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(71) Applicant: **Shell Internationale Research Maatschappij B.V.**
**2596 HR Den Haag (NL)**

(72) Inventors:
- **Bakker, Peter**
  **2288 GS Rijswijk (NL)**
- **Hsu, Chia-Fu**
  **2288 GS Rijswijk (NL)**

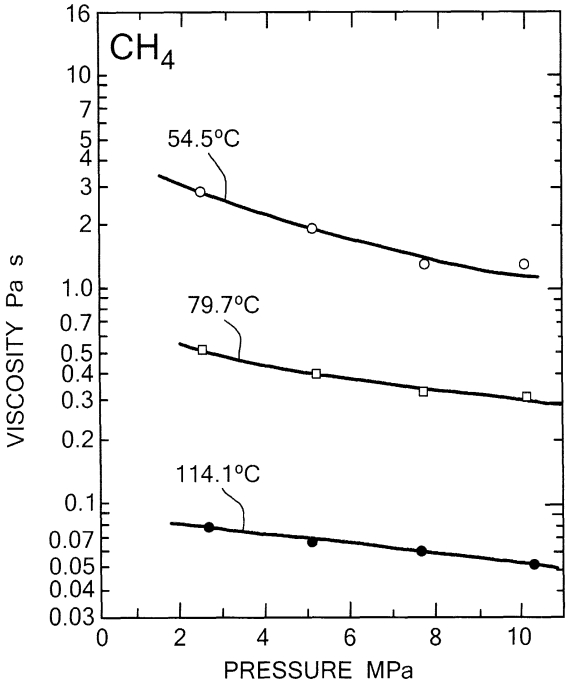
(74) Representative: **Zeestraten, Albertus W. J.**
**Shell International B.V.**
**Intellectual Property Services**
**P.O. Box 384**
**2501 CJ The Hague (NL)**

(54) **Solvent assisted method to mobilize viscous crude oil**

(57) A solvent assisted method to mobilize viscous crude oil comprises the steps of:
- injecting steam and a solvent comprising methane into a viscous crude oil containing formation; and
- producing a heated solvent and crude oil containing fluid mixture from the formation.
The injection of a solvent comprising methane reduces the viscosity of crude oil and counteracts an increase of the viscosity of the crude oil resulting from flashing of methane during the steam injection.

Fig.1

Effect of saturation pressure on the viscosity of $CH_4$ saturated Peace River bitumen

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## Description

### BACKGROUND OF THE INVENTION

**[0001]** The invention relates to a solvent assisted method to mobilize viscous crude oil in a viscous crude oil containing formation.

**[0002]** Such a method is known from US patent 5,899,274.

**[0003]** This prior art reference describes that known steam soak methods have the limitation that steam and heat are lost to the formation. In steam soak methods steam injection and heated crude oil production is cyclically carried out via a single steam injection and production well.

**[0004]** A steam soak method comprises the steps of:

a) injecting steam into the formation through a steam injection and production well;
b) closing the well during a period sufficiently long to allow the heat to soak and reduce the viscosity of the crude oil in the formation surrounding the well;
c) producing heated crude oil via the steam injection and production well; and
d) cyclically repeating the steps a) through c).

**[0005]** In US patent 5,899,274 it is proposed to substitute steam injection by injection of a partially miscible solvent that will exist predominantly in a vapor phase in the reservoir, without the need for heat input or pressure adjustment. This prior art reference furthermore discloses that the solvent may comprise a mixture of methane, ethane and/or propane, which dissolves in oil and reduces its viscosity.

**[0006]** It is an object of the present invention to provide an improved method solvent assisted method to mobilize viscous crude oil in a viscous crude oil containing formation.

### SUMMARY OF THE INVENTION

**[0007]** In accordance with the invention there is provided a solvent assisted method to mobilize viscous crude oil, the method comprising the steps of:

- injecting steam and a solvent comprising methane into a viscous crude oil containing formation; and
- producing a heated solvent and crude oil containing fluid mixture from the formation.

**[0008]** The method according to the invention is based on the insight that a viscous crude oil generally comprises at least a small fraction methane, which reduces the viscosity of the viscous crude oil and that the injected steam tends to mobilize the methane, thereby stripping the crude oil and leaving an even more viscous methane depleted crude oil in the formation. In the method according to the invention a methane containing solvent is injected into the viscous crude oil to counteract the depletion of methane and/or increase the methane content of the crude oil such that the viscosity of the crude oil is reduced in an optimum manner.

**[0009]** Preferably the solvent comprises at least 75% methane ($CH_4$) on a molar basis.

**[0010]** It is furthermore preferred that the steam stimulation method is a cyclic steam stimulation method, comprising the sequence of steps of:

a) injecting steam via a steam injection and production well into the formation,
b) closing the well during a period of time; and
c) producing heated crude oil via the steam injection and production well,
d) cyclically repeating the sequence steps a) through c); and wherein the method further comprises the step of
e) injecting during at least one sequence of steps a) through c) the methane containing solvent into the well prior to step b).

**[0011]** In such case the methane containing solvent preferably is injected into the well before step a).

**[0012]** The viscous crude oil may comprise bitumen, which has a lower viscosity if methane is dissolved in the bitumen.

**[0013]** In such case the viscosity of bitumen in which methane is dissolved may be less than 55 cp at 8.73 MPa and the viscosity of methane-depleted bitumen may be more than 65 cp at 3.55Mpa.

**[0014]** These and other features, embodiments and advantages of the method according to the invention are described in the accompanying claims, abstract and the following detailed description with reference to the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0015]**

Fig.1 shows a diagram, which illustrates the effect of saturation pressure on the viscosity of CH4 saturated bitumen from the bitumen containing Peace River formation in Canada;
Fig.2 is a forecast based on computer simulations, which shows the oil to steam ratio improvement of the method according to the invention compared to a traditional steam soak method without solvent injection; and
Fig.3 is a forecast based on computer simulations, which shows the steam injection and crude oil production rates of a traditional steam soak without solvent injection and a steam soak method with solvent injection in accordance with the invention.

DETAILED DESCRIPTION OF THE DEPICTED EMBODIMENT

**[0016]** The diagram shown in Fig.1 illustrates that the viscosity of bitumen in the Peace River formation in Canada can be reduced by adding methane. The higher the saturation pressure the more methane will be dissolved in the bitumen.

**[0017]** Laboratory experiments indicate that at 121 degrees Celsius the viscosity of bitumen from the Peace River reservoir in Alberta, Canada, without a methane fraction is 70 cp at 3.55 MPa and that the viscosity of Peace River bitumen saturated with methane is 50 cp at 8.73 MPa.

**[0018]** Fig.2 is a forecast based on computer simulations, in which the continuous line 2 depicts the oil to steam ratio improvement of the method according to the invention, wherein methane is injected prior to each steam soaking step such that at least part of the bitumen in the reservoir is saturated with methane, compared to a traditional steam soak method without solvent injection, wherein after a few steam soak cycles the bitumen in the reservoir is substantially methane depleted, which is depicted by the broken line 3.

**[0019]** Fig.3 is a forecast based on computer simulations, which shows the steam injection and crude oil production rates of a traditional steam soak without solvent injection and a steam soak method with solvent injection in accordance with the invention. In Fig.3 the broken lines 4 and 5 depict the steam injection and crude oil production rates of a traditional steam soak process, without solvent injection and the continuous lines 6 and 7 depict the steam injection and crude oil production rates of the solvent assisted steam soak method according to the invention.

## Claims

1. A solvent assisted method to mobilize viscous crude oil, the method comprising the steps of:

   - injecting steam and a solvent comprising methane into a viscous crude oil containing formation; and
   - producing a heated solvent and crude oil containing fluid mixture from the formation.

2. The method of claim 1, wherein the solvent comprises at least 75% methane on a molar basis.

3. The method of claim 2, wherein the solvent comprises at least 90% methane on a molar basis.

4. The method of claim 1,2 or 3, wherein the steam stimulation method is a cyclic steam stimulation method comprising the sequence of steps of:

   a) injecting steam via a steam injection and production well into the formation,
   b) closing the well during a period of time; and
   c) producing heated crude oil via the steam injection and production well,
   d) cyclically repeating the sequence steps a) through c) and wherein the method further comprises the step of
   e) injecting during at least one sequence of steps a) through c) the methane containing solvent into the well prior to step b).

5. The method of claim 4, wherein the methane containing solvent is injected into the well before step a).

6. The method of any preceding claim, wherein the viscous crude oil comprises bitumen, which has a lower viscosity if methane is dissolved in the bitumen.

7. The method of claim 6, wherein the viscosity of bitumen in which methane is dissolved is less than 55 cp at 8.73 MPa and the viscosity of methane depleted bitumen is more than 65 cp at 3.55Mpa.

# Fig.1

Effect of saturation pressure on the viscosity of $CH_4$ saturated Peace River bitumen

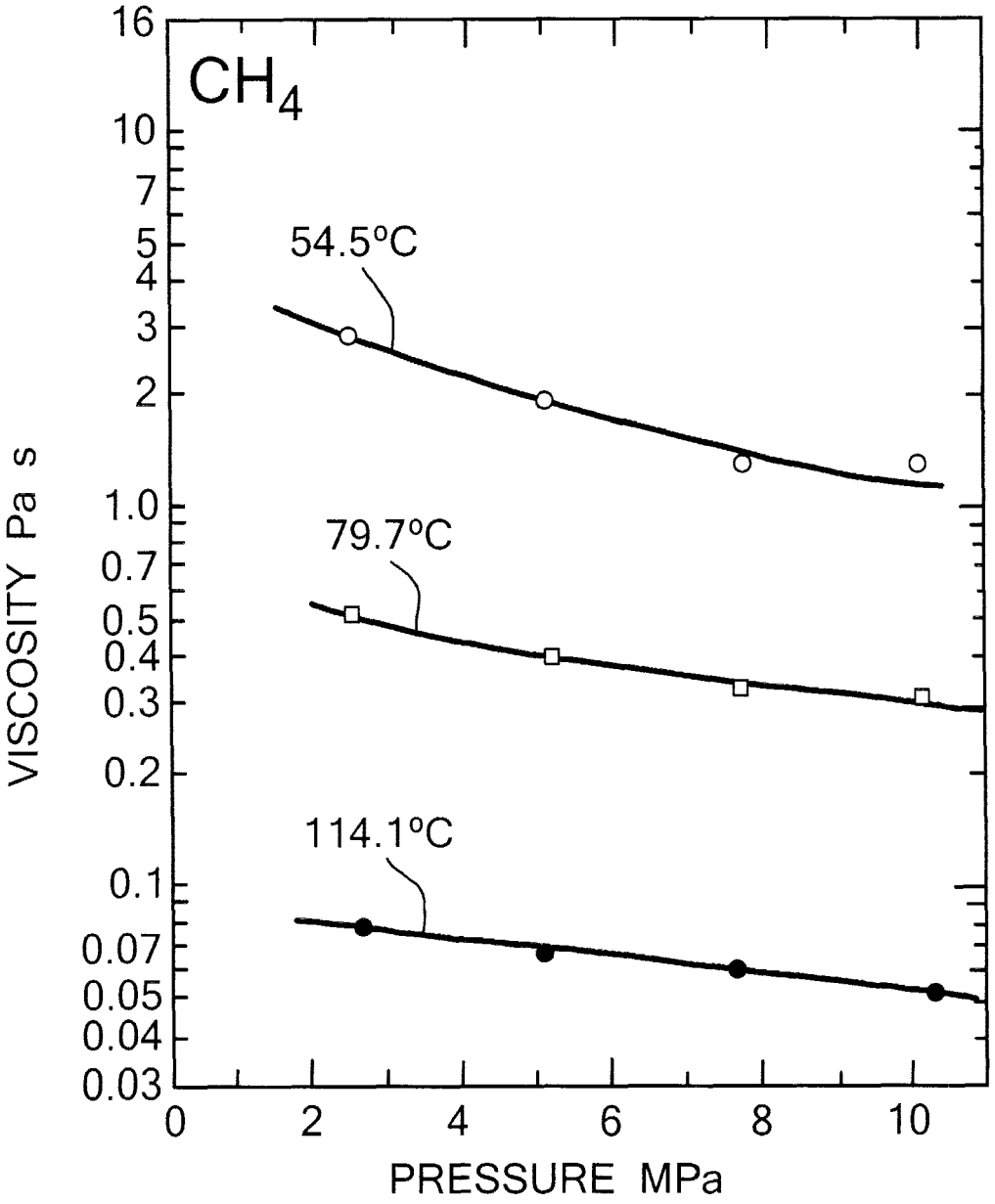


Fig.2

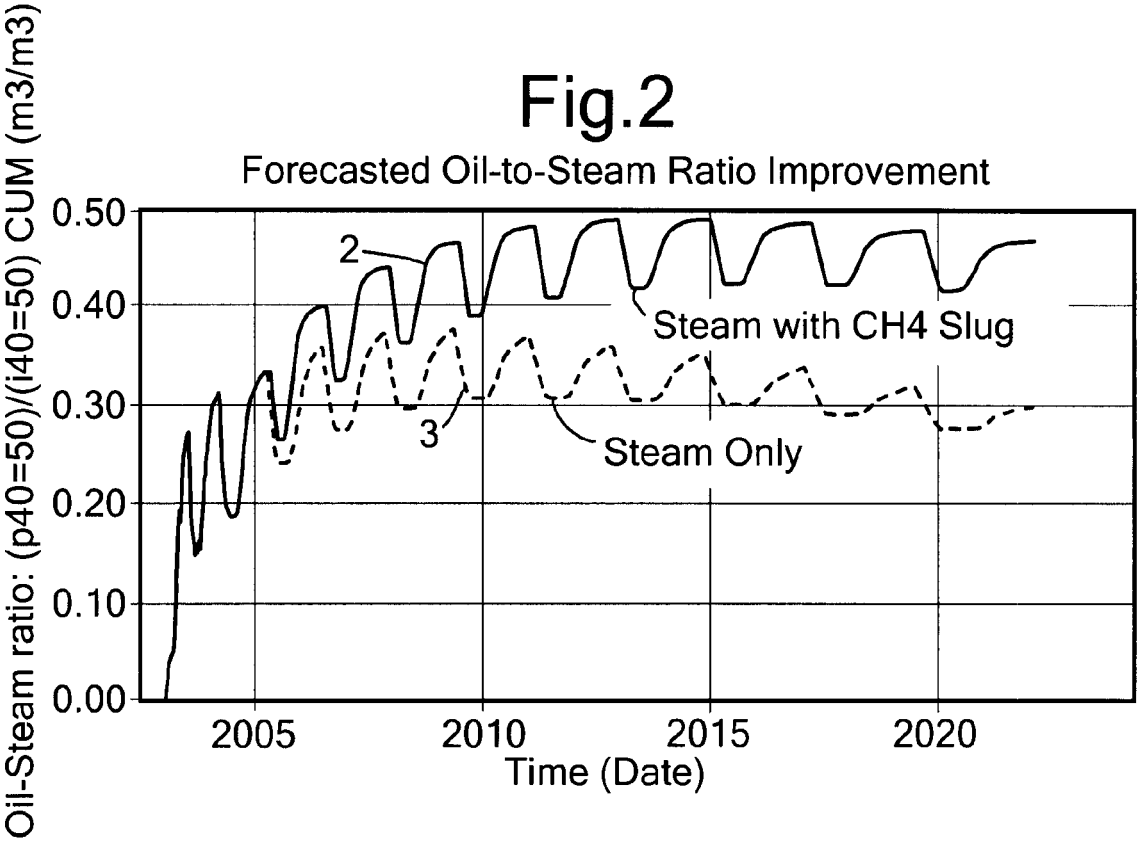
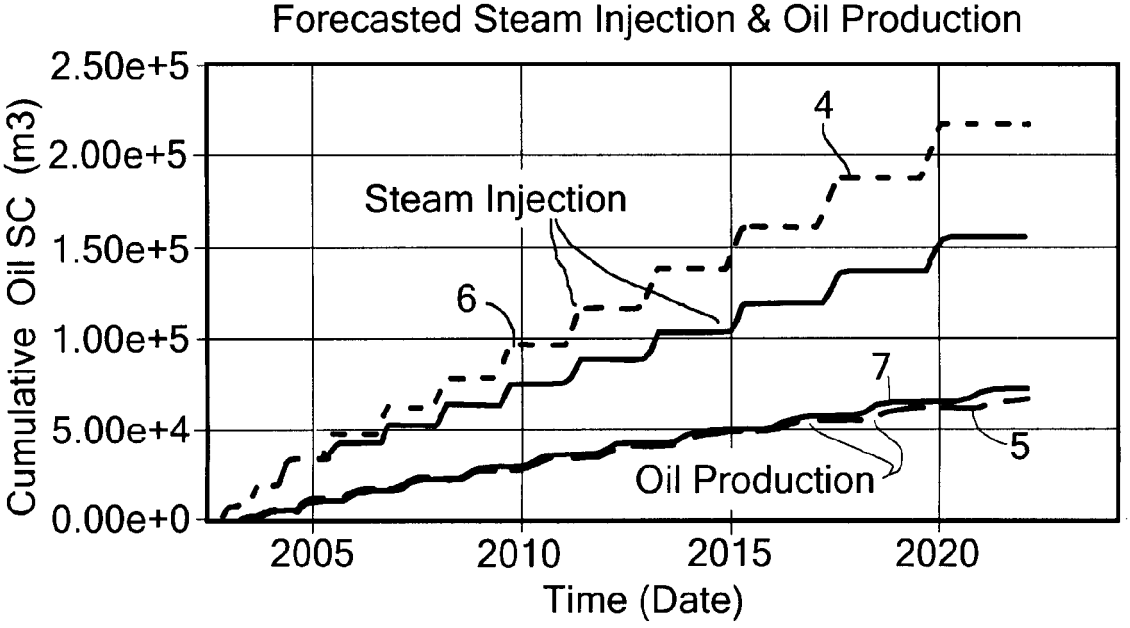

Forecasted Oil-to-Steam Ratio Improvement
Oil-Steam ratio: (p40=50)/(i40=50) CUM (m3/m3)
0.50
0.40
0.30
0.20
0.10
0.00
2005
2010
2015
2020
Time (Date)
2
3
Steam with CH4 Slug
Steam Only

Fig.3


Forecasted Steam Injection & Oil Production
Cumulative Oil SC (m3)
2.50e+5
2.00e+5
1.50e+5
1.00e+5
5.00e+4
0.00e+0
2005
2010
2015
2020
Time (Date)
4
Steam Injection
6
7
5
Oil Production

European Patent Office

# EUROPEAN SEARCH REPORT

Application Number
EP 07 11 3850

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
| X | US 4 513 819 A (ISLIP PHILIP N [US] ET AL)<br>30 April 1985 (1985-04-30)<br>* claims 1,5,9 *<br>* the whole document * | 1-7 | INV.<br>E21B43/24 |
| X | US 4 121 661 A (REDFORD DAVID A)<br>24 October 1978 (1978-10-24)<br>* column 1, line 64 - column 2, line 13; claims 1,10 *<br>soak standard technique<br>* the whole document * | 1-7 | |
| X | US 4 099 568 A (ALLEN JOSEPH C)<br>11 July 1978 (1978-07-11)<br>* claims 1,7 * | 1-3,6,7 | |
| X | US 3 908 762 A (REDFORD DAVID ARTHUR)<br>30 September 1975 (1975-09-30)<br>* claims 1,3 *<br>* the whole document * | 1,4-7 | |
| X | US 4 141 415 A (WU CHING H ET AL)<br>27 February 1979 (1979-02-27)<br>* the whole document * | 1 | TECHNICAL FIELDS SEARCHED (IPC)<br>E21B |
| X | US 2003/015321 A1 (LIM GIT B [CA] ET AL LIM GIT B [CA] ET AL)<br>23 January 2003 (2003-01-23)<br>* the whole document * | 1 | |
| E | US 2007/199712 A1 (HOCKING GRANT [US])<br>30 August 2007 (2007-08-30)<br>* paragraphs [0025], [0026] * | 1 | |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 3 January 2008 | van Berlo, André |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 11 3850

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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03-01-2008

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 4513819 A | 30-04-1985 | CA 1225927 A1 | 25-08-1987 |
| US 4121661 A | 24-10-1978 | CA 1089355 A1 | 11-11-1980 |
| US 4099568 A | 11-07-1978 | CA 1028943 A1 | 04-04-1978 |
| US 3908762 A | 30-09-1975 | CA 1018062 A1<br>YU 262674 A1 | 27-09-1977<br>28-02-1982 |
| US 4141415 A | 27-02-1979 | NONE | |
| US 2003015321 A1 | 23-01-2003 | CA 2349234 A1 | 30-11-2002 |
| US 2007199712 A1 | 30-08-2007 | NONE | |

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- US 5899274 A **[0002] [0005]**