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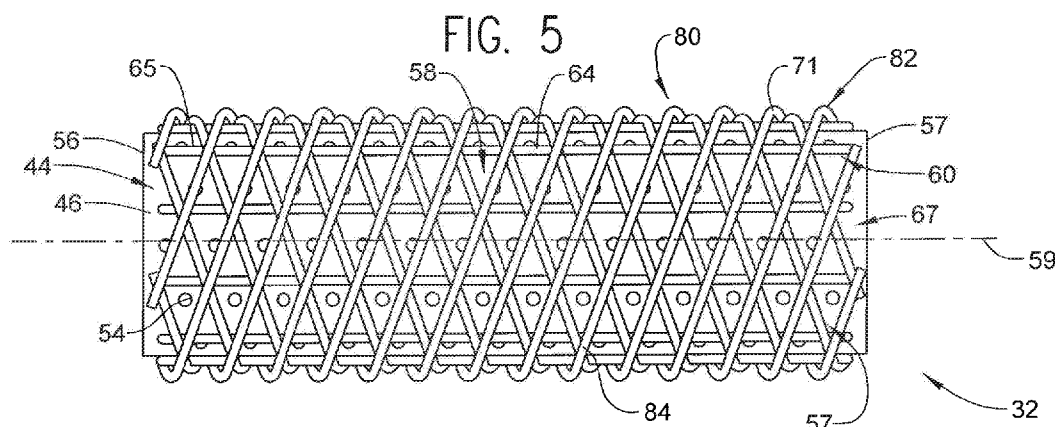
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(54) Title: MATERIAL MESH FOR SCREENING FINES



(57) Abstract: A tubular for reservoir fines control includes a body having an outer surface and an inner surface defining a flow path. A plurality of openings are formed in the body connecting the outer surface and the flow path. A material mesh is overlaid onto the outer surface. The material mesh is formed from a material swellable upon exposure to a selected fluid. The material mesh has a selected porosity allowing methane to pass into the flow path while preventing passage of fines.



MATERIAL MESH FOR SCREENING FINES

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Patent Application Serial No. 62/504,676 filed May 11, 2017, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Resource extraction techniques typically include forming a borehole and introducing a system of tubulars to guide a resource, such as oil or gas uphole to be captured and processed. Often time, methane gas may be found in a coalbed. Coalbed methane wells typically include numerous thin layers of clay or interburden between coal seams. During extraction, water is pulled from the coal seams allowing gas to escape. However, water flow over reactive clay interburden produces particulate such as fines that may enter into a downhole pump. In some cases, there are so many layers of interburden, zonal isolation is not practical. That is, isolating layers of interburden may block off productive portion of the coal seams leaving the gas trapped in the formation.

[0003] A tubular for reservoir fines control includes a body having an outer surface and an inner surface defining a flow path. A plurality of openings are formed in the body connecting the outer surface and the flow path. A material mesh is overlaid onto the outer surface. The material mesh is formed from a material swellable upon exposure to a selected fluid. The material mesh has a selected porosity allowing methane to pass into the flow path while preventing passage of fines.

[0004] A method of forming a permeable cover on a perforated tubular includes positioning a material mesh permeable to a downhole gas on an outer surface of the perforated tubular formed from a material swellable upon exposure to a selected fluid.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Referring now to the drawings wherein like elements are numbered alike in the several Figures:

[0006] FIG. 1 depicts a resource recovery and exploration system including a material mesh for providing borehole support and fines screening, in accordance with an exemplary embodiment;

[0007] FIG. 2 depicts a perforated tubular having a first material mesh layer of the material mesh, in accordance with an exemplary embodiment;

[0008] FIG. 3 depicts the first material mesh layer of the material mesh, in accordance with another aspect of an exemplary embodiment;

[0009] FIG. 4 depicts the perforated tubular of FIG. 2 having a second material mesh layer of the material mesh, in accordance with an exemplary embodiment;

[0010] FIG. 5 depicts the perforated tubular of FIG. 3 having a third material mesh layer of the material mesh, in accordance with an exemplary embodiment;

[0011] FIG. 6 depicts a cross-sectional view of the perforated tubular of FIG. 5;

[0012] FIG. 7 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0013] FIG. 8 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0014] FIG. 9 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0015] FIG. 10 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0016] FIG. 11 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0017] FIG. 12 depicts an exemplary cross-sectional profile of a cord forming one or more of the first, second, and third material mesh layers, in accordance with an exemplary aspect;

[0018] FIG. 13 depicts the material mesh after being exposed to a selected fluid, in accordance with an exemplary aspect;

[0019] FIG. 14 depicts a material mesh formed from a continuous cord, in accordance with an exemplary embodiment;

[0020] FIG. 15 depicts a material mesh as a pre-fabricated woven sleeve, in accordance with an exemplary embodiment;

[0021] FIG. 16 depicts the material mesh as a pre-fabricated woven mat, in accordance with an exemplary embodiment;

[0022] FIG. 17 depicts the pre-fabricated woven mat, in accordance with another aspect of an exemplary embodiment;

[0023] FIG. 18 depicts the material mesh as a pre-fabricated mat formed from a plurality of particles joined by a binder material, in accordance with another aspect of an exemplary embodiment; and

[0024] FIG. 19 depicts the material mesh as a pre-fabricated sleeve formed from a plurality of particles joined by a binder material, in accordance with yet another aspect of an exemplary embodiment.

DETAILED DESCRIPTION

[0025] A resource exploration and recovery system, in accordance with an exemplary embodiment, is indicated generally at 2, in FIG. 1. Resource exploration and recovery system 2 may include a surface system 4 operatively connected to a downhole portion 6. Surface system 4 may include pumps 8 that aid in completion and/or extraction processes. Surface system 4 may also include a fluid storage member 10. Fluid storage member 10 may contain a gravel pack fluid or slurry (not shown), water, or other fluid which may be utilized in drilling and/or extraction operations.

[0026] Downhole portion 6 may include a downhole string 20 formed from a plurality of tubulars, one of which is indicated at 21 that is extended into a wellbore 24 formed in formation 26. Wellbore 24 includes an annular wall 28 that may be defined by formation 26. It is to be understood that annular wall 28 may also be defined by a casing. One of tubulars 21 may be define a perforated tubular 32 covered by a material mesh 38.

[0027] In accordance with an exemplary aspect depicted in FIG. 2, perforated tubular 32 includes a body 44 having an outer surface 46, and an inner surface 48 (FIG. 5) that defines a flow path 50 (FIG. 5). Perforated tubular 32 includes a plurality of openings, one of which is shown at 54, that extend through outer surface 46 and inner surface 48 such that when deployed downhole, flow path 50 may be fluidically connected with wellbore 24. Perforated tubular 32 includes a first end 56, a second end 57, and an intermediate portion 58 defining a longitudinal axis 59 extending therebetween.

[0028] In accordance with an aspect of an exemplary embodiment, material mesh 38 may include a first material mesh layer 60 applied to outer surface 46. First material mesh layer 60 may include a plurality of discrete elements or cords 64 that extend axially along

longitudinal axis 59 of perforated tubular 32. It should however be understood that cords 64 may extend at an angle relative to longitudinal axis 59 or may wrap around outer surface 46 as shown in FIG. 3. Cords 64 may be formed from a first material 65 that is swellable upon being exposed to a selected fluid. In accordance with an exemplary embodiment, the selected fluid may be a downhole fluid such as oil, water, or combinations thereof. In accordance with another exemplary aspect, the selected fluid may be a fluid introduced from surface system 4.

[0029] In further accordance with an exemplary aspect, material mesh 38 may include a second material mesh layer 67 such as shown in FIG. 4. Second material mesh layer 67 may be formed from a cord member 69 formed from a second material 71. Second material 71 is swellable upon being exposed to a selected fluid. Further, second material 71 may be similar to first material 65 or may be distinct therefrom. For example, first material 65 may be swellable upon being exposed to water and second material 71 may be swellable upon being exposed to oil or vice versa. In accordance with another exemplary aspect, the selected fluid may be a fluid introduced from surface system 4. Second material mesh layer 67 may be overlaid onto first material mesh layer 60 in a variety of patterns. As shown in FIG. 3, second material mesh layer 67 may be spirally wrapped about first material mesh layer 60 with a selected spacing between adjacent wraps (not separately labeled).

[0030] In still further accordance with an exemplary aspect, material mesh 38 may include a third material mesh layer 80 as shown in FIG. 5 and 6. Third material mesh layer 80 may be formed from a cord element 82 formed from a third material 84. Third material 84 is swellable upon being exposed to a selected fluid. Further, third material 84 may be similar to first material 65 and second material 71 or may be distinct therefrom. For example, third material 84 may be swellable upon being exposed to water and/or oil.

[0031] In accordance with another exemplary aspect, third material 84 may be swellable upon being exposed to a selected fluid that is introduced from surface system 4. Third material mesh layer 80 may be overlaid onto second material mesh layer 67 in a variety of patterns. As shown in FIG. 5, third material mesh layer 80 may be spirally wrapped about second material mesh layer 67 with a selected spacing between adjacent wraps (not separately labeled). Further, a wrap angle (not separately labeled) of third material mesh layer 80 may be opposite to a wrap angle (also not separately labeled) for second material mesh layer 67. As shown in FIG. 6, material mesh 38 may take the form of a number of layers overlaid onto each other.

[0032] It should be appreciated that each of cord 64, cord member 69, and cord element 82 may include a selected cross-section shape. The cross-sectional shape may be similar or may vary depending upon desired screening requirements. For example, one or more of cord 64, cord member 69, and cord element 82 may include a generally circular cross-section such as shown at 89 in FIG. 7, a generally rectangular cross-section 92 such as shown in FIG. 8, a generally triangular cross-section 94 such as shown in FIG. 9, a generally cross-shaped cross-section 96 such as shown in FIG. 10, a generally t-shaped cross-section 98 such as shown in FIG. 11, and/or a generally multi-segmented cross-section 100 such as shown in FIG. 12.

[0033] In accordance with an exemplary embodiment, after a selected time period, which can vary, upon being exposed to the selected fluid, material mesh 38 will expand so as to define a larger outer diameter that abuts annular wall 28 of wellbore 24 and establish a desired permeability or porosity to screen out fines that may be present in wellbore fluid passing into perforated tubular 32 via openings 54 such as shown in FIG. 13.

[0034] Reference will now follow to FIG. 14, wherein like reference numeral represent corresponding parts in the respective views, in describing a material mesh 105 in accordance with another exemplary aspect. Material mesh 105 may include a continuous cord 107 formed from a material 109. Continuous cord 107 may be applied in a single layer or in multiple layers. Continuous cord 107 may include a constant cross-sectional dimension or a cross-sectional dimension that varies. Continuous cord 107 may be applied to perforated tubular 32 at surface system 4 or at an off-site location.

[0035] Further, continuous cord 107 may be extruded at surface system 4 such that diameters, shapes and materials may vary according to downhole conditions. In this manner, operators may adjust to downhole conditions on the fly without delays associated with fabricating, transporting, and installing preformed mesh. Further, material selection may vary such that a portion of material mesh 105 is swellable upon being exposed to a first fluid and other portions of material mesh 105 are swellable upon being exposed to a second fluid that is distinct from the first fluid.

[0036] Reference will now follow to FIG. 15, wherein like reference numeral represent corresponding parts in the respective views, in describing a material mesh 112 in accordance with another aspect of an exemplary embodiment. Material mesh 112 may be pre-formed from a material weave or interlaced cord 114 into a material sleeve 116. Material sleeve 116 may have a continuous outer surface (not separately labeled) as shown in FIG. 15, or may take the form of a pre-fabricated woven mat 119 having a discontinuity, such as

shown at 120 in FIGs. 16 and 17. Discontinuity 120 may define a first end 121 and a second end 122. First end 121 may be bonded to second end 122 with an adhesive 125 or, as shown in FIG. 16, woven mat 119 may be secured to perforated tubular 32 with one or more clamps 127, 128. It is to be understood that material mesh 112 may be formed from a plurality of discrete particles such as shown at 140 in FIG. 18 joined by a binder material (not separately labeled) to form a mat 142. Alternatively, particles 140 may be formed into a sleeve 146 such as shown in FIG. 19. The discrete particles are swellable upon being exposed to one or more selected fluids.

[0037] At this point, it should be understood that exemplary embodiments describe a material mesh that may take the form of one or more layers of cord applied to an outer surface of a tubular, or a woven mesh. The material mesh may be formed from one or more materials that are swellable when exposed to a selected fluid to establish a selected porosity or permeability. Upon swelling, material mesh provides support to internal surfaces of a well bore to enhance fluid production by, for example, providing reservoir fines control. At the same time, material mesh defines a fluid permeable cover which screens out fines that may be present in the fluid, such as a downhole gas, passing uphole.

[0038] The teachings of the present disclosure may be used in a variety of well operations. These operations may involve using one or more treatment agents to treat a formation, the fluids resident in a formation, a wellbore, and/or equipment in the wellbore, such as production tubing. The treatment agents may be in the form of liquids, gases, solids, semi-solids, and mixtures thereof. Illustrative treatment agents include, but are not limited to, fracturing fluids, acids, steam, water, brine, anti-corrosion agents, cement, permeability modifiers, drilling muds, emulsifiers, demulsifiers, tracers, flow improvers etc.

[0039] Embodiment 1: A tubular for reservoir fines control comprising: a body including an outer surface and an inner surface defining a flow path, a plurality of openings are formed in the body connecting the outer surface and the flow path; and a material mesh overlaid onto the outer surface, the material mesh being formed from a material swellable upon exposure to a selected fluid, the material mesh having a selected porosity allowing methane to pass into the flow path while preventing passage of fines.

[0040] Embodiment 2: The tubular according to any previous embodiment, wherein the material mesh includes a first material mesh layer extending along the outer surface and a second material mesh layer overlaid onto the first material mesh layer.

[0041] Embodiment 3: The tubular according to any previous embodiment, wherein the first material mesh layer extends axially along the body.

[0042] Embodiment 4: The tubular according to any previous embodiment, wherein the first material mesh layer extends at an angle relative to a longitudinal axis of the body.

[0043] Embodiment 5: The tubular according to any previous embodiment, wherein the first material mesh layer comprises a plurality of cord members extending axially along the body.

[0044] Embodiment 6: The tubular according to any previous embodiment, wherein the second material mesh layer is wrapped about the body.

[0045] Embodiment 7: The tubular according to any previous embodiment, wherein the first material mesh layer comprises a first outer diameter and the second material mesh layer comprises a second outer diameter that is distinct from the first outer diameter.

[0046] Embodiment 8: The tubular according to any previous embodiment, wherein the material mesh includes a non-circular cross-section.

[0047] Embodiment 9: The tubular according to any previous embodiment, wherein the material mesh includes a first portion formed from a material that is swellable upon exposure to a first selected fluid and a second portion formed from a material that is swellable upon exposure to a second selected fluid that is distinct from the first selected fluid.

[0048] Embodiment 10: The tubular according to any previous embodiment, wherein the first selected fluid comprises oil and the second selected fluid comprises water.

[0049] Embodiment 11: The tubular according to any previous embodiment, wherein the selected fluid comprises a downhole fluid.

[0050] Embodiment 12: The tubular according to any previous embodiment, wherein the material mesh comprises a weave.

[0051] Embodiment 13: The tubular according to any previous embodiment, wherein the material mesh comprises a preformed sleeve.

[0052] Embodiment 14: The tubular according to any previous embodiment, wherein the material mesh comprises a mat having a first end and a second end.

[0053] Embodiment 15: The tubular according to any previous embodiment, wherein the mat is clamped to the outer surface.

[0054] Embodiment 16: The tubular according to any previous embodiment, wherein the mat is secured about with outer surface with the first end being bonded to the second end.

[0055] Embodiment 17: The tubular according to any previous embodiment, wherein the material mesh comprises a continuous cord.

[0056] Embodiment 18: The tubular according to any previous embodiment, wherein the continuous cord includes a first portion having a first dimension and a second portion having a second dimension that is distinct from the first dimension.

[0057] Embodiment 19: The tubular according to any previous embodiment, wherein the material mesh is formed from a plurality of discrete particles suspended in a binder material.

[0058] Embodiment 20: A method of forming a permeable cover on a perforated tubular comprising: positioning a material mesh permeable to a downhole gas on an outer surface of the perforated tubular formed from a material swellable upon exposure to a selected fluid.

[0059] Embodiment 21: The method of any previous embodiment, wherein positioning the material mesh includes directly wrapping the material mesh about the outer surface of the tubular.

[0060] Embodiment 22: The method of any previous embodiment, wherein directly wrapping the material mesh includes positioning a first material mesh layer formed from a first material on the outer surface and overlaying a second material mesh layer formed from a second material upon the first material mesh layer.

[0061] Embodiment 23: The method of any previous embodiment, wherein positioning the first material mesh layer arranging one or more discrete elements axially along the outer surface of the tubular and positioning the second material mesh layer includes wrapping the second material about the tubular over the first material mesh layer.

[0062] Embodiment 24: The method of any previous embodiment, further comprising: wrapping a third material mesh layer over the second material.

[0063] Embodiment 25: The method of any previous embodiment, further comprising: forming the material mesh directly on the tubular.

[0064] Embodiment 26: The method of any previous embodiment, wherein positioning a material mesh includes arranging a woven material on the outer surface of the tubular.

[0065] Embodiment 27: The method of any previous embodiment, wherein positioning the material mesh includes securing a sleeve to the outer surface of the tubular.

[0066] Embodiment 28: The method of any previous embodiment, wherein positioning a material mesh includes securing a pre-fabricated mat to the outer surface of the tubular.

[0067] Embodiment 29: The method of any previous embodiment, wherein securing the pre-fabricated mat included adhesively bonding the mat about the tubular.

[0068] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Further, it should further be noted that the terms “first,” “second,” and the like herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another. The modifier “about” used in connection with a quantity is inclusive of the stated value and has the meaning dictated by the context (e.g., it includes the degree of error associated with measurement of the particular quantity).

[0069] The teachings of the present disclosure may be used in a variety of well operations. These operations may involve using one or more treatment agents to treat a formation, the fluids resident in a formation, a wellbore, and / or equipment in the wellbore, such as production tubing. The treatment agents may be in the form of liquids, gases, solids, semi-solids, and mixtures thereof. Illustrative treatment agents include, but are not limited to, fracturing fluids, acids, steam, water, brine, anti-corrosion agents, cement, permeability modifiers, drilling muds, emulsifiers, demulsifiers, tracers, flow improvers etc. Illustrative well operations include, but are not limited to, hydraulic fracturing, stimulation, tracer injection, cleaning, acidizing, steam injection, water flooding, cementing, etc.

[0070] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited.

[0071] While one or more embodiments have been shown and described, modifications and substitutions may be made thereto without departing from the spirit and

scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

CLAIMS:

1. A tubular (21) for reservoir fines control comprising:
a body (44) including an outer surface (46) and an inner surface (48) defining a flow path (50), a plurality of openings (54) are formed in the body (44) connecting the outer surface (46) and the flow path (50); and
a material mesh (38, 105, 112) overlaid onto the outer surface (46), the material mesh (38, 105, 112) being formed from a material swellable upon exposure to a selected fluid, the material mesh (38, 105, 112) having a selected porosity allowing methane to pass into the flow path (50) while preventing passage of fines.
2. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) includes a first material mesh layer (60) extending along the outer surface (46) and a second material mesh layer (67) overlaid onto the first material mesh layer (60).
3. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) includes a non-circular cross-section.
4. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) includes a first portion formed from a material that is swellable upon exposure to a first selected fluid and a second portion formed from a material that is swellable upon exposure to a second selected fluid that is distinct from the first selected fluid.
5. The tubular (21) according to claim 1, wherein the selected fluid comprises a downhole fluid.
6. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) comprises a weave.
7. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) comprises a preformed sleeve.
8. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) comprises a mat having a first end (56, 121) and a second end (57, 122).
9. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) comprises a continuous cord (107).
10. The tubular (21) according to claim 1, wherein the material mesh (38, 105, 112) is formed from a plurality of discrete particles suspended in a binder material.
11. A method of forming a permeable cover on a perforated tubular (32) comprising:

positioning a material mesh (38, 105, 112) permeable to a downhole gas on an outer surface (46) of the perforated tubular (32) formed from a material swellable upon exposure to a selected fluid.

12. The method of claim 11, wherein positioning the material mesh (38, 105, 112) includes directly wrapping the material mesh (38, 105, 112) about the outer surface (46) of the tubular (32).

13. The method of claim 12, wherein directly wrapping the material mesh (38, 105, 112) includes positioning a first material mesh layer (60) formed from a first material (65) on the outer surface (46) and overlaying a second material mesh layer (67) formed from a second material (71) upon the first material mesh layer (60).

14. The method of claim 11, further comprising: forming the material mesh (38, 105, 112) directly on the tubular (32).

15. The method of claim 11, wherein positioning a material mesh (38, 105, 112) includes securing a pre-fabricated mat to the outer surface (46) of the tubular (32).

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FIG. 1

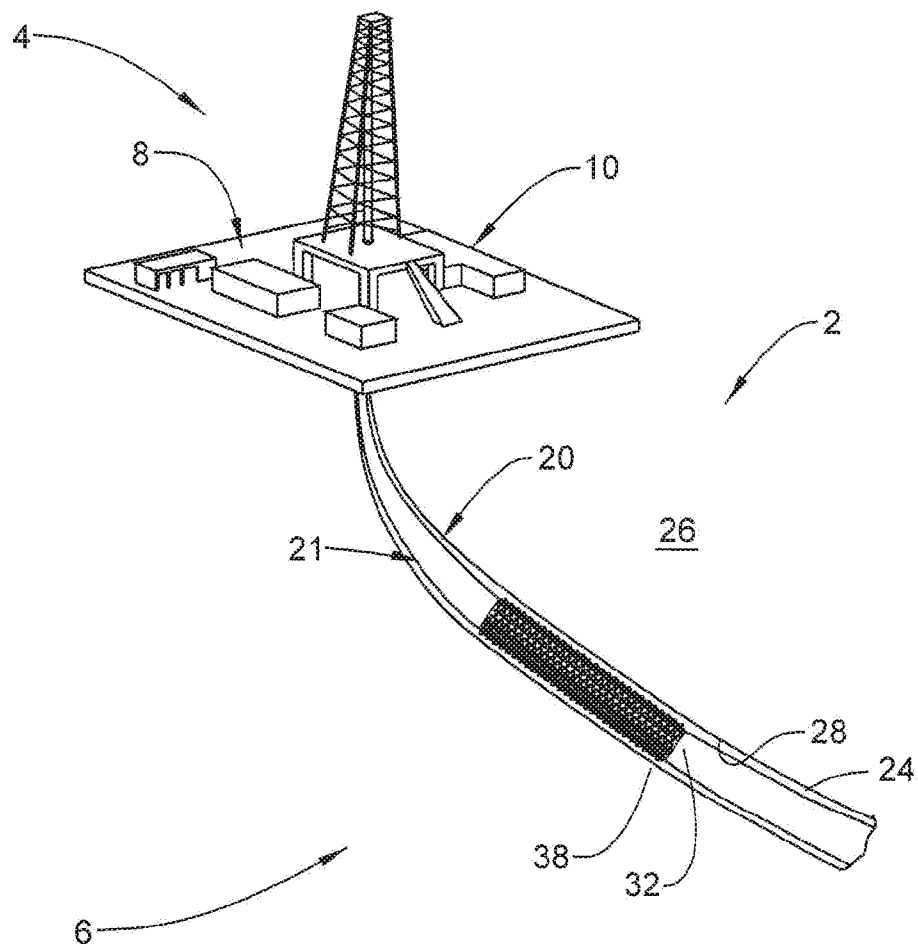


FIG. 2

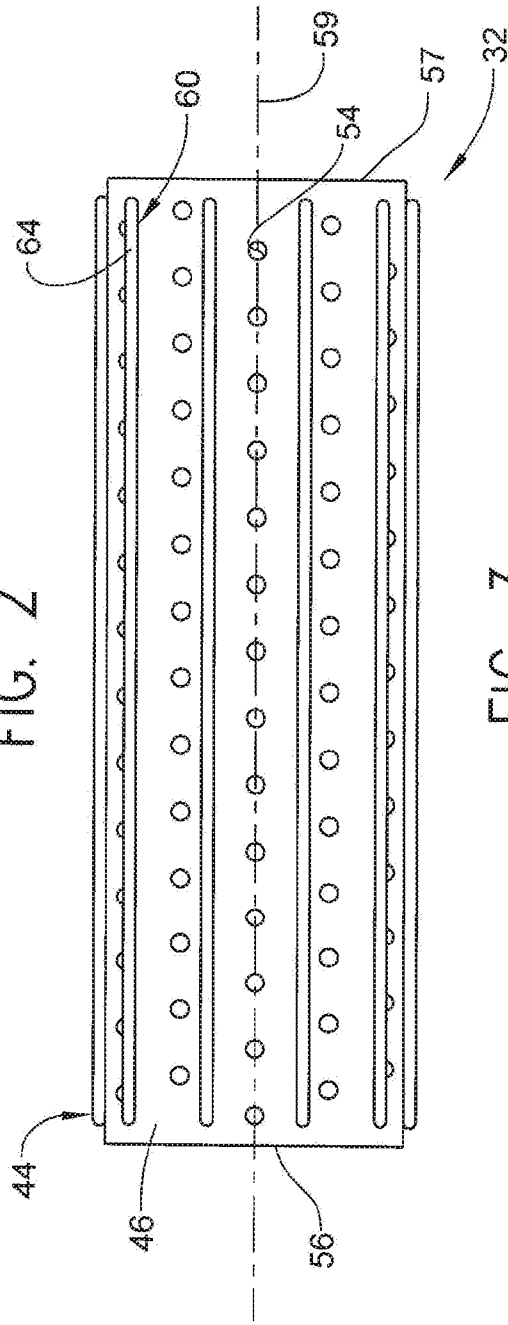


FIG. 3

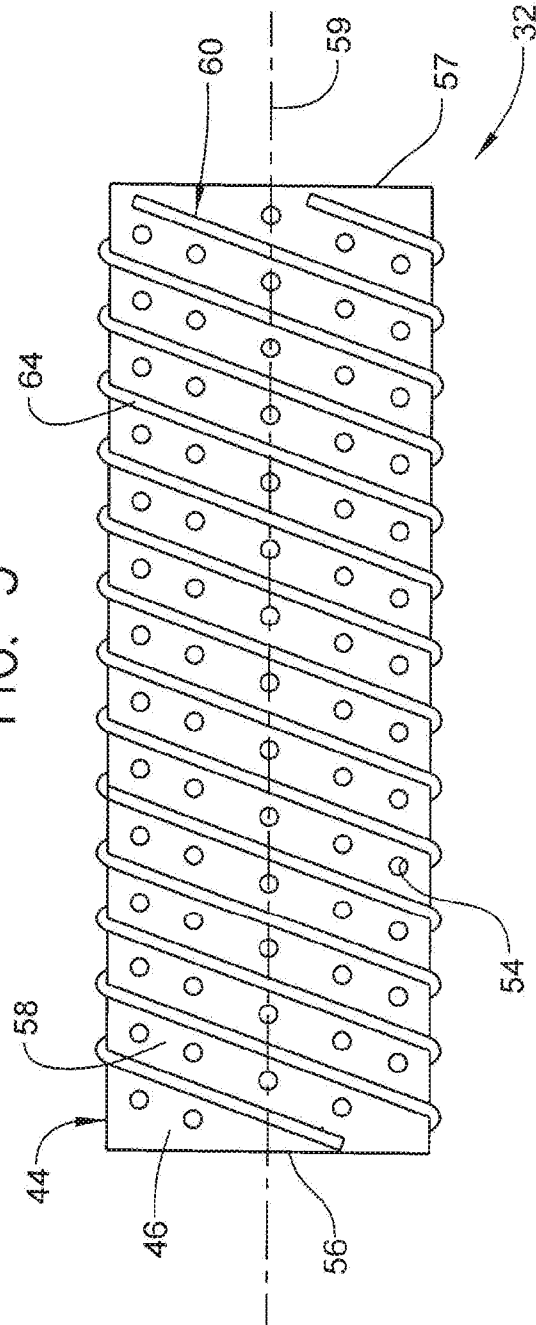


FIG. 4

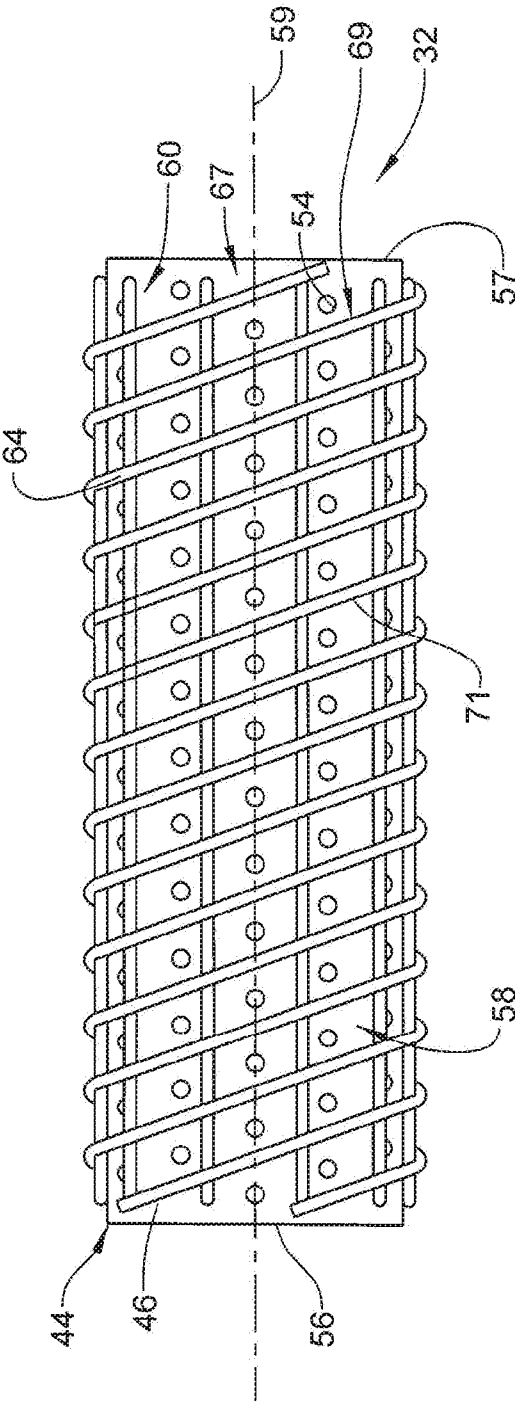


FIG. 5

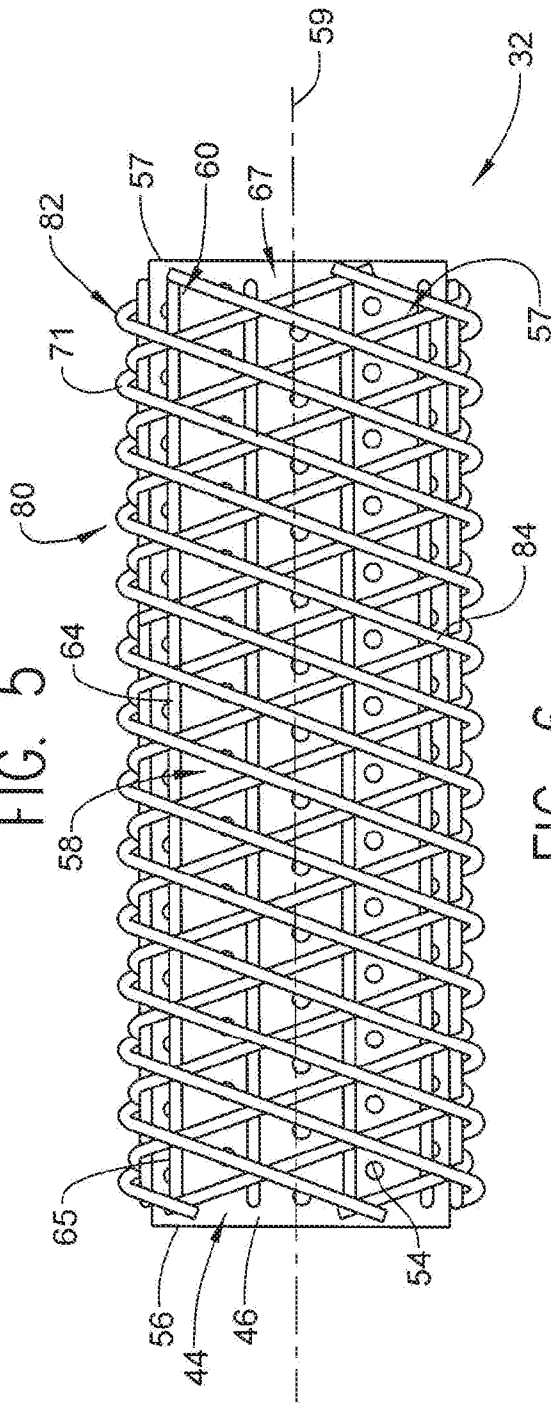


FIG. 6

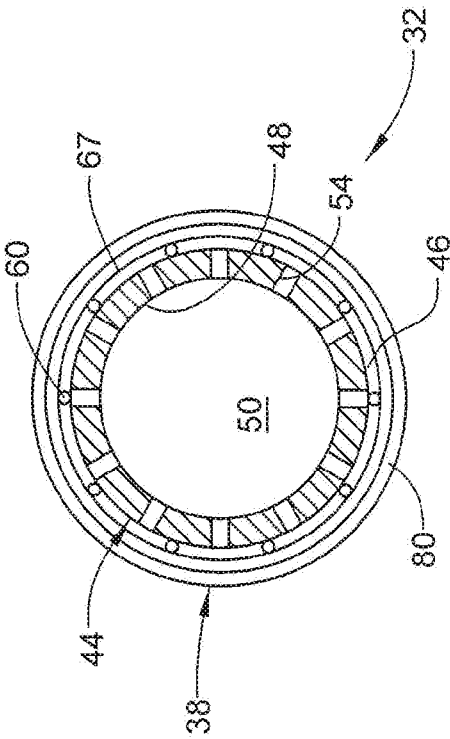


FIG. 7

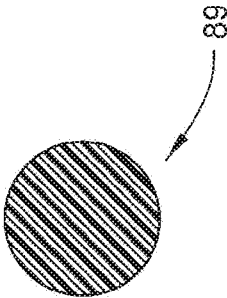


FIG. 8

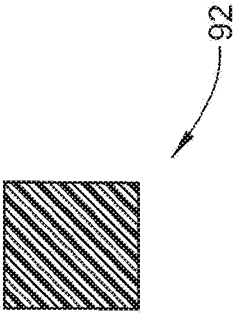
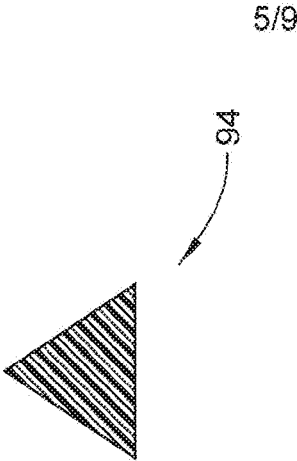


FIG. 9



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FIG. 10

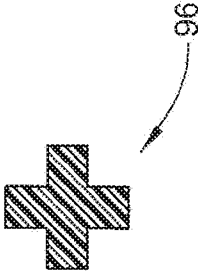


FIG. 11

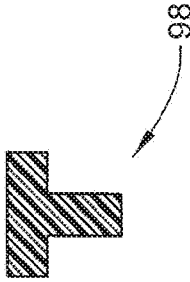


FIG. 12

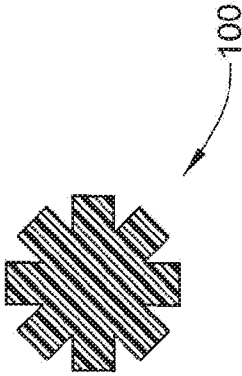


FIG. 13

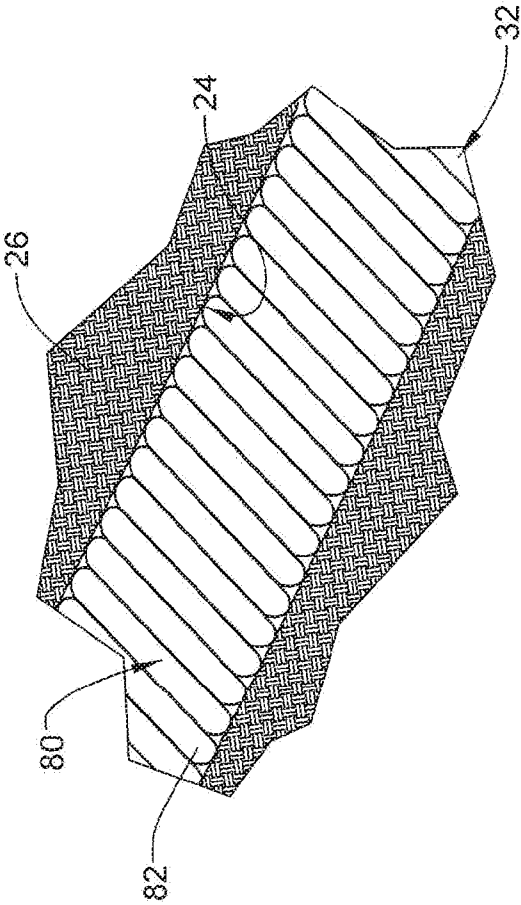
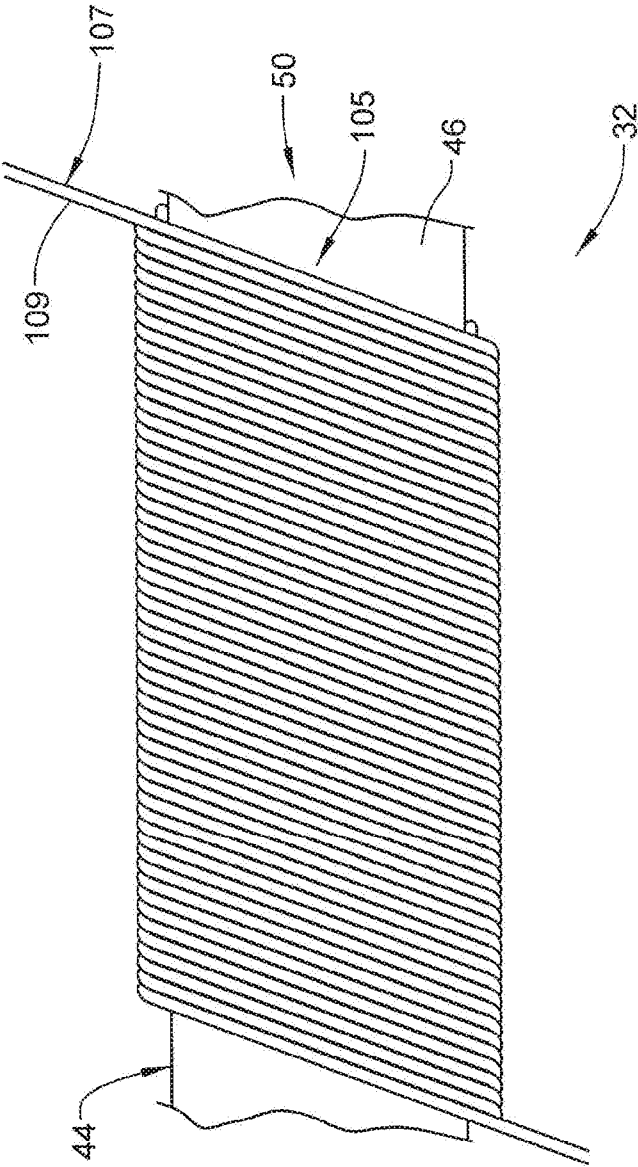


FIG. 14



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FIG. 15

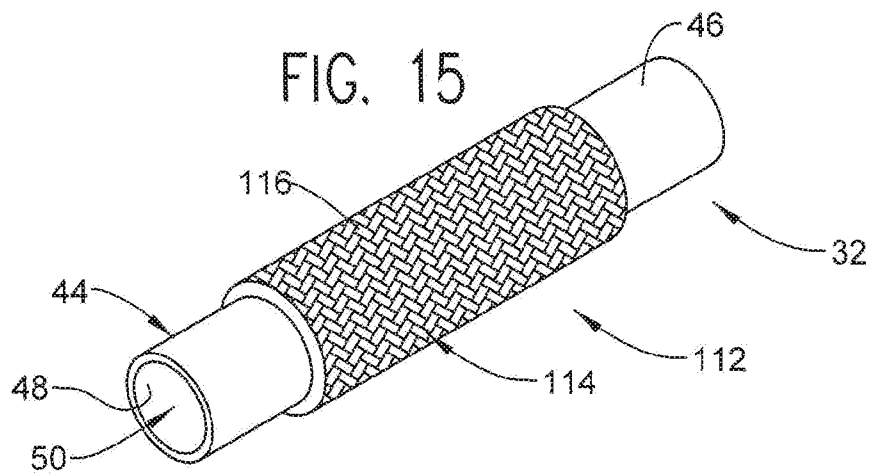


FIG. 16

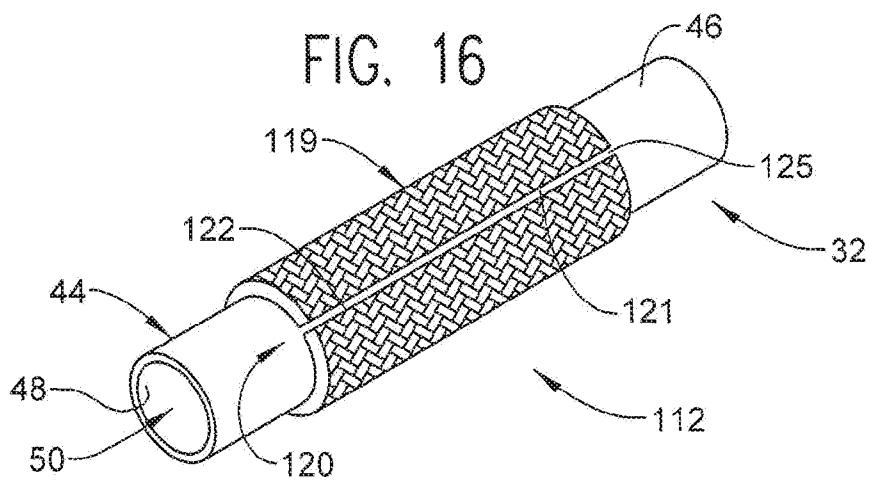
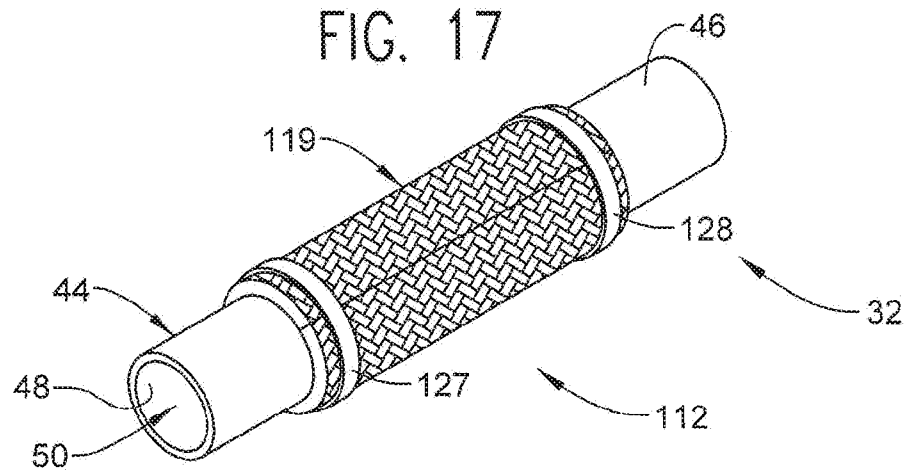


FIG. 17



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FIG. 18

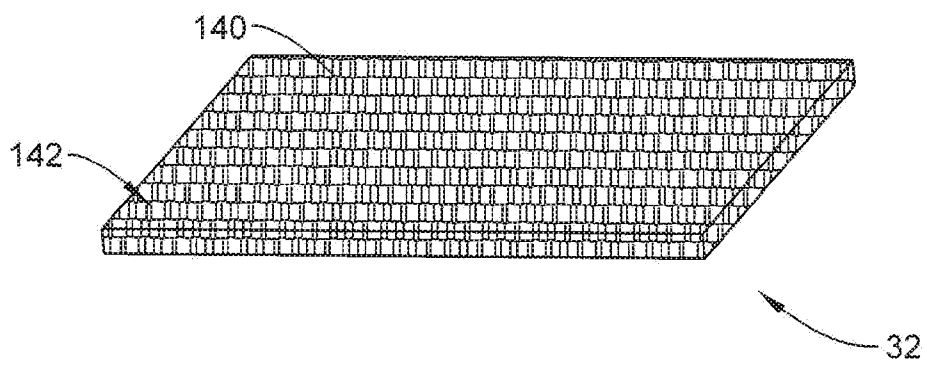
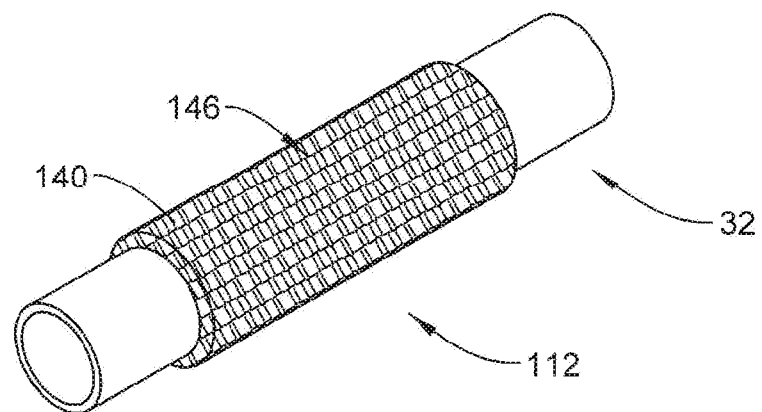


FIG. 19



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/026440**A. CLASSIFICATION OF SUBJECT MATTER****E21B 43/08(2006.01)i, E21B 43/10(2006.01)i**

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)

E21B 43/08; E03B 3/18; F16L 9/14; E21B 33/12; F16L 55/00; E21B 23/00; E21B 34/10; E21B 43/10

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & keywords: perforated tubular, openings, swellable, material mesh, methane, and fines

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014-0360613 A1 (ABSHIRE et al.) 11 December 2014 See paragraphs [0013]-[0019], [0023] and figures 1-6.	1-3, 5-15
Y		4
Y	US 2010-0252254 A1 (NUTLEY et al.) 07 October 2010 See paragraph [0086] and figure 1.	4
A	US 2010-0051271 A1 (GANO et al.) 04 March 2010 See paragraph [0058] and figure 5.	1-15
A	US 2010-0051262 A1 (DUSTERHOFT et al.) 04 March 2010 See paragraphs [0048]-[0054] and figures 2A-2B.	1-15
A	US 2006-0175065 A1 (ROSS, DONALD W.) 10 August 2006 See paragraph [0027] and figures 2A-2C.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

10 July 2018 (10.07.2018)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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