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(54) Downhole hydraulic power unit

(57) A self-contained and downhole powered hydraulic power unit (10) is used to supply pressurized hydraulic fluid to manipulate downhole tools. In one embodiment, the unit (10) is self contained and is powered by a battery located down hole and can be lowered into the well by wire line, coiled tubing or tubing process. When properly positioned and actuated the unit (10) will deliver fluid to actuate the downhole tool. A battery-powered motor drives a hydraulic piston in a cylinder to pump fluid carried by the unit to the well tool.

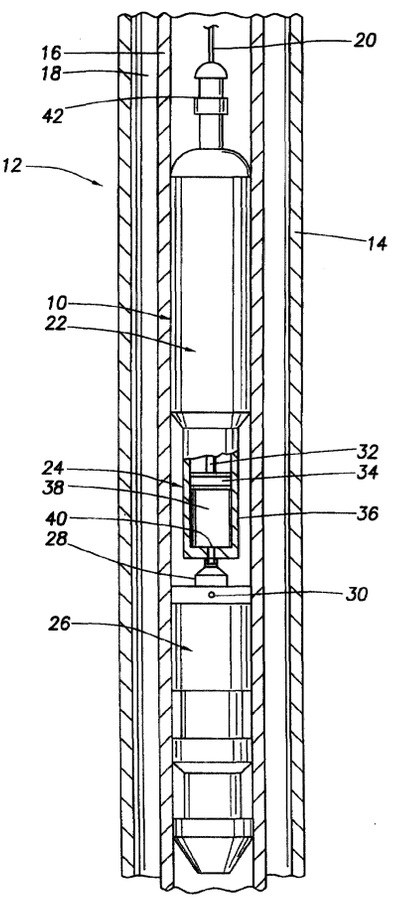

FIG. 1

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Description

[0001] The present invention relates to improvements in apparatus and methods used to manipulate or operate subterranean actuated well tools. More particularly the present invention relates to self-contained and self-powered apparatus used to manipulate hydraulic downhole tools and methods therefore.

[0002] Subterranean or downhole well tools and apparatus are manipulated or operated using pressurized hydraulic fluids. These tools typically have variable volume piston cylinder or inflatable assemblies for converting a supplied hydraulic pressure into force and movement to remotely manipulate the tool from one condition or state to another. Tool manipulation is used in its broadest sense to refer to down hole tool related operations including tool setting, tool removal, tool actuation, tool operation, tool removal and the like. For example, increasing the downhole fluid pressure by using pumps located at the surface is conventionally used to set hydraulic tools such as tubing and casing annulus packers. In some wells tool size and downhole pressures limitations make conventional tubing pressure setting impossible. In any case, pump use for this purpose add to costs. Hydraulic tools located inside the tubing use conduits connected between the surface and the tool to supply actuating fluid to the tool. However lowering conduits into the well is expensive in that it is a time consuming and equipment dependent process. Therefore, there is a need for apparatus and methods for manipulating downhole hydraulic tools without supplying pressure from the surface which can be simply positioned in the well by slick line or the like.

[0003] The present invention contemplates the use of improved hydraulic well tool manipulation units which are self contained, in that, these units do not require external of surface power and in one embodiment do not require external actuation fluid. These units can be positioned in the well by convention pump down or slick line process.

[0004] According to the present invention, a self-contained and downhole powered hydraulic power unit is used to supply pressurized hydraulic fluid to manipulate downhole tools. In one embodiment, the unit is a self contained and is powered by a battery located down hole and can be lowered into the well by wire line, coiled tubing or tubing process. When properly positioned and actuated the unit will deliver fluid to actuate the downhole tool. In this embodiment, a battery-powered motor drives a hydraulic piston in a cylinder to pump fluid carried by the unit to the well tool. In another embodiment the unit is self contained and self powered and cycles to deliver fluid to an actuator tool. When tools such as packers, plugs, retainers, whipstocks, and the like are to be set in the well, the unit is assembled and connected to the well tool at the well surface, the assembly is moved into the well and properly positioned in the well. The unit is operated to hydraulically set the well tool and thereafter the unit is removed from the tool and the well using wire line equipment or the like.

[0005] When the well tool to be manipulated is preinstalled in the well, the unit is assembled, moved downhole, hydraulically connected to the tool and operated to hydraulically manipulate the tool. Thereafter, the unit can be removed from the well by wire line or the like.

[0006] According to another aspect of the invention there is provided a method of manipulating a fluid operated well tool at a subterranean location in the well, the method comprising: transporting an electrically isolated tool into the well to the subterranean location; and operating the electrically isolated tool to deliver fluid to the fluid operated well tool to manipulate the fluid operated well tool.

[0007] In an embodiment, the electrically isolated well tool further comprises an electrical energy storage device having an electrical connection to an electrically operated pump.

[0008] In an embodiment, the electrically isolated well tool further comprises an electrical energy producing device having an electrical connection to an electrically operated pump.

[0009] According to another aspect of the invention there is provided a method of manipulating a fluid operated well tool at a subterranean location in the well, the method comprising: placing a volume of fluid in a chamber in an electrically operated tool before transporting the electrically operated tool into the well; transporting the electrically operated tool into the well to the subterranean location; and operating the electrically operated tool to deliver the fluid to the fluid operated well tool to manipulate the fluid operated well tool.

[0010] In an embodiment, the electrically operated tool comprises an electrical energy storage device having an electrical connection to an electrical pump.

[0011] In an embodiment, the electrically operated tool comprises an electrical energy producing device having an electrical connection to an electrical pump.

[0012] According to another aspect of the invention there is provided an electrically operated tool for use in manipulating a fluid operated well tool located at a subterranean location in a well by delivering fluid under pressure to the well tool, the electrically operated tool comprising: a tool housing of a size to fit into a well and be transported to the subterranean location of the well tool; a self powered electrically operated fluid delivery system on the housing; and a subterranean electrical power supply for connection to the fluid delivery system whereby the fluid delivery system can be operated to supply fluid under pressure to the well tool to operate the well tool without requiring that electrical power be supplied from the well surface.

[0013] In an embodiment, the electrical power supply comprises a battery on the tool housing.

[0014] In an embodiment, the electrical power supply comprises a downhole generator.

[0015] In an embodiment, the self powered electrical-

ly operated fluid delivery system is an electrically operated pump.

[0016] In an embodiment, the electrically operated pump is a piston cylinder assembly.

[0017] According to another aspect of the invention there is provided an electrically operated tool for use in manipulating a fluid operated well tool located at a subterranean location in a well by delivering fluid to the fluid operated well tool, the electrically operated tool comprising: a tool housing of a size and shape to fit into a well and be transported to the subterranean well tool location; a closed chamber on the housing; a supply of actuation fluid in the chamber of a volume sufficient to manipulate the fluid operated well tool; and an electrically powered fluid delivery system on the housing connected to the supply of actuation fluid whereby the fluid delivery system can be operated to supply fluid under pressure to the fluid operated well tool to operate the fluid operated well tool without requiring an external supply of actuation fluid.

[0018] In an embodiment, the electrically operated fluid delivery system is an electrically operated pump.

[0019] In an embodiment, the electrically operated pump is a piston cylinder assembly.

[0020] In an embodiment, the tool further comprises: a self contained electrical power supply electrically connected to the fluid delivery system.

[0021] In an embodiment, the electrical power supply comprises a battery on the tool housing.

[0022] In an embodiment, the electrical power supply comprises a downhole generator.

[0023] Thus, the present invention provides self powered apparatus and method for their use that allow manipulating downhole hydraulically actuated tools without the necessity of supplying pressurized hydraulic actuating fluid or power from the well surface. The apparatus of the present inventions can be quickly operated without the need to work string or related handling equipment and without needing pressure pumps at the well site.

[0024] Reference is now made to the accompanying drawings, in which:

Figure 1 is a side elevation view partially in section illustrating an embodiment of a hydraulic tool installation unit according to the present invention shown removably attached to a hydraulically actuated tool in a subterranean location in a cased well;

Figure 2 is a view similar to Figure 1 illustrating another embodiment of the of the present invention positioned at a subterranean location inside the tubing of a cased well with it fluid output connected to the fluid input of a hydraulically actuated packer located in the tubing casing annulus;

Figure 3 is an electrical schematic diagram illustrating a typical circuit for the hydraulic tool installation unit of the present inventions;

Figure 4 is a fluid schematic illustrating an illustrative embodiment of a hydraulic tool installation unit according to the present invention;

Figure 5 is a fluid schematic illustrating another illustrative embodiment of a hydraulic tool installation unit according to the present invention; and

Figure 6 is a fluid schematic illustrating an addition illustrative embodiment of a hydraulic tool installation unit according to the present invention.

[0025] The present invention will be described by reference to drawings showing one or more examples of how the invention can be made and used. In these drawings, reference characters are used throughout the several views to indicate like or corresponding parts. In the description of the invention that follows, certain terms are employed to refer to the operational characteristics and relationships among certain apparatus and methods. The word "actuation" is used to mean to manipulate or change condition. The terms "electrically operated" mean operated with electricity. The term "self contained" means an autonomous unit having all working parts except as specifically indicated.

[0026] In FIGURE 1, a hydraulic power unit assembly 10 of the present invention is shown in a subterranean location in a well 12. Assembly 10 is assembled at the well surface, moved into the well, and is operated to manipulate a hydraulically (fluid) actuated well tool. The well 12 is illustrated as having a casing 14 with tubing 16 therein forming an annulus 18. As will be described the assembly 10 is self powered and self contained allowing it to be supported in the well by a slick line 20 suspended from wire line equipment located at the well surface. Alternatively the assembly 10 could be placed in the well using conventional work string, coil tubing, pump down equipment and methods.

[0027] In this embodiment, assembly 10 comprises a mechanical power unit 22, a fluid pump subassembly 24 and a hydraulically actuated well tool assembly 26. For illustration purposes the tool 26 is an inflatable tubing packer but other hydraulically set down hole equipment such as bridge plugs, cement retainers, sump packers, whipstocks and the like could be used. The inflatable packer uses an inflatable variable volume actuator to set or manipulate the packer. Other suitable well tools use variable volume piston cylinder assemblies as actuators, as it is only important that the tool have and input for supply or removal of pressurized fluid to manipulate the tool.

[0028] The tool 26 is releasably coupled to the actuator, a piston-cylinder fluid pump 24, by a coupling 28 in the form of a retrievable running sub of the type conventionally used to connect tools to work strings and the like. The coupling provides fluid communication between a discharge on the fluid pump 24 and the input on the well tool assembly 26. The releasable aspect of the illustrated coupling comprises a shear pin 30, although other conventional selectively operable couplings would be adequate. To separate or disconnect the

pump 24 from the set tool assembly 26, sufficient tension force is applied to the wire line 20 to cause the pin 30 to shear.

[0029] The downhole mechanical power unit 22 comprises a housing having an electrical battery bank therein for storing electrical power. It is envisioned that the supply of electrical power could be obtained from a downhole source such as a battery pack or generator placed in the well by means independent of the unit. A self contained power actuator such as a motor or solenoid on the housing is powered by the batteries and through mechanical linkage can cause rod 32 to reciprocate in an out of the housing. A controller circuit is located in the housing and is coupled to the batteries and actuator to selectively operate the actuator in the well. The controller circuit includes one or more of the following transducers: timers, motion sensors, pressure sensors, radio frequency and sonic receivers. The control circuit can be programmed to operate in response to the change in one or more variables such as the passage of time, movement, pressure, and/or signals received from the well surface. Conventional downhole mechanical power units suitable for this purpose are described in U.S. Patent No. 5,492,173.

[0030] The fluid pump 34 comprises a variable volume chambered piston cylinder assembly. Rod 32 is connected to piston 34 in cylinder 36. A variable volume chamber 38 has a discharge passageway 40. Chamber 38 is closed volume in that it is sealed from the exterior except through discharge passageway 40. Before inserting the unit assembly 10 in the well the piston 34 is moved to a position to attain the desired size for volume 38. Preferably volume 38 is filled with fluid for delivery though discharge 38. When the unit assembly is properly positioned in the well the mechanical power unit 22 is operated to move rod 32 and reduce the volume of chamber 38 causing fluid under pressure to move through discharge 40, coupling 28, and into the actuator chamber of tool 26. Typically inflatable packers, plugs and the like have internal check valves to control fluid flow into and out of the actuator chamber, however where necessary internal valves (not shown) could be included with the pump assembly 24 to control the direction and flow through discharge 40.

[0031] The method of using the hydraulic power unit assembly 10 to manipulate hydraulic well tools at a downhole location is exemplified by the remote setting of an inflatable tubing packer 26. The assembly 10 is made up, assembled, at the well surface with the controller circuit preprogrammed to operate in response to an input such as the passage of time. At the surface chamber 38 is charged with fluid and joined to coupling 28 on inflatable packer 26. The electrically charged internal batteries are in place and the packer 26 is releasably coupled to the pump discharge 40. The assembly 10 is connected to the slick line 20 by a slick line collar locator 42 and lowered into the well 12 by wire line equipment located at the well surface. When the wire line equipment indicates the tool 26 is properly positioned in the well it is held in position until the mechanical power unit 22 is actuated by timer in the control circuit. As the unit 22 actuates it moves piston 34 in chamber 38 to deliver actuator fluid to actuate or set packer 26. Thereafter, slick line 20 is tensioned to shear pin 30 and disconnect coupling 28 allowing removal of the unit while leaving the tool 26 set in the well. According to this method no electrical or hydraulic power from the surface is required to manipulate the downhole tool, nor are any well fluids required for delivery to the well tool.

[0032] In Figure 2 an alternative embodiment of the hydraulic well tool assembly 50 of the present invention is illustrated. In this embodiment, a preinstalled downhole tubing annulus packer assembly 52 is manipulated. Packer assembly 52 is installed in the tubing string 16 as it is made up and lowered in to the well casing 14.

[0033] In this particular example a tubular locator sub 54 and tubular packer assembly 52 are connected in the tubing string 16. The locator sub 54 contains surfaces or shoulders which cooperate with a movable tool to accurately position the tool. Locators or this type are accurate in positioning a tool in a well and are especially useful to mate or connect up with movable well service tools and preinstalled tools such as packer assembly 52.

[0034] Packer 52 is a conventional hydraulic (pressure) set packer of the type known in the art. For purposes of description packer 52 is shown dramatically as having an input fluid passage 56 and a variable volume chamber 58 formed between piston 60 and cylinder 62. As shown input passage 56 is formed in the wall 88 of packer 52 and communicates between the interior of the tubing 16 and chamber 58. When fluid pressure is supplied to chamber 58 through passage 56 piston 60 will move in cylinder 62 to engage packer slip 64 and expandable seal member 66 with the interior wall of the casing 14, thus setting the packer 52. A ratchet 68 holds the packer in the set position.

[0035] The embodiment 50 of the hydraulic assembly unit contains a mechanical power unit and fluid pump as described with respect to Figure 1. However, it uses a locator tool 70 to interact with locator sub 54 to allow precise positioning of the assembly 50 in the well. In operation as the assembly 50 moves into the well, it engages mating surfaces in the locator sub 70 to hold the unit in place.

[0036] A seal assembly 80 is connected to the pump 24. Seal sub assembly has a tubular body 82 with internal fluid passageways, valves and external discharge passage 92 and input passage 94. Two axially spaced sets of seals 84 and 84 such a V-packing are mounted on the exterior of the body 82 on opposite sides of the discharge port 92. These seals are of a size to seal with the interior of wall 88 and form an annular chamber 90. By presetting the axial separation between the locator 70 and chamber 90 to equal the distance between the locator sub 54 and input passage 56, chamber 90 will overlap passage 56 on packer 52, thus, discharge pas-

sage 92 on the body 82 is in fluid connection with input passage 56 on packer 52.

[0037] In this embodiment, two flow passages 96 and 98 in body 82 connect to pump discharge 40. Passage 96 connects passage 40 to discharge passage 92. Passage 98 connects passage 40 to input passage 94. Valves 100 and 102 are connected in passages 96 and 98, respectively. Valve 100 limits fluid flow though passage 96 in the discharge direction from passage 40 to discharge passage 92. Valve 102 limits fluid flow through passage 98 in the input direction from passage 94 to discharge passage 40. As will be appreciated, when pump piston 34 is reciprocated fluid will be pumped into chamber 38 from the well through passages 94, 98 and 40 and will be pumped from chamber 38 and into packer chamber 58 through passages 40, 96, 92, and 56.

[0038] The control circuit in this embodiment is programmed to reciprocate the piston 34 the desired number of strokes necessary to set the packer 52 whether that be only one or many strokes. Although not shown a pressure relief valve could be connected to the discharge and set slightly above the designed packer set pressure to prevent damage from damaging pressures resulting from over stroking the piston 34.

[0039] The method of using the hydraulic power unit assembly 50 of Figure 2 is similar to that described with regard to Figure 1. The unit 50 is assembled with the seal sub assembly 80 attached at the lower end and the chamber 38 filled with actuation fluid. The upper end of unit 50 is connected to a slick line or electric line, tubing, etc. 20 (or left off if pump down and pump up procedures are used) for placement in the well. The locator 70 is attached and control circuit set to actuated the power unit 22 when properly positioned in the well. In this case an accelerometer is present to sense when the unit stops moving for a set period of time. The assembly 50 is lowered into the well 10 until the locator 70 engages the locator sub 54 and stops in the position shown in Figure 2. Next, the control circuit sensing lack of movement for the set period of time, actuates the motor to move the piston 34 to deliver actuation fluid to the tool. If a larger volume of fluid is required, the piston is reciprocated by reversing the motor to pump fluid into the packer actuation chamber 58 until the packer 52 is set. After the packer is set the unit 50 can be removed from the well by the slick line or other methods (coiled tubing, electric line, etc.) 20.

[0040] In Figure 3 a typical electrical schematic for the mechanical power unit is illustrated. The battery pack 100 is connected to the control circuit 102. Control circuit 102 is connected to the motor 104, which reciprocates piston 32 through a gearbox 106. The motor 104 is preferably reversible and can be powered by the battery pack. The battery pack 100 has sufficient electrical storage capacity to operate the motor 104 a sufficient time to pump a sufficient volume of fluid to manipulate the well tool. Controller 102 contains one or more sensors or transducers responsive to: changes in movement, changes in pressure, changes in temperature, the passage of time, and or the receipt of sonic and radio frequency signals. Control circuit 102 contains conventional power switching circuits to first operate the motor in one direction and them reverse the motor and operate it in the opposite direction to cause the piston 34 to reciprocate in the cylinder 36.

[0041] Alternatively, the motor could be replaced with a solenoid attached to a plunger pump. Also, the piston pump could be replaced with other types of pumps such as a gear pump or the like.

[0042] In Figures 4-6 fluid delivery schematics are shown for various embodiments. Figure 4 illustrates the fluid flow diagram for the Figure 1 embodiment. In this embodiment chamber 38 contains sufficient capacity to manipulate the tool 26 with a single stroke of the piston 34.

[0043] Figure 5 illustrates the flow diagram for the Figure 2 embodiment. The chamber 38 contained insufficient volume to set the tubing annulus packer, and thus the controller circuit was set to reciprocate the piston to pump additional amounts of fluid into the chamber 58 of packer 52. A timer or pressure switch 110 can be connected to the control circuit to operate the motor until the packer is completely actuated.

[0044] It is to be understood that single piston stroke could be used with any type of downhole tool when the fluid pumped by the piston in that one stroke is sufficient. Also as illustrated in Figure 6 a reciprocating or multiple stroke configuration could be used with a releasably attached inflatable packer 26. It is anticipated that the present inventions and methods could be used to manipulate any and all hydraulically operated downhole well tool without the need for surface provided power or pressure.

[0045] The embodiments shown and described above are only exemplary. Many details are often found in the art such as: downhole tools including packers, plugs, whipstocks, retainers and the like. Suitable downhole mechanical power units are described and illustrated in U.S. Patent No. 5,493,173. Therefore, many such details are neither shown nor described. Even though numerous characteristics and advantages of the present inventions have been set forth in the foregoing description, together with details of the structure and function of the inventions, the disclosure is illustrative only, and changes may be made in the detail, especially in matters of shape, size and arrangement of the parts within the principles of the inventions to the full extent indicated by the broad general meaning of the terms used in the attached claims. It will therefore be appreciated that modifications may be made.

Claims

1. A method of manipulating a fluid operated well tool

at a subterranean location in the well, the method comprising: transporting an electrically isolated tool into the well to the subterranean location; and operating the electrically isolated tool to deliver fluid to the fluid operated well tool to manipulate the fluid operated well tool.

2. A method according to claim 1, wherein the electrically isolated well tool further comprises an electrical energy storage device having an electrical connection to an electrically operated pump.

3. A method according to claim 1 or 2, wherein the electrically isolated well tool further comprises an electrical energy producing device having an electrical connection to an electrically operated pump.

4. A method of manipulating a fluid operated well tool at a subterranean location in the well, the method comprising: placing a volume of fluid in a chamber in an electrically operated tool before transporting the electrically operated tool into the well; transporting the electrically operated tool into the well to the subterranean location; and operating the electrically operated tool to deliver the fluid to the fluid operated well tool to manipulate the fluid operated well tool.

5. An electrically operated tool for use in manipulating a fluid operated well tool located at a subterranean location in a well by delivering fluid under pressure to the well tool, the electrically operated tool comprising: a tool housing of a size to fit into a well and be transported to the subterranean location of the well tool; a self powered electrically operated fluid delivery system on the housing; and a subterranean electrical power supply for connection to the fluid delivery system whereby the fluid delivery system can be operated to supply fluid under pressure to the well tool to operate the well tool without requiring that electrical power be supplied from the well surface.

6. A tool according to claim 5, wherein the electrical power supply comprises a battery on the tool housing.

7. A tool according to claim 5 or 6, wherein the self powered electrically operated fluid delivery system is an electrically operated pump.

8. An electrically operated tool for use in manipulating a fluid operated well tool located at a subterranean location in a well by delivering fluid to the fluid operated well tool, the electrically operated tool comprising: a tool housing of a size and shape to fit into a well and be transported to the subterranean well tool location; a closed chamber on the housing; a supply of actuation fluid in the chamber of a volume sufficient to manipulate the fluid operated well tool; and an electrically powered fluid delivery system on the housing connected to the supply of actuation fluid whereby the fluid delivery system can be operated to supply fluid under pressure to the fluid operated well tool to operate the fluid operated well tool without requiring an external supply of actuation fluid.

9. A tool according to claim 8, wherein the electrically operated fluid delivery system is an electrically operated pump.

10. A tool according to claim 8 or 9, further comprising: a self contained electrical power supply electrically connected to the fluid delivery system.

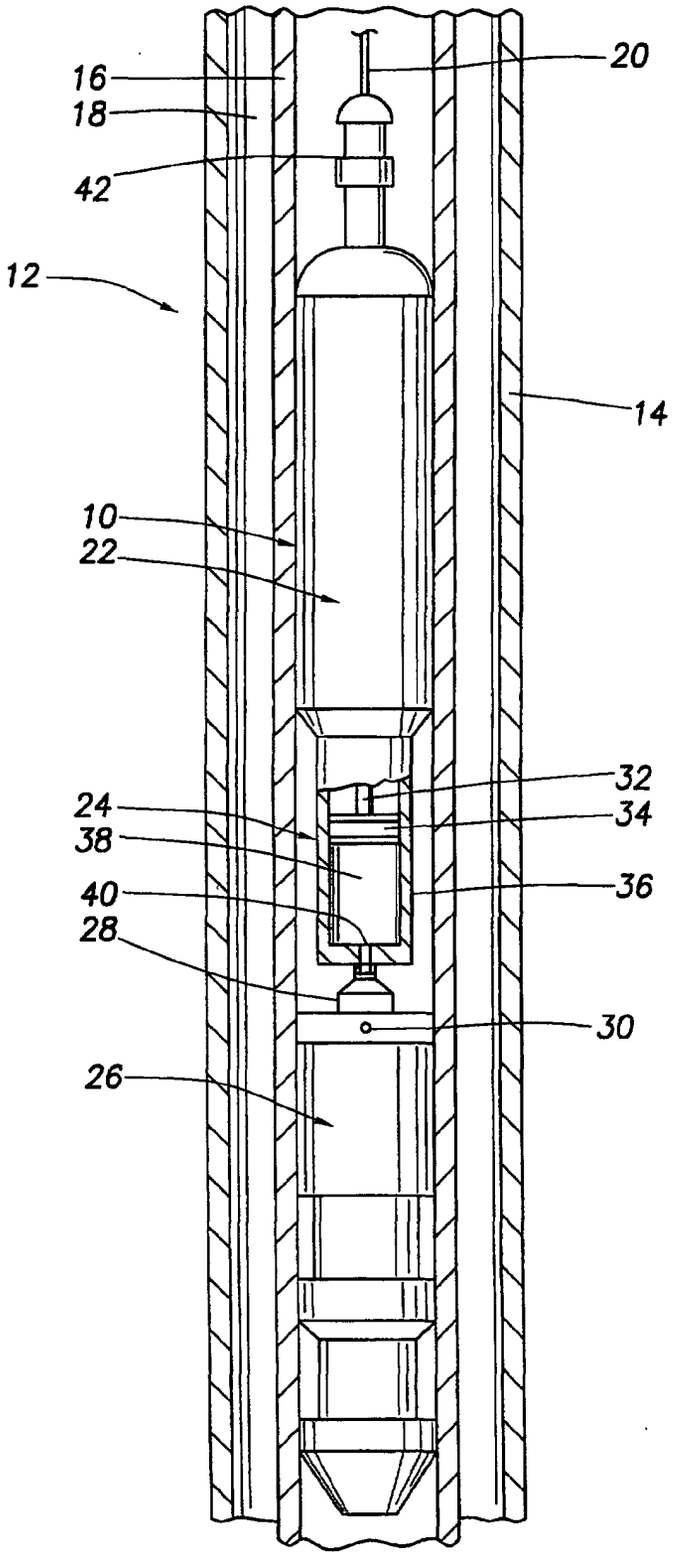

FIG. 1

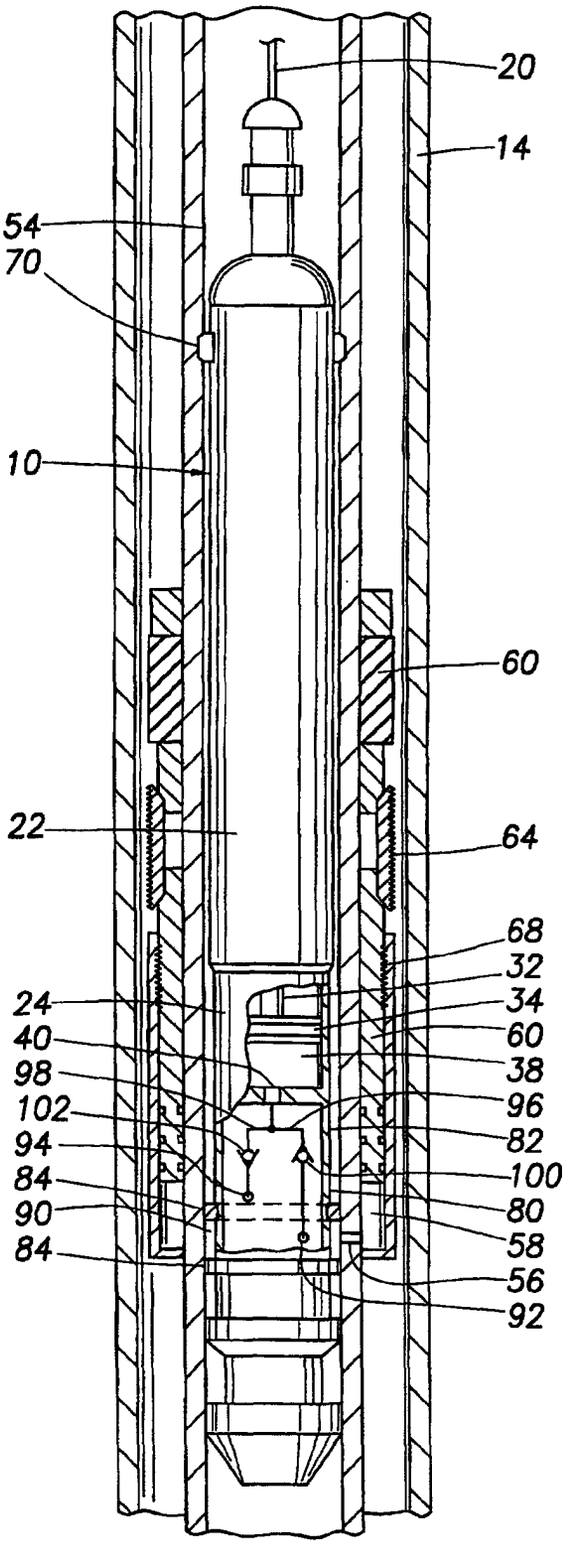
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FIG.2

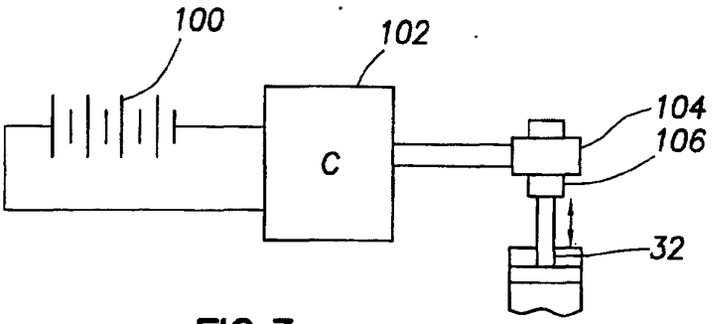

FIG.3

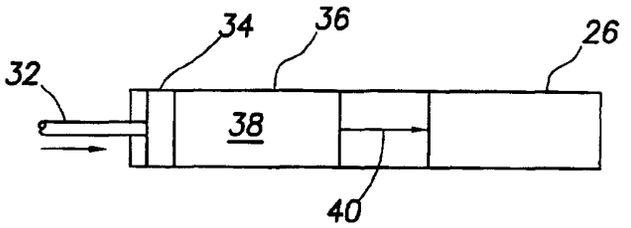

FIG.4

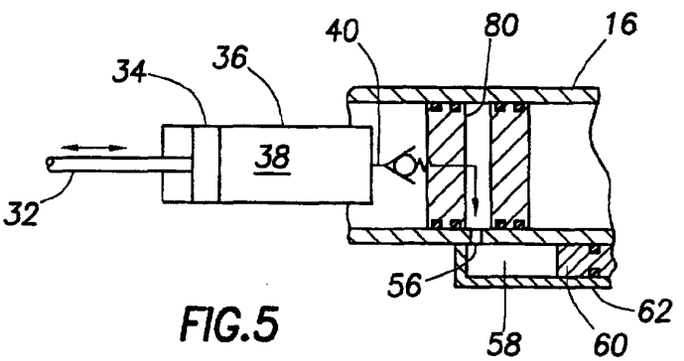

FIG.5

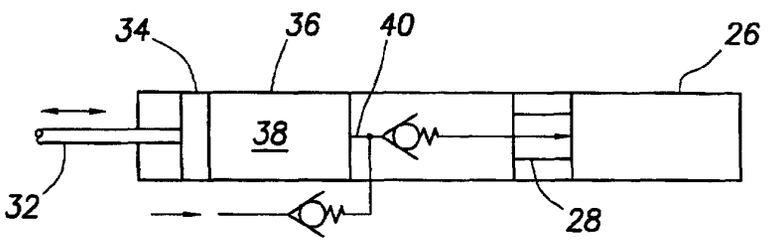

FIG.6