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(54) Title: LOW PROFILE MAGNETIC ORIENTING PROTECTORS

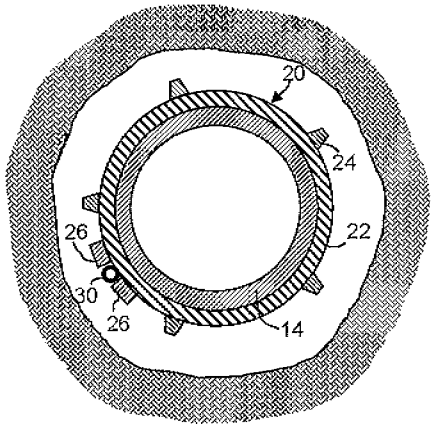

Fig. 2

(57) Abstract: A system for providing information about a region of interest in a borehole, comprises a tubular passing through the region of interest, an optical fiber deployed on the outside of the tubular in the region of interest and optically connected to a light source and optical signal receiving means, at least one metal strip deployed on the outside of the tubular adjacent to the optical fiber, wherein the strip has at least one longitudinal face that is flat or concave so as to conform to the outside of the tubular, and means for holding the optical fiber and the metal strip in a fixed azimuthal location with respect to the tubular.

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LOW PROFILE MAGNETIC ORIENTING PROTECTORS

This application claims the benefit of priority of U.S. Provisional Patent Application No. 61/608,447, filed on March 8, 2012, the disclosure of which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0001] The invention relates to a system and apparatus for deploying fiber optic sensors in a borehole without requiring expensive modifications to the drilling operation.

BACKGROUND OF THE INVENTION

[0002] The use of fiber optic (FO) sensors in downhole applications is increasing. In particular, optical fibers that can serve as distributed temperature sensors (DTS), distributed chemical sensors (DCS), or distributed acoustic sensors (DAS), and, if provided with Bragg gratings or the like, as discrete sensors capable of measuring various downhole parameters. In each case, light signals from a light source are transmitted into one end of the cable and are transmitted and through the cable. Signals that have passed through the cable are received at receiver and analyzed in microprocessor. The receiver may be at the same end of the cable as the light source, in which case the received signals have been reflected within the cable, or may be at the opposite end of the cable. In any case, the received signals contain information about the state of the cable along its length, which information can be processed to provide the afore-mentioned information about the environment in which the cable is located.

[0003] In cases where it is desired to obtain information about a borehole, an optical fiber must be positioned in the borehole. For example, it may be desirable to use DTS to assess the efficacy of individual perforations in the well. Because the optical fiber needs to be deployed along the length of the region of interest, which may be thousands of meters of borehole, it is practical to attach the cable to the outside of tubing that is placed in the hole. In many instances, the cable is attached to the outside of the casing, so that it is in close proximity with the borehole.

[0004] In some instances, a current practice for deployment of fiber optic sensor cables may entail the addition of one or more wire ropes that run parallel and adjacent to the fiber optic cable. Both the ropes and the cable may be secured to the outside of the tubing by clamps such as, for example clamps and protectors or with stainless steel bands and buckles and rigid

centralizers. Such equipment is well known in the art and is available from, among others, Cannon Services Ltd. of Stafford, Texas. The wire ropes are preferably ferromagnetic (i.e. electromagnetically conductive), so that they can serve as markers for determining the azimuthal location of the optical fiber and subsequently orienting the perforating guns away from the fiber cable. These wire ropes may be on the order of 1 to 2 cm diameter so as to provide sufficient surface area and mass for the electromagnetic sensors to locate. Because of their size, the use of wire ropes can require costly "upsizing" of the wellbore in order to accommodate the added diameter. Besides necessitating a larger borehole, the wire ropes are susceptible to being pushed aside when run through tight spots or doglegs in the wellbore. Wire ropes that have been dislodged from their original position are less effective, both for locating the fiber optic cable and for protecting the optical cable from damage.

[0005] Hence it is desirable to provide a system for protecting and magnetically determining the azimuthal position of optical fiber deployed on the outside of a downhole tubular without requiring an expanded borehole.

SUMMARY OF THE INVENTION

[0006] Preferred embodiments of the invention provide a system for protecting and magnetically determining the azimuthal position of optical fiber deployed on the outside of a downhole tubular without requiring an expanded borehole. Specifically, preferred embodiments include a system for providing information about a region of interest in a borehole, comprising a tubular passing through the region of interest, an optical fiber deployed on the outside of the tubular in the region of interest and optically connected to a light source and optical signal receiving means, at least one metal strip deployed on the outside of the tubular adjacent to the optical fiber, wherein the strip has at least one longitudinal face that is flat or concave so as to conform to the outside of the tubular, and means for holding the optical fiber and the metal strip in a fixed azimuthal location with respect to the tubular. In some preferred embodiments, the strips are not magnetic, but are electrically conductive so that they will affect an electromagnetic flux signal from an orienting tool such as are known in the art and commercially available.

[0007] The tubular may be a casing, production tubing, cladding, coiled tubing, or the like. The metal strip(s) may have a rectangular, triangular, or trapezoidal cross-section and

preferably has an aspect ratio greater than 1.25. The metal strips preferably comprise steel and have a smooth outer surface.

[0008] In some instances, the ferromagnetic strip may be provided on a spool.

[0009] As used in this specification and claims the following terms shall have the following meanings:

"casing" is used to refer to both casing and liner strings; and

"up," "down," "above," and "below" refer to positions that are relatively nearer or farther from the surface in a borehole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a more detailed understanding of the invention, reference is made to the accompanying wherein:

Figure 1 is a schematic side view of a system in accordance with the present invention deployed in a borehole; and

Figure 2 is a cross-section taken along lines 2-2 of the Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Referring to Figures 1 and 2, a system 10 in accordance with one preferred embodiment is shown deployed in a borehole 12. System 10 includes a tubular 14 to which is clamped a fiber optic mount 20. Fiber optic mount 20 preferably includes a clamp 22, spacers or centralizer vanes 24, and at least one, and preferably two, metal strips 26. Strips 26 preferably extend along the full length of the tubing. A fiber optic cable 30 also extends along the tubular between strips 26, or, if there is only one strip, adjacent to the strip 26 and preferably between strip 26 and a spacer or centralizer vane 24.

[0012] Between mounts 20, it may be desirable to provide additional support for strips 26 and cable 30. In such cases, one or more spaced-apart clamping rings 40 may be applied around the tubular, cable, and strips. Clamping rings 40 may be half-shell clamps or other similarly-functioning devices, such as are known in the art.

[0013] Spacers or vanes 24 serve to maintain an annulus between the tubular and the borehole wall, so as to maintain a relative uniform and concentric cement sheath, prevent the fiber cable from abrading on the borehole wall while running, and mitigate pinching or damage to the fiber cable.

[0014] Tubular 14 may be casing, production tubing, cladding, coiled tubing, or the like. In any event, tubular 14 can be any tubular or other structure that is intended to remain in the hole for the duration of the measurement period. Depending on the setup, tubular 14 and the other components of system 10 may be cemented in place.

[0015] In order to serve as magnetic markers that effectively indicate the azimuthal location of fiber optic cable 30 metal strips 26 are preferably constructed of an electrically conductive or ferromagnetic material such as nickel, iron, cobalt, and alloys thereof, such as steel or stainless steels, and are preferably extruded or roll formed. Strips 26 preferably have sufficient mass to ensure they can be detected by an electromagnetic metal detector, such as are commercially available. The width and height of each strip can be optimized to reduce running clearance and while maintaining adequate metal mass to act as a magnetic marker.

[0016] Metal strips 26 may have a generally rectangular cross-section, as shown, and/or may have a concave inner surface that corresponds to the curvature of the outer surface of clamp 22.

[0017] Metal strips 26 are preferably positioned between a pair of adjacent spacers 24 and in some instances may be positioned adjacent to a selected spacer so as to derive mechanical protection from that spacer. Metal strips 26 are preferably spaced apart just enough to receive fiber optic cable 30 between them, as best illustrated in Figure 2. In preferred embodiments, metal strips 26 have a thickness, measured radially with respect to tubular 14, that is at least as great as the diameter of fiber optic cable 30. In this configuration, strips 26 provide mechanical protection and positioning for cable 30, particularly during run in.

[0018] Strips 26 may be provided on spools and may be unspooled and applied to the outside of tubular 14 along with fiber optic cable 30 as the tubular is run into the hole. Metal strips 26 are preferably held in place on the outside of tubular 14 by means of clamps 40 and banding. In addition, if desired, strips 26 can be affixed to tubular 14 by adhesive.

[0019] When provided in the manner described above, strips 26 provide a low-profile system that replaces the wire rope system currently in use. The smaller running diameter of the system reduces or eliminates the need to "upsize" the wellbore in order to accommodate fiber optic cables (and possibly electronic gauge systems). The smooth surface of the steel strip is less susceptable to drag in the wellbore than with wire rope, increasing the probability of successful deployments.

[0020] Thus, the advantages of the present system include:

- Low profile, reduced running diameter that can be optimized to match size of FO cable;
- Spoolable; can be stored and deployed on a wooden or metal spools similar to wire rope
- Solid metal, resists deformation under loading
- Formable; can be punched, drilled, or formed (bent) to provide special features for attachment points to clamps or for other devices.
- Smooth surface; lower coefficient of friction when compared to wire ropes; less likely to drag in the wellbore

[0021] While the advantages of the present invention have been described with reference to a the preferred embodiments, it will be understood that variations and modifications can be made thereto without departing from the scope of the invention, which is set out in the claims that follow.

CLAIMS

1. A system for providing information about a region of interest in a borehole, comprising:

a tubular passing through the region of interest;

an optical fiber deployed on the outside of the tubular in the region of interest and optically connected to a light source and optical signal receiving means;

at least one metal strip deployed on the outside of the tubular adjacent to the optical fiber, wherein said strip has at least one longitudinal face that is flat or concave so as to conform to the outside of the tubular; and

means for holding the optical fiber and the metal strip in a fixed azimuthal location with respect to the tubular.

2. The system according to claim 1 wherein the tubular is selected from the group consisting of casing, production tubing, cladding, and coiled tubing.

3. The system according to claim 1 wherein the tubular is casing.

4. The system according to claim 1 wherein the metal strip has a rectangular or triangular cross-section.

5. The system according to claim 1 wherein the metal strip has an aspect ratio greater than 1.25.

6. The system according to claim 1 wherein the metal strip comprises steel.

7. The system according to claim 1 wherein the metal strip is provided on a spool.

8. The system according to claim 1 wherein the metal strip has a smooth outer surface.

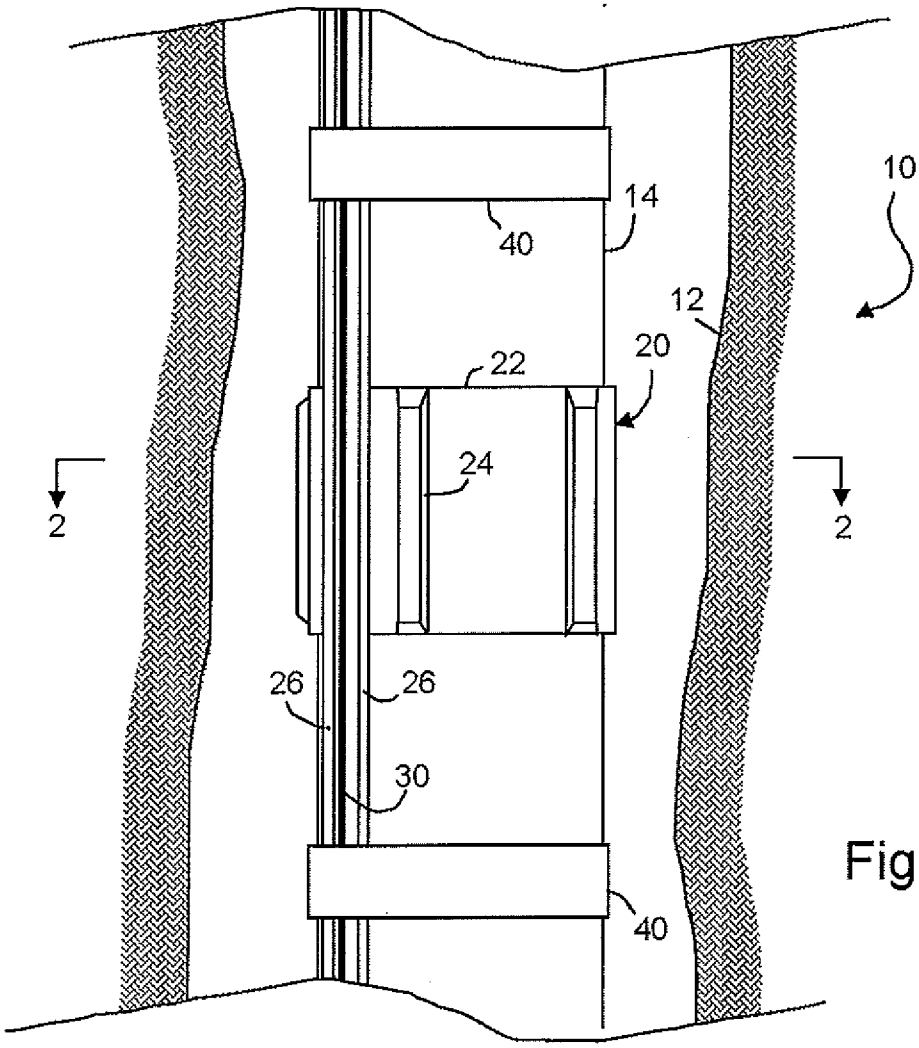

Fig. 1

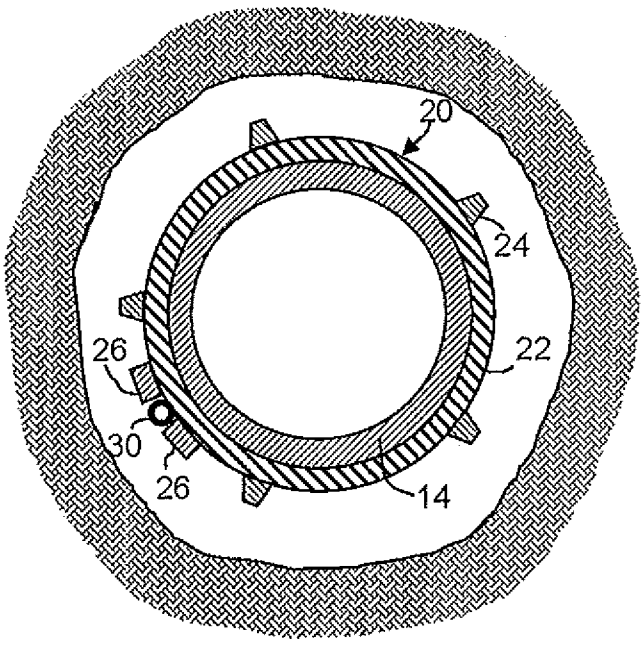

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/029012

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 43/00 (2013.01)
USPC - 166/380
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B23K 37/04; E21B 17/00, 17/02, 23/00, 23/01, 43/00, 47/00, 47/12, 49/00 (2013.01)
USPC - 102/319; 166/55, 55.1, 242.1, 319, 380

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - E21B 17/006, 17/023, 49/003 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Google Scholar, Google Patents, Patbase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010/0066560 A1 (MCDANIEL et al) 18 March 2010 (18.03.2010) entire document	1-8
Y	US 2004/0134658 A1 (BELL et al) 15 July 2004 (15.07.2004) entire document	1-8
Y	US 2011/0215234 A1 (ROSE) 08 September 2011 (08.09.2011) entire document	5,6
A	US 2005/0236161 A1 (GAY et al) 27 October 2005 (27.10.2005) entire document	1-8

☐ *Further documents are listed in the continuation of Box C.* ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 April 2013	02 MAY 2013
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774