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Datasheet for the decision of 25 April 2013

Case Number:	T 1554/09 - 3.4.03
Application Number:	99402827.2
Publication Number:	1003053
IPC:	G01V 3/32
Language of the proceedings:	EN

Title of invention:
Formation evaluation using magnetic resonance logging measurements

Applicants:
Schlumberger Holdings Limited
Services Petroliers Schlumberger
SCHLUMBERGER TECHNOLOGY B.V.

Headword:
-

Relevant legal provisions:
RPBA Art. 13(3)

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (no) - main request, second auxiliary request"
"First auxiliary request not admitted"

Decisions cited:
-

Catchword:
-

Case Number: T 1554/09 - 3.4.03

D E C I S I O N
of the Technical Board of Appeal 3.4.03
of 25 April 2013

Appellants: (Applicants)

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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 12 February 2009 refusing European patent application No. 99402827.2 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman: G. Eliasson
Members: R. Q. Bekkering
T. Bokor

Summary of Facts and Submissions

I. This is an appeal against the refusal of application No. 99 402 827 for added subject-matter, Article 123(2) EPC.

II. The appellant requested at oral proceedings before the board that the decision under appeal be set aside and that a patent be granted

as main request

on the basis of the claims according to the main request as filed with the letter of 25 March 2013, or

as first auxiliary request

on the basis of the claims according to the auxiliary request filed during the oral proceedings of 25 April 2013, or

as second auxiliary request

on the basis of the claims according to the third auxiliary request filed with the letter of 25 March 2013.

III. Claim 1 according to the main request reads as follows:

"*A method for determining properties of earth formations surrounding a borehole, comprising the steps of:*
(a) providing a logging device that is moveable through the borehole;

(b) transmitting electromagnetic energy from said logging device into the formations, and receiving nuclear magnetic resonance spin echoes at said logging device;
(c) performing step (b) a plurality of times, with a respective plurality of different transmitting and/or receiving conditions to obtain a plurality of measurements;
(d) generating a formation model that includes a plurality of model components for a brine phase and a plurality of model components for a native oil phase, including generating a set of model amplitude components that define the transverse relaxation time distribution of the brine phase, and a further set of model amplitude components that define the transverse relaxation time distribution of the native oil, and a further set of model components that define the constituent viscosities of the native oil;
(e) modifying the model components to optimize the model with respect to the measurement signals; and
(f) outputting model components of the optimized model."

IV. Claim 1 according to the first auxiliary request reads as follows:

"*A method for determining properties of earth formations surrounding a borehole, comprising the steps of:*
(a) providing a logging device that is moveable through the borehole;
(b) transmitting electromagnetic energy from said logging device into the formations, and receiving

nuclear magnetic resonance spin echoes at said logging device;

(c) performing step (b) a plurality of times, with a respective plurality of different transmitting and/or receiving conditions to obtain a plurality of measurements, comprising performing step (b) N times to obtain a suite of N measurements taken at a plurality of respectively separate measurement region shells having a spacing of 10 mm, wherein said shells are substantially cylindrical shells having radial extents of about 1 mm;

(d) generating a formation model that includes a plurality of model components for a brine phase and a plurality of model components for a native oil phase, including generating a set of model amplitude components that define the transverse relaxation time distribution of the brine phase, and a further set of model amplitude components that define the transverse relaxation time distribution of the native oil, and a further set of model components that define the constituent viscosities of the native oil, wherein the formation model comprises a relaxation model for $A^p{}_j$ *according to the following equation:*

$$A_j^p = \sum_{l=1}^{N_s} a_l \exp(-\frac{j*TE_p}{T_{2,l}^{\dagger}(p)})(1-\exp(-\frac{W_p}{\xi*T_{2,l}})) + \sum_{k=1}^{N_o} b_k \exp(-\frac{j*TE_p}{T_{2,o}^{\dagger}(\eta_k, p)})(1-\exp(-\frac{W_p}{T_{1,o}(\eta_k)})) + A_{OBMF}\exp(-\frac{j*TE_p}{T_{2,OBMF}^{\dagger}(p)})(1-\exp(-\frac{W_p}{T_{1,OBMF}}))$$

wherein:

$A^p{}_j$ *represents the amplitude of the j-th echo acquired during measurement p;*

TE is the echo spacing;

W_p is the wait time;
ζ [sic] is the apparent T_1/T_2 ratio of the brine phase;
b_k is the crude oil T_2 amplitude of constituent k of the native oil phase; and
η_k is the viscosity of constituent k of the native oil phase;
(e) modifying the model components to optimize the model with respect to the measurement signals;
(f) outputting model components of the optimized model; and
(g) deriving, from the output model components, the viscosity of the native oil of the formations, the diffusion constants of the native oil constituents of the formations, and the relaxation times of the native oil constituents of the formations."

V. Claim 1 according to the second auxiliary request corresponds to claim 1 of the first auxiliary request with the following deletion in step (c) (highlighted):

"*(c) performing step (b) a plurality of times, with a respective plurality of different transmitting and/or receiving conditions to obtain a plurality of measurements, comprising performing step (b) N times to obtain a suite of N measurements taken at a plurality of respectively separate measurement region shells* ***~~having a spacing of 10 mm~~****, wherein said shells are substantially cylindrical shells having radial extents of about 1 mm;*".

VI. Reference is made to the following documents

D1: WO 97 34166 A

D6: Looyestijn, "*Determination of Oil Saturation from Diffusion NMR Logs*", Paper SS presented at the 37th Annual Meeting of the Society of Professional Well Log Analysts, 1996, pages 1-11

D7: US 4 710 713 A

all cited in the application as originally filed (cf description, pages 2 and 5).

VII. The appellant in substance provided the following arguments:

None of the prior art disclosed a method for determining properties of earth formations surrounding a borehole involving the definition of a set of model components that defined the constituent viscosities of the native oil. In document D1 only a single oil viscosity was considered. There was no disclosure of the effect of the crude oil being a mixture on the assessment of viscosity. Document D6 mentioned that crude oils were mixtures of a large range of components, but the individual viscosities of these components were not considered.

Accordingly, the subject-matter of claim 1 of the main request was both novel and involved an inventive step.

Claim 1 of the first auxiliary request involved an inventive step because the spacing of 10 mm of the shells was nowhere suggested in the cited prior art and was advantageous in that it minimized differences in saturation from shell to shell that could be caused by drilling fluid invasion, thereby simplifying the formation evaluation. Since claims 14 to 16 as originally filed specifically addressed a plurality of measurement shells with a specific radial extent, and the description specifically addressed the spacing of the shells, it had to be assumed that this feature was searched.

The subject-matter of claim 1 according to the second auxiliary request involved an inventive step because the radial extents of 1 mm of the shells were nowhere suggested in the cited prior art and allowed the multiple shells to be closely spaced, simplifying the formation evaluation by minimizing differences in saturation from shell to shell due to drilling fluid invasion.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request*

2.1 *Amendments*

Claim 1 according to the appellant's main request is based on claims 1 and 4 as originally filed.

Accordingly, the amendments to claim 1 comply with Article 123(2) EPC.

2.2 *Novelty*

2.2.1 *Document D1*

Document D1 discloses, using the terminology of claim 1, a method for determining properties of earth formations surrounding a borehole, comprising the steps of:
(a) providing a logging device that is moveable through the borehole,
(b) transmitting electromagnetic energy from said logging device into the formations, and receiving nuclear magnetic resonance spin echoes at said logging device (cf page 1, lines 1 to 25; page 3, lines 4 to 30; page 8, lines 19 to 21);
(c) performing step (b) a plurality of times, with a respective plurality of different transmitting and/or receiving conditions to obtain a plurality of measurements (page 3, line 31 to page 4, line 3; page 5, line 25 to page 6, line 8);
(d) generating a formation model that includes a plurality of model components for a brine phase and a plurality of model components for a native oil phase, including generating a set of model amplitude components that define the transverse relaxation time distribution of the water (brine) phase, and a further set of model amplitude components that define the transverse relaxation time distribution of the native oil, and a further set of model components that define the constituent viscosities of the native oil (page 3, lines 12 to 16; page 6, line 33 to page 7, line 15);
(e) modifying the model components to optimize the model with respect to the measurement signals; and

(f) outputting model components of the optimized model (page 3, lines 21 to 23; page 7, line 33 to page 8, line 8).

Reference is also made to the application, acknowledging the teaching of document D1 (and of closely related document D6) (cf application as published, page 2, line 58 to page 3, line 29).

However, in the example given in D1 relating to the determination of water saturation in a rock formation containing a medium gravity oil and water, the oil is modelled by one transverse relaxation time and one corresponding volume fraction (page 6, line 21 to page 7, line 15).

The subject-matter of claim 1, thus, differs from document D1 in that the formation model is generated to include "*a further set of model components that define the constituent viscosities of the native oil*".

Accordingly, the subject-matter of claim 1 according to the main request is new over document D1 (Article 54(1) EPC 1973).

2.2.2 *Document D6*

The teaching of document D6 is closely related to that of D1.

In particular, according to D6, "*As indicated, the intrinsic (bulk-) relaxation time of hydrogen spins in a fluid is related to the molecular motion, and thus to the temperature and the viscosity of the fluid*" and

"*Most crudes, and in particular heavy crudes, are mixtures of a large range of components. As a consequence, these oils do not exhibit a single-exponential relaxation decay, but rather a decay that is to be described by a spectrum of exponentials. An easier, be it approximate, way to this into account is a stretched exponential', which gives a fairly good fit of the experimental data while introducing only one additional parameter per liquid phase*" (page 3, left-hand column, 2nd and 3rd paragraph).

The subject-matter of claim 1, thus, also differs from document D6 in that the formation model is generated to include "*a further set of model components that define the constituent viscosities of the native oil*".

Accordingly, the subject-matter of claim 1 according to the main request is also new over document D6 (Article 54(1) EPC 1973).

2.2.3 The subject-matter of claim 1 according to the main request is also new over the remaining available, more remote prior art.

2.3 *Inventive step*

Document D1 is considered to provide the closest prior art.

As discussed above, the subject-matter of claim 1 differs from document D1 in that the formation model is generated to include "*a further set of model components that define the constituent viscosities of the native oil*".

The effect of this difference is that the method, in determining the properties of earth formations surrounding the borehole, allows for distinguishing between oil components having different viscosities, eg between light and heavy oil.

Accordingly, the objective problem to be solved relative to D1 is to make the logging method suitable for distinguishing between oil components having different viscosities.

As is generally known to a person skilled in the art at issue of NMR logging in the oil industry, and noted in document D6, crude oil typically consists of a mixture of a large range of components having different viscosities (cf D6, page 3, left-hand column, 3rd paragraph). It would be obvious to the skilled person that knowledge about the presence of respective oil components is valuable for evaluating the earth formation surrounding a borehole.

Accordingly, it would be obvious to the skilled person to pose the problem above.

The solution claimed is generating the formation model to include "*a further set of model components that define the constituent viscosities of the native oil*".

According to document D1, in fact by referring to what is common general knowledge of the skilled person working in NMR logging, in the presence of a magnetic field gradient, the time-evolution of the measured NMR echoes is affected by molecular self-diffusion. Thus, the distinction between the echoes from the individual fluids can be made through the diffusion effect on the measured NMR echo response (page 4, lines 4 to 8).

In particular, according to D1, when applying a Carr-Purcell-Meiboom-Gill (CPMG) NMR logging sequence with a constant Carr-Purcell spacing t_{cp}, "*for a single fluid the NMR echo decay curve in a gradient magnetic field and a constant Carr-Purcell spacing is described by:*

$$M(t) = M(0) \sum A_i \exp(-t/T_{2,i}) \exp(-t \gamma^2 D G^2 t_{cp}^2/3) (1-\exp(-TR/T_{1,i})) \quad (3)$$

in which
A_i is the fluid fraction with transverse relaxation time $T_{2,i}$
M(0) is the signal amplitude at time t = 0
$T_{2,i}$ is the transverse relaxation time of fluid fraction A_i
$T_{1,i}$ is the longitudinal relaxation time of fluid fraction A_i
γ is the gyromagnetic ratio of the subject nucleus of the fluid
G is the gradient of the magnetic field
D is the molecular self-diffusion coefficient of the fluid in the porous rock.
The NMR echo curve from a formation which contains a plurality of fluids is the superposition of the echoes generated by the individual fluids according to:

$$M(t) = \sum M_j (t) \quad (4)$$

in which $M_j(t)$ is the NMR echo decay rate of the j-th fluid fraction as described by eq. (3).

The magnitude of the diffusion coefficient D is related to the temperature and the viscosity of the fluid an can be approximated by the empirical relationship

$$D = 2.5\ T/300\eta\ (10^{-9}\ m^2/s) \qquad (5)$$

in which
T is temperature (K);
η is viscosity (cP)"

(cf page 4, line 15 to page 5, line 20).

Therefore, according to D1, in particular according to equation (4) above, components corresponding to each fluid are to be included in the model. Typically, components are included in the model for oil, water and possibly gas (cf eg document D1, page 1, lines 23 to 25; see also document D6, page 3, right-hand column, 3rd paragraph).

However, it would be obvious to the skilled person from the above, that for oil components having different diffusion coefficients and viscosities, and thus different transverse relaxation times T_2 (cf D6, page 3, left-hand column, 2d paragraph), the model used should comprise respective model amplitude components for each oil component to be individually detected, including the viscosities of each oil component.

Accordingly, it would be obvious to the skilled person to include "*a further set of model components that define the constituent viscosities of the native oil*" as per claim 1.

The appellant argued that in D1 only a single oil viscosity was considered. There was no disclosure of the effect of the crude oil being a mixture on the assessment of viscosity. Document D6 mentioned that crude oils were mixtures of a large range of components, but the individual viscosities of these components were not considered. It was recognised that one effect of crude oil comprising a mixture was that the exponential decay measurements were not simple. The approach in D6, however, was to consider the spectrum of exponential decays as a "*stretched exponential*" and to derive a stretch factor α.

It is, however, noted that according to D6 "*Most crudes, and in particular heavy crudes, are mixtures of a large range of components. As a consequence, these oils do not exhibit a single-exponential relaxation decay, but rather a decay that is to be described by a spectrum of exponentials. An easier, be it approximate, way to this into account* [sic] *is a 'stretched exponential', which gives a fairly good fit of the experimental data while introducing only one additional parameter per liquid phase*" (page 3, left-hand column, 3rd paragraph). Likewise, in D1 the oil is modelled by one transverse relaxation time (page 7, lines 3 to 5). As would, however, be clear to the skilled person, such a simplification is only appropriate where the individual components of the native oil are of no interest. In both documents D1 and D6, the specific example of use of the NMR method relates to the determination of the oil saturation in earth formations surrounding the borehole. The determination is based on measuring the amount of movable water, which varies with the oil saturation, by varying the interecho spacing. As in this case the individual components of the native oil are irrelevant, the simplification above may be used. It would, however, be readily apparent to the skilled person that where the individual components of the native oil are of interest, all respective exponential relaxation decays of the individual components of the native oil are to be included in the model. As discussed above, the model would, thus, include model components that define the viscosities of each oil component of interest.

The subject-matter of claim 1 according to the main request, thus, lacks an inventive step in the sense of Article 56 EPC 1973.

Accordingly, the appellant's main request is not allowable.

3. *First auxiliary request*

Claim 1 according to the first auxiliary request includes with respect to claim 1 of the main request *inter alia* the following additional feature in step (c):

"*comprising performing step (b) N times to obtain a suite of N measurements taken at a plurality of respectively separate measurement region shells having a spacing of 10 mm, wherein said shells are substantially cylindrical shells having radial extents of about 1 mm*".

The features of claim 1 that step (c) comprises performing step (b) N times to obtain a suite of N measurements, that the measurements are taken at a plurality of respectively separate measurement region shells and that the shells are substantially cylindrical shells having radial extents of about 1 mm, were originally contained in claims 14, 15 and 16 of the application as filed.

The feature of claim 1 that the measurement region shells have a spacing of 10 mm, on the other hand, is not contained in any of the claims as originally filed.

The feature is, however, disclosed in the description of the application as originally filed. In particular, according to the description, "*In the described embodiment the shells within a band are closely spaced (e.g., of the order of 10 millimeters) so that the fluid saturation can be assumed constant over the extent of the band*" and "*Note that the shells are generally closely spaced to minimize differences in saturation from shell to shell that could be caused by drilling fluid invasion. If invasion is not a factor (e.g. for deep NMR measurements), then more widely spaced shells could be employed*" (page 6, line 15 to 16 and page 10, lines 8 to 11). Reference is also made to page 16, lines 30 to 40 of the application.

The appellant argued in particular that the subject-matter of claim 1 according to the first auxiliary request involved an inventive step because the spacing of 10 mm of the shells was nowhere suggested in the cited prior art and proved particularly advantageous in that it minimized differences in saturation from shell to shell that could be caused by drilling fluid invasion thereby simplifying the formation evaluation.

In the board's judgement, however, this amendment raises issues, which the board cannot deal with without adjournment of the oral proceedings.

In particular, as the spacing of the shells is not the subject of any of the originally filed claims and there is no reason apparent why the search would have been extended to this particular aspect of the description, it has to be concluded that this feature was not the subject of the search performed by the search division.

The appellant argued that because claims 14 to 16 as originally filed specifically addressed a plurality of measurement shells with a specific radial extent, and the description specifically addressed the spacing of the shells, it had to be assumed that the search covered the matter.

The board cannot agree. The search report does in fact not cite any document specifically with respect to originally filed claims 14 to 16 or relating to measurement shells in general. According to the description of the application, "*Figure 2 also illustrates a general representation of the type of closely spaced cylindrical thin shells, 38-1, 38-2...38-N, that can be frequency selected using the referenced type of multifrequency logging device. As is known in the art, for example as disclosed in U.S. Patent No. 4,710,713, the logging device can select the shell region to be investigated by appropriately selecting the frequency of the RF energy in the transmitted pulses*" (page 5, lines 29 to 34). Moreover, radial extents of the measurement shells of about 1 mm or the technical relevance hereof are nowhere disclosed in the original description. With the application acknowledging that the use of measurement shells was known and attributing no technical relevance to radial extents of the shells of about 1 mm, there was indeed no reason for the search to specifically address this matter.

Document D7, ie U.S. Patent No. 4,710,713 cited above, discloses the use of measurement shells, but does not specify the radial extent and spacing of the shells. Although the board has doubts whether in particular the spacing of the measurement shells of 10 millimeter even differs from commonly used spacing values, neither D7 nor any other cited prior art provides supporting evidence in this respect, so that the board sees itself unable to judge in the matter.

As the corresponding amendment was sought to be made only at the oral proceedings, the first auxiliary request is not admitted into the proceedings in accordance with Article 13(3) of the Rules of Procedure of the Boards of Appeal.

4. *Second auxiliary request*

4.1 Claim 1 according to the second auxiliary request corresponds to claim 1 of the main request, with the following additional features:

in step (c):

"comprising performing step (b) N times to obtain a suite of N measurements taken at a plurality of respectively separate measurement region shells,

wherein said shells are substantially cylindrical shells having radial extents of about 1 mm",

in step (d):

"wherein the formation model comprises a relaxation model for $A^p{}_j$ according to the following equation:

$$A_j^p = \sum_{l=1}^{N_s} a_l \exp(-\frac{j*TE_p}{T_{2,l}^{\dagger}(p)})(1-\exp(-\frac{W_p}{\xi * T_{2,l}})) + \sum_{k=1}^{N_o} b_k \exp(-\frac{j*TE_p}{T_{2,o}^{\dagger}(\eta_k, p)})(1-\exp(-\frac{W_p}{T_{1,o}(\eta_k)})) + A_{OBMF} \exp(-\frac{j*TE_p}{T_{2,OBMF}^{\dagger}(p)})(1-\exp(-\frac{W_p}{T_{1,OBMF}}))$$

wherein:
$A^p{}_j$ represents the amplitude of the j-th echo acquired during measurement p;
TE is the echo spacing;
W_p is the wait time;
ζ [sic] is the apparent T_1/T_2 ratio of the brine phase;
b_k is the crude oil T_2 amplitude of constituent k of the native oil phase; and
η_k is the viscosity of constituent k of the native oil phase",

and

"(g) deriving, from the output model components, the viscosity of the native oil of the formations, the diffusion constants of the native oil constituents of the formations, and the relaxation times of the native oil constituents of the formations."

4.2 *Amendments*

The amendment to step (c) of claim 1 is based on originally filed claims 14 to 16. The amendment to step (d) is based on the description page 6, equation (1). Step (g) is based on originally filed claims 26 to 28.

Accordingly, the amendments to claim 1 according to the appellant's second auxiliary request comply with Article 123(2) EPC.

4.3 *Inventive step*

4.3.1 Having regard to claim 1 of the main request, step (c) of claim 1 according to the second auxiliary request further includes:

"comprising performing step (b) N times to obtain a suite of N measurements taken at a plurality of respectively separate measurement region shells, wherein said shells are substantially cylindrical shells having radial extents of about 1 mm",

However, as noted in the application as originally filed, "*As is known in the art, for example as disclosed in U.S. Patent No. 4,710,713, the logging device can select the shell region to be investigated by appropriately selecting the frequency of the RF energy in the transmitted pulses*" (page 5, lines 32 to 34). In fact, according to the above US patent (document D7), "*A useful feature resulting from the radially extending, azimuthally uniform static magnetic field amplitude gradient is that at different frequencies of the RF magnetic field, different* *cylindrical regions 9 (FIG. 1) at different radial separations from longitudinal axis 11 are subject to NMR excitation. This feature enables regions at differing radial separations from the longitudinal axis to be scanned by varying the RF magnetic field frequency*" (column 8, lines 4 to 12).

Accordingly, it would be obvious for the skilled person to apply the teaching of D7 and, thus, to perform NMR echo measurements a number of times (N) to obtain a suite of (N) measurements taken at a plurality of respectively separate measurement region shells, wherein the shells are substantially cylindrical shells, as per claim 1.

As noted above, document D7 is silent as to the radial extent of the cylindrical measurement region shells. The radial extent of the measurement shells, however, as would be readily apparent to the skilled person, depends on the magnetic field distribution and on the frequency spread of the RF pulses. The magnetic field distribution depends in particular on the parameters of the magnet of the NMR logging apparatus, the frequency spread on the parameters of the RF pulses, in particular the frequency and the length of the RF pulses. By selecting common appropriate values for these parameters, the skilled person would arrive at radial extents of about 1 mm without the exercise of inventive skills. It is noted in this respect that the value of 1 mm must be regarded as arbitrary as no particular technical relevance is attributed to it in the application as discussed above.

4.3.2 Step (d) of claim 1 according to the second auxiliary request, compared to claim 1 of the main request, further includes that the formation model comprises a relaxation model for the amplitude of the j-th echo acquired during measurement p according to the following equation:

$$A_j^p = \sum_{l=1}^{N_s} a_l \exp(-\frac{j*TE_p}{T_{2,l}^{\dagger}(p)})(1-\exp(-\frac{W_p}{\xi * T_{2,l}})) + \sum_{k=1}^{N_o} b_k \exp(-\frac{j*TE_p}{T_{2,o}^{\dagger}(\eta_k, p)})(1-\exp(-\frac{W_p}{T_{1,o}(\eta_k)})) + A_{OBMF} \exp(-\frac{j*TE_p}{T_{2,OBMF}^{\dagger}(p)})(1-\exp(-\frac{W_p}{T_{1,OBMF}}))$$

However, as discussed above for the main request, it is known from document D1 that the NMR echo curve from a formation, which contains a plurality of fluids, is the superposition of the echoes generated by the individual fluids according to:

$$M(t) = \sum M_j (t)$$

in which $M_j(t)$ is the NMR echo decay rate of the j-th fluid fraction as described by

$$M(t) = M(0) \sum A_i \exp(-t/T_{2,i}) \exp(-t \gamma^2 D G^2 t_{cp}^2/3) (1-\exp(-TR/T_{1,i}))$$

the latter equation being a straightforward derivation from the standard expression for the decay

$$M(t) = M(0) \sum A_i \exp(-t/T_{2,i})(1-\exp(-TR/T_{1,i}))$$

and the standard expression for the observed transverse relaxation time T_2^* for a fluid in a gradient magnetic field

$$1/T_2^* = 1/T_2 + \gamma^2 D G^2 t_{cp}^2/3$$

in which
A_i is the fluid fraction with transverse relaxation time $T_{2,i}$,
M(0) is the signal amplitude at time t = 0,
$T_{2,i}$ is the transverse relaxation time of fluid fraction A_i,
$T_{1,i}$ is the longitudinal relaxation time of fluid fraction A_i,
$T_{2,i}$ is the transverse relaxation time,
TR is the wait time between CPMG sequences,
γ is the gyromagnetic ratio of the subject nucleus of the fluid,
G is the gradient of the magnetic field,
D is the molecular self-diffusion coefficient of the fluid, and
t_{cp} is the Carr-Purcell spacing.

By generating the model based on these known equations to include respective components for each of the fluids of interest, in particular brine, various constituent oil components and oil based mud filtrate (OBMF), and by entering the appropriate parameters, the person skilled in the art would arrive at the equation as provided in claim 1 without an inventive step being involved.

4.3.3 Finally, regarding step (g) of claim 1, it is known from D1 to fit the model to the measured NMR echo curve, and to derive from the model components of each fluid the respective relevant parameters for each fluid (cf page 3, lines 21 to 23). In particular, as the relaxation time, the diffusion coefficient and the viscosity of the fluid are related to each other, and characteristic of each fluid present in the formation, it would be obvious to the skilled person to derive these parameters in order to determine the properties of the earth formation surrounding the borehole.

4.3.4 The appellant argued in particular that the subject-matter of claim 1 according to the second auxiliary request involved an inventive step because the radial extents of 1 mm of the shells were nowhere suggested in the cited prior art and allowed the multiple shells to be closely spaced, which was particularly advantageous in that it simplified the formation evaluation by minimizing differences in saturation from shell to shell due to drilling fluid invasion.

However, as discussed above, the radial extent of the shells depends on measurement parameter settings, notably relating to the magnetic field distribution and the RF pulse frequency and length, which the skilled person would select as matter of routine practice. The claimed value of about 1 mm would, thus, be arrived at without an inventive step being involved. As to the alleged advantage of minimizing differences in saturation from shell to shell due to drilling fluid invasion, it is noted that any differences in saturation from shell to shell, rather than depending on the radial extent of the shells, mainly depend on the spacing between the shells and on the extent of drilling fluid invasion, if any, into the shells.

4.3.5 Accordingly, the subject-matter of claim 1 according to the second auxiliary request is obvious to the skilled person and, therefore, lacks an inventive step in the sense of Article 56 EPC 1973.

The appellant's second auxiliary request, thus, is not allowable either.

Order

For these reasons it is decided that:

The appeal is dismissed.

Registrar: Chair:

S. Sánchez Chiquero G. Eliasson