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(54) Protective film for a downhole tool

(57) The present invention relates to a method for corrosion protection and protection against abrasive wear of a downhole tool. The method comprises the steps of applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface of the downhole tool and heating the downhole tool to cure the paint, thereby providing a protective film comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool. Furthermore, the invention relates to a heating device for heating a downhole tool according to the method, to the use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface of a downhole tool, and to a downhole tool comprising the protective film

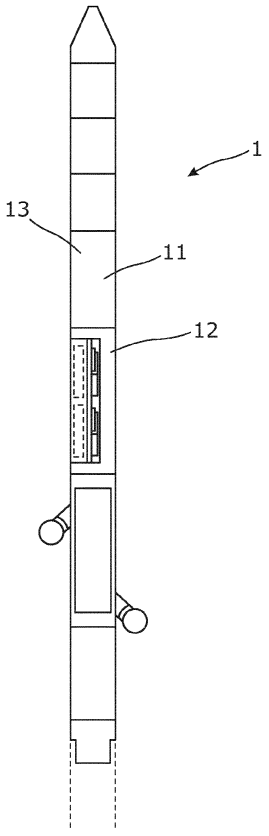

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to a method for corrosion protection and protection against abrasive wear of a downhole tool. Furthermore, the invention relates to a heating device for heating a downhole tool according to the method, to the use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface of a downhole tool, and to a downhole tool comprising the protective film.

Background art

[0002] The environment in hydro carbon producing wells is often very harsh due to pressure conditions, high temperatures and the presence of corrosive fluids. This is sometime worsened by injection of highly corrosive acids, such as hydrochloric acid, for stimulating the well. Downhole tools must be able to operate under these conditions and during multiple cycles or for longer periods of time. At the same time, the reliability of downhole tools is a major concern, since a malfunctioning tool may shut down a well, which entails considerable economic losses due to loss of production. Also, downhole tools often comprise complicated mechanical and electrical components which are expensive to produce and replace. It is thus desirable that downhole tools are able to withstand these conditions so that they are not worn down too fast or risk breaking down during operations downhole. A need thus exists for ways of protecting or reducing the impact of the downhole conditions, especially corrosive fluids, on particular components of a downhole tool or on the entire tool during operations in hydro carbon producing wells.

[0003] Downhole conditions pose some serious challenges to the use of coatings or protective layers due to amongst others the considerable fluctuations in pressure. The changing pressure may reduce the ability of a coating or protective layer to adhere to the exterior of downhole tools, which may cause pieces of coating to detach from the tool downhole. This may be highly undesirable, as detached pieces of coating may cause valves, tools, etc. to malfunction. Also, the application of protective coatings poses serious challenges, as downhole tools are often used far from high-tech manufacturing facilities where tools may be dismantled and coatings may be applied, removed or repaired

Summary of the invention

[0004] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved protective layer for a downhole tool and a method of applying such a protective layer.

[0005] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a method for corrosion protection and protection against abrasive wear of a downhole tool, comprising the steps of:

- applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface of the downhole tool, and
- heating the downhole tool to cure the paint, thereby providing a protective film comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool.

[0006] In an embodiment, two layers of polytetrafluoroethylene (PTFE)-containing paint may be applied to the exterior surface of the downhole tool.

[0007] In another embodiment, the polytetrafluoroethylene (PTFE)-containing paint may be applied with a layer thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm.

[0008] In another embodiment, heating of the downhole tool may be done by arranging at least a section of the downhole tool inside a heating chamber of a heating device.

[0009] Furthermore, heating of the downhole tool may be done by successively heating one section of the downhole tool at a time inside the heating chamber of the heating device.

[0010] Moreover, the polytetrafluoroethylene (PTFE)-containing paint may be applied by spraying, using a brush or dipping at least a part of the downhole tool into the paint.

[0011] In addition, the method may comprise the step of curing the polytetrafluoroethylene (PTFE)-containing paint at a temperature of 80°C -140°C for approximately 30-60 minutes.

[0012] Furthermore, the method may comprise the step of adding a hardener to the paint.

[0013] The method described above may further comprise the step of pre-treating the exterior surface of the downhole tool before applying or re-applying the polytetrafluoroethylene (PTFE)-containing paint to the downhole tool.

[0014] In an embodiment, the exterior surface of the downhole tool may be pre-treated by phosphatising, anodising, anodic coating, pickling or sandblasting the exterior surface of the downhole tool.

[0015] In addition, the exterior surface of the downhole tool may be pre-treated by applying a primer.

[0016] Moreover, the polytetrafluoroethylene (PTFE)-containing paint may comprise at least one surfactant for lowering the surface tension of the paint.

[0017] The surfactant may have a hydrophilic group and a hydrophobic group.

[0018] Furthermore, the polytetrafluoroethylene (PTFE)-containing paint may be applied to an already existing layer of protective film to provide an additional layer

of protective film.

[0019] Also, the method described above may comprise the steps of curing each layer of polytetrafluoroethylene (PTFE)-containing paint to provide a layer of protective film before a next layer of polytetrafluoroethylene (PTFE)-containing paint is applied. Hereby, the best possible adhesion is achieved as a thin layer of paint will give the best adhesion.

[0020] In an embodiment, the method may further comprise the step of applying the polytetrafluoroethylene (PTFE)-containing paint on an already existing layer of protective film.

[0021] Additionally, the method described above may further comprise the step of fully of partly removing an existing layer of protective film provided on the exterior surface of the downhole tool before repainting the downhole tool with the polytetrafluoroethylene (PTFE)-containing paint.

[0022] Also, the polytetrafluoroethylene (PTFE)-containing paint may only be applied to part of the exterior surface of the downhole tool, resulting in a protective film covering from 74% to 95%.

[0023] Moreover, the method described above may further comprise the steps of inserting the downhole tool into a well, removing the downhole tool from the well after a certain period of time, repeating one or more of the steps of applying the polytetrafluoroethylene (PTFE)-containing paint, heating the downhole tool to cure the paint, and pre-treating the exterior surface of the downhole tool, and inserting the downhole tool into the well once again to carry out the same or a different operation.

[0024] In an embodiment, the above-mentioned steps may be repeated for any number of cycles.

[0025] Furthermore, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) or a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

[0026] The present invention furthermore relates to a heating device for heating a downhole tool according to the method described above, the heating device comprising:

- a heating box defining a heating chamber, and
- a heating means for heating the heating chamber,

wherein a first side of the heating box is provided with a first opening, thereby defining a passage into the heating box configured for receiving a section of the downhole tool.

[0027] In one embodiment, a second side of the heating box is provided with a second opening, thereby defining a passage through the heating box configured for receiving a section of the downhole as well.

[0028] The present invention furthermore relates to the use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface of a downhole tool to prevent corrosion and/or protection against abrasive wear of the downhole tool.

[0029] Moreover, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

[0030] In an embodiment, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE).

[0031] Moreover, the protective film comprising polytetrafluoroethylene (PTFE) may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

[0032] Also, the protective film comprising polytetrafluoroethylene (PTFE) may be a high-molecular polymer film.

[0033] Additionally, the protective film may have excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface of the downhole tool.

[0034] The downhole tool described above may further comprise a protective film covering from 74% to 95%.

[0035] Moreover, the polytetrafluoroethylene (PTFE)-containing paint may be applied with a layer thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm.

[0036] Furthermore, at least part of the protective film may constitute a pattern comprising longitudinal or transversal sections or stripes of protective film.

[0037] Finally, the present invention relates to a downhole tool comprising a protective film as described above.

[0038] Moreover, the protective film provided on the downhole tool may have excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface of the downhole tool.

[0039] In an embodiment, the protective film provided on the downhole tool may be a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

[0040] Furthermore, the polytetrafluoroethylene (PTFE)-containing paint may be applied in at least two layers each having a thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm.

[0041] In addition, the polytetrafluoroethylene (PTFE)-containing paint may contain a hardener. The polytetrafluoroethylene (PTFE)-containing paint may contain 1-5 % by weight hardener, preferably 2-3 % by weight hardener.

[0042] By introducing a hardener into the polytetrafluoroethylene (PTFE)-containing paint, the temperature at which the paint hardens can be lowered so that the paint is cured at approximately 80°C-100°C for approximately 30-60 minutes, preferably at approximately 80°C-90°C for approximately 30-60 minutes. The amount of hardener in the paint is 1-5 % by weight, preferably 2-3 % by weight.

[0043] Moreover, the polytetrafluoroethylene (PTFE)-containing paint may comprise at least one sur-

factant for lowering the surface tension of the paint.

[0044] Finally, the surfactant may have a hydrophilic and a hydrophobic group.

Brief description of the drawings

[0045] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows a downhole tool provided with a layer of protective film comprising polytetrafluoroethylene (PTFE),

Fig. 2 shows a heating device for heating a downhole tool, and

Figs. 3a and 3b each shows a part of a downhole tool comprising a layer of protective film constituting a pattern.

[0046] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0047] Fig. 1 shows a downhole tool 1 in the form of a downhole tractor. The downhole tool is provided with a protective film 13 comprising polytetrafluoroethylene (PTFE) for covering an exterior surface 11 of the downhole tool. The protective film of polytetrafluoroethylene (PTFE) has excellent adhering properties and adheres very well to metal surfaces even when subjected a harsh downhole environments. The protective film may be a solid film lubricant comprising polytetrafluoroethylene (PTFE), such as a solid film lubricant sold under the trade name Gleitmo SFL by Fuchs Lubritech. The protective film 13 is applied to the external surface 11 of the downhole tool 1 to prevent corrosion of the downhole tool to protect the tool from abrasive wear when particles pass in the well fluid and increase the resistance of the downhole tool towards well fluids, such as acids, solvents, mineral oils, synthetic oils and sea water. Thus, the protective film 13 reduces wear and abrasion of the downhole tool and furthermore has good lubricating properties.

[0048] In one exemplary use, the protective film 13 is applied to the downhole tool 1 before the tool is inserted into a well. The protective film may be applied any number of times, such as prior to each insertion of the downhole tool into a well. The protective film is applied by applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface 11 of the downhole tool, followed by the downhole tool 1 being heated to cure the paint, thereby providing the firmly adhering protective film 13 on the exterior surface of the downhole tool. Tests have shown that the protective film has very good adhesion capabilities and that the adhesion is very strong compared to known paints and coatings. Furthermore, the exterior surface 11 of the downhole tool does not have to be cleaned from former layers of protective film since the paint is able to adhere to surfaces partly covered with former layers of the protective film. However, before applying the paint, the downhole tool may be thoroughly cleaned, e.g. degreased, to remove substances and impurities reducing the adhering capabilities of the protective film. To increase the high adhesive strength of the protective film, the exterior surface 11 of the downhole tool may also be pre-treated by phosphatising, anodising, anodic coating, pickling or sandblasting before the paint is applied. Also, an existing protective layer may be partly or fully removed before the downhole tool is repainted with the polytetrafluoroethylene (PTFE)-containing paint. For example, only loose parts of the existing protecting film may be removed, whereas the remaining parts still firmly adhering to the exterior surfaces 11 of the downhole tool are maintained. The paint may be applied by spraying, using a brush, dipping the downhole tool into the paint or by any other method know by the skilled person.

[0049] Experiments have shown that even though the polytetrafluoroethylene (PTFE)-containing paint is applied to only a part of the exterior surface 11 of the downhole tool, resulting in only part of the exterior surface being covered by a protective film, the remaining, uncovered parts of the exterior surface still experience improved corrosion resistance and resistance towards well fluids. This is due to the protective film on parts of the exterior surface having an inhibiting effect on uncovered parts of the exterior surface. Thus, even though the exterior surface of the downhole tractor is not fully covered by the protective film, the uncovered parts of the exterior surface are still protected.

[0050] The inhibiting effect of the protective film may be exploited by painting the exterior surface of the downhole tool so that the resulting protective film 13 covers from 50% to 95%, preferably 74% to 95% of the exterior surface of the downhole tool. A considerable advantage of this way of applying the paint is that parts of the downhole tool particularly dependent on fine tolerances, such as joints, interfaces or screw holes, need not be painted and covered by protective film. Also, slots or other interfaces of fasteners, such as screws, need not be covered by paint, whereby the downhole tool may be easier to dismantle after use. In one exemplary embodiment utilising the above-mentioned inhibiting effect, the exterior surface may be painted in a specific pattern, as shown in Figs. 3a and 3b. For example, the pattern may comprise longitudinal or transversal sections or stripes of protective film.

[0051] The downhole tool is heated to cure the paint by inserting the downhole tool into a heating device 2, as shown in Fig. 2. The heating device 2 comprises a heating box 21 defining a heating chamber 22 provided

with a heating means 23 for heating the heating chamber. A first side 31 and a second side 32 of the heating box are provided with openings 41, 42 defining a passage 24 through the heating box. Hereby, one section 12 of the downhole tool may be arranged inside the heating chamber 22 at a time, with the remainder of the downhole tool extending from the heating chamber through the openings in the sides of the heating box. Thus, if the full length of the downhole tool has to be heated, one section 12 of the downhole tool is successively heated inside the heating chamber 22 at a time. By using a heating device utilising the design described above, the heating device may be very compact, making it easy to transport to and set up at e.g. an off shore installation. Alternatively, the downhole tool may be heated using any kind of heat gun or other heating means known by the person skilled in the art.

[0052] The polytetrafluoroethylene (PTFE)-containing paint comprises a combination of solid polytetrafluoroethylene (PTFE) lubricants, organic binders and solvents. The polytetrafluoroethylene (PTFE)-containing paint may further comprise at least one surfactant for lowering the surface tension of the paint. The surfactant has a hydrophilic group and a hydrophobic group. Upon curing, the paint forms a dry solid film lubricant 13 firmly adhering to the exterior surfaces 11 of the downhole tool 1. The protective film is a high-molecular polymer (HMP) film. More specifically, the protective film is a heat-curing solid film lubricant comprising polytetrafluoroethylene (PTFE) as a constituent. Such a polytetrafluoroethylene (PTFE) solid film lubricant is for example sold under the trade name Gleitmo SFL by Fuchs Lubritech. After being cured, the protective film forms a dry, firmly adhering lubricating film or solid film lubricant (SFL). The applied paint is cured at approximately 120°C-140°C for approximately 30-60 minutes, thus protecting the downhole tool 1 and enabling energy efficiency. Once formed, the layer thickness of the protective film is about 2-30 μm, preferably 3-10 μm, and the protective film is able to withstand high temperatures, such as up to 250°C. The polytetrafluoroethylene (PTFE)-containing paint may be applied in a plurality of layers each having a thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm. Before applying a second layer, the previous layer is cured by means of heat. When submerged into a well fluid, the protective layer is subjected to particles in the fluid sliding past the tool surface at a high velocity, and thus a tool without a protective layer is subjected to significant abrasive wear.

[0053] By introducing a harderner into the polytetrafluoroethylene (PTFE)-containing paint, the temperature at which the paint hardens can be lowered so that the paint is cured at approximately 80°C-100°C for approximately 30-60 minutes, preferably at approximately 80°C-90°C for approximately 30-60 minutes. The amount of hardener in the paint is 1-5 % by weight, preferably 2-3 % by weight.

[0054] Tests have shown that the polytetrafluoroethylene (PTFE)-containing paint and the resulting protective film adhere remarkably better than prior known paints and coatings. Prior known paints and coatings do not have the ability to adhere so well to the exterior surface of a downhole tool, especially after the downhole tool has been subjected to the harsh environment downhole. For example, prior known paints and coatings can easily be scratched off after the downhole tool has been submerged in an acid bath for testing, whereas the protective film according to the invention maintains its high adhesive strength. The protective film thus has adhesion capabilities like no other known paint and coating previously known for use with downhole tools.

[0055] In the following, one exemplary method of corrosion protecting and protection against abrasive wear of a downhole tool will be disclosed.

[0056] Prior to inserting the downhole tool 1 into a well, the tool is de-greased using e.g. a solvent, and the polytetrafluoroethylene (PTFE)-containing paint is applied to one or more exterior surfaces 11 of the downhole tool. Subsequently, the paint is cured by heating the downhole tool using a heating device 2 according to the above. For example, the downhole tool 1 may be heated by successively heating one section 12 of the downhole tool at a time inside the heating chamber 22 of a heating device 2. The process of applying the paint and subsequently heating the tool to cure the paint may be repeated any number of times deemed necessary by the skilled person. For example, a first layer of paint may be applied followed by the downhole tool being heated to cure the paint. Subsequently, a second layer of paint is applied on top of the cured protective film, followed by the downhole tool being heated once again to cure the second layer of paint.

[0057] After curing the downhole tool 1, the downhole tool may be inserted into an open hole or cased well to perform a desired operation. In the period of time during which the tool is in the well, the tool is protected from the harsh environment downhole by the protective film 13 due to the exceptional adhesion capabilities of the protective film. When the downhole tool has been retrieved from the well, the tool may be inspected to assess the condition of the protective film. If certain parts of the protective film have been damaged of worn, the protective film may be partly or fully removed.

[0058] Before the downhole tool 1 is inserted into the well once again, the tool may be coated with an additional new layer of protective film 13. In one exemplary method, the additional layer is applied on top of the already existing layer which has preferably been thoroughly cleaned to remove grease, oil residue, well fluids or other similar remains after the tool has been inserted in the well during the first run. The application of the second layer on top of the already existing layer is possible because the proposed polytetrafluoroethylene (PTFE)-containing paint adheres remarkably better than known paints and coatings previously used for downhole tools.. Due to the simple application of the polytetrafluoroethyl-

ene (PTFE)-containing paint and the relative compact heating device, the above process of coating the downhole tool with the protective film may very well be accomplished at the well site, e.g. at an off shore installation. Thus, by fully or partly reapplying the protective film, optimal protection of the downhole tool during each run downhole may be ensured.

[0059] The downhole tool may be any kind of well tool or operational tool, such as a driving unit or downhole tractor, a stroking tool, a key tool, an anchoring tool, a setting tool, a cleaning tool, a milling tool, a packer tool, a dart, a self-propelling tool, a release tool, a logging tool, a casing collar locator or a scanning tool.

[0060] By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0061] By a downhole tractor is meant any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®. A downhole tractor can be used to push the tool all the way into position in the well, in the event that the tool is not submergible all the way into the casing. The downhole tractor may have projectable arms having wheels, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing. Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A method for corrosion protection of a downhole tool (1), comprising the steps of:

   - applying a polytetrafluoroethylene (PTFE)-containing paint to an exterior surface (11) of the downhole tool, and
   - heating the downhole tool to cure the paint, thereby providing a protective film (13) comprising polytetrafluoroethylene (PTFE) on the exterior surface of the downhole tool.

2. A method according to claim 1, wherein heating of the downhole tool is done by arranging at least a section of the downhole tool inside a heating chamber (22) of a heating device (2).

3. A method according to claim 2, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied with a layer thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm.

4. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied by spraying, using a brush or dipping at least a part of the downhole tool into the paint.

5. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is applied in at least two layers each having a thickness of 2-30 μm, preferably 3-10 μm, more preferably 3-5 μm.

6. A method according to any of the preceding claims, wherein the polytetrafluoroethylene (PTFE)-containing paint is only applied to part of the exterior surface of the downhole tool, resulting in a protective film covering from 50% to 95%, preferably 74% to 95% of the exterior surface of the downhole tool.

7. A method according to any of the preceding claims, further comprising the steps of:

   - inserting the downhole tool into a well,
   - removing the downhole tool from the well after a certain period of time,
   - repeating one or more of the steps of applying the polytetrafluoroethylene (PTFE)-containing paint, heating the downhole tool to cure the paint, and pre-treating the exterior surface of the downhole tool, and
   - inserting the downhole tool into the well once again to carry out the same or a different operation.

8. A method according to any of the preceding claims, wherein the protective film comprising polytetrafluoroethylene (PTFE) is a solid film lubricant comprising polytetrafluoroethylene (PTFE) or a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

9. A heating device (2) for heating a downhole tool according to the method of any of the claims 2-8, the heating device comprising:

   - a heating box (21) defining a heating chamber (22), and
   - a heating means (23) for heating the heating chamber,

   wherein a first side (31) of the heating box is provided with a first opening (41), thereby defining a passage (24) into the heating box configured for receiving a section (12) of the downhole tool.

10. A heating device according to claim 9, wherein a second side (32) of the heating box is provided with a second opening (42), thereby defining a passage (24) through the heating box configured for receiving a section of the downhole as well.

11. Use of a protective film comprising polytetrafluoroethylene (PTFE) for covering an exterior surface (11) of a downhole tool (1) to prevent corrosion and/or protection against abrasive wear of the downhole tool.

12. Use of a protective film comprising polytetrafluoroethylene (PTFE) according to claim 12, wherein the protective film comprising polytetrafluoroethylene (PTFE) is a solid film lubricant comprising polytetrafluoroethylene (PTFE) sold under the trade name Gleitmo SFL by Fuchs Lubritech.

13. A downhole tool comprising a protective film of polytetrafluoroethylene (PTFE)-containing paint sold under the trade name Gleitmo SFL by Fuchs Lubritech.

14. A downhole tool according to claim 14, wherein the protective film has excellent adhesion capabilities, thereby providing a very strong adhesion to an exterior surface (11) of the downhole tool.

15. A downhole tool according to claim 14, wherein the protective film covers from 50% to 95%, preferably 74% to 95% of the exterior surface of the downhole tool.

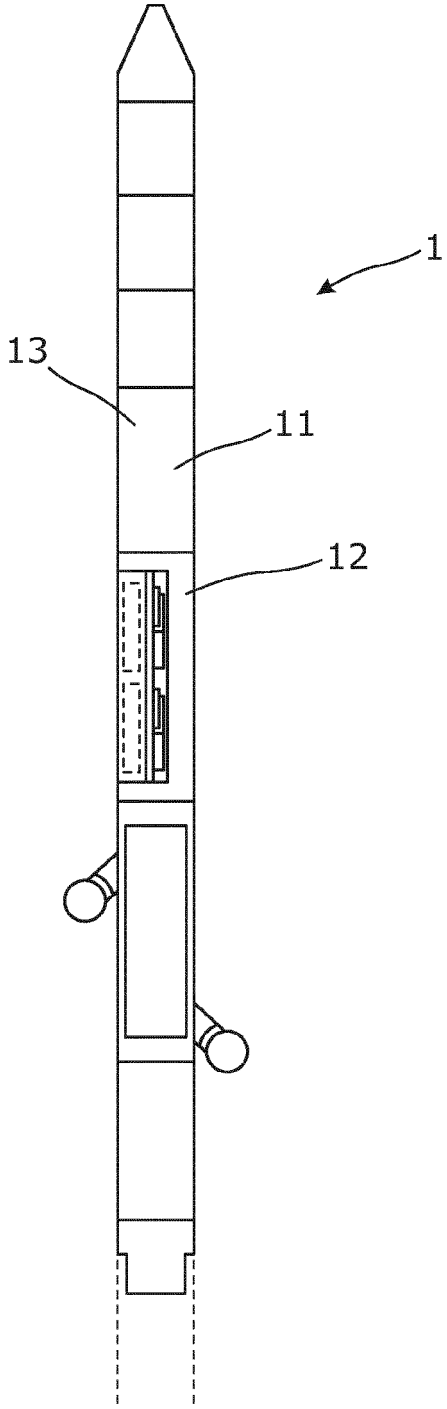

Fig. 1

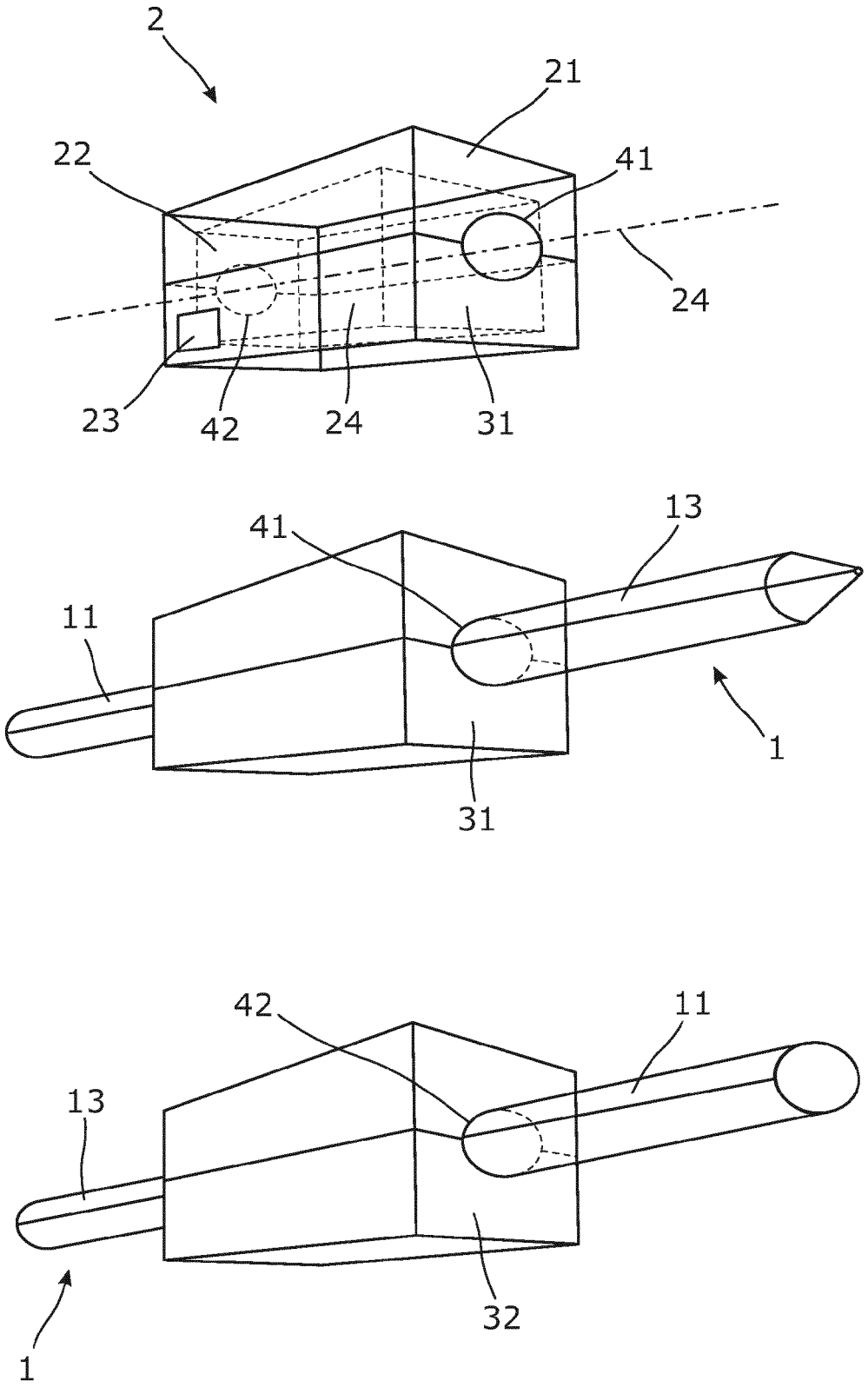

Fig. 2

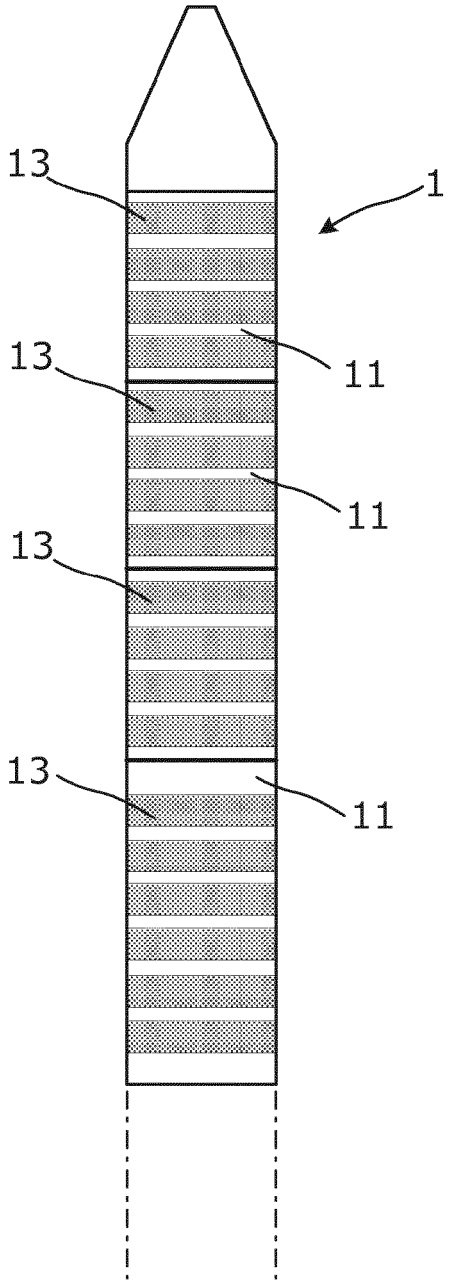

Fig. 3a

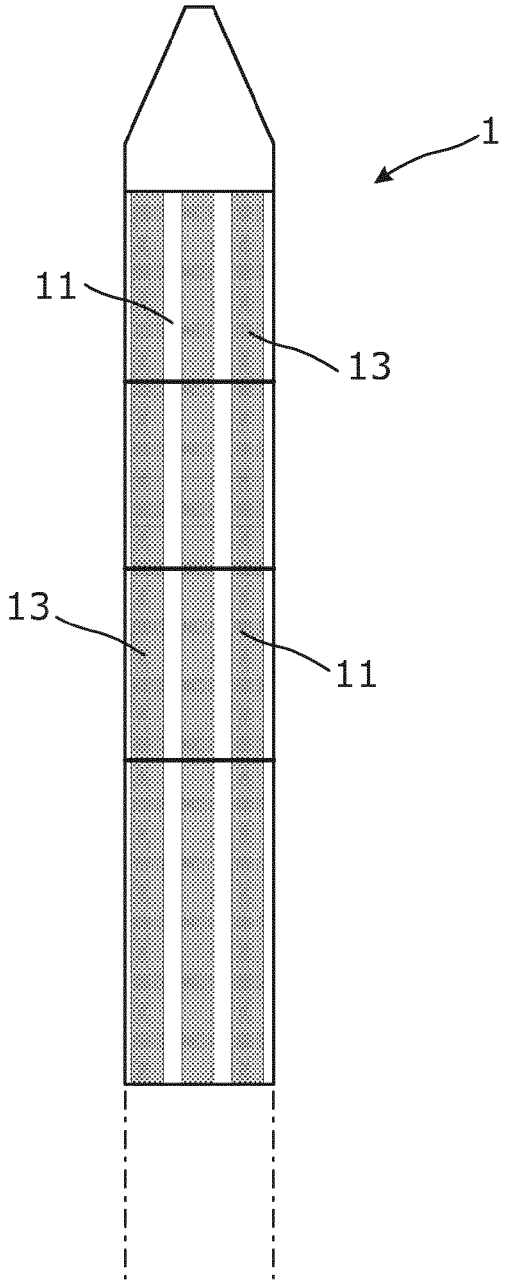

Fig. 3b

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 13 16 0663

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 2006/108110 A1 (MCKEEN LAURENCE W [US] MCKEEN LAURENCE WAINO [US]) 25 May 2006 (2006-05-25) * paragraphs [0013] - [0015], [0017] - [0019], [0021], [0034] * -----	1-8, 11-15	INV. E21B41/00 E21B41/02
X	US 2007/051510 A1 (VENERUSO ANTHONY F [FR] ET AL) 8 March 2007 (2007-03-08) * claims 1,7,16,17 * -----	1-8, 11-15	

TECHNICAL FIELDS SEARCHED (IPC)

E21B

~~The present search report has been drawn up for all claims~~

2

Place of search	Date of completion of the search	Examiner
Munich	19 July 2013	Bellingacci, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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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)

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Application Number
EP 13 16 0663

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

see additional sheet(s)

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 13 16 0663

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-8, 11-15

   Method of corrosion protection of a downhole tool and related use and apparatus

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2. claims: 9, 10

   Heating device

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 16 0663

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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19-07-2013

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