



(51) International Patent Classification:
E21B 47/10 (2012.01)

(21) International Application Number:
PCT/GB2014/051974

(22) International Filing Date:
27 June 2014 (27.06.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1311608.2 28 June 2013 (28.06.2013) GB

(71) Applicant: **JOHNSON MATTHEY PUBLIC LIMITED COMPANY** [GB/GB]; 5th floor, 25 Farringdon Street, London EC4A 4AB (GB).

(72) Inventor: **HARDY, Simon Andrew**; Tracerco Limited, Unit 12, Belasis Court, Billingham Cleveland TS23 4AZ (GB).

(74) Agent: **GIBSON, Sara Hillary Margaret**; Johnson Matthey Catalysts, PO Box 1, Belasis Avenue, Billingham Cleveland TS23 1LB (GB).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

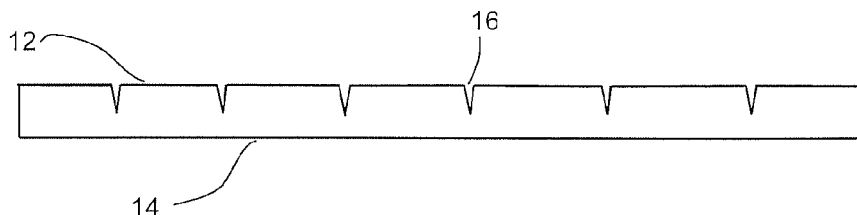
(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: TRACER MATERIAL

Figure 2



(57) Abstract: A tracer material having the form of a flexible sheet comprises a tracer compound dispersed in a solid polymeric matrix.



Tracer Material

The present invention concerns a tracer material suitable for releasing a tracer compound into a fluid.

It is well known to place tracers in a well in order to detect flow of fluid from a part of the well where a tracer has been placed. For example, European Patent Number 1991759 describes a method of monitoring the flow of fluid within or from a reservoir comprising the steps of inserting a solid non-radioactive tracer into the reservoir by means of a perforation tool, thereafter collecting a sample of fluid within or flowing from the reservoir and analysing said sample to determine the amount of said tracer contained in the sample. From the presence or absence of tracer in the sample, its amount and other parameters such as timing of the sample collection etc, information about the fluid flow within the reservoir may be gathered. US 3,623,842 describes a method of determining fluid saturations in reservoirs by injecting at least two tracers having different partition coefficients between fluid phases (e.g. oil and water) into the formation and monitoring the appearance of the two tracers in the produced fluids. Radioactive tracers have been widely used for many years in well-monitoring applications. As an example, see US 5,077,471, in which radioactive tracers are injected into a perforated well-bore, sealed and then monitored for decay to indicate the fluid flow from the formation. US 4,755,469 describes the use of rare metal tracers for tracing oil and associated reservoir fluids by mixing an oil-dispersible rare metal salt with oil or an oil-like composition, injecting the dissolved tracer composition into a subterranean reservoir and analysing oil fluids produced from a different part of the reservoir for the presence of the rare metal to determine whether the oil mixed with the tracer has been produced from the reservoir.

It is desirable to associate tracers with liner tubing and other well-completion apparatus with provision for delayed or controlled release of the tracer over a period of time so that fluids flowing from a part of the well and contacting a delayed release tracer material can be identified downstream of the location of the tracer material. Well tubing with tracer provision has been described in US 6672385 which describes a combined prefabricated liner and matrix system with defined properties for well or reservoir completion, monitoring and control. An embodiment of the combined prefabricated liner and matrix system comprises an outer perforated tubular pipe/pipe system, an inner tubular screen, and a matrix. US 6645769 describes placing different tracers at different parts of the well by adhering polymeric tracers to parts of the completion apparatus so that the tracers may be carried with a fluid as it flows to the well-head. WO2011/153636 describes a wellbore screen including: an apertured base pipe; an intermediate filtering layer including a plurality of metal fibers wrapped helically around the apertured base pipe and a fluid tracing filament wrapped helically about the apertured base pipe, the fluid tracing filament including a filament structure and a tracer

carried by the filament structure, the tracer being entrainable in produced fluids in a wellbore environment; and an outer apertured shell over the intermediate layer.

It is an object of the present invention to provide a tracer material system that provides improvements over the materials described in the prior art.

- 5 According to the invention we provide a tracer material comprising a tracer compound dispersed in a solid polymeric matrix, said material having the form of a flexible sheet. As used in this specification, "sheets" of material have two opposing, generally parallel, major surfaces separated by the thickness of the sheet and bounded by one or more minor surfaces. The average thickness of the sheet is normally in the range from 2mm to 20mm,
10 especially about 5 - 15 mm. The thickness of the sheet is generally uniform and the average thickness does not include portions of the sheet which form protrusions such as ribs, embossments, bosses; or depressions, channels or incisions. At least one major surface of the sheet may be textured and therefore it is appropriate to describe an average thickness.

- According to the invention, a method of tracing a fluid flow within a subterranean reservoir
15 having a borehole extending therethrough comprises the steps of placing a pipeline and a tracer material within said borehole, said tracer material being a tracer material according to the invention in the form of a flexible sheet. The tracer material may contact a surface of the pipeline and conforms to the shape of the pipeline surface. The borehole may be a well for extraction of fluids from the subterranean reservoir. The well may be a hydrocarbon
20 production well.

- The sheet may be provided with surface features such as a texture and/or ribs, channels, protrusions and bosses to promote flow over the surface of the tracer. A textured surface means that the surface is not perfectly flat on a macroscopic scale. The sheets of tracer material may include depressions, incisions or channels extending from at least one major
25 surface thereof towards the other major surface. The depressions, incisions or channels may extend completely through the thickness of the sheet or they may extend only partially through the thickness of the sheet. Depressions, incisions or channels may be present on one or both major surfaces of the sheet. A sheet of tracer material may incorporate linear channels extending partially through the thickness of the sheet. Channels may extend
30 between one edge of the sheet and an opposed edge. The channels may be incised into the surface of the sheet material or excised from the sheet material. The linear channels may be straight or curved. The linear channels may be parallel to each other. The channels allow the sheet to be formed around a curved shape such as a pipe or tube so that the external surface of the sheet containing the channels can deform to accommodate an external curve. When
35 the sheet is formed into such a curved shape, the channels open, thereby providing means for fluid flow along the sheet and an increased surface area for the fluid to contact the tracer.

A tracer material in the form of a flexible sheet may include ribs, bosses or other protrusions extending outwardly from one major surface thereof in a direction away from the other major surface, i.e. to protrude from a major surface of the sheet. A "rib" in the context of this patent application means a generally elongate protrusion or projection extending outwardly from a surface. A rib may, but need not, extend continuously or discontinuously from an edge of a sheet to the same or another edge of a sheet. A rib may be of uniform dimension or shape along its length. A rib may taper to a smaller dimension at a distance further from the surface of the sheet than its corresponding dimension nearer to the sheet. For example the width of a rib may become smaller as its height, or distance from the surface, increases. A "boss" or "embossment" is intended to mean a protrusion or projection from a surface of the sheet. A boss may, for example take the form of a generally circular, irregular or polyhedral shaped portion of the sheet extending outwardly from a major surface of the sheet. Ribs, bosses or other protrusions may be present on both major surfaces of the sheet. A sheet of tracer material may possess at least one channel or incision and also at least one rib, protrusion or boss. Ribs may be straight or curved. Ribs may be parallel to each other.

A tracer material the form of a flexible sheet comprising a tracer compound dispersed in a solid polymeric matrix, the flexible sheet having two opposing, generally parallel, major surfaces separated by the thickness of the sheet and bounded by one or more minor surfaces, may incorporate a plurality of channels extending from at least one major surface of the sheet towards the other major surface of the sheet and a plurality of protrusions extending outwardly from one major surface of the sheet in a direction away from the other major surface of the sheet. A tracer sheet incorporating both ribs and channels may provide a particular advantage when the sheet is curved to fit around a curved surface such as the exterior or interior surface of a circular pipe. When such a sheet is curved, channels on the external surface of the curve may open to allow a greater surface area to come into contact with a fluid passing over or through the pipe. Ribs or protrusions on the internal side of the curve may provide a similar benefit. A tracer material in the form of a flexible sheet may incorporate both channels and protrusions on either or both major surfaces of the sheet.

The tracer sheet may be made from a relatively inflexible material which is made flexible by means of channels to facilitate forming the sheet into a shape. Alternatively the sheet may be formed from a flexible material, such as an elastomer, gel or foamed material for example. When soft materials are used, they may be reinforced using particulate fillers or fibres. A woven or non-woven fibre structure may be present within, or laminated to, the sheet. When the sheet is made using a flexible material, channels may be provided to facilitate deformation of the sheet into a particular shape such as a curve.

The sheet may be perforated with holes extending completely through the sheet. If present the holes may be of sufficient size to allow the flow of fluids through the sheet. In some

cases, it may be desirable to perforate the sheet to increase access of the fluid to the tracer material, which may increase the rate of release of tracer. It may also be possible to adapt a tracer sheet to different required tracer release rates by adjusting the size and number of perforations accordingly. The sheet may be perforated in situ, within a well completion, for example, for example by means of an explosive charge carried by a perforation tool.

The sheet may incorporate fixing means to enable it to be fixed into position where it is to be used to contact a flowing fluid. Such a position may include a surface of well completion apparatus, including well liner or a screen etc. The fixing means may include an adhesive layer. Alternatively the tracer material may be fixed in a position for use by means of straps, cable ties, clips, cages etc.

The tracer material may be selected or treated to provide a surface which attracts the fluid or a selected portion of the fluid. For example a solid polymeric matrix containing tracer may have a hydrophilic or hydrophobic surface depending on whether the tracer is intended to be released into an organic or aqueous fluid. The surface of the tracer material may be coated with or laminated to a layer of a second material containing a different amount of tracer or a different tracer compound from the tracer material. The second material may contain no tracer. The second material may have the function of providing suitable surface characteristics for the tracer material. Alternatively it may provide a delayed, controlled or sustained release function by delaying contact of a fluid with the tracer compound or tracer material whilst the surface layer is partially removed by hydrolysis, dissolution, abrasion or by other means. As a further alternative, the second material may contain a different tracer compound or mixture of tracer compounds from the tracer material. Additional layers may also be provided.

The tracer compound may comprise a dye which can be detected by visual means or by a spectroscopic method. The dye may be coloured or not coloured to the eye. Fluorescent compounds, detectable by fluorescence spectroscopy, are well-known for use as tracers and may be suitable for this application. Chemical tracer compounds which are detected by atomic absorption spectroscopy or other methods may be used. The tracer compound may be soluble in the fluid flowing in the well or it may be carried in the flow as a particle. The tracer compound may be selected to partition into an organic phase or into an aqueous phase such as in the water co-produced in an oil or gas well. The selection of suitable tracer compounds is known in the art and the skilled person is capable of selecting one or more appropriate tracer compounds. More than one tracer compound may be used within the same tracer material. For example, different combinations of tracers may be used in different tracer materials to identify different flows. Tracer materials containing different tracer compounds or different combinations of tracer compounds may be placed in different locations, e.g. at different parts of a well, so that fluid passing contacting each tracer material

at its respective location may be identified. When different tracer materials are used in a well, they may be designed to release tracer compounds at different rates by appropriate selection of one or more matrices or other means for controlling or delaying release of the tracer. In this way fluid contacting the tracer materials may be detected at different stages in the production history of the well. The tracer compounds in each tracer material may be the same or different. Sheets of different tracer materials containing different tracer compounds may be made readily identifiable by colouring the polymeric material or applying other visible indicators to the sheet.

The tracer compound may be chemically bound to the matrix or may simply be physically dispersed therein. The tracer compound is typically released into fluid flowing past the material by dissolution of either the matrix material or the tracer compound in the fluid. Alternatively the matrix may be selected to degrade in a controlled manner on contact with the fluid, for example by hydrolysis of a hydrolytically unstable polymer matrix. The dissolution or degradation mechanism may be enhanced by the conditions of temperature and pressure found in the well. The use of controlled/sustained/delayed release tracer materials is preferred in some installations to provide a traceable flow over a longer period. However in other cases it is only required to trace a flow over a short period, for example to determine if a perforation operation has resulted in a successful fluid flow. Therefore the selection of tracer material depends upon the purpose for which the tracer material is to be used.

The invention will be further described, by way of example, with reference to the accompanying drawings, which are:-

Figure 1: a schematic view of a tracer material according to the invention;

Figure 2: a section through the tracer material portion of Fig 1.

Figures 3 - 5: show a section through a different embodiment of the invention.

Figure 6 shows, in section, a pipeline to which is attached a tracer material according to the invention.

In Figs 1 and 2 a sheet of tracer material 10, formed from a tracer compound dispersed in a solid flexible polymeric matrix has an upper surface 12, a lower surface 14 and V-shaped channels 16 extending partially through the thickness of the sheet from the upper surface towards the lower surface. The sheet shown in section in Fig 3 has channels extending from both major surfaces of the sheet. Fig 4 shows an example of a tracer sheet having channels and further including triangular-section ribs extending from one of the major surfaces of the sheet. Fig 5 shows an alternative embodiment of a ribbed sheet in which the ribs have a rectangular cross-section. Any combination of ribs and channels may be used.

In Fig 6, a pipeline 20 has a tracer material sheet 10 fixed to a surface thereof. The fixing is not shown but may include a strap surrounding the tracer material and the pipe. The channels 16 on the outer surface of the tracer material open to allow fluids to access the portions of the tracer material bounding the channel. Ribs 18 provide a means by which fluid

5 can contact the inner surface of the tracer material.

Claims

1. A tracer material comprising a tracer compound dispersed in a solid polymeric matrix, said material having the form of a flexible sheet.
2. A tracer material as claimed in claim 1 having an average thickness in the range from 2mm to 20mm.
3. A tracer material according to claim 1 or claim 2, wherein said sheet has a textured surface.
4. A tracer material according to any one of the preceding claims wherein the surface of said sheet incorporates at least one topographical feature selected from protrusions, bosses, ribs, depressions, channels and incisions.
5. A tracer material as claimed in claim 4, wherein said sheet incorporates a plurality of channels extending from a first major surface thereof towards an opposed major surface.
6. A tracer material as claimed in claim 4 or claim 5, wherein said sheet incorporates a plurality of protrusions, ribs or bosses, said protrusions, ribs or bosses protruding from a major surface of the sheet.
7. A tracer material according to any one of the preceding claims, wherein said sheet is perforated with holes extending completely through the sheet.
8. A tracer material according to any one of the preceding claims, wherein at least one surface of said sheet is treated to change the hydrophilicity of the surface.
9. A tracer material according to any one of the preceding claims, comprising a plurality of layers of polymeric material.
10. A tracer material according to any one of the preceding claims, wherein said tracer compound comprises a dye or a chemical tracer.
11. A tracer material according to any one of the preceding claims, wherein said tracer compound is selected to partition into an organic phase.
12. A tracer material according to any one of the preceding claims, wherein said tracer compound is selected to partition into an aqueous phase.
13. A tracer material according to any one of the preceding claims, containing more than one tracer compound.

14. A method of tracing a fluid flow within a subterranean reservoir having a borehole extending therethrough comprising the steps of placing a pipeline and a tracer material within said borehole, said tracer material being a tracer material in the form of a flexible sheet, as claimed in any one of the preceding claims.
15. A method as claimed in claim 14, wherein said tracer material contacts a surface of said pipe and conforms to the shape of said surface.

Figure 1

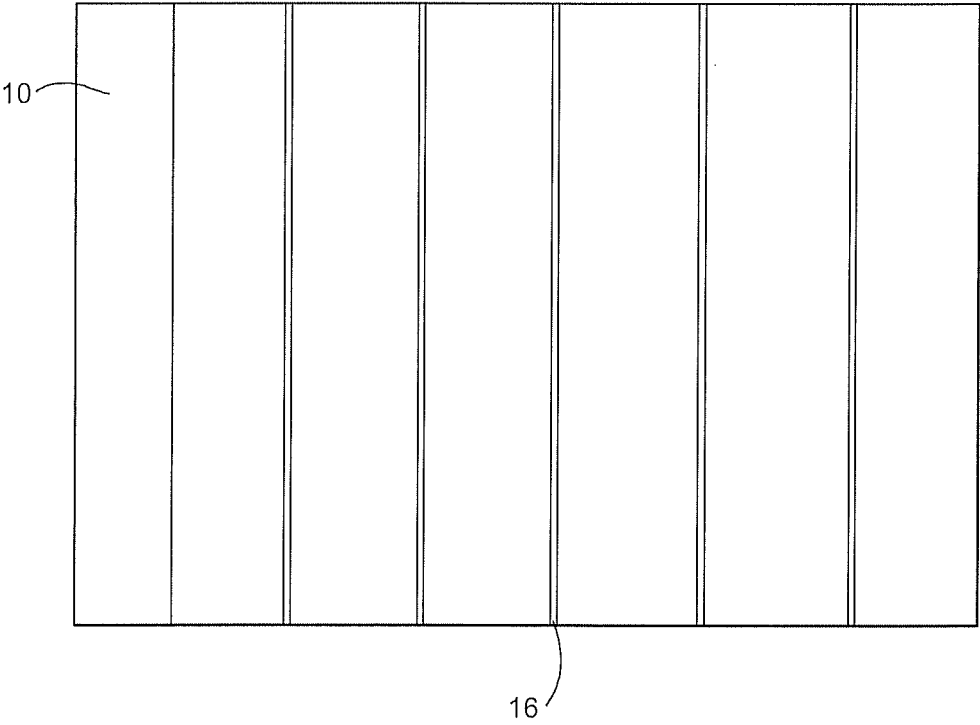


Figure 2

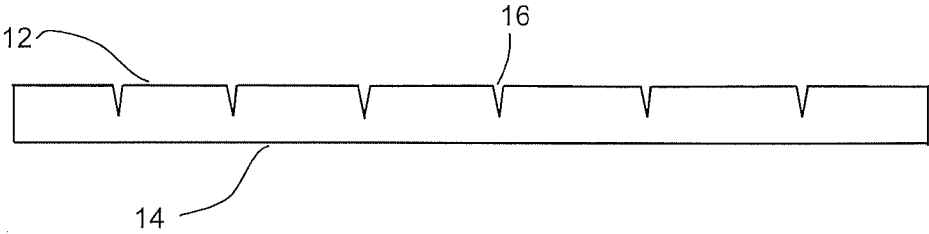
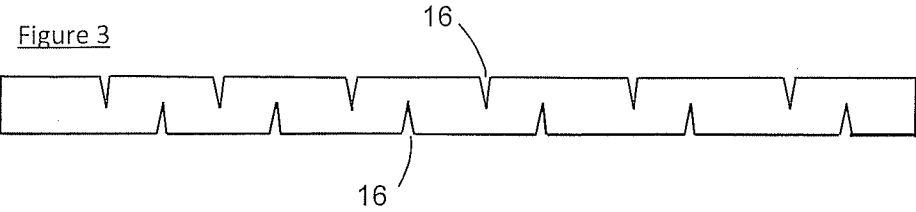


Figure 3



2/2

Figure 4

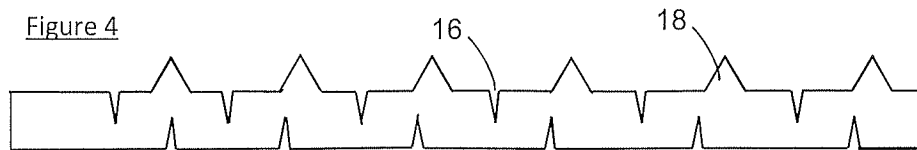


Figure 5

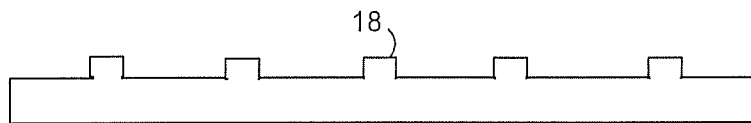


Figure 6

