [2010] RPC 10

17 It appears from the correspondence between the applicant and the examiner that there is a general agreement that the construction of the claims is relatively straightforward in light of the disclosure of the description and common general knowledge.

18 In their pre-hearing report of 4 October 2021, the examiner referred to the scope of the term ‘physical system’ within claim 1, noting the passage at lines 4-12 of page 27 of the description, which states that a physical system may be ‘artificially designed’ and the final paragraph of the description, which states that ‘the energy of an eigenstate of a physical system may correspond to a cost function of an optimization problem’. The examiner therefore construed ‘physical system’ to include ‘artificial, modelled, virtual or simulated versions of such systems’.

19 At the hearing, it was argued that the reference to a system being ‘artificially designed’ did not mean that the system in question was abstract or ‘non-real’ but rather that such a system might be one which is not naturally occurring, potentially an engineered system designed for a particular purpose. Reference was made to Carbon 60 as an example of an engineered, non-naturally occurring system of atoms. It was noted that the scope of the claim has been limited to a physical system comprising one or more atoms and that, while this may encompass matter such as pharmaceutical products which do not occur naturally in nature, the physical system has the potential to exist and could potentially be created.

20 It was argued that what was meant by the energy levels corresponding to a cost function of an optimisation problem was that the energy levels can be used to solve optimisation problems in the same way that a physical system can be mapped onto a different problem. It was argued that such an approach can be taken, for example, using soap bubbles on a wire frame to identify optimal routes between multiple different locations, or through the running of an electrical current through a plasma within a maze to help identify the shortest path through the maze. As with such examples, a physical system can be mapped onto a problem which may be a cost function but that is not to say that the physical system being modelled is, itself, abstract.

21 I do not think that there is too great a distance between the applicant’s and examiner’s viewpoints. Claim 1 as it now stands is limited to a ‘physical system [which] comprises one or more atoms’. While I am not sure that the applicant’s interpretation of ‘artificially designed’ can be determined directly from the application, I am happy to accept that the system need not be naturally occurring in nature but must be representative of a potential, possible physical arrangement. The physical system may act as a proxy for a more abstract problem and as such can be viewed as a form of modelling or simulation from that perspective. Ultimately, however, the physical system must represent one or more atoms and their respective eigenstates, which are expected and intended to reflect what would be found if one were able to construct and measure the same system in the real world.

(2) Identify the contribution

22 In their pre-hearing report of 4 October 2021, the examiner identified the contribution as follows:

> A computer-implemented method of determining an energy level of an atomic system by iteratively determining the degree of overlap between a trial state and a known state of the system and, in response, adjusting the trial state until a stopping criterion is reached, wherein the degree of overlap is determined by a quantum computer performing either a destructive SWAP test or variational quantum deflation algorithm.

23 It is asserted in the aforementioned report that the applicant accepted the formulation of the contribution identified by the examiner. There were, however, subsequent amendments to the claims made between this report and the matter coming before me at the hearing, as per the underlined and italicised portions of claim 1 set out above. At the hearing it was again confirmed that the applicant was content to accept the examiner's formulation, and furthermore it was confirmed that it was not felt that the latest amendments had any notable impact on the contribution – these amendments were intended to help underpin subsequent arguments.

24 Particularly in light of the extensive and helpful analysis on this point set out by the examiner in their final report of 4 October 2021, I am happy to accept the agreed-upon contribution and continue my analysis on that basis.

(3) and (4) Ask whether the contribution falls solely within the excluded subject matter; and check it is actually technical in nature

25 At the hearing, three broad arguments were put to me. Two of these arguments related to what the invention does, with my attention being drawn to the decisions in *WesternGeco*[5] and *Halliburton*[6], respectively. The third argument related to how the invention does what it does. I will consider each of these arguments in turn, and will also consider the *AT&T* signposts, particularly in relation to the third of these arguments.

26 One of the general themes put to me was that the claimed invention is concerned with a real-world problem, i.e. determining the energy levels of a physical system, and that this was distinguished from a situation such as that in *Gale*[7] which was concerned with an abstract mathematical procedure (calculating a square root).

27 As part of this argument, my attention was drawn to the decision in *WesternGeco*. It was argued that both *WesternGeco* and the current application are concerned with determining a physical property, be it one or more parameters relating to physical properties of the Earth's interior or the energy level of an atom in a physical system. As *WesternGeco* was not considered to be excluded from patentability, it was argued that neither should the current application. It was put to me that as the invention was concerned with determining energy levels it was 'tied in' to a physical, real world system and went beyond an abstract, mathematical method that has nothing to do with the real world or which was self-contained within a computer.

28 It was highlighted that the examiner had not agreed on this point, arguing that the invention was distinguished from *WesternGeco* as the patentable aspects of

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[5] WesternGeco Limited BL O/135/07
[6] *Halliburton Energy Services Inc's Patent Application* [2011] EWHC 2508 (Pat)
[7] *Gale's Application* [1991] RPC 11

WesternGeco were concerned with the processing of data inputs that comprised actual measurements of a physical system, i.e. real world data measured at the Earth's surface. In contrast the current application was said to relate to atomic systems which do not physically exist, such that the system does not rely on actual measurements of a physical system for its inputs.

29 It was argued at the hearing that this was not the case and that claim 14 of *WesternGeco*, which was found by the hearing officer to be patentable, made no reference to the acquisition or measurement of geophysical data and was not therefore limited to using such data measured from such a physical system.

30 It was also noted that the most recent amendments to claim 1, to clarify that the known state, with which the second prepared state corresponded with or was based on, was the known state of 'a physical system'. It was argued that the claimed method does require the input of data from a physical system and was, therefore, on all fours with *WesternGeco*.

31 I do not find these arguments persuasive. At the hearing it was submitted that the data for the numerical inputs for the claimed invention, i.e. the trial state and the known state of the physical system, could be derived from other testing, could have been determined empirically, or alternatively icould have been determined using similar algorithms to that of the claimed invention. Properties which related to the atoms of the physical system of interest would be provided, but it is not important where or how those properties were determined, either as some form of measurements or some form of estimate, and that there are many different methods which could be used. Conversely, the claims which were granted in the patent in question in *WesternGeco* were directed towards 'A method of processing geophysical data…', 'A method of seismic surveying…' and 'An apparatus for processing geophysical data..', all of which appear *prima facie* to relate to the use of real world measurements. Even if it is not spelt out explicitly in the claims that real world, measured data sets are used in the claimed method, it would appear implicit from the wider application. The invention in *WesternGeco* is specifically concerned with getting improved results from seismic data which has been collected in such a way that the data points are not regularly distributed. In my view there is a distinction to be drawn between *WesternGeco*, which I believe at least implicitly requires the use of measured real-world data, and the present application which does not, and may use estimates or indeed any other form of input.

32 More importantly, however, I believe that this analysis misses the point as to what was deemed to be patentable in *WesternGeco*. As previously noted, the invention in *WesternGeco* was concerned with how to best process seismic or geophysical data which was collected in such a way that the data points were not evenly distributed in a grid pattern. The further the data points were from a grid pattern, the less accurate or reliable the images which could be determined from the data set were. It was not simply that the invention in *WesternGeco* utilised real world data which made it patentable, but rather the fact that this data was processed in such a way as to provide a better image from a particular data set than could be achieved using previous methods. The hearing officer was, I believe, strongly influenced by the

decision in *Vicom*[8] when coming to his decision. It was the application of the novel and inventive process utilised in *WesternGeco* in order to provide an improvement in the quality of the images which could be produced from a particular data set which was felt to provide the required technical character to the invention.

33 The present invention does not result in an improved image and this analogy with *Vicom*, upon which *WesternGeco* relies, falls away. Nor is the present invention analogous to *WesternGeco* in other ways. In *WesternGeco* the end result was an improved seismic image. In the present case the end result is a value for at least one unknown energy level of a physical system. It does not follow that, because the relevant claim in *WesternGeco* was found patentable, then the present invention is also patentable. Regardless of whether the input data is measured or not, the claimed invention does not overcome a problem associated with the handling of difficult input data. Nor, given that it is an iterative method where the accuracy is simply chosen through the selection of a stopping criterion, can the current invention be considered to inherently provide a result which is better in some fashion than results achieved by other means that make use of the same starting data. I therefore conclude that *WesternGeco* does not help in deciding the present case.

34 A second line of argument revolved around the parallels that could be drawn between the current claimed invention and that which was the focus of the decision in *Halliburton*. It was argued that rather than simulating different variations of a drill bit and outputting those results, as was the case in *Halliburton*, the current invention involves modelling different variations of physical states and outputting the results.

35 My attention was drawn to the comments in *Halliburton* at paragraph 72, which read:

> *"[In Halliburton] the contribution is not solely a mathematical method (on top of being a computer program) because the data on which the mathematics is performed has been specified in the claim in such a way as to represent something concrete (a drill bit design etc.). This is an important difference between the position in* Gale *and the position here. In* Gale *the claim was broadly drafted and it was nothing more than a mathematical method implemented on a computer."*

36 It was argued that while mathematics is involved with the current invention, the contribution cannot be considered solely a mathematical method or computer program *per se* as the data used by the method represents something concrete, i.e. the physical quantum state of an atomic system. This however perhaps misses the nuance of what was being said in *Halliburton* in which the contribution was deemed to be patentable because the 'something concrete' which the data represented was, itself, technical in nature. It is whether the data relates clearly enough to something technical in nature, rather than to something physical as was repeatedly stressed at the hearing, which I think is important if an invention's contribution is to derive a technical character in this way. In paragraph 71 of *Halliburton* Birss J (as he then was) found that the invention related to designing a drill bit, and this did not fall within any of the excluded categories. He later commented that "designing drill bits is obviously a highly technical process". I am not convinced that the present invention, which relates to determining an unknown energy level of a physical system, is at all

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[8] VICOM SYSTEMS INC/Computer-related invention T208/84, [1987] O.J. E.P.O. 14, [1987] 2 E.P.O.R. 74

analogous to designing a drill bit. It does not seem to me that the energy levels of atoms are in and of themselves technical in nature in the sense that drill bit design is.

37 It is important to note that a person skilled in the art would be able to take the output of the claimed invention in *Halliburton* and be expected, without exercising inventive effort, to manufacture the improved drill bit. That is not to say that a manufacturing step cannot be inventive, or is inherently obvious, but where an invention lies in the design of an article, its subsequent manufacture may often be a straightforward step for the skilled person. The decision in *Halliburton* recognised that, in such circumstances, the inclusion of a manufacturing step within a claim was not necessary or important to the substance of the claimed invention, which enabled better drill bits to be designed.

38 I do not believe that the same can be said in the case of the current application – the notional 'use step' or 'application step' which is missing is simply too nebulous and broad. Merely knowing the energy level of an atom in a system would not enable the skilled person to necessarily manufacture a better drug or better photovoltaic article, and they would almost certainly be required to carry out inventive work to do so. The output from the current invention is simply too detached from any patentable invention for it to gain any technical character in this fashion.

39 It is obviously the case that there are similarities between *Halliburton* and the present application – both make use of an iterative methodology to produce a result – but that in and of itself does not act in any way to imbue patentability. Beyond the iterative methodology, I am not convinced that *Halliburton* has much bearing on this application. *Halliburton* is directed towards designing a drill bit, which Birss J found to be technical. The present invention is directed to something different, namely determining an energy level for a physical system.

40 Considering the contribution made by the present invention on its own merits, I am not convinced that determining and outputting a value representing a calculated energy level of a physical system in itself makes a technical contribution. This value is merely the result of the claimed algorithm implemented on a quantum computer, and possibly also a conventional computer. Although it does in some sense represent a physical property of the physical system of interest, the invention relates entirely to how this property is calculated in terms of the algorithm implemented on a quantum computer. It is not clear that the physical system in question is an actual existing physical system, although I note that the claim is restricted to a physical system containing one or more atoms, and I have construed the claim as relating to physical systems which could in theory be potential possible physical arrangements. In the language of signpost (i) of the *AT&T* signposts, there is no effect on a process outside of the computer, and nor is such an effect implied as was the case in *Halliburton* (namely that a better drill bit was designed and could then be manufactured).

41 The third and final main strand of argument presented to me at the hearing related not to what the invention does but rather to how it does it. These arguments naturally overlap and lead on to discussion of *AT&T* signposts, so I will consider the signposts as they arise within these arguments.

42 It was highlighted during the hearing that in *HTC v Apple* Lewison LJ emphasised that the signposts were not intended to act as a definitive test. Furthermore, it was pointed out that the *AT&T* signposts were not used in the decision in *Halliburton*. It was argued that it is not clear how the signposts would necessarily be applied to *Halliburton* but, despite not clearly aligning with one or more of the *AT&T* signposts, the invention of *Halliburton* was nevertheless found to be patentable. It was at least implied that the current invention should be viewed as patentable even if it could not be argued that it clearly aligned with one or more signposts. I agree that the signposts are not a definitive test, but they can provide a useful indication of whether or not a computer program is more than a computer program as such. In my view they are a relevant consideration in the current case.

43 There was some discussion at the hearing as to whether a different approach should be taken for quantum computers as opposed to classical computers in relation to the signposts. I have reflected upon this and have reached the conclusion that the signposts are valid for quantum computers as for classical computers and still provide useful signposts as to whether the claimed invention makes a technical contribution. I will not go through the case law in detail which Lewison LJ considered when developing the signposts, but that case law is equally relevant to quantum computers as it is to classical computers. It is still valid to ask whether there is an effect on a process outside of the computer, as in signpost (i). I note that a system involving both quantum and classical computers would fall within the definition of the 'computer' for this signpost. Although, in the case of signpost (ii), the concept of what constitutes the 'architecture' level of the computer may be less clearly defined, the definition provided by the signpost itself, namely whether the effect is produced irrespective of the data being processed or the applications being run, is relevant and can be applied when the invention involves quantum computers. Similarly the other signposts may be applied to quantum computers. The questions as to whether the computer itself is a better computer or is made to operate in a new way, and whether the perceived problem is solved rather than circumvented, are relevant to quantum computers and their applications.

44 Furthermore, given the level of abstraction of 'computer programs' as described and claimed in patents, it is important to consider whether or not the claimed invention, or rather its contribution, relates to the instructions which are provided to the computer, in its broadest sense, in order to direct how it operates. If the contribution does relate solely to such instructions, the question to then be determined is whether those instructions result in some form of contribution which is something more than a computer program as such, and I do not believe that the fact that a computer is a quantum computer or has a quantum element makes any meaningful difference to that deliberation

45 Turning to the application in suit, the core of the final main argument revolves around the overlap estimation routine, which uses either the Variational Quantum Deflation algorithm or the destructive SWAP test. This enables the control signalling, which interacts with the qubits within the quantum computer, to be derived from linear functions of the Hamiltonian rather than from quadratic functions of the Hamiltonian. As a result of this approach, the control signalling requires a smaller number of control pulses or samples which in turn results in less noise being introduced into the quantum system. As less noise is introduced into the system, the eventual results

achieved are subject to less noise and are hence more accurate. It was argued that the invention is not merely a new algorithm but represents a new way of taking the algorithm and translating it into how the qubits are physically manipulated.

46 It was explained that a method involving a quantum computer may result in an output which contains some useful information and also contains a greater or lesser amount of noise or may alternatively end up with so much noise that the output is not meaningful at all. The quality of the output depends on the balance between the complexity of the algorithm and the complexity of the quantum computer. It was stated that the current method is a more sophisticated method of controlling a quantum computer which requires fewer control pulses to achieve the same effect, resulting either in a meaningful output which has less noise than would have occurred using previous methods, or in a meaningful output whereas under previous methods no useful output would have been achieved at all.

47 It was argued that it is difficult to draw a clear analogy on this point with classical computers. Classical computers are strictly binary in nature such that running the same algorithm repeatedly will normally result in the same result each time. This contrasts with the analogue aspects of quantum computers which are such that different results may arise each time an algorithm is run. While not a perfect analogy, the claimed invention was perhaps akin to a new method for a classical computer which resulted in fewer errors arising when the algorithm was run, or, in a possibly hypothetical situation where an algorithm provided a range of answers, a method that enabled a range of answers with a smaller standard deviation to be achieved.

48 It was argued that as the claimed method potentially enables a quantum computer to provide a meaningful result in situations where, using prior methods, no result at all would have been achieved, the computer must be viewed as working in a new way as per signpost (iii). Even in situations where a previous method would have enabled a result to be achieved, the current method enables a better result to be achieved through the computer operating in a new way. Similarly, it was argued that it is difficult to see that the computer is not operating as a better computer, as per signpost (iv), if it outputs a result when otherwise it would not do so.

49 These arguments do not lead me to believe that, in the present invention, the computer can be considered to be operating in a new or better way. Rather, it would appear that the computer operates in a normal fashion, but with a mathematical method being chosen which requires less interaction with the qubits such that less noise enters the quantum system, equating to better programming rather than a better computer. In a classical computer, a particular method may require a mathematical function to be performed and it might be possible to perform that function in one of a number of ways. The different approaches will have differing demands on the hardware – for example a greater or lesser requirement for memory. Making a decision to utilise one approach or the other because it makes a more efficient use of the resources available does not amount to creating a better computer or operating a computer in a new way, even if it performs those mathematical functions more quickly or accurately as a result. Rather, it is merely a better program which has been designed to make best use of the strengths and weaknesses of the particular hardware upon which it is run. At the other extreme, it is certainly possible to program a classical computer so badly or inefficiently that it will simply not operate at all. I think the present situation is, to an extent, analogous,

with the claimed method simply acting to work more efficiently in relation to the particular strengths and weaknesses of the quantum computer. Moreover I note that the benefits of reduced noise are not available to all algorithms (or programs) implemented on the quantum computer, but only to those algorithms within the scope of the claims. I do not therefore believe that this argument demonstrates that the invention satisfies the requirements of signposts (iii) or (iv).

50 In relation to signpost (ii), there was some discussion as to what would be considered the 'architectural level' of a quantum computer. It was acknowledged that the invention did not provide a general improvement to the workings of a quantum computer in all circumstances but was limited to the specific method or class of methods defined in the claims. An analogy was drawn with analogue audio signal processors. It was argued that it would be uncontroversial to say that if such an audio signal processor could process any audio signal with improved signal-to-noise performance then that processor would potentially be patentable subject matter. However, it is also the case that audio signal processors can be only suitable for processing certain specific types of audio signal. An example was provided of forensic voice print analysis, which can be used to help identify a speaker in a recording irrespective of how they try to disguise their voice. It was argued that if an audio signal processor provided an improvement to the signal-to-noise ratio or some other similar feature but only to the extent of, or for the purpose of, forensic voice print analysis, then it would still potentially be considered to make a technical contribution and be patentable despite it not being of general applicability to all forms of signal noise processing. As such, the fact that the current contribution only provides improvements when seeking to find the energy level of a physical system, rather than to any and all processing on a quantum computer, should not prevent it from being patentable.

51 I think this argument perhaps conflates issues around signposts (i) and (ii). In the example provided of forensic voice print analysis, the contribution would relate to a better voice print analysis and it is that that would make the technical contribution in accordance with signpost (i), rather than the contribution relating to a general improvement in audio signal processing. In the present invention the contribution relates to an improvement in determining unknown energy levels of physical systems. I do not believe that this contribution satisfies signpost (i), very much for the reasons set out above in the discussion around *Halliburton*. The invention provides an improvement in using a quantum computer to determine a number, an energy level of a physical system, as part of its performance as a computer program, but it does not inherently provide a better article or make an improvement in a process beyond the computer. The claimed invention does not directly relate to any process outside of the computer.

52 With regard to signpost (ii), I the key feature required to meet the requirements of the signpost, irrespective of the exact nature of the 'architecture', is that it is necessary that the benefits of the new computer program are available (even if not utilised) irrespective of the type of data, method or process being run by the computer. It is relatively straightforward to envisage methods or programs for quantum computers which could be considered to operate at the level of the architecture. Such a process might better control the microwaves or lasers that interact with the qubits so as to reduce noise associated with each interaction or enable faster calculations so that a

greater amount of processing can be performed before decoherence, irrespective of the nature of the data being processed. The current invention cannot be said to provide any such benefit, being restricted to a particular process and therefore particular data, and thus it does not meet the requirements of signpost (ii).

53 While it was not discussed at the hearing, I will comment briefly on signpost (v) – whether or not the contribution overcomes the perceived problem or circumvents it. The problem the present invention seeks to address relates to improving the operation of a quantum computer in determining an unknown energy level of a physical system. Although it achieves this by generating less noise in the quantum computer and shortening coherence times, this effect arises out of improvements in the mathematical algorithm rather than general improvements in the quantum computer itself which enable to calculation to be performed using fewer interactions. The problem is therefore circumvented rather than solved in a technical sense in terms of general improvements to the quantum computer. Signpost (v) is therefore not satisfied.

54 Taking a step back, I have seen nothing which convinces me that the invention results in the computer itself operating in a new or better way. I do not believe that the invention has any technical effect on any process outside of the computer and the output from the method does not relate to a clearly technical process, as was the case in *Halliburton*. The invention does not resolve or address any of the shortcomings of current generation quantum computers, but rather circumvents them through using algorithms which better play to the strengths and weaknesses of quantum computers. Beyond these points, I can see nothing which leads me to believe that the contribution of the claimed invention is more than a program for a computer as such. It may well be a better computer program that better utilises the resources of a quantum computer but, as has been discussed, that in itself is not enough for the contribution to escape the exclusion.

55 I will also consider whether or not the contribution is more than a mathematical method as such. I note the following passage from Nicholls L.J. in *Gale* at 327:

> *"In the present case Mr Gale claims to have discovered an algorithm. Clearly that, as such, is not patentable. It is an intellectual discovery which, for good measure, falls squarely within one of the items, mathematical method, listed in section 1(2). But the nature of this discovery is such that it has a practical application, in that it enables instructions to be written for conventional computers in a way which will, so it is claimed, expedite one of the calculations frequently made with the aid of a computer. In my view the application of Mr Gale's mathematical formulae for the purpose of writing computer instructions is sufficient to dispose of the contention that he is claiming a mathematical method as such."*

56 I believe that the current invention is on all fours with this position. The mathematical method of the current invention does potentially provide a better way in which the computer can make certain types of calculation, and its application to that purpose is sufficient to avoid being a mathematical method *as such*. However, as was also the case in *Gale*, while those instructions may make more efficient use of the computer's resources, they cannot be viewed as anything more than a computer program *as such*, albeit perhaps a better computer program *as such*, and must be considered excluded.

Possible amendments

57 There is one final point for me to address. At the hearing a request was made that, if I were to find the claims as they now stand to be excluded, would I consider if an amendment to further limit claim 1 to some form of application or use of the determined energy level might help adjust the scope of the claim so that it was patentable. My attention was drawn to the third paragraph of page 25 of the description, which, along with subsequent paragraphs, list a number of potential uses to which the determined energy levels could be put, such as determining the properties of chemical structures and the design of pharmaceuticals. I note however that the details as to how the invention currently claimed could or would be used for such applications is extremely sketchy, the disclosure being little more than a list of possible applications. I have doubts as to whether an amendment to such an application would be fully supported or sufficient, although I do not decide this point. However, when viewed as a whole, the application clearly teaches that the invention relates to determining an unknown energy level for a physical system, not to any specific use of the claimed invention. There are a number of possible applications for such an invention, such as those listed on page 25, but the invention, at its core, relates to the determination of the energy level itself, not to any particular application. This differs from the invention in *Halliburton*, where the entire method was specifically focussed on the design of a drill bit. There is nothing to suggest that the skilled person would not, when provided with the invention currently claimed in claim 1, understand the nature of the invention and immediately consider a number of applications of the invention, including at least some of those listed on page 25. I do not believe there is sufficient disclosure in the specification of a specific application which would result in a patentable invention. I therefore conclude that, if claim 1 was limited to any of the applications listed in the specification, it would remain excluded from patentability as a program for a computer as such.

Conclusion

58 In conclusion, I have found that the claimed invention lies solely in the excluded field of a program for a computer as such and therefore does not comply with the requirements of sections 1(1)(d) and 1(2) of the Act. I therefore refuse the application under section 18(3).

Appeal

59 Any appeal must be lodged within 28 days after the date of this decision.

B Micklewright

Deputy Director, acting for the Comptroller