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(54) Title: DUAL-WALLED COILED TUBING DEPLOYED PUMP

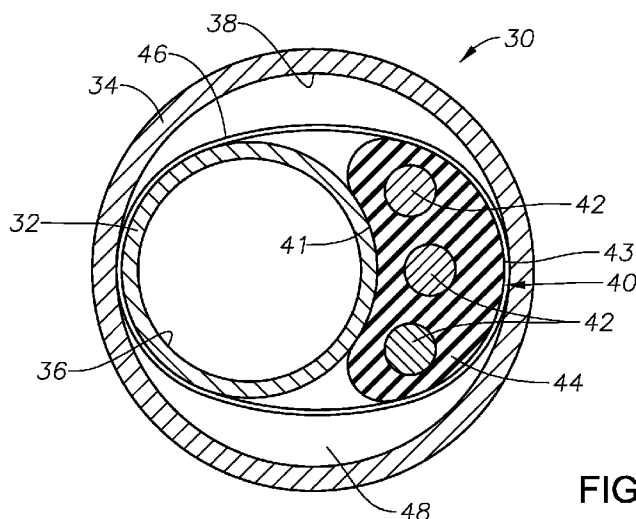


FIG. 3

(57) Abstract: Dual-walled coiled tubing assemblies are used to dispose an electric device, such as an electric submersible pump into a wellbore. Dual-walled coiled tubing assemblies include an Inner coiled tubing string and an outer coiled tubing string as well as a power cable.



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DUAL-WALLED COILED TUBING DEPLOYED PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates generally to the use of strings of coiled tubing to dispose devices, such as electrical submersible pumps into a wellbore.

2. Description of the Related Art

[0002] Electric submersible pumps (ESPs) are used to pump hydrocarbon fluids and/or water from subterranean locations. ESPs require electrical power to be supplied to them from surface. A typical ESP assembly includes a centrifugal pump that is mounted to an electrical motor. A power cable extends from the surface to the motor of the ESP assembly. Conventionally, when ESPs are run into a wellbore, the power cable is strapped to the outer surface of production tubing sections.

SUMMARY OF THE INVENTION

[0003] The invention provides systems and methods for disposing an ESP, or similar device, into a wellbore using running arrangements which incorporate inner and outer coiled tubing strings as well as a power cable which provides power to the motor of the ESP. In a first described embodiment, a power cable is disposed radially between inner and outer coiled tubing strings. In a second described embodiment, a power cable is disposed within the inner coiled tubing string. These running arrangements provide flow paths which allow for the flow of produced fluids. In certain embodiments, two flow paths are provided.

[0004] The use of dual-walled coiled tubing string running assemblies provides the possibility of injecting an ESP into a live well which has pressure at surface.

Depending upon the corrosiveness of the wellbore environment and the cable location

(i.e., within the inner coiled tubing string or between the inner and outer coiled tubing strings), tubing of different grades, including Cr16, could be used. With the proper selection of coiled tubing and ESP components, arrangements constructed in accordance with the present invention provide the potential to run an ESP assembly deeper into a well than conventional technologies permit.

[0005] Production arrangements are described which use dual-walled coiled tubing run ESPs to produce hydrocarbon production fluids from wellbores. Embodiments are described wherein capillary lines are located within the dual-walled coiled tubing assembly. The invention encompasses dual-walled coiled tubing assemblies that are used to dispose an electric device (such as an ESP) into a wellbore. Additionally, the invention encompasses hydrocarbon production assemblies that include an ESP as well as a dual-walled coiled tubing assembly that is used to dispose the ESP into a wellbore.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The advantages and further aspects of the invention will be readily appreciated by those of ordinary skill in the art as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference characters designate like or similar elements throughout the several figures of the drawing and wherein:

[0007] Figure 1 is a side, cross-sectional view of an exemplary wellbore within which is disposed a dual-walled coiled tubing running arrangement and an ESP assembly in accordance with the present invention.

[0008] Figure 1a is a side, cross-sectional view of a wellbore within which is disposed an alternative dual-walled coiled tubing running arrangement and ESP assembly.

[0009] Figure 1b is a side, cross-sectional view of a wellbore within which is disposed a further alternative dual-walled coiled tubing running arrangement and ESP assembly.

[0010] Figure 2 is a side, cross-sectional view of a first embodiment for a dual-walled coiled tubing running arrangement which might be used with the ESP assembly shown in Figs. 1, 1a or 1b.

[0011] Figure 2a is a side, cross-sectional view of a modified first embodiment for a dual-walled coiled tubing running arrangement wherein the inner coiled tubing string and power cable are twisted to form a spiral configuration.

[0012] Figure 2b is a side, cross-sectional view of a further modified embodiment for a dual-walled coiled tubing running arrangement wherein the inner coiled tubing string and power cable are twisted to form a spiral configuration.

[0013] Figure 3 is an axial cross-section taken along lines 3-3 in Figure 2.

[0014] Figure 4 is a side, cross-sectional view of an alternative embodiment for a dual-walled coiled tubing running arrangement which might be used with the ESP assembly shown in Fig. 1.

[0015] Figure 5 is an axial cross-section taken along lines 5-5 in Figure 4.

[0016] Figure 6 is a side, cross-sectional view of the lower end of a hydrocarbon production assembly being used to produce gas-impregnated production fluid.

[0017] Figure 7 is an axial cross-sectional view of a dual-walled coiled tubing assembly containing capillary lines in a first exemplary arrangement.

[0018] Figure 8 is an axial cross-sectional view of an exemplary dual-walled coiled tubing assembly containing capillary lines in a second exemplary arrangement.

[0019] Figure 9 is an axial cross-sectional view of an exemplary dual-walled coiled tubing assembly containing capillary lines in a third exemplary arrangement.

[0020] Figure 10 is an axial cross-sectional view of an exemplary dual-walled coiled tubing assembly containing capillary lines in a fourth exemplary arrangement.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 [0021] The term "dual-walled," as used herein, is intended to refer broadly to arrangements wherein an inner tubular string or member is located radially within an outer tubular string or member to provide a dual-walled tubing structure. A structure can be dual-walled without regard to whether the inner and outer tubular strings are coaxial or concentric.

10 [0022] Figure 1 depicts an exemplary wellbore 10 that has been drilled through the earth 12 from the surface 14 down to a hydrocarbon-bearing formation 16. It is desired to pump hydrocarbon fluids from the formation 16 to the surface 14. It is noted that, while wellbore 10 is illustrated as a substantially vertical wellbore, it might, in practice, have portions that are inclined or horizontally-oriented. The wellbore 10 is lined with
15 metallic casing 18 in a manner known in the art.

[0023] In the arrangement shown in Figure 1, an electric submersible pump (ESP) assembly 20 is disposed within the wellbore 10 having been run in by a coiled tubing running arrangement 22. There is no downhole packer. The ESP assembly 20 includes a motor 24 and a fluid pump 26 which is powered by the motor 24. In
20 operation, production fluid is drawn into fluid inlets 27 of the pump 26 and exits via the top of the pump 26 into the coiled tubing running arrangement 22. Conduit 28 transmits electrical power past the pump 26 and to the motor 24. The ESP assembly 20 might also incorporate a seal section or other components as is known in the art.

[0024] According to a second exemplary arrangement, which is depicted in Figure
25 1a, an ESP assembly 20 is disposed within wellbore 10 below a downhole packer 70

and having been run in by a coiled tubing running arrangement 22. The ESP assembly 20 includes a motor 24 and a fluid pump 26 which is powered by the motor 24. In operation, production fluid is drawn into fluid inlets 27 of the pump 26 and exits via the top of the pump into the running arrangement 22 or into the casing annulus 29, or both, as illustrated by arrows 25. The electrical conduit 28 transmits electrical power through the packer 70 past the pump 26 and to the motor 24. Conduit 28 may contain hydraulic lines and or instrumentation lines as well as the electrical cable powering the motor 24. The ESP assembly 20 might also incorporate a seal section or other components as is known in the art.

[0025] Figure 1b depicts a third exemplary arrangement which includes a downhole packer 70. An ESP assembly 20 is disposed within the wellbore 10 above the downhole packer 70, having been run in by a dual-walled coiled tubing assembly 22. The ESP assembly 20 includes a motor 24 and a fluid pump 26 which is powered by the motor 24. In operation, production fluid is drawn into the bottom of the packer 70, from there into the bottom of pump 26 and exits via the top of the pump 26 into the annulus 29. In this example, the motor 24 is located above the pump 26. Electrical power is supplied to the motor 24 directly via the dual-walled coiled tubing assembly 22. The ESP assembly 20 might also incorporate a seal section or other components as is known in the art. It is noted that there may be other arrangements depicting different locations of the motor 24 relative to the pump 26 and either of these relative to the packer 70. It is also noted that there may be additional combinations of production flow paths available within or outside the dual-walled coiled tubing assembly 22.

[0026] Figures 2 and 3 illustrate a first embodiment for a dual-walled coiled tubing assembly 30 which might be used for the coiled tubing running arrangement 22. The

dual-walled coiled tubing assembly 30 includes an inner coiled tubing string 32 and an outer coiled tubing string 34 which radially surrounds the inner coiled tubing string 32. The inner coiled tubing string 32 defines an inner coiled tubing central axial passage 36 along its length. The outer coiled tubing string 34 also defines an outer coiled tubing central axial passage 38 along its length. Exemplary sizes for the inner and outer coiled tubing strings 32, 34 would be: 1.25" O.D. x 0.125" wall thickness for the inner coiled tubing string 32 and 2.375" O.D. x 0.156" wall thickness for the outer coiled tubing string 34. However, these dimensions are exemplary only, and other sizes and dimensions might be used. The inner and outer coiled tubing strings 32, 34 are normally connected together mechanically at surface and downhole ends and both would be hung off from the wellhead. Therefore, both strings 32, 34 may aid in supporting the weight of the ESP assembly 20 as well as the inner and outer coiled tubing strings 32, 34 and power cable 40.

[0027] A power cable 40 is disposed radially between the inner and outer coiled tubing strings 32 and 34. The depicted power cable 40 has three electrical conductors 42 contained within an insulating sheath 44. The power cable 40 may contain other elements, such as a gas barrier, a jacket or armor, as generally known in the art. Although three power conductors 42 are depicted and are typical, there may be more or fewer than three depending upon the requirements for downhole power and control. Referring to Figure 3, it can be seen that the power cable 40 preferably has a generally kidney-shaped or oblong, curved cross-sectional area. This cross-sectional shape permits the cable 40 to fit between the inner and outer coiled tubing strings 32, 34. The side surface 41 of the cable 40 which abuts the inner coiled tubing string 32 is concave and curved in a manner to be generally complementary to the outer surface of the inner coiled tubing string 32. The opposite side surface 43 of the cable 40 is

convex and curved in a manner to be generally complementary to the inner surface of the outer coiled tubing string 34. It should be noted that the cable 40 need not necessarily have a kidney shape, but may, if desired, be round, rectangular or have other cross-sectional shapes. The cable 40 may be built flat or installed flat to bend somewhat during installation to substantially match the outer contour of the inner coiled tubing string 32. Alternatively, the cable 40 may become bent into a curved or kidney shape due to the clamping forces of straps 46. Friction between the cable 40/inner coiled tubing string 32 and the outer coiled tubing string 34 will help transmit a portion of the weight of the cable 40 and ESP assembly 20 to the outer coiled tubing string 34.

[0028] Flexible straps 46 are used to secure the cable 40 to the inner coiled tubing string 32. The term "strap" is used here to denote any form of tensile or compressive fastener, such as a cable, rope, tie, binder, clamp and the like. The straps 46 may be secured about the cable 40 and inner coiled tubing string 32 by tightening, tying, latching, bolting or in other ways known in the art. The straps 46 enclose both the cable 40 and inner coiled tubing string 32. When the dual-walled coiled tubing assembly 30 is assembled, an axial fluid flowpath 48 is defined within the outer coiled tubing string 34. In the depicted assembly 30, the central axial passage 36 provides a first axial fluid flowpath while the axial fluid flowpath 48 serves a second axial fluid flowpath. The presence of two, separate axial fluid flowpaths within a single assembly 30 provides the advantage of allowing two separate streams of fluid to be transmitted along the assembly 30. Fluids might be transmitted uphole as a result of the ESP pump 26 or transmitted downhole in instances wherein one of the flow paths is being used to inject specialized fluids, which might include scale or asphaltene inhibitors.

[0029] It is noted that the inner coiled tubing string 32 is shown as offset from the center of the outer coiled tubing string 34 due to the presence of the cable 40. As illustrated in Fig. 2a, the cable 40 and inner coiled tubing string 32 are preferably twisted along their length to provide a spiral configuration. An alternative embodiment is depicted in Fig. 2b wherein the cable 40 is spiraled around the inner coiled tubing string 32. The inventors have determined that these spiral configurations are desirable since they distribute the stresses on the cable 40 more uniformly as the dual-walled coiled tubing assembly 30 is spooled onto and off of a reel. It should be appreciated that, in alternative embodiments, the coiled tubing strings 32, 34 may be arranged concentrically rather than having offset centers.

[0030] The dual-walled coiled tubing assembly 30 may be assembled by first disposing the cable 40 in parallel contact with the inner coiled tubing string 32 and then affixing the cable 40 to the inner coiled tubing string 32 with straps 42. Preferably, the straps 42 are used to affix the cable 40 to the inner coiled tubing string 32 in appropriate spaced intervals which are sufficient to affix the cable 40 to the inner coiled tubing string 32 without permitting a large degree of sagging of the cable 40 and to ensure that the cable weight is held uniformly by the inner coiled tubing string 32 in order to prevent breakage of the cable 40. Thereafter, the inner coiled tubing string 32 and affixed cable 40 are disposed into the outer coiled tubing string 34. This may be done vertically while the outer coiled tubing string 34 is hanging in a well. Alternatively, it may be done horizontally with the outer coiled tubing string 34 stretched out and with the inner coiled tubing string 32 and affixed cable 40 either pushed or pulled into the outer coiled tubing string 34. Metal-to-metal lubricants can be used to reduce the contact friction and ease the installation. More typically, the cable 40 can be fastened to the inner coiled tubing string 32 as the inner coiled tubing

string 32 is disposed into the outer coiled tubing string 34. As the cable 40 is affixed to the inner coiled tubing string 32, both are disposed into the outer coiled tubing string 34. This may be done vertically as the outer coiled tubing string 34 is hanging in a well. Alternatively, it may be done horizontally with the outer coiled tubing string 34 stretched out and with the inner coiled tubing string 32 either pushed or pulled into the outer coiled tubing string 34, taking the cable 40 along with it. Again, metal-to-metal lubricants can be used to reduce the contact friction and ease installation.

[0031] An assembled dual-walled coiled tubing assembly 30 can be wound onto a coiled tubing reel of a type known in the art for retaining spools of coiled tubing and transported to a well site for use. An ESP assembly, such as ESP assembly 20 is then affixed to the coiled tubing assembly 30 and run into the wellbore in conventional fashion.

[0032] A further method of injecting cable through a coiled tubing string would be to use a water-based metal-on-metal lubricant with a low coefficient of friction, such as EasyReach™ lubricant, that will permit longer lengths of cables and coiled tubing strings to be disposed within surrounding coiled tubing strings. Modeling of these lengths could be performed taking into account coiled tubing sizes and cable sizes and using suitable software designed for design and planning for coiled tubing operations.

[0033] Figures 4-5 illustrate an alternative embodiment for a dual-walled coiled tubing assembly 50 which might be used for the coiled tubing running arrangement 22. The dual-walled coiled tubing assembly 50 includes an inner coiled tubing string 32 and an outer coiled tubing string 34. Power cable 40' is disposed within the central axial passage 36 of the inner coiled tubing string 32. Power cable 40' preferably has a circular cross-section and is shaped and sized to fit tightly within the central axial

passage 36 of the inner coiled tubing string 32. To the extent that there is a radial gap 51 between the power cable 40' and the inner coiled tubing string 32, this gap 51 may be used as a second and separate flow path to transmit fluid through the dual-walled coiled tubing assembly 50. Alternatively, power cable 40' may have a non-circular cross-section or may not fit tightly within the central axial passage 36 of the inner coiled tubing string 32. The power cable 40' may fit loosely and rely upon the contact friction of its spiraled shape within the inner coiled tubing string 32 to support its weight. Also, the power cable 40' may fit loosely and be supported at regular intervals by support clamps attached to the cable 40'. In these situations, there could be fluid flow past the cable 40'.

[0034] The dual-walled coiled tubing assembly 50 may be assembled by first disposing the cable 40' into the central axial passage 36 of the inner coiled tubing string 32. This may be done vertically by lowering the cable 40' into the inner coiled tubing string 32 while it is hanging vertically in a well. Alternatively, it may be done horizontally with the inner coiled tubing string 32 stretched out and with the cable 40' pulled into the inner coiled tubing string 32. Once more, metal-to-metal lubricants can be used to reduce the contact friction and ease installation. The cable 40' may also be placed into the inner coiled tubing string 32 while the inner coiled tubing string 32 is being manufactured. The inner coiled tubing string 32 and cable 40' are then inserted into the outer coiled tubing string 34. These two previous steps may be reversed. An assembled dual-walled coiled tubing assembly 50 can be wound onto a coiled tubing reel of a type known in the art for retaining spools of coiled tubing and transported to a well site for use. An ESP assembly, such as ESP assembly 20 is then affixed to the coiled tubing assembly 50 and run into the wellbore 10.

[0035] The inventors believe that dual-walled coiled tubing assemblies constructed in accordance with the present invention are advantageous for running ESPs into wellbores. The cable 40 is protected from damage since it is contained within the protection of the outer coiled tubing string 34. Such damage has been known to occur as a result of wellbore debris or disposal of the cable through deviated or horizontal wellbore portions. In some constructions, dual fluid flowpaths are available for flow of fluid along the assembly. Additionally, disposing the cable within the outer coiled tubing string 34 permits a standard packer to be set in the wellbore without the need for a specialized arrangement having a bypass to allow a separate cable to be disposed through the packer. The various fluid flowpaths provided by the dual-walled coiled tubing assemblies (i.e., 30, 50) of the present invention might also provide one or more pressurized paths for use in downhole activation schemes in which a port is opened or closed or a tool, such as a packer is activated.

[0036] Figure 6 illustrates an exemplary production arrangement which incorporates a dual-walled coiled tubing assembly in accordance with the present invention and which is being used to produce gas-impregnated production fluid. A production assembly 60 includes dual-walled coiled tubing assembly 30 wherein dual fluid flowpaths are provided. An ESP assembly 20 is affixed to the dual-walled coiled tubing assembly 30 and includes a motor section 24, pump section 26 and a gas separator section 29 of a type known in the art. First and second bypass conduits 62 and 64 extend from the gas separator section 29 past the motor section 24 and enter the dual-walled coiled tubing assembly 30. The bypass conduits 62, 64 are shown in Fig 6 to be located external to the ESP assembly 20 but may, more typically, be located internally within the ESP assembly 20. During operation, the gas separator section 29 separates gas from the raw feed of gas-impregnated hydrocarbon production fluid. In

particular, flow (indicated by arrow 66) from the first bypass conduit 62 is directed into axial fluid flowpath 48. The remaining hydrocarbon production fluid is directed through second bypass conduit 64 (arrow 68) into axial fluid flowpath 36. The dual-walled coiled tubing assembly 30 is shown passing through a packer 70. Because in this example the power cable 40 is retained within the outer coiled tubing string 34, a conventional packer 70 may be used without the need for a device that allows for a separate pass-through for the cable 40.

[0037] An arrangement which the inventors believe would be desirable for certain production situations would be an arrangement similar to that depicted in Fig. 1 with hydrocarbon flow up one flow path. A second arrangement which the inventors believe would be desirable for certain production situations would be an arrangement similar to that shown in Fig. 1a with fluid flow going up one flow path and with the outer coil casing annulus isolated by the packer 70. Both of these arrangements become possible for installation into live wells due to the ability to seal around the outer coiled tubing string 34 using conventional coiled tubing running equipment. This removes the possibility of well damage resulting from having to kill the well during conventional tubing installation. The inventors believe that using dual-walled coiled tubing assemblies with conventional equipment improves the speed of installation of the ESP as opposed to conventional tubing, thereby minimizing down time, lost production time and reducing cost.

[0038] Figures 7, 8 and 9 illustrate exemplary placements for capillary lines within dual-walled coiled tubing assemblies in accordance with the present invention. Capillary lines may be used to provide hydraulic motive force to actuate valves or to inflate or release certain hydraulic downhole equipment. Alternatively, capillary lines can be used to provide conduits to inject specialized fluids into the dual-walled tubing

assembly 30 or 50 at depth. These specialized fluids may include scale or asphaltene inhibitors. In further embodiments, capillary lines are instrumentation lines which can, for example, be used to monitor downhole temperatures or pressures among other downhole parameters. In further embodiments, high strength steel cables (or other material) can be installed within the ESP bundle, their purpose being to carry some of the ESP cable weight. In each described embodiment, capillary lines are retained radially inside of the outer coiled tubing string, thereby providing protection from damage for the capillary lines.

[0039] Figure 7 depicts a first exemplary dual-walled coiled tubing assembly 72 which is similar in most respects to the dual-walled coiled tubing assembly 30 described previously. The dual-walled coiled tubing assembly 72 includes an inner coiled tubing string 32 and an outer coiled tubing string 34 as well as power cable 40. Capillary lines 74 are disposed within the outer coiled tubing central axial pathway 38 alongside the inner coiled tubing string 32 and the cable 40. Straps 46 secure the cable 40 and the capillary lines 74 to the inner coiled tubing string 32.

[0040] Figure 8 illustrates an alternative exemplary dual-walled coiled tubing assembly 76. The dual-walled coiled tubing assembly 76 includes an inner coiled tubing string 32 and an outer coiled tubing string 34 as well as power cable 40a. Capillary lines 74 are disposed within the power cable 40a alongside the conductors 42.

[0041] Figure 9 depicts a further alternative exemplary dual-walled coiled tubing assembly 78 in accordance with the present invention. The dual-walled coiled tubing assembly 78 is similar in many respects to the dual-walled coiled tubing assembly 50 described previously. The dual-walled coiled tubing assembly 78 includes inner coiled tubing string 32 and an outer coiled tubing string 34. Power cable 40' is disposed

within the inner coiled tubing string central axial passage 36. Capillary lines 74 are disposed radially between inner coiled tubing string 32 and outer coiled tubing string 34. Straps 46 secure the capillary lines 74 to the inner coiled tubing string 32. A fluid flow path 48 defined within the dual-walled coiled tubing assembly 78.

5 **[0042]** Figure 10 depicts a further alternative exemplary dual-walled coiled tubing assembly 80 which is similar in many respects to the dual-walled coiled tubing assembly 50 described previously. The dual-walled coiled tubing assembly 80 includes inner coiled tubing string 32 and outer coiled tubing string 34. Power cable 40' is disposed within the inner coiled tubing string 32 central axial passage 36.
10 Capillary lines 74 are disposed within the power cable 40' alongside the conductor 42. A fluid flow path 48 is defined within the dual-coiled tubing assembly 80. Where there are multiple capillary lines 74, at least first and second fluid injection paths are provided within the outer coiled tubing string 34 by the multiple capillary lines.

[0043] The use of dual-walled coiled tubing assemblies, such as assemblies 30, 50
15 described herein, provide the possibility of injecting an ESP assembly 20 into a live wellbore 10 which is under pressure from surface 14. Because the power cable 40/40'/40a is contained within the outer coiled tubing string 34, it is mechanically protected from damage due to friction or abrasion with a surrounding casing or other objects or surfaces during run-in. ESPs run on standard coiled tubing or on regular
20 tubing, where the power cable is strapped to the outside of the tubing, the ESP assembly cannot normally be run into live wells since there is currently not an effective way to seal around the tubing and cable during running in. Therefore, the pressure at surface cannot be contained. In order to run into a live wellbore, in one embodiment, the system would be sealed into a downhole packer and fluid produced up the dual-
25 walled coiled tubing assembly.

[0044] Depending upon the corrosiveness of the wellbore environment into which the ESP 20 will be run, and the location of the power cable 40 or 40'/40a, coiled tubing of different grades, including Cr16 grade stainless steel, could be used. For example, depending upon downhole conditions, the inner and outer coiled tubing strings 32, 34
5 may be made of different grades of steel, thereby maximizing their resistance to corrosion.

[0045] The foregoing description is directed to particular embodiments of the present invention for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes to the embodiment set
10 forth above are possible without departing from the scope and the spirit of the invention.

CLAIMS

What is claimed is:

1. A dual-walled coiled tubing assembly to dispose an electric submersible pump (20) into a wellbore, the dual-walled coiled tubing assembly characterized by:
an inner coiled tubing string (32) defining an inner coiled tubing central axial passageway (36) along its length;
an outer coiled tubing string (34) radially surrounding the inner coiled tubing string, the outer coiled tubing string defining an outer coiled tubing string central axial passage (38) along its length; and
a power cable (40) to provide electric power to the electric submersible pump, the power cable being disposed within the outer coiled tubing string central axial passage.

2. The dual-walled coiled tubing assembly of claim 1 wherein the power cable (40) is further disposed within the inner coiled tubing central axial passageway (36).

3. The dual-walled coiled tubing assembly of claim 1 wherein the power cable (40) is disposed radially between the inner coiled tubing string (32) and the outer coiled tubing string (34).

4. The dual-walled coiled tubing assembly of claim 1 further characterized by one or more capillary lines (74) disposed within the outer coiled tubing string (34).

1 5. The dual-walled coiled tubing assembly of claim 4 wherein the one or more
2 capillary lines (74) is/are located radially between the inner coiled tubing string (32)
3 and the outer coiled tubing string (34).

1 6. The dual-walled coiled tubing assembly of claim 4 wherein the one or more
2 capillary lines (74) is/are located radially within the inner coiled tubing string (32).

1 7. The dual-walled coiled tubing assembly of claim 4 wherein the one or more
2 capillary lines (74) is/are located within the power cable (40).

1 8. The dual-walled coiled tubing assembly of claim 1 further characterized by
2 separate first and second fluid flow paths (36, 48) defined within the outer coiled tubing
3 string (34).

1 9. The dual-walled coiled tubing assembly of claim 1 further characterized by at
2 least one strap (46) securing the power cable (40) to the inner coiled tubing string (32).

1 10. The dual-walled coiled tubing assembly of claim 1 wherein the electric
2 submersible pump (20) includes a pump section (26) and a motor section (24).

1 11. The dual-walled coiled tubing assembly of claim 1 wherein the power cable (40)
2 presents an axial cross-section having:

3 a first side surface (41) that is concave and shaped to be generally
4 complementary to an outer radial surface of the inner coiled tubing string (32); and

5 a second side surface (43) that is convex and shaped to be generally
6 complementary to an inner radial surface of the outer coiled tubing string (34).

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1 12. A hydrocarbon production assembly to produce hydrocarbon fluid from a
2 wellbore, the production assembly being characterized by:

3 an electric submersible pump (20);

4 a dual-walled coiled tubing assembly (22) to dispose the electric submersible
5 pump into the wellbore, the dual-walled coiled tubing assembly comprising:

6 an inner coiled tubing string (32) defining an inner coiled tubing central axial
7 passageway (36) along its length;

8 an outer coiled tubing string (34) radially surrounding the inner coiled tubing
9 string, the outer coiled tubing string defining an outer coiled tubing string central axial
10 passage (38) along its length; and

11 a power cable (40) to provide electric power to the electric submersible pump,
12 the power cable being disposed within the outer coiled tubing string central axial
13 passage.

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1 13. The hydrocarbon production assembly of claim 12 wherein the power cable (40)
2 is further disposed within the inner coiled tubing central axial passageway (36).

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1 14. The hydrocarbon production assembly of claim 12 wherein the power cable (40)
2 is disposed radially between the inner coiled tubing string (32) and the outer coiled
3 tubing string (34).

- 1 15. The hydrocarbon production assembly of claim 12 further comprising one or
2 more capillary lines (74) disposed within the outer coiled tubing string (34).

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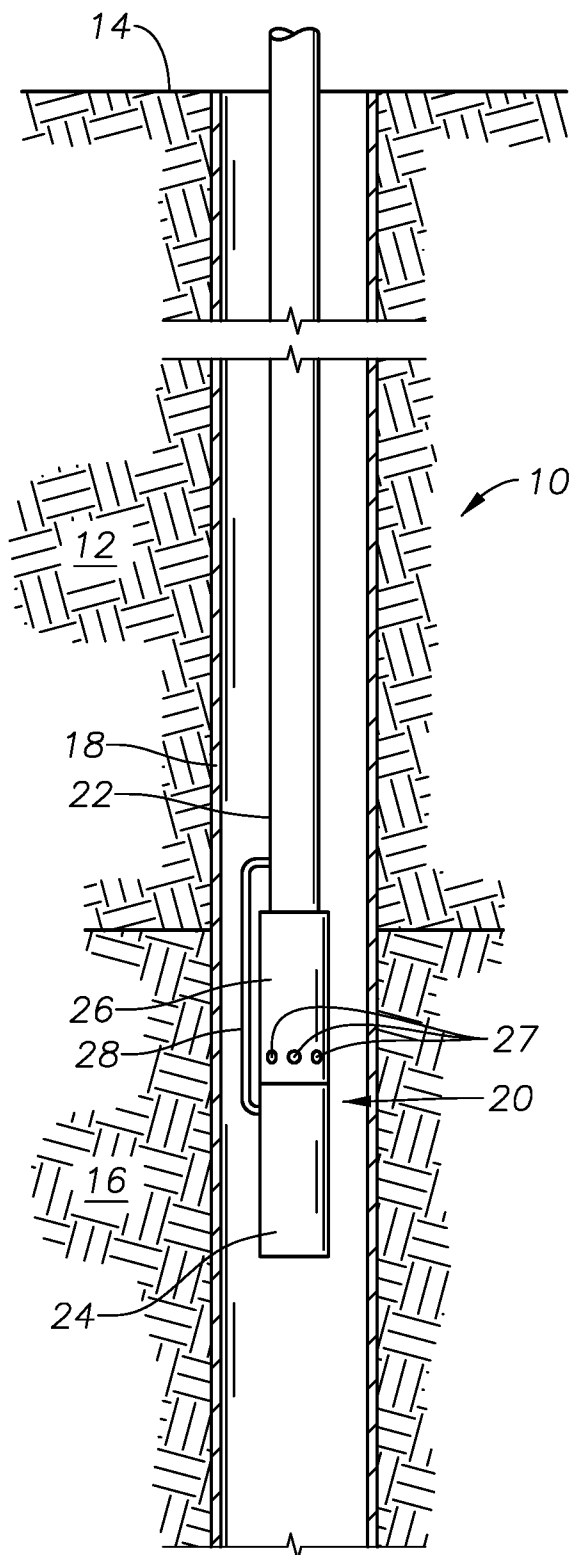


FIG. 1

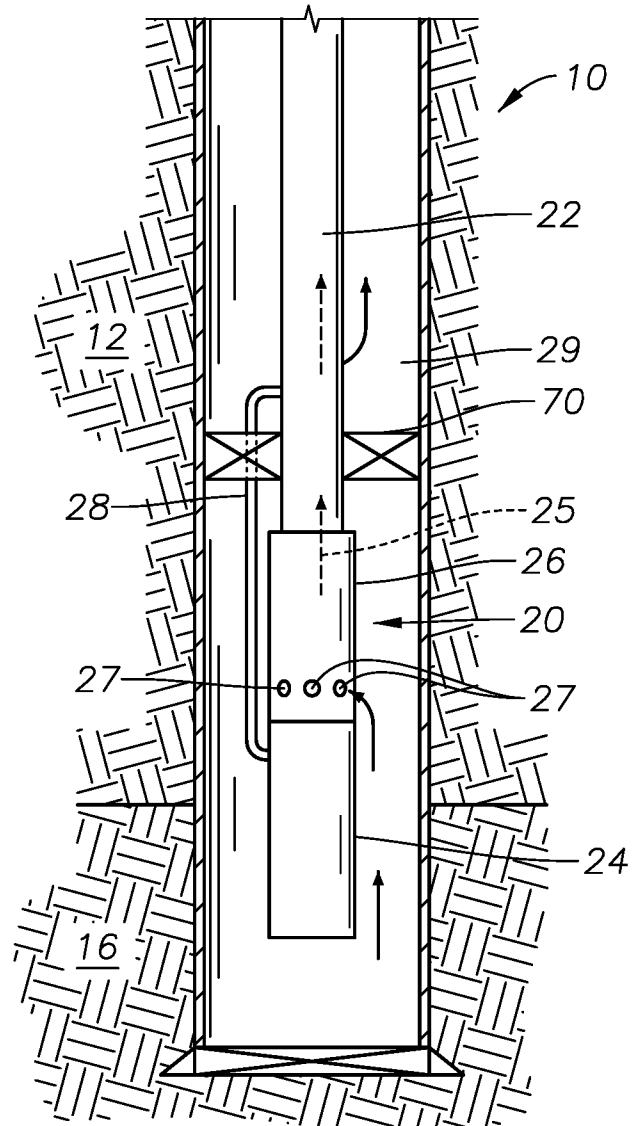


FIG. 1a

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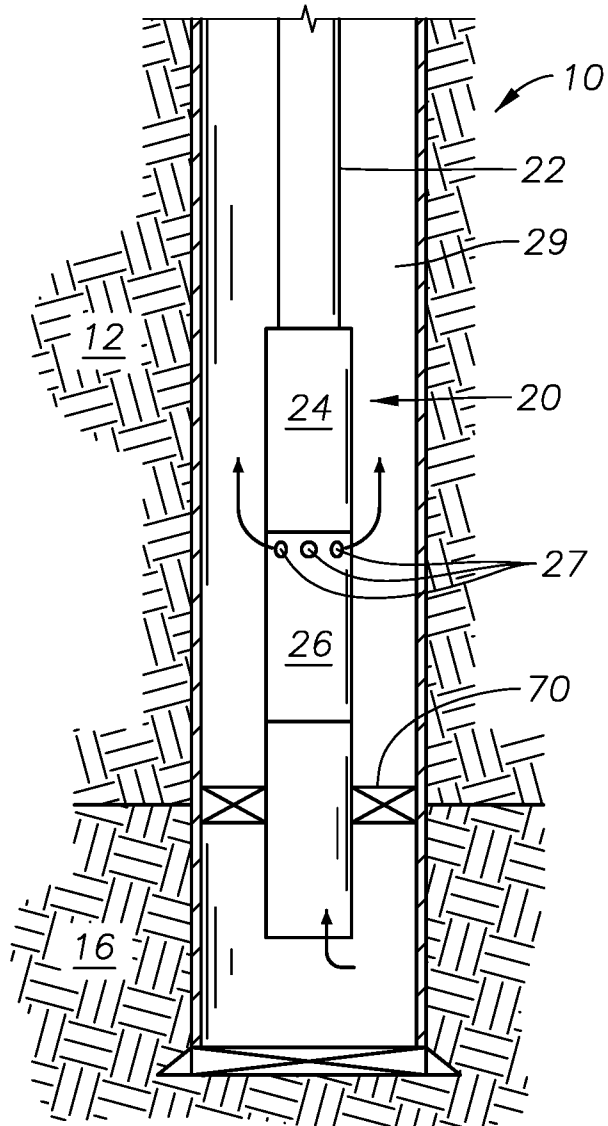


FIG. 1b

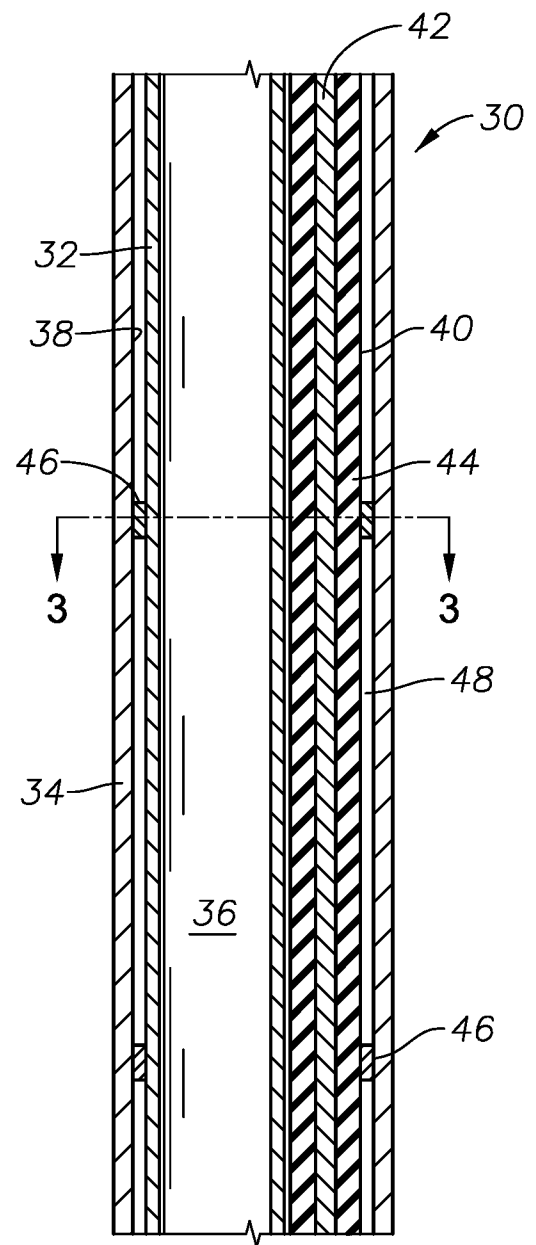


FIG. 2

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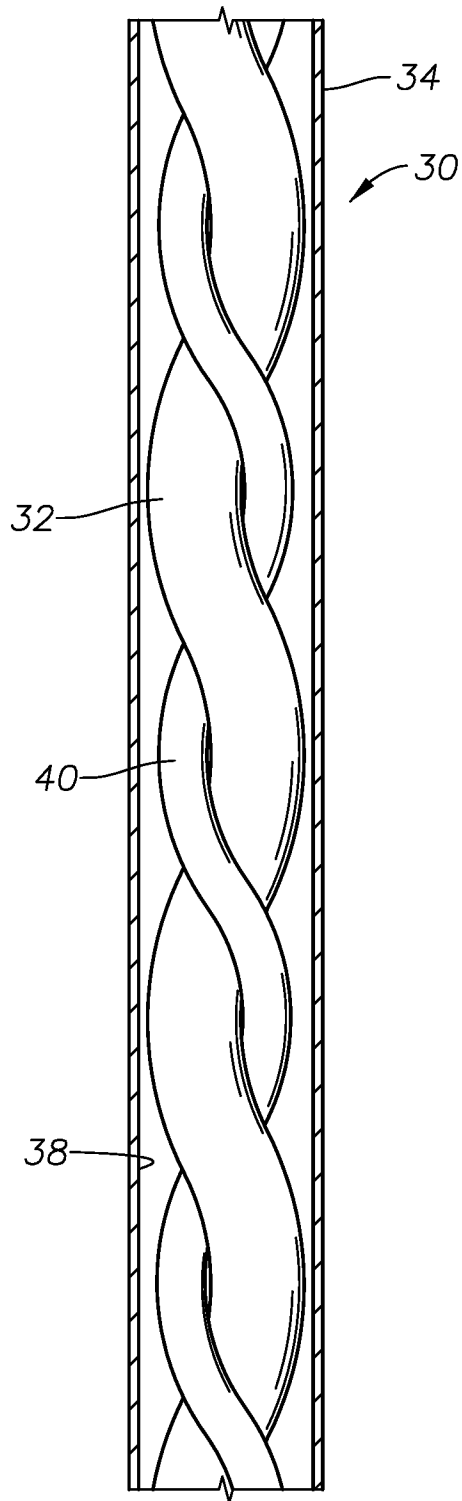


FIG. 2a

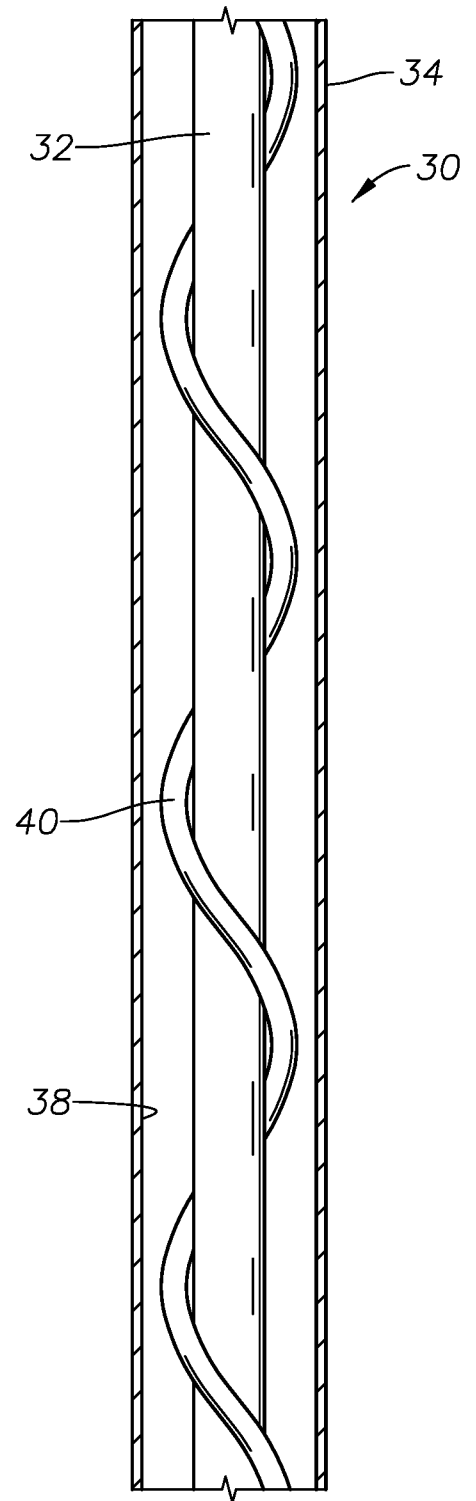


FIG. 2b

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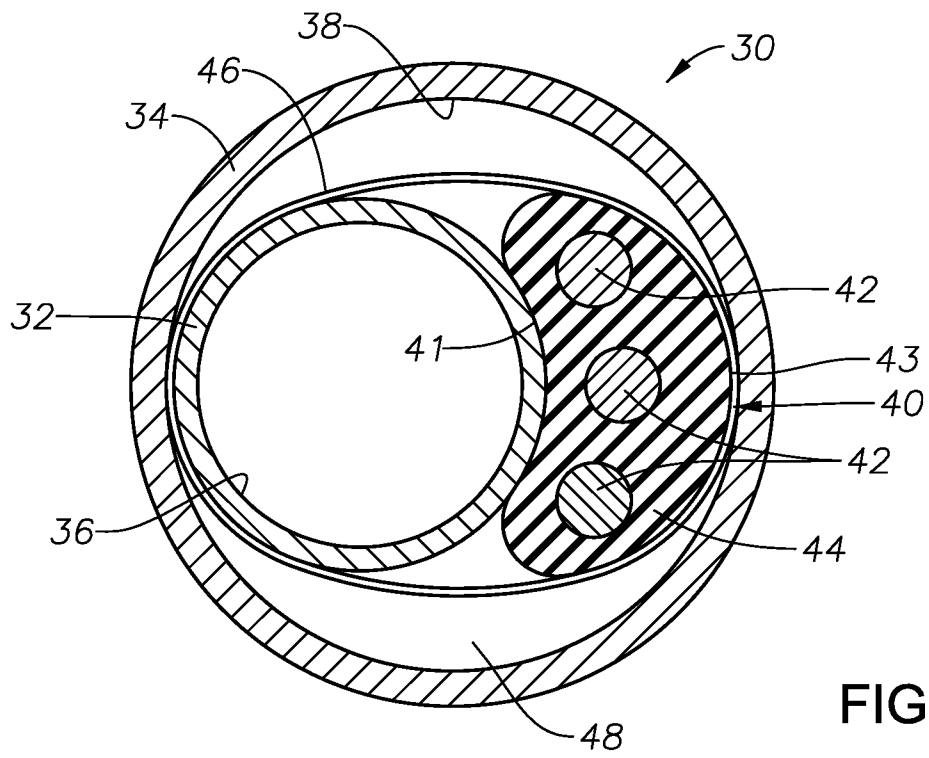


FIG. 3

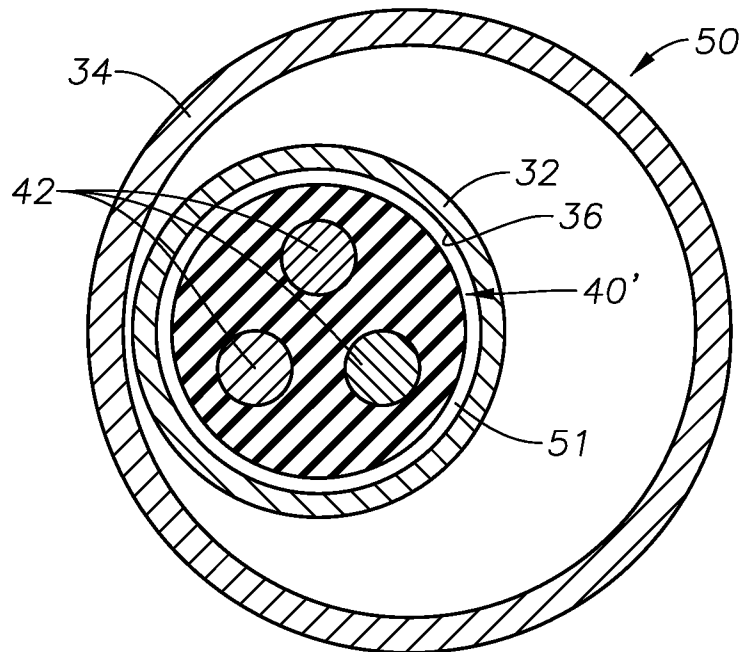


FIG. 5

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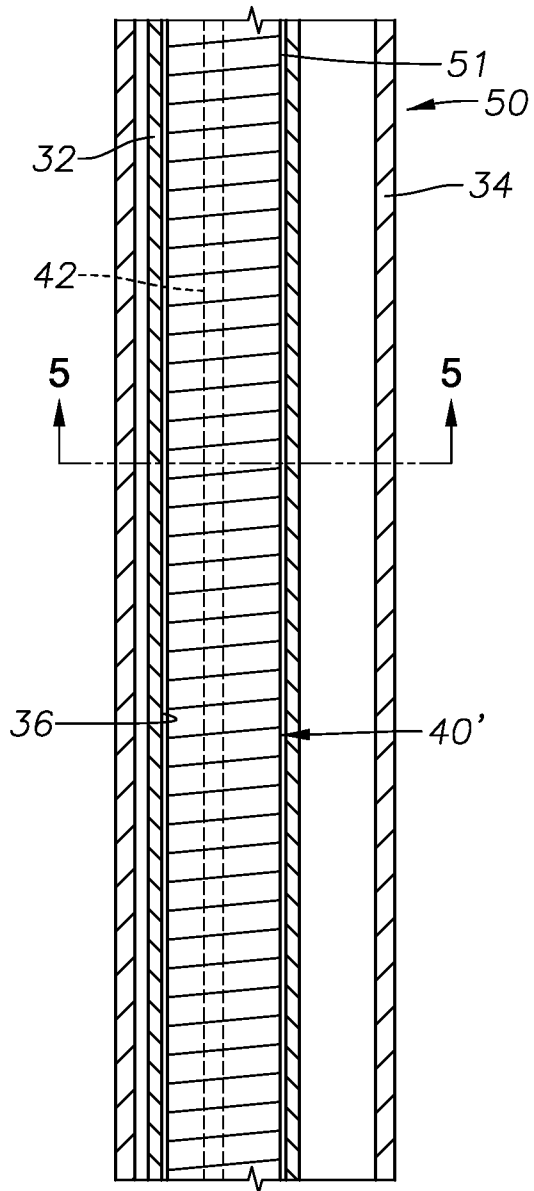


FIG. 4

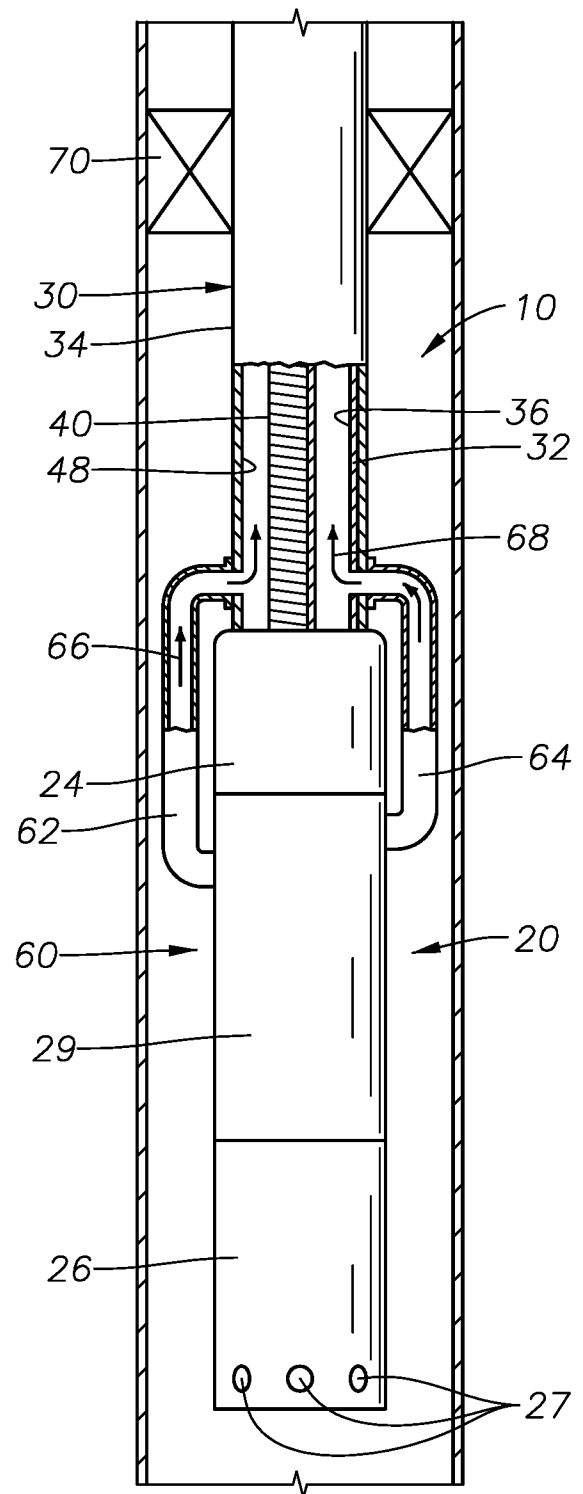


FIG. 6

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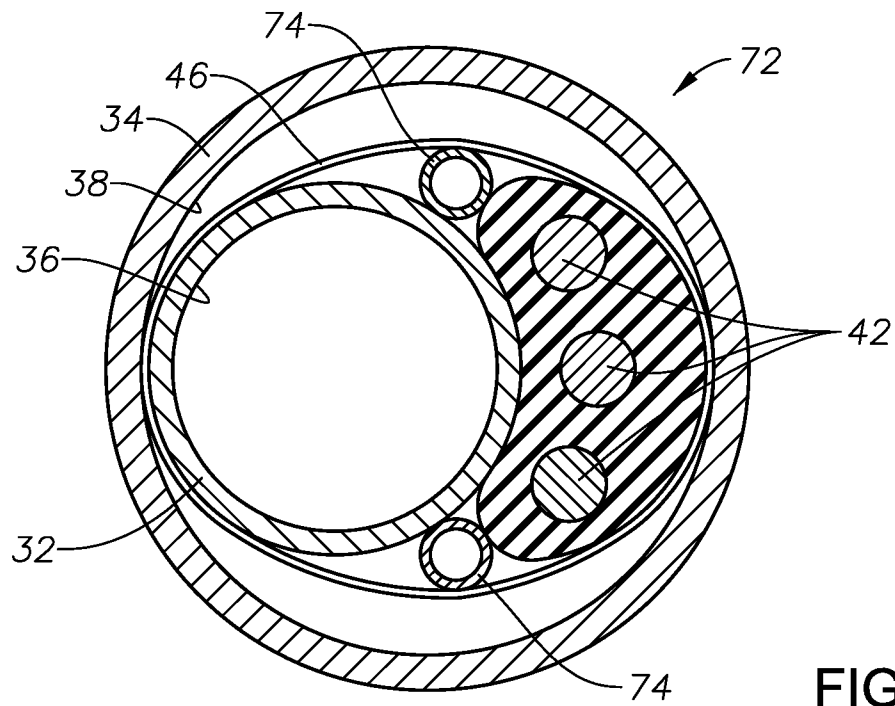


FIG. 7

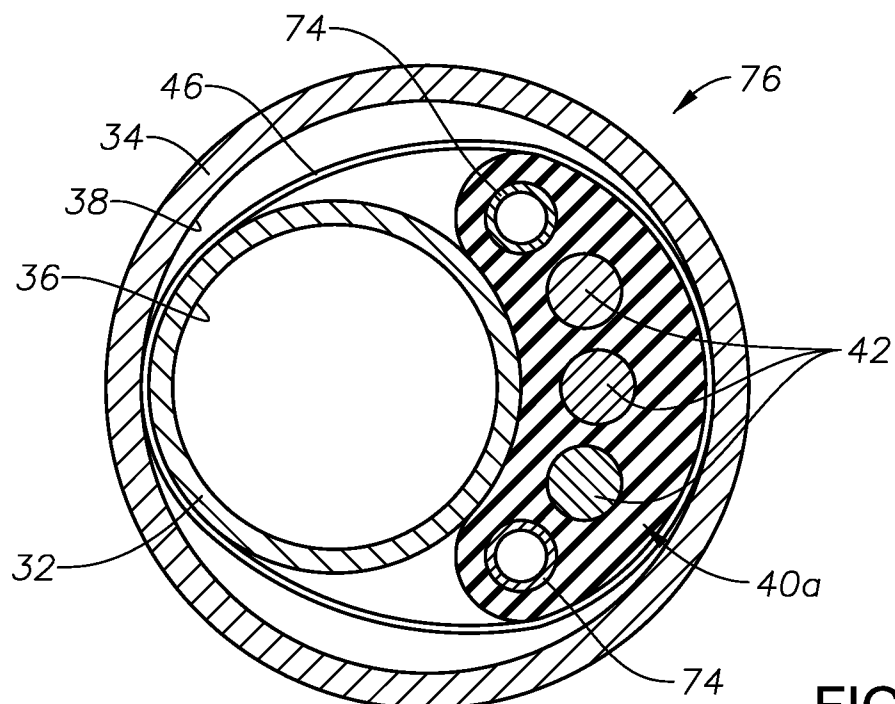


FIG. 8

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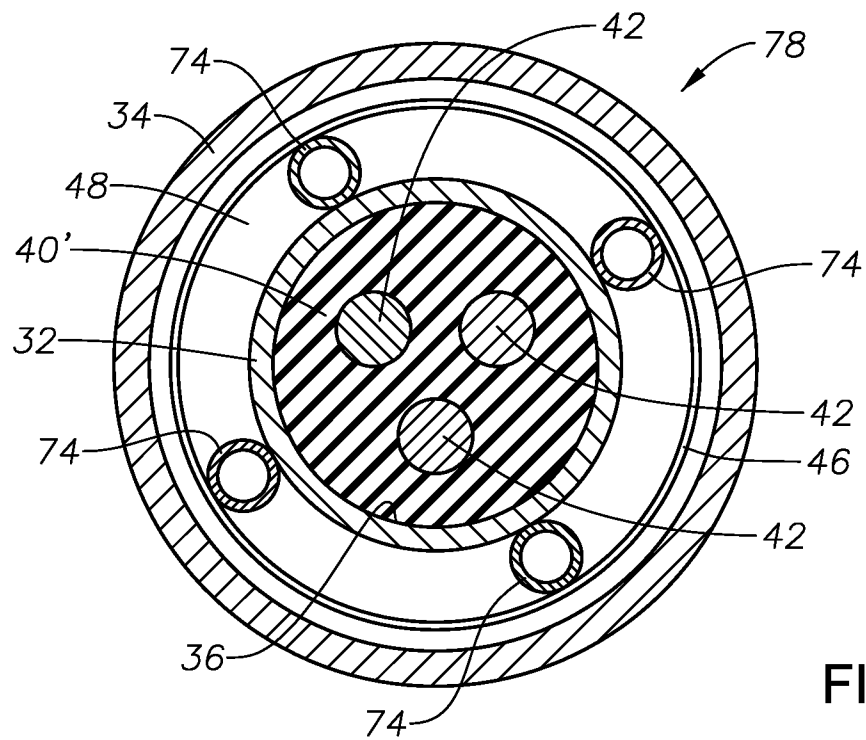


FIG. 9

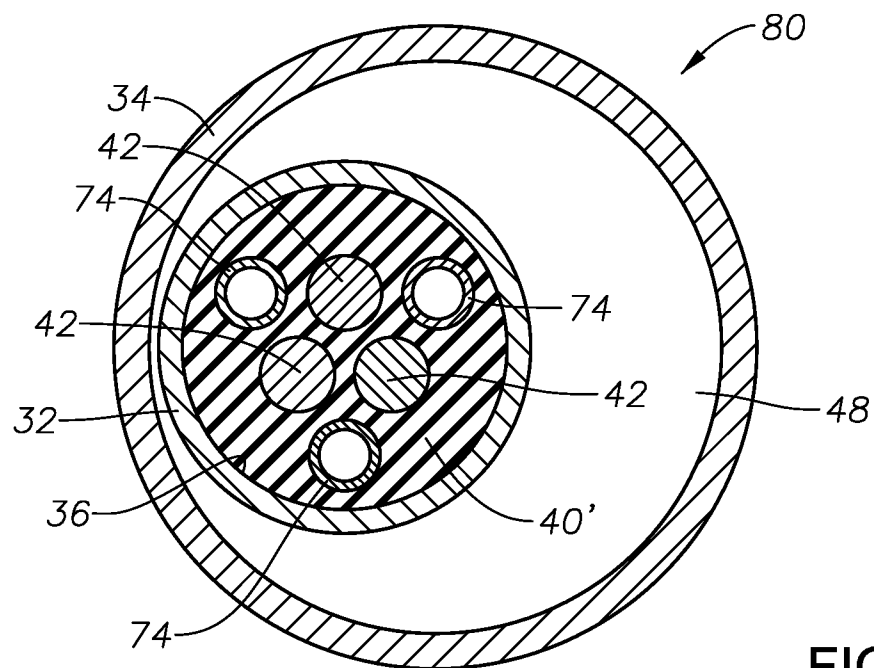


FIG. 10

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/019899**A. CLASSIFICATION OF SUBJECT MATTER****E21B 17/18(2006.01)i, E21B 47/12(2006.01)i, F04D 13/10(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 17/18; E21B 33/03; E21B 43/00; F16L 9/18; E21B 43/14; E21B 23/00; E21B 43/38; E21B 47/12; F04D 13/10

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: dual wall, coiled tubing, electric submersible pump, power cable, capillary line and strap

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002-0070030 A1 (SMITH, LESLIE DEAN et al.) 13 June 2002 See paragraphs [0034]-[0062] and figures 3-5.	1-10, 12-15
A		11
A	US 2009-0145612 A1 (OLSON, DAVID L. et al.) 11 June 2009 See paragraphs [0020]-[0026] and figures 2-3B.	1-15
A	US 6143988 A (NEUROTH, DAVID H. et al.) 07 November 2000 See column 3, line 10 - column 4, line 15 and figures 2-3.	1-15
A	US 5269377 A (MARTIN, FRED S.) 14 December 1993 See column 2, line 43 - column 5, line 2 and figures 1-4.	1-15
A	US 6179056 B1 (SMITH, DAVID RANDOLPH) 30 January 2001 See column 5, line 55 - column 12, line 4 and figures 1A-6.	1-15



Further documents are listed in the continuation of Box C.



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"&" document member of the same patent family

Date of the actual completion of the international search

26 June 2016 (26.06.2016)

Date of mailing of the international search report

28 June 2016 (28.06.2016)

Name and mailing address of the ISA/KR

International Application Division

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/019899

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5269377 A	14/12/1993	None	
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		GB 2334050 B	10/07/2002