Abstract: A probe assembly for use with a well data acquisition tool includes a probe and a probe guard. The probe includes a body and a tip extending from the body along a longitudinal axis of the tip to a terminal end. The tip defines a length and a surface area along the length and is configured for sensing one or more well characteristics. The probe guard extends about the tip of the probe and leaves a majority of the surface area of the tip exposed to a flow that is angularly offset from the longitudinal axis of the tip of the probe.


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WELL DATA ACQUISITION TOOL PROBE GUARD

Background

[001] Oil and gas explorations and/or productions rely on well logging, a process of taking well measurements in order to evaluate a well throughout its various life-cycle phases, including drilling (e.g., logging-while-drilling or measurement-while-drilling), wireline logging, testing, completion, production, and abandonment phases. Over the years, increasingly sophisticated tools and testing strategies have been developed to characterize well properties and performance. Measurements are often made of the fluid moving in the well, where the fluid may include mixtures of oil, water, gas, and particulate in various proportions. Measurements of local fluid properties in oil wells often include electrical resistivity and optical reflectivity, among others. Often times, the probes utilized for these measurements include relatively delicate tips with diameters tapering from about 1 millimeter to about 50 micrometers, for example. Due to the sensitivity of the tips, there is often an increased risk of tip damage, during conveyance within the well or from debris in the fluid flowing across the tip, for example.

Summary

[002] Some embodiments relate to a probe guard to help decrease risk of probe damage during conveyance and data logging while promoting probe responsiveness. In some implementations, the probe guard is utilized in association with well data acquisition tools, such as well reservoir evaluation tools, or well drilling tools, such as logging- or measuring-while-drilling tools.

[003] Some embodiments relate to a probe assembly for use with a well data acquisition tool, the probe assembly including a probe and a probe guard. The probe includes a body and a tip extending from the body along a longitudinal axis of the tip to a terminal end. The tip defines a length and a surface area along the length and is configured for sensing one or more well characteristics. The probe guard extends about the tip of the probe and leaves a majority of the surface area of the tip exposed to a flow that is angularly offset from the longitudinal axis of the tip of the probe.

[004] Some embodiments relate to securing a probe guard about a tip of a probe. The probe extends from a probe body, along a longitudinal axis, and to a terminal end. The probe tip defines a length and a surface area along the length and is configured for sensing one or more well characteristics. The probe guard is extended about the tip of the probe such that a
majority of the surface area of the tip is left exposed to a flow that is angularly offset from the longitudinal axis of the probe tip.

[005] While multiple embodiments with multiple elements are disclosed, still other embodiments and elements will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

**Brief Description of the Figures**

[006] FIG. 1 is a schematic diagram of a well data acquisition tool, according to some embodiments.

[007] FIG. 2 is a side view of a probe assembly that can be used with the well data acquisition tool of FIG. 1, according to some embodiments.

[008] FIG. 3 is a top view of the probe assembly of FIG. 2, according to some embodiments.

[009] FIG. 4 is an isometric view of the probe assembly of FIG. 2, according to some embodiments.

[010] FIG. 5 is an end view of a probe guard that can be used with the probe assembly of FIG. 2, according to some embodiments.

[011] FIG. 6 is an end view of another probe guard that can be used with the probe assembly of FIG. 2, according to some embodiments.

[012] FIG. 7 is a side view of another probe assembly that can be used with the well data acquisition tool of FIG. 1, according to some embodiments.

[013] Some embodiments are shown in the figures by way of example. Additional or alternate features are contemplated.

**Detailed Description**

[014] Various embodiments of the present disclosure are described below including method, apparatus and system embodiments. These described embodiments and their various elements are examples of the presently disclosed techniques. It should be appreciated that in the development of any actual implementation, as in any engineering or design project, numerous implementation-specific decisions can be made to achieve the developers’ specific goals, such as compliance with system-related and business-related constraints, which can vary from one implementation to another. Moreover, it should be appreciated that such a
development effort might be time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit(s) of this disclosure.

[0015] When introducing elements of various embodiments of the present disclosure, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there can be additional elements other than the listed elements. Additionally, it should be understood that references to "one embodiment" or "an embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the listed elements.

[0016] FIG. 1 shows an example of a well data acquisition tool 10 that can be deployed into a well 12 as part of a well production logging operation. In some embodiments, the well 12 can be inclined or horizontal with the tool 10 being lowered into the well 12 in a compact state and then expanded to engage the walls of the well 12. The tool 10 may be optionally connected to the surface (or other desired location) by a rod, a cable, or other coupling means (not shown). While the coupling means are optionally utilized for conveying data from the tool 10 to the desired location, in addition or as an alternative the tool 10 can optionally include telemetry means for conveying data to the desired location.

[0017] As shown, the tool 10 includes a body 20 and an expansion assembly 22 connected to the body 20. The expansion assembly 22 includes a first arm 24 and a second arm 26, the first and second arms 24, 26 being configured to articulate with each other and with the body 20. As shown, the body 20 is supported on the lower wall of the well 12. During deployment, the arms 24, 26 are in shape of a "V" located in a vertical plane passing through a longitudinal axis of the well 12. A plurality of probe assemblies 28, such as electrical resistivity probes/sensors or optical reflectivity probes/sensors, are located on the tool 10, such as on the first arm 24 and the body 20. In some embodiments, the tool 10 can be same as or similar to those made by Schlumberger Ltd. under the trade name "Flow Scanner". In other embodiments, the tool 10 can be same as or similar to those made by Schlumberger Ltd. under the trade name "FloView Holdup Measurement Tool".

[0018] In some embodiments, the probe assemblies 28 can be configured for sensing one or more well characteristics. For example, the probe assemblies 28 can optionally include one or more probes that are same as or similar to those made by Schlumberger Ltd. under the trade name "FloView," "GHOST," or others. In some embodiments, the plurality of probe assemblies 28 may include a probe assembly 28A, such as that shown schematically in Fig. 2.
Although the probe assemblies 28, 28A are described in association with well production logging tools, any of a variety of well data acquisition tools may employ the probe assemblies 28, 28A, such as any tools associated with one or more of drilling (e.g., logging-while-drilling or measurement-while-drilling), wireline logging, testing, completion, production, and abandonment phases.

FIG. 2 is a top view, FIG. 3 is a side view, and FIG. 4 is an isometric view of the probe assembly 28A, according to some embodiments. As shown, the probe assembly 28A includes a probe 50, a probe guard 52, and a support 54. In some embodiments, the probe 50 includes a body 60 and a tip 62. As previously described, the probe 50 can optionally be an electrical, resistivity probe or sensor, where the tip 62 senses electrical impedance of fluid touching the tip 62 in order to, for example, distinguish water, which is low-impedance, from high-impedance oil and gas. In other embodiments, the probe 50 can be an optical, reflectivity probe or sensor that is sensitive to a fluid's index of refraction.

The body 60 can optionally be elongate (e.g., about 2 to about 6 cm long overall, although other dimensions are contemplated) and cylindrical, defining one or more outer diameters (e.g., about 5 mm to about 20 mm in diameter, although other dimensions are contemplated). The body 60 may optionally house electrical, optical, or other components 66.

In some embodiments, the tip 62 can be relatively small and configured for measuring tiny droplets of fluid as the fluid flows past the tip 62. As indicated by FIG. 2, the tip 62 is elongate (e.g., about 1 cm to about 3 cm long overall, although other dimensions are contemplated) and is relatively thin. For example, the tip 62 is cylindrical, having a continuous diameter or tapering from a first diameter (e.g., about 0.1 mm to about 1 mm) to a second diameter (e.g., about 0.050 mm to about 0.005 mm), although other dimensions are contemplated. The tip 62 extends from the body 60 and defines a terminal end 68.

In some embodiments, the probe guard 52 can be secured about at least a portion of the probe 50. As shown in FIGS. 2-4, the probe guard 52 defines a first end 70, a second end 72, and an intermediate portion 74 and extends over the body 60 and the tip 62 of the probe 50 and then beyond the tip 62. The probe guard 52 can be formed by an elongate member that is helically-shaped, such as a piece of wire stock that has been suitably formed. The elongate member of the probe guard 52 may optionally have a substantially circular cross-section, although a variety of cross-sections (e.g., square, triangular, octagonal, diamond, or others) are contemplated. As shown in FIGS. 2-4, the probe guard 52 has a helical shape with a variable pitch - the angle at which the helix progresses longitudinally changes along a
longitudinal axis Y of the helix, or in different terms, tangent lines at different points along
the helix are at a variable angle to the longitudinal axis Y of the helix.

[0024] In some embodiments, the probe guard 52 can have a helical shape that is
characterized by a minimum pitch (i.e., the tangent line that corresponds to an axial location
corresponding to the terminal end 68 of the tip 62). In some embodiments, the probe guard
52 may have a helical shape with a constant radius (r), such that when viewed from the end,
the probe guard 52 has a circular profile (FIG. 5). In other embodiments, the helical shape of
the probe guard 52 may have a variable radius (r), such that when viewed from the end, the
probe guard 52 has a non-circular profile, such as an elliptical (FIG. 6) or other profile. In
still other embodiments, the probe guard 52 may have a discontinuously varying radius (r)
such that when viewed from the end, the probe guard 52 has a rectangular, diamond, or other
end profile (not shown).

[0025] In some embodiments, the support 54 can be formed as part of the tool 10, such as
part of the first arm 24 as shown in FIG. 1. The support 54 can define an inner face 78 and
include one or more mounting features 80 for maintaining the probe 50 and the probe guard
52 as desired. The mounting features 80 may optionally include hooks, clamps, welds,
fasteners, or other means for securing the probe 50 and the probe guard 52 to the inner face
78 of the support 54.

[0026] In some embodiments, assembly of the probe 50, the probe guard 52, and the
support 54 can include securing the probe 50 to the support 54 at a desired orientation with
respect to flow F (illustrated, by way of example, as an arrow in FIG. 1 and as two arrows in
FIG. 2 with one at a first, slanted angle and the other at a second, perpendicular angle). The
probe guard 52 can be secured about the probe 50, including the probe tip 62. In some
embodiments, the first end 70 of the probe guard 52 can be secured to the probe 50 (e.g., the
body 60) using one or more mounting features 80 (e.g., a spot weld), the intermediate portion
74 of the probe guard 52 can be secured to the support 54 using one or more of the mounting
features 80 (e.g., a spot weld), and the second end 72 of the probe guard 52 can be secured to
the support 54 using one or more of the mounting features 80 (e.g., a spot weld). As shown
in FIGS. 2-4, in some embodiments, the second end 72 of the probe guard 52 can be secured
at a location on the support 54 that is located beyond the terminal end 68 of the tip 62.
Greater or fewer locations for fixing the probe guard 52 are contemplated.

[0027] In some embodiments, the probe guard 52 may be mounted such that the tip 62 of
the probe 50 is spaced from the support 54 by a desired distance - e.g., to help allow flow to
pass between the tip 62 and the support 54. In some embodiments, the probe guard 52 may
define a longitudinal axis Y that is coaxial with the longitudinal axis X of the tip 62 such that
the terminal end 68 of the tip 62 is located centrally within the probe guard 52. As shown in
FIGS. 2-4, the probe guard 52 may extend about the probe 50 at a varying distance from the
inner face 78 of the support 54. In some embodiments, the terminal end 68 of the tip 62 may
be located adjacent a portion of the probe guard 52 that is at a maximum distance Dmax from
the inner face 78 of the support 54 (FIG. 3).

[0028] In some embodiments, during use liquid flow F passes the probe 50 and
measurements or other information regarding the flow F of liquid can be gathered using the
probe tip 62. As shown in FIGS. 2-4, the probe guard 52 can leave a majority of the surface
area of the tip 62 exposed to the flow F that is offset from the longitudinal axis X of the tip
62. For example, the probe guard 52 can be configured to leave over 50%, over 60%, over
70%, over 80%, over 90%, over 95%, over 98%, or over 99% of the surface area of the tip 62
exposed to the flow F that is offset from the longitudinal axis X of the tip 62. As another
example, the probe guard 52 can be configured to leave from 50% to 99%, from 80% to 90%,
almost 100%, or some other percentage of the surface area of the tip 62 exposed to the flow F
that is offset from the longitudinal axis X of the tip 62.

[0029] Restriction of the flow F to the tip 62 can result in decreased responsiveness and
measurement error. The probe guard 52 helps provide responsiveness while protecting the tip
62 by configuring the probe guard 52 with a minimum pitch and radius that promotes the
flow F to the tip 62 while providing sufficient structure to help deflect debris, to help prevent
the probe tip 62 from striking the well wall during conveyance or other positioning, or
otherwise protect the tip 62 from physical contact with unwanted objects.

[0030] As shown in FIGS. 2-4, the helical shape can have a relatively larger pitch distal of
the tip 62 (toward the second end 72) and a relatively larger pitch proximal of the tip 62
(toward the first end 70). In different terms, the probe guard 52 can include a plurality of
interconnected turns with adjacent turns defining a pitch of the probe guard 52 where the
pitch decreases around the probe tip 62 and increases proximally and distally of the probe tip
62. In some embodiments, the probe guard 52 may be configured such that the helical shape
of the probe guard 52 distal to the terminal end 68 of the probe tip 62 extends through one
half of a turn and in a coiling direction (e.g., right handed) which is selected to help avoid
masking the probe tip 62 and is configured proximally to the probe tip 62 to help limit
downstream flow restriction and facilitate flow evacuation, although a variety of other
configurations and features are contemplated.

[0031] FIG. 7 shows a schematic, side view of another probe assembly 128A including a
guard 152 extending about a probe tip 162 of a probe 150, according to some embodiments. As shown, the probe guard 152 can leave a majority of the surface area of the tip 162 exposed to flow F1 that is offset from the longitudinal axis X1 of the probe tip 162. The probe guard 152 can include a plurality of interconnected turns 200 with adjacent turns defining a pitch of the probe guard 152. As shown, the pitch decreases around a terminal end 168 of the probe tip 162 and increases proximally and distally of the probe tip 162. The probe guard 152 can optionally be secured to the probe 150 and a support 154 by mounting features (not shown) in a similar manner to that described in association with the probe assemblies 28, 28A. The probe guard 152 can optionally be formed of one or more elongate members (e.g., wire stock material). As shown, the probe guard 152 defines a maximum distance from an inner face 178 of the support 154 adjacent to the probe tip 162, and in particular the terminal end 168. [0032] Various modifications, additions and combinations can be made to the described embodiments and their various features. For example, while the embodiments described above refer to particular features, the scope of disclosure also includes embodiments having different combinations of features and embodiments that do not include all of the above described features.
WE CLAIM:

1. A probe assembly for use with a well data acquisition tool comprising:
   a probe including a body and a tip extending from the body along a longitudinal axis of
   the tip to a terminal end, the tip defining a length and a surface area along the length
   and being configured for sensing one or more well characteristics; and
   a probe guard extending about the tip of the probe, the probe guard leaving a majority of
   the surface area of the tip exposed to a flow that is angularly offset from the
   longitudinal axis of the tip of the probe.

2. The probe assembly of claim 1, wherein the probe guard includes a helically-shaped
   member.

3. The probe assembly of any of the preceding claims, wherein the probe guard is formed by
   a helically-shaped wire.

4. The probe assembly of any of the preceding claims, wherein the probe guard is formed by
   an elongate member having a substantially circular cross-section.

5. The probe assembly of any of the preceding claims, wherein the probe guard has a helical
   shape with a variable pitch.

6. The probe assembly of any of the preceding claims, wherein the probe guard has a helical
   shape with a constant radius.

7. The probe assembly of any of claims 1 to 5, wherein the probe guard has a helical shape
   with a variable radius.

8. The probe assembly of any of the preceding claims, wherein the probe guard has a helical
   shape defining a longitudinal axis that is coaxial with the longitudinal axis of the tip of the
   probe.

9. The probe assembly of any of the preceding claims, further comprising a support
maintaining the probe and the probe guard such that the tip of the probe is spaced from the support.

10. The probe assembly of any of claims 1 to 8, further comprising a support maintaining the probe, the support defining a face that is positioned toward the probe, and the probe guard extending along the probe at a varying distance from the face of the support.

11. The probe assembly of claim 10, wherein the terminal end of the tip is located adjacent a portion of the probe guard that is at a maximum distance from the face of the support.

12. A method comprising securing a probe guard about a tip of a probe extending from a probe body, along a longitudinal axis, and to a terminal end, the probe tip defining a length and a surface area along the length and being configured for sensing one or more well characteristics, wherein the probe guard is extended about the tip of the probe such that a majority of the surface area of the tip is left exposed to a flow that is angularly offset from the longitudinal axis of the probe tip.

13. The method of claim 12, wherein the probe guard has a helical shape and the probe guard is secured about the tip of the probe such that a longitudinal axis of the helical shape is coaxial with the longitudinal axis of the probe tip.

14. The method of claim 12 or 13, further comprising securing the probe to a support defining a face that is positioned toward the probe such that the probe guard extends along the probe tip to define a varying distance from the face of the support.

15. The method of claim 14, further comprising securing a portion of the probe guard that is at a maximum distance from the face of the support adjacent to the terminal end of the tip.
**INTERNATIONAL SEARCH REPORT**

PCT/US2012/063764

**A. CLASSIFICATION OF SUBJECT MATTER**

INVENTION CLASSIFICATIONS

According to International Patent Classification (IPC) or to both national classification and IPC:

- E21B47/01

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols):

- E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched:

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used):

- EPO-Internal
- WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**Date of the actual completion of the international search**

12 December 2012

**Date of mailing of the international search report**

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