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METHOD AND APPARATUS FOR MOVING WIRE-LINE TOOLS
THROUGH DEVIATED WELL BORES

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2 Sheets-Sheet 2

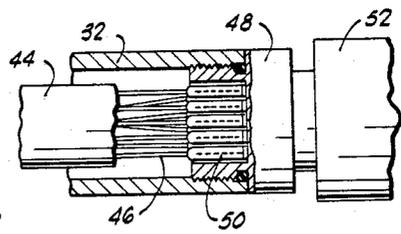
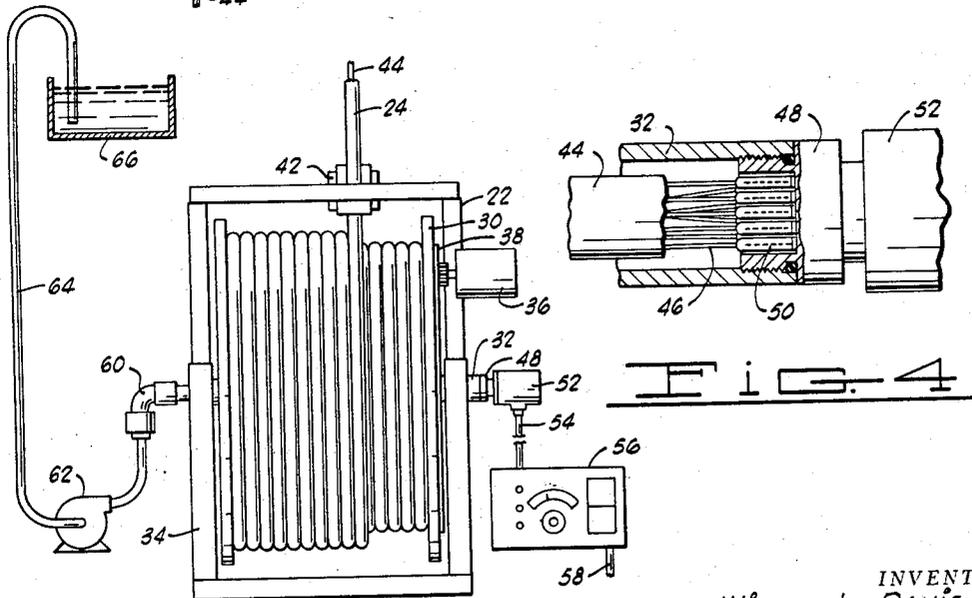
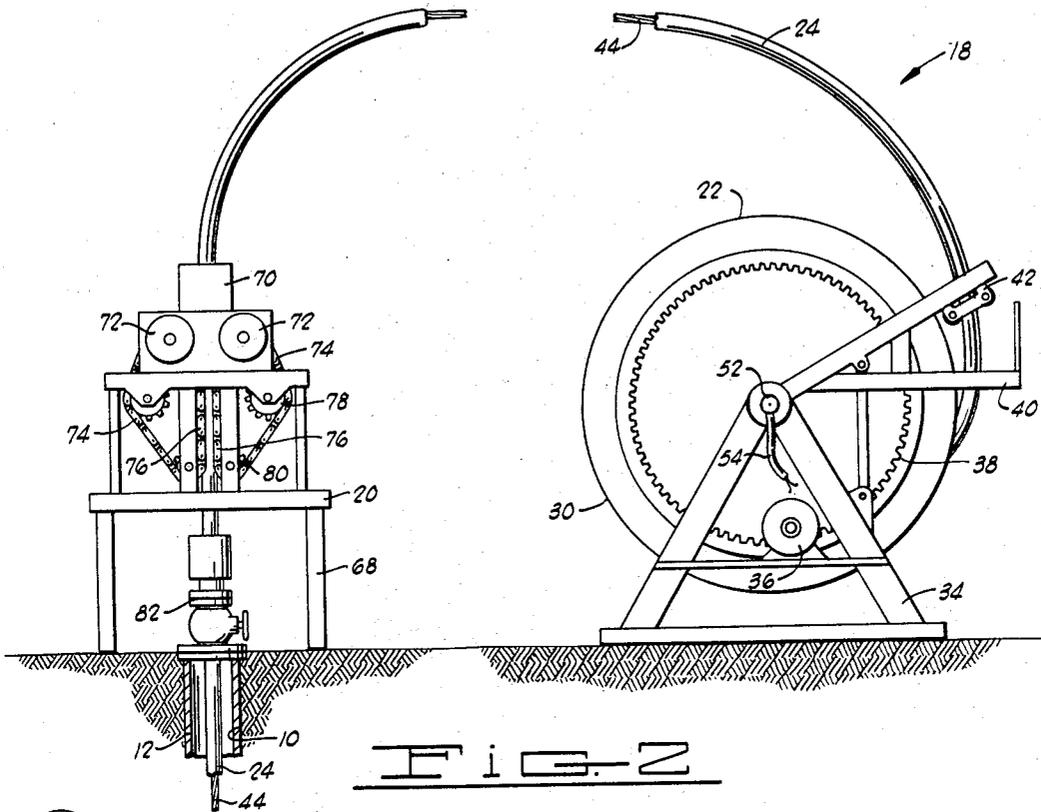


FIG. 3

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METHOD AND APPARATUS FOR MOVING WIRE-LINE TOOLS THROUGH DEVIATED WELL BORES

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This invention relates generally to improved methods and apparatus for moving wire-line actuated well tools through well bores wherein the well bore includes a portion that deviates from the usual vertical orientation. More particularly, but not by way of limitation, this invention relates to an improved method and apparatus wherein a wire-line is disposed in a relatively flexible elongated conduit and wherein the conduit and wire-line are injected into the well bore to move the well tool through the deviated portions thereof.

It has become relatively common within the last few years to drill wells in the search for oil and gas and the like with a portion of the bore deviating from the usual vertical orientation thereof. The deviation may extend for a considerable distance at an angle of eighteen to twenty degrees from the horizontal and then return to the usual vertical orientation. In drilling such wells, a device known as a whipstock is set at spaced intervals along the well bore as the drilling progresses to cause the well bore to deviate approximately six degrees from the vertical until the desired relatively horizontal deviation angle is attained. The well bore is then drilled for as much as several thousand feet along the deviation angle and may then be returned to the vertical orientation by setting the whipstock at spaced intervals as previously mentioned.

As is well known in the art of drilling wells, there are many well tools that are generally run into the well bore on a wire-line and/or cable to perform various operations therein. Such tools depend upon the force of gravity to permit positioning of the well tools at the desired formation in the well bore.

Manifestly, the relatively horizontal angle of the deviated portion of the well bore will not permit the wire-line actuated tools to move into the lower portion of the well bore since the friction of the well tool in the deviated portion will be sufficient to overcome the force of gravity. Thus, it has become essential to provide some means of forcing the wire-line actuated tools through the deviated portion of the well bore.

This invention, in one aspect, provides an improved method for moving a wire-line tool through a well bore having a deviated portion including the steps of: extending the wireline through a length of conduit; connecting the wire-line tool to the wire-line adjacent one end of the conduit; extending the tool, wire-line, and conduit into the well bore until the tool is disposed in the deviated portion of the well bore; and, applying a force to the tool through the conduit in a direction to move the tool, conduit, and wire-line along the deviated portion of the well bore.

In another aspect, this invention provides improved apparatus useful in well bores having a deviated portion including: a relatively flexible elongated conduit; a wire-line extending through the interior of the conduit; a well tool connected with one end of the wire-line and arranged to be actuated thereby, the well tool being engageable with the conduit; and, force applying means for exerting a force on the well tool to inject the conduit, wire-line, and well tool into the well bore and through the deviated portion thereof.

One object of the invention is to provide an improved

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method for moving wire-line actuated tools through a well bore having a deviated portion.

Another object of the invention is to provide an improved apparatus useful in well bores having a deviated portion.

A further object of the invention is to provide improved apparatus including force applying means arranged to exert a force on a wire-line actuated well tool to move the tool through a deviated portion of a well bore.

The foregoing and additional objects and advantages of the invention will become more apparent as the following detailed description is read in conjunction with the accompanying drawings wherein like reference characters denote like parts in all views and wherein:

FIGURE 1 is a schematic view illustrating a well bore having a deviated portion with apparatus constructed in accordance with the invention disposed therein;

FIGURE 2 is an enlarged view illustrating apparatus for injecting a flexible conduit into the well bore;

FIGURE 3 is an enlarged view, partly in schematic, illustrating a portion of the apparatus shown in FIGURE 2;

FIGURE 4 is an enlarged cross-sectional view of a pressure sealed bulkhead connector used with the apparatus of FIGURE 1;

FIGURE 5 is an enlarged cross-sectional view illustrating the apparatus utilized to place the wire-line in the interior of the elongated conduit; and,

FIGURE 6 is an enlarged view of part of the deviated portion of the well bore illustrating in more detail the apparatus for moving the well tool therethrough.

Referring to the drawing and to FIGURE 1 in particular shown therein and generally designated by the reference character 10, is a well bore having a vertical upper portion 12 extending to the surface, a vertical lower portion 14, and a deviated portion 16 connecting the upper and lower portions 12 and 14, respectively. The deviated portion 16 is illustrated as extending at an angle of 20° relative to the horizontal. It should be pointed out that the vertical portions 12 and 14 and the intermediate or deviated portion 16 are normally several thousand feet in length.

Arranged in operable relationship to the well bore 10 and located on the surface is an injector assembly generally designated by the reference character 18. The injector assembly 18 includes an injector 20 and a reel 22. The injector assembly 18 will be described more fully in connection with FIGURES 2 and 3.

It can be seen in FIGURE 1 that an elongated conduit 24 extends from the reel 22 through the injector 20 and into the well bore 10. A jetting head 26 is attached to the lower end of the conduit 24 and a logging tool 28 is connected to the jetting head 26. The jetting head and logging tool 28 are illustrated as being disposed in the deviated portion 16 of the well bore 10. The surface mounted injector assembly 18, which is shown in some detail in FIGURE 2 is illustrated and described in considerably more detail in an article entitled "Instant Workovers" appearing on pages 72 and 73 of the Jan. 13, 1964 issue of "The Oil & Gas Journal."

As shown in FIGURE 2, the reel includes a drum 30 that is sized to receive approximately 15,000 feet of the conduit 24. The drum 30 is of the continuous-type, that is, the innermost end of the conduit 24 is connected to a hollow pipe 32 (see FIG. 4) that serves as an axle for the drum 30 and also provides for the continuous pumping of fluid through the conduit 24 as will be described.

The drum 30 is rotatably supported in a suitable frame 34 and is caused to rotate by a motor 36 and ring gear 38. The motor 36 is mounted on the frame 34 and the ring gear 38 is mounted on the drum 30. Also mounted

on the frame 34 is an operator's platform 40 and a suitable level-wind mechanism 42 that is arranged to move laterally across the drum 30 so that the conduit 24 will be evenly reeled thereon.

As can be seen in FIGURE 2, a wire-line or cable 44 extends through the conduit 24. The wire-line 44 includes sufficient conductors 46 (see FIG. 4) for operating the logging tool 28 or whatever type of wire-line actuated well tool may be connected therewith. Although the wire-line 44 appears to be large as compared to the size of the conduit 24, it should be pointed out that the conduit 24 preferably has an internal diameter of approximately one inch while the outside diameter of a seven conductor logging cable has an outside diameter of approximately $\frac{7}{16}$ of an inch. Thus, it can be appreciated that the wire-line 44 will occupy only a very small area of the interior of the conduit 24.

One end of the wire-line 44 extends into the hollow shaft 32 and the conductors 46 contained therein are connected to a pressure-sealed bulkhead connector 48. As shown in FIGURE 4, each of the conductors 46 is connected with an insulated pin 50 that forms a portion of the bulkhead connector 48. The bulkhead connector 48 is threadedly attached to one end of the hollow shaft 32 and is, therefore, rotatable therewith.

Although not illustrated in detail, the bulkhead connector 48 includes a collector ring assembly 52 that is constructed in a manner well known to those skilled in the well logging art. Generally, the collector-ring assembly 52 provides a means for transmitting the signal carried by each of the pins 50 to a non-rotating multi-conductor cable 54 (see FIG. 3).

The multi-conductor cable 54 is, at its other end, electrically interconnected with a control and recording panel 56. The panel 56 is connected with a source of EMF (not shown) by a conductor 58. The panel 56 includes the necessary switches, recorders, and other control and information gathering devices to operate any wire-line well tool, such as the logging tool 28, that is connected with the wire-line 44.

As shown in FIGURE 3, the opposite end of the hollow shaft 32 is connected with a rotatable swivel joint 60 that is, in turn, connected with a pump 62. The pump 62 is connected by a suction pipe 64 with a reservoir 66. The arrangement is such that fluid can be continuously pumped from the reservoir 66 through the pump 62 and swivel joint 60, into the conduit 24 while the drum 30 is rotating.

Referring again to FIGURE 2, the injector 20, forming a portion of the injector assembly 18, is provided with a suitable framework 68 for mounting the injector 20 in alignment with the well bore 10. Mounted on the upper end of the framework 68 is a pipe straightener and guide 70 wherein the conduit 24 is straightened as it starts into the injector 20. A pair of motors 72 are located on the framework 68 just below the straightener 70.

Each of the motors 72 drives a pair of endless chains 74 (only one chain is shown for each of the motors 72 in FIGURE 2). As clearly shown therein each of the chains 74 includes a vertically disposed portion 76 that extends along and in engagement with the conduit 24. Appropriate idlers 78 and pressure wheels 80 are provided to maintain the chains 74 in engagement with the conduit 24. As will be readily apparent from viewing FIGURE 2, the chains 74 are driven in relatively opposite directions so that the vertical portions 76 thereon, which are in engagement with the conduit 24, are moving in the same direction to move the conduit 24 in the appropriate direction either into or out of the well bore 10.

FIGURE 2 illustrates the upper portion 12 of the well bore 10 as being lined by a well casing. Also, appropriate well head apparatus 82 is provided as required by the particular well conditions, whereby the conduit 24, well tool 28, and wire-line 44 can be injected therein.

As previously mentioned, the conduit 24 may be as long as 15,000 ft. Due to the extreme length of the conduit 24, special consideration must be given to the apparatus used for placing the wire-line 44 therein. FIGURE 5 illustrates one form of apparatus that can be utilized for this purpose.

As shown therein, one end of the wire-line 44 is extended through a cap 84 and seal 85 which form a portion of a stuffing box 86. A sealing member 88 is then placed over the end of the wire-line 44 and connected thereto by suitable means such as a collar 90. The sealing member 88 is then placed in the end of the conduit 24 and the stuffing box 86 connected thereto as illustrated. The sealing member 88 is large enough in diameter to sealingly engage the conduit 24, but it must be slidable therein.

After the stuffing box 86 has been screwed on the conduit 24, the cap 84 is screwed on the stuffing box 86, deforming the seal 85 into fluid-tight sealing engagement with the wire-line 44. The pipe 92 is connected to the stuffing box 86 and to a pump (not shown). Fluid is then pumped through the pipe 92 into the stuffing box 86 and into the interior of the conduit 24, forcing the sealing member 88 and the attached wire-line 44 to move through the conduit 24. The pumping is continued until the wire-line 44 has been pumped entirely through the conduit 24.

After this has been accomplished, one end of the wire-line 44 is extended through the hollow shaft 32 and connected with the bulkhead connector 48 as previously described and as shown in FIGURE 4. The other end of the wire-line 44 is inserted through the jetting head 26 as shown in FIGURE 6 and connected in a conventional manner to the logging tool 28.

As shown in FIGURE 6, the jetting head 26 includes a body 94 that is threadedly connected with one end of the conduit 24. A passageway 96 extends partially through the body 94 and is in fluid communication with the interior of the conduit 24. Openings 98 extend through the wall of the body 94 intersecting the passageway 96. The openings 98 are oriented rearwardly to direct fluid flowing through the conduit 24 and the passageway 96 in a relatively reverse direction, that is, back along the exterior of the conduit 24. As the fluid flows through the jetting head 26, a force is exerted thereon tending to move the head 26 and the attached conduit 24 relatively toward the lower end 14 of the well bore 10.

An adapter 100 connects the body member 94 with the logging tool 28 and houses a packing 102 that encircles a portion of the wire-line 44. The packing 102 is constructed so that screwing the adapter 100 into the body member 94 exerts a force thereon deforming the packing 102 into engagement with the wire-line 44 inhibiting the flow of fluid from the passageway 96 into the cable head portion of the logging tool 28.

As is also shown in FIG. 6 an electrode 104 is located on the conduit 24 relatively above the jetting head 26. It will be understood that the electrode 104 is optional and utilized only when certain types of operations such as resistivity or spontaneous potential logs are being made. The electrode 104 is connected with one or more of the conductors 46 contained in the wire-line 44 and is mounted on an electrically insulated portion of the conduit 24 in a manner well known to those skilled in the logging art.

Operation

After the apparatus has been assembled as described hereinbefore, the conduit 24 is extended through the injector 20. The jetting head 26 and logging tool 28 are attached thereto also as previously described. The logging tool 28, jetting head 26 and conduit 24 are then placed in the upper portion 12 of the well bore 10 and are lowered therein by gravity or forced therein by operation of the motor 72 and conduit engaging chains 74. Generally, the tool 28 can be lowered by gravity into the well bore 10

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until such time as the frictional engagement of tool 28 with the wall of the deviated portion 16 is sufficiently great to overcome the force of gravity.

When this occurs, the motor 72 is placed in operation whereby the chains 74, that is, the vertical portions 76 thereof engage the conduit 24, forcefully injecting the tool 28 into the well bore 10. Care should be exercised when attempting to inject the tool 28 into the well bore 10 due to the chance of buckling the relatively long flexible conduit 24.

To avoid buckling of the conduit 24 and to aid in moving the tool 28 through the deviated portion 16 of the well bore 10, the pump 62 is placed in operation, forcing fluid from the reservoir 66 through the swivel 60, the hollow shaft 32 and the conduit 24 into the passageway 96 in the jetting head 26. As previously mentioned, fluid flowing through the passageway 96 passes outwardly through the openings 98, resulting in a reactive force that tends to force the jetting head 26, the connected conduit 24 and the well tool 28 toward the lower end 14 of the well bore 10. Thus, it is possible by either using the injector 20, or the jetting head 26, or by using a combination of the injector 20 and the jetting head 26 to move the logging tool 28 through the deviated portion 16 to the desired position in the well bore 10.

Manifestly, it is essential to be able to send and receive signals from the logging tool 28 continuously as the logging tool 28 is moved along the well bore 10. The continuous signal transmission is possible due to the structure of the previously described bulkhead conductor 48 and collector 52. The switches contained in the control panel 56 may be actuated at any time to place the logging tool 28 in operation whereby the desired portion of the well bore 10 can be logged.

If a different type of well tool is being utilized other than the logging tool 28, for example, a perforating tool, the apparatus is connected and moved to the proper zone or formation in the well bore 10 as previously described. After reaching the desired zone, the appropriate switch or switches in the control panel 56 are operated to fire the perforating tool through the electrical circuit provided by connector 48 and the wire-line 44.

The well tool 28 may be moved upwardly or downwardly through the well bore 10 by changing the direction of rotation of the motor 72. When it is desired to remove the logging tool 28 from the well bore 10, the motor 72 is caused to rotate in a direction whereby the vertical portions 76 of the chains 74 move relatively upwardly in engagement with the conduit 24. Thus, an upwardly directed force is exerted on the conduit 24 moving it relatively upwardly in the well bore 10. The motor 36 is simultaneously actuated to rotate the drum 30 in the proper direction to reel in the conduit 24, wire-line 44, and, thereby, remove the logging tool 28 from the well bore 10.

It is believed apparent from the foregoing detailed description of the structure and operation of the apparatus that there is provided highly effective methods and apparatus whereby wire-line actuated well tools may be moved through well bores having a relatively horizontal deviated portion therein.

It will also be understood that the single embodiment described hereinbefore is presented by way of example only and that many changes and modifications can be made thereto without deviating from the spirit of the invention or from the scope of the annexed claims.

What I claim is:

1. A method of moving a wire-line tool through a well bore having a deviated portion, the method including the steps of:

- extending the wire-line through a length of conduit;
- connecting the tool to the wire-line adjacent one end of the conduit;
- extending the tool, wire-line and conduit into the well

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bore until the tool is disposed in the deviated portion of the well bore; and, applying a force to the tool through the conduit in a direction to move the tool, conduit, and wire-line along the deviated portion of the well bore.

2. The method of claim 1 and also including the steps of:

- connecting the opposite end of the conduit to a pump system whereby fluid can be moved through said conduit;

- connecting a jet head to the other end of the conduit adjacent the tool prior to extending the conduit into the well bore, said jet head including at least one opening arranged to direct the fluid relatively away from the tool to exert a moving force on said tool; and,

- pumping fluid through said conduit and opening to exert an additional force on the tool to assist in moving the tool through the deviated portion of the well bore.

3. The method of claim 1 wherein the wire-line is extended through the conduit by the following steps:

- inserting one end of the wire-line through a stuffing box;

- connecting said one end of the wire-line to a sealing member;

- placing the sealing member into one end of the conduit and in sliding and sealing engagement therewith;

- connecting the stuffing box with said one end of the conduit;

- connecting a pump system in fluid communication with the stuffing box; and,

- pumping said sealing member and connected wire-line through said conduit.

4. The method of claim 1 and also including the steps of:

- connecting the opposite end of the wire-line with switch means for actuating the tool; and,

- operating said switch means to transmit a signal to said tool through said wire-line whereby said tool is actuated.

5. A method of moving a wire-line tool through a well bore having a deviated portion, the method comprising the steps of:

- extending the wire-line through the conduit by inserting one end of the wire-line through a stuffing box,

- connecting said one end of the wire-line to a sealing member,

- placing the sealing member into one end of the conduit and in sliding and sealing engagement therewith,

- connecting the stuffing box with said one end of the conduit,

- connecting a pump system in fluid communication with the stuffing box, and

- pumping said sealing member and connected wire-line through said conduit;

- connecting one end of the conduit to a jet head having at least one opening for directing fluid flowing through the conduit in a reverse direction relative to the length of the conduit;

- connecting the end of the wire-line adjacent said jet head to the well tool;

- connecting the other end of the wire-line to switch means for actuating the well tool;

- connecting the other end of the conduit to a pump system;

- extending the tool, jet head, wire-line and conduit into the well bore until the tool is disposed in the deviated portion of the well bore;

- applying a force to the tool through the conduit to move the tool along the deviated portion of the well bore;

simultaneously pumping fluid through the conduit and opening to exert a force on the tool to aid in moving the tool along the deviated portion of the well bore; and,

operating said switch means to actuate said tool through said wire-line. 5

6. Apparatus useful in well bores having a deviated portion, said apparatus including:

a relatively flexible elongated conduit;
a wire-line extending through the interior of said conduit; 10

a well tool connected with one end of said wire-line and arranged to be actuated thereby, said well tool being engageable with said conduit; and,

force applying means including means on said conduit for exerting a force on said tool to inject said conduit, wire-line, and well tool into the well bore and through the deviated portion thereof. 15

7. The apparatus of claim 6 and also including:

pump means connected in fluid communication with one end of said conduit, said pump means being located on the surface adjacent the top of said well bore; and,

a jet head connected with the other end of said conduit and engageable with said well tool, said jet head having an opening therein in fluid communication with said conduit and oriented in a relatively reverse direction, whereby fluid pumped through said conduit and opening exerts a force on said conduit and well tool to move said tool relatively along the deviated portion of said well bore. 25 30

8. The apparatus of claim 6 and also including:

a pressure-sealed connector operably connected to the opposite end of said conduit and to said wire-line; and, 35

switch means connected with said connector, whereby operation of said switch means actuates said well tool through said connector and wire-line.

9. The apparatus of claim 6 wherein said force applying means includes: 40

reel means for holding said conduit, said reel means

being located on the surface proximate said well bore; and,

injector means aligned with and located over the upper end of said well bore, said injector means engaging said conduit extending from said reel means and arranged to forcibly move said conduit into and out of said well bore.

10. The apparatus of claim 9 wherein

said reel means includes a hollow shaft connected in fluid communication with one end of said conduit; and,

said apparatus also includes

a pressure sealed connector operably connected to one end of said hollow shaft and to said wire-line,

switch means connected with said connector, whereby operation of said switch means actuates said well tool through said connector and wire-line,

pump means connected in fluid communication with the other end of said hollow shaft, said pump means being located on the surface adjacent the top of said well bore, and

a jet head connected with the end of said conduit adjacent said well tool and engageable with said well tool, said jet head having an opening therein in fluid communication with said conduit and oriented in a relatively reverse direction, whereby fluid pumped through said conduit and opening exerts a force on said conduit and well tool to move said tool relatively along the deviated portion of said well bore.

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