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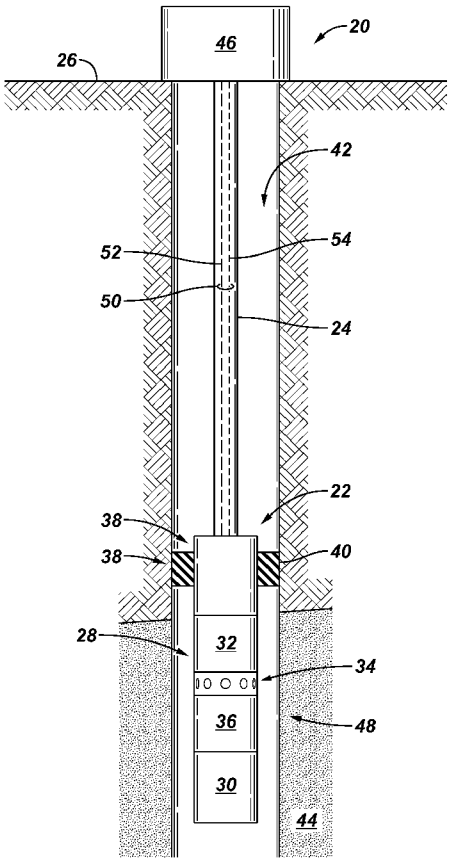
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(54) Title: PERMANENT CABLE FOR SUBMERSIBLE PUMPS IN OIL WELL APPLICATIONS

FIG. 1



(57) Abstract: A technique facilitates the employment of an electric submersible pumping system or other well system downhole into a wellbore. The electric motor system is coupled with a signal carrying cable for conveyance to a desired downhole location in the wellbore. The signal carrying cable is constructed with sufficient strength to solely support the electric motor system during deployment and use in the wellbore without addition of a separate supporting mechanism.

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PERMANENT CABLE FOR SUBMERSIBLE PUMPS IN OIL WELL APPLICATIONS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present document is based on and claims priority to U.S. Provisional Application Serial No.: 61/307682, filed February 24, 2010 incorporated herein by reference.

BACKGROUND

[0002] Electric motors often are placed downhole in an oil or gas field to perform a variety of functions. For example, an electric motor may be placed downhole to perform an artificial lift function in which the motor drives a pump used to bring downhole fluids to the surface. The electric motors and associated pumping system components, e.g. an electric submersible pumping system, are deployed downhole and supported by various conveyance mechanisms, such as production tubing, coiled tubing, wireline or slickline. Because the electric motor requires power, cables or other electrical power conductors are run downhole along the supporting conveyance mechanism. However combination of the supporting conveyance mechanism and separate electrical power conductor can present difficulties due to expense, complexity, and other factors associated with the separate systems.

SUMMARY

[0003] In general, the present application provides a technique for deploying an electric motor system, such as an electric submersible pumping system, downhole into a wellbore. The electric motor system is coupled with a signal carrying cable for conveyance to a desired downhole location in the wellbore. The signal carrying cable is constructed with sufficient strength to solely support the electric motor system during

deployment into the wellbore without addition of a separate supporting mechanism. The signal carrying cable may be used to convey, maintain and/or retrieve the electric motor system without additional support.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Certain embodiments will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

[0005] Figure 1 is a front elevation view of an electric submersible pumping system deployed in a wellbore with a signal carrying cable, according to an embodiment;

[0006] Figure 2 is a cross-sectional view of a first stage of cable construction in forming an embodiment of a cable with sufficient strength to support the electric submersible pumping system, according to an embodiment;

[0007] Figure 3 is a cross-sectional view of a subsequent stage of cable construction, according to an embodiment;

[0008] Figure 4 is a cross-sectional view of a subsequent stage of cable construction, according to an embodiment;

[0009] Figure 5 is a cross-sectional view of a subsequent stage of cable construction, according to an embodiment;

[0010] Figure 6 is a cross-sectional view of a subsequent stage of cable construction, according to an embodiment;

[0011] Figure 7 is a cross-sectional view of a subsequent stage of cable construction, according to an embodiment;

[0012] Figure 8 is a cross-sectional view of a subsequent stage of cable construction to create an embodiment of the system supporting cable, according to an embodiment;

[0013] Figure 9 is a cross-sectional view of another cable construction, according to an embodiment;

[0014] Figure 10 is a cross-sectional view of a first stage of cable construction in forming an alternate embodiment of a cable with sufficient strength to support a downhole system, according to an embodiment;

[0015] Figure 11 is a cross-sectional view of a subsequent stage of cable construction, according to an alternate embodiment;

[0016] Figure 12 is a cross-sectional view of a subsequent stage of cable construction, according to an alternate embodiment;

[0017] Figure 13 is a cross-sectional view of a subsequent stage of cable construction, according to an alternate embodiment;

[0018] Figure 14 is a cross-sectional view of a subsequent stage of cable construction, according to an alternate embodiment;

[0019] Figure 15 is a cross-sectional view of a subsequent stage of cable construction, according to an alternate embodiment;

[0020] Figure 16 is a cross-sectional view of a subsequent stage of cable construction to create another example of a system supporting cable, according to an embodiment; and

[0021] Figure 17 is a cross-sectional view of another cable construction, according to an alternate embodiment.

DETAILED DESCRIPTION

[0022] In the following description, numerous details are set forth to provide an understanding of various embodiments. However, it will be understood by those of ordinary skill in the art that these embodiments may be practiced without many of these details and that numerous variations or modifications from the described embodiments may be possible.

[0023] The present application generally involves a technique which simplifies deployment and signal transmission with respect to systems deployed downhole in a wellbore. For example, the technique enables both deployment and powering of electric motors, such as electric motors employed in electric submersible pumping systems. A cable is constructed with sufficient strength to support an electric submersible pumping system and/or other downhole systems during conveyance through the wellbore. No other support members, e.g. production tubing, coiled tubing, wireline or slickline, are utilized during conveyance and retrieval of the downhole system. The cable may even be used to provide sole support of the downhole system during its operation.

[0024] Many oil wells are able to rely on natural gas pressure to propel crude oil to the surface. In more mature oilfields where gas pressure has diminished or in wells with heavy oil, however, this natural pressure is not sufficient to bring the oil out of the well. In these instances, the oil must be pumped out of the wells.

[0025] Sucker rod pumps can been used to pump oil to the surface in low-pressure wells, but sucker rod pumps are often replaced with electric submersible pumping systems (ESPS), such as the REDA ESPS. REDA ESPS are centrifugal electric submersible pumps. The electric submersible pumping systems comprise one or more

submersible pumps and submersible motors attached to the bottom of the production string to pump oil up from the bottom of the well. The pump portion comprises a series of rotors and stators to pump fluid. Electrical power is provided to the electric motor of the ESPS.

[0026] Separate "permanent" cables are designed for long-term deployment in the well. However, these cables generally do not have sufficient strength to carry the cable weight combined with the weight of the pumping system. Therefore, these systems often require an additional element for support.

[0027] Some embodiments described herein eliminate the need for a support element by providing a cable with sufficient strength to be used as support during deployment and retrieval of the ESPS and/or other downhole system. These embodiments are constructed as permanent cables for use with submersible motors/pumps, such as those employed in electric submersible pumping systems for extracting oil from low-pressure wells. In some embodiments, the cables provide support and power to the electric submersible pumping systems while withstanding the conditions of long-term exposure in the downhole environment. Also, some cable embodiments described herein may be designed to present a smooth surface which allows for sealing pressure at the top of the well.

[0028] Additionally, embodiments of the cable may comprise data carriers, such as one or more optical fibers, which may be used to provide telemetry of depth-referenced data such as temperature, strain, and other parameters. A variety of optical fiber designs and other data carrier designs may be incorporated into the cable. Generally, the data carriers are protected by the cable design to enable use in permanent cables, such as permanent cables employed with electric submersible pumping systems used to extract oil from low-pressure wells. The cables have sufficient strength to provide support during conveyance and use, to provide power and/or data transmission with respect to the electric submersible pumping system, and to withstand the conditions of long-term exposure in the downhole environment.

[0029] Referring generally to Figure 1, an example of a well system 20 is illustrated. In this embodiment, a downhole assembly 22 is solely supported by a cable 24 which is also able to carry signals between the downhole assembly 22 and a surface location 26. In the particular embodiment illustrated, downhole assembly 22 comprises an electric submersible pumping system 28 which may have a variety of components. For example, the electric submersible pumping system 28 may comprise a submersible electric motor 30 which powers a submersible pump 32, such as a submersible centrifugal pump. The electric submersible pumping system 28 also may comprise other components, such as a pump intake 34 and a motor protector 36. Depending on the application, the downhole assembly 22 also may incorporate other components 38, such as one or more packers 40 used to isolate regions of the wellbore 42.

[0030] In the embodiment illustrated, wellbore 42 is formed in a subterranean formation 44 and may comprise generally vertical and/or deviated sections. The wellbore 42 extends down from the surface location 26 beneath surface equipment, such as a wellhead 46. Cable 24 is a permanent cable and supports its own full weight and the weight of the electric submersible pumping system 24. In other words, no other support members are required to convey electric submersible pumping system 28 through wellbore 42 during deployment to a desired downhole location 48 in wellbore 42. Similarly, no other support members are required during retrieval from the wellbore 42. Cable 24 is permanent in the sense that it remains downhole while being functionally attached to the downhole assembly 22 during operation of the downhole assembly 22 for production of oil or performance of other desired functions.

[0031] As illustrated, cable 24 comprises at least one signal carrier 50 along which signals may be carried to and/or from the downhole assembly 22. By way of example, signal carrier 50 may comprise a power carrier 52, such as one or more conductors routed along the cable 24. Signal carrier 50 also may comprise a data carrier 54, such as one or more optical fibers or other data carriers routed along cable 24. The design of cable 24 provides a flexible member while also providing sufficient strength to

serve as the sole support member in conveying the electric submersible pumping system 28 and/or other downhole systems through wellbore 42.

[0032] In one embodiment, cable 24 is formed of a plurality of layers of armor wire strength members which are isolated by a plurality of separation layers, such as polymer layers. The armor wire strength members can have interstices. The layers of armor wire strength members surround the signal carrier 50 which may comprise power and/or data carriers. Additionally, the polymer layers may comprise one or more types of polymer materials able to provide protection and/or insulation.

[0033] Some embodiments of cable 24 employ plural, e.g., three or four, different types of non-metallic layers, and e.g. polymer materials/layers although other non-metallic materials may be employed in some applications. For example, a polymer 1 may comprise an electrical insulation which is used, for example, to insulate conductors, e.g. large copper electrical power conductors, in a core of the cable 24. This first polymer also may be formed from various combinations of polymer materials. According to embodiments, polymer 1 can comprise the polymeric materials useful in the cables and may include polyolefins (such as EPC, modified EPC or polypropylene), Ethylene Propylene Diene Monomer (EPDM), Ethylene-Propylene Octane, Ethylene Propylene block copolymer, polyaryletherether ketone, polyaryl ether ketone, polyphenylene sulfide, polymers of ethylene-tetrafluoroethylene, polymers of poly(1,4-phenylene), polytetrafluoroethylene, perfluoroalkoxy polymers, fluorinated ethylene propylene, perfluoromethoxy polymers, Parmax®, and any mixtures thereof. According to some embodiments, the polymers can include polymeric materials such as Ethylene Propylene Diene Monomer, polypropylene, Ethylene Propylene block polymer, perfluoroalkoxy polymer, and perfluoromethoxy polymer. A polymer 2 may comprise a softer polymer material which is used as an interstitial filler if needed. The interstitial filler may be positioned around, for example, the conductors in the cable core which are insulated by polymer 1. Examples of polymer 2 can comprise of any soft polymer with a Shore A hardness between 10 and 100 may be used like Santoprene, thermoplastic Fluoro elastomers, Ethylene-Propylene co-polymers, Ethylene Propylene block copolymer or any other soft thermoplastic elastomers or thermoplastic. .....

[0034] Additionally, a polymer 3 may be employed as, an outer jacket to the cable core. Polymer 3 generally is a harder polymer able to provide protection of the

cable core or other cable components. Polymer 3 can comprise polymers that can be used as is or reinforced with, carbon, glass, aramid or any other suitable natural or synthetic fiber and or any other reinforcing additives such as micron sized PTFE, Graphite, Ceramer™ are by nonlimiting example, polyolefins (such as EPC, modified EPC or polypropylene), polyaryletherether ketone, polyaryl ether ketone, polyphenylene sulfide, polymers of ethylene-tetrafluoroethylene, polymers of poly(1,4-phenylene), polytetrafluoroethylene, perfluoroalkoxy polymers, fluorinated ethylene propylene, perfluoromethoxy polymers, Parmax®, and any mixtures thereof. Preferred polymeric materials are polypropylene, ethylene-tetrafluoroethylene polymer, perfluoroalkoxy polymer, and perfluoromethoxy polymer. Also, a polymer 4 may be employed to protect the layers of armor wire strength members. Examples of polymer 4 can comprise a protective polymeric coating that is applied to each strand of armor wire for corrosion protection. The following coatings may be used: fluoropolymer coating, FEP, Tefzel®, PFA, PTFE, MFA, PEEK or PEK with fluoropolymer combination, PPS and PTFE combination, and Latex or Rubber Coating. Each strand of armor wire may also be plated with a .5-mil to 3-mil metallic coating which may enhance bonding of the armor wires to the polymeric jacket materials. The plating materials may include: ToughMet® (a high-strength, copper-nickel-tin alloy manufactured by Brush Wellman), Brass, Copper, Copper alloy, Nickel and its alloys, and any other suitable metals or combination of the same. Of course, the specific arrangement of polymer layers and polymer material types may be changed or substituted according to the needs of a given application and environment. One or more of the polymers 1, 2, 3, and 4 may be used to create the desired cable 24 for a specific downhole application and environment. Further, the first polymer layer can be chemically bonded to the second polymer later through the interstices of the first armor layer. The second polymer layer can be chemically bonded to the third polymer layer through interstices of the second armor layer. This configuration is available for any two polymer layers separated by an armor layer.

[0035] Referring generally to Figures 2-9, one embodiment of cable 24 is illustrated in sequential stages of construction. In this embodiment, a cable core 56 is initially constructed with one or more conductors 58 that form power carrier 52, as

illustrated in Figure 2. The conductors may be constructed from a variety of conductive materials in a variety of forms, e.g. copper conductors each formed of a solid copper element or of copper strands. By way of example, the cable core 56 may comprise three conductors 58 to enable delivery of three-phase power to motor 30 of the electric submersible pumping system 28. In the example of Figure 2, the three conductors, e.g. three large copper conductors, are cabled together in a triad configuration. Additionally, each conductor 58 is covered by a layer of electrical insulation material 60. By way of example, insulation material 60 may be formed from polymer 1.

[0036] In this example, another layer of material 62 is placed around cable core 56, as illustrated in Figure 3. The layer of material 62 may be used to fill interstitial spaces between conductors 58 and also may be designed to create an outer circular profile 64. By way of example, the layer of material 62 may be formed from a softer polymer material, such as polymer 2. Additionally, the layer of material 62 may be used to surround one or more data carriers 54 which can be constructed as part of cable core 56 or routed through other regions of the overall cable 24. By way of example, data carrier 54 comprises an optical fiber 66 enclosed in a protective layer or tube 68.

[0037] Referring generally to Figure 4, another layer of material 70 may be placed over layer of material 62. By way of example, layer of material 70 may be formed from a harder, protective polymer, such as polymer 3, and it may be extruded as a jacket layer over material 62. Additionally, material 70 is disposed along a radial interior of a first layer 72 of armor wire strength members 74, as illustrated in Figure 5. The layer of armor wire strength members 74 may be cabled over layer 70 at a desired lay angle (see arrow 75). Depending on the environment in which cable 24 is employed, armor wire strength members 74 may be formed from a variety of materials. However, the selected materials should be sufficiently strong to assist in supporting the full weight of both cable 24 and downhole assembly 22 during conveyance downhole and retrieval. For example, the armor wire strength members 74 may be constructed from a suitable metal, such as a ,Galvanized Improved Plow Steel of different carbon content, Stainless steel, Copper-clad steel, Aluminum-clad steel, Anodized Aluminum-clad steel, Titanium-clad steel, Alloy 20Mo6HS, Alloy GD31Mo, Austenitic Stainless Steel, High Strength Galvanized Carbon Steel, Titanium clad copper, or any other suitable strength members.

[0038] Another layer of material 76 is located over the first layer 72 of armor wire strength members 74, as illustrated in Figure 6. By way of example, the layer of material 76 may comprise a polymer layer formed of a suitable polymer, such as polymer 4. In some embodiments, layer of material 76 is extruded over the first armor wire layer 72. A second layer 78 of armor wire strength members 74 may be positioned around layer of material 76, as illustrated in Figure 7. The second layer 78 of armor wire strength members 74 may be cabled over layer of material 76 at a desired lay angle (see arrow 79) different from the lay angle of the first armor wire layer 72. For example, the lay angle of armor wire strength members 74 of the second layer 78 may be arranged contrahelically with respect to the lay angle of armor wire strength members 74 of the first layer 72. The layer of material 76 and layer of material 70 may be chemically bonded to one another though interstices of the strength members74.

[0039] As illustrated in Figure 8, another layer of material 80 may be located over the second armor wire layer 78 to complete formation of the cable 24. By way of

example, the layer of material 80 comprises a polymer layer formed of a suitable polymer, such as polymer 4. In some embodiments, layer of material 80 is extruded over the second armor wire layer 78. The material 80 can be selected to provide a smooth outer surface which facilitates sealing against pressure at the top of the wellbore 42. Additionally, a variety of enhancers 82 may be added to layer 80 to enhance desired cable properties, such as strength and abrasion resistance, as illustrated in Figure 9. The enhancers 82 comprise, for example, fibers, beads, or other materials designed to achieve the desired, enhanced cable properties. The layer 76 can be chemically bonded to the layer 80 through interstices of the armor wire layer 78.

[0040] The various cable layers can be arranged in various configurations to achieve the desired high strength cable 24 able to convey and retrieve the electric submersible pumping system 28 without addition of another support component. For example, another embodiment of cable 24 is a coaxial cable illustrated in sequential stages of construction in Figures 10-17. Elements of the alternate embodiment which are the same or similar to elements of the embodiment illustrated in Figures 2-9 may be labeled with common reference numerals.

[0041] In this alternate embodiment, the cable core 56 is initially formed with one internal conductor 58 which may be formed as a solid member or as a plurality of strands, as illustrated in Figure 10. The single, large conductor 58 may be surrounded by an insulation material 84, e.g. a polymer insulation material, which is surrounded by a conductive layer 86 sometimes formed as a layer of smaller conductors 88 as further illustrated in Figure 11. The layer of smaller conductors 88 may be cabled (or served) around the center connector 58 at a desired lay angle (see arrow 89) to provide a shield of the coaxial cable. By way of example, center conductor 58 and conductive layer 86 may be formed of a conductive metal, such as copper.

[0042] Additionally, a layer of material 90 may be placed around cable core 56, as illustrated in Figure 12. By way of example, layer of material 90 may be formed from a harder, protective polymer, such as polymer 3. In some embodiments, the layer of

material 90 is extruded as a jacket layer over conductive layer 86 to protect the cable core 56. Material 90 is disposed along a radial interior of the first layer 72 of armor wire strength members 74, as illustrated in Figure 13. The layer of armor wire strength members 74 may be cabled over layer of material 90 at a desired lay angle (see arrow 75). Depending on the environment in which cable 24 is employed, armor wire strength members 74 can be formed from a variety of materials. However, the selected materials should again be sufficiently strong to assist in supporting the full weight of both cable 24 and downhole assembly 22 during conveyance downhole and retrieval. For example, the armor wire strength members 74 may be constructed from a suitable metal, such as a stainless steel. The layer of material 90 could be chemically connected with insulation material 84.

[0043] As with the embodiment illustrated in Figures 2-9, the layer of material 76 may be located over the first layer 72 of armor wire strength members 74, as illustrated in Figure 14. By way of example, the layer of material 76 comprises a polymer layer formed of a suitable polymer, such as polymer 4, and it can be extruded over the first armor wire layer 72. The second layer 78 of armor wire strength members 74 is similarly positioned around layer of material 76, as illustrated in Figure 15. The second layer 78 of armor wire strength members 74 may be cabled over layer of material 76 at a desired lay angle (see arrow 79) different from the lay angle of the first armor wire layer 72. For example, the lay angle of armor wire strength members 74 of the second layer 78 may be arranged contrahelically with respect to the lay angle of armor wire strength members 74 of the first layer 72.

[0044] As illustrated in Figure 16, the layer of material 80 may be similarly located over second armor wire layer 78 to complete formation of the cable 24. Again, the layer 80 may comprise a polymer layer formed of a suitable polymer, such as polymer 4, and it can be extruded over the second armor wire layer 78. The layer 80 could be chemically connected with the layer 76 through interstices of the armor layers. Enhancers 82 also may again be added to layer of material 80 to enhance desired cable properties, such as strength and abrasion resistance, as illustrated in Figure 17. As

discussed above, the enhancers 82 may comprise fibers, beads, or other materials designed to achieve the desired, enhanced cable properties. One or more data carriers 54 also may be routed along cable 24 within core 56 or at another suitable location outside conductive layer 86.

[0045] Although embodiments of well system 20, downhole assembly 22 and cable 24 have been illustrated and described, many variations in components and designs may be employed for a given application and/or environment. For example, a variety of electric submersible pumping system components may be incorporated into the design. Additionally, the downhole electric motor may be combined with other types of pumping systems or downhole systems powered by electric motors.

[0046] Cable 24 may be employed to convey and/or retrieve a variety of other heavy systems to or from downhole environments. Various embodiments illustrated, cable 24 provides sufficient strength to convey electric submersible pumping system 28 and other types of downhole systems to desired location 48 in wellbore 42 by combining flexible layers of polymer and flexible layers of armor wire strength members. Various embodiments illustrated and described are readily capable of delivering the electric submersible pumping system 28 to well depths exceeding 1000 feet, 5000 feet, and even wells in excess of 10,000 feet deep without requiring an additional support member during conveyance and/or retrieval of the downhole system. Depending on the specific parameters of a given application and wellbore environment, the number, materials, and arrangements of the cable layers may be adjusted to accommodate the specific parameters.

[0047] Although only a few embodiments have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this application. Accordingly, such modifications are intended to be included within the scope of this invention as defined in the claims.

CLAIMS

What is claimed is:

1. A method of deploying an electric submersible pumping system downhole in a wellbore, comprising:

providing a signal carrying cable with sufficient strength to solely support the electric submersible pumping system during deployment and retrieval to a desired downhole location in the wellbore;

coupling the signal carrying cable to the electric submersible pumping system; and

conveying the electric submersible pumping system solely via the signal carrying cable to the desire downhole location.

2. The method as recited in claim 1, further comprising retrieving the electric submersible pumping system to a surface location solely via the signal carrying cable.

3. The method as recited in claim 1, wherein providing the signal carrying cable comprises providing an electrical power carrying cable to enable transmission of electrical power downhole to power the electric submersible pumping system.

4. The method as recited in claim 1, wherein providing the signal carrying cable comprises providing a data signal carrying cable.

5. The method as recited in claim 1, wherein providing the signal carrying cable comprises providing a combined data and electrical power carrying cable.

6. The method as recited in claim 1, wherein conveying comprises conveying the electric submersible pumping system solely via the signal carrying cable to a well depth of at least 1000 feet.

7. The method as recited in claim 1, wherein conveying comprises conveying the electric submersible pumping system solely via the signal carrying cable to a well depth of at least 5000 feet.

8. The method as recited in claim 1, wherein conveying comprises conveying the electric submersible pumping system solely via the signal carrying cable to a well depth of at least 10,000 feet.

9. The method as recited in claim 1, further comprising preparing the signal carrying cable with at least one central conductor element surrounded by a plurality of layers of armor wire strength members interspersed with a plurality of layers of polymeric material.

10. A system to convey and support an electric submersible pumping system downhole in a wellbore, comprising:

at least one internal conductor;

a first layer of polymer insulating the at least one internal conductor;

a second layer of polymer surrounding the at least one internal conductor and the first layer of polymer to create an outer circular profile;

a third layer of polymer layered over the second layer of polymer;

a first layer of armor wire strength members cabled over the third layer of polymer at a first lay angle;

a fourth layer of polymer positioned around the first layer of armor wire strength members;

a second layer of armor wire strength members cabled over the fourth layer of polymer at a second lay angle different from the first lay angle; and

a fifth layer of polymer surrounding the second layer of armor wire strength members to create a cable with sufficient strength to support the electric submersible

pumping system during conveyance downhole to a desired operational location in the wellbore.

11. The system of claim 10, wherein the first polymer layer outside the conductor is chemically bonded to the second polymer layer through interstices in the first armor layer.

12. The system of claim 10, wherein the second polymer layer is chemically bonded to the third polymer layer through interstices of the second armor layer

13. The system of claim 10, wherein the first polymer layer is chemically bonded to the second polymer layer through interstices in the first armor layer; and

the second polymer layer is chemically bonded to the third polymer layer through interstices of the second armor layer.

14. The system as recited in claim 10, wherein the at least one internal conductor comprises three internal conductors able to carry three-phase power.

15. The system as recited in claim 10, wherein the first, second, third, fourth and fifth layers of polymer comprise a plurality of different types of polymer materials.

16. The system as recited in claim 10, wherein the first, second, third, fourth and fifth layers of polymer comprise at least four different types of polymer materials.

17. The system as recited in claim 10, wherein the second lay angle is arranged contrahelically with respect to the first lay angle.

18. A system to convey and support an electric submersible pumping system downhole in a wellbore, comprising

an internal conductor;

a conductor layer surrounding the internal conductor;

a first layer of polymer positioned around the conductor layer;

a first layer of armor wire strength members cabled over the first layer of polymer at a first lay angle;

a second layer of polymer positioned over the first layer of armor wire strength members;

a second layer of armor wire strength members cabled over the second layer of polymer at a second lay angle; and

a third layer of polymer surrounding the second layer of armor wire strength members to create a cable with sufficient strength to support the electric submersible pumping system during conveyance downhole to a desired operational location in the wellbore.

19. The system of claim 18, wherein the first polymer layer is chemically bonded to the second polymer layer through interstices in the first armor layer.

20. The system of claim 18, wherein the second polymer layer is chemically bonded to the third polymer layer through interstices of the second armor layer

21. The system of claim 18, wherein the first polymer layer is chemically bonded to the second polymer layer through interstices in the first armor layer; and

the second polymer layer is chemically bonded to the third polymer layer through interstices of the second armor layer.

22. The system as recited in claim 18, wherein the first, second and third layers of polymer comprise a plurality of different types of polymer materials.

23. The system as recited in claim 18, wherein the second lay angle is arranged contrahelically with respect to the first lay angle.

24. A method of forming a cable for routing signals along a wellbore, comprising:

forming a plurality of layers of armor wire strength members around a signal carrier;

isolating layers of the plurality of layers of armor wire strength members with non-metallic layers; and

arranging the plurality of layers of armor wire strength members and the non-metallic layers into a cable having sufficient strength to support an electric submersible pumping system during deployment downhole into a wellbore without another support member.

25. The method as recited in claim 24, wherein forming comprises forming the plurality of layers of armor wire strength members around the signal carrier comprising at least one electrical conductor; and isolating comprises isolating with polymer layers.

26. The method as recited in claim 25, wherein forming comprises forming the plurality of layers of armor wire strength members around the signal carrier comprising a data signal carrier.

27. The method as recited in claim 25, wherein forming comprises forming the plurality of layers of armor wire strength members around the signal carrier comprising an optical fiber.

28. The method as recited in claim 25, further comprising coupling the electric submersible pumping system to the cable, and deploying the electric submersible pumping system downhole into a wellbore solely via the cable.

29. The method as recited in claim 28, further comprising powering the electric submersible pumping system with electrical power supplied through the at least one electrical conductor.

FIG. 1

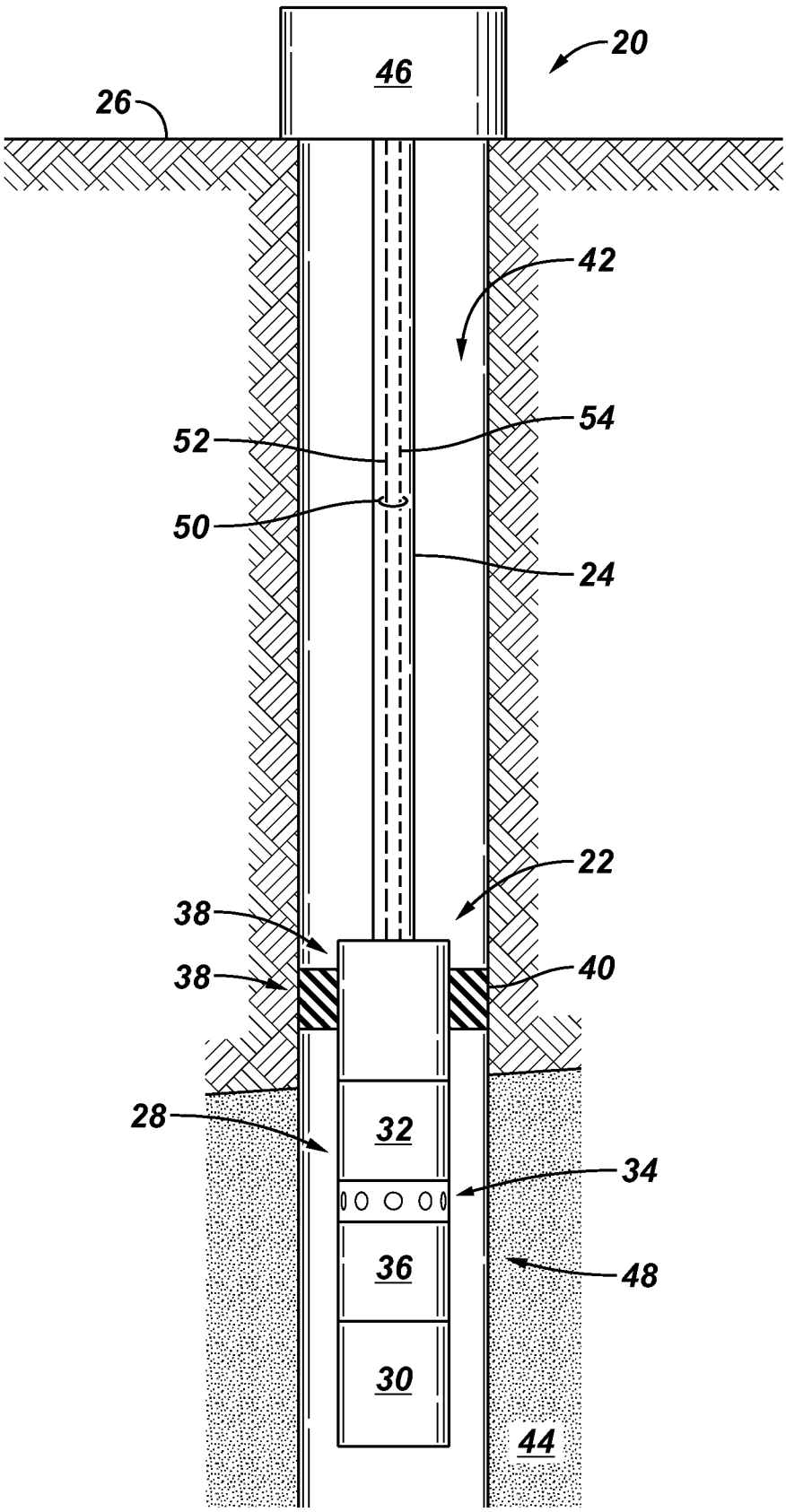


FIG. 2

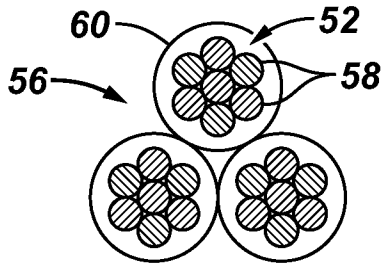


FIG. 3

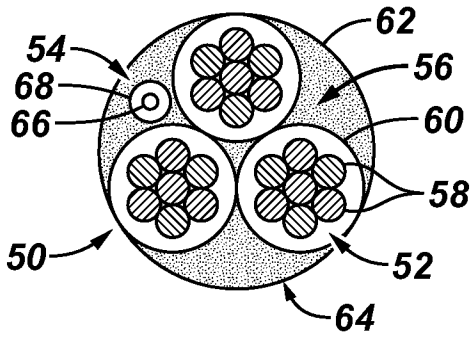


FIG. 4

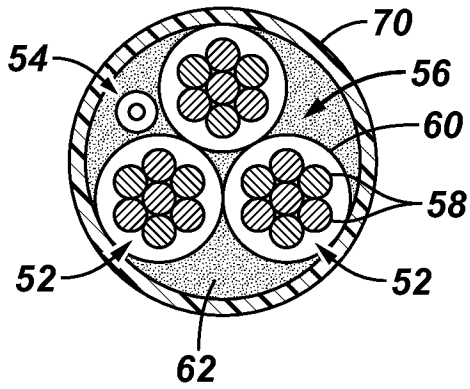


FIG. 5

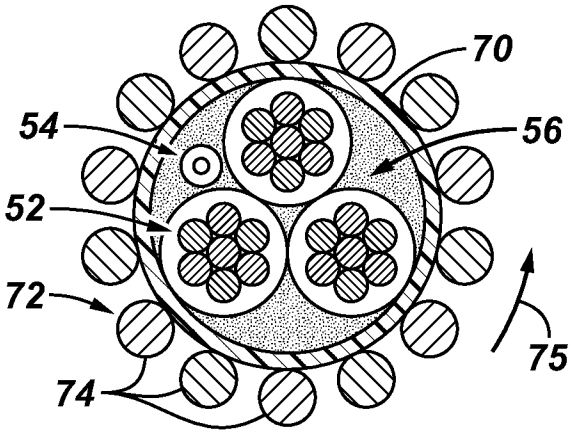


FIG. 6

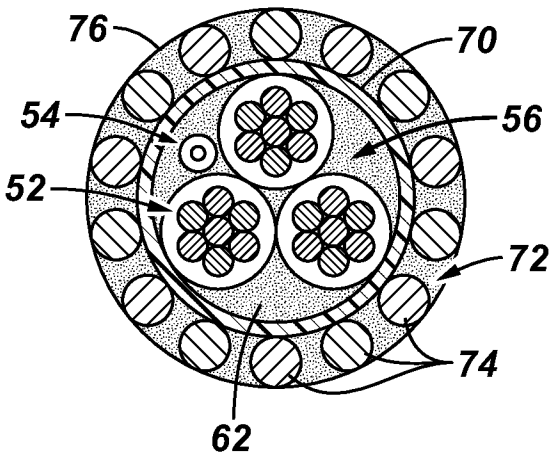


FIG. 7

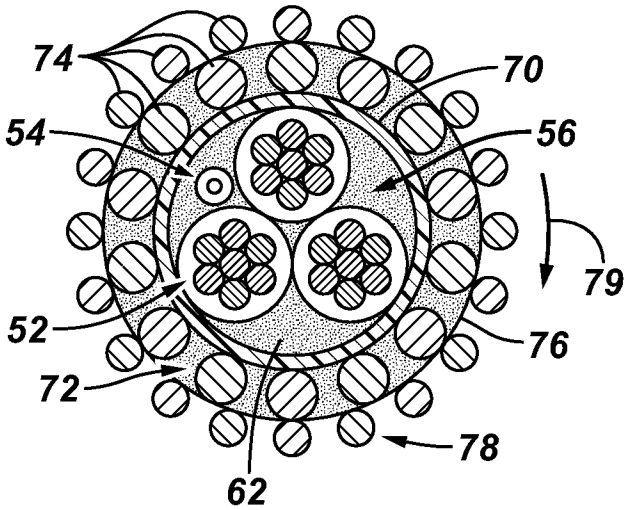


FIG. 8

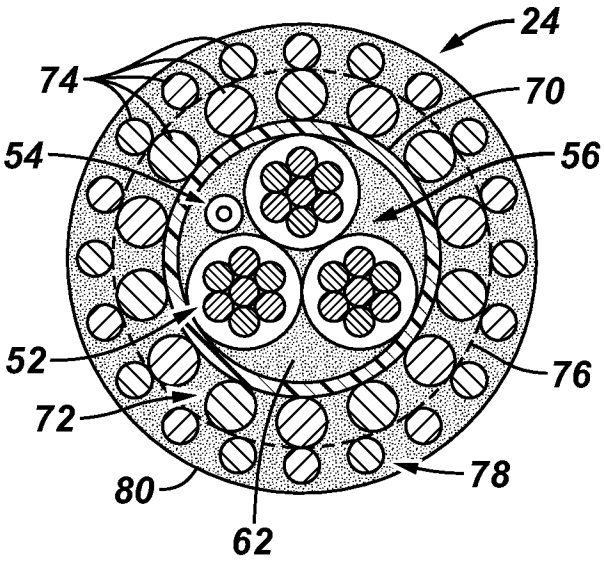


FIG. 9

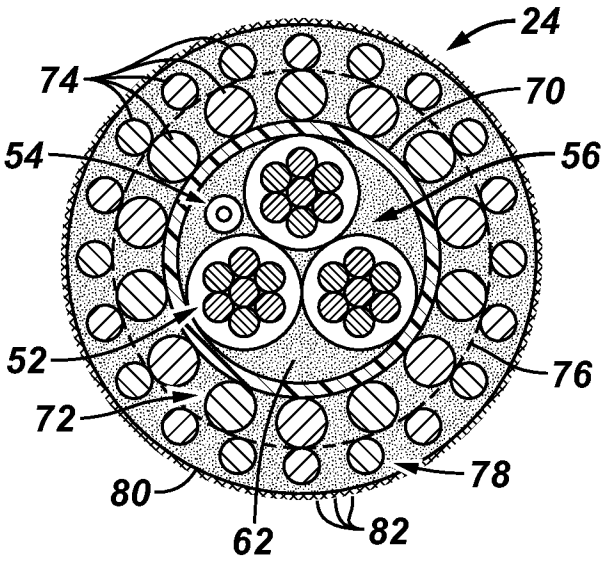


FIG. 10

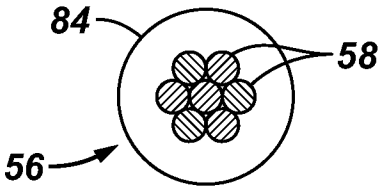


FIG. 11

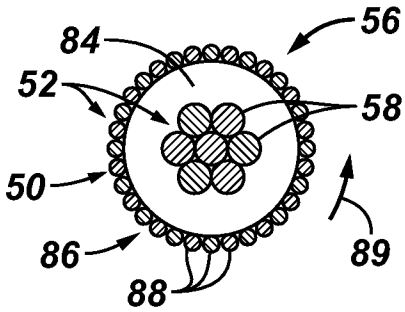


FIG. 12

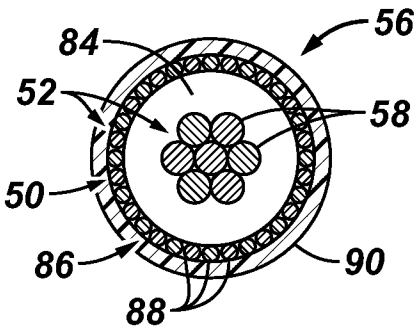


FIG. 13

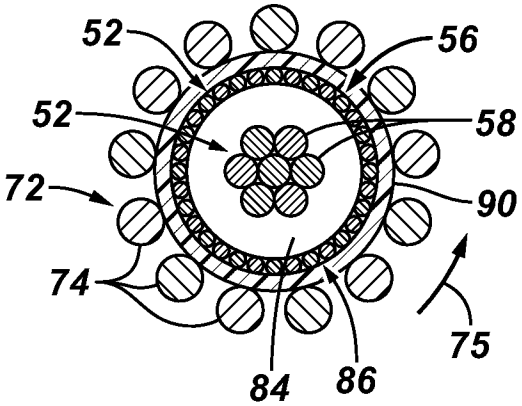


FIG. 14

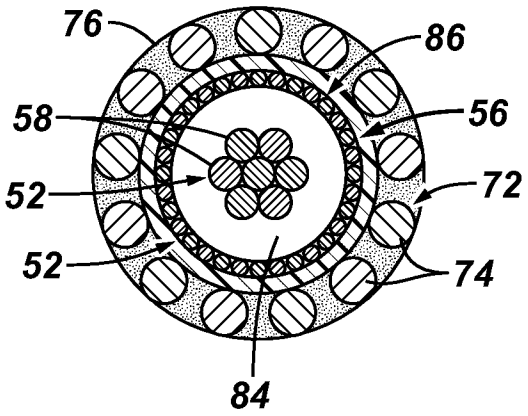


FIG. 15

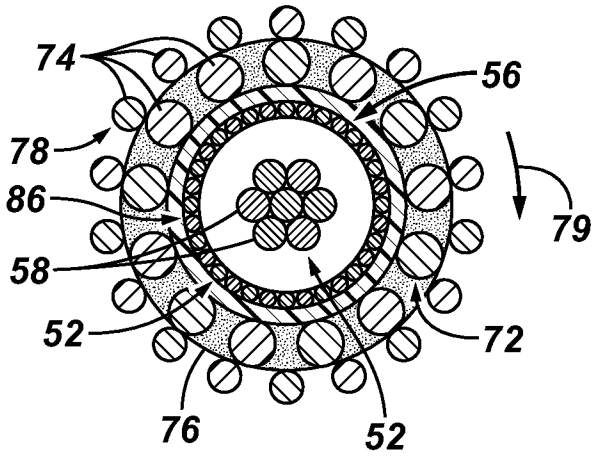


FIG. 16

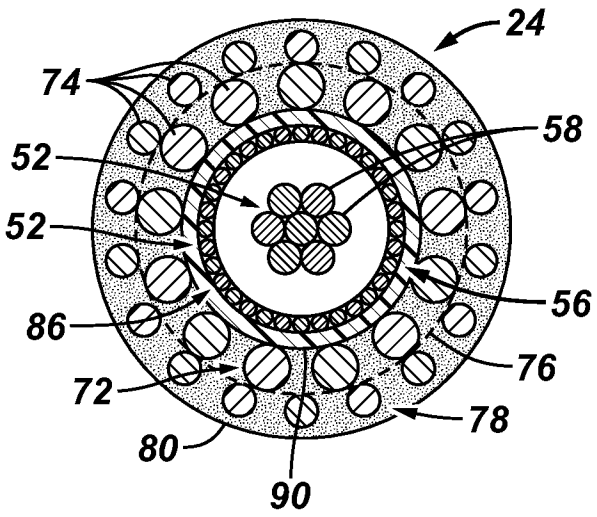


FIG. 17

