England and Wales High Court (Patents Court) Decisions

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Case No: HC07C01084/1487/1488

**IN THE HIGH COURT OF JUSTICE
CHANCERY DIVISION
PATENTS COURT**

Royal Courts of Justice
Strand, London, WC2A 2LL
19/01/2009

B e f o r e :

MR JUSTICE MANN

Between:

SCHLUMBERGER HOLDINGS LIMITED (a company incorporated in the British Virgin Islands)	**Claimant**
- and -	
ELECTROMAGNETIC GEOSERVICES AS (a company incorporated in Norway)	**Defendant**

**MR. M. SILVERLEAF Q.C. and MR. H. CUDDIGAN (instructed by Freshfields Bruckhaus Deringer LLP) for the Claimant.
MR. G. BURKILL Q.C. and MR. G. PRITCHARD (instructed by Lovells LLP) for the Defendant.
Hearing dates: 17th, 18th, 19th, 20th, 24th, 25th, 26th, 27th, 30th June 2008
1st, 2nd, 3rd, 22nd, 23rd, 24th, 25th July 2008**

HTML VERSION OF JUDGMENT

Mr Justice Mann :

Introduction

1. This is a patent action whose subject matter is three patents (known in this action as the 019, 887 and 640 patents) relating to technology which is intended to be deployed in oil exploration. The technology is known as controlled source electro-magnetism or magnetics ("CSEM"). The proprietor of each of the three patents is the defendant, a Norwegian company ("EMGS"). The claimant ("Schlumberger") is another company involved in (inter alia) oil exploration and it seeks the revocation of all three patents on the grounds of anticipation and/or obviousness. On the way important questions arise as to the identity of the skilled addressee to whom the patents should be taken as being addressed.

2. The technology and physics involved is complex to a layman and requires a grasp of some less than everyday science and mathematics. The parties have agreed that I should have the assistance of an expert adviser, and I have had the services of Professor Richard Bailey of the University of Toronto. He is a professor of geophysics, and instructed me in the background physics in this matter, so that I was then in a better position to understand the prior art and the expert evidence. He was also able to explain to me, in a non-partisan way, the meaning of some of the more technical material with which I was presented. His role was, of course, not judicial. It was to inform and educate on matters of science. He performed his role with great distinction (and, I might add, even greater patience), and the court is grateful to him for his assistance. If any of the science in this judgment is wrong then the fault is that of the pupil and not the teacher.

The scientific and physical background

3. In what follows I set out the background against which the patents in suit operate. I shall have to deal with some physics and geology. I shall do so in terms which are generally appropriate for describing those matters at a lowish level, and which will not be a full scientific description of the phenomena involved. A pure physicist may well find some of the description inadequate in scientific terms. I am sure it is. It will, however, suffice for present purposes. My adoption of this technique, and in particular my adoption of what may seem to the purist to be less than wholly accurate metaphor from time to time, does not necessarily betoken a failure on my part to understand accurately the actual physics involved. Nor does it betoken a shortage of evidence on a properly expressed scientific basis - I was certainly not short of that in this case. It is merely an appropriate way of setting out the background at this stage. The same applies, to an extent, in the later, more detailed, parts of this judgment. As will be seen, the adoption of metaphor has a precedent in the facts of this case - the central patent itself adopts a metaphor rather than an accurate description of the physics, and uses scientific terms in a manner which the scientists involved in this case accepted was technically inaccurate.

4. Those who drill for and extract oil obviously have a problem finding it because it is, in the main, found in layers under the ground, sometimes buried to a depth of thousands of metres. Layers of sedimentary rock which hold it have to be identified. At the end of the day only a test drilling of a promising site can demonstrate clearly that there is oil there, and whether it is worth the extra cost of extraction, but drilling is expensive, and the oil companies need to have sufficient reason to drill (in terms of evidence of a sufficient likelihood of finding oil) before doing so. The expense is greater if (as is sometimes the case) the potential sites are under the sea, and greater again if the layer of interest is in deeper as opposed to shallower water.

5. In regions in which those searching for oil are interested, the earth for several kilometres below the surface is made up of various layers. The trick is to find a layer which contains the oil. Unfortunately the layers vary enormously in their physical content, their lateral and vertical extent, and their boundary definition. Potential oil-bearing sites have to be identified, and the surrounding geology often has to be determined as well (for example, to determine the nature and extent of the layers through which one would have to penetrate to get to the oil-bearing layer). The techniques

for identifying potential sites and the surrounding layers are various. They include a general knowledge of the geology which already exists (which can rule out large areas of the earth's surface), gravity measurements and seismic investigations. Seismics involves making something in the nature of a blow to the earth and measuring how the resulting effect is perceived at various distances ("offsets") from the seismic event. There are two different techniques - reflection seismics and refraction seismics. Reflection seismics, described basically, assesses the received signal and detects the transmitted effect of the "bang" by detecting seismic waves which have apparently been reflected from the various layer boundaries. Refraction seismics benefits from the sensing of sound waves which have been refracted. Refraction occurs under some circumstances when the sound waves generated by the "bang" cross boundaries of substances with different properties. Under some conditions the wave is "bent" and then passes through or along the refracting layer at a greater speed than it passes through other layers. In those circumstances the refracted wave arrives at the receiver earlier than parts of the wave that have taken a different route (i.e. direct or reflected waves). It is identifiable to seismologists as being a wave that has taken such a route, and its presence reveals things about the structure below (when taken with the other information from the survey). Refraction seismics was the first standard seismic technique until some decades ago, when reflection seismics began to be important in the search for oil. The main use of refraction seismics in oil exploration has been for carrying out surveys on a wider rather than a more local scale - on a "basin scale".

6. Although there have been significant improvements in modern times (including the introduction of 3D seismics in the 1980s), seismics does not provide a complete solution in the search for oil. It does not always give the detail and characterisation of sub-strata that an oil company would wish to have. It is sometimes useful to have a different "view" of what is down there. The more information that is available, the better. Under some conditions seismics cannot see everything that needs to be seen. Various other techniques are therefore used as well. One of them is, or according to the invention can be, the use of electromagnetic ("EM") means.

7. EM has been used in various ways for the purposes of mapping aspects of the earth's substructure. At its heart it involves mapping electric or magnetic fields in the earth's surface. Those two fields are closely related as a matter of physics. For present purposes I can ignore the latter and concentrate on the former. In that context electric fields are used to determine and map the resistivity of the sub-surface structures, and thereby enable the observer to draw some conclusions as to their structure and character. The substances which make up the sub-surface layers and structures (and indeed all substances) have differing resistivities, that is to say that they vary in their capacity to conduct an electric current. Air is highly resistive, or to use a counterpart expression, it is highly non-conductive. It hardly conducts current at all. Electric fields behave in the opposite fashion - they are able to pass through or penetrate resistive material with less attenuation than if they were passing through conductive material. Thus an electric field will be able to pass farther (and indeed faster) through air (which is resistive) than through metal (which is highly conductive).

8. These properties can be used by those interested in the earth's structures. Those people include what have been called in the context of this case "solid earth geophysicists" (those interested in studying the earth's structure for what might be called academic purposes) and "exploration geophysicists" (those interested in using geophysical techniques and studies for the purposes of practical exploration for substances including, but not limited to, oil and other hydrocarbons). It is unnecessary to set out an extensive catalogue of the manner in which use of EM techniques can be made by those groups, but one or two examples will be helpfully illustrative. Other examples will appear in the consideration of the prior art below.

9. Electric currents are induced to flow in the earth's structure by currents which have been made to flow in the ionosphere, which are in turn made to flow by solar activity. The currents in the earth can be analysed to study the resistivity of the earth's structure down to several hundred kilometres (depending on the frequency of the current). This technique is called magnetotellurics ("MT"). There was a dispute, which I need not resolve, as to the success with which such methods have

been used in the oil industry. They are not the subject of the patent. They are distinguished for present purposes from the subject matter of the patents in suit by the source of the currents. Those currents have a natural source. The subject matter of the patents has a man-made source. Electric fields are induced to flow under the earth's surface by generating a field from two widely spaced (offset) electrodes connected to an electrical source. These techniques are called "controlled source electromagnetic" (CSEM) methods. The practitioners in this area measure or detect the field in a variety of ways and come to conclusions which enable them (in the present context) to assess the resistivity of the earth's surface at various points.

10. Water and oil have different resistivities, and their presence in underlying rocks gives a layer containing those substances differing resistitivies too. Thus a sedimentary layer which contains water (in particular, salt water) will have a different (lower) resistivity to one containing oil. By measuring the resistivity of a questioned layer an oil company can get a picture of the relative oil or water content of that layer. This measurement technique is used on a local scale down boreholes. There are reasons why an oil company would wish to get a better picture of the nature of the subsurface at a particular level than an analysis of the drilling detritus can give, or would wish to get a picture of the oil and water content of a known layer. Information can be obtained by lowering equipment down the borehole to the desired point, generating an electro-magnetic field and obtaining a resistivity reading from the EM field at and around the relevant point. That field is measured by the receiving equipment and the results are analysed. Although there are many complications which might arise, to put the matter at its simplest a higher resistivity would be more consistent with oil and a lower resistivity with water.

11. That deals with a localised application, but fields generated over a wider area can yield information over that wider area. Electrodes can be placed in the earth to generate a field, and detectors can be placed in the earth some significant distance away (kilometres, if necessary or appropriate) and a signal generated by the transmitter can be picked up by the receivers. By measuring the phase and/or amplitude of the signal, and by applying some mathematical principles, an assessment can be made of the resistivity of the earth through which the field has passed, and by varying the signal and the positioning of the equipment and measuring the signal at various frequencies at those various distances, and applying some more mathematical principles and some modelling techniques, a calculation can be made of the resistivity of various areas under the surface. That enables the construction of (depending on the complexity of the analysis) a 1D (one-dimensional) or 2D "picture" of the layers below the surface in terms of its resistivity, which again, combined perhaps with other knowledge, enables the characteristics of those layers to be more closely determined. Thus, to take an example from the prior art, it would be possible (depending ultimately on the data) to find the boundary between an upper, highly resistive, basalt layer and a lower, relatively more conductive (and therefore relatively less resistive) sedimentary layer by getting information about resistivities. The details of how this is done do not matter at this point.

12. Among the first practitioners of a form of CSEM were the founders of Schlumberger, the Schlumberger brothers, between 1912 and 1926. They used direct current to introduce steady-state currents into the earth through a pair of electrodes. Nowadays a variable current is used. The source can be either a continuous waveform, for example in the sense of a sinusoid wave, or a square wave, or it can be "transient", ie an on/off event (confusingly, this is sometimes repeatedly achieved as a repeating square wave). This area of the technology has a relevance to the patent and the prior art, and I develop the point later.

13. CSEM has two flavours, land based and marine. As their respective names suggest, the former is carried out on land, and the latter at sea. Practitioners in the latter are a smaller group than practitioners of the former, and the development of marine CSEM is of more recent origin than land CSEM. As will probably be obvious, it is not so easy to induce an electrical current in the sea bed because you cannot simply drive electrodes into the sea bed, and cannot easily lower EM sources into holes on the sea bed. However, as will appear later, it is possible to induce currents by placing an electric dipole above the sea bed and placing a dipole detector elsewhere. A dipole is basically

two electrodes. The transmitting dipole is typically towed by a ship. The receiver may be towed, or may be deposited on the sea bottom and retrieved later. A large current is passed through the transmitter dipole. This creates an electric field in the surrounding area. Saline (sea water) is relatively conductive and the electric field attenuates relatively rapidly with distance in the water. However, the underlying seabed is less conductive (more resistive) and if the field is large enough and strong enough to get to the seabed it attenuates less therein. The fields thus generated are detected by the detector dipoles, and measurements are taken. The detected field will be affected by the strength of the original current, the frequency of the signal, the distance from the transmitter and the signal paths through the intervening material (sea, seabed and, to a certain extent, the air above the sea). As frequency and distance can be made to vary, conclusions can be drawn from the variation that those elements produce in the received signal.

Terminology and concepts

14. A grasp of certain concepts will be necessary when considering this matter and it will be useful to set them out here.

Skin depth

15. "Skin depth" is a significant concept. It is useful to have a measure by which the rate of attenuation of a signal in a given material can be measured. The extent to which an EM field can penetrate a substance is a function of the frequency of the signal and the resistivity of the substance. "Skin depth" is the term used to describe this quality. It is represented by the formula:

$d = 1/\sqrt{\pi\mu\sigma f}$

Where d is distance, μ is the permeability of free space (a constant for these purposes) σ is the electrical conductivity of the substance and f is the source frequency. In layman's terms, it works out to a reduction to approximately 37% of the original signal - in other words, the skin depth of a substance for any given frequency is the distance over which the signal has attenuated to 37% of its original strength. It will be apparent from that formula that the lower the frequency, the greater the skin depth. Since a lower frequency also means a longer wavelength, it also means that the longer the wavelength, the greater the skin depth or degree of penetration possible. Longer wavelengths give greater penetration. Greater resistivity (lower conductivity) also allows greater penetration.

16. The practical effect of this, when conducting a CSEM survey, is that you have to have a sufficient skin depth to penetrate at least to the depth that you are interested in. So far as wavelength/frequencies are chosen as part of the survey, you have to choose them accordingly. Too short a wavelength or too high a frequency, and the field will not penetrate to regions of interest.

Resistivity

17. I have explained resistivity in general terms. It is measured in ohm-metres (abbreviated in various ways using the symbol Ω to signify the ohms).

Wave physics vs diffusion physics

18. There was a dispute between the experts as to the applicability of wave physics as opposed to diffusion physics when applying CSEM. The concept of refraction, strictly so called, depends on the applicability of the full set of Maxwell's equations. Those equations apply to the propagation and behaviour of the electromagnetic spectrum in general. However, they are not always applied in their full rigour, in particular at lower frequencies. In the conducting media pertinent to useful CSEM signals, Dr Chave (Schlumberger's expert) considered that the physics involved was more diffusion physics than wave physics. Professor Shultz (one of EMGS's experts) considered that it contained elements of both. So far as diffusion physics is the appropriate view, a different set of equations (a simpler subset of the full set of Maxwell's equations) is sufficient and appropriate (the "diffusive

limit"). Fortunately it is not necessary to go into these equations, but it is necessary to bear the situation in mind when considering the patents in suit, and in particular the 019 patent. That patent talks in terms of reflected and refracted waves. Strictly speaking (at least from the point of view of a purist physicist) those terms are inaccurate when applied to the fields in question because those terms are applicable to waves, and the CSEM transmissions have more elements of diffusion to which the notions are not strictly applicable. They are, however, a useful metaphor provided that they are not taken too literally. As will appear, even Dr Chave used the metaphor in one of his publications.

TE & TM mode

19. The expressions TE and TM modes are used in relation to the 887 patent, along with the expressions "inline" and "broadside". Inline and broadside refer to the alignment of the transmitter and receiver. If they are inline, then the dipoles are positioned thus in plan view:

If they are broadside, they are effectively parallel, and are positioned thus:

20. TE and TM mode refer to electric fields, and are abbreviations for transverse electric and transverse (or toroidal) magnetic modes respectively. I shall avoid overly-technical explanations. For present purposes it can be said that a horizontal electric dipole close to the sea bed induces both horizontal and vertical currents. The TM mode is associated with currents flowing primarily in the vertical plane, and TE mode is associated primarily with currents flowing in the horizontal plane. This means that their respective impacts on differently positioned receivers are different and their detection will be differentially affected by sub-surface layers of differing resistivity. For the present it is sufficient to note that the inline configuration is more sensitive to TM mode than the broadside configuration. This is a feature which is exploited by the 887 patent.

Frequency domain, time domain and transient signals

21. These concepts will have to be considered when I come to deal with some of the prior art. At a simple level, when applied to a CSEM survey, they can be described as follows. A signal is in the frequency domain when it is, or contains, a single frequency, or where the signal changes discrete frequencies to a different frequency from time to time. A frequency domain system relies on this. The response to the given frequencies is assessed at the receiver. A transient system does something different. In a transient system, the transmitted signal is turned on and off, possibly at intervals, with the response (the received signal) measured after the on or off state of the transmitted signal has been established. A transient system has benefits over frequency domain signals in land-based CSEM. Frequency domain signals are not favoured in land-based systems because the insulating quality of the air means that there is a large and slowly attenuating wave in it (the "air wave") which gets in the way of measuring the interesting signal from the Earth. In a transient system it is easier to devise a method which allows extraneous matters to dissipate before measurement starts, and before another signal is transmitted.

22. The transient signal technique has been referred to as operating in the time domain. That is an accurate description so far as what is usually measured is variations which are related to the time of

travel of the signal. However, it is a little dangerous to treat transient systems and time domain as being essentially synonymous, and I shall refrain from doing so, despite the fact that Dr Chave seemed to suggest that they were equivalents in his first report. Difficulties of categorisation might, if one were not careful, arise in relation to square waves. Square waves have an "on-constant-off" or "on-constant-reversal-constant-on" sort of pattern which might make it tempting to refer to them as operating in the time domain. However, as a matter of physics, a square wave signal can be taken as representing an aggregate of the odd harmonics starting with the fundamental frequency of the wave. Those frequencies can be determined and studied by a process known as Fourier transformation, so that they can be studied in a CSEM context as if broadcast separately. This scientific quality has an impact on the effect of some of the prior art, so it is important not to create additional difficulty by pre-judging matters by potentially erroneous labelling.

Witnesses

23. I heard evidence from one witness of fact and three experts. They were as follows.

Dr Terje Eidesmo

He is the President and CEO of EMGS and has worked for it since its birth in 2002. It was spun out of the Norwegian state oil company (Statoil) and he was involved within the Statoil group prior to taking up his present rule. He has a doctorate in Physics awarded by the Norwegian University of Science and Technology and has held a professorship in Petrophysics. He is plainly experienced in the techniques of oil exploration and oil reservoir management. Dr Eidesmo claims to be one of the inventors of the invention embodied in the 019 patent, and he gave evidence of how it came to him, how he procured its testing and what the reaction of others was. His first language is Norwegian, but his English was very good - he did not require an interpreter. The fact that English was not his first language probably explained an apparent unwillingness sometimes to give a simple yes or no answer where he could probably have done so - he was being cautious, not tricky. He came across as a man who plainly wished to defend his invention and who plainly thought that it was an invention. I think that he viewed the reaction of others, to some extent, through those spectacles. I can safely take as accurate his factual account of how the invention was conceived and developed, but I regard with a little more care his accounts of the reaction of others to it. I make it plain that I do not consider that he has told deliberate untruths; it is just that his strength of view as to the novelty of his invention might be thought to have tended to colour his view of the expressed perception of others.

Professor Adam Schultz

Professor Schultz is professor of Marine Geology and Geophysics at the College of Oceanic and Atmospheric Studies at Oregon State University, and gave expert evidence for EMGS. He has a background in geology, physics and mathematics, has a PhD in geophysics, and has done research in both terrestrial and marine geophysics generally. Although he spent a limited time working in the oil industry, his main point of view is that of the academic - a solid earth geophysicist. He gave evidence about the skilled addressee, the 019 and 887 patents and the prior art. He is plainly an experienced man and his evidence was helpful to my understanding of the case. However, I sometimes had the impression that he was a little too concerned to defend a particular corner and be an advocate for his client's cause rather than a completely dispassionate expert. That feature was certainly not so strong as to taint the whole of his evidence, and he had a cross-examination to contend with that was at times quite hostile, but it is a feature which I had to bear in mind when considering the totality of what he said to me. There is, however, one thing I acquit him of. In his final speech Mr Silverleaf sought to paint him as a witness who "sought refuge in obfuscation and diversion". I do not consider him to have been guilty of that. He was plainly uncomfortable with some of the hypotheses that Mr Silverleaf invited him to accept, particularly in relation to the piece of prior art called "Srnka", and wished to consider the matter carefully. To a large extent the sometimes laboured nature of the exchanges is really more attributable to the difficulties in understanding the prior art; I do not consider that Professor Schultz sought to obfuscate.

Professor Martin Landro

He is a professor of Applied Geophysics at the Norwegian University of Science and Technology and was the second expert witness for EMGS. He was able to give me evidence about the use of seismics in geological (and particularly oil) exploration; seismics was (for these purposes) his principal area of expertise, though he obviously had an understanding of wider issues. Again, his first language was Norwegian, not English, but he spoke clear and fluent English without an interpreter. He was inclined to be a bit dogmatic, but subject to that I did not detect the same tendency to fight his side's corner that I detected in Professor Shultz.

Dr Alan Chave

He is currently a senior scientist at the Woods Hole Oceanographic Institution at Woods Hole, Massachusetts. He has had over 32 years experience in studying, teaching, researching, experimenting and consulting in marine geophysics, physical oceanography and oceanographic technology, and was the sole expert who gave evidence for Schlumberger. Unlike the other experts, he had considerable expertise in CSEM, and indeed was the author (or principal co-author) of one of the key pieces of prior art. His expertise was unquestioned, and he was plainly a thoughtful witness, although at times, like Prof Schultz, he tended to defend a particular corner as if defending or arguing a particular case. He brought to bear a strictness of approach, and from time to time found the inaccurate use of scientific language and concepts irritating and frustrating. He might be thought in some ways to be a purist, and a little vein of that sometimes ran through his evidence. It sometimes led him into a degree of dogmatism that was not always appropriate, but he was not overall as dogmatic as EMGS sought to portray him. What I think that I have to bear in mind in relation to his evidence is that his great expertise might have tended to have led him to treat as obvious or clear things which those with lesser experience might have found less so.

The Patents in suit – generally

24. The three patents are related. The first in time (019) claims an invention in the form of a method of detecting hydrocarbon layers under the seabed by means of measuring resistivities and claiming to detect a particular wave from a hydrocarbon layer which is not present in a less resistive layer. The second (887) builds on that and claims to improve detection by measuring and comparing signals from inline and broadside transmission/reception, and again detecting the hydrocarbon layer. The third (640) claims an improvement in procedures by carrying out the invention in the 019 patent and refraction (not reflection) seismic surveys at the same time and at the same location (as opposed to at different times at the same location). The starting point for the latter two is the 019 patent, so it is necessary and appropriate to deal with that first, and to resolve questions about the skilled addressee in that context. No-one suggested that the skilled addressees for the two later patents would be any different.

The 019 patent

25. The full number of this patent is EP 1 256 019 B1; its priority date is 2nd February 2000. It is entitled "Method for Determining the Nature of Subterranean Reservoirs" and its inventors are said to be Dr Eidesmo, Svein Ellingsrud, Fan-Nian Kong and Harald Westerdahl. The original proprietors were Statoil ASA and Norges Geotekniske Institutt; it has since been assigned to EMGS.

26. The first four paragraphs of the introduction set out the problem which is said to be addressed. I set them out here with some italicisation (which is mine) which shows words as to which points of construction or debate arise in this case (I do not thereafter italicise all subsequent instances of those words):

> "[0001] The present invention relates to a method for determining the nature of submarine and subterranean *reservoirs*. The invention is particularly suitable for determining whether a *reservoir*, whose

> approximate geometry and location are known, contains *hydrocarbons* or water, though it can also be applied to detecting reservoirs with particular characteristics.
>
> " [0002] Currently, the most widely used techniques for geological surveying, particularly in sub-marine situations, are seismic methods. These seismic techniques are capable of revealing the structure of the subterranean strata with some accuracy. However, whereas a seismic survey can reveal the location and shape of a potential reservoir, it cannot reveal the nature of the reservoir.
>
> "[0003] The solution therefore is to drill a borehole into the reservoir. However, the costs involved in drilling an exploration well tend to be in the region of £25m and since the success rate is generally about 1 in 10, this tends to be a very costly exercise.
>
> "[0004] It is therefore an object of the invention to provide a system for determining, with greater certainty, the nature of a subterranean reservoir without the need to sink a borehole."

27. The "reservoir" and "hydrocarbon" points arise in relation to one of the items of prior art which relates to the use of CSEM to determine certain characteristics of methane hydrates. Having referred to the use of EM within a well bore, paragraph 0006 sets out the invention in the terms of Claim 1 but which I will set out here as well:

> "0006 According to the invention, there is provided a method of performing a survey of subterranean strata in order to search for a hydrocarbon containing subterranean reservoir, or to determining [sic] the nature of a submarine or subterranean reservoir whose approximate geometry and location are known, which comprises: applying a time varying electromagnetic field to the subterranean strata; detecting the electromagnetic wave field response; *seeking*, in the wave field response, a component representing a *refracted wave*; and determining the presence and/or nature of any reservoir identified based on the presence or absence of a refracted wave component; in which the transmitted field is in the form of a wave, and in which the distance between the transmitter (37) and a receiver (38) is given by the formula
>
> $0.5\,\lambda \leq l \leq 10\,\lambda$;
>
> where λ is the wavelength of the transmission through the overburden (34) and l is the distance between the transmitter (37) and the receiver (38)."

Again, I have emphasised words whose meaning and effect are important later. The "overburden" is essentially the layer (or layers) beneath the seawater but above the potentially oil-bearing layer. What is sought to be detected, or investigated, is the layer underneath that. That is apparent from the drawing in Fig 2 of the patent which is reproduced at Appendix 2 to this judgment. The patent goes on:

> "0007 Given that the distances and geometry of the reservoir will be known from previous seismic surveys, an optimum λ and l would be selected."

"l", the distance between the transmitter and receiver, is known as the "offset". The general nature of the overburden will be known, and the wavelength of the transmission through the overburden can be chosen (if it is to be chosen at all - that is an issue that arises later and I do not intend to pre-judge it here) by reference to the skin depth formula, so that it is not so short as to be likely to fail to get through the overburden, or so long as to penetrate too far.

28. Further background is then set out:

> "0008 It has been appreciated by the present applicants that while the seismic properties of oil-filled strata and water-filled strata do not differ significantly, their electromagnetic resistivities (permittivities) do differ. Thus, by using an electromagnetic surveying method, these differences can be exploited and the success rate in predicting the nature of a reservoir can be increased significantly. This represents potentially an enormous cost saving."

The word "permittivities" was agreed by the parties to add nothing except a modicum of confusion, and should be ignored.

29. There then follow two paragraphs which are said to lie at the heart of the invention, explaining, as they do, the "refracted wave" referred to in paragraph 0006.

> "[0009] The present invention arises from an appreciation of the fact that when an EM field is applied to subterranean strata which include a reservoir, in addition to a direct wave component and a reflected wave component from the reservoir, the detected wave field will include a 'refracted' wave component from the reservoir. The reservoir containing hydrocarbon is acting in some way as a wave guide. For the purposes of this specification, however, the wave will be referred to as a 'refracted wave', regardless of the particular mechanism which in fact pertains.
>
> "[00010] Be that as it may, a refracted wave behaves differently, depending on the nature of the stratum in which it is propagated. In particular, the propagation losses in hydrocarbon stratum are much lower than in a water-bearing stratum while the speed of propagation is much higher. Thus, when an oil-bearing reservoir is present, and an EM field is applied, a strong and rapidly propagated refracted wave can be detected. This may therefore indicate the presence of the reservoir or its nature if its presence is already known.
>
> "Preferably, therefore, the method according to the invention further includes the step of analyzing the effects on any detected refracted wave component that have been caused by the reservoir in order to determine further the content of the reservoir based on the analysis."

30. This is best explained by reference to the drawing in Appendix 2. 37 and 38 are the transmitter and receiver respectively. 41 represents the "direct wave", which can be considered to be the wave which passes directly through the water. Since seawater is relatively conductive (relatively less resistive) the signal or wave attenuates faster than waves passing through more resistive structures. 34 is the seabed (the top of the overburden). 35 is the target layer, supposed for these purposes to be more resistive if it contains oil than it would be if it contained water. 42a and 42b represent a supposed reflected wave, being reflected off the top of the questioned layer. 43 is the "refracted wave". It represents a wave which is said to pass into the layer, and then to be refracted so that it can be picked up via the sort of route shown. This is the key to the invention. It depends on being able to "seek" this wave and identify it. If the layer contains water and not oil, the wave will not be present, or at least not in the same way, and the overall measured signals picked up will be different. As will appear from paragraph 0012 of the patent, it is said that the direct wave and the reflected wave, both of which will have passed through media which will have a lower resistivity than the questioned (oil-bearing) layer, will have attenuated more than the refracted wave, so that detection

is facilitated; and it is said it (the refracted wave) will travel faster and with less attenuation in the more highly resistive layer, and so be detected first and more strongly. In the words of the patent:

> "[0035] The transmitted wave also results in a refracted wave 43. This is composed of a downward portion 43a which descends through the overburden 34, a refracted portion 43b which travels along the layer 35, and an upward portion 43c which travels back up through the overburden 34. Since the refracted portion 43b travels much faster through the oil-bearing layer 35 and with far less attenuation, the refracted wave 43 is detected first by the detector 38 and at a relatively high signal level, compared to the direct wave 41 and the reflected wave 42a, 42b."

31. It was common ground that the description of the phenomena contained in the patent is not particularly pure physics. The patent itself, in using the words "regardless of the particular mechanism which in fact pertains" acknowledges this. The extent of the lack of purity was not completely agreed between the experts, though the end result was. The end result is that if one goes a sufficient distance away from the transmitter, one is picking up a signal which represents a relatively high portion of the signal that has gone through the resistive layer than the proportion that is received closer in. As will become apparent, the magic distance seems to be an offset of about 3 times the burial depth of the buried layer. Dr Chave insisted that the relevant physical laws were those of diffusion and not waves, so that the use of the term "wave", the depiction of the various waves in the diagram as if they were rays and the concepts of reflection and refraction (which strictly only apply in wave physics) were inapposite and incorrect. He went so far as to describe the use of "refracted wave" as not "provid[ing] any meaningful technical information" and the terms "direct wave" and "refracted wave" as not being "technically meaningful". When pursued, however, he accepted that it would have a practical significance and meaning to practical people, and indeed he used the concept of waves in the piece of prior art authored by him when he is apparently describing the same phenomenon. Amongst other references to waves, he used the expression "lossy wave guide which traps and guides the signal" in his own description of it in his prior art paper. Professor Schultz acknowledged that strictly speaking systems using the frequencies and conductivities used in the patent demonstrated "more diffusive" behaviour as well as wave behaviour, and he preferred to view the situation as one involving a "lossy wave equation". While accepting that this would not appear technically correct to the CSEM specialist, he said it would have meaning to his version of the skilled addressee, which was essentially a non-CSEM versed exploration geophysicist.

32. Despite first appearances, I do not think that the experts were all that far apart at the end of the day. Dr Chave was perhaps a stricter physicist, and wished to stand his ground as such. However, since even he was prepared to use what he described as "loose" terminology, and since he acknowledged that it had a practical meaning to practical people, and since Professor Schultz took that view as well, it is apparent that the patent is adopting an accessible manner of describing an understood phenomenon. It might even be regarded as a metaphor, and while there may be dangers in using metaphors to describe key integers of patents, it matters less if the underlying matter can be clearly understood. In this case I think it can be. Both Dr Chave and Professor Schultz used Poynting vectors to illustrate it. Their diagrams show energy flow through a structure. Dr Chave took more cases than did Professor Schultz, but each took the energy flow from a horizontal electric dipole where the layers, reading downwards, were sea, overburden more resistive than the sea, sediment layer very significantly more resistive than the overburden, and a further layer less resistive than the sediment layer; in other words, a more resistive layer sandwiched between two relatively less resistive layers, with the sea above. The Poynting vectors are arrows which show energy flow by their direction and show field strength by a differentially sized blob in the middle (Professor Schultz's vectors) or their density on the page (Dr Chave's vectors). Both show a strong directional energy flow along the buried layer when compared with the energy flow in the other strata (and sea and air). There is energy flow in the same and other directions at various points in the other strata, but one can see from this why the metaphors of wave guides, ducted waves and refracted waves are

used. This is the phenomenon of which the patent speaks, whatever the appropriateness or inappropriateness of the labels used. It is important to bear this in mind when considering the prior art. Where convenient I shall myself use the patent's descriptions of the phenomenon without thereby prejudging any questions that I otherwise have to decide - I have to use some description, and that is as convenient as any. It is also right to record that Dr Chave's diagrams (derived from computer modelling, not from field data) also show flows from a relatively conductive buried layer (which he also models) but those flows are different in strength and to some extent in direction.

33. The description is not confined to in-line configurations, though in-line is preferred:

> "[0011] Preferably, the applied electromagnetic field is polarized. Preferably, the polarization is such as if created by in-line horizontal transmitter and receiver antennas".

34. Paragraph 0012 deals with offset:

> "If the offset between the transmitter and receiver is significantly greater than three times the depth of the reservoir from the seabed (ie the thickness of the overburden), it will be appreciated that the attenuation of the refracted wave will often be less than that of direct wave and the reflected wave. The reason for this is the fact that the path of the refracted wave will be effectively distance from the transmitter down to the reservoir ie the thickness of the overburden, plus the offset along the reservoir, plus the distance from the reservoir up to the receivers ie once again the thickness of the overburden."

35. The description does not confine itself to marine CSEM:

> "[0014] The technique is applicable in exploring land-based subterranean reservoirs but is especially applicable to submarine, in particular sub-sea, subterranean reservoirs."

Claim 1 as granted includes all subterranean reservoirs, but as will appear EMGS proposes an amendment to add a claim 1A which confines itself to submarine reservoirs.

36. Paragraphs 0017 to 0026 deal with some more background, explanations and technicalities. So far as relevant to this judgment they provide as follows.

37. Paragraph 0017 acknowledges that electro-magnetic surveying techniques were known, but not widely used in practice. It points out that in carrying out an electro-magnetic survey, in order to achieve any reasonable degree of resolution, short wavelengths are necessary. Unfortunately, those wavelengths suffer from very high attenuation. Long wavelengths do not provide adequate resolution. "For these reasons, seismic techniques are preferred".

> "[0018] However, while longer wavelengths applied by electro-magnetic techniques cannot provide sufficient information to provide an accurate indication of the boundaries of the various strata, if the geological structure is already known, they can be used to determine the nature of a particular identified formation, if the possibilities for the nature of that formation have significantly differing electro-magnetic characteristics. The resolution is not particularly important and so longer wavelengths which do not suffer from excessive attenuation can be employed.
>
> "[0019] The resistivity of seawater is about 0.3 ohm-m and that of the overburden beneath the seabed would typically be from 0.3 to 4 ohm-m, for example about 2 ohm-m. However, the resistivity of an oil reservoir is likely to be about 20-300 ohm-m. This large difference can be exploited using the techniques of the present invention. Typically, the resistivity of a

> hydrocarbon-bearing formation will be 20 to 300 times greater than the water-bearing formation.
>
> "[0020] Due to the different electro-magnetic properties of a gas/oil bearing formation and a water-bearing formation, one can expect a reflection and refraction of the transmitted field at the boundary of a gas/oil bearing formation. However, the similarity between the properties of the overburden and a reservoir containing water means that no reflection or refraction is likely to occur.
>
> "[0021] The transmitted field may be pulsed, however a *coherent continuous wave with stepped frequencies* is preferred. It may be transmitted for a significant period of time, during which the transmitter should preferably be stationary (although it could be moving slowly), and the transmission stable. Thus, the fields may be transmitted for a period of time from 3 seconds to 60 minutes, preferably from 3 to 30 minutes, for example about 20 minutes. The receivers may also be arranged to detect a direct wave and a wave refracted from the reservoir, and the analysis may include extracting phase and amplitude data of the refracted wave from corresponding data from the direct wave.
>
> "[0022] Preferably the wavelength of the transmission is given by the formula
>
> $0.1s \leq \lambda \leq 5s$;
>
> where λ is the wavelength of the transmission through the overburden and s is the distance from the seabed to the reservoir. More preferably λ is from about 0.5s to 2s. The transmission frequency may be from 0.01Hz to 1kHz, preferably from 1 to 20 Hz, for example 5Hz."

38. The succeeding paragraphs deal with data analysis and suggest mathematical modelling, comparing mathematical models of various possibilities with the actual data received. Paragraph 0025 contains references to domains:

> "[0025] Preferably, the analyzing means is arranged to analyze phase and amplitude. The data can be analyzed using time domain and frequency domain techniques, and other pulse sharpening techniques. Thus, the data can be made to mimic seismic data so that the conventional seismic post-processing techniques can be employed."

39. Paragraph 0027 refers to combining these techniques with seismic surveys:

> "[0027] The present invention also extends to a method of surveying subterranean measures which comprises; performing a seismic survey to determine the geological structure of a region; and where that survey reveals the presence of a subterranean reservoir, subsequently performing a method as described above."

40. The patent goes on to describe an experiment which was carried out and which is described "by way of example". A drawing is annexed to illustrate it. The drawing appears in Appendix 1 to this judgment. It is quicker to describe the experiment in my own words than set out the words of the patent. The drawing shows a waterbed mattress, containing fresh water (12) suspended in a medium of saline water. A transmitter and receiver (13 and 14 respectively) are placed in the water and a signal is transmitted. With the transmitter and receiver in the upper position the signal is turned down until it cannot be detected passing through the water. The transmitter and receiver are then

lowered to the lower position, at which point it is said that the signal re-emerges. It is said that the route of this re-emerging signal is the "refracted" wave route shown as 21 on the diagram. This is said to simulate a more resistive oil-bearing layer. Although it is not expressed in the patent, the experiment relies on the scientific fact that fresh water is more resistive than saline (seawater).

41. The patent then sets out a "more practical example" in the form of the diagram in Appendix 2 to this judgment and describes it more extensively than I have done, but I do not need to set out the relevant paragraphs. I have already set out paragraph 0035, above.

42. The relevant claims in the patent are set out in Appendix 3 to this judgment. That appendix includes Claims 1A, 1B and 1C, which are claims which EMGS seeks to add by amendment. If the amendments are allowed, there are consequential amendments to later claims. The amendment to claim 1 (to substitute "submarine" for "subterranean") is sought unconditionally. EMGS does not concede that in its unamended form it is invalid, but nonetheless does not seek to maintain it in that unamended form. The amendment to add claim 1A is sought conditionally - it will not be pursued if amended claim 1 is valid. It is only if it is invalid that I have to consider the validity of claim 1A. There was no significant opposition to the amendment, save that it was said that the amendments would not save the patents or give rise to valid claims, and in those circumstances I would be minded to allow the amendments so far as they give rise to a valid claim. I shall consider validity of the proposed amendments on the assumption (for the purposes of the validity arguments) that there has been an amendment. The principal purpose of claim 1A is to expand on the "nature" of the reservoir, so that it becomes explicit that what is being looked for is whether the reservoir contains hydrocarbons or water. In the latter part of the appendix I have shown claim 1 broken down into its integers, to some of which reference will be made hereafter.

The inventive concept

43. It will be helpful at this stage to identify the inventive concept which is alleged to be contained in the patent. For present purposes I can take it from a formulation in Mr Burkill's skeleton:

> "The inventive concept of this claim is the realisation that the presence or absence of the refracted wave can act as a discriminator for hydrocarbons."

This makes various things clear. First, there is no claim to have discovered the refracted wave itself. It is accepted that the refracted wave is a physical phenomenon which has always existed and has been identified before. Nor is it claimed that the invention is the detection of the wave. It is narrower than that. It is the use of the wave for the direct detection of hydrocarbons.

44. When put this way it risks perpetuating the misdescription of the physics. It makes it look as though what one has to do is carry out a survey by sailing a ship with the necessary electrical equipment, recording a signal, looking at the result (with appropriate equipment and expertise) and then identifying a wave from the signal. That does not describe the physics or the practicalities. It is common ground that there is no wave which one can individually look at with equipment and identify as the particular kind of wave described in the patent. A CSEM survey involves the receipt of a transmitted signal, and determining such things as its amplitude, or phase, or frequency content. It does not involve separating out different sorts of wave components (other than any Fourier transformations necessary to look at desired frequencies).

45. This has potential ramifications for the word "seek" in claim 1 of patent 019. What claim 1 requires one to "seek" is not a component of the response representing such a wave. Something else has to be looked at, or looked for. It is necessary to bear this in mind because when looking at the prior art one has to see whether there is disclosure of the equivalent of the underlying true concept whether or not it is described in the same terms, and the process of "seeking" has to be considered in the light of a close appreciation of what one is doing. The word "seek" will mean different things in different contexts. The seeker of a rare butterfly is carrying out some well-understood physical

activities; a scientist who seeks the Higgs boson is doing something less well understood, with some rather different tools (many of them theoretical); and a seeker after justice and truth is doing something physically very different again, though it will be a metaphorical equivalent of the other two activities. So one must understand the sort of thing which is the subject of the inquiry before one can judge what activities are necessary to "seek" it.

46. Because metaphors are at work, they should be penetrated before measuring the invention against the prior art (or vice versa). Fortunately it is unnecessary for me to make elaborate scientific findings as to what the relevant effect is. All the experts agreed that it is for at least some purposes, including the present, adequately described as a ducted wave. It is probably sufficient for me to describe it as the phenomenon, in terms of signal received, which is observed when a more resistive substance carries an electric field, and an electric signal, farther, faster and with less attenuation than other adjacent less resistive substances. This phenomenon has to be detected by sophisticated electronic means, and by analysing the pattern of receipt of signals with appropriate tools. "Seeking" therefore has a metaphorical, more abstract quality within the range of meaning referred to above. It does not involve tuning in receiving equipment so that it responds only, or mainly, to a particular signal in a way which gives a filtered read-out which shows zero for everything but the relevant signal. The signal received at a given point at a given time will be the result of the environment on the transmitted field, and (metaphorically) the route or routes that it has taken to get there - a direct route through one medium, a less direct route through more than one medium, the resistivities of the materials en route and so on. The invention claims that there is an offset between the transmitter and receiver at which the wave which has passed along the more resistive layer is the predominant signal, the signals taking other routes having attenuated more. "Seeking" involves (inter alia) determining the point at which it can be inferred that the signal received has this characteristic, or determining that a received signal has this characteristic, by studying and comparing such things as amplitude and/or phase of the received signal.

The skilled addressee

47. A patent is to be taken to be addressed to the skilled addressee, someone skilled in the subject matter of the invention ("a person skilled in the art" in the words of the statute). There was a serious dispute as to who this notional person was in the present case. EMGS said it was an exploration geophysicist, and the expertise of a CSEM expert did not form part of the skills of a skilled addressee. Its main point was that the invention involved the realization that CSEM could be deployed in this area, and to allow a CSEM expert into a skilled addressee team, as contended for by Schlumberger, would be to assume the invention and the inventive step of the 019 patent. Schlumberger said it was a team which included a CSEM expert (and also a geophysicist). The difference between the parties was therefore as to the presence of a CSEM expert as part of such a team. This also raised an insufficiency squeeze. Schlumberger said that if the patent was not to be taken to be directed to (inter alia) a CSEM expert, then it was insufficient because it could not be worked without such expertise being available. EMGS's counter to that was, first, that it failed on the facts, because the patent could be worked by a geophysicist; and second, that so far as necessary one could have different skilled persons for sufficiency purposes on the one hand and obviousness (and presumably construction) purposes on the other.

48. It will be convenient to deal with those two counters first.

49. The first is a question of fact. On the evidence it seems to me to be artificial to consider that an exploration geophysicist could have worked this patent in the manner intended by patent law. I consider that Schlumberger is correct in saying that the patent itself does not provide enough information to enable it to be worked by an exploration geophysicist with no prior experience. It specifies the idea, but it does not tell you how to go about the task of conducting a CSEM survey at sea in order to "seek" the refracted wave. It does not cover the practical points of how the survey is physically conducted, and it does not cover the more theoretical points of how you interpret the data when you have got it other than to refer to mathematical modelling in paragraph 26. The

geophysicist would have to do a lot of work in order to put himself in the position of conducting and analysing the survey. That was demonstrated by the cross-examination of Professor Landro. He gave evidence to the effect that a geophysicist could work it. He would start from the patent, and would have the benefit of some basic teaching from works such as Kearey and Brooks (a standard student textbook). He went carefully through that book looking for material which would help him put together a survey (and, to be fair to him, identifying at least one remark which highlighted the difficulties in achieving what he was notionally setting out to achieve). He described that he would do literature searches, and how it was that the patent spoke to him in terms that he understood as a seismologist. It gave him some material with which he could work in order to choose frequencies (via skin depths) which would be appropriate for the job. He would look at three particular works which Kearey & Brooks identify as being relevant. An electrical engineer would be engaged to make the right sort of hardware.

50. Looking at his evidence overall, I do not think that it would be fair to describe what he was doing as an account of how a geophysicist would work the patent. What he was basically saying was that in order to carry out the teaching of the patent he would have to indulge in so much self-education that he would be putting himself in the position of a CSEM practitioner. In other words, without acquiring, or bringing in, another expertise, EMGS's skilled addressee could not work the patent.

51. Professor Schultz's evidence was consistent with that. He confirmed that someone without knowledge or expertise in carrying out CSEM surveys would have to acquire that knowledge or expertise before he or she could put the teaching of the 019 patent into effect. There was "learning involved". He said that in fact the way one would acquire the knowledge is actually by putting together a team of people who, in aggregate, have the elements of the expertise required.

> "The contrast with the EM expert is, in one person there is a much broader range of expertise at their mastery and they would have not to buy in additional help to that extent."

So the CSEM expert shortcuts the need to put together the expertise in bits; but there is still a need to acquire some expertise.

52. The real effect of this evidence is that the geophysicist cannot work the invention without himself becoming a CSEM specialist. The work involved cannot be characterised as merely boning up on a couple of practical matters. To say otherwise is to disguise the real need for a CSEM expert to work this invention. There are some details or suggestions of wavelengths and offsets, but not enough to enable the patent to be worked. If time is a significant measure, it would take months for a geophysicist to put himself in a position of working this invention. That is not absolutely determinative, but it is an indication of the real work involved, and an indication that any attempt to say that it can be done is really to disguise the fact that a CSEM expert is necessary.

53. The second is a question of law and construction of the statute. The wording of the Patents Act 1977 does not provide a lot of support for the proposition that there can be two skilled addressees, one for obviousness (and, I suppose, construction) and another for sufficiency. Section 3 provides:

> "3. An invention shall be taken to involve an inventive step if it is not obvious to a person skilled in the art …"

Section 14(3) provides:

> "14(3) The specification of an application shall disclose the invention in a manner which is clear enough and complete enough for the invention to be performed by a person skilled in the art."

And section 72(1) provides for the revocation of a patent on grounds which include that:

> "(c) the specification of the patent does not disclose the invention clearly enough and completely enough for it to be performed by a person skilled in the art."

54. Those provisions use the same expression throughout in describing the skilled addressee, and there is no verbal basis for distinguishing between the person or persons who fulfil the requirements of section 3 and those fulfilling the requirement for sections 14 and 72. The reference to the art must be to the art relating to the invention. It would not make a lot of sense for the art in sections 14 and 72 to be the art of implementation but not the invention itself. The statute therefore seems to point strongly to the same persons being the skilled addressee throughout, and for all purposes.

55. This seems to me to accord with common sense and principle. It produces a sensible result. The circumstances in which it really matters who is in the notional team are on questions of obviousness, and to a lesser extent construction. Imagine a case like the present in which the invention is said to be the introduction and application of Technology 2 (T2) into an area in which formerly just Technology 1 (T1) was applied, and obviousness is in issue. If the introduction and application would not be obvious to the skilled addressee in either field, then the introduction of a T2 skilled addressee to the team would make no difference to validity. If it would not have been obvious to a T1 skilled addressee, but would have been obvious to a T2 skilled addressee, then I can see no reason why inventiveness should be claimable for the invention. Why should the T2 skilled addressee be prevented from doing something which is obvious to him? In my view it would be contrary to principle if he were so prevented. On this basis a person with those skills would not fall to be excluded from the team, and if he has to be introduced to render the patent sufficient, it produces a consistent overall pattern. He is, by the very nature of his expertise, a person interested in the area in which the patent is to be practised.

56. I therefore approach the skilled addressee point on the footing that the patent could not be worked without a CSEM expert, and that there is no legal justification for (as it were) two different notional skilled addressees as contended for by EMGS.

57. There is one further background point of fact that was raised by EMGS in relation to this issue. On the evidence, it appears that oil companies and oil exploration companies did not routinely involve CSEM specialists in their surveys, at least in the circumstances of the intended operation of these patents. As a matter of practicality, they did not have CSEM specialists as part of their actual exploration teams. As at the priority date those responsible for researching for oil companies had some knowledge of CSEM. Well-logging was an established application, and that involved CSEM. An exploration geophysicist would have acquired a general knowledge of CSEM (as to which see below), and would know of the existence of the techniques, at least generally. However, with the possible exception of Russia, where land-based CSEM was deployed in a manner of which the western world was not wholly clear, there is no evidence that any of the oil explorers routinely used, or considered, CSEM techniques. There is no evidence that those with an expertise in, or deep knowledge of, CSEM were brought in to the planning or execution of oil surveying. Accordingly, looking at what actually happened in practice, those with a practical interest in this invention would not have included a CSEM specialist, especially where a marine survey was involved. There were only two sources (sets of equipment) in the world capable of carrying out marine CSEM of the sort needed, and they were in the hands of academics in Cambridge/Southampton, and at the Scripps Institute in San Diego. Professor Landro confirmed that a typical team, in real life, would not normally include such a specialist.

58. However, that point is not determinative of the constitution of the skilled addressee. The skilled addressee is a notional construct for the purposes of the statute. One does not identify him/her, or the constituents of the team, by finding some actual equivalent in the real world. The addressee is the notional person to whom the patent is taken to be addressed. Obviously the real world provides a context, but the absence of any CSEM specialist on the exploration teams of any oil company, or the absence of any involvement of such a specialist with such a team, is not necessarily

determinative of the appropriate addressee of the patent.

59. With those points disposed of I can therefore turn to identifying the skilled addressee and considering the rest of the submissions of the parties. Schlumberger relies on statements in well-known cases to which I will come, but particularly relies on what Pumfrey J said in *Minnesota Mining & Manufacturing Co v ATI Atlas Co* [2001] FSR 514. In that case Pumfrey J was faced with a patent which exploited the behaviour of enzymes as indicators of the effectiveness of a sterilisation process. At the priority date the persons concerned with sterilisation indicators were microbiologists (see paragraph 29). The inventive step was said to be the discovery that enzymes could survive when micro-organisms would not. The defendants maintained that that was obvious to an enzymologist, and he should be part of the notional addressee team. The claimants apparently disputed that. Pumfrey resolved the dispute at paragraph 30 of his judgment:

> "30 It seems to me that as a matter of principle invention cannot lie in bringing into a notional team working on a particular problem a new notional member with different skills from those of the existing notional team. The specification necessarily describes the attributes of the team to which it is addressed. Here, the team consists (notionally) of a microbiologist and an enzymologist. There was some suggestion that the patent is addressed to a microbiologist alone, who would have sufficient knowledge of enzymology to put the invention into effect but insufficient insight to appreciate the significance of enzymes in the survival of bacteria or of their spores. I reject this suggestion. The addressee of a specification is the person likely to have practical interest in an invention: here, it is the maker and seller of sterilisation indicators who wishes to make an indicator following the directions of the patent, and I am satisfied that for this purpose he employs a microbiologist with interests in the relevant area and an enzymologist who can carry out the directions of the specification. The notional team will also have a good knowledge of the relevant standards existing in 1988, and will be aware of the simple statistical assumptions which underlie sterilisation detectors."

60. EMGS says that the skilled addressee is an exploration geophysicist, and one stops there. It relies particularly on the fact that the invention was to introduce CSEM into the activity in the first place, and to include a CSEM specialist into the skilled addressee team would be to assume the invention and the inventive step. It would be approaching the matter with the benefit of hindsight into the usefulness of the invention. In support of this Mr Burkill relied on various cases, but in particular on a case in the Technical Board of Appeal, *Jalon T422/93*. The case concerned the incorporation of security fibres, and the invention was said to be pre-dyeing the fibres in question. At paragraph 3.6 of its judgment the Board reversed the finding of the Opposition Division in relation to the identity of the skilled person. The Division had found that the skilled person was an expert in dyeing fibres. The Board said:

> "In the present case, however, the principle of introducing a rare earth chelate by a dyeing process quite clearly forms part of the solution to the technical problem to be solved … The expert in dyeing cannot therefore be the skilled person who was faced with the task of solving the problem, because the very fact of choosing to introduce rare earth chelates by a dyeing process is the essential feature of the solution proposed. The board consequently takes the view that the skilled person faced with the task of solving the problem posed was not an expert in dyeing, but rather an expert in security materials …"

Later, the board warned against hindsight:

> "The technical problem addressed by an invention must however be so formulated as not to contain pointers to the solution, since including part of

> a solution offered by an invention in the statement of the problem must, when the state of the art is assessed in terms of that problem, necessarily result in an ex post facto view being taken of the inventive step."

61. The starting point in this area of debate should be the classic formulation in *Catnic Components Ltd v Hill & Smith Ltd* [1982] RPC 183. At p 242 Lord Diplock said :

> "My Lords, a patent specification is a unilateral statement by the patentee, in words of his own choosing, addressed to those likely to have a practical interest in the subject matter of his invention (ie 'skilled in the art'), by which he informs them what he claims to be the essential features of the new product or process for which the letters patent grant him a monopoly … The question in each case is: whether persons with practical knowledge and experience of the kind of work in which the invention was intended to be used, would understand that strict compliance with a particular descriptive word [etc]". (My emphasis)

62. The important words are those which I have emphasised. Who are those persons? It does not mean the oil companies – the people who run those cannot be skilled addressees. The skilled addressee has to be a practical man. So who, in the present context, is the person with the knowledge and experience in the emphasised passage? In my view it should not be taken to be just the kind of person who, in the real world, constituted the usual team (which would therefore not include a CSEM specialist). In order to utilise the invention at all a CSEM specialist has to be engaged, as I have found above. The whole technique involves the use of CSEM. As a document, it is apparently addressed to a person who can carry out such activities (as well as others). One is looking at the addressee of the document, not just those constituting actual teams in what I have called the real world.

63. Mr Burkill's submissions that such a conclusion looks at the team with the benefit of hindsight themselves take the wrong starting point. His description of the invention is useful for various purposes, but it cannot be used to define or limit the constitution of the skilled addressee team. The novelty of the invention as described by him has to be tested against the knowledge and skills of the addressee team. Logically and conceptually one has to set up the team, so that the inventiveness of the alleged new invention can be tested. The team is notionally set up by looking at the terms of the patent, not at the distillation of what is said to be the invention in it.

64. The approach that I have identified is consistent with other authority. First, it is consistent with *Horne Engineering Co Ltd v Reliance Water Controls Ltd* [2000] FSR 90. At paragraph 14, in the context of considering common general knowledge, Pumfrey J said:

> "I would add that although it has to be remembered that a specification may fail to provide sufficient details for the addressee to understand and apply the invention, and so be insufficient and invalid, it is often possible to deduce the attributes which the skilled man must possess from the assumptions which the specification clearly makes about his abilities."

That is the case in the matter before me. It is clearly possible to deduce that the skilled addressee is to have an expertise in CSEM techniques, surveys and analysis. The skilled addressee is assumed to have the ability to carry them out.

65. It is also consistent with what Laddie J said in Inhale *Therapeutic Systems Inc v Quadrant Healthcare plc* [2002] RPC 21. He was faced with arguments which concerned whether the skilled addressee should have an expertise in one type of freeze drying rather than spray drying. The patentee argued that the skilled addressee would have expertise in the former only, notwithstanding the fact that the claimed monopoly related to the latter. Laddie J rejected these arguments. In paragraph 41 he pointed up the oddity which would result if an invention which was obvious to

those practising in spray drying (the field with which it was concerned) was nonetheless valid because it was not obvious to those who knew about freeze drying (with which the invention was not concerned). That supports part of my own reasoning above. Then in paragraph 42 he said:

> "In some cases a patent claim may cover a wide field so that some parts of it will be obvious to the notional skilled person in one field and other parts will be obvious to the notional skilled person in another. That is not unfair to the patentee … but [is] simply a reflection of the fact that the scope of the protection sought is wide. I accept, of course, that in some cases there will be invention in marrying together concepts from two unrelated arts, but that is not what Mr Carr is arguing for here."

66. All these cases, of course, turn on their own facts, but the principle behind Laddie J's statement applies to the case before me. The claims in the patent go into the realms of CSEM. A CSEM specialist is needed to work them. It is not unfair to have regard to the views on obviousness of such a specialist because the patent is wide enough to bring in his field. His remarks about invention in marrying two concepts from unrelated arts indicate that he was not actually considering that position, which (at least according to EMGS) I am, but in my view I do not see that the position should be any different, for the reasons given above.

67. Mr Silverleaf said it was also in line with *Richardson-Vicks Inc's Patent* [1997] RPC 888. Aldous LJ said (having just referred to section 3 of the Patents Act 1997, but not any of the later sections):

> "It is therefore clear that the relevant person must have skill in the art with which the invention described in the patent is concerned. In some cases the patent may include within it information derived from or utilising more than one aspect of science or technology and in such cases the notional skilled addressee, the person skilled in the art, will consist of a combination of scientists or technicians having those skills …"

68. Applied literally, these words would probably bring a skilled CSEM person within the team. The patent utilises the technology of marine CSEM. However, on its facts that case was an exclusion case - it was concerned with qualifications for inclusion in the team (which the candidate under discussion did not have) rather than providing an all-embracing definition of who was necessary for the team. Carefully read, it does not provide the support that Mr Silverleaf seeks to take from it.

69. One also needs a little care in applying his other authority, namely *Minnesota*. His submissions, and my conclusion, are not inconsistent with what Pumfrey J said there, but I prefer to rely on the reasoning above than what appears in *Minnesota*. Pumfrey J's line of reasoning in arriving at the constitution of his team is, with respect, not wholly clear or articulated, and part of it might be said to be inconsistent with *Mutoh Industry Ltd's Application* [1984] RPC 35. But I do not need to say any more about that, because there are other lines of reasoning available to me.

70. I do not consider that what I have said above is inconsistent with *Jalon*. It is not apparent that there was an insufficiency problem in *Jalon*. What the Board did in that case was repudiate the Opposition Division's choice of the dyer as the skilled person, when that choice was made on the basis of prior art. The point in issue there was apparently the choice of the sole skilled person, and the remarks of the Board were made in that context. The equivalent of the Opposition Division's choice of skilled addressee in the present case would be a CSEM specialist as the sole addressee. That, for what it is worth, was Dr Chave's skilled addressee, and I do not consider that that is right. It would be too much of a distortion of the notion of the person to whom it is addressed. The CSEM specialist is there, but for a different reason.

71. It also arrives at a result which is in line with principle, for reasons already given above. Suppose that there is a cloistered world of CSEM experts to whom the application of their marine craft to oil exploration was quite obvious, but whose views had not crossed into the realms of the actual oil explorers, and let it be supposed that the application of CSEM was in no way obvious to the latter.

If Mr Burkill's submissions were correct, there would be a skilled addressee team of geophysicists, and the patent would not fail for obviousness; and the CSEM specialists would be prevented from doing something which is quite obvious to them. That seems to be wrong in principle, and that result is avoided if they are part of the team. If, next, one supposes that CSEM is not obvious to them, then their introduction to the skilled addressee team still does not render the invention obvious, and the new technique is truly inventive. Again, that is consonant with principle. The invention will result from marrying together two unrelated arts (to revert to what Laddie J said in *Inhale*) but that would be a correct result where the inventive concept would not be obvious to the practitioners of either. I stress that this part of the reasoning is not used to determine the constitution of the team; it is used to test the consequences of the arguments.

72. Accordingly, in my view the skilled addressee in the present case would be a team, comprising a geophysicist and a CSEM specialist. I do not consider that the latter would necessarily be a marine CSEM specialist, but that will not make any difference to this case at the end of the day. I consider that, in a very real sense, this patent is addressed to both of them, notwithstanding that it claims to be inventive in involving the latter in the first place. I repeat a point made above. This conclusion produces a result which is consistent with principle. If the invention is obvious to a CSEM expert, why should the patentee be entitled to its exclusive use because it is not obvious to a geophysicist? Why should the CSEM expert, who can work it out, be prevented from applying it?

73. Having said all that, I doubt if that point will make a lot of difference at the end of the day. In relation to the 019 patent there is no allegation of obviousness over common general knowledge. As a result of the position adopted by EMGS by the end of the trial in relation to the knowledge of a geophysicist in relation to CSEM, the baseline common general knowledge of both the geophysicist and the CSEM specialist, while different in extent, will have had sufficient common elements to mean that they would not take different views in relation to obviousness over any of the prior art. However, insofar as that is wrong, then as a result of my conclusion as to the constitution of the team, Schlumberger would be entitled to have the benefit of the position of the CSEM specialist. So far as the questions of construction are involved, I cannot see that adopting the position of either member of the notional team would lead to differing views on those questions.

74. That conclusion and reasoning also deals with the sufficiency point. Since the skilled addressee is a team which includes someone who can carry out a CSEM survey, the patent is not insufficient. I would, however, add that if my conclusions are wrong, and a CSEM specialist is not among the skilled addressees, then the patent would be void for insufficiency, because it would not contain sufficient directions for carrying out what is proposed in it.

Points of construction

75. Various points of construction arose in relation to this patent. I have dealt with one or two already and the rest are better dealt with in the context of the issues in relation to which they actually arise rather than in a generalised sense here.

Contemporaneous evidence going to obviousness

76. This is a case in which the patentee sought to rely on the reaction of scientists and the industry at the time the invention was conceived, developed and announced. It sought to say that that reaction demonstrated that the invention was not obvious. Schlumberger did not dispute the relevance of such evidence as a matter of principle, but sought to say that evidence of that nature needed to be kept in its place (that is to say, it was secondary), and that the actual evidence in this case had little or no weight, or indeed significance.

77. The leading authority on the place of this evidence is the decision of the Court of Appeal in *Mölnycke AB v Procter & Gamble Ltd* [1994] RPC 49 at p 112ff. The relevant passage is set out in Terrell on Patents at paragraph 7-51, and it is unnecessary to lengthen this already long judgment by setting it out in full. The material points which emerge from it are:

i) The expert evidence is the primary evidence; the contemporaneous evidence is relevant, and has the merit of being untainted by hindsight, but secondary. It can be used to test the expert evidence.

ii) There is a danger in getting too caught up in an investigation of what was and what was not obvious to certain identified (and even more so unidentified) individuals, because they may not all have been aware of the state of the art - the state of the art (within the meaning of the statute) is the important starting point.

iii) The evidence may invite a degree of inadmissible speculation as to the inventiveness of the persons involved.

iv) Commercial success (if relied on) may be attributable to novelty (want of obviousness), but there may be other factors operating. Care must be taken to ensure that is not the case.

v) The importance and weight of the evidence will vary from case to case.

78. In addition, where contemporaneous evidence is relied on, and it demonstrates some sort of commercial success of the idea, one must be live to the distinction between what was commercially obvious (or not obvious) and what was technically obvious (or not obvious). A new approach may find success because it has become appreciated that it has become commercially worthwhile, rather than its being appreciated as something new which will assist. If the success is attributable to the former, then the evidence does not support novelty in patent terms.

79. I bear all those points in mind. So far as they demonstrate potential vices, most are present in the evidence in this case.

The history of the invention and subsequent events

80. It is necessary for me to deal with the history of the invention, and its first implementation, because EMGS maintains that there are elements in it which support a finding of non-obviousness.

81. In the 1990's Dr Eidesmo and a colleague Mr Svein Ellingsrud were investigating the use of EM fields and radar to map the motions of oil/water contacts within oil reservoirs. In late 1997 they had a meeting with representatives of NASA, who had some general EM expertise, and some others. NASA representatives mentioned a powerful magnetic source which they believed could penetrate deep underground. That was a trigger for a discussion between Dr Eidesmo and Mr Ellingsrud on a flight on the way home about using such a source to survey the seabed for highly resistive hydrocarbon-filled reservoirs. They knew about the use of EM in well-logging, and knew that such reservoirs were more highly resistive than their surroundings. They appreciated that a low frequency signal would be required to penetrate down to the layer (because low frequency signals attenuate less rapidly than higher frequency signals) and wondered whether it would be possible to use a strong low frequency signal to impact on the layer in a manner which would transmit detectable energy back to the seafloor. They worked with the Norwegian Geotechnical Institute ("NGI") on this idea, and reports were produced based on modelling using an EM source and transmitters.

82. The first report involved modelling and claimed to show that "the reservoir refracted EM-waves (TE-mode) are surprisingly strong". It is common ground that this reference to TE mode is a mistaken reference; it should be TM mode. The second report, called "Radar 1" for short (that was a code-name - it did not reflect the technology) had as one of its main tasks the object of analysing the feasibility of detecting a thin buried oil layer, in the expectation that it would act as a wave guide. The authors conducted a literature survey and set out what they considered the "state of the art" to be. They identified the three groups in the world who were active in the area (Scripps Institute, Cambridge University and the University of Toronto), and identified the "Main aim of the research" as being "Detect earth resistivity versus depth where deep part has a higher resistivity; Detection of thin lens (layer) is also discussed at [the Chave prior art paper]." This demonstrates that the researchers had relied, inter alia, on Dr Chave's prior art paper (see below); it is also

identified as one of the papers relied on in the extensive bibliography. Various equations are set out, derived from the prior art, and it describes the tank experiment that is identified in the patent. In its conclusions it concluded that the refracted wave would be bigger than the direct wave in a 2D case for TM mode, and that the "guide wave phenomenon had been observed in the two tank experiments". The results worked in in-line but not in broadside mode.

83. Meanwhile Dr Eidesmo had been talking to some of the academics who had been conducting work in the field. In 1998 Dr Eidesmo and Mr Ellingsrud had visited Prof Constable and Dr Cox at the Scripps Institute in San Diego, and had a discussion about EM methods generally without saying that they planned to use them for direct hydrocarbon detection. The visitors had their own ideas on that which they would not have wanted to disclose at that point. Those two academics were leading exponents of the use of CSEM in geological exploration and had written a number of papers about it. Prof Constable was a co-author of the Chave prior art. There is no doubting their eminence in the CSEM field. Dr Eidesmo's second witness statement says that Prof Constable commented "just as a statement" that he did not think it was possible to use CSEM for oil exploration. I have difficulty in accepting this evidence and think that Dr Eidesmo is mistaken about it. His cross-examination revealed that (understandably) a lot if not most of the detail of this conversation has been forgotten by now (it was, after all, 10 years ago), and while that remark, if made, might have been more likely to stick in the mind than some of the detail, I still think that it is misremembered detail. Dr Eidesmo was unable to provide any context for it, and bearing in mind that they were not talking about direct detection of hydrocarbons (probably because Dr Eidesmo was steering clear of a direct approach so as not to reveal his hand) it is not easy to imagine how it came up. For Prof Constable to have said this is probably inconsistent with the stance he had apparently taken in 1984, which was to try to interest industry (including, presumably the oil industry) in marine CSEM. Furthermore, it is inconsistent with what Prof Constable said in a later email, to which I will come later in the narrative. This remark, therefore, which is relied on by EMGS in support of its obviousness case, is not proved.

84. When some more work had been done on the project, in November 1999, Statoil invited Prof Constable to carry out a peer review of its work. He was invited to Trondheim for that purpose. He was given presentations of the work, and his response was said to have been one of positive surprise. He was given the information which was used to run a 1D model of what Statoil was looking at. Statoil (or the NGI) had used its own software to model. Prof Constable used his own, on his own laptop, and said that his model verified Statoil's conclusions.

85. He followed this up with a letter dated 7th November 1999. The letter says it is to serve as a report for his peer review conducted on 1st to 3rd November, and the second paragraph reads:

> "Statoil proposes the use of seafloor electromagnetic (EM) sounding as a fluid predictor over existing prospects. The seafloor EM method is not new - it has been in development for nearly 20 years and is being carried out by universities such as Cambridge, Toronto, and Scripps Institute of Oceanography. I personally have been active in this field for 16 years. The method works by injecting EM energy of around 1 Hz into the seafloor. Measurements of attenuation as a function of range and frequency provide estimates of seafloor resistivity. *The proposed application to direct detection of hydrocarbons is, to the best of my knowledge, novel."* (My emphasis)

The emphasised words are relied on by EMGS. I shall return to them. The letter goes on (omitting irrelevant parts):

> > "The conclusions of the model assessment are that if the target is not too small compared with its depth of burial, and the water depth is sufficient to suppress the air wave, then the controlled source signature of the oil-filled layer is detectable, yielding the controlled source amplitudes that are a factor of 2 to 10 different than for models without the oil layer. The signals

> are above the noise threshold, and the experimental parameters (frequency, range, antenna length, and power) are practicable."

That paragraph is merely approving techniques. It does not purport to express a view on novelty. The letter goes on:

> "The study also showed that (i) an inline Tx/Rx gives a stronger signal than the parallel Tx/Rx case, (ii) the method is robust to variations in overburden resistivity typical of well logs, and (iii) that controls on location and depth from seismic studies can be used to optimize survey parameters and generate off-target/on-target discriminators.
>
> "There are weaknesses to the study: computer models of a 3D source and 1D target could have been carried out fairly easily with publically [sic] available code, and one of the analogue model studies used radar frequencies and wave propagation rather than the diffusive propagation necessary to detect deep targets. However, the work took the group from almost no experience in this field to having a reasonable physical insight into the method. Their conclusions are not only basically correct, but they have discovered properties of the method known only to a very few experts (ie that the parallel/inline mode split is diagnostic of buried layers)."

This commends the techniques, and the research, but does not suggest novelty. On the contrary, it concludes that the work has brought the group up to speed with others, albeit only a very small number of others.

> "I used a 3D source/1D target code during my visit to verify Statoil's qualitative and quantitative conclusions. I would also note that the choice of controlled source EM is appropriate, as a thin resistive layer is invisible to other commonly used EM method, magnetotelluric sounding. In conclusion it is my opinion that the proposed method has a reasonable chance of success for sufficiently large targets (the type being suggested)."

86. He then goes on to say it would be appropriate to have a field trial. Practical matters that would have to be considered are suggested the effect of which cannot be assessed by modelling (including some logistical matters). Models would need to be run "to determine when targets get too small, deep and thin to detect". He ends by saying:

> "I wish Statoil every success in its endeavour; it is pleasing to see innovative research coming out of the industry sector."

87. This last statement is heavily relied on by EMGS in support of a submission that contemporaneous reactions of people in the know showed that what Statoil was proposing was novel.

88. On 19th September 2000 Prof Constable emailed Mr Ellingsrud, apparently about confidentiality issues in relation to the engagement of Scripps to do work. During the course of his email Prof Constable said:

> "However, I explained to Nancy Wilson (my contracts officer) that (a) this was a great research project that was going to make us all famous …"

That, again, is relied on by EMGS to demonstrate contemporaneous views of novelty.

89. Statoil proceeded to carry out a practical test of its ideas (which it called Sea Bed Logging) off the coast of Angola, where there was a known field. For this purpose they engaged the services of

various CSEM experts and their equipment. Prof Martin Sinha and Dr Lucy Macgregor (both of whose names will be seen later in the consideration of the prior art) of the Cambridge/Southampton project, were engaged, along with their equipment, to carry out field trials. Prof Constable was also taken along.

90. Dr Eidesmo first met Prof Sinha on 15th March 2000. They outlined to him their proposal to use Sea Bed Logging as a direct hydrocarbon indicator. Dr Eidesmo's evidence was that at no time did Prof Sinha suggest that he had thought of this approach before; on the contrary he was excited by the presentation, and thought it would work. I have seen Prof Sinha's note of the meeting. It reflects neither excitement nor a sense of déja vu. In a subsequent email of 31st March 2000 Prof Sinha agreed with a view apparently previously expressed by Dr Eidesmo:

> "'I will say that in my opinion a positive field test will change dramatically the field of active source EM (and may be MT) because of the large impact this will have for the oil industry.' I'm continuing with some modelling, but nothing I've seen yet discourages me at all."

91. The Angola survey took place in autumn 2000. Its results were written up in a couple of journal reports, authored by a number of people including Dr Eidesmo, Drs Constable and MacGregor and Prof Sinha. The title of one such article is:

> "Sea Bed Logging (SBL), a new method for remote and direct identification of hydrocarbon filled layers in deepwater areas."

92. It starts with an epitome of the article which itself starts by identifying the basic dipole equipment involved. It goes on:

> "The array of sea floor receivers measures both the amplitude and the phase of the received signal that depend on the resistivity structure beneath the sea bed. A survey consisting of many transmitter and receiver locations can be used to determine a multi dimensional model of sub-sea floor resistivity."

No-one has suggested that so far this describes anything new. The epitome goes on:

> "In deepwater areas the geological strata are generally dominated by shale or mud rocks with rather low resistivity. A hydrocarbon reservoir can have resistivity perhaps 10 – 100 times greater. With an in-line antenna configuration the transmitted electric field enters the high resistive carbon layer under a critical angle and is guided along the layer. Electro magnetic signals constantly leak from the layer and back to the sea floor. The guiding of the electric fields significantly alters the overall pattern of current flow in the overburden layer."

93. Thus far, the epitome describes known physics, albeit by the metaphor which some would think is technically inappropriate but which is a helpful description of what is going on. The epitome continues:

> "A broad-line antenna configuration does not generate guided waves, and thus the two antenna configurations have different sensitivity to thin buried resistive layers. This so-called 'split' effect that is diagnostic for buried resistive layers is verified by 1-dimensional modelling. 1- and 2-dimensional modelling and real data acquired offshore West Africa also demonstrate that by careful positioning of transmitter tow tracks and receivers relative to suspected hydrocarbon bearing structure, the SBL technique can provide detailed information on the presence and lateral

> extent of the hydrocarbon reservoir."

This last part of the epitome describes the technique used by the 887 patent, and the essence of the invention is described in the closing reference to the detection of hydrocarbons.

94. The introduction starts by pointing out that measurements of electrical resistivity beneath the sea floor have "played a crucial role in hydrocarbon exploration and reservoir assessment and development. In the oil and gas industry, sub-sea floor resistivity data has, in the past, been obtained almost exclusively by wire-line logging of wells. However, there are clear advantages to developing non-invasive geophysical methods capable of providing such information….. Several electromagnetic methods for mapping sub-seafloor resistivity variations have been developed (e.g. … Chave et al 1991 [the Chave prior art paper]). Here we concentrate on marine controlled source electromagnetic (CSEM) sounding in the frequency domain. This technique has been successfully applied to the study of oceanic lithosphere and active spreading centres…."

    It goes on to describe the method which depends on differential resistivity.

95. There is then a detailed discussion of modelling and the effect of geometry (in-line versus broadside). The purpose of the survey is then set out:

    > "The objective of the survey was to demonstrate that the SBL technique could be used in a practical situation to directly detect hydrocarbon filled layers in the subsurface in deepwater areas…."

    The paper claims to have proved that the results of the survey coincided with the modelling predictions.

96. The publication of the results of the Angola survey seems to have attracted some attention. EMGS produced what was said to be examples of post-survey comment. They include the following:

    i) Another paper by Prof Constable, in which he said:

    > 'The marine CSEM method is not new, but the application to hydrocarbon detection is.'

    ii) A talk given by Mr Dave Peace to the Petroleum Exploration Society of Great Britain in October 2005 in which he said:

    > "These methods have however been rightly regarded as somewhat fringe geophysical methods of use only as regional exploration tools of low resolution and then only suitable for applications in certain more difficult geological provinces such as sub-salt, sub-basalt, sub-carbonates etc.
    >
    > "EM methods have recently undergone a metamorphosis and the new Controlled Source Electro-Magnetics (CSEM) techniques are now showing that modern electromagnetic techniques can and are being used around the world to help evaluate the fluid content of reservoirs, define reservoir extent and even 'quality' to some extent."

97. The extent of the novelty of this technique, and of what was done off Angola, is emphasised in a later paper published in a publication called The Leading Edge in October 2002. In describing the experimental method (involving a "horizontal electric dipole (HED) source to transmit a discrete frequency electromagnetic signal from the source to an array of sea floor receivers", in order to "determine sub-sea floor resistivity structure") the paper said:

> "The method has been used in academia for many years, primarily to study ocean basins and active spreading centers. However, this survey is the first application to direct hydrocarbon detection."

98. After the Angola survey it seems that others took up the use of CSEM in hydrocarbon surveys. Why that was not done before is something that I will deal with below under the heading "Mindset".

99. Prof Constable also expressed some of his views about the project when he was commenting on the proposed text of one of the later papers about the Angola survey. In an email of 18th December 2001 he wrote:

> "From an academic point of view, this project was an application of standard CSEM practice and represents no new techniques, just a novel target. However, I don't see any harm in introducing SBL as a terminology - I can appreciate that it looks good within Statoil, and it will probably help 'sell' the technique."

And on 3rd May 2002 he returned to the topic in an email, apparently in the context of a request to keep certain "proprietary know-how and technology" confidential. He was obviously a little puzzled about this, because he said:

> "However, as someone who has worked in marine controlled source electromagnetic sounding (CSEM, aka 'seabed logging') for nearly 20 years, it is not clear to me what intellectual property Statoil is claiming in this regard. CSEM as practised off Angola is an innovation pioneered by Scripps Institution of Oceanography over 20 years ago, and indeed your colleagues visited me and Charles Cox in late 1998 to learn more about it from us. Also, the use of CSEM for hydrocarbon exploration has been advocated for some time, see for example Hoversten … and indeed appears in my proposals for my 'Seafloor Electromagnetic Methods Consortium' since at least mid-1998."

100. EMGS put much stress on Prof Constable's apparent expressions of view in his peer review and subsequently. It seems to me that the court must be careful about the weight that is put on this sort of evidence. Prof Constable would probably have been qualified to be an expert in these proceedings. To place too much reliance on his expressed views on novelty (or, I suppose, against novelty had he expressed any clear ones) would be to admit extra expert evidence without leave, and, worse still, without proper testing in cross-examination. That would be true in any case where such evidence was relied on, but it is even truer in the present case where his later remarks might be thought to be less consistent with real novelty than his first remarks might be said to be. At one level he is not saying much which turned out to be particularly controversial at the end of the day. In his two later emails he stated that nothing new was done so far as the techniques were concerned. That was not disputed by EMGS - the actual CSEM techniques were not relied on as novel as far as the 019 patent is concerned. The most that Prof Constable said was new was actually pointing those techniques at hydrocarbon layers. The most he seems to be saying is that that had not been done before in fact (though he did say that others had thought about it). If he was getting excited about anything in his peer review letter then it was about no more than that. The question of whether that is true as a matter of fact, and if so whether that supports novelty, is a matter to be judged by reference to all the evidence and the prior art. If he was expressing a view on novelty in his peer review, it was seriously tempered by what he said about previous advocates of the idea in his last email. I think it just as likely that he was expressing keenness and encouragement because the oil industry was at last picking up and running with a ball that he had thought had been available for play for some time. All in all, therefore, the expressed but untested attitude of Prof Constable does not assist me much.

101. EMGS also rely on what Prof Sinha and Dr MacGregor said and did, which is said to support

EMGS's case of novelty. In addition to the matters referred to above, they were both named as inventor in an English patent granted to Southampton University (GB 2382875, date of filing 7th December 2001) which sought to protect an invention similar to that said to be embodied in the 887 patent (the "split"). (The copy of the patent I have seen identifies only Prof Sinha as inventor, but in the entitlement proceedings which followed it seems to have been found that Dr MacGregor was an inventor too.) The patent does not in terms refer to a "ducted" wave, though it does refer to the propagation of a field downwards, "along within the underlying strata … and back up to the receiving antenna"; the emphasis of the invention is on the split. Statoil challenged the University's entitlement to the patent in entitlement proceedings, which lasted 6 days. Statoil won. The hearing officer decided in its favour on the basis that the invention captured by the patent had been disclosed to Prof Sinha and Dr MacGregor by Dr Eidesmo and Mr Ellingsrud, and EMGS was entitled to the patent. EMGS rely on the evidence in those proceedings, as embodied in findings of fact in the decision, as demonstrating that the two academics had not thought of the invention before, which, it is said, supports the novelty (non-obviousness) claim.

i) At the hearing Prof Sinha said that Dr Eidesmo and Mr Ellingsrud told him that they had found the "split" - the difference between in-line and broadside signals when compared in and in the absence of a hydrocarbon layer. Prof Sinha said he was not initially convinced there would be one. That is said in these proceedings to support the novelty of the invention in the 887 patent.

ii) No evidence was produced by Prof Sinha or Dr MacGregor to show that they contemplated using EM methods for the direct detection of buried hydrocarbon reservoirs despite contacts and presentations to oil industry representatives in the late 1990s. The hearing officer found that when asked in 1998 by an oil company whether an EM survey could be used for direct hydrocarbon detection, Prof Sinha said it would not be possible using magneto-telluric techniques and apparently did not even consider whether CSEM techniques would work.

iii) Prof Sinha and Dr MacGregor were offering CSEM techniques for detecting sedimentary layers below basalts. Nothing in their evidence suggested they contemplated using CSEM directly to detect thin relatively resistive layers in more conductive substrates.

102. EMGS also relies on the fact that these academics patented their alleged invention at all. That, it is said, demonstrates that it had not previously been obvious to them.

103. It is not disputed that Prof Sinha and Dr MacGregor gave evidence to the above effect. However, again this evidence has to be treated with caution. Again, putting a lot of weight on it is tantamount to admitting another two more experts without their evidence being properly tested in the context of this action. It also has to be noted, in the context of the 019 patent, that the actual invention in the Southampton patent relates to the split. There is no particular claim to the direct detection techniques, without the split, claimed in the 019 invention. There may be a number of reasons, not inconsistent with obviousness, why these two academics had not previously turned their minds to marine CSEM and hydrocarbons (if they hadn't), some of them demonstrating how clever it was and others demonstrating that they were thinking about something else. The application for the patent may demonstrate no more than their view that what was referred to was patentable, motivated by an attempt to get some financial benefit from it. Whether they are right about patentability is the question that arises in this action. They were certainly not saying the whole thing was old hat, but what else they should be taken as saying is more questionable. Accordingly, while there is material here that EMGS is entitled to rely on, it must be approached with caution. I do not, however, dismiss it from my consideration of the matter.

Industry reaction and commercial success

104. Dr Eidesmo produced several publications demonstrating that CSEM had been taken up as a useful tool since the Angola survey, and that the oil industry had taken it up in a significant way. Its virtues were puffed by such commentators as Morgan Stanley and the Wall Street Journal. It does seem from the evidence that there has been a significant take up of CSEM since the Angola survey and

that it has been treated as if it were a significant advance in the detection of hydrocarbon layers. I am satisfied that this is the case.

105. What is less clear is whether this is attributable to an appreciation of something new (and if so, what is new), or whether other features are operating. Dr Eidesmo exhibited various commentaries, many of which emphasise the fact that what was said to be happening was the application of established techniques to a new target. A Mr Dave Peace (admittedly an employee of Schlumberger at the time, though his material is exhibited by Dr Eidesmo) said, in 2005:

> "Electro-Magnetic explorations methods have been around … as deep water marine methods since the mid-1990's when Marine MT was essentially declared a commercial exploration tool. These methods have however been rightly regarded as somewhat fringe geophysical methods of use only as regional exploration tools of low resolution and then only suitable for applications in certain more difficult geological provinces such as sub salt, sub basalts, sub carbonates etc.
>
> "However with the addition of higher frequency source and a change in the basic geophysical technique, EM methods have recently undergone a metamorphosis…"

106. A Wall Street Journal article in August 2004 refers to the activities of Dr Len Srnka (the inventor of a patent heavily relied on as prior art and one of the pioneers of CSEM). It says (in a very journalistic, rather than scientific, style):

> "He was hired by Exxon in the 1980s to apply the method [of using the electromagnetic properties of earth water and rock] to finding oil but was stymied for years by technological and funding hurdles."

It goes on to describe how electromagnetics was referred to at a certain workshop, and comments:

> "This was hardly a breakthrough concept in the industry. Oil is a resistive material … Scientists have nurtured the notion that the same technology could be used to explore for oil from the surface … But the idea had been discredited by a succession of failures … All the computer models looked good, but Dr Srnka told his bosses [at Exxon] that the project would take years, cost millions and be very risky … Executives decided to pass. At that time, 3D seismic technology was all the rage. And companies weren't yet able to work in the deep waters suited to Dr Srnka's method."

107. In April 2005 Martyn Unsworth, an academic from Edmonton, published an article on new developments in exploration with EM methods. He referred to a rapid development in EM methods that are useful for hydrocarbon exploration, and explained that marine magnetotellurics were developed to study the lithosphere and mid-ocean ridges. The seawater in deep oceans screened out the high frequency signals needed to image structure in the upper few kilometres of the seafloor.

> "However, with modern recording equipment in low noise environments, higher frequency signals can be detected in moderate water depths."

This potentially attributes the new-found preferences to better equipment.

108. This material does not demonstrate clearly what factors were behind the takeup of marine CSEM in the period after 2000 but they suggest what some of them may have been. They suggest that better equipment and different techniques may have been among those reasons. Lack of funding for development also affected it previously. It may have been the case that the change in demand for oil played a part in resurrecting an idea that had previously have been thought to be not worth

pursuing. I can make no clear finding about it. What I do find, however, is that I cannot infer from the takeup of CSEM in that period, when it had not been taken up before, that it was providing something novel or non-obvious in patent terms. There may be other explanations that were operating consistent with want of novelty.

109. Dr Eidesmo also produced evidence of what was said to be the commercial success for marine CSEM so far as EMGS was concerned. His evidence is not very profound, and I gained no assistance from it at all. It purported to deal with success rates, but was not a properly reasoned statistical piece of work, and did not contain any sensible comparators. I give it no weight.

110. EMGS went on to rely on the position adopted by Schlumberger in the last few years. It relied on evidence that Schlumberger was a leading player in the oil exploration field but had not used CSEM to detect hydrocarbons directly before EMGS's activities were known, though it has since been extolling its virtues. I am asked to draw inferences from the fact that Schlumberger, like the rest of the industry, seems to have started to use CSEM and been keen to use it and (via a subsidiary) to puff its virtues and the fact that it is a "significant advance". Mr Burkill pointed out that no witness had been called from Schlumberger itself to explain why, if the alleged invention is obvious, it did not start to use it itself until after Statoil published its own CSEM results. In particular Schlumberger did not produce their own employee Dr Habashy, who had some CSEM expertise, to explain why Schlumberger had not used CSEM before if it was obvious. A couple of email exchanges were relied on to show that he had some expertise.

111. There is only a limited amount in this point. The first email exchange relied on (in 2000) is one in which Dr Habashy was dealing with a specific question posed, and while he demonstrates that he was not aware of marine CSEM techniques no sensible inference can be drawn from it as to obviousness. The question posed did not call for an answer which would be likely to shed light on Schlumberger's attitude. All that one gleans is that Dr Habashy was not aware that anyone had used marine CSEM commercially. That merely re-states the industry position at the time. The second email exchange arose out of the publication of the 019 patent, apparently. The significant email is from a Brian Clark of Schlumberger, whose status is unknown to me. It demonstrates that Schlumberger considered it was capable of modelling the situation, and could determine whether the technique would work or not. Again, it shows that Schlumberger had not used CSEM before, but that was known anyway. The email does not take the matter much farther forward. So we are left with the fact that Schlumberger, like the rest of the industry, had not deployed marine CSEM commercially, but without clear evidence why, and some potential explanations. Where the case on obviousness is such a technical one, I do not think that much support one way or the other can be taken from a failure by Schlumberger to call its own internal witness to say why it had not used it before. I think I can infer that its use was not obvious to Dr Habashy, but that does not take me very far.

Common general knowledge and mindset

112. The context for this point must be borne in mind. Schlumberger do not advance a case of obviousness over common general knowledge as such (though its case of obviousness over the Chave prior art, which is said to be common general knowledge, amounts to something similar). It only advances a case of obviousness over certain pieces of prior art.

113. EMGS's starting point for common general knowledge was to consider what was common general knowledge to its skilled addressee, the geophysicist (and not a CSEM expert). Such a person would have knowledge of seismics, but EMGS's initial stance was that his knowledge of EM techniques would not go beyond what appeared in a student textbook called Kearey & Brooks. However, by the end of the trial its position had moved. In his final speech Mr Burkill accepted that the Chave prior art paper was "latent" common general knowledge for such a person (adopting terminology used by Mr Michael Fysh QC in *Dyson Appliances Ltd v Hoover Ltd* [2001] RPC 473). Quite what this means in practice is something I will address below.

114. Schlumberger's starting point was, of course, the CSEM expert as the skilled addressee. In his final speech Mr Silverleaf summarised various matters which he said that Dr Chave relied on as being the relevant part of such a person's common general knowledge. Such a person would have a physics qualification and have a knowledge of basic geology and oceanography. He would know that CSEM was a well-defined tool for mapping variations in sub-surface resistivity; that hydrocarbon-bearing formations were usually resistive whereas brine is relatively conductive; that in CSEM, the TM mode was preferentially sensitive to buried resistive layers; how to model resistivity, and how to use that modelling to specify the survey techniques required, how to invert survey results to yield information about a target and how to conduct a geophysical survey at sea.

115. At this point some equivocation set in. In paragraph 57 of his first report Dr Chave listed a number of "key papers" which the CSEM-qualified expert would have "read and understood". They included some of the pieces of prior art, and in particular the piece of prior art which (for the purposes of this action) bore his name. This passage strongly suggested that these papers were relied on as common general knowledge. There was a considerable degree of equivocation on Schlumberger's part as to whether the contents of these papers, and in particular the Chave prior art paper, were themselves part of any relevant common general knowledge. The position on the pleadings was that it was pleaded as one of the specific pieces of prior art over which the invention was said to be obvious. It was inconsistent with that pleading that it should be treated as the common general knowledge of anyone relevant, whether a CSEM specialist or geophysicist. Mr Silverleaf's skeleton argument was somewhat equivocal as to the extent to which the publications were to be relied on as common general knowledge. In his opening Mr Silverleaf expressly disclaimed reliance on the Chave prior art as being common general knowledge, even for a CSEM practitioner, though he said it did not matter because it was there as a piece of prior art anyway which gathered together the current state of knowledge into one document which he could use as a disclosure for obviousness and anticipation purposes.

116. As the trial progressed, however, it appeared that Mr Silverleaf was indeed seeking to rely on the Chave prior art as actually constituting common general knowledge, even for a geophysicist. He cross-examined Professor Schultz on that footing, and claimed to have scored a hit by getting him to acknowledge that it (and the other documents listed by Dr Chave) would have been known to CSEM practitioners. In order to clarify the matter I required that the matter be dealt with as a matter of pleading and invited Mr Silverleaf to plead his case on the point, so that I could consider it in the context of (in essence) an application to amend the statements of case. I heard the argument on this on Day 11 of the trial, after Professor Schultz had given his evidence but before Professor Landro's evidence - hardly ideal, but the manner in which the point arose did not really permit (or even flag up the need for) debate any earlier.

117. Mr Silverleaf's first attempt at an amendment claimed that <u>all</u> the publications listed by Dr Chave were common general knowledge to the CSEM practitioner, but for the purposes of the argument he then cut that down to the Chave prior art paper. Mr Burkill opposed the amendment (thereby adopting the position that it was not common general knowledge), pointing out that an assertion that the paper was common general knowledge was not only contrary to the assertions made by Mr Silverleaf on Day 2, it was inconsistent with the pre-trial utterances of Schlumberger's solicitors in pre-trial correspondence, including requests for elaboration of the particularisation that was required. There was much in what Mr Burkill said in this respect, but he did not necessarily say that none of the paper could be common general knowledge. His problem was that the paper had a large amount of detail, some of which might be accepted to be common general knowledge and some of it not. The real significance was going to be whether Schlumberger should be entitled to "mosaic" any, and if so, what, parts of the paper with other pieces of the prior art. It might be that some mosaicing would not be challenged, but some might be, and that extent had not been indicated by Mr Silverleaf. It would be unfair, he said, to allow the whole of the paper, with its immense detail, to be allowed in so as to give Mr Silverleaf a completely free hand in this respect. Having heard what was said in argument, I then decided that I would not rule on it at that point, but would incorporate the issue in my final judgment.

118. When it came to the cross-examination of Professor Landro, Mr Silverleaf put to him that the Chave paper would be one of the works that he would consult if he wanted to learn about CSEM surveys, because it was in a book published by the Society of Exploration Geophysicists (which it was) and Professor Landro would go off to such works if he wished to find out about the point. Professor Landro agreed he would look, would find it and would consult it. In his written submissions Mr Burkill characterised this as putting to Professor Landro that the work was common general knowledge to geophysicists, but I do not think that that quite characterises the questions properly - what was put was that the work would be consulted as part of research as to how to conduct a CSEM survey.

119. At the end of the day it appears that there is no substantial area of dispute in relation to this matter for two reasons. First, Mr Silverleaf did not, in the end, seek to rely on any significant amount of mosaicing from the Chave prior art so there is no need for a debate as to the precise limits (if any) on the Chave paper as common general knowledge. Second, Mr Burkill accepted as a result of the evidence that at least the main strands relating to CSEM (though not all the detail) could appropriately be regarded as common general knowledge even for an exploration geophysicist, though he relied on it as being "latent". This was consistent with the position that Mr Burkill had taken on the amendment debate. The latency is said to be attributable, at least in part, to the mindset of the industry. Other than the extent of the latency there is no material dispute between the parties, so I will not lengthen this judgment by any form of elaborate ruling on the amendment point, and will confine myself to saying that Schlumberger is entitled to seek to rely on the general principles (though not every little detail) of that paper as being common general knowledge.

120. That deals with the extent to which Schlumberger is, as a matter of formality and pleading, entitled to seek to rely on the Chave paper as common general knowledge, and it is now necessary to consider the extent of that common general knowledge. I have determined that the skilled addressee is a team which includes a CSEM expert. I accept Dr Chave's evidence that the main principles of the Chave paper would be something with which such a person would be familiar. It is among the seminal works with which a practitioner would be familiar by 2000, and its principles would be known as principles. That is demonstrated, inter alia, by the occasions on which it is referred to in other pieces of prior art. The tenor of Professor Schultz's evidence is also to the effect that CSEM practitioners would know the general parts by the priority date. On the basis of all that, I find that the principal thrusts were common general knowledge by that time.

121. In case this case goes further, it will also be useful if I express my alternate findings if I am wrong about the identity of the skilled addressee. Mr Burkill's final position was that, since the Chave paper was published in a reference work by the Society of Exploration Geophysicists, and since it was available for consultation and study by them, it was part of their common general knowledge as described by Laddie J in *Raychem Corp's Patents* [1998] RPC 31 at 40, but subject to the qualifications expressed there:

> "The common general knowledge is the technical background of the notional man in the art against which the prior art must be considered … It includes all that material in the field he is working in which he knows exists, which he would refer to as a matter of course if he cannot remember it and which he understands is generally regarded as sufficiently reliable to use as a foundation for further work or to help understand the pleaded prior art. This does not mean that everything on the shelf which is capable of being referred to without difficulty is common general knowledge nor does it mean that every word in a common text book is either. In the case of standard textbooks, it is likely that all or most of the main text will be common general knowledge." (My emphasis)

Mr Burkill stresses the underlined words as excluding the more arcane and detailed parts of the Chave paper. So far as the exploration geophysicist is concerned, he is in my view right to do so.

Such a person would not have that material as part of his common general knowledge. However, he is also right to accept that the overall significant pieces would be common general knowledge by the priority date. They would be added to Kearey and Brooks for that purpose.

122. The end result of this is that, subject to the mindset and latency point to which I shall now turn, there is, on the facts, no material difference between the parties as to the common general knowledge of the skilled person even allowing for the fact that they identify different people and skills. By "material" I mean material to this case, because the case does not turn on what appears in the interstices of the Chave paper. In another case that might matter, but it does not on the facts of this case.

123. EMGS's case on this was qualified by the latency and mindset point. They are linked. In *Dyson v Hoover* Mr Fysh QC found that a vacuum cleaner engineer would have:

> " … some knowledge latent or otherwise, of the working of commercial cyclones" (para 33)."

Despite that, the mindset of the vacuum cleaner industry, of which the engineer was part, was such that there was an "addiction" to bags such that he would not have thought of using a cyclone as a dust separator. Mr Fysh does not seem to have relied on latency as a reason for suppressing the realisation of the utility of cyclones; rather he remarked on the latent general knowledge as existing despite the "addiction". Mr Burkill says that in the present case there would be <u>latent</u> knowledge of CSEM generally (and of the less detailed parts of the Chave prior art) in the same way. It co-existed with a mindset in the industry which held that CSEM had nothing particularly useful to contribute over seismic techniques when it came to discerning potentially hydrocarbon-bearing layers.

124. In support of his case on mindset he relied on the preceding non-interest of the industry; the fact that CSEM was primarily the interest of academics; the reliance on seismics; the fact that Kearey & Brooks, while it referred to EM techniques, referred only to detecting salt domes and anticlinal structures constituting potential hydrocarbon traps; the fact that a particular reference in one of the pieces of prior art ("Edwards") to a belief of many that the conductivity of seawater inhibited useful seafloor electrical measurements; a reference to "discouraging" outcomes in another textbook (Yungul); and what he said was an unconvincing set of explanations from Dr Chave as to why CSEM had not been attractive to the oil industry.

125. I confess to having difficulty with the concept of "latent" common general knowledge. Something is either common general knowledge or it is not. The concept is one designed to encapsulate all that which should be <u>treated</u> as being known to the deemed skilled person, against which inventiveness or obviousness can be measured. So either something is part of the knowledge or it is not; it is either treated as known, or it is not. If it is treated as known then it is part of the body of knowledge. If the word "latent" is intended to suggest something that should not be treated as known, then it is not part of the common general knowledge at all.

126. However, it is right to bear in mind the mindset of the skilled addressee. If that mindset is such that it is believed that a particular piece of knowledge has no relevance to the industry, then the realisation that it can be applied is capable of being an inventive step - see the application of cyclones to vacuum cleaners in *Dyson*. This does not make the knowledge of cyclones latent, or something other than deemed knowledge. It means that despite the knowledge of existence and properties of cyclones, it was not appreciated they could be applied. This is the analysis that I prefer over the concept of latency.

127. I therefore turn to the facts relevant to Mr Burkill's mindset point. It was undoubtedly the case that marine CSEM was not used by the oil exploration industry in the manner of the alleged inventions in the 019 and 887 patents until after the Angola survey. It is almost a truism to say that it had not occurred to the industry to use CSEM in that way before then. Mr Burkill relies on a mindset in the industry to the effect that "CSEM was not useful for hydrocarbon exploration" (to take the

formulation in his written final submissions). The invention lay in overcoming this mindset; and it was this mindset that suppressed the knowledge that might otherwise have been gleaned from the Chave prior art paper.

128. One must be careful to identify the mindset relied on because the effect it has depends very much on what it is. In the *Dyson* case the industry mindset was (in the memorable expression of the Court of Appeal) "bag-ridden" - that is to say, there was a positive view that vacuum cleaners had to have bags. Mr Burkill's industry mindset is ostensibly a similarly positive one - CSEM was not useful for oil exploration. If such a mindset existed I would have expected there to have been positive evidence of it, and the natural witness to give it would have been Professor Landro. He did not, however, give evidence to that effect. He gave evidence about the use of seismics, and the increasing sophistication of that technique (including its ability, in some circumstances, to distinguish between hydrocarbon-bearing layers and non-hydrocarbon bearing layers). He referred to the common knowledge as involving an assumption that the maximum penetration for EM waves would be of the order of 500m (derived from Kearey & Brooks), and says that the technique would have been regarded as a near-surface tool, for use at a depth which is not sufficiently deep for typical hydrocarbon reservoirs.

> "Since most hydrocarbon reservoirs are deeper, it is reasonable to say that EM methods lived a life in the shadow of seismic methods."

129. This evidence falls well short of the sort of the positive mindset relied on by Mr Burkill in his submissions. The other material that he referred to (identified in general terms above) does not establish it either. What I think that the evidence establishes (so far as exploration geophysicists were concerned) is not a positive view (akin to a mindset) that CSEM had no part to play in oil exploration, but an absence of an appreciation that it could. I think that there is an important, if subtle, distinction between those two. The one is more positive than the other, and may require more inventiveness to overcome it. I think that the truer analysis is that the industry was being reasonably well served by seismic techniques, and in those circumstances had not had great cause to look at (for example) CSEM. That is a more accurate view of industry thinking than a positive mindset of the kind relied on by Mr Burkill and which would be analogous to the mindset in *Dyson*.

The prior art and the 019 patent

130. I shall take each item of the prior art relied on by Schlumberger as invalidating this patent and consider it in terms of the anticipation and obviousness cases advanced. In each case Schlumberger runs alternative anticipation and obviousness claims.

Chave

131. This piece of prior art has been foreshadowed by what has gone before in this judgment. It is an article entitled "Electrical exploration methods for the seafloor", by Dr Chave, Prof Constable and R Nigel Edwards, published in 1991 in Electromagnetic Methods in Applied Geophysics Volume 2. As already explained, this was a reference work for geophysicists; overall it seems to have contained a lot of diverse material. It is a detailed, thorough and closely reasoned article with a lot of material in it. Since it can probably fairly be described as one of the two main planks of Schlumberger's anticipation and obviousness arguments it will be necessary to set out some large parts of it. Although authored by 3 distinguished scientists, for the purposes of this litigation it has borne the name of Dr Chave alone. Without intending any disrespect to the other authors, I shall, for the sake of convenience, continue to allow the work to bear that label.

132. The paper contains an introductory section which itself contains the following:

> "Recent developments in instrumentation and submarine geology have spawned increasing interest in the use of electromagnetic (EM) methods for seafloor exploration. Previously, little attention had been given to their

> use in the marine environment, due both to the success of the seismic techniques in delineating sub-surface structure and to a pervasive belief that the high electrical conductivity of seawater precluded the application of EM principles. Marine EM exploration of the solid earth has progressed substantially in academic circles over the past two decades; the adaptation of this technology for commercial purposes is only beginning.
>
> "Over three-fifths of the Earth's surface is covered by oceans. Even though petroleum is produced from huge deposits on the relatively shallow continental shelf, the immense area of the ocean represents a largely unexplored and an exploited resource base. Until recently, little economic interest was shown in the ocean floor environment ... however, the recent discovery of intense hydrothermal activity and poly-metallic sulphide deposits of unprecedented concentration and scale on the crest of the East Pacific rise ... has aroused interest in the possibility of deep-sea mining and spurred research into the mid-ocean ridge ore genesis as an analog to terrestrial occurrences ... While [visual location is] capable of examining its surficial geology, they are not able to adequately assess the actual extent of the deposits and the nature of the geological structures in which they are found. Seafloor conductivity mapping is one of the few geophysical tools suitable for this purpose, just as the EM methods are one of the major geophysical techniques used in mineral exploration on land.
>
> "Over the past few decades, the search for petroleum reserves has been extended from the continent's off-shore into progressively deeper water, making the continental shelves a focus for geophysical exploration. The principal geophysical tool for this is the seismic method, and the success of the seismic approach is attested to by the level of offshore drilling activity and the subsequent production of oil. However, there are marine geological terranes [sic] in which the interpretation of seismic data is difficult, such as regions dominated by scattering or the high reflectivity that is characteristic of carbonate reefs, volcanic cover, and submarine permafrost. Alternative, complementary geophysical techniques are required to study these regions.
>
> "... This paper emphasises the differences between seafloor and terrestrial EM applications, especially with regard to noise, resolving ability, and apparatus....Most of the existing work on seafloor EM has been motivated by solid earth problems as opposed to exploration ones. The real data discussed reflect this difference, which is principally one of scale."

133. There is then much discussion of the theories behind EM surveying, with a reference to TM and TE modes. This discussion is accompanied by a certain amount of algebra and a number of graphs. The relevant equipment is described. At page 947 of the publication Dr Chave turns to "Controlled Source EM Methods". The technique is described. He deals with the fact that thin resistive layers are relatively insensitive to the TE mode and at page 948 he deals with the nature of the transmission. He says:

> "The choice of operating an EM system in either the frequency domain, transmitting a set of discrete frequencies one or a few at a time, or the time domain, transmitting a square or triangular step and measuring the transient response of the seafloor-ocean system, also exists. The physics of the two methods are identical, the response in one domain being the Fourier transform of the response in the other domain. Because of the finite and inexact nature of practical measurements, this transformation cannot

> usually be made outside the realm of theoretical studies. The choice of one system over another must be made on the basis of practical and logistical considerations."

134. At page 950 Dr Chave turns to some modelling. His modelling seeks to demonstrate the effect of buried layers of differing resistivities on the signals generated by the sort of equipment shown in the patent.

> "It is instructive to examine the behaviour of the horizontal electric field for geometric (range-dependent) and parametric (frequency-dependent) soundings in the presence of the simplest structural complication, a buried layer. In each case a specific model consisting of a half-space of conductivity 0.05S/m containing 1 km thick layers either 10 times more or less conductive and centered at depths of 1.5 and 5.5 km is considered; these values are intended only to be illustrative. Figure 16 shows the geometric sounding curves. The low conductivity zone behaves as a lossy waveguide which traps and guides the signal, resulting in slower attenuation with range when compared to the half-space case. The deep buried layer produces a smaller effect, as expected from the diffusion nature of EM induction, and requires a larger range for the trapping to become apparent. If the buried layer has a higher conductivity than the surrounding material, greater attenuation will ultimately result at long range, but the low conductivity waveguide created between the seafloor and the layer results in an increase in signal strength at intermediate distances. The HED [horizontal electric dipole] method is preferentially sensitive to relatively low conductivity zones due to the presence of the TM mode. The existence of a minimum usable source-receiver spacing of 1-3 times the burial skin depth, depending on the sense of the conductivity contrast, is also apparent. Longer ranges are required to detect low conductivity material. Figure 17 shows parametric sounding curves for the same model at ranges of 5 and 10 km."

135. Figure 16 shows, by way of a graph, that the attenuation of the received signal, as one moves farther away than the transmitter, is less than where there is a uniform half space. The relative differences are less marked where the buried layer is deeper, but it is still shown to exist.

136. Schlumberger claims that this particular section of the paper contains the meat of the invention. It models a more resistive layer between two less resistive layers. The model demonstrates that the signal strength at a range of 1-3 times the burial skin depth is stronger where one has that resistive sandwich than where there is a uniform half space, and suggests that this is due to the waveguide effect. This, says Schlumberger, is the refracted wave. It is the same refracted wave as (in the metaphor of the case) travels along the relatively resistive layer of the hydrocarbon layer in the patent.

137. Then the paper sets out details of the equipment developed at Scripps for conducting marine CSEM surveys and gives some information about experiments and surveys conducted. At page 958 it refers to an experiment in the ocean with an express reference to a basalt layer. At page 959 there is a reference to another survey involving a different system:

> "The layout is based on the same frequency domain dipole-dipole system used for deep sounding, so the theory developed by Chave and Cox (1982) and Chave (1984b) is directly applicable. In particular, it may be shown that resistive features such as permafrost layers and basalt flows can be mapped using frequencies and source-receiver ranges attainable by the experimental system ..."

I cite this and the previous reference to basalt because they are relied on by Mr Burkill.

138. Schlumberger relies on this paper as being an anticipation of the invention in the 019 patent. It describes CSEM; it describes a "lossy waveguide", and thus the refracted wave; it demonstrates that buried resistive layers can be detected by going out to source-receiver offsets of 1 to 3 skin depths; it identifies hydrocarbons as being detectable by this method. It anticipates the invention; and if it does not do that then the invention is obvious given this paper as a starting point.

139. EMGS does not accept this. Mr Burkill accepts that this paper refers to the refracted wave (using different terminology). His main points are that:

i) It does not teach a method for searching for a hydrocarbon-containing reservoir;

ii) It does not teach a method of determining the nature of a submarine reservoir;

iii) It does not teach seeking a component representing a refracted wave and determining the presence and/or nature of any reservoir identified based on the presence or absence of such a component.

iv) It does not teach the relationship between source-receiver separation and wavelength (integer 10).

140. As Laddie J held in *Inhale Therapeutic Systems Inc v Quadrant Healthcare plc* [2002] RPC 419 there are two ways in which anticipation can occur.

> "First, if the prior art describes something falling within its scope then, assuming that the description is enabling, the claim is anticipated. In such a case it is not necessary to carry out any experiments, or give evidence of what would have happened if the prior art were put into practice, because it already describes what it achieves …
>
> "The second way of proving anticipation is by showing that the inevitable result of carrying out what is described in the prior art would be a product or process falling within the scope of the claim." (p436)"

He relied on the well-known statements in *General Tire and Rubber Co v Firestone Tyre and Rubber Co* [1972] RPC 457 at 485:

> "To anticipate the patentee's claim the prior publication must contain <u>clear and unmistakable directions</u> to do what the patentee claims to have invented … A signpost, however clear, upon the road to the patentee's invention will not suffice, the prior inventor must be clearly shown to have planted his flag at the precise destination before the patentee." (my emphasis)

141. I find it impossible to say that the Chave paper anticipates in either of those manners. It tells its reader to do, or how to do, a large number of things. Some of the things appearing there appear in the patent. It describes the process of generating an electrical field, and detecting the results. It refers to the effects of a horizontal electric dipole in producing a field which can be detected, and it identifies the equivalent of the refracted wave through a resistive layer. In its text and small graphs it demonstrates, by modelling, the detection of the refracted waves at greater, rather than close, offsets, where there is such a resistive layer and refracted wave. In other words, it identifies the underlying physics (or its observable effects). However, it does not closely and sufficiently immediately relate this to the operating field of the patent. Thus it does not, in express terms, relate the exercise to identifying (specifically) a hydrocarbon layer (or reservoir) situated between two less resistive layers. It does not, in terms, refer to the exercise of distinguishing hydrocarbon-

containing layers from water-containing layers. While it talks of offsets which can partially be equated (via algebra and algebraic substitutions) with the formula in claim 1, there is no clear exposition of that idea. If one takes the article, without knowing of the invention as it is described in the patent, one cannot really see it fully there.

142. Bearing in mind the nature of the article, that is not wholly surprising. The article is intended to set out where the EM industry had got to by the time of its writing. It is in the nature of a mini-textbook, designed to teach generally, and not specifically in relation to particular applications. It is therefore not an article focused on any particular application; it is more general in its tenor and purpose. A considerable process of filtration would be necessary in order to get close to the invention. The need for filtration would not, of itself, be a bar to anticipation if the relevant acts were sufficiently clearly set out. But they are not, and even if the filtration were carried out one would then have to add elements which do not explicitly appear in the context of an elaboration of the effects of the physics. There is, in my view, no relevant flag-planting. Nor will carrying out the techniques inevitably lead to performing the invention. The techniques are not sufficiently linked to the direct detection in the invention.

143. However, Mr Silverleaf also mounted an obviousness claim in the alternative. Schlumberger's case was that, given the content of the Chave paper, if it did not actually anticipate, then the invention was obvious over it.

144. Such a claim is perhaps a more promising approach than anticipation given the nature of the Chave paper and the number of directions in which it manages to point. Many of the integers of claims 1 and 1A are present in the paper. It will be useful to approach this point in accordance with the now well-known *Windsurfer* test, as elaborated by Jacob LJ in *Pozzoli Spa v BDMO Spa* [2007] EWCA 588. Having identified the skilled addressee, I need to identify what the inventive step is, identify the differences between the Chave paper and the inventive step, and consider whether the differences would be steps obvious to the skilled addressee.

145. The inventive concept in the relevant claims (there is no need to distinguish between them for these purposes) is the application of the CSEM techniques described in Chave to the search for, or identification of, hydrocarbon-bearing layers. The Chave paper does not go so far as to apply its techniques specifically to that end, but it contains all the other elements short of that. It models a marine CSEM survey and shows the anticipated result where a relatively resistive layer is sandwiched between two less resistive layers. It identifies the benefits of using a horizontal (as opposed to a vertical) electric dipole and identifies that the TM component of the signal is more sensitive to resistive layers. Where a CSEM survey is modelled in those conditions the refracted wave has the effect that one can detect the signals from the survey. The resistive layer operates as a sort of waveguide. Professor Schultz accepted that all that was present in the Chave paper. He also accepted that the authors of the paper had in mind the mapping of resistive layers. What is not present there is an express link with a search for hydrocarbon in a layer, and there is no express statement that the technique could be used for that purpose. Mr Burkill and EMGS's experts drew attention to certain non-parallels - the limited references to oil exploration; the references to basalt and other features which were probed by CSEM and other EM techniques; the lack of reference to hydrocarbon reservoirs; the fact that the layer thicknesses in the models were far greater than typical hydrocarbon layers. Several of those are valid distinctions, but in my view they miss the point. The apparent purpose of the paper was to inform about EM techniques generally, and the particulars of various active and passive techniques. When properly read, it is not just about sulfide deposits, or carbonate reefs, or basalt extrusions, or permafrost, or any of the other particular geological phenomena which are specifically addressed from time to time. They are the context of some of the content and of the discussion, but the paper is aimed more widely than that. The search for petroleum reserves is explicitly referred to in the third paragraph of the introduction (set out above, beginning "Over the past few decades…"), and there are a couple of other references in the paper (not, admittedly, in terms of a clear focal point of the techniques in question). That particular sphere of activity is, in my view, plainly one of the areas of endeavour which the authors invited the

reader to consider directing EM generally (which includes CSEM specifically) at. The specific modelling which is related to the refracted wave uses values for resistivity which are expressly said to be "intended only to be illustrative", so differences in the values provided for those models were not necessarily material of themselves (as Professor Schultz recognised). The introduction says that differences between whole-earth data (in relation to which marine EM techniques had more traditionally been employed) and exploration was "principally one of scale", and therefore not one of principle. The paper plainly invites parallels to be drawn and lessons to be learnt.

146. So the missing step is the application of those marine CSEM techniques to a search for, or identification of, hydrocarbon layers. Dr Chave's evidence was that that step would be an obvious one for the skilled addressee to take, and I accept that evidence. Even if the paper is directed to other objects in terms of exposition (permafrost, and so on), it is general in its terms, and describes general techniques. Hydrocarbon layers are, for these purposes, just other resistive layers, albeit thinner than others under consideration. I think that Dr Chave is right about this.

147. I therefore find that the application of the Chave modelling technique to potentially hydrocarbon-bearing layers was obvious. That is the heart of the alleged invention. In his contemporaneous correspondence Prof Constable expressed the view that what was happening was the application of an established technique to a new target; I think that he was right. But the application to the new target was not, in patent law terms, inventive over the Chave paper. It was, in my view, obvious to do it, and the contemporaneous evidence relied on in support of the secondary case does not gainsay that. True it is that the industry had not done it before, but on the facts of this case that does not demonstrate lack of obviousness.

148. Reducing the obviousness point to the integers of Claim 1, integers 1, 5, 6, 7, 8 and 9 are all present in Chave. They describe the conduct of a marine CSEM survey. There was some debate about 7 and whether the paper involved "seeking" the component referred to. However, when one appreciates that the patent is using an analogy to describe known physics, and the Chave paper describes the same physics in a different way, it becomes apparent that they are talking about the same exercise. There is no individual component of an EM signal that can be looked at and identified as the refracted wave. The overall signal at any point is made up of parts of it which have taken various routes, and they have one composite effect at the receiver. The refracted wave is the part that (metaphorically) gets transmitted along the wave guide, and in both the Chave paper and the patent you "seek" it by spacing the source and receiver at such a distance that you conclude that what you are picking up must be the refracted wave because the direct wave, and perhaps other parts of the signal which have taken different routes, have long since attenuated so that the strength of the signal must be attributable to a wave which has had a refracted journey. That leaves integers 2 to 4, and 10. Integers 2 to 4 are the integers which bring in the application of the CSEM techniques to hydrocarbon exploration. I accept Dr Chave's evidence that it would have been obvious to apply the CSEM for that purpose, in the light of the contents of the paper and for the reasons given above.

149. The only other integer which it is necessary to deal with in this context is integer 10 - the wavelength formula. This is not dealt with in terms in the Chave paper. The patent teaches an offset calculated by reference to wavelengths. Paragraph 0007 of the specification provides:

> "Given that the distances and geometry of the reservoir will be known from previous seismic surveys, an optimum λ [wavelength]…would be selected."

A wavelength would be chosen by reference to the thickness of the overburden - one would certainly not want one which gives a shorter skin depth than that thickness. The maths works out with the effect that the wavelength corresponding to a skin depth can be related as follows:

> $\lambda = 2\pi$ times skin depth (δ).

> 2π is roughly 6, so the formula becomes:

$\lambda = 6\delta$

That can be treated as common general knowledge. Dr Chave gave undisputed evidence about that. If one then applies that to the wavelength formula in claim 1, one sees that the offset is said to be between 3 and 60 times skin depth. The outer limits are very extreme, but what this integer teaches is that the offset is to be greater than three times skin depth, and perhaps much greater than three times skin depth. The Chave paper, in commenting on the modelling, teaches that:

> "The existence of a minimum usable source-receiver spacing of 1-3 times the burial skin depth, depending on the conductivity contrast, is also apparent."

It extracts this from graphs of the modelled results which show a less attenuated signal emerging at different ranges depending on the depth of the buried layer. There was a dispute between the parties as to whether the Chave paper was confining itself to suggesting offsets within the range of 1 to 3 skin depths (Professor Schultz's view of the paper), or whether the range of 1-3 times skin depth was the starting point for an extending range of offsets going beyond the 3. I consider that Schlumberger's arguments on this are correct. Professor Schultz's arguments ignore the effect of the word "minimum". The Chave paper proposes 1-3δ as a starting point for offsets - the offsets might be greater (see the word "minimum"). Relatively conductive layers are at the bottom of the range, and relatively resistive layers are at the top. That means that the latter starts at 3. That is the starting point for wavelength formula in Claim 1. What the integer does is introduce a non-inventive refinement of what has already appeared in Chave. If there is a difference, it is covered by obviousness.

Claim 1A

150. Claim 1 is therefore void for obviousness. The purpose of introducing claim 1A by amendment was said to be to overcome any issues on construction of the word "nature". It does not refer to searching for a reservoir. It would not have been pursued if claim 1 were good. Since it is not, then it becomes necessary to consider the fate of claim 1A. It fares no better than claim 1 in the light of Chave. The overall effect of Claim 1A is to use the refracted wave to distinguish water-bearing (less resistive) layers from hydrocarbon-bearing (more resistive layers). Everything said about Chave above applies to this Claim, and it too is invalid because it is obvious over Chave.

Claims 1B and 1C

151. Claim 1B was abandoned as a separate claim. It survives only as something which has to be read into 1C, so I need only consider this latter claim.

152. What Claim 1C adds to Claim 1 is a particular technique for generating the EM field. The field is generated in a continuous wave (as opposed to a transient on/off signal) with stepped frequencies. The principal purpose of introducing it is to distinguish the patent from another piece of prior art ("Hördt & Strack"). It is not maintained against Chave. At pages 948-9 Chave deals in general terms with the sort of transmissions that take place in a CSEM survey, and that description either anticipates this integer or, if this particular combination is not described, makes the use of frequencies described in 1C obvious.

Claims 2, 11 and 16

153. These are not maintained against Chave. I therefore do not consider them further in this context.

The remaining prior art in relation to the 019 patent

154. Since Schlumberger is entitled to have the patent revoked on the footing that the alleged invention is obvious over the Chave prior art, it is strictly unnecessary to determine whether other pieces of prior art give rise to invalidity as well. However, this is said to be a very significant patent, and in

case the matter goes further I will express my views on that prior art.

MacGregor

155. This piece of prior art is a paper prepared for the 61st conference of the European Association of Geoscientists & Engineers in June 1999 by Dr Lucy MacGregor, Professor Sinha and Prof Constable. It is entitled "Use of Marine Controlled Source Electromagnetic Sounding for Sub-Basalt Exploration".

156. In the introduction the authors summarise the paper:

> "There are numerous regions in the world where the presence of shallow high velocity layers makes the imaging of deeper structure using conventional seismic reflection techniques a difficult task. Of particular interest are continental shelf areas where potentially oil bearing sedimentary structures are obscured by layers of basalt, carbonate or salt. These high velocity layers limit the penetration of seismic waves and can cause reverberations which mask reflections from deeper sedimentary structures, leading to ambiguities in interpretation.
>
> "Additional constraint on the structure can be gained by studying the electrical resistivity. The resistivity of basalt, carbonate and salt is typically in the range 100-1000 Ωm, whereas the resistivity of the surrounding sedimentary sequences are typically 1-10 Ωm. This marked contrast provides an ideal target for electromagnetic prospecting techniques. By mapping such variations in resistivity many of the ambiguities inherent in conventional seismic techniques can be resolved. In addition sediment resistivity is in itself an interesting property to measure."

The method is then set out -- it is essentially an abbreviated account of CSEM:

> "The controlled source electromagnetic sounding method uses a horizontal electric dipole source ... to transmit a discrete frequency electromagnetic signal to an array of sea bottom receivers which record two orthogonal components of the horizontal electric field at the seafloor. Because the resistivity of the seawater is less than that of the seafloor, the signal in the water is rapidly attenuated, with the result that the fields measured by a receiver remote from the source have followed crustal diffusion paths. During the experiment the source is towed at a height of about 50 m from the sea bottom, within the array of receiving instruments. By studying the variation in the amplitude and phase of the received electric field as a function of source receiver separation and geometry, and the frequency of the signal, the resistivity structure of the underlying crust can be determined. Frequencies in the range 0.25-40 Hz are transmitted in a typical experiment. Lower frequencies lack the resolution of crustal scale structures which are of interest ... At higher frequencies only signals at the very shortest source-receiver separation can be detected above the ambient noise level. Such signals contain little information about the sub-surface resistivity structure. The range of frequencies which in practice can be employed is therefore quite limited.... Although depths of resolution up to 30 km have been achieved in the past … the strength of this technique lies in the resolution of shallower (0-5 km depth structure)."

157. In the middle of the text there is a schematic diagram of a ship towing a horizontal dipole source, and indicating a source-receiver separation of 0-20 km.

158. A modelling exercise is then summarised. Its purpose is to consider three thicknesses of basalt -- 1 km, 1.5 km and 2 km -- bounded at the top by seawater and underneath by a more conductive structure.

> "Modelling results
>
> Of particular interest is the problem of imaging conductive sedimentary structure beneath more resistive layers such as basalt...
>
> We wish to establish if the controlled source electromagnetic technique can detect the sub-basalt sediments, and if so how accurately their depth of burial, thickness and properties can be determined."

159. The authors then prepare two data sets of the amplitude of the electric field at four separate frequencies and for in-line and parallel signal sets. The synthetic data was contaminated with noise and then inverted for solutions. The results are plotted in graphs. The conclusions are expressed thus:

> "It is clear that the presence of the sub-basalt sediments can be detected, and that the three models can be distinguished using these synthetic datasets, which are comparable to those which could be collected in practice. The resistivity of the sub-basalt sediments is recovered well, and the presence of the basement beneath can also be detected.... for the examples shown this method locates the base of the basalt layer to within 200 m.…"

160. Schlumberger's case is that this paper anticipates the patent. It takes the known physics of CSEM. Basalt is highly resistive. The technique is said to be to use the fact that it can therefore propagate EM signals and that it can then be used to look at the relatively conductive hydrocarbon sediments below. Although the problem is described in terms of hydrocarbon (or sediments) buried under basalt, the target is still the sedimentary layer. Characterising the layer via its resistivity is part of what the authors proposed. While the paper does not expressly disclose using CSEM to differentiate between hydrocarbon- and water-bearing layers, it does teach discerning resistivity, and since the relative resistivities are common knowledge, then it would be obvious to apply the methodology of MacGregor for that differentiation purpose. Although the initial thrust of the attack on the patent based on this paper seemed to be anticipation (particularly in the first report of Dr Chave), by the time of final speeches there was an equal emphasis, if not a greater emphasis, on obviousness.

161. Dr Landro considered this article was more about mapping the basalt, and in particular finding out where the base of it was so that that could assist further seismic study. He did not consider it had relevance to the sedimentary layer that Schlumberger placed on it. Mr Burkill emphasised the absence of an intention to discriminate between the possible contents and nature of the sedimentary layer, and that so far as the sedimentary layer was being looked at it was relatively conductive, not resistive. He also relied on the fact that the authors had provided secondary material which was said to demonstrate that this article did not contain or anticipate the key point of the invention, and that it did not render the invention obvious. So far as Dr MacGregor and Prof Sinha are were concerned, the judgment of the hearing officer in the entitlement proceedings recorded that there was nothing in their evidence to suggest that they had previously contemplated using CSEM to detect oil reservoirs directly, and Dr MacGregor conceded that she had not previously considered the problem of detecting a relatively resistive thin layer. So far as Prof Constable is concerned, 5 months after this paper he wrote his peer review with the references to novelty and innovation appearing above.

162. I do not consider that this paper anticipates any of the claims. Some of the integers of claim 1 are present. It is certainly a method of performing a survey of subterranean strata, it applies a time varying electromagnetic field to subterranean strata, and the wave field response is detected. However, it does not seek the refracted wave within the meaning of the patent. The refracted wave is, of course, there as a matter of physics if there are differing relative resistivities, but this paper

does not seek to exploit it in the manner referred in Claim 1. The only possible explicit reference to it is in the passage which refers to "crustal diffusion paths", and to that extent the paper relies on the effect of the "refraction" as enabling the detection of any signals at all. However, that is not the emphasis of the paper. The emphasis of the paper is elsewhere - it is the fact that the signals, and the different effects of the strata on radial and azimuthal signals, can tell you something about the underlying strata, and in particular the depth of the basalt and the resistivity of what is beneath it. As the caption to one drawing says:

> "The variation of the electric field with source-receiver separation and geometry and the frequency of the transmitted signal can be used to determine the sub-seafloor resistivity structure."

The refracted wave is part of that, but is not clearly identified as a key thing that is utilised.

163. Thus integers 7 and 8 are not clearly disclosed. Integer 9 is present. Integer 10 (the wavelength criterion) is not present in terms. If one does the maths (which Dr Chave did) one can see that the part of the source-receiver offset distance is within the formula but part is without. So integer 10 is not disclosed either.

164. In addition, I accept Mr Burkill's submission that integers 2 to 4 are not clearly disclosed. The technique described in the paper, in terms of its description, stops short of the process described there. What happens is described in general terms - "the resistivity of the sub-basalt sediments is recovered well, and the presence of the basement beneath can also be detected." The search and detection referred to in these integers is not clearly present whether in relation to a hydrocarbon-bearing layer or not. Furthermore, the sediment is not detected by a refracted wave in the manner as the patent describes. It is a relatively conductive, not resistive, layer in the context of this model.

165. Accordingly the clarity of disclosure required for anticipation is not present so far as Claim 1 is concerned. The same applies to claim 2, and the other live subsidiary claims.

166. Again, however, obviousness is a different matter. Although the paper does not disclose the alleged invention, it does demonstrate an application of the same principles of physics in the context of geological exploration in a situation where there are different resistivities which affect the received signal in a way that can be interpreted to provide information about the strata. The focus is on resolving the extent of a highly resistive layer, which is basalt and not a hydrocarbon layer, but with the view of learning something about the layer underneath. As the introduction says, the model maps contrasts. It is finding out about the resistive layer between two less resistive layers, and also trying to find out about something underneath (including where it starts, in vertical terms). It is doing that by relying on signals that have taken a refracted route. It is obvious that that technique can be applied to layers other than basalt; and obvious that it is their comparative resistivities that are discernible. Although the relatively resistive layer in this case is not a hydrocarbon-filled layer, the application of these techniques to oil exploration is flagged by the references to "potentially oil bearing sedimentary structures" in the article itself. The technique in this paper was the utilisation of known physics, including the refracted wave through a known resistive layer. It was, in Dr Chave's view, which I accept, obvious to do it the other way round, that is to say to see if the effects of the refracted wave could be detected in order to see if it indicated a resistive layer, and to do that in the context of a sedimentary layer which was not beneath a more resistive layer. The paper was not, as Prof Landro suggested it was, all about taking the results back to those who were utilising seismics. It was pointing in another direction as well - the application of CSEM as a strand of exploration in its own right. Accordingly, since it was obvious to utilise it for oil exploration, the non-anticipated elements in integers 2 to 4 are obvious. Given common general knowledge of CSEM techniques, the wavelength criteria represent wavelengths which it would be obvious to try.

167. I do not consider that the secondary evidence about the subjective attitudes of Dr MacGregor and Prof Constable improves EMGS's position on obviousness. True it is that they did not go further in

this paper and point out how the technique could be used in the circumstances envisaged in the 019 patent, and the secondary evidence suggests that at least Dr MacGregor did not consider doing so. Where a particular written paper is relied on as prior art but does not anticipate, a fortiori it does not contain the inventive concept. It is not a complete answer (by itself) to an obviousness case to say that if it had been obvious the author would have included it in the paper. The real question is why it is not there. We do not know why Dr MacGregor did not go on. The reasons for that have not been tested in cross-examination. I prefer the obviousness case that has been tested in court to inferences that might be drawn from another expert (albeit the author of this paper) whose views have not been fully tested. So far as Prof Constable is concerned, the same sort of reasoning applies, but the inferences that might otherwise be drawn are weaker because all that he apparently regarded as novel (judging from the limited expressions that are available) is the target. That sheds little light on the real obviousness point.

168. It follows that the invention is obvious over the MacGregor paper.

169. The same applies to Claim 1A. MacGregor does not anticipate this claim; but the invention is obvious over the prior art in this respect.

170. Only subclaim 11 is said to be relevant to MacGregor. This deals with the choice of wavelength given the depth of the buried layer. The figures for resistivity in the overburden, and the frequency range, appearing in the paper would demonstrate that a wavelength (λ) range would be 8.6-109km. The application of subclaim 11, given the depth of the overburden, would give a wavelength of 0.1-20km. There is an overlap between those figures, but not a complete coincidence. That is why the paper does not anticipate this claim; there is no clear and unambiguous flag-planting. However, it would, on the basis of the evidence, be obvious to use wavelengths within the subclaim 11 range given the state of the prior art and the general expertise of the skilled addressee.

171. My overall conclusion is therefore that the invention is obvious over all relevant parts of this piece of prior art.

Srnka

172. Srnka is a United States patent (number 4617518) dated 14th October 1986. The inventor is Dr Leonard Srnka (referred to several times above); the assignee is, or was, Exxon. The patent was actually allowed to lapse in 1994.

173. It was filed on 21st November 1983. It was common ground at the hearing before me that some of the critical aspects are not at all easy to understand[1], and one crucial one, by his own admission, was misunderstood by Dr Chave when he wrote his first report. He corrected the position in his second report. It is obvious that this is not a good start for the allegation made by Schlumberger that the disclosure in this patent anticipates the 019 patent, or alternatively that the 019 patent is obvious over it.

174. Immediately before the abstract, there is a list of cited documents. One of the cited documents is the Chave prior art paper.

175. The patent is entitled "Method and apparatus for offshore electromagnetic sounding utilising wavelength effects to determine optimum source and detector positions". The abstract reads as follows:

> "An improved method and apparatus for electromagnetic surveying of a subterranean earth formation beneath a body of water. An electric dipole current source is towed from a survey vessel in a body of water substantially parallel to the surface of the body of water and separated from the floor of the body of water by a distance less than approximately

> one-quarter of the distance between the surface and the floor. Alternating electric current, preferably including a plurality of sinusoidal components, is caused to flow in the source. An array of electric dipole detectors is towed from the survey vessel substantially collinearly with the current source. Each electric dipole detector of the array is separated from the current source by a distance substantially equal to an integral number of wavelengths of electromagnetic radiation, of frequency equal to that of a sinusoidal component of the source current, propagating in the water. A gradient detector array is also towed by the survey vessel in a position laterally separated from, or beneath, the mid-point of the current source. Additionally, an array of three-axis magnetic field sensors mounted in controllable instrument pods are towed by the seismic vessel on the flanks of the current source. Frequency-domain and time-domain measurements of magnetic and electric field data are obtained and analysed to permit detection of hydrocarbons or other mineral deposits, or regions altered by their presence, within sub-floor geologic formations covered by the body of water."

176. The section headed "background of the invention" contains, inter alia, the following:

> "Electromagnetic survey systems are being used increasingly to explore for oil and gas on land. However, at present, practical methods for exploring for oil and gas in the offshore environment are restricted to the measurement of the natural magnetic and gravitational fields at the earth's surface, of the reflection of seismic energy from subsurface structures, or the seepage of chemical substances from mineral deposits beneath the sea floor into the sea water or atmosphere. Although passive techniques such as natural-source magnetotellurics can provide useful information about the lower crust and upper mantle, electromagnetic sounding techniques employing an active source are better suited for surveying subterranean formations within five to ten kilometres beneath the sea floor. Because practical techniques for active electromagnetic sounding of earth formations beneath the sea floor have not hitherto been known, the electrical structures of continental margins and offshore basins remain largely unknown, despite the scientific and economic importance of these areas….
>
> "'Resistivity' methods using an active source of direct electric current, or very low frequency alternating current…have been proposed for determining the apparent resistivity of geologic formations beneath the sea…"

177. At column 3 there appears a "Summary of the Invention":

> "According to the method of the invention, an electric dipole current source is towed from a survey vessel in a body of water substantially parallel to the surface of the body of water and separated from the floor by a distance less than approximately one-quarter of the distance between the surface and the floor. Alternating electric current is caused to flow in the source, said current including at least one sinusoidal frequency component. At least one electric dipole detector, including a pair of detector electrodes, is also towed from the survey vessel substantially collinear with the current source and spaced from the current source by a distance substantially equal to an integral number of wavelengths of electromagnetic radiation propagating in the water and having frequency

> equal to that of the sinusoidal component. A characteristic of the current emitted by the source and a characteristic of the potential difference between the pair of detector electrodes are measured. From these measurements, a characteristic of the "*complex mutual impedance*" of the current source and the dipole detector is determined. Preferably the current emitted by the source includes a plurality of sinusoidal components, each having a distinct frequency. Preferably, several dipole detectors are towed collinearly with the source. Measurements of the current characteristic and the potential difference characteristic should preferably be made at a plurality of frequencies for each source-detector pair…
>
> "Potential difference measurements at the electrode pairs of the gradient array and dipole array, and magnetic field measurements at the magnetic field sensors, are made while the vessel is moving or stationary, and the measurements are interpreted to permit the detection of hydrocarbons or other mineral deposits, or regions altered by their presence, within sub-floor geologic formations covered by the body of water. Frequency-domain measurements of magnetic and electric field data are analysed to construct the complex impedance spectrum of the sub-floor formation beneath each survey station…"

178. The real difficulties start to creep in in the section entitled "Description of the Preferred Embodiment":

> "…The potential differences between [the source and transmitter electrodes] are measured and amplified, and thereafter further processed and recorded by electrical equipment…aboard [the] vessel. The measured data is interpreted in a manner to be discussed below, to permit characterisation of earth formation beneath floor of body of water and to locate regions in sub-floor formation which possess '*anomalous*' properties indicative of mineral deposits. In a particular application, the measured data is interpreted to determine the presence and depth of a buried resistive layer, such as resistive layer 25, which has a resistivity different from the average resistivity of that portion of [the formation above that layer]."

Layer 25 is a reference to one of the drawings (I have omitted other numeric cross-references to drawings). It shows a layer below the overburden similar to the layer shown in the drawing of the patent. The italicised words in the above passages are my emphasis in order to identify terms which are important to the patent and which cause problems of interpretation.

179. The description goes on:

> "It is preferred that [the source dipole] and the electric dipole detectors be towed substantially collinearly, substantially parallel to [the] surface, and in approximately the lower quarter of the column of [the] water between [the] surface and [the] floor. As the depth below surface at which dipole current source and the dipole detectors are towed decreases to less than three-fourths the distance between the floor and the surface, the strength of the signal at the dipole detectors which is indicative of the electrical resistivity of the sub-floor formation (the '*anomaly*' signal) rapidly decreases due to masking by the water between the floor and the dipole detectors. It is additionally desirable to tow the apparatus within the lower quarter of the column of water between surface and floor because in that

region, the sensitivity of the anomaly signal to the height above floor at which the apparatus is towed is sufficiently weak that fish need only control the actual tow depth to within about 5% of the desired tow depth.

"If [the source electrodes] are separated by a first distance, and adjacent pairs of [detector electrodes] are also separated by substantially the first distance, then for direct detection of buried resistive layer located a second distance D, below floor, the mid-point of current source and the mid point of one of the electric dipole detectors should be separated by at least two D and preferably should be separated by at least three D. Also for detection of [the] buried layer, the output current at [the source dipole] should preferably include a sinusoidal component having frequency equal to the 'skin depth frequency' associated with [the] buried resistive layer. Such skin depth frequency [and here the patent sets out the skin depth formula referred to above]…is that frequency which makes the electromagnetic skin depth in the [overburden] equal to the depth, D, of the buried resistive layer". [This recitation omits the cross-referencing to the drawing but is sufficiently clear without it.]

"...I have found that the influence of the electromagnetic coupling directly between [the] source and each dipole detector (which coupling is independent of the characteristics of earth formation [in the overburden]) on the potential difference measurements at such dipole detector may be desirably reduced by spacing each such dipole detector from the source an integral number, n, of wavelengths λ_W of the electromagnetic signal from [the] source. Wavelength λ_W is given by [a given expression]. If [the source and detector] are so spaced from each other, all of the changes in the phase of the signal measured at each detector (relative to the phase of the output current at [the] source) are due to electromagnetic signals propagating along or below [the] floor…

"If it is desired to make the surveying system particularly sensitive to a resistive layer buried at a depth D below the floor, and if the average conductivity…of [the overburden] is known to a depth just above depth D, then the separation between [the source and detector] should be chosen to be substantially equal to an integral multiple of $2\pi D(\rho_{\omega}\sigma)^{1/2}$ and the source current should be chosen so as to include a sinusoidal component having frequency substantially equal to the skin depth frequency associated with depth D.

"It is desirable to generate, from the potential difference measurements made at each dipole detector, a signal indicative of the complex mutual impedance of [the source and detector]. From analysis of variations or 'anomalies' in the phase and amplitude of such complex mutual impedance signal, the presence of a buried resistive layer such as [the layer shown in the drawing] may be determined. I have found that the depth to such buried layer may be estimated by employing a plurality of detector dipoles in the electric dipole detector array and employing a variable frequency dipole source, and making potential difference measurements at each detector for each of a plurality of distinct source frequencies. In particular, it has been found that the frequency at which the phase or amplitude anomalies indicative of [the] buried layer are at a peak (or maximum) will decrease as the separation between source and detector increases, until such separation increases to a critical separation equal to three times the depth of [the] buried layer beneath [the] floor. Beyond such critical

> separation, the value of source frequency giving the peak signal anomalies remains substantially constant. By determining the value of such substantially constant frequency…the depth of [the] buried resistive layer may be estimated as…"

180. Srnka relies on "complex mutual impedance". In technical terms that means:

> "the linear relationship between the EM field and a source current for a given frequency source receiver offset in geometry." (Dr Chave)

In more everyday terms it can be viewed as the strength and phase of the received signal. The complex mutual impedance instructions involve comparing the amplitude and phase of the received signal with the amplitude and phase of the source signal. They will vary in accordance with the frequency and in accordance with offset.

181. Schlumberger's case is that this patent anticipates; alternatively that the invention is obvious over it. The anticipation case is the prime case, and it is advanced with vigour. Srnka describes the conduct of a CSEM survey. It is maintained that although it does it in different terms, Srnka is relying on the refracted wave, and that it shows that the wave is picked up at distances which are more than 3 times the burial depth.

182. EMGS says that Srnka does not refer to the refracted wave and that it teaches a different phenomenon based on variations with frequency. Furthermore, it is non-enabling, because it teaches an unrealistic source-detector spacing, and there are difficulties in understanding what Srnka is looking for (in terms of the signal and its analysis) and whether it is there at all. It does not enable, because on the proper interpretation of the key word "anomaly" it can be shown not to work; and if it works it is impractical. It does not teach direct detection - it is focused on ascertaining the depth of a buried layer. It contains inconsistent or impractical teaching on source-receiver separation.

183. A number of issues therefore arise as to this piece of prior art:

i) What does it actually teach?

ii) Does its teaching enable?

iii) Does its teaching anticipate? This raises two points - does it teach sufficiently unambiguously to anticipate; and if so, does it actually anticipate?

What does Srnka actually teach?

184. Its teaching seems to be based on the following main elements, which I describe generally at this stage so as not to pre-judge questions of construction and enablement that arise:

i) The carrying out of a marine CSEM survey with fairly conventional equipment, though not conventionally arrayed.

ii) Looking for and analysing an "anomaly" signal.

iii) There is some teaching about spacing of source and detector and frequencies.

iv) There is some teaching about spacing source and detector by reference to whole wavelengths of the signal in water.

v) It plainly has in mind the context of a hydrocarbon (or potentially hydrocarbon) layer, though it also refers to minerals generally.

Disputes arise out of a number of those elements.

Srnka's "anomaly"

185. Key to Srnka's invention is the identification of an "anomaly". This expression occurs a number of times in the patent, as appears from the above extracts. Unfortunately it is not fully defined, and the experts differed as to what it meant. The dispute is important because it is common ground that if the meaning propounded by EMGS is correct the patent cannot anticipate. It is only if the meaning now propounded by Schlumberger is correct that the anticipation argument is capable of succeeding (though it would not necessarily determine it in Schlumberger's favour).

186. In his first report Dr Chave observed that "anomaly" was "defined as 'variations' of the complex mutual impedance" and that the term meant "the EM field response as a function of the experimental parameters." When dealing with integer 7, he said:

> "All that the skilled addressee reading Srnka could do is to measure the electromagnetic field as a function of range, frequency and geometry. Srnka refers to different readings as 'variations' or 'anomalies'. Analysis of such 'anomalies' to determine the resistivity of the reservoir under investigation is, and would have been understood by the skilled addressee to be, the same as 'seeking the refracted wave' … Neither Srnka nor the 019 Patent discloses the details of this analysis/seeking."

I am not sure how clear that is as to what Dr Chave actually thought the expression meant, as opposed to what he thought the "anomaly" reflected in experimental results. It does, however, appear that he did not view the determination of the anomaly as a comparative exercise; he regarded the measurement taken as being an absolute measurement. His position became clearer in cross-examination, when it seems he accepted that his initial view was the same as Professor Schultz's.

187. Professor Schultz's first report stated that:

> "the solid earth geophysicist or EM Expert would regard Srnka's statement as indicating that variations in the phase or amplitude of the complex mutual impedance are equivalent to 'anomalies'.
>
> "116 … I conclude that the dependent variable ie the observable, is the amplitude or phase of the complex mutual impedance, and that there must exist independent variables (eg source-receiver offset, source signal frequency, resistivity) which, by varying, would lead to changes in the complex mutual impedance. It is those changes that Srnka calls the 'anomaly' ..
>
> …
>
> "124. The EM Expert would understand Srnka to teach that one should scan at various frequencies to find, for each offset, the frequency at which the phase and/or the amplitude is greatest. I believe that Srnka is teaching that behaviour between the offset and the frequency of the peak value would be something similar to the following:
>
> [Graphs shown]
>
> ….
>
> "126. Therefore it is my belief that the reader would expect that by graphing the amplitude or phase of the complex mutual impedance as a function of both offset and frequency, he could identify a constant frequency F_c (ie the frequency at which the above curve levels off) that

> indicates the presence and depth of a resistive layer."

At paragraph 123 he had observed:

> "123. Srnka expects that this relationship will have two distinctly different behaviours depending on the separation between the source and the receiver.
>
> "(a) At separations less than approximately three times the depth to the buried layer, Srnka says that as the separation between source and receiver increases the frequency giving rise to the peak 'anomaly' will decrease.
>
> "(b) Srnka then says that at a critical separation equal to three times the depth of the buried resistor, there will be a change in behaviour, namely that the value of frequency giving the peak 'anomalies' will then remain substantially constant."

Professor Schultz did not seek to justify his view by reference to any textual or other reasoning, but he did elaborate on the meaning.

188. Whatever it was that Dr Chave meant precisely in his first report, it seems that his view was much the same as Professor Schultz's. At Day 7 page 950-951 he gave answers demonstrating that he meant the measurements to be assessed in absolute terms as opposed to terms which are relative to other measurements or models, and at Day 7 page 973, having had it put to him that what one measured was just the E-field as a function of frequency, he responded: "On a much more cursory reading, that is how I did it in the first report." However, he revisited the question as part of his second report, which was a reply to Professor Schultz. His explanation for revisiting the point (given in cross-examination) was that Professor Schultz had spent such a large part of his report in dealing with Srnka that he felt he needed to go into it some more. I also think it likely that he reconsidered it because Professor Schultz had demonstrated that his (and Dr Chave's initial) view of the meaning had the result that the patent did not achieve what Srnka said it would do - modelling demonstrated that one would not get the anomalies Srnka described. In other words, that part of the invention did not work. I will come back to that point, but for the moment will continue with the construction point.

189. Dr Chave's new interpretation was that "anomaly" and its derivatives meant a difference between the reading that one got on site with a buried layer and the reading one would expect to get if there were no resistive (or perhaps conductive) layer, the latter being based on a known physical reference survey or a model. He did not give reasons for his newly-expressed view. He did, however, strongly defend it in cross-examination. In doing so he is likely to have been influenced by some modelling that he did which, he said, demonstrated that "anomaly" in his sense did coincide with the results of modelling - one could see the results and effects that Srnka described.

190. If "anomaly" has what I will call Professor Schultz's meaning then it is common ground that the patent does not enable because one does not get the effect described. Although there were some indications that Dr Chave might not personally have accepted that, that was the position of Schlumberger at the trial. Detecting the anomaly is the only thing relied on as being the equivalent of seeking the refracted wave in the 019 patent, so if Professor Schultz is correct then Srnka cannot anticipate. The meaning of "anomaly" is therefore a vital issue.

191. This point, in this context, involves not merely a determination of the true construction of a document. Srnka is relied on as an anticipation, so what is necessary (if that is to be achieved) is a sufficient degree of clarity. In order to be an anticipation the disclosure must be clear and unambiguous. I repeat the classic exposition in *General Tire & Rubber Co. v. Firestone Tyre & Rubber Co. Ltd*:

> "To anticipate the patentee's claim the prior publication must contain clear and unmistakable directions to do what the patentee claims to have invented . . .
>
> "A signpost, however clear, upon the road to the patentee's invention will not suffice.
>
> "The prior inventor must be clearly shown to have planted his flag at the precise destination before the patentee."

Jacob J reinforced the need to have "clear and unambiguous instructions to do something within the claim" in *Hoechst Celanese Corp v BP Chemicals Ltd* [1998] FSR 586. In *BSH Industries Ltd's Patents* [1995] RPC 183 Aldous J was minded to come to a conclusion as to what a drawing in some prior art showed, but considered that that conclusion was not sufficiently clear to amount to clear and unmistakable directions, and that therefore the prior art did not anticipate.

192. Many of the references to "anomaly" are equivocal or simply unclear. They merely refer to the "anomaly signal". One has to indulge in a certain amount of careful textual and geophysical analysis to begin to form a view as to what is meant. The first reference ("regions in subfloor formation ... which possess 'anomalous' properties …") probably tends to suggest a comparative or referential exercise, as Professor Schultz was minded to agree. The reference to "variations or 'anomalies'" is probably equivocal, but might be said to support Professor Schultz's views. Mr Silverleaf suggested that the reference to using the anomaly to determine the *presence* as opposed to the depth of a buried layer suggested that what was required was a comparative exercise with a different model. That may be right; Mr Silverleaf suggested that Professor Schultz accepted that, but I am not sure he did. Dr Chave and Schlumberger also have on their side dictionary definitions of "anomaly" (which would coincide with the normal use of the word):

> "1. A deviation from uniformity in physical properties; a perturbation from a normal, uniform, or predictable field. 2. Observed minus theoretical value. 3. A portion of a geophysical survey, such as magnetic or gravitational, that is different in appearance from the survey in general. 4. A gravity measurement that differs from the value predicted by some model, e.g., a Bouguer or free- air anomaly (q.v.). 5. In seismic usage, generally synonymous with structure. Also used for unexplained seismic events. 6. A deviation that is of exploration interest; a feature that may be associated with petroleum accumulation or mineral deposits …"

193. These pointers mean that if a court of construction had to work out what anomaly meant, it would probably (but only just) come to the conclusion that Dr Chave's second thoughts were correct. However, this court is not, in this context, a court of construction. If this document is to anticipate then it must contain the necessary clarity. I do not think it does. That is apparent just from looking at the document. Furthermore, the initial view of both experts was one that did not involve a comparative exercise with a different area or model. Then one of them changed his mind. Of course, that does not of itself mean that the directions in the patent lack the clarity necessary to anticipate. The mere fact that experts disagree on meaning does not necessarily mean that flags are not sufficiently clearly planted; nor does the fact that the position of one of them is arrived at after a change of mind. However, on the facts of this case, and as the matter developed, I think that Dr Chave's initial views and change of mind are important matters. He is, on any footing, and on any meaning of the words, a highly skilled man. If he is confused by the wording of this patent then it is likely to be confusing. He was, of course, able to come to a conclusion which he found clear, but that does not leave the patent sufficiently clear for anticipation purposes. He probably did so only because Professor Schultz demonstrated that the first meaning did not work. Given that the prior art here is a patent that may point to insufficiency, not a proper alternative meaning (though I do not need to decide a sufficiency point). Even if an alternative meaning can be shown to work (which

may well be the case here), that does not make that alternative meaning sufficiently clear, particularly if one had to cast about for it in the first place.

194. In those circumstances I find myself in the same position as Aldous J in *BSH Industries*. If I had to come to a conclusion as to what "anomaly" meant, faced with the two propounded meanings, I would probably prefer Schlumberger's final case. But that is not the point. The point is that Srnka does not, sufficiently clearly, plant the flag. It points two ways.

195. At this point I need to digress to give a ruling on an admissibility point on which I heard separate argument with a view to giving a ruling at the time, but which I then decided I would rule on in this judgment. It concerns the admissibility of evidence that Dr Chave relied on in support of the workability of his construction of "anomaly" in Srnka.

196. I have indicated how he came to change his mind about that. During the course of his evidence he sought to show that his interpretation, unlike Professor Schultz's, worked so as to produce the effect that Srnka sought to describe. He sought to show that this interpretation produced results that worked in distinguishing a resistive layer. He did not do so in his second report, but when being cross-examined he drew some freehand graphs of modelled results which he said demonstrated that on this interpretation Srnka described an exercise which was capable of distinguishing a resistive layer. He was answering questions from Mr Burkill and offered to demonstrate what he meant on a flipchart. I accepted that offer. He then drew his freehand graphs. He said they were the result of some "simple calculations" that he had done, and the nature of those calculations, but not the detailed figures on which they were based, was made available overnight to Professor Schultz so that it could be considered by him. Professor Schultz had not seen anything relating to this before. This was done as a result of a request made by Mr Burkill in cross-examination. The document consisted of one and a half pages of narrative and general equations, showing methodology but not detailed figures.

197. The next day, at the very end of the cross-examination, Mr Burkill touched on this area again. He did not cross-examine on the document that had been produced to his expert, but he did elicit from Dr Chave that he had considered putting in justifying material formally some weeks before but had been told by Schlumberger's solicitors not to do so, and Mr Silverleaf told me that that was because he had considered it was too late to do so.

198. Mr Silverleaf raised this material with Professor Schultz during the latter's cross-examination but without actually cross-examining on the overnight document itself. Professor Schultz had had a chance to consider the material, and pointed out some holes or unknowns in the material. He said (not surprisingly) that a fuller exercise really needed to be done. He was minded to accept that on Dr Chave's interpretation of this part of Srnka the patent would work after a fashion, but not with sufficient clarity to be of interest to oil companies. During this line of questioning no point was taken by Mr Burkill about the admissibility of the Chave evidence.

199. In his written closing skeleton argument Mr Burkill addressed this evidence. He did so in terms of its weight, not its admissibility. Nevertheless, in his oral submissions he went on to invite me to exclude it altogether on the basis that the nature of the evidence was such that it amounted to an experiment, and no prior notice of experiments had been given. He strengthened his case by relying on what emerged from Schlumberger's side about the circumstances in which the evidence had not been formally adduced earlier. Each side relied on the history of the introduction of other material in their submissions on the question as to whether this material amounted to an experiment of which notice ought to have been given.

200. This was an unsatisfactory episode. In a case as complex as this one, additional scientific material of this nature should be notified in advance if it is to be relied on. I think that there is much to be said for EMGS's case that the material comes under the experiments regime so that notice should normally have been given of it. However, I do not think it is necessary for me to lengthen this

already long judgment by an elaborate consideration and ruling. I am prepared to assume for these purposes that it was an experiment. The point underlying any the requirement to disclose experiments in advance is the need for an orderly and fair trial, (and possible control of costs) and the need to avoid unfair ambushes. For Dr Chave to be relying on material which he has not disclosed is not at all desirable. However, it was not deployed as an ambush (unless it was a very cleverly crafted one indeed). The material arose as a result of Dr Chave being asked to develop his views on Srnka. He offered to demonstrate what he was saying, and it was I who accepted that offer. The provision of written material was a result of a request by Mr Burkill. This is hardly an ambush. At the very end of the cross-examination Mr Burkill elicited the fact that Mr Silverleaf had advised that it was too late to seek to introduce detailed material. In his final speech Mr Burkill said that the purpose of this bit of cross-examination was to obtain evidence for the application to exclude, yet he did not make the application when the material emerged, or when it was cross-examined upon. The application to exclude materialised much later, long after Professor Schultz was cross-examined on the point. It is that, if anything, which smacks of ambush.

201. But assuming that a discretion to exclude arises, the real question is one of prejudice to EMGS if it is allowed in, balanced against prejudice to Schlumberger if it is excluded, the exercise being conducted in order to achieve the overriding objective. There is some prejudice to EMGS in allowing it in, in that it has not had a full chance to determine the correctness of what Dr Chave had calculated. However that prejudice is tempered by the fact that the material saw the light of day because of Mr Burkill's questions and request, and Professor Schultz did have some chance to consider it. Furthermore, as material it was not nearly as weighty as it might have been. The underlying exercise and figures were not disclosed, and Professor Schultz fairly observed that a much more thorough study would be necessary in order to see if Dr Chave's interpretation held good as a matter of experiment or modelling. If I take that quality into account, and bear in mind the lack of detail or the opportunity to check detail, and apply that to my determination of the weight of the evidence (so far as relevant) the prejudice to EMGS is not very great. So far as the prejudice to Schlumberger is concerned, the potential for prejudice would be greater if Dr Chave's supporting material were completely excluded, since there would be no material backing at all for what could be a material part of his evidence.

202. Accordingly, and bearing in mind the manner in which the material was introduced, the failure to take an objection earlier (which might have led to different ways of resolving this matter), and the balance of prejudice, I admit the evidence. However, since it does not contain a full rationalisation, and since the circumstances of its introduction mean that it has not been fully tested, I do not give it a lot of weight and I approach it with caution.

203. On this topic I add one further point. There is, I suppose, a prior point as to whether the short written material of Dr Chave was actually ever put in as evidence. He did not formally produce it to the court, and it was not put to him in cross-examination. When Professor Schultz was asked about it it was done without putting it to him. It only found its way into the trial bundles at a late stage and even then it only went into the solicitors' correspondence bundle. However, Mr Silverleaf does make it part of his case, and as a piece of paper it exists. There is no challenge as to its authorship. Accordingly, I find that it should be treated as being capable of being evidence in the case, and having so found my other conclusions as to its admissibility, admission and weight then stand in relation to it.

204. In the light of my finding on the lack of clarity in the Srnka patent, this decision is of much less significance. But there is one point to which Schlumberger seemed to be suggesting it went. Mr Silverleaf put to Professor Schultz that the fact that Dr Chave's (second) interpretation worked, and that his (Professor Schultz's) did not, pointed towards the former's being correct. That is not really a question for the experts, but it does not assist anyway. If one is construing a commercial document it is a well established principle of normal documentary construction that if there are two possible meanings, and one has a sensible and commercial effect, and one has a very odd and uncommercial effect, the former is likely to be favoured. But this is not such a document. It is a patent, to which

those principles do not apply in that manner; or at least it was not demonstrated that they do as a matter of US patent law. The question is one of enabling disclosure. While the speeches of Lord Reid in *C van der Lely* v *Bamfords Ltd* [1963] RPC 61 and Lord Walker's speech in *Synthon BV v SmithKline Beecham plc* [2005] UKHL 59 make it clear that the skilled man might have to use a bit of skill and to indulge in some trial and error in order to understand a patent, that does not mean one can or should go as far as Schulmberger seeks to go in relation to this piece of prior art. This is not a case in which there is some (probably limited) ambiguity resolvable with some reasonable trial and error. This is a case in which both experts came to an apparently similar view, and one then demonstrated that that did not produce a patent which worked in line with its apparent disclosure. That then led the other of them to reconsider the interpretation, and to come up with a second one, which he then demonstrated worked better, though not (as I find) very well. That is a different sort of exercise. So far as anticipation goes, and if it does not extend the flag-planting metaphor to an impermissible extent, what Schlumberger's approach seems to require (so far as it relies on preferring one interpretation because it works better than the other one) is a provisional flag-planting, a discovery that that ground is not very sound, prodding about in some different though related ground, finding some with a more robust footing, and then planting the flag there. While one must never let the metaphor govern the substance, that not unfair parallel does in my view encapsulate what Schlumberger would seem to be seeking, and insofar as it does then it is some way from the principles of clear disclosure encapsulated in the metaphor in its original form.

205. That conclusion is sufficient to deal with anticipation, but I will deal briefly with the other issues that arose in relation to anticipation.

206. The next dispute on the meaning of the Srnka patent is whether it is concerned merely with finding the depth of a buried resistive layer, or whether it claims to be able to detect the *presence* of such a layer. EMGS claimed it was concerned only with the former; Schlumberger claimed it was concerned with both. I consider that Schlumberger is correct about this. It is true that in considering certain bits of prior research the patent comments on four pieces of prior research, and the patent comments in respect of each that it does not disclose any method for determining the depth of a resistive layer. That might lead one to think that is what the Srnka patent is then going to address. However, the summary of the invention provides that measurements are "interpreted to permit the detection of hydrocarbons or other mineral deposits". That is not ascertaining the depth. There are other references as well –

> "… If electrodes 33 and 34 are separated by a first distance … then for direct detection of buried resistive layer 35 …
>
> "From analysis of variations or 'anomalies' in the phase and amplitude of such complex mutual impedance signal the presence of a buried resistive layer … may be determined."

There are other references to determining the depth, but the patent as a whole is not devoted solely to that issue. I find that it is not so devoted. It purports to deal with both depth and presence.

207. There was next a complicated debate about whether Srnka's suggested source-receiver spacing by reference to complete multiples of wavelength was workable. This solution is said to cancel out the effect of the direct wave travelling through the water. Schlumberger says it was feasible, and I think that it (or rather Dr Chave) was right about this. If one towed several receivers, with differing spacing, one could produce an array which was, in Srnka's terms, tuned to some complete multiples of wavelengths as regards some of them, and other wavelengths as regards others. Such a technique would, however, limit the wavelengths (and therefore frequencies, which are a function of wavelengths) which could be used. Furthermore, Srnka proposes a wavelength determined by the skin depth of the overburden. Those two sets of wavelengths can be mathematically related, and initial suggestions by Mr Burkill that they could not be reconciled, were abandoned, but the consequences on the useful working of the patent remained somewhat uncertain. I do not need to

enter into this very difficult area of debate.

208. I have already concluded that Srnka does not anticipate. In that event Schlumberger's alternative case is that it renders the invention in the 019 patent obvious. Of course, if the invention is obvious over the Chave prior art then this question does not arise. Nevertheless, I will consider it on the footing that I am wrong about Chave.

209. It is obviously a problem with Srnka that its detailed teaching is somewhat unclear and obscure. If it stood by itself that lack of clarity, and that obscurity, would almost certainly stand in the way of an obviousness claim, or at least an obviousness claim based on the detailed teaching. But it does not stand alone for these purposes. I have already found the central teachings of Chave to be common general knowledge. This includes teaching of the refracted wave. If Mr Burkill is right that that paper does not disclose the application of the known physics to the direct detection of a hydrocarbon layer, then in my view Srnka does. Its text makes it plain that it is concerned with detecting the presence (as well as the depth) of hydrocarbon layers, even though other things are mentioned, and even though it is not plain how that is to be achieved in practice. Accordingly, if the invention is not obvious over Chave because the missing element of seeking hydrocarbon layers is not an obvious application (contrary to my primary view) it is obvious over Srnka when Srnka is placed against the permissible background of the common general knowledge elements of Chave. I accept that there was no direct evidence from Dr Chave on that particular way of putting the case, but it is a conclusion that I consider I am entitled to draw on the basis of the very extensive evidence that was given about Srnka, the Chave paper and common general knowledge. If there is a gap in between the Chave paper (embodying common general knowledge for these purposes) and the invention of the kind suggested by Mr Burkill in his description of the inventive step, then it is, in effect, filled by Srnka.

210. That essentially deals with obviousness and claim 1 of the 019 patent. Claims 1B, 1C and 2 are not materially different for these purposes, and would fail for the same reason. It is not clear to me that, if the other claims fail for obviousness, claims 11 and 15 are pressed against Srnka, but there was little or no argument on the refinements that might be involved in that question, and I make no determination on it at present. The matter can be further argued if either party convinces me that it matters in the light of my decisions on other points.

Hördt & Strack

211. This is a paper presented to a seminar held in Germany in 1994, the seminar being entitled "Interpretation Strategies in Exploration and Production". Its authors were the two people whose names appear above. The title of the paper is: "Reservoir surveying through the combined use of seismic and electromagnetic methods". It describes a land-based CSEM process. At least as a matter of chronology, its pleading as a piece of prior art led to the application to amend the claims in the 019 patent down to submarine surveying. It has the following relevant content.

212. In the section entitled "Introduction", it refers to the need to obtain accurate information concerning porosity, permeability and geometry of hydrocarbon storage sites. Seismic surveys can only take one so far.

> "A surface method which supplements seismics by providing information concerning porosity, permeability and possibly the actual fluid in order to be able to interpolate with greater reliability between the wells is desirable. Electromagnetic methods suggest themselves here. These measure electric conductivity, which depends precisely on the important parameters porosity, permeability and conductivity of the fluid.
>
> "The long-offset transient electromagnetics (LOTEM) method suggests itself for use in reservoir surveying as penetration depths of up to several kilometres can be achieved with this method… Hitherto it has been used

> inter alia for crustal studies…and used in hydrocarbon exploration…Compared with other electromagnetic methods, the LOTEM method has the advantage that an earthed electric bipole is used as transmitter. Good resolution even of poorly conductive layers is therefore possible through the measurement of electric fields. This is particularly important because hydrocarbons are generally poor conductors…
>
> "The aim of this paper is to show that there are cases where the LOTEM method can serve as an important aid to characterisation.
>
> **"The LOTEM method**
>
> "LOTEM is a transient electromagnetic depth-sounding method which uses a horizontal electric bipole as transmitter….A direct current of ca 30 amperes is fed through [a] cable into the ground which has its polarity reversed at regular time intervals…every switching event produces induction currents in the subsurface, which spread sideways and downwards in time. The form of the propagation depends on the conductivity structure of the sub-surface. Expressed in simplified terms, a high conductivity produces a low velocity of propagation and vice versa".

213. There then follows a schematic diagram of the setup. It shows a broadside, not an in-line, configuration. In the top left hand corner it shows the "transmitter current wave form" and demonstrates it to be an apparent square wave form. The text goes on:

> "An important property of the LOTEM method is the possibility of the resolution of thin, poorly conductive layers. This is made possible by the direct supply of a current into the earth, as vertical currents are also produced in the sub-surface. By contrast, in the case of methods which use a loop as a transmitter, only horizontal currents are induced…Horizontal currents penetrate thin, poorly conductive layers while vertical currents are blocked, with the result that charge accumulations form. These can in turn be interpreted by measuring the electric fields".

214. Mr Silverleaf interprets this as anticipating the teaching of the 019 patent. Fig.5 shows "schematic behaviour of the physical parameters for a reservoir with variable porosity". The text comments:

> "The interval velocity of the P-waves decreases as the porosity increases, regardless of the pore liquid. The conductivity depends on the fluid. For salt water, it increases with the porosity, said increase being not just but of a higher order [sic]. Hydrocarbons are poor conductors, for which reason the conductivity decreases here as the porosity increases. If the porosities are therefore successfully determined with seismics, electromagnetics help with a direct recognition of hydrocarbons".

215. It is Schlumberger's case that this paper anticipates the unamended claim 1, and insofar as the claims become limited to submarine (as opposed land-based) CSEM, then all other integers are anticipated, and the translation from land-based to marine is obvious. In the alternative, an obviousness case is run.

216. EMGS's case is that this paper does not anticipate, and does not raise an obviousness case, for a number of reasons, including primarily the following:

i) It is a land-based system.

ii) It is a transient-based system, whereas the 019 patent is frequency based.

iii) There is no indication that it exploits the refracted wave.

iv) The importance of using in-line orientation is not taught or appreciated.

217. As to the first (land-based system vs marine system), this is certainly a land-based system. That is not a distinction so far as the unamended claim 1 is concerned. It is a distinction so far as the amended claim is concerned. Mr Silverleaf's response at that point becomes one of obviousness - it would be obvious to translate its teaching to the marine environment. I shall deal with this, so far as material, below.

218. Next is a somewhat complex point which occupied a good deal of time in this trial. It turns on integer 10, and the nature of the transmission in Hördt & Strack. EMGS says that integer 10 demonstrates that the teaching of the patent involves transmitting signals with wavelengths which are actually utilised to determine the transmitter/receiver offset. The patent is confined to frequency domain systems, and furthermore it requires that a wavelength be selected for these purposes, and that the signal be transmitted and analysed by reference to that wavelength. It is said that Hördt & Strack does not demonstrate this feature. Hördt & Strack uses a transient method. The signal is switched on and off abruptly and its effect is measured in the time domain by assessing the differential in the signal progression (or the delay) which is caused by the medium through which it has to pass in order to get to the receiver. There is no teaching of any reliance on any particular wavelength, and one cannot infer one. Accordingly there is no anticipation of integer 10 of claim 1 (the relationship between wavelength and offset). Furthermore, it is said that it is of the nature of a transient system that so far as a wavelength might be identifiable by reference to the regularity of transmission of a square wave (with the frequency of its on-off-on pattern) then it is inevitable that the wavelength will fall outside the parameters of integer 10. This is said to be because it is of the essence of a transient system that one waits for unwanted noise to die away before measuring the signal, and that means that the frequency of transmission has to be such that if you transmit square waves as in Hördt & Strack you have to let the "turning off" state die away and pass before you can transmit another signal. Mr Burkill sought to demonstrate that that limited the frequency of signal states, and thus increased wavelengths such that Hördt & Strack's wavelengths, so far as they can be inferred, would be too long to accommodate the Hördt & Strack offsets for the purposes of integer 10.

219. Schlumberger's riposte to this was to say that the patent was not confined to frequency domain systems, to rely on the underlying physics to demonstrate the inevitability of wavelengths and offsets which fall within integer 10, and to challenge Mr Burkill's analysis of wavelength on the footing that it was unsupported by evidence and unprincipled. There is also a suggestion that the offset formula in integer 10 is not a limitation; it is an indication of the offsets at which useful information will be obtained from various wavelengths. Because of the laws of physics, all wavelengths are being transmitted, and/or they can be extracted by a process of Fourier transformation, and the wavelengths and offsets referred to in integer 10 are those that would be recognised by the skilled addressee as being the useful ones to be utilised for the purposes of assessing the results of the CSEM survey.

220. Some of those points require one to construe the patent, so I now turn to that. The questions of construction are whether the claims in the patent are limited to exercises carried out in the frequency domain, or whether they cover exercises in the time domain, and whether integer 10 is merely an indication of what results should be analysed or whether it is a limitation.

221. I shall first address the question of whether integer 10 is a limitation or not. Looking at claim 1 by itself, and as a matter of grammar, it plainly seems to be one. The claim describes "A method" with a defined purpose, and then sets out some characteristics - applying a time-varying magnetic field, seeking the refracted wave, and so on. Then the method is described as one "in which the transmitted field is in the form of a wave … and in which [the offset is given by a formula]". As a matter of wording and structure, integer 10 seems to be as much a limitation as all the other

elements. It does not appear to be in the nature of an observation of what will be useful.

222. That conclusion is not weakened by anything elsewhere in the patent. In paragraph 7 of the description, which appears after what is an equivalent wording to claim 1, there is the sentence:

> "Given that the distances and the geometry of the reservoir will be known from previous seismic surveys, an optimum λ and l would be selected."

This envisages a process of choice for the purposes of the integer, not an indication of how to extract information from results. Again, paragraphs 18 and 19, which refer to the advantages and disadvantages of short and long wavelengths, indicate that there will be a choice of wavelength in order to achieve a useful result, which again supports the idea that integer 10 is a limitation and not just an observation.

223. Paragraph 21 suggests that the transmitted field may be pulsed, which probably refers to transient signals, which in turn suggests a time domain signal without a particular choice of wavelength. However, it also refers to discrete frequencies. Paragraph 22 refers to "the wavelength of the transmission through the overburden", which again supports the notion of selection. Paragraph 25 introduces some more potential equivocation by referring to time domain techniques, but that is in terms of data analysis. Paragraph 40, describing a modelled exercise at sea, refers to a choice of frequency (and therefore of wavelength). Overall, nothing in the description does much, if anything, to support Mr Silverleaf's submission on this point, and where relevant it points away from it.

224. In my view integer 10 introduces a limitation.

225. Next is the question of whether the patent applies only to CSEM surveys conducted by reference to the frequency domain. I do not actually consider this to be a relevant point to consider. There are dangers in some of these labels, and claim 1 does not express itself to operate in a domain. It talks in terms of wavelengths, which presuppose the selection of frequency, or at least a fixed and determined frequency, and I do not think it necessary to go beyond that. The description refers to the possibility of analysing using time or frequency domain techniques, and Dr Chave pointed out that one can do either by employing Fourier transformation (where necessary). So I do not think that the claim is necessarily specifying either. Certainly it is not necessary for me to decide that.

226. With those points out of the way I return to consider whether Hördt & Strack anticipates so far as integer 10 is concerned. It specifies a separation or offset of 2-15 km in its Figure 1, but it does not specify a frequency. Indeed, it seems to teach a square wave. Treating the period of the square wave as if it were a frequency for these purposes, Dr Chave sought to demonstrate that Hördt & Strack taught a wavelength range of 1 to 1000m, so that the range of integer 10 (0.5λ to 10λ) yielded a range of 0.5km to 10,000km. That partially overlapped the offset (for the range 0.5km to 2km), and it is said that that anticipates integer 10. Dr Chave arrived at that conclusion by calculating the electromagnetic diffusion time (the period of time it takes for the signal to travel to its destination, which must be allowed to pass before another signal is sent), which in turn depends on the assumed resistivity of the overburden and a constant. From this he calculated the period of the square wave and ended up with his conclusion.

227. The first point to be made about that is that is not an exercise to see what Hördt & Strack teaches. It is an exercise to see what can be deduced from Hördt & Strack if you are looking for the particular feature in question. That seems to me to be a different exercise. If one is looking for what Hördt & Strack clearly teaches (in terms of the test for anticipation) you cannot see what Dr Chave deduces in the text, and you can only get there by a process of reasoning which, even if accurate, is a process that yields conclusions about what they must have done, not what should be done. It also depends on the questionable assumption that the period of a square wave should be treated as a frequency for these purposes.

228. The next point is that even if the process of deduction as to what Hördt & Strack must have done is

a legitimate one, it is not inevitable that operating Hördt & Strack will mean that one falls within the limits of integer 10. There is only an overlap. Much of the potential operational range would fall without integer 10. For that reason, too, it does not anticipate. Dr Chave's view was that the skilled addressee would understand that the larger wavelengths were not usable, but in my view that does not answer the point. The exercise of deduction and inference is further removed from what is appropriate to anticipation.

229. Further uncertainty was then injected by an exercise undertaken by Mr Burkill with Dr Chave. He put to him a series of calculations which demonstrated (if they were accurate and proceeded on the correct footing) that if Hördt & Strack were carried out, there would be no overlap at all between the wavelengths and offsets used by Hördt & Strack and the wavelengths and offsets provided by integer 10. Dr Chave could find no fault with the mathematical progressions involved, though he was reluctant to accept the conclusion. He viewed them as wrong because they did not seem to him to coincide with what he considered the physics of the situation to be. However, he was unable to demonstrate where the calculations went wrong, or to identify any false premise, and was left in the position that he was able only to express surprise at the result. It is therefore even less clear that there is any overlap between figures to be deduced from Hördt & Strack and integer 10. So it is even more apparent that there is no anticipation.

230. These matters assume that it is appropriate to treat the rate of repetition of a square wave as a frequency for these purposes. Hördt & Strack indicates that the reason for repetition is to be able to "stack" the responses - that is a process which adds one result to another to cancel out error and to reinforce the real signal readings. It is a way of improving accuracy. This is not a technique which directly involves the identification of a frequency in the results - or at least not overtly. If one wants a label, it is, as already described, a transient system.

231. Dr Chave's ultimate answer to this is to look at some of the physics underlying the square wave. In terms of the frequencies that can be analysed in it, a square wave consists of the fundamental (that is to say a frequency corresponding to the on-off pattern itself) and then all the odd harmonics up to infinity, though they get weaker as you go up. All that information is available in the transmitted signal. According to Dr Chave, since they are there they are inevitably detected, and it is the way of things that those figures will generate wavelengths which will operate within integer 10 at some point. The physical effects are there. They must be, as a matter of physics.

232. I am sure Dr Chave is right as a matter of physics - indeed, it is not disputed. There will be wavelengths which can be (notionally) extracted from the received signal which are capable of falling within integer 10. However, that does not meet the point that Hördt & Strack does not explicitly rely on them in the paper itself, does not refer to their being extracted, and their technique does not involve considering them as a chosen transmission frequency, or a chosen frequency for analysis. It is not an inevitable inference that they were extracted. The measurements in Hördt & Strack are by reference to something else - probably time differentials, however determined.

233. For those reasons, therefore, integer 10 is not anticipated.

234. The same conclusion applies to the detection of the refracted wave. The techniques in Hördt & Strack do not explicitly rely on this effect. Integers 7 and 8 expressly refer to seeking the refracted wave, and determining the nature or presence of a reservoir based on the presence of the refracted wave. It is not apparent from the text of Hördt & Strack that that is done. There is no reference to it, or to anything like it. Again, Dr Chave's and Schlumberger's response is that the refracted wave is there whether or not Hördt & Strack talk about it. When challenged on the alleged absence of disclosure of the refracted wave, Dr Chave said:

> "The fact that they are able to detect a buried thin layer inevitably means that there is a refracted wave present or you would not be able to do it. Just because they do not use that term does not mean that the physics is not there."

But again that misses the point. The point, on anticipation, is whether or not the document discloses the refracted wave. The form of that disclosure does not matter. If it had done so by a different metaphor, or in some more scientific terms, it would have disclosed it. However, it is not disclosed merely because it is there as a matter of physics. If that were not the case then the whole of the invention would be disclosed by anything which described a conventional CSEM survey, because the refracted wave (and, incidentally, all wavelengths within integer 10) would be disclosed because they exist as a matter of physics. In fact, a very large number of other principles or features of physics would be disclosed, because it is impossible to conduct a physical activity without complying with the laws of physics. But that is not what anticipation, in the realms of patent law, is concerned with. It is concerned with clear and unmistakable directions to do something. Hördt & Strack does not do that in relation to the refracted wave.

235. That is sufficient to deal with the anticipation claim. It is unnecessary to go into it any further.

236. As usual, Schlumberger raises an obviousness case in the alternative. There are too many distinctions which would have to be covered. I do not think that this claim succeeds. There are sound practical reasons why a transient system is not likely to work in the sea, which were canvassed in evidence. The apparent method here was a broadside method, whereas the patent in suit (albeit not in the claims) emphasises inline transmissions. The particular reliance on the refracted wave does not appear, and is not an obvious application of Hördt & Strack. The obviousness case fails.

Yuan

237. This is a "poster presentation" given at the American Geophysical Union meeting in San Franciso in December 1998. A "poster presentation" is in effect a paper which is "delivered" by its being placed on a large board so that those interested can read it and, if they think fit, copy it. It is entitled "Electromagnetic assessment of offshore methane hydrate deposits in the Cascadia margin" and it is by J Yuan, G Cairns and R N Edwards. For the purposes of this litigation it has been taken to have the name of the first of those authors.

238. Methane hydrate is an ice-like white solid. It is, as its name suggests, a form of methane in a sort of ice-like form. Technically, it is a "clathrate" i.e. gas molecules encased in water molecules. It is perhaps, in the future, a potential source of methane, though at the moment no-one knows how to extract it economically and practically. At present it is a nuisance to drilling. It occurs in sedimentary layers. Technically it is a hydro-carbon.

239. Yuan contains the following. It starts with a section entitled "Importance of Assessment" and says:

> "The assessment of off-shore methane hydrate is relevant because the deposits are expected to become a very important natural energy resource…."

Under the problem of "assessment", she says:

> "It is difficult to assess the total mass of hydrates from conventional geophysical remote sensing. While the base of hydrate deposits stands out clearly on seismic sections as the Bottom Simulating Reflector (BSR), the diffuse upper boundary is not well delineated.
>
> ….
>
> "Our group is developing a number of complementary geophysical techniques, one of which, the use of an electromagnetic method, is described here."

240. Next is a section entitled "Refraction electromagnetics":

> "Marine sediment conducts electrical current ionically through saline fluid present in interconnected pores and fractures. Methane hydrate, like ice, is electrically insulating. Deposits of hydrate in sediment replace the conductive pore water, restrict the flow of electric current and thereby increase the bulk resistivity of the rock. Refraction electromagnetic data are obtained by measuring the analogue of the time taken for an electrical disturbance generated in a sea floor transmitter to diffuse through the sediment to a sea floor receiver (Edwards 1997). The travel time is related linearly to the resistivity: the higher the resistivity the shorter the travel time. The analog used is the phase difference between the transmitted and received signals viewed as a function of frequency. In simple terms, a linear variation in phase difference with frequency between the transmitted and received signals corresponds with a simple time delay and may be converted to an apparent resistivity."

241. Next there is a section entitled "Electrical conductivity of hydrate" which I do not need to quote save for the last sentence:

> "The amount of hydrate present can be directly related to conductivity."

242. Under "apparatus" Yuan sketches a conventional marine CSEM setup and refers to the prior art Chave paper. The diagram shows one transmitter and two receivers.

243. Yuan apparently conducted a 10 day experiment on board ship in 1998 off Canada's west coast.

244. The paper then goes on to show the result of some modelling, demonstrating apparent resistivity and phase differences for a transmitter/receiver separation of 500 metres. Details of the survey are then given and there is shown "apparent resistivity computed using the phase difference method for transmitter receiver separations of 85, 185, 200 and 300 metres…." The actual results are then graphed. The first graph (fig.9) is entitled: "Recorded stacked transient signals on the sea floor and in the water column". The data analysis section declares that:

> "Using this scheme we inverted all data in frequency domain with half space models."

245. Fig.10 is:

> "A plot of the difference in phase measured at a given site and the phase of the signal in the water column against corresponding theoretical models having a variable sea floor conductivity."

246. The conclusions include the following:

> "1. We have designed and constructed a marine sea floor transient electric dipole-dipole apparatus suitable for assessing offshore methane hydrate.
>
> "2. The apparatus has been tested successfully over known hydrate deposits west of Vancouver Island.
>
> "3. Estimates of apparent electrical resistivity of the sea floor have been obtained with an experimental accuracy of better than one per cent for a wide range of transmitter-receiver separation using a differential phase analysis method.

> "4. Preliminary results reveal that the resistivity of the sea floor is remarkably uniform at about 1.15 ohm.metres to a depth of in excess of 100 metres. There is some evidence for higher resistivity values near [a relevant site] which may indicate the presence of hydrate."

247. Schlumberger's case is that this poster presentation anticipates. It is said that it is a standard CSEM survey; it involves the detection of a refracted wave; the target is a hydrocarbon reservoir, and its resistivity is sought; the wavelengths involved fall within (in the sense of overlapping with) the wavelength element of the claims; and all other integers are matched. If that is not right, then it is said that it would be obvious to apply the teaching of Yuan to looking for hydrocarbon-bearing reservoirs and to measure their resistivity.

248. EMGS's case is that there are material differences between the 019 patent and this paper. In particular there is no seeking a reservoir within the meaning of the patent; this paper involves seeking the limits of a known deposit, not discriminating between two possible contents of a reservoir (or looking for one); the outcome of the test in Yuan was that it was a "failure" and it is therefore non-enabling. EMGS originally took a point that this paper referred to a transient wave system so that the signal was not in the frequency domain (similar to the Hördt & Strack point), but abandoned this point in Mr Burkill's oral final speech (it is a measure of the difficulty of these matters that it was not abandoned until then). It was left that the wavelength would not comply with the wavelength requirement in integer 10.

249. The first point that I need to consider is whether this paper is directed at the detection of, or the contents of, a reservoir. EMGS says it is not. A "reservoir", within the meaning of the patent, is said to be something that contains a fluid (it being common ground that, for these purposes, gas too is a fluid), and methane hydrate is a solid. Reliance is placed on a definition in Schlumberger's own Oilfied Glossary:

> "A subsurface body of rock having sufficient porosity and permeability to store and transmit fluids. Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system."

This is said to be an appropriate meaning in the context in which the word appears in the patent in suit. Emphasis is placed on the reference to "fluids". Methane hydrate is a solid, and what is more the evidence showed that it was not always contained in anything which might be called a reservoir - it can be found simply lying on the ocean floor. Therefore a layer of methane hydrate is not a reservoir. Professor Landro agreed with the definition but said that in his view an oil exploration expert would not call a hydrate layer a reservoir, "because it is not producible". He went on:

> "Maybe in 20 years from now, I do not know, if technology has advanced, that we will include it as a reservoir; but presently I would not consider it as a reservoir. But I see your point that reading this [viz the Schlumberger glossary], you can end on both interpretations, I think."

250. Dr Chave's interpretation of reservoir was "a structure containing something of interest". This was his own formulation of what the skilled addressee would think the expression meant. Yuan disclosed one of those, and it contained a hydrocarbon, so the relevant integers of the patent in suit were matched.

251. Dr Chave's definition of reservoir is, in my view, too vague. I prefer the Schlumberger definition, adopted by Professor Landro. It should be noted, however, that according to this definition it does not have to contain anything. It merely has to be capable of containing something (namely fluids). A reservoir can be an empty reservoir. I think that it is used in that sense in the 019 patent - see the

opening sentence, which uses the word broadly. While the claim is concerned with hydrocarbon bearing reservoirs, the first sentence is not so confined. So its generic use is general.

252. That helps to determine whether a sedimentary layer which contains methane hydrate in its pores is a hydrocarbon-containing reservoir. It is a reservoir because of its porosity, which is capable of holding a fluid. The methane hydrate is a hydrocarbon, literally speaking. So sediment containing methane hydrate in its pores is literally a reservoir which contains a literal hydrocarbon. But it is not a fluid. Does that make a difference? In my view it does not. The sediments are still a reservoir in the sense of its capacity to hold fluid. It so happens that what fills it is a solid form of something. That does not affect its capacity. Furthermore, it is a solid form of something that might otherwise have existed in a liquid form. Methane hydrate is a clathrate. It is molecules of something that would otherwise be expected to be a gas or liquid, clad in water molecules. So it is not artificial or strained to call this a hydrocarbon-bearing reservoir. On the evidence, if the hydrate were not there, the pores would be likely to be filled with water. It does not make any difference to this conclusion that you can find hydrate outside a reservoir (it can sometimes be found lying on the ocean floor); the fact that the contents take a different form elsewhere does not affect the proper description of the container of that substance in other geophysical circumstances. Nor does it make a difference that with modern technology an oil exploration company would not be concerned to find methane hydrates (other than to know they are there so that they can be avoided and coped with). The meaning of the word "reservoir" in the 019 patent is not so limited. Accordingly, this is not a distinguishing feature between the 019 patent and Yuan.

253. However, there is an important difference between them in the area of searching for a hydrocarbon containing reservoir or determining its nature. That is the important description of the activities which the patent is described as facilitating. Yuan deals with something else. It is to provide "additional information" relating to the total mass of known deposits (see "The Problem of Assessment"). The first conclusion is that a system has been constructed "for assessing offshore methane hydrate". The technique is to measure resistivity. "The amount of hydrate present can be directly related to conductivity." Again, therefore, it plainly appears that resistivity is being used to measure the quantity of something known to be there, rather than seeing whether it is there, or assessing what might be there (which are the subject matter of the patent). This aspect of the patent is therefore not anticipated by Yuan, and the anticipation claim therefore fails for this reason alone.

254. In addition, I also find it fails because Yuan is not plainly enabling. I agree with Mr Burkill that the conclusions are tentative - "There is some evidence for higher resistivity values near ODP site 889B which may indicate the presence of hydrates." Dr Chave put it thus:

> "I would describe this experiment as being an inconclusive experiment" (Day 8 pp1107-8); and
>
> "It is a preliminary - how to say, it is reporting the first attempt at doing this. It is not the final attempt." (Day 8 pp 1112-3)

He also pointed out that Yuan sought to measure a model with a buried layer, but failed to do so (Day 8 p 1111). All that lacks the flag-planting clarity required for anticipation.

255. So far as using the refracted wave is concerned, it is not plain that Yuan was using that either. It is true that there is a section of the paper called "Refraction Electromagnetics"; it is true that one of the physical aspects of refracted waves, namely the quicker transmission of signals, is relied on, and it is true that the refracted wave is always there (in terms of physics, as Dr Chave pointed out) but it is not clearly exploited in the manner in which the 019 patent seeks to exploit it. This paper is much more focussed on measuring bulk resistivity and modelling results. Again, therefore, the paper does not anticipate.

256. The last main point of distinction relied on is non-coincidence between the offsets shown in Yuan and the range of offsets described in claim 1. One can see what Yuan's offsets were because she

tells the reader. The maximum offset actually used (as opposed to modelled) was 300m; the minimum offset was 85m (or perhaps 84.5m if one takes the figure from Figure 9). What one does not know, just looking at the text of Yuan, is precisely what wavelengths she used. In fact she does not talk in wavelengths at all; where reference is made to such things it is to frequency, but wavelengths can be deduced from frequency. Nevertheless, she does not even explicitly disclose her actual frequencies. She shows a model in accordance with various frequencies, but her actual frequencies are not used. Her modelled frequencies, when "plugged into" the relevant formulae, show a wavelength range of 575 to 32,000m. When those wavelengths are applied to the offset formula in integer 10 of claim 1, this would give a range of offsets from 288m to 320 Km. There is a slight overlap between the top of Yuan's actual ranges and the bottom of the ranges generated with integer 10. Mr Silverleaf says that this means that there is anticipation because Yuan shows an operation within this integer. I disagree. Yuan has not necessarily operated with in this integer. There is a slight overlap at one end, not a clear operation within it. Second, so far as Mr Silverleaf relies on actual operations, as opposed to modelling, we do not know with what frequencies Yuan operated. There was a certain amount of reconstruction of likely frequencies which Mr Burkill attempted with Dr Chave in the latter's cross-examination. Mr Burkill sought to draw inferences from disclosed phase differences, showing the likely maximum frequency as 5Hz. Dr Chave did not accept that as a proper inference; he thought it likely that Yuan actually used higher frequencies (and shorter wavelengths). The debate might have had some academic interest (sed quaere), but its uncertainties mean that the subject area cannot support a case of anticipation. The most that can be said is that there is some overlap, and that is not enough. It does not disclose the whole of the limitation in integer 10.

257. That is sufficient to deal with the anticipation case. It fails.

258. That case having failed, Mr Silverleaf relies on obviousness over Yuan. Dr Chave says that the skilled addressee reading Yuan would have found it obvious that it could be applied to search for hydrocarbon-bearing subterranean reservoirs and to measure the resistivity of reservoirs whose contents are not known. I do not accept that. Even against the background of the principles of Chave as common general knowledge, this is a paper focussed on a particular problem. It is an application of resistivity assessment to the quantification of the amount of methane hydrate. I do not think that it is obvious to go from there to the sort of detection that is the subject of the 019 patent. I think that Dr Chave is using hindsight in opining to the contrary.

The 887 Patent

259. The 887 patent effectively builds on the 019 patent and exploits what is called the "split" by exploiting the different nature of the responses to transmissions in the in-line and broadside modes. Transmissions are made from a horizontal dipole towed behind a ship and the response signals are measured in the in-line and broadside modes. If there is a thin resistive layer, such as a hydrocarbon-bearing layer, then there will be a difference between those signals. If there is no such layer, or if there is a conductive layer, there will be no difference or a different difference (as it were). A study of those differing signals can therefore provide an indication of the presence (or otherwise) of a hydrocarbon-bearing layer. It is not suggested that a discovery of those differences in signals is inventive. What is said to be inventive is the application of the technique to the detection of hydrocarbons.

260. The 019 patent is not prior art for the purposes of the 887 patent. The priority date is 14th August 2000. The latter patent repeats a lot of the material in the former. If the 019 patent had been novel and inventive, then there would be little debate about the novelty of the 887 patent. Since, however, I have held it is not, then those elements of the 019 patent which appear in the 887 patent are equally uninventive.

261. The patent opens with some background which is essentially the same as the background to the 019 patent and in almost exactly the same words. It describes how seismics can sometimes provide only

an incomplete answer and in paragraph 0007 it describes an electromagnetic field and "seeking in the wave field response, a component representing a refracted wave from the hydrocarbon layer; and determining the content of the reservoir, based on the presence or absence of a wave component refracted by the hydrocarbon layer."

262. Having then set out various alternative ways of presenting the same sort of thing, it goes on to explain how a "refracted wave" behaves, depending on the nature of the stratum in which it is propagated.

> "In particular, the propagation losses in hydrocarbon stratum are much lower than in a water-bearing stratum while the speed of propagation is much higher. Thus, when an oil-bearing reservoir is present, and an electromagnetic field is applied, a strong and rapidly propagated refracted wave can be detected. This may therefore indicate the presence of the reservoir or its nature if its presence is already known."

This is setting out the characteristics of the physics underlying the 019 patent.

263. Paragraph 0013 refers to the differential resistivities of sea water, over-burden and oil reservoirs. Paragraph 0015 points out that:

> "0015 Due to the different electromagnetic properties of a gas/oil bearing formation and a water bearing formation, one can expect a reflection and refraction of the transmitted field at the boundary of a gas/oil bearing formation. However, the similarity between the properties of the over-burden and a reservoir containing water means that no reflection or refraction is likely to occur."

264. Paragraph 0016 refers to the refraction phenomenon, using the term "ducted (guided) wave":

> "Depending on the angle of incidence and state of polarisation, an electromagnetic wave incident upon a high resistive layer may excite a ducted (guided) wave mode in the layer. The ducted mode is propagated laterally along the layer and leaks energy back to the overburden and receivers positioned on the sea floor. The term 'refracted' wave in this specification is intended to refer to this wave mode."

265. Then the specification turns to the split:

> "0017 Both theory and laboratory experiments show that the ducted mode is excited only for an incident wave with transverse magnetic (TM) polarisation (magnetic field perpendicular to the plane of incidence) and at angles of incidence close to the Brewster angle and the critical angle (the angle of total reflection). For transverse electric (TE) polarisation (electric field perpendicular to the plane of incidence) the ducted mode will not be excited. Since the induced current is proportional to the electric field, the current will be parallel to the layer interfaces for TE polarisation but, for TM polarisation, there is an appreciable current across the layer interfaces.
>
> "0018 A horizontal dipole source on the sea floor will generate both TE and TM waves, but by varying the orientation of the receiver antennae, it is possible to vary the sensitivity to the two modes of polarisation. It appears that an in-line orientation (source and receiver dipoles in-line) is more sensitive to the TM mode of polarisation, whereas a parallel orientation (source and receiver dipoles in parallel) is more sensitive to the TE mode of polarisation. The TM mode is influenced by the presence of buried high resistive layers, whereas the TE mode is not. By measuring with the two antenna configurations and exploiting the difference between the two sets of measurements, it is possible to identify deeply buried high resistivity zones, i.e. a hydrocarbon reservoir."

266. Paragraph 0020 introduces the claim:

> "The present invention has arisen from this realisation and comprises methods as set forth in the independent claims 1 and 2."

There are then set out the equivalent of claims 1 and 2, which appear in Appendix 4 to this judgment. The difference between the two is that the ducted wave referred to in the latter claim is to be one which has been "caused by a high resistivity zone". Paragraphs 0022 and 0023 elaborate on this:

> "The first mode may be considered to be a TM mode, and the second mode a TE mode.
>
> "0023 Thus, according to the invention, measurements are taken with the transmitter and receiver both in-line and parallel and the two sets of measurements are compared. A characteristic difference in values indicates a highly resistive layer located beneath highly conductive strata. High resistivity indicates the presence of hydrocarbons and so the difference in values is a direct hydrocarbon indicator."

267. The specification then goes on to discuss preferred arrangements and techniques; I do not need to set out that detail. Paragraphs 0035 and 0036 set out wavelength and offset formulae which are the equivalent of those appearing in the 019 patent.

268. As I have indicated, claims 1 and 2 are set out in a separate appendix to this judgment. They are accompanied by other subsidiary claims. There was also an application for amendment to insert an independent claim 1A, again in the form appearing in the appendix. I would be minded to allow the amendment, subject to validity, and will treat the debate on the validity on the assumption that there has been an amendment. Its principal purpose is to narrow down the concept of "the nature" of the reservoir in a similar manner to that which is sought in relation to the 019 patent. The subsidiary claims were not defended with much vigour at the hearing before me, though that did not betoken their abandonment by Mr Burkill. Rather, as I understood it, Mr Burkill had an eye to the cost effectiveness of the proceedings, and doubtless to the wealth of the detail with which these proceedings were already attended. He invited me to put them on one side for the present so that they could be revisited in the light of my conclusions elsewhere. That is an invitation to which I shall accede. I shall therefore consider the validity of the three claims referred to above.

The inventive step

269. It is not suggested that the discovery of the different electromagnetic responses in TE and TM mode is new. It is accepted that that was known physics. What is said to be new is the application of that known physics in a survey which seeks a resistive hydrocarbon-bearing layer. It builds on the 019 patent (which is not prior art for these purposes) and adds the fact that the orientation of the transmitter will affect the energy received, the presence of a resistive layer such as a hydrocarbon reservoir will affect the energy received differentially as between those orientations, and that that differentiation, or "split" can be used as a direct hydrocarbon indicator. It is said that that had not been done before and was not demonstrated in any prior art. Further reliance is placed on the attitude of Professor Sinha and Dr MacGregor in applying for and obtaining their own patent, which covers very much the same ground – it relies on the split response. EMGS also rely on the evidence given to the examiner in the entitlement proceedings, which is said to reflect the fact that it had not occurred to those two skilled and knowledgeable academics to do this sort of thing before.

The attack on the patent

270. There is an insufficiency attack which is mounted basically as a squeeze, but the principal attack on this patent arises from one piece of prior art (comprising two disclosures which, it is common ground, can be read together). Mr Silverleaf says that the disclosure in this piece of prior art anticipates the invention in the patent or alternatively renders the patent obvious; in his final speech he seemed to rely principally on obviousness. Originally, there were two other pieces of prior art said to anticipate or to produce an obviousness case, but they were both abandoned by the time of

final speeches. There was no claim that this patent was obvious over common general knowledge. At one stage it looked as though Schlumberger were trying to mount such a claim, but that was firmly denied by Mr Silverleaf in his final speech. He nailed his colours to the mast of the piece of prior art identified below. It is therefore that case that I will consider.

The skilled addressee

271. It was not suggested that the skilled addressee of this patent was any different from the skilled addressee of the 019 patent. I think that this is correct. The skilled addressee is the person or team which I have identified above, essentially for the same reasons.

The prior art

272. The prior art relied on as anticipating, or as rendering the invention obvious, is a combination of two papers which both sides accept can and should be read together. The first is a paper entitled: "The RAMESSES experiment – III. Controlled-source electromagnetic sounding of the Reykjanes Ridge at 57º 45'N". It is authored by Dr MacGregor, Prof. Constable and Professor Sinha, published in an original form in June 1996 and then (in the form in which I saw it) in 1998 in the Geophysical Journal International, Vol 135. I will call this "Ramesses". The second is a paper by Prof Sinha called: "Controlled source EM sounding: Survey design considerations for hydrocarbon applications". It appeared in a publication called Lithos Science Report, published by the University of Cambridge, in April 1999. The Acknowledgments for this publication acknowledge "support and encouragement" from companies identifiable as oil companies, and from "Schlumberger Cambridge Research".

Ramesses III

273. The Ramesses experiment concerned a survey carried out over a submarine axial volcanic ridge "AVR". It is common ground that the manner in which the survey was carried out amounted to a survey with in-line (described as "radial" in the papers) and broadside (described as "azimuthal" in the papers) configurations. The summary of the Ramesses paper says:

> "The most intriguing feature in the data is the large difference in amplitude between fields transmitted along and across the AVR axis. A significant zone of low-resistivity material is required at approximately 2 kilometres depth beneath the ridge crest in order to explain this difference. It is coincident with the low-velocity zone required by the seismic data and has a total electrical conductance in excellent agreement with the results of the magnetotelluric study. The low-resistivity zone can be explained by the presence of a body of partially molten basalt in the crust."

274. The Introduction section sets the scene:

> "The electrical resistivity of solid, dry basalt exceeds that of molten basalt or seawater by orders of magnitude, so seawater penetration into cracks, the presence of hydrothermal systems, or the presence of melt will all decrease crustal resistivity. Electrical exploration methods, sensitive to these resistivity variations, thus provide information on the amount, distribution and temperature of fluid present, all of which are important parameters in understanding the processes occurring at mid-ocean ridges.
>
> "Controlled-source electromagnetic (CSEM) methods utilise time-varying electric and magnetic fields from an artificial source. At frequencies sufficiently high that electromagnetic fields are attenuated rapidly in the seawater, energy detected by a receiver remote from the transmitter follows diffusion paths through the crust, and is therefore sensitive to its resistivity structure…..
>
> "Several CSEM experiments using a horizontal electric dipole source operated in the

frequency domain have been performed to study the resistivity structure of normal oceanic crust…. Evidence against the presence of a low-resistivity anomaly in the crusts led to the conclusion that any melt present must be in the form of small isolated pockets, suggesting that at 13 degrees north the East Pacific Rise is in a state of magmatic quiescence compared with other parts of the ridge."

275. Thus far the paper has referred to standard CSEM techniques for mapping resistivity, but if there is an emphasis it is on looking for low resistivity regions in the context of high resistivity regions, as opposed to high- resistivity in the region of otherwise low resistivity.

276. The data was inverted in one dimension. The in-line and broadside data (described as on-axis and off-axis data respectively) are set out. Under the heading "Off-axis data" the authors observe that:

> "The noticeable feature of the off-axis data is the large difference in amplitude between the 0.75 Hz data recorded by [the receiver in a tow recording broadside mode] and the 0.35 Hz data recorded by the same instrument during [an in-line tow].
>
> "….The large difference in amplitude between these two groups of data can be explained by the geometrical effect on the response of buried conductive layers. The magnitude of the radial fields is increased by the presence of buried conductive layers, an effect described in terms of galvanic current channelling by Unsworth (1991) or a lithospheric wave guide by Chave, Flosadóttir & Cox (1990). In contrast, azimuthal fields are more strongly affected by the attenuative effects of a conductive layer. If there is any increase in the field magnitude, it is much less than that observed in the radial component. This results in a distinctive radial/azimuthal field split."

277. Then the authors refer to forward modelling in two dimensions and further data is referred to. In the course of this discussion, certain data is set out and the following sentence, heavily relied on by Mr Silverleaf, appears:

> "The resistivity structure to a depth of one kilometre on the axis of the AVR is constrained by the on-axis data recorded by [a particular receiver] during the first tow. Below this, the resistivity must be increased to fit the off-axis data (the 40 Ωm zone in the model)."

278. Mr Silverleaf relies on this sentence as being the key one which anticipates the 887 patent, perhaps alongside the previously quoted sentence referring to the "distinctive radial azimuthal field split".

279. The subsurface model which is generated by the data is that appearing in Appendix 5 to this judgment. It represents a sort of stylised cross-section. The vertical axis is depth below the seabed (the seabed being the uppermost non-straight horizontal line). The numbers within the frame are the resistivities of the various areas and models. Of particular significance to Mr Silverleaf's submission is the quadrilateral bearing the number 40, meaning 40 Ωm. This shows the mapping of a relatively resistive layer sandwiched between two less resistive (more conductive) layers.

280. Professor Sinha's paper cross-references to the Ramesses study. Mr Silverleaf points out the reference to hydrocarbons in the title. The abstract reads:

> "Controlled source electromagnetic sounding can provide useful constraints on submarine geological structures that are overlain by significant thicknesses of basalt lava flows or sills. Experience of conducting and interpreting the CSEM surveys over oceanic lithosphere has led to the development of viable instrumentation and survey methodologies for such applications. Even in the case of a layered earth, the CSEM response of a structure depends strongly on receiver locations relative to the orientation of the source dipole. Particularly in situations where the target structure is likely to include conductive structures overlain by more resistive layers, it is essential to collect

data along more than one receiver azimuth. A 1-D modelling and inversion study shows that a CSEM survey that could be readily undertaken within the limits of current technology could reliably detect sediments beneath two kilometres of basalts, and could provide useful constraints on sediment resistivities and on the depths of their upper and lower boundaries."

281. The Introduction refers generally to CSEM techniques and refers to particular studies, including the Ramesses study. It observes:

> "Such studies have driven the development of practical methodologies for data acquisition and analysis, suitable for application to studies of relatively conductive geological targets underlying thicknesses of 1-3 kms of basalt and in water depths of 1.5 kms or more.
>
> "One consideration that makes electromagnetic techniques potentially attractive for studying sub-basalt structures is that the sequences of basaltic sills or lavaflows tend to have high electrical resistivities. This property means that electromagnetic signals can propagate through them with relatively little attenuation. The result is that these structures – which are commonly distressingly opaque to seismic waves – can act as electromagnetically transparent windows to the underlying structure in electromagnetic surveys."

282. Professor Sinha then sets out some of the basic features of marine CSEM surveys, and points out that a more resistive propagation path between source and receiver would result in less attenuation of the signal and a smaller phase delay, while a more conductive propagation path would result in greater attenuation and a larger phase delay.

> "Hence by determining signal amplitude and phase for a large number of source and receiver positions, corresponding to many different propagation paths through the sea floor, it is in principle possible to determine the resistivity structure beneath the survey by the application of suitable modelling and geophysical inversion techniques."

283. A "simple layered earth" model is then considered and a modelled graph shown which demonstrates the increased amplitude of a broadside configuration which can be observed at a greater distance where a less resistive layer overlies a more resistive layer than where the layers are the other way round (ie the more resistive overlays a less resistive) . This is followed by an important section entitled "The influence of source orientation on the CSEM response". It points out the difference between the current loops flowing in the horizontal and vertical planes, as referred to in the explanation set out earlier in this judgment. It relies on the concepts of inductive coupling (which is applicable to the horizontal loops) and the galvanic coupling (more associated with the vertical loops).

> "However, for vertical current loops, the situation is more complex. The current loops themselves cross boundaries between layers, transferring charge vertically through the structure by means of galvanic coupling. Away from the plane through the dipole itself, vertical current loops are coupled to each other inductively. Thus both galvanic and inductive effects are occurring in this mode.
>
> "Since a horizontal dipole source generates both of the above modes, the response can in general include both galvanic and inductive contributions. The extent to which each affects the response depends on the receiver azimuth. For a receiver azimuth of 90 degrees – i.e. a receiver placed along a direction orthogonal to the dipole axis – the observed field is dominated by horizontal current loops generated at the transmitter. The result is that the coupling between the source field at the sea floor and the currents flowing beneath the sea floor is dominantly inductive. Hence higher resistivities lead to larger amplitudes and smaller phase delays, while lower resistivities lead to smaller

amplitudes and larger phase delays… The largest signals are those that have propagated along the most resistive paths – making any data collected using this geometry particularly sensitive to the more resistive parts of the underlying resistivity structure. It is this feature of the CSEM response that has led to the common assertion that 'controlled source EM is sensitive to resistive structures'.

"However, for a receiver placed along the direction of the source dipole axis – i.e. an azimuth of 0 degrees – both horizontal and vertical current loops contribute significantly to the response. Since the vertical current loops include an element of galvanic coupling between layers, the result is that buried conductive layers can lead to an increase in the total current flowing in themselves and hence in the layers above and below them.

"The extra current leads to larger electric fields in these layers. Thus for this configuration, a buried conductive layer can actually increase, rather than decrease, the amplitudes of fields at the sea floor."

284. Sinha then goes on to illustrate the effect by reference to a figure and to a model of a layer of greater resistivity overlying a layer of less resistivity (greater conductivity).

"[in the broadside configuration] inductive effects dominate, and the presence of the more conductive lower layer leads to reduced amplitudes at ranges comparable to, or greater than, the thickness of the upper layer… however for an azimuth of 0 degrees, both inductive and galvanic effects occur. This leads first to an increase in amplitude at moderate ranges, and ultimately to a decrease at larger ranges. This increase in amplitudes along the transmitting dipole axis due to buried conductive structure has been described by various authors as 'a wave guide effect'….or as 'current channelling'… The important point, though, is that the interplay between inductive and galvanic effects means that the data from a CSEM survey will show extremely different patterns from source azimuths of 0 degrees and 90 degrees. Specifically, buried conductive layers lead to a 'splitting' of amplitudes for the two geometries at particular ranges with the observed amplitudes along the 0 degrees azimuth significantly exceeding the amplitudes along the 90 degrees azimuth. The consequence is that, provided data are collected at both (or all) azimuths, CSEM surveys are extremely sensitive to the presence of buried conductive layers".

285. Sinha then goes on to apply this to a putative physical situation. He presents:

"A simple model study based on the principles outlined above, that investigates the resolving power of a realistic EM survey in the case of a region of conductive sediments sandwiched between an overlying layer of resistive basalt lava flows and an underlying resistive basement."

In terms of the sort of sandwich referred to before, this is a relatively conductive layer between two more resistive layers. He creates a model of data, introduces noise, and then carries out an inversion. He concludes:

"Thus, based on a 1-D modelling and inversion approach and a realistically achievable data set, this study shows that a CSEM survey would be expected to provide very clear evidence of the presence of conductive sediments between a thick basalt sequence, and of the presence of an underlying resistive basement below the sediments. It would also provide reasonable estimates (~±30%) of the resistivities within both the basalts and the sediments. Although the inverted structure contains no sharp boundaries, it would set

useful limits (~±300 metres on the depths of the top and bottom boundaries of the sediments)."

286. In the Conclusions section he says:

> "Controlled source electromagnetic sounding represents a viable method for obtaining sub-seafloor structural information to depths of several kilometres, and in the presence of thick basalt sequences. Since the target – sub-basalt sediments – is likely to represent a relatively conductive sequence underlying a more resistive overburden, it is essential to use a survey geometry that incorporates receivers placed both along and orthogonal to the axis of the transmitting dipole….
>
> "A simple one-dimensional model study shows that a CSEM survey that could be readily undertaken within the limits of current technology could reliably detect sediments beneath two kilometres of basalts, and could provide useful constraints on the sediment resistivities and on the depths of their upper and lower boundaries."

287. This material is said both to anticipate the invention and to render it obvious. Dr Chave was of the view it did both.

288. The anticipation claim fails. It is true that both Ramesses and Sinha rely on the "split" – the difference between the inline and broadside signals - but each goes on to deal with it in a context different to the claims in the patent.

289. Claim 2, and claim 1 in its amended form, involve at least two key elements which are not anticipated by Ramesses. The first is the focus in each of searching for, or identifying, hydrocarbons. On any sensible reading of Ramesses, it is not anticipated by it. Ramesses concerns a survey with a view to investigating basalt and anomalies in resistivity in basalt areas. There is not a word about hydrocarbons. It is in no way specifically geared to searching for hydrocarbons, seeing whether layers contain hydrocarbon or water, or anything like that. This was accepted by Dr Chave in the following exchange:

> "Q. This is a practical description of a survey carried out on the mid-ocean ridge with no prospect whatever of finding oil reservoirs when doing it?
>
> A. No intent of finding oil reservoirs either."

290. That, by itself, is probably enough to make Ramesses non-anticipatory in respect of those claims, but in addition there is the focus of the paper on higher conductivity, as opposed to resistivity. That emphasis appears from the extracts set out above, and it appears elsewhere. Note in particular the references to "buried conductive layers … the attenuative effects of a conductive layer …" in the comments on "Off-axis data". This is reinforced elsewhere, including a passage in the Conclusions in Ramesses (which I have not cited above) which says:

> "… (3) The most striking feature of the model is the presence of a large zone of anomalously low resistivity at mid-crustal levels beneath the AVR axis... …
>
> "(4) The resistivity of the sub-axial anomaly must be less than 2.5 Ωm in order to produce an adequate fit to the data..… Although the shape of the low-resistivity anomaly is not constrained by the CSEM data …"

The patent deals with relative <u>resistivity</u>. Claim 2 expressly relies on the patented technique "to determine the presence and/or nature of any high-resistivity zone". Ramesses does not profess to do that. It is differently focused and looks at higher conductivity zones. To that extent at least it does not anticipate. Claims 1 and 1A do not contain that express limitation, but it is inherent in the use of the expression "ducted wave" in those claims, because when that expression is used earlier in the patent it is done in the context of ducting in a resistive layer (see the extracts from para 0016 above). Dr Chave points out that Ramesses refers to the phenomenon of a ducted wave, using the expression "lithospheric waveguide", but it does not do so in relation to relatively resistive layers. Again, therefore, Ramesses does not anticipate. Mr Silverleaf also points out a cross-reference in the paper to a paper by Chave, Flosadottir and Cox on the split, which concerns itself with resistive layers. It is true that there is such a cross-reference, and that earlier paper does indeed consider it in that context, but that does not affect the thrust of what Ramesses seems to be discussing, with is the split in the context of investigating a relatively conductive layer.

291. Much of Schlumberger's case on anticipation seemed to rely on the introduction of the 40Ωm band, shown in the diagram at Appendix 5. This would be an accidental anticipation if it were one at all. In my view it is not. This area of relatively high resistivity has to be introduced into the modelling "to fit the off axis-data". Schlumberger says that this shows the detection of an area of relatively high resistivity by the split method, which anticipates the claims in the patent. I consider that this does not give the relevant sentence (and it is only one sentence) the correct emphasis (or, more precisely, lack of emphasis). It is one sentence relating to one aspect of modelling in order to get the data to fit a model, in a context in which the focus is on something else – relative conductivity of another region. It demonstrates the technique of using this form of CSEM to map resistivity. It does not clearly indicate the technique identified in Claim 1 of focusing on the reservoir and seeking the ducted wave from that reservoir. I refer again to the need for clarity in an alleged anticipation. This sentence, relating to the relevant element in the diagram, does not provide it. There is no other material in this paper which would support an anticipation claim. It was put to Dr Chave that the target in this paper was a

> "conductive sequence under a resistive layer …[of] basalt, which is the exact opposite of the 887 problem where you are trying to find a resistive oil layer buried amongst conductive targets"

To which he responded:

> "A. The 887 is certainly a different problem, yes." (Day 8, page 1173)

That encapsulates the point. The 887 patent was addressing a different problem. That would not, of itself, prevent anticipation, but it makes anticipation much more difficult, and there is in fact nothing there to achieve it.

292. The position, so far as Schlumberger is concerned, is not materially improved by reading Ramesses with Sinha. The combination does advance the anticipation argument by being more expressly referable to hydrocarbons and hydrocarbon detection. The word "hydrocarbon" is mentioned in the title and in the Introduction of Sinha, and is plainly much more the focus of this presentation. However, on its face, it still does not involve the detection of the ducted wave as it passes along a relatively resistive layer/reservoir, and furthermore it does not involve the detection of a relatively resistive hydrocarbon reservoir. So far as setting out the theory is concerned, (before turning to modelling), the paper points out a difference between in-line and broadside responses, but refers to an increase in amplitudes "due to buried conductive structure" (my emphasis), ascribed to a wave-guide effect.

> "The consequence is that, provided data are collected at both (or all) azimuths, CSEM surveys are extremely sensitive to the presence of buried conductive layers." (my emphasis)

The result is that the emphasis on looking for or detecting conductive layers, which was seen in Ramesses, is continued. Professor Schultz thinks that Sinha has got things a bit back to front in his description of the physics. He thinks that the correct exposition is that the inline response would be more sensitive to the resistive, rather than more conductive, layers, and that Professor Sinha has got this the wrong way round in his paper. Dr Chave disagreed. I tend to think, after extensive debate, that Professor Schultz is right about this, but that does not matter for present purposes. What matters is that Prof Sinha is, on the face of the paper, apparently concentrating on the effects of conductive layers, not resistive layers, contrary to the thrust of the 887 patent. To that extent, and for that reason, thus far it does not anticipate. What is important is what he says, not what he might have meant had he not, arguably, got the physics (or his expression of it) the wrong way round. If an aspect of a piece of prior art contains a slip or mistake which would be obvious to the skilled addressee, then it would be proper to read the prior art as if the slip were corrected. However, that is not the case here. There is no obvious mistake which can be thus corrected. The paper should be taken to mean what it says. It is talking about conductivity not resistivity.

293. When Prof Sinha turns his attention to his model involving a sedimentary, potentially oil-bearing, layer, the emphasis remains the same. He models:

> "a region of conductive sediments sandwiched between an overlying layer of resistive basalt lave flows and an underlying resistive basement".

In other words, a conductive sandwich not a resistive sandwich, which is the converse of the sandwich which is contemplated by the 887 patent. The result of his model is to show:

> "… very clearly the presence of a substantial <u>conductive</u> region beneath the basalts, and also shows an indication of the presence of the resistive basement." (again, my emphasis)

This is not the model of the 887 patent. Nor is there any reference to ducted waves being detected having passed along a resistive layer. The whole purpose of this experiment is to rely on the fact that the basalt is relatively resistive, so that the fields can, as it were, get through to the conductive layer beneath. That is not the language or concept of the 887 patent.

294. Accordingly, the two papers combined do not anticipate claims 1, 1A or 2. Since all the other claims are dependent, it does not anticipate those either.

295. It is therefore necessary to turn to obviousness. The inventive concept has been identified above. As Mr Burkill put it in his closing submissions, the real novelty was said to be applying a known technique (the split) to looking for thin hydrocarbon layers. He says that Sinha/Ramesses are looking at something different – conductive layers – and that it was not obvious to apply the technique to the detection of hydrocarbon layers. He particularly relies on the fact that Professor Sinha did not spot the point, and went off and sought to patent its application to that very situation. Schlumberger submits that if the prior art does not anticipate (which I have held it does not) it nonetheless teaches "beyond" the scope of the 887 patent, and while it teaches how to find a hydrocarbon layer buried beneath a layer of basalt, it goes beyond the more straightforward case of a hydrocarbon layer buried in "typical subsea sediment" (I use the phraseology set out in Schlumberger's closing skeleton argument).

296. Dr Chave's evidence on this piece of prior art focuses on a dissection of the claims into their integers in an attempt, principally, to show that the integers are all disclosed in the prior art. He also takes issue with the expression of the science in the papers and, to some extent, by Professor Schultz. He does not focus on the *Windsurfer* exercise in relation to the inventive concept as it is described above. That is doubtless explicable, in part, by the fact that the point had not been so refined at the date of his two reports, and it might have been said that the differences between the 887 patent disclosures and the prior art were greater (for these purposes) than they are now said to be. However, in the course of his exercise he nonetheless did express various views on obviousness in relation to what can now be identified as the inventive concept for these purposes. His basic theme on this is essentially twofold – first, that the skilled addressee would understand that the techniques discussed could be used to discriminate resistive layers as well as conductive layers, and second that it was known that hydrocarbons were relatively resistive (at least compared with water

in a layer) so that a hydrocarbon layer could thus be as discernible as another resistive layer. Putting it another way, he considered it obvious that the disclosure in Sinha and Ramesses could be used to map the resistivity structure of a reservoir as a function of location and depth, and thus its nature (Claim 1); and since the relative restistivity of hydrocarbon was known it could be used to discriminate hydrocarbon layers from water (brine) bearing layers (Claims 1 and 2). In cross-examination he said that the reason that that was not explicitly mentioned in the prior art was because the authors were looking at a different problem.

297. Both Professor Schultz and Professor Landro dealt with this prior art, but their reports do not explicitly deal with obviousness. Only Professor Schultz was cross-examined on the prior art and most of his cross-examination was apparently focused on an attempt to show that the teaching in the documents included (and even, according to Mr Silverleaf, went beyond) the invention. There was little explicit reference to obviousness in his cross-examination, but there were passages which help on the point so far as they contain more generalised indications of what the two papers separately were referring to.

298. Taking the scientific evidence first (that is to say, without the evidence afforded by the Sinha/MacGregor patent application), I prefer the evidence of Dr Chave, and the conclusion that the invention is obvious over this prior art. Ramesses refers to waveguides, and the cross-reference to the Flossadottir paper makes it clear that that is a reference to the refracted wave. Professor Schultz accepted that. It is common ground that the papers disclose the split, so the question is whether it would be obvious to deploy that technique to identify a buried resistitive layer, and to use it to differentiate one which bore hydrocarbon (making it relatively resistive) from one which bore water (making it less resistive). Dr Chave said in his report that it would have been obvious to a skilled addressee that the differential responses could be used to determine the resistivity structure of a reservoir. Professor Schultz accepted that Sinha's conclusions were that CSEM represented a viable method for obtaining subfloor structural information (in the context of marine CSEM); and that useful information could be obtained on sediment resistivities and depths of upper and lower layer boundaries. It was being done:

> "in an effort to try to understand something about the resistivity of the sediments and something about their thickness". (Day 10 page 1590)

He also recognized that this effort would be of interest to oil companies. He did not accept that the Sinha paper was a deployment or description of EMGS's Seabed Logging process, and I think he was right about that, since the actual technique described was different. However, I think that his answers referred to above, and the rest of his evidence, were consistent with Dr Chave's evidence that what was being mapped was areas by reference to resistivity. I find that while the focus of the two papers (and particularly Ramesses) was on relative conductivity, the techniques involved, or resulted in, a mapping of the structure, including layers of relative resistivity. That is built into the physics, as Dr Chave would say, and is demonstrated by the fact that in Ramesses the authors had to map in a relatively resistive layer (or 2 dimensional shape) in order to produce a model that coincided with the data. They were not looking for that layer/shape, but it arose from the mapping. There was considerable debate in the cross-examination of Professor Schultz about the modelling process that resulted in this, and the fact that this layer was introduced as a result of 2D modelling which was different from the 1D modelling process, or 1D study, which the 887 patent envisages. The Ramesses study, in the view of Professor Schultz, was complicated by the fact that there were long tow lines which would involve the EM signals being affected as the tow crossed the vertical edges of the structures underneath. That, he said, meant that the physics was different from that involved in the 887 patent, which did not involve vertical edges. I am prepared to accept that he was correct about that, and that that introduces a complicating factor which is not present in the 887 patent. Nevertheless, the material in that paper, particularly when combined with Sinha, was such that it was obvious to take the studies of relative conductivity, carried out by passing signals through layers of resistivity, and apply it to map layers of relative resistivity (which is inherent in the process anyway), and apply that to the search for hydrocarbons (to which Sinha makes express reference).

Accordingly, taking that scientific evidence by itself, I would conclude that the invention is rendered obvious by it. The inventive step (applying the split to the search for resistive layers, and resistive layers containing hydrocarbon) would be one that the skilled person would see as obvious.

299. However, that is not the entirety of the evidence. EMGS's case on (or rather, against) obviousness depends heavily on the statements and activities of Prof Sinha and Dr Macgregor in relation to their patent and the entitlement proceedings. Mr Burkill pointed to the terms of the University of Southampton patent and the fact that it referred to Ramesses in terms. It referred to the work in that paper and says:

> "This approach is now applied to the case of surveying for thin hydrocarbon reservoirs."

300. That does not seem to me to contribute much to the debate. So far as it suggests that it is doing something novel, that is the question which I have to decide. The fact that it is being propounded by two academics in the field has the same problems as those identified above – one does not know what their thought–processes were, and there are dangers in admitting inferential expert evidence by such a hearsay route.

301. Mr Burkill also relied on the findings of the hearing officer referred to above which are said to demonstrate that these two academics had not thought of the split until Prof Sinha was informed of it by Mr Ellingsrud and Dr Eidesmo, and had not thought whether CSEM techniques would work to detect hydrocarbon layers directly. These contemporaneous expressions and overt actions of the two academics are relied on as demonstrating the non-obviousness of the invention, and in particular the non-obviousness over the results of the Ramesses survey.

302. I do not attribute great weight to this material. The novelty of an invention is always tested against a background in which it is said it has not been propounded before. That does not usually assist in a determination of obviousness points; obviousness is tested by reference to other evidence. What is added to the inquiry by contemporaneous expressions that persons with an interest did not think about the invention, or thought it would not work? In terms of the obviousness debate, taken by itself that evidence seems to me to add little. The real question is why it did not occur to those people (assuming that it did not), or why they dismissed it. There may be a number of reasons why it did not occur to them as individuals – for example, their work did not take them in that direction, they were under misapprehensions, or they were simply wrong about a bit of the science. Such surmise does not assist much in determining the real question, which is whether it would have been obvious to the notional skilled addressee. The proper evidence for that question is that of the expert in court who rationalises the relevant state of mind and can have his/her evidence tested. The untested pronouncements, or even established states of mind, of those interested persons cannot assist much, even assuming that that evidence is admissible. What this all boils down to is the same point as is referred to above. To give great weight to this material is to allow untested expert evidence to have an unwarranted amount of weight. While it cannot simply be dismissed as having no weight at all, when placed against the tested expert evidence I prefer to give the latter more weight. Accordingly, this factor does not give Mr Burkill's case the assistance that he seeks to derive from it. It does not cause me to alter the conclusions that I draw from the rest of the evidence; nor is it sufficiently weighty to point to an overall conclusion of obviousness if put into the overall evidential pot.

303. Accordingly, and subject to any arguments as to the validity of any subsidiary claims that I have put on one side, I find that the 887 patent fails as being obvious over the prior art, and falls to be revoked. In the circumstances it is not necessary for me to embark on a consideration of the insufficiency point.

The 640 patent

304. This is a UK patent number 2399640B. Its priority date is 17th March 2003, which means that by this time the 019 patent had been published, as had been EMGS's papers describing their seabed logging techniques.

305. The patent is entitled: "Method and apparatus for determining the nature of submarine reservoirs". Like the other patents in this action, this patent too is the subject of an application to amend by EMGS. The relevant claims, in their amended form, are set out in Appendix 6 to this judgment. There is no opposition to the claim for amendment, and EMGS does not seek to sustain claim 1 in its unamended form. In the circumstances I shall consider the patent on the footing of the amendment, which, subject to validity, I would allow.

306. The essence of the patent is to combine two techniques namely refraction seismics and a CSEM search for a refracted wave, to carry them out at the same time and in the same place, to compare the results and thereby to identify whether a reservoir is or is not hydrocarbon-bearing. There is no novelty claimed in combining the effects of seismic and CSEM surveys, and Mr Burkill did not seem to be claiming novelty for the idea of doing them at the same place. The novelty in this invention is said to be in using refraction seismics and seeking the refracted EM wave at the same place and at the same time. This is said to save costs and to assist in the elimination of false positives by, for example, detecting that a relatively resistive layer which might be hydrocarbon-bearing does not in fact have the seismic qualities of such a layer but is, for example, a salt dome. Mr Burkill said that the key limitation of carrying out these exercises at the same time is implicit in amended claim 1. I do not think he is right about that. The amended claim 1 refers to doing these things at the same location. It does not suggest doing them at the same time. However, claims 9 and 10 are in substance claims that the exercises are done at the same time, and so on any footing the key point relied on by Mr Burkill and EMGS arises under this patent. It did not seem that Mr Burkill sought to maintain even amended claim 1 if it did not import the requirement of simultaneous execution.

307. I do not need to set out very much of the specification. It starts by referring to the then extant application for the 019 patent, referring to the refraction features relied on in it. It points out the shortcomings of conducting just an electromagnetic surveying technique and says:

> "It is an object of the present invention to provide a method and apparatus for reliably locating and identifying submarine reservoirs, in particular, hydrocarbon reservoirs, but at a reduced cost and with reduced operational requirements."

308. It then sets out, in essence, claim 1, and goes on to provide some indication of preferable ways of carrying out the electromagnetic survey. At page 5 it refers again to some of the limitations on an electromagnetic survey and says:

> "Seismic surveying techniques, however, can detect the boundaries of subterranean strata with some accuracy, but cannot readily identify the nature of the strata located. Thus by using both techniques, the results can be combined and potential hydrocarbon-bearing reservoirs can be identified with greater certainty."

309. Further details of the two different types of survey are then set out and at page 7 it is stated:

> "Preferably, the receiver antenna and seismic receiver are mounted on the same structure and the EM field and the seismic event are applied simultaneously. Alternatively, the EM field and seismic event are applied closely sequentially, for example five to 25 seconds.
>
> "In a preferred system, the EM wave field response and/or the seismic response is analysed to identify the respective refracted wave component. Then, the two refracted wave components are used to determine the presence and nature of the strata. Preferably, the system additionally includes extracting and using phase and/or

> amplitude information from the responses, more preferably from the refracted wave responses. Preferably, the reflected wave is also identified in the seismic response, and the reflected wave component is also used to identify subterranean strata."

310. There is then a lot of discussion which repeats many of the features of the 019 patent, and indeed one or two of the 887 patent. At page 12 the patent deals with the merits of combining the two surveys:

> "The electromagnetic signals are sensitive to the electrical resistivity of subterranean layers and, therefore, electromagnetic methods are well suited for the detection of high resistive layers such as H/C reservoirs. However, layers without hydrocarbons may also have high electrical resistivities, e.g. layers consisting of salt, basalt, calcite strings or other dense rocks with low porosities and low water content. High-resistive layers of this type will generally have higher seismic velocities than the low-resistive overburden, whereas high-resistive H/C reservoirs generally have lower seismic velocities than the low-resistive overburden. Seismic methods can therefore be used to distinguish high resistive H/C reservoirs from other high-resistive layers.
>
> "A distinction between H/C reservoirs and other high-resistive layers can be made on the basis of available seismic reflection data for the prospect in question. However, a more reliable distinction will be obtained from seismic refraction data recorded with large offsets between the seismic source and the seismic receiver. This can preferably be carried out in combination with the electromagnetic data collection….
>
> "It will be appreciated that the absence of any refracted wave component in either the EM wave field response or the seismic response will indicate no formations with a differing resistivity or differing acoustic properties present. The presence of a refracted wave component in both the EM field response and the seismic response will indicate the presence of a formation with high resistivity and high acoustic velocity (low porosity) which would suggest e.g. basalt or a salt dome. The presence of a refracted EM wave component and the absence of a refracted seismic wave component will indicate high resistivity together with low acoustic velocity and so low porosity, which would suggest an H/C (hydrocarbon) reservoir in perhaps a porous rock formation such as sandstone."

311. The claims have already been referred to. It is not suggested that any of the later claims will save the patent if Claims 1, 9 and 10, fail. I can therefore concentrate on the main question which is the inventiveness of combining refraction seismics and CSEM at the same place and at the same time.

312. There was little debate as to the skilled addressee in relation to this patent. In my view it is the same team as above. By the priority date of this patent the 019 patent, and the seabed logging papers, had been published, and CSEM would be likely to figure even more largely in the planning of oil exploration, so it is even more likely that a CSEM expert would be part of a team that would also contain a geophysicist.

313. I deal first with obviousness over common general knowledge, which Mr Silverleaf makes his first line of attack on this patent. When one bears in mind what is now relied on as the inventive concept contained in this patent, there was little evidence from the experts which went to it. Professor Landro's report stated that he would have regarded "contemplation [sic] of refraction seismics with CSEM as an unusual combination to consider." The context reveals that he must have meant "combination". A combination of reflection seismics and CSEM would have been obvious, though he seems to have been referring to a combination of the results of the techniques rather than their simultaneous co-located occurrence. He seems to regard the difference between those two positions as arising out of the fact that refraction seismics tends to be used on large scales. To that extent he was supported by Dr Chave who considered that the longer offsets required by refraction seismics

made that technique and CSEM less likely bedfellows as a matter of principle. However, the combination of the data from refraction seismics and CSEM is not what is relied on as novel in this case. Mr Burkill explicitly disavowed that using those two types of data when they were taken at different points in time but from the same location was novel. It is the simultaneous deployment of the two techniques that is relied on. I therefore approach the obviousness question that arises in this case from the starting point that the use of the two types of data is not novel.

314. Professor Landro does not specifically address this narrow point in his reports. In relation to claim 9 (which in terms assumes the two techniques being deployed together) he ostensibly points out the advantages, but pursuing his cross-references demonstrates that he says the advantage is doing the things at the same time – it is circular. Nor was there a lot of reference to it in his cross-examination. Mr Silverleaf put to Professor Landro that it would be "reasonable" and "sensible" to deploy both techniques simultaneously. He eventually opined that it would be reasonable to do that if the explorers had decided it would save money to do so, though his previous views about the oddness of combining the data at all made him resistant to the idea. His evidence on the point did not really start from Mr Burkill's starting point (namely that using both sets of data from the same place, but taken at different times, would not be novel).

315. Dr Chave's report does not in terms deal with this point either, outside the context of the prior art. However, his evidence in relation to the 019 prior art assists on this point. The application for the 019 patent was relied on as prior art for these purposes. It teaches that the invention of the 019 patent comprises performing a seismic survey to determine geological structure:

> "and where that survey reveals the presence of a subterranean reservoir, subsequently performing a method as described above [i.e. a CSEM survey]"

316. In relation to that Dr Chave said that:

> "It would have been obvious to the skilled addressee that he/she should approach the task of designing the seismic and CSEM surveys with a view to obtaining the best set of information on the area being surveyed in the light of cost and logistical constraints. It would have been obvious to the skilled addressee that the EM and seismic surveys could be carried out simultaneously, or closely sequentially, and with the equipment and method of analysis described in the 640 Patent. That is what the skilled addressee would have done if he/she considered that it would give the best results depending on the geological and other conditions."

317. He was cross-examined about this. He accepted that to carry out the exercises together would eliminate false positives, but did not think that as a practical matter they would be carried out together because of what he considered to be the offsets involved. In response to questions about the 019 patent application he said:

> "... the idea of combining seismic refraction and CSEM, or in fact any other particular kind of seismic information, is something that the skilled addressee would normally do. He would normally take whatever, and collect whatever useful information you could, and the issue of whether you would collocate sources and/or receivers would be made on a variety of grounds. Whether the physics allows it would be one of them. It would not necessarily be something that you would feel you have to do. It would be something that you might or might not do.
>
> "... it may very well be that combining the logistics does not gain you anything. That would have to be decided on a case by case basis.
>
> "[the statement that you would approach the task of designing seismic and CSEM surveys with a view to obtaining the best set of information] would apply independent of whether it is refraction or any other kind of seismics, you want the best set of

information and you are going to do that in the light of cost and logistical constraints ... The idea of combining CSEM with seismic refraction or any other kind of seismics would be well within the normal working practices of the skilled addressee."

318. What Dr Chave is essentially saying is that where two techniques are to be employed, it is obvious to do them together if it makes practical sense. I accept his evidence on that point. It seems to me to be plainly right. The 019 patent does not confine itself to reflection seismics, so can be taken to cover both types. It is carrying out the techniques simultaneously that is relied on as the novel feature of the patent. That extension is obvious. Accordingly, on this footing the patent is obvious over the 019 patent application.

319. However, I think that the real effect of this evidence is wider. Professor Landro himself accepted that combining seismic surveys and CSEM was part of the common general knowledge of the skilled addressee at the priority date of the 640 patent (see his cross-examination at Day 12 page 1843). I accept that evidence. To that extent, therefore, the relevant passage of the 019 patent application is setting out common general knowledge. Professor Landro confirmed that seismics in this context would include both reflection and refraction seismics. He was resistant to the idea that at the priority date one would take refraction seismic data and then add a CSEM survey because the refraction seismic data was done on too large a scale (and in any event in 2003 he said a different technique, namely 3D seismics, would be deployed anyway), but it was no part of EMGS's case that combining refraction seismic data and CSEM data for the same place was novel. Accordingly, the idea of combining them was, in my view, part of common general knowledge. This is the position which Dr Chave addressed in his remarks directed to the 019 patent. His views about that therefore amount to a statement about obviousness over common general knowledge because the relevant statement in the 019 patent essentially encapsulated that knowledge. On this footing I find that the patent is obvious over common general knowledge as well.

320. One other piece of prior art was relied on in the end in Schlumberger's obviousness attack (two others were abandoned at the trial). It may not be strictly necessary to deal with it in the light of my already expressed conclusions on obviousness, but I will deal with it relatively briefly. That other piece is the Ramesses study referred to above in the context of the 887 patent. This time all three papers are, in terms, relied on. They are, respectively:

i) "Magmatic processes at slow spreading ridges: implications of the RAMESSES experiment at 57º 45'N on the Mid-Atlantic Ridge", by Sinha, Constable, Peirce, White, Heinson, MacGregor and Navin

ii) "The RAMESSES experiment – II: Evidence for accumulated melt beneath a slow spreading ridge from wide-angle refraction and multichannel reflection seismic profiles" by Navin, Peirce and Sinha

iii) Ramesses III – the Ramesses paper which is prior art to the 887 patent.

321. As appears above, these papers are concerned with an academic study of a magmatically active ridge in the Mid-Atlantic Ridge. The emphasis is on looking for a conductive layer. They are not directly concerned with the problem of finding hydrocarbon reservoirs. For this purpose they disclose the use of a combination of refraction seismics and CSEM techniques, though not simultaneously and the tows for each technique were not down precisely the same lines.

322. Schlumberger's case was that the invention was obvious over this paper. It was obvious to apply the techniques of this paper to the search for hydrocarbon layers, and it was obvious to move from sequential application of the two techniques to simultaneous application. EMGS counters that those papers were not concerned with trying to find and identify resistive layers, because they were concerned with conductive layers, and they were not concerned with a search for hydrocarbon either; and it was not obvious to use the two techniques at the same time.

323. The first of EMGS's points has its answer in the discussion above, in relation to the corresponding point under the 887 patent. The technique is designed to map relative resistivities (or conductivities, which is the counterpart), so it is, to that extent, obvious to apply it to resistive layers if that is what you are interested in. By the same token, it does not matter what that resistive layer is, and it is obvious to apply it to the search for hydrocarbons. So far as the simultaneous application is concerned, Dr Chave again expressed the view that once one was applying the two techniques at all, it was obvious to use them together when that made sense logistically. I accept that evidence. Accordingly, if it matters, I find that the invention is rendered obvious by the Ramesses papers.

324. For the sake of completeness, I should record that in the context of this patent Mr Silverleaf relied on *Sabaf SPA v MFI Furniture Centres Ltd* [2005] RPC 209 in support of the proposition that there can be no invention in putting into a claim two features each of which performs its own known function and between which there is no synergy and which produce no new effect. He then applied that to the 640 patent by saying that there were two established elements (refraction seismics and CSEM), which were combined without producing any new effect. They still fulfilled their respective functions and produced no new "synergy".

325. The relevant principles start with the formulation of Lord Tomlin in *British Celanese Ltd v Courtaulds Ltd* (1935) 52 RPC 171 at 193:

> "A mere placing side-by-side of old integers so that each performs its own proper function independently of any of the others is not a patentable in combination, but that where the old integers when placed together have some working inter-relation producing a new or improved result then there is patentable subject-matter in the idea of the working interrelation brought about by the collocation of the integers."

326. In *Sabaf* Lord Hoffmann plainly approved this formulation (see paragraph 24), and he also approved the EPO Guidelines for Substantive Examination, where the following appears:

> "The invention claimed must normally be considered as a whole. When a claim consists of a 'combination of features', it is not correct to argue that the separate features of the combination taken by themselves are known or obvious and that 'therefore' the whole subject-matter claimed is obvious. However, where the claim is merely an "aggregation or juxtaposition of features" and not a true combination, it is enough to show that the individual features are obvious to prove that the aggregation of features does not involve an inventive step. A set of technical features is regarded as a combination of features if the functional interaction between the features achieves a combined technical effect which is different from, e.g. greater than, the sum of the technical effects of the individual features. In other words, the interactions of the individual features must produce a synergistic effect. If no synergistic effect exists, there is no more than a mere aggregation of features ..."

327. Lord Hoffmann set out his own version of the principles:

> "If the two integers interact upon each other, if there is synergy between them, they constitute a single invention having a combined effect and one applies s3 to the idea of combining them. If each integer "performs its own proper function independently of any of the others", then each is for the purposes of s3 a separate invention and it has to be applied to each one separately."

328. If these principles are applied one reaches the same result as that which I have arrived at above. The two elements of refraction seismics and CSEM do not achieve a new technical effect. There is no "synergy". The benefits of combining them is no more than the aggregate of the results of each of them, in the terminology of the EPO. The benefits alleged are not technical. The first benefit relied on is the removal of false positives. But that benefit exists even if the two techniques are not carried out simultaneously. It is not an additional technical effect arising from carrying them out

together. The alleged logistical benefit is again not a new technical effect; it is a direct effect of the aggregation of the benefit of the two separate techniques (again using the terminology of the EPO).

329. Accordingly the 640 patent fails on the grounds of obviousness and falls to be revoked.

Conclusions

330. Accordingly, on the basis of the reasoning set out in this judgment, all three patents in suit fall to be revoked (in the case of the 887 patent, subject to any additional argument as to the validity of subsidiary claims). Since none of the amendments proposed will amend to a valid patent, I formally disallow the proposed amendments.

Appendix

Appendix 1
Diagram of water bed experiment, from 019 patent

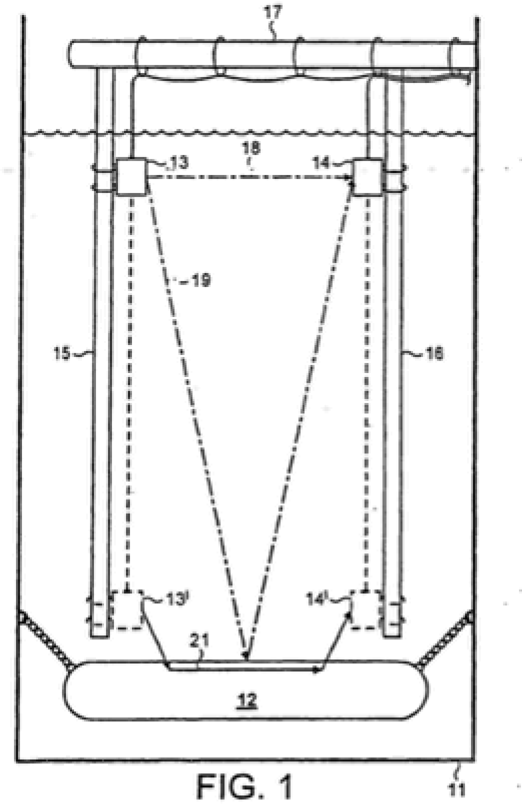


FIG. 1

Appendix 2
Figure from the 019 patent

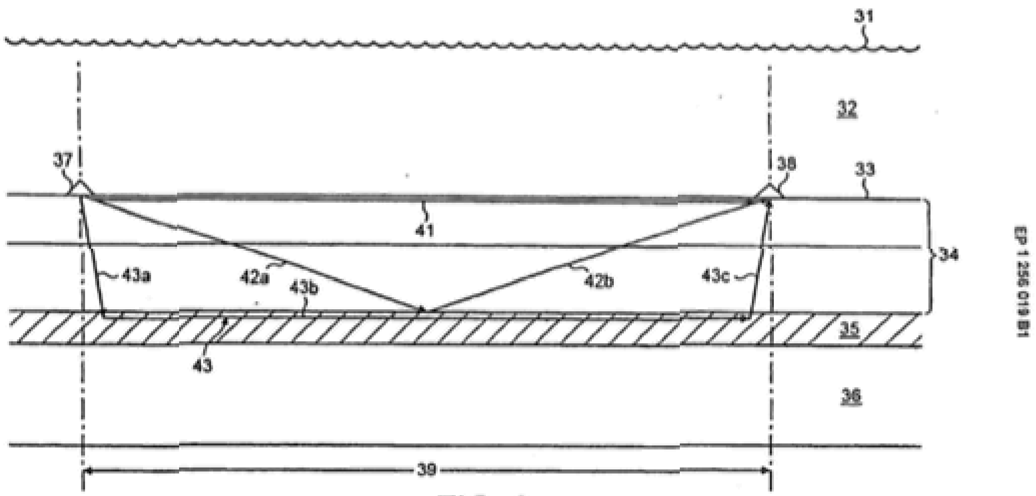


FIG. 2

Appendix 3

019 patent claims

1. A method of performing a survey of subterranean strata in order to search for a hydrocarbon containing submarine ~~subterranean~~ reservoir (35), or to determining *[sic]* the nature of a submarine ~~or subterranean~~ reservoir (35) whose approximate geometry and location are known, which comprises: applying a time varying electromagnetic field to the subterranean strata; detecting the electromagnetic wave field response; seeking, in the wave field response, a component representing a refracted wave (43,43C); and determining the presence and/or nature of any reservoir (35) identified based on the presence or absence of a refracted wave component (43,43C); in which the transmitted field is in the form of a wave, and in which the distance between the transmitter (37) and a receiver (38) is given by the formula

$0.5\,\lambda \leq L \leq 10\,\lambda$;

where λ is the wavelength of the transmission through the overburden (34) and l is the distance between the transmitter (37) and the receiver (38).

Claim 1A is like claim 1 above, but with additional differences indicated below:

1A. A method of performing a survey of subterranean strata in order to ~~search for a hydrocarbon containing submarine reservoir (35), or to determining the nature of~~ determine whether a submarine reservoir (35), whose approximate geometry and location are known, contains hydrocarbons or water, which method comprises: applying a time varying electromagnetic field to the subterranean strata; detecting the electromagnetic wave field response; seeking, in the wave field response, a component representing a refracted wave (43,43C); and determining ~~the presence and/or nature of any reservoir (35) identified~~ whether the reservoir (35) contains hydrocarbons or water based on the presence or absence of a refracted wave component (43,43C); in which the transmitted field is in the form of a wave, and in which the distance between the transmitter (37) and a receiver (38) is given by the formula ... [etc]

The other relevant claims are the following:

1B. A method as claimed in Claim 1 or Claim 1A, in which the electromagnetic field applied is a coherent continuous wave.

1C. A method as claimed in Claim 1B, in which the electromagnetic field is applied with

stepped frequencies.

2. A method as claimed in Claim 1, or Claim 1A, Claim 1B or Claim 1C, characterised by the further step of analyzing the effects on any detected refracted wave component (43C) that have been caused by the reservoir (35) in order to determine further the content of the reservoir (35) based on the analysis.

11. A method as claimed in any preceding Claim, characterised in that the wavelength of the transmission is given by the formula

0.1s ≤ λ ≤ 10s;

where λ is the wavelength of the transmission through the overburden (34) and s is the distance from the seabed (33) to the reservoir (35).

16. A method as claimed in any of Claims 11 to 15, characterised by suppressing the direct wave (41), thereby reducing the required dynamic range of the receivers (38) and

increasing the resolution of the refracted wave (43, 43C).

Integers of claim 1

(1) A method of performing a survey of subterranean strata

(2) in order to search for a hydrocarbon containing

(3) submarine reservoir (35),

(4) or to determining [sic] the nature of a submarine reservoir (35) whose approximate

geometry and location are known,

(5) which comprises: applying a time varying electromagnetic field to the subterranean

strata;

(6) detecting the electromagnetic wave field response;

(7) seeking, in the wave field response, a component representing a refracted wave

(43,43C);

(8) and determining the presence and/or nature of any reservoir (35) identified based on the presence or absence of a refracted wave component (43,43C);

(9) in which the transmitted field is in the form of a wave,

(10) and in which the distance between the transmitter (37) and a receiver (38) is given by the formula

0.5 λ ≤ L ≤ 10 λ ;

where λ is the wavelength of the transmission through the overburden (34) and L is the

distance between the transmitter (37) and the receiver (38).

[Note: capital L used for legibility: original uses lower-case l].

Appendix 4

EP (UK) 1,309,887

1. A method of determining the nature of a subterranean reservoir which comprises deploying an electric dipole transmitter antenna (34) with its axis generally horizontal, deploying an electric dipole receiver antenna (35) in-line with the transmitter (34), applying an electromagnetic (EM) field to the strata containing the reservoir using the transmitter and detecting the EM wave field response using the receiver characterised by: identifying in the response a component representing a ducted wave from the reservoir according to a first mode; deploying an electric dipole receiver antenna (35) parallel to the transmitter; applying an EM field to the strata using the transmitter; detecting the EM wave field response using the receiver and identifying in the response a component representing a ducted wave from the reservoir according to a second mode; and comparing the first mode ducted wave response with the second mode ducted wave response in order to determine the nature of the reservoir.

1. A A method of determining whether a subterranean reservoir, whose approximate location and geometry are known, contains hydrocarbons or water, which method comprises an electric dipole transmitter antenna (34) with its axis generally horizontal, deploying an electric dipole receiver antenna (35) in-line with the transmitter (34), applying an electromagnetic (EM) field to the strata containing the reservoir using the transmitter and detecting the EM wave field response using the receiver characterised by: identifying in the response a component representing a ducted wave from the reservoir according to a first mode; deploying an electric dipole receiver antenna (35) parallel to the transmitter; applying an EM field to the strata using the transmitter; detecting the EM wave field response using the receiver and identifying in the response a component representing a ducted wave from the reservoir according to a second mode; and comparing the first mode ducted wave response with the second mode ducted wave response in order to determine whether the reservoir contains hydrocarbons or water.

2. A method of searching for a hydrocarbon-containing subterranean reservoir which comprises deploying an electric dipole transmitter antenna (34) with its axis generally horizontal, deploying an electric dipole receiver antenna (35) in-line with the transmitter, applying an EM field to subterranean strata using the transmitter and detecting the EM wave field response using the receiver characterised by: seeking in the response a component representing a ducted wave according to a first mode, caused by a high resistivity zone; deploying an electric dipole receiver antenna (35) parallel to the transmitter; applying an EM field to the strata using the transmitter; detecting the EM wave field response using the receiver; seeking in the response a component representing a ducted wave according to the second mode; and comparing the first mode ducted wave response to the second mode ducted wave response in order to determine the presence and/or nature of any high-resistivity zone.

3. A method as claimed in Claim 1, Claim 1A or Claim 2, characterised in that the first mode is a TM mode of polarisation and/or the second mode is a TE mode of polarisation.

4. A method as claimed in any preceding Claim, characterised in that the transmitter (34) and/or receiver (35) comprises an array of dipole antennae.

5. A method as claimed in any preceding Claim, characterised in that the transmitter (34) and/or receiver (35) is located on or close to the seabed (33) or the bed of some other area of water.

6. A method as claimed in any preceding Claim, characterised in that the transmitter (34) and receivers (35) are located on a common cable (32) arranged to be towed behind a vessel (31).

7. A method as claimed in Claim 6, characterised in that the transmitter (51) and/or receiver each comprise two dipole antennae (34, 35) arranged mutually at right angles.

8. A method as claimed in any preceding Claim, characterised in that the frequency of the EM field is continuously varied over the transmission period.

9. A method as claimed in any preceding Claim, characterised in that the field is transmitted for a period of time for 3 seconds to 60 minutes, preferably from 3 to 30 minutes.

10. A method as claimed in any preceding Claim, characterised in that the wavelength of the transmission is given by the formula:

    $0.1s \leq \lambda \leq 10s;$

    wherein λ is the wavelength of the transmission through the overburden and s is the distance from the seabed (33) to the reservoir.

11. A method as claimed in any preceding Claim, characterised in that distance between the transmitter and the receiver is given by the formula:

    $0.5s \leq \lambda \leq 5s;$

    wherein λ is the wavelength of the transmission through the overburden and L is the distance between the transmitter (34) and the receiver (35).

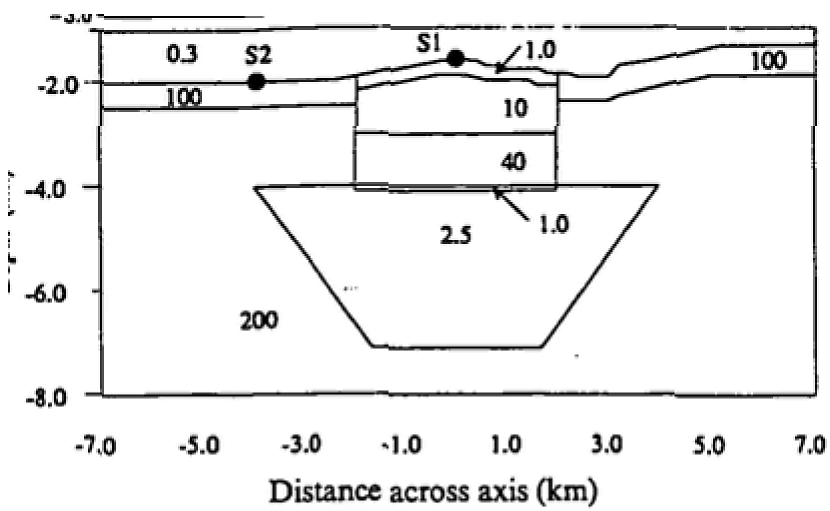
12. A method as claimed in any of Claims 8 to 11, characterised in that the transmission frequency is from 0.01 Hz to 1 kHz, preferably from 1 to 20 Hz.

13. A method as claimed in any preceding Claim, characterised in that it includes suppressing the direct wave and/or any other known wave contribution that may disturb the measurements, thereby reducing the required dynamic range of the receiver (35) and increasing the resolution of the refracted wave.

    14A method of surveying subterranean measures which comprises: performing a seismic survey to determine the geological structure of a region and where that survey reveals the presence of a subterranean reservoir, subsequently performing a method as claimed in any preceding Claim.

Appendix 5

Diagram from Ramesses III



Appendix 6

GB 2,399,640 AMENDED CLAIMS

1 A method of producing a survey report of subterranean strata to determine whether a reservoir containing hydrocarbons or water is present therein and to determine whether the reservoir contains hydrocarbons or water, which method comprises: deploying an electromagnetic(EM) field transmitter; deploying a seismic source at substantially the same location as the EM field transmitter,; deploying an EM field receiver at a predetermined offset distance from the transmitter; deploying a seismic receiver at substantially the same location as the EM field receiver; applying an EM field to the strata using the EM field transmitter; detecting the EM wave field response using the EM field receiver; applying a seismic event to the strata using the seismic source at substantially the same location as the EM field transmitter; detecting the seismic response using the seismic receiver at substantially the same location as the EM field receiver; analysing the EM wave field response; analysing the seismic response; identifying the refracted wave component of the EM wave field response; identifying the refracted wave component of the seismic response; and reconciling the two responses using the two refracted wave components in order to produce a report on the presence and nature of the strata.

2 A method as claimed in Claim 1, which additionally includes extracting and using phase and/or amplitude information from the responses.

3 ~~A method as claimed in any preceding Claim, which includes identifying the refracted wave component of the EM wave field response, identifying the refracted wave component of the seismic response, and using the two refracted wave components to produce the survey report~~. (Deleted)

4 A method as claimed in ~~Claim 3~~ any preceding Claim, in which phase and/or amplitude information from the two refracted wave components is used.

5 A method as claimed in any preceding Claim, in which the EM field transmitter, the seismic source and the two receivers are all in the same plane.

6 A method as claimed in any preceding Claim, in which the EM field transmitter comprises an electric dipole antenna.

7 A method as claimed in any preceding Claim, in which the EM field receiver comprises an electric dipole antenna.

8 A method as claimed in any preceding Claim, in which the EM field receiver and the seismic receiver are mounted on the same structure.

9 A method as claimed in any preceding Claim, in which the EM field and the seismic event are applied simultaneously.

10 A method as claimed in any of Claims 1 to 88, in which the EM field and the seismic event are applied closely sequentially for example 5 to 25 seconds.

11 A method as claimed in any preceding Claim, in which the reflected wave component of the seismic response is also identified and the reflected wave component is also used to identify subterranean strata.

12 A method as claimed in any preceding Claim, which includes: additionally, deploying a magnetic receiver at substantially the same location as the EM field receiver; detecting a magnetic field response and using the magnetic field response in combination with the EM wave field response and the seismic response.

13 A method as claimed in any preceding Claim, which comprises repeating the procedure with the EM field transmitter and seismic source, and/or the EM field receiver and seismic receiver, in

different locations for the plurality of EM transmissions and seismic events.

14 A method as claimed in any preceding Claim, in which the procedure is repeated at different offsets.

15A method as claimed in any preceding Claim, which includes the deployment and use of a plurality of EM field receivers and/or a plurality of seismic receivers.

16 A method as claimed in Claim 15, in which the EM field receivers and the seismic receivers are mounted on a cable.

17 A method as claimed in any preceding Claim, in which the EM field transmitter and receiver and/or the seismic source and receiver, are located on or close to the seabed or the bed of some other area of water.

18 A method as claimed in Claim 17, in which the seismic source is located at or near the surface of the area of water.

19 A method as claimed in any preceding Claim, in which the frequency of the EM field is continuously varied over the transmission period.

20 A method as claimed in any preceding Claim, in which the EM field is transmitted for a period of time for 3 seconds to 60 minutes.

21 A method as claimed in Claim 19, in which the transmission time is from 10 seconds to 5 minutes.

22 A method as claimed in any preceding Claim, in which the wavelength of the transmission is given by the formula

$0.1s \leq \lambda \leq 5s$;

Wherein λ is the wavelength of the transmission through the overburden and s is the distance from the seabed to the reservoir.

23 A method as claimed in any preceding Claim, in which the offset between the EM field transmitter and the EM field receiver is given by the formula:

$0.5s \leq \lambda \leq 10s$;

where λ is the wavelength of the transmission through the overburden and L is the distance between the transmitter and the receiver.

24 A method as claimed in any of Claims 11 to 23, in which the transmission frequency is from 0.01 Hz to 1 kHz.

25 A method as claimed in Claim 24, in which the transmission frequency is from 0.1 to 20 Hz.

26 A method as claimed in any preceding Claim, in which the seismic receiver records a full flow component seismic recording, comprising three displacement vector components and a pressure component.

27 Apparatus for use in carrying out a method as claimed in any preceding Claim, including a receiver assembly comprising: a support structure; an electric dipole receiver antenna mounted on the support structure; a three axis seismic receiver mounted on the support structure; a geophone arrangements mounted on the support structure; a hydrophone mounted on the support structure and an anchor arranged to attach the support structure to the sea bed.

28 A survey report produced by a method as claimed in any of Claims 1 to 26.

Note 1 It was the view of Dr Chave, who maintained the disclosure in this work was workable and ultimately understandable, that "it would be fair to state that this patent is written … to obfuscate as opposed to make things very clear". No-one was prepared to argue with him about that. [Back]
