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(54) **Title**: SYSTEMS AND METHODS TO REDUCE EROSION IN WIRE WRAP SCREEN ON PERFORATED BASE PIPE

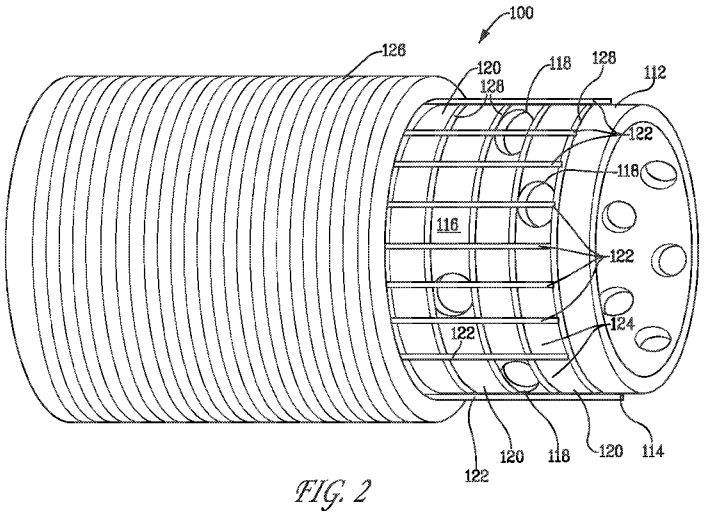


FIG. 2

(57) **Abstract**: A well screen system (100) having enhanced resistance to erosion, including a tubular (112) defined by a circumferential wall (114) having an outer surface (116) and a first plurality of apertures (118) circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall; a series of circumferential channels (120) positioned about the outer surface of the circumferential wall; a plurality of longitudinal ribs (122) positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels (124); and a wire (126) helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels, wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels. A method for producing a well screen having enhanced resistance to erosion is also provided.

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SYSTEMS AND METHODS TO REDUCE EROSION IN WIRE WRAP SCREEN ON PERFORATED BASE PIPE

Cross Reference To Related Applications

[0001] This application claims the benefit of U.S. Provisional Application No. 62/247,900, filed October 29, 2015, entitled "Systems and Methods to Reduce Erosion in Wire Wrap Screen on Perforated Base Pipe," and U.S. Provisional Application No. 62/213,827, filed September 3, 2015, entitled "Systems and Methods to Reduce Erosion in Wire Wrap Screen on Perforated Base Pipe," the entirety of each of which are incorporated by reference herein.

Field

[0002] The present disclosure relates to systems and methods for reducing erosion in wire wrap screen tubulars.

Background

[0003] Wells have been drilled to extract oil, natural gas, water, and other fluids from subterranean formations. In extracting the fluids, a production string is provided in a wellbore, both reinforcing the structural integrity of the wellbore, as well as assisting in extraction of fluids from the well. To allow fluids to flow into production string, apertures are often provided in the tubing string in the section of the string corresponding with production zones of the well. Although perforations allow for ingress of the desired fluids from the formation, these perforations can also allow unwanted materials to flow into the well from the surrounding foundations during production. Debris, such as formation sand and other particulate, can fall or be swept into the tubing together with formation fluid, contaminating the recovered fluid. Not only do sand and other particulates contaminate the recovered fluid, this particulate can cause many additional problems for the well operator. For example, as the particulate flows through production equipment, it gradually erodes the equipment.

[0004] Unwanted particulate can block flow passages, accumulate in chambers, and abrade components. Repairing and replacing production equipment damaged by particulate in-flow can be exceedingly costly and time-consuming, particularly for downhole equipment sometimes located several thousand feet below the earth's surface. Consequently, to guard against particulate from entering production equipment, while at the same time preserving

sufficient fluid flow pathways, various production filters and filtration methods have been developed and employed including gravel packs and well screen assemblies.

[0005] Current technologies for controlling sand inflow in a well involve wrapping the pipe with wires spaced accordingly with the particle size to be retained. This system is called wire wrap screen and is widely utilized for wells expected to produce sand along with oil or gas. The aim of wire wrap screen is to reduce the amount of solids entering the production stream and avoid erosion of the production components. More specifically, this system is produced by running a series of wires along the axis of the base pipe spaced about one-half inch from each other. These wires are called "rib wires." A possibly different wire, called "wrap wire," is tack welded to the rib wire as it is wrapped around the pipe. The space between two screen wires is called the "screen gap," and it is sized according to the particle size to be retained.

[0006] Although conventional well screen designs have been used for many years in oilfield operations worldwide and a great deal is known about their fluidic performance, their erosion characteristics and failure mechanisms are not well understood. In operations, erosion-based degradation may be experienced from time-to-time and its prevention is highly desirable.

[0007] Therefore, what are needed are improved systems and methods for reducing the screen erosion characteristics of wire wrap screen.

Summary

[0008] In one aspect, disclosed herein is a well screen system having enhanced resistance to erosion. The well screen system includes a tubular defined by a circumferential wall having an outer surface and a first plurality of apertures circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall; a series of circumferential channels positioned about the outer surface of the circumferential wall; a plurality of longitudinal ribs positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels; and a wire helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels, wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels.

[0009] In some embodiments, the series of circumferential channels is defined by a plurality of circumferential ribs.

[0010] In some embodiments, the plurality of circumferential ribs is affixed to the outer surface of the circumferential wall and the plurality of longitudinal ribs is affixed to the plurality of circumferential ribs.

[0011] In some embodiments, the plurality of circumferential ribs is normal to the plurality of longitudinal ribs.

[0012] In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the circumferential wall.

[0013] In some embodiments, the series of circumferential channels is defined by a plurality of grooves formed within the outer surface of the circumferential wall.

[0014] In some embodiments, the plurality of longitudinal ribs is affixed to the outer surface of the circumferential wall.

[0015] In some embodiments, the plurality of grooves is normal to the plurality of longitudinal ribs.

[0016] In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the circumferential wall.

[0017] In some embodiments, the plurality of longitudinal ribs is affixed to the outer surface of the circumferential wall.

[0018] In some embodiments, the series of circumferential channels is defined by a second plurality of apertures, the second plurality of apertures formed along each of the plurality of longitudinal ribs.

[0019] In some embodiments, each of the second plurality of apertures is substantially circular.

[0020] In some embodiments, each of the plurality of longitudinal ribs include a series of scallops on one edge thereof, the scallops facing the outer surface of the circumferential wall and therewith forming the second plurality of apertures.

[0021] In some embodiments, each of the plurality of longitudinal ribs includes a series of scallops on one edge thereof, the scallops facing the helically disposed wire and therewith forming the plurality of second apertures.

[0022] In yet another aspect, a method for producing a well screen having enhanced resistance to erosion. The method includes obtaining a tubular having a first plurality of apertures extending radially; forming a series of circumferential channels about the outer surface of the tubular; positioning a plurality of longitudinal ribs adjacent the series of circumferential channels so as to form a series of longitudinal channels; and helically

wrapping a wire around the tubular and substantially enclosing the series of circumferential channels and the series of longitudinal channels, wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels.

[0023] In some embodiments, the method further includes affixing a plurality of circumferential ribs to the outer surface of the tubular to form the series of circumferential channels.

[0024] In some embodiments, the method further includes affixing the plurality of longitudinal ribs to the plurality of circumferential ribs.

[0025] In some embodiments, the plurality of circumferential ribs is normal to the plurality of longitudinal ribs.

[0026] In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the tubular.

[0027] In some embodiments, the method further includes forming a plurality of grooves within the outer surface of the tubular to form the series of circumferential channels.

[0028] In some embodiments, the method further includes affixing the plurality of longitudinal ribs to the outer surface of the tubular.

[0029] In some embodiments, the plurality of grooves is normal to the plurality of longitudinal ribs.

[0030] In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the tubular.

[0031] In some embodiments, the method further includes affixing the plurality of longitudinal ribs to the outer surface of the tubular.

[0032] In some embodiments, the method further includes forming a second plurality of apertures along each of the plurality of longitudinal ribs to form the series of circumferential channels.

[0033] In some embodiments, each of the second plurality of apertures is substantially circular.

[0034] In some embodiments, each of the plurality of longitudinal ribs include a series of scallops on one edge thereof, the scallops facing the outer surface of the tubular and therewith forming the second plurality of apertures.

[0035] In some embodiments, each of the plurality of longitudinal ribs includes a series of scallops on one edge thereof, the scallops facing the helically disposed wire and therewith forming the plurality of second apertures.

Brief Description of the Drawings

[0036] FIG. 1 presents a schematic view of a conventional well screen system for controlling particulate inflow.

[0037] FIG. 2 presents a schematic view of an illustrative, nonexclusive example of a well screen system for controlling particulate inflow, according to the present disclosure.

[0038] FIG. 3 presents a schematic view of another illustrative, nonexclusive example of a well screen system for controlling particulate inflow, according to the present disclosure.

[0039] FIG. 4 presents a schematic view of yet another illustrative, nonexclusive example of a well screen system for controlling particulate inflow, according to the present disclosure.

Detailed Description

[0040] In FIGS. 1-4, like numerals denote like, or similar, structures and/or features; and each of the illustrated structures and/or features may not be discussed in detail herein with reference to the figures. Similarly, each structure and/or feature may not be explicitly labeled in the figures; and any structure and/or feature that is discussed herein with reference to the figures may be utilized with any other structure and/or feature without departing from the scope of the present disclosure.

[0041] In general, structures and/or features that are, or are likely to be, included in a given embodiment are indicated in solid lines in the figures, while optional structures and/or features are indicated in broken lines. However, a given embodiment is not required to include all structures and/or features that are illustrated in solid lines therein, and any suitable number of such structures and/or features may be omitted from a given embodiment without departing from the scope of the present disclosure.

[0042] FIGS. 2-4 provide illustrative, non-exclusive examples of methods and systems for controlling particulate inflow within subterranean wells, according to the present disclosure, together with elements that may include, be associated with, be operatively attached to, and/or utilize such a method or system.

[0043] Although the approach disclosed herein can be applied to a variety of subterranean well designs and operations, the present description will primarily be directed to novel well screen systems for controlling particulate inflow within subterranean wells.

[0044] Wire-wrapped screens offer an effective means for retaining gravel in an annular ring between the screen and the formation. Wire-wrapped screens typically have substantially more inflow area than a slotted liner. The screen consists of an outer jacket that is fabricated on special wrapping machines that resemble a lathe. In a conventional well screen system, the shaped wire is simultaneously wrapped and welded to longitudinal rods to form a single helical slot with any desired width. The jacket is subsequently placed over and welded at each end to a supporting pipe base, containing perforations comprising drilled holes, to provide structural support.

[0045] FIG. 1 presents, for illustrative purposes, a schematic view of a conventional well screen system 10 for controlling particulate inflow within a subterranean well. The well screen system 10 includes a tubular 12 defined by a circumferential wall 14 having an outer surface 16 and a plurality of apertures 18 circumferentially disposed longitudinally along at least a portion thereof. As shown, the plurality of apertures 18 extends radially through the circumferential wall 14.

[0046] A plurality of longitudinal ribs 22 is affixed to the outer surface 16 of the circumferential wall 14 and extending radially therefrom. As may be appreciated, the plurality of longitudinal ribs 22 forms a series of longitudinal channels 24.

[0047] To complete the well screen system 10, a wire 26 is helically disposed around the tubular 12, enclosing the series of longitudinal channels 24, wherein the series of circumferential channels 120 is structured and arranged to permit fluid communication with plurality of apertures 18.

[0048] Referring now to FIG. 2, a schematic view of an illustrative, nonexclusive example of a well screen system 100 for controlling particulate inflow within a subterranean well, the well screen system 100 having enhanced resistance to erosion. The well screen system 100 includes a tubular 112 defined by a circumferential wall 114 having an outer surface 116 and a first plurality of apertures 118 circumferentially disposed longitudinally along at least a portion thereof. As shown, the first plurality of apertures 118 extends radially through the circumferential wall 114.

[0049] A series of circumferential channels 120 is positioned about the outer surface 116 of the circumferential wall 114. A plurality of longitudinal ribs 122 is positioned adjacent the series of circumferential channels 120 and extending radially therefrom. As may be appreciated, the plurality of longitudinal ribs 122 forms a series of longitudinal channels 124. To complete the well screen system 100, a wire 126 is helically disposed around the tubular

112, substantially enclosing the series of circumferential channels 120 and the series of longitudinal channels 124, wherein the series of circumferential channels 120 is structured and arranged to permit fluid communication with the series of longitudinal channels 124.

[0050] In some embodiments, the series of circumferential channels 120 is defined by a plurality of circumferential ribs 128. In some embodiments, the plurality of circumferential ribs 128 is affixed to the outer surface 116 of the circumferential wall 114. In some embodiments, the plurality of longitudinal ribs 122 is affixed to the plurality of circumferential ribs 128.

[0051] Still referring to FIG. 2, in some embodiments, the plurality of circumferential ribs 128 is normal to the plurality of longitudinal ribs 122. In some embodiments, the plurality of longitudinal ribs 122 extends axially along the outer surface 116 of the circumferential wall 114.

[0052] Referring now to FIG. 3, a schematic view of an illustrative, nonexclusive example of a well screen system 200 for controlling particulate inflow within a subterranean well, the well screen system 200 having enhanced resistance to erosion. The well screen system 200 includes a tubular 212 defined by a circumferential wall 214 having an outer surface 216 and a first plurality of apertures 218 circumferentially disposed longitudinally along at least a portion thereof. As shown, the first plurality of apertures 218 extends radially through the circumferential wall 214.

[0053] A series of circumferential channels 220 is positioned about the outer surface 216 of the circumferential wall 214, the series of circumferential channels 220 defined by a plurality of grooves 228 formed within the outer surface 216 of the circumferential wall 214. A plurality of longitudinal ribs 222 is positioned adjacent the series of circumferential channels 220 and extending radially therefrom. As may be appreciated, the plurality of longitudinal ribs 222 forms a series of longitudinal channels 224. To complete the well screen system 200, a wire 226 is helically disposed around the tubular 212, substantially enclosing the series of circumferential channels 220 and the series of longitudinal channels 224, wherein the series of circumferential channels 220 is structured and arranged to permit fluid communication with the series of longitudinal channels 224.

[0054] In some embodiments, the plurality of longitudinal ribs 222 is affixed to the outer surface 216 of the circumferential wall 214.

[0055] Still referring to FIG. 3, in some embodiments, the plurality of grooves 228 is normal to the plurality of longitudinal ribs 222. In some embodiments, the plurality of

longitudinal ribs 222 extends axially along the outer surface 216 of the circumferential wall 214.

[0056] Referring now to FIG. 4, a schematic view of an illustrative, nonexclusive example of a well screen system 300 for controlling particulate inflow within a subterranean well, the well screen system 300 having enhanced resistance to erosion. The well screen system 300 includes a tubular 312 defined by a circumferential wall 314 having an outer surface 316 and a first plurality of apertures 318 circumferentially disposed longitudinally along at least a portion thereof. As shown, the first plurality of apertures 318 extends radially through the circumferential wall 314.

[0057] A plurality of longitudinal ribs 322 is affixed to the outer surface 316 of the circumferential wall 314. As shown in detail "Δ", in some embodiments, a series of circumferential channels 320 is defined by a second plurality of apertures 310', the second plurality of apertures 310' formed along each of the plurality of longitudinal ribs 322'. Alternatively, as shown in detail "Δ", in some embodiments, a series of circumferential channels 320 is defined by a second plurality of apertures 310'', the second plurality of apertures 310'' formed along each of the plurality of longitudinal ribs 322''. In some embodiments, the second plurality of apertures 310'' is substantially circular.

[0058] As may be appreciated, the series of circumferential channels 320 of the FIG. 4 embodiment is positioned about the outer surface 316 of the circumferential wall 314. The plurality of longitudinal ribs 322 is thus positioned adjacent the series of circumferential channels 320 and extending radially therefrom. As with the other embodiments depicted, the plurality of longitudinal ribs 322 forms a series of longitudinal channels 324.

[0059] To complete the well screen system 300, a wire 326 is helically disposed around the tubular 312, substantially enclosing the series of circumferential channels 320 and the series of longitudinal channels 324, wherein the series of circumferential channels 320 is structured and arranged to permit fluid communication with the series of longitudinal channels 324.

[0060] From a materials standpoint, a stainless steel jacket, may be formed from a grade such as 316L, or the like. The stainless steel jacket may be placed over the tubular base pipe, which may be a grade N80 oil well drilling tube, made from 36Mn2V non-quenched and tempered steel. The inflow area of the screen may be designed to vary from about 6 to about 12%, or higher, depending on the perforations. Screens with the smallest openings may be typically 6 gauge (0.006 in.).

[0061] In another aspect of the present disclosure, a wellbore is provided. The wellbore includes a borehole extending into an earth formation; and a tubular member extending into the borehole, the tubular member having a well screen system according to the present disclosure, as depicted in FIGS 2-4, positioned along a length thereof.

[0062] In yet another aspect of the present disclosure, a method of forming a completion system within a wellbore is provided. The method includes installing a tubular member into the borehole, the tubular member having a well screen system according to the present disclosure, as depicted in FIGS 2-4, positioned along a length thereof. In some embodiments, the method of includes installing one or more packers to isolate one or more production zones within the wellbore.

[0063] In still yet another aspect of the present disclosure, a method of producing hydrocarbons from a subterranean formation, the method comprising providing a borehole extending into a hydrocarbon-bearing zone of the formation, installing a tubular member into the borehole, the tubular member having a well screen system according to the present disclosure, as depicted in FIGS 2-4, positioned along a length thereof, and producing a fluid comprising hydrocarbons.

[0064] In a further aspect of the present disclosure, a method for producing a well screen having enhanced resistance to erosion is provided. The method includes obtaining a tubular having a first plurality of apertures extending radially; forming a series of circumferential channels about the outer surface of the tubular; positioning a plurality of longitudinal ribs adjacent the series of circumferential channels so as to form a series of longitudinal channels; and helically wrapping a wire around the tubular and substantially enclosing the series of circumferential channels and the series of longitudinal channels, wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels.

[0065] In some embodiments, the method further includes affixing a plurality of circumferential ribs to the outer surface of the tubular to form the series of circumferential channels. In some embodiments, the method further includes affixing the plurality of longitudinal ribs to the plurality of circumferential ribs. In some embodiments, the plurality of circumferential ribs is normal to the plurality of longitudinal ribs. In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the tubular.

[0066] In some embodiments, the method further includes forming a plurality of grooves within the outer surface of the tubular to form the series of circumferential channels. In some

embodiments, the method further includes affixing the plurality of longitudinal ribs to the outer surface of the tubular. In some embodiments, the plurality of grooves is normal to the plurality of longitudinal ribs. In some embodiments, the plurality of longitudinal ribs extends axially along the outer surface of the tubular.

[0067] In some embodiments, the method further includes affixing the plurality of longitudinal ribs to the outer surface of the tubular. In some embodiments, the method further includes forming a second plurality of apertures along each of the plurality of longitudinal ribs to form the series of circumferential channels. In some embodiments, each of the second plurality of apertures is substantially circular. In some embodiments, each of the plurality of longitudinal ribs include a series of scallops on one edge thereof, the scallops facing the outer surface of the tubular and therewith forming the second plurality of apertures. In some embodiments, each of the plurality of longitudinal ribs includes a series of scallops on one edge thereof, the scallops facing the helically disposed wire and therewith forming the plurality of second apertures.

[0068] As used herein, the term "and/or" placed between a first entity and a second entity means one of (1) the first entity, (2) the second entity, and (3) the first entity and the second entity. Multiple entities listed with "and/or" should be construed in the same manner, i.e., "one or more" of the entities so conjoined. Other entities may optionally be present other than the entities specifically identified by the "and/or" clause, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, a reference to "A and/or B," when used in conjunction with open-ended language such as "comprising" may refer, in one embodiment, to A only (optionally including entities other than B); in another embodiment, to B only (optionally including entities other than A); in yet another embodiment, to both A and B (optionally including other entities). These entities may refer to elements, actions, structures, steps, operations, values, and the like.

[0069] As used herein, the phrase "at least one," in reference to a list of one or more entities should be understood to mean at least one entity selected from any one or more of the entity in the list of entities, but not necessarily including at least one of each and every entity specifically listed within the list of entities and not excluding any combinations of entities in the list of entities. This definition also allows that entities may optionally be present other than the entities specifically identified within the list of entities to which the phrase "at least one" refers, whether related or unrelated to those entities specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or,

equivalently "at least one of A and/or B") may refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including entities other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including entities other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other entities). In other words, the phrases "at least one," "one or more," and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C," "at least one of A, B, or C," "one or more of A, B, and C," "one or more of A, B, or C" and "A, B, and/or C" may mean A alone, B alone, C alone, A and B together, A and C together, B and C together, A, B and C together, and optionally any of the above in combination with at least one other entity.

[0070] In the event that any patents, patent applications, or other references are incorporated by reference herein and define a term in a manner or are otherwise inconsistent with either the non-incorporated portion of the present disclosure or with any of the other incorporated references, the non-incorporated portion of the present disclosure shall control, and the term or incorporated disclosure therein shall only control with respect to the reference in which the term is defined and/or the incorporated disclosure was originally present.

[0071] As used herein the terms "adapted" and "configured" mean that the element, component, or other subject matter is designed and/or intended to perform a given function. Thus, the use of the terms "adapted" and "configured" should not be construed to mean that a given element, component, or other subject matter is simply "capable of" performing a given function but that the element, component, and/or other subject matter is specifically selected, created, implemented, utilized, programmed, and/or designed for the purpose of performing the function. It is also within the scope of the present disclosure that elements, components, and/or other recited subject matter that is recited as being adapted to perform a particular function may additionally or alternatively be described as being configured to perform that function, and vice versa.

Examples

Example 1

[0072] Screen coupon experiments were conducted to observe the local erosion behavior of conventional well screen systems near the perforations. In these experiments, severe erosion was observed beneath the screen near the perforations. These tests suggest that a

conventional wire-wrap screen may fail from the bottom facing the perforations and not from the top, which is exposed to the approach flow.

[0073] While not wishing to be bound by any theory, the failure pattern may be due to secondary flow along the screen gaps connecting the different channels created by the axial rib wires beneath the wire wrap. This behavior is believed to be detrimental to screen performance, especially when considering that the phenomenon is localized to the perforation area which usually represents only 10% of the entire screen, while the remaining 90% of the screen does not experience such erosion.

Example 2

[0074] In order to demonstrate that maximizing fluid communication below the wrap wire reduces erosion, a set of screen coupon experiments were conducted in which the wire wrap "floated" above the perforated base tubular. Although a laboratory configuration, this geometry allowed for full communication between all the channels. Coupon testing demonstrated that this geometry is effective in reducing localized erosion of the wire wrap portion of the screen over a conventional axial rib design typical of commercially available wire wrap screens.

Example 3

[0075] Since it is not possible to "float" the screen above the base tubular in an actual application, an additional set of tests were performed where the screen was separated from the base pipe via a cross pattern of rib wires. This configuration is sound from a manufacturing standpoint and coupon testing yielded a substantial improvement over a conventional axial rib design typical of commercially available wire wrap screens.

[0076] Illustrative, non-exclusive examples of apparatus, systems and methods according to the present disclosure have been presented. It is within the scope of the present disclosure that an individual step of a method recited herein, including in the following enumerated paragraphs, may additionally or alternatively be referred to as a "step for" performing the recited action.

Industrial Applicability

[0077] The apparatus, system and methods disclosed herein are applicable to the oil and gas industry.

[0078] It is believed that the disclosure set forth above encompasses multiple distinct inventions with independent utility. While each of these inventions has been disclosed in its preferred form, the specific embodiments thereof as disclosed and illustrated herein are not to

be considered in a limiting sense as numerous variations are possible. The subject matter of the inventions includes all novel and non-obvious combinations and subcombinations of the various elements, features, functions and/or properties disclosed herein. Similarly, where the claims recite "a" or "a first" element or the equivalent thereof, such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements.

[0079] It is believed that the following claims particularly point out certain combinations and subcombinations that are directed to one of the disclosed inventions and are novel and non-obvious. Inventions embodied in other combinations and subcombinations of features, functions, elements and/or properties may be claimed through amendment of the present claims or presentation of new claims in this or a related application. Such amended or new claims, whether they are directed to a different invention or directed to the same invention, whether different, broader, narrower, or equal in scope to the original claims, are also regarded as included within the subject matter of the inventions of the present disclosure.

CLAIMS

1. A well screen system having enhanced resistance to erosion, the well screen system comprising:

a tubular defined by a circumferential wall having an outer surface and a first plurality of apertures circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall;

a series of circumferential channels positioned about the outer surface of the circumferential wall;

a plurality of longitudinal ribs positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels; and

a wire helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels,

wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels.

2. The system of claim 1, wherein the series of circumferential channels is defined by a plurality of circumferential ribs.

3. The system of claim 2, wherein the plurality of circumferential ribs is affixed to the outer surface of the circumferential wall and the plurality of longitudinal ribs is affixed to the plurality of circumferential ribs.

4. The system of claim 3, wherein the plurality of circumferential ribs is normal to the plurality of longitudinal ribs.

5. The system of claim 4, wherein the plurality of longitudinal ribs extend axially along the outer surface of the circumferential wall.

6. The system of claim 1, wherein the series of circumferential channels is defined by a plurality of grooves formed within the outer surface of the circumferential wall.

7. The system of claim 6, wherein the plurality of longitudinal ribs is affixed to the outer surface of the circumferential wall.

8. The system of claim 7, wherein the plurality of grooves is normal to the plurality of longitudinal ribs.

9. The system of claim 8, wherein the plurality of longitudinal ribs extend axially along the outer surface of the circumferential wall.

10. The system of claim 1, wherein the plurality of longitudinal ribs is affixed to the outer surface of the circumferential wall.

11. The system of claim 10, wherein the series of circumferential channels is defined by a second plurality of apertures, the second plurality of apertures formed along each of the plurality of longitudinal ribs.

12. The system of claim 11, wherein each of the second plurality of apertures is substantially circular.

13. The system of claim 11, wherein each of the plurality of longitudinal ribs include a series of scallops on one edge thereof, the scallops facing the outer surface of the circumferential wall and therewith forming the second plurality of apertures.

14. The system of claim 11, wherein each of the plurality of longitudinal ribs include a series of scallops on one edge thereof, the scallops facing the helically disposed wire and therewith forming the plurality of second apertures.

15. The system according to any of the preceding claims used in a method for producing a well screen having enhanced resistance to erosion, the method comprising:

obtaining a tubular having a first plurality of apertures extending radially;

forming a series of circumferential channels about the outer surface of the tubular;

positioning a plurality of longitudinal ribs adjacent the series of circumferential channels so as to form a series of longitudinal channels;

helically wrapping a wire around the tubular and substantially enclosing the series of circumferential channels and the series of longitudinal channels; and

installing the well screen in a wellbore and flowing wellbore fluids through the screen;

wherein the series of circumferential channels is structured and arranged to permit fluid communication with the series of longitudinal channels.

16. The method of claim 15, further comprising affixing a plurality of circumferential ribs to the outer surface of the tubular to form the series of circumferential channels.

17. The method of claim 15-16, further comprising affixing the plurality of longitudinal ribs to the plurality of circumferential ribs.

18. The system according to any of the preceding claims including a wellbore comprising:

a borehole extending into an earth formation; and

a tubular member extending into the borehole, the tubular member having a well screen system positioned along a length thereof, the well screen system comprising i) a tubular defined by a circumferential wall having an outer surface and a first plurality of apertures circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall; ii) a series of circumferential channels positioned about the outer surface of the circumferential wall; iii) a plurality of longitudinal ribs positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels; and iv) a wire helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels.

19. The system according to any of the preceding claims further comprising:

a method of forming a completion system within a wellbore, the method comprising installing a tubular member into the borehole, the tubular member having a well screen system positioned along a length thereof, the well screen system comprising i) a tubular defined by a circumferential wall having an outer surface and a first plurality of apertures circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall; ii) a series of circumferential channels positioned about the outer surface of the circumferential wall; iii) a plurality of longitudinal ribs positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels; and iv) a wire helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels.

20. A method of producing hydrocarbons from a subterranean formation, the method comprising:

providing a borehole extending into a hydrocarbon-bearing zone of the formation, installing a tubular member into the borehole, the tubular member having a well screen system positioned along a length thereof, the well screen system comprising i) a tubular defined by a circumferential wall having an outer surface and a first plurality of apertures circumferentially disposed longitudinally along at least a portion thereof, the first plurality of apertures extending radially through the circumferential wall; ii) a series of circumferential channels positioned about the outer surface of the circumferential wall; iii) a plurality of longitudinal ribs positioned adjacent the series of circumferential channels and extending radially therefrom, the plurality of longitudinal ribs forming a series of longitudinal channels; and iv) a wire helically disposed around the tubular, substantially enclosing the series of circumferential channels and the series of longitudinal channels and

producing a fluid comprising hydrocarbons.

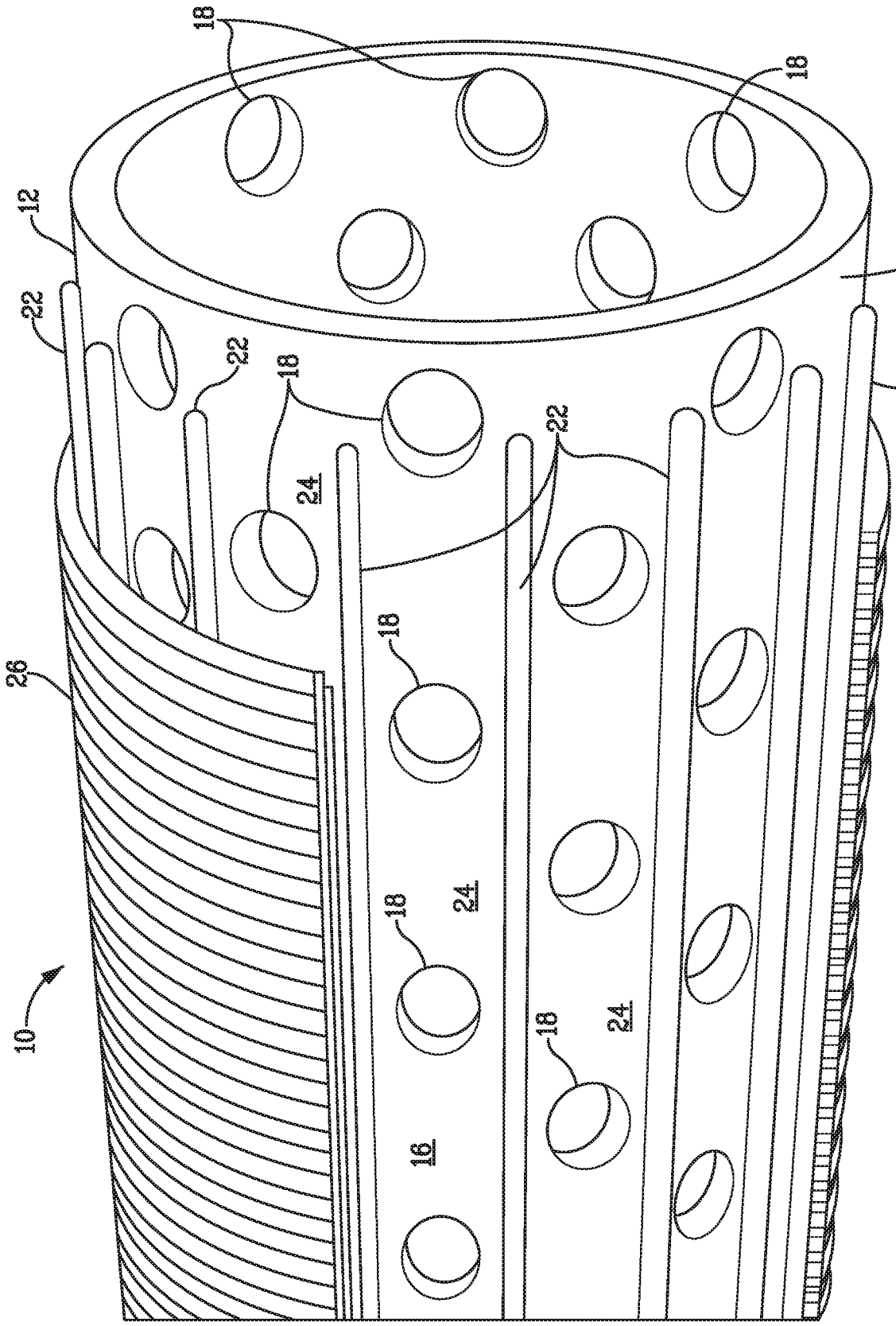


FIG. 1

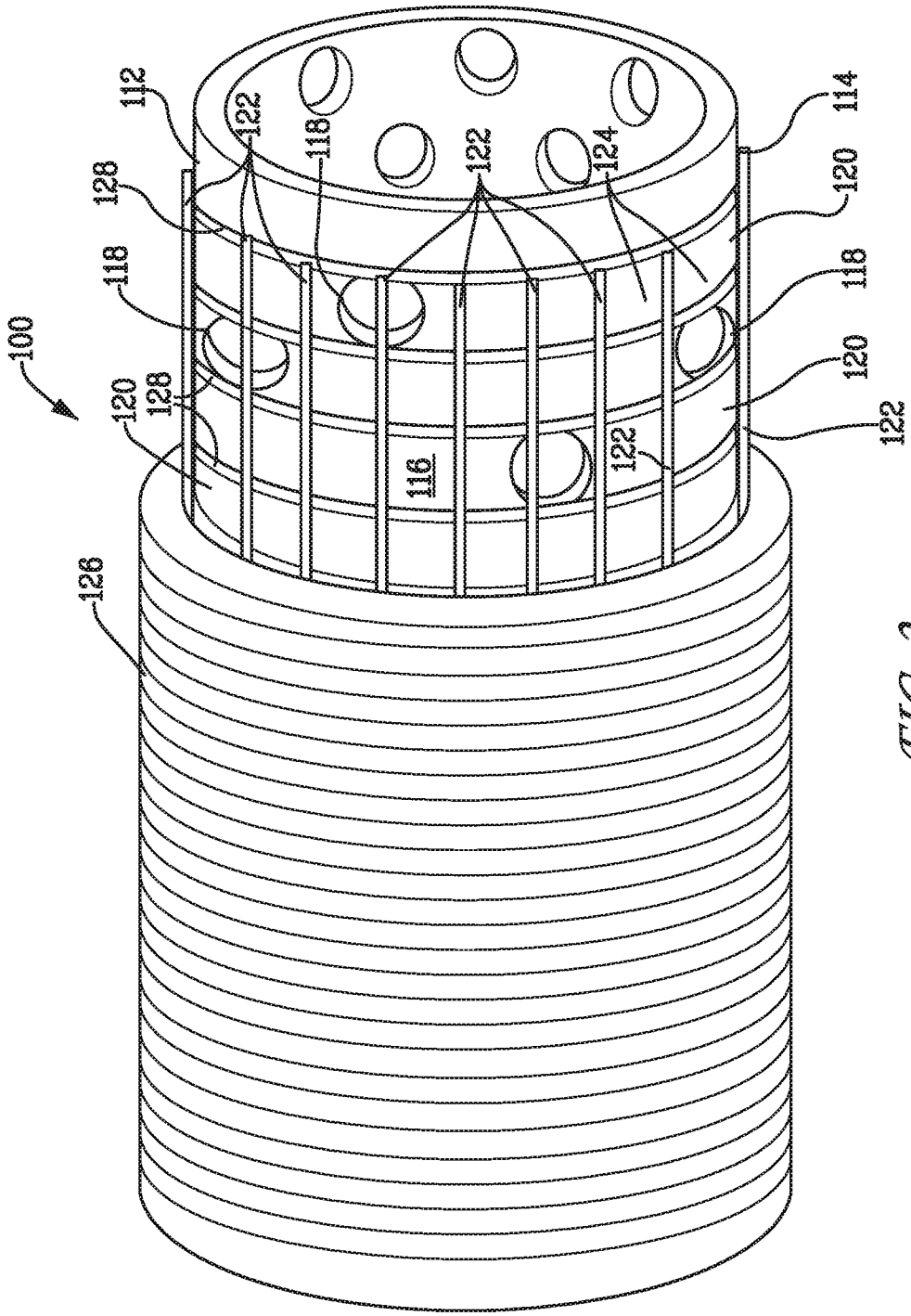


FIG. 2

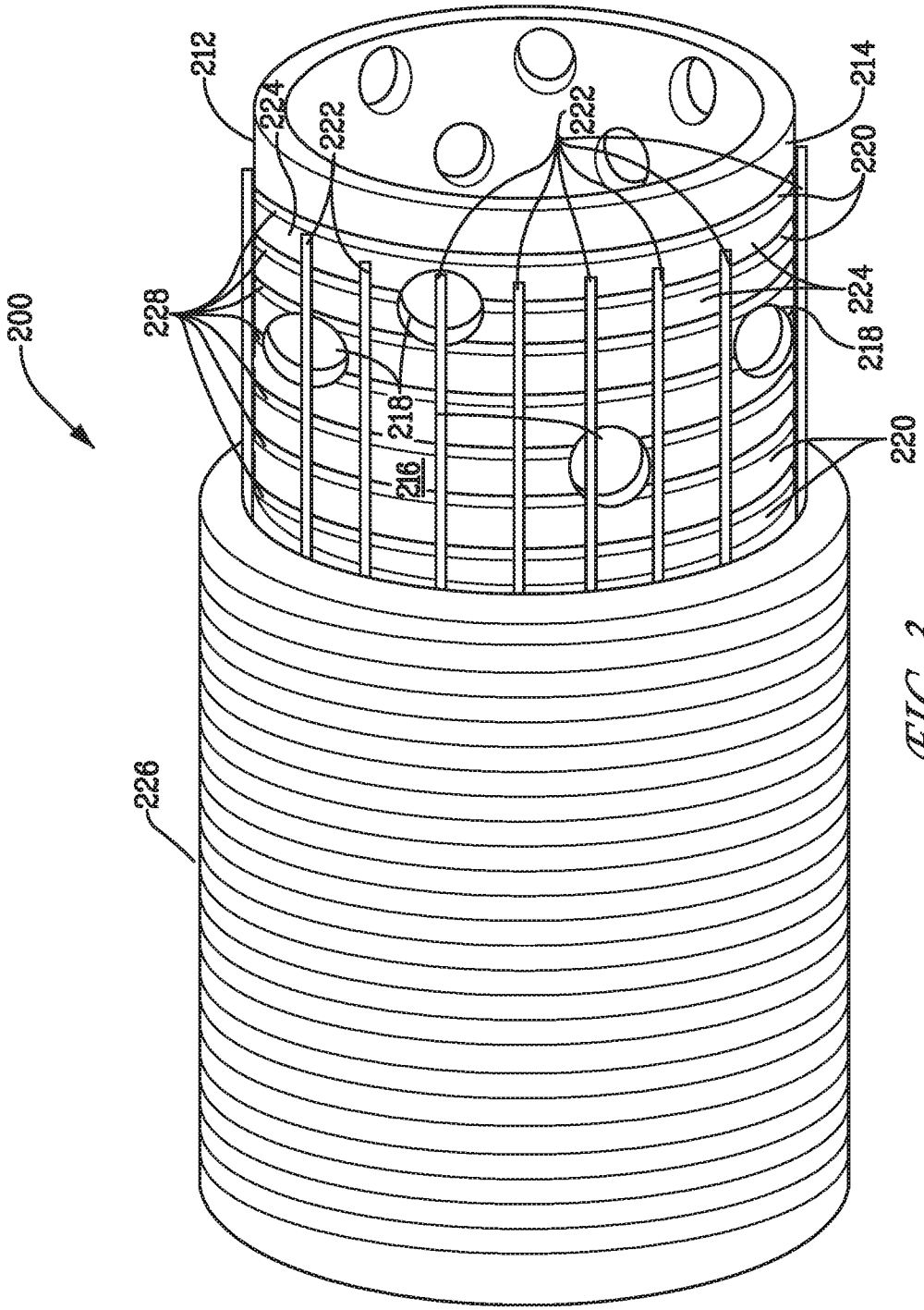
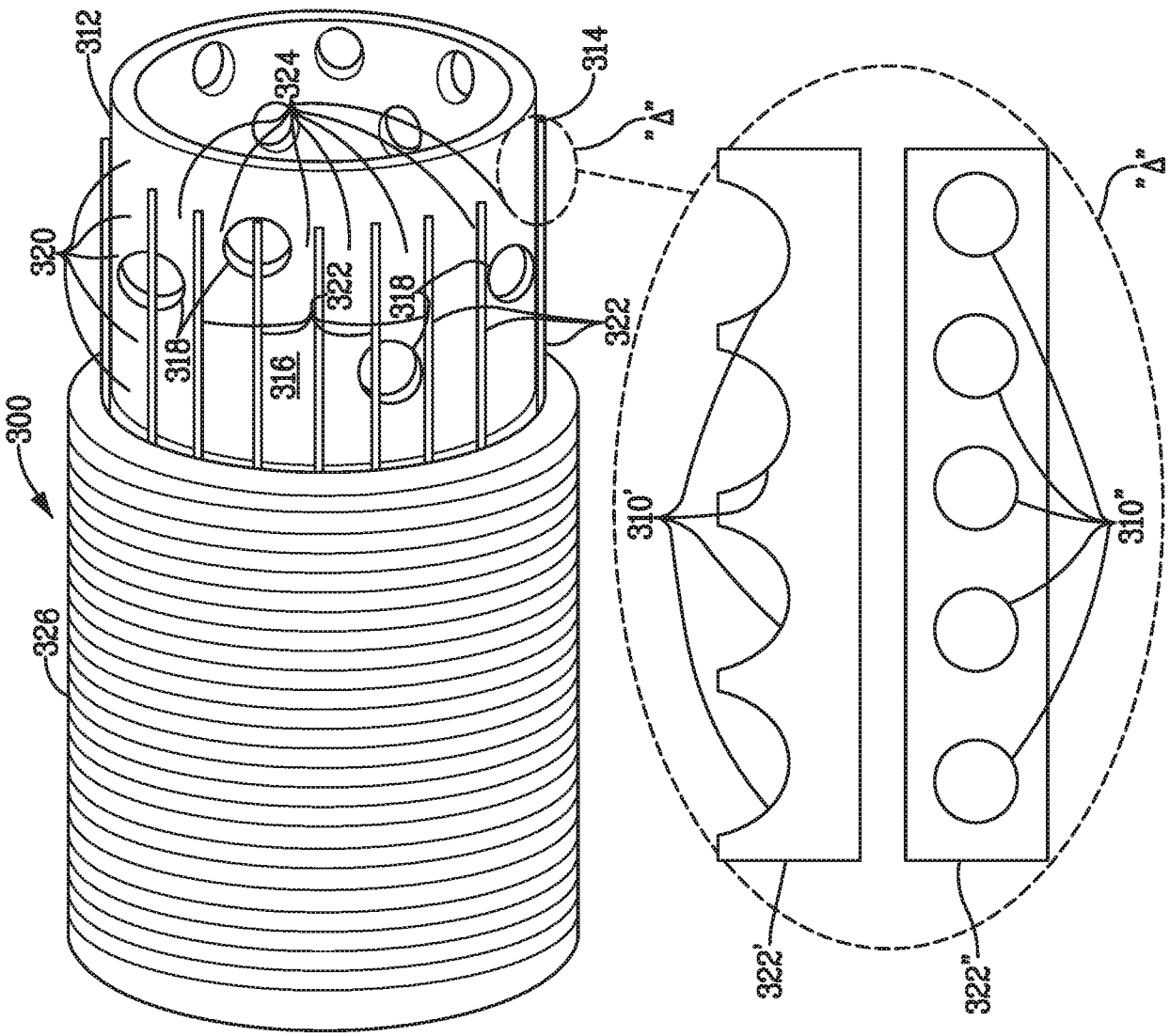


FIG. 3

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/041972

A. CLASSIFICATION OF SUBJECT MATTER
INV. E21B43/08
ADD.

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 B01D

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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X	US 2008/289815 A1 (MOEN TERJE [NO] ET AL) 27 November 2008 (2008-11-27) paragraph [0023]; figures 3,5,9 paragraph [0030] - paragraph [0031]; claims 13-17	1,10-12, 15,18-20
X Y	US 5 957 205 A (BOHME CALVIN G [CA] ET AL) 28 September 1999 (1999-09-28) figures 5,6	1,10,11, 14,15,20 13
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 October 2016	20/10/2016

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/041972

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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