FIP8011 OR 3,554,284

United States Patent [11] 3,554,284

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[54] **METHODS FOR FACILITATING THE DESCENT OF WELL TOOLS THROUGH DEVIATED WELL BORES**
11 Claims, 4 Drawing Figs.

[52] U.S. Cl. 166/250, 166/315, 166/77
[51] Int. Cl. E21b 47/12
[50] Field of Search 166/250, 254, 315, 66, 77, 206, 212, 214, 117.5, 243, 63; 175/78

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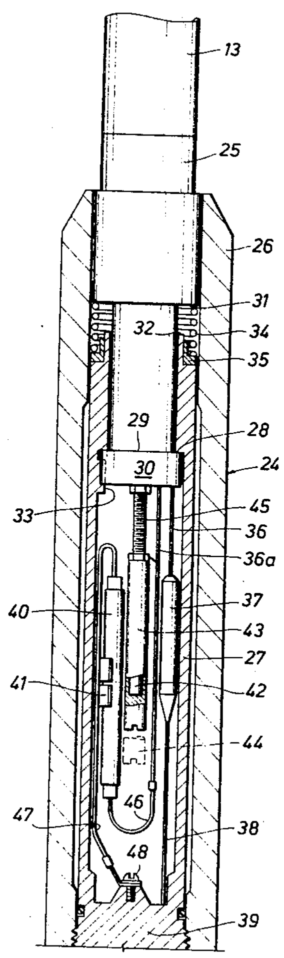
ABSTRACT: To practice the new and improved methods of the invention disclosed herein, a well tool is dependently suspended from an electrical logging cable that is uniquely constructed to withstand limited axial compressive loading without undue lateral bending. In this manner, by selectively moving the suspension cable downwardly from the surface, corresponding axial compressive forces are developed in the lower portion of the cable, which forces are, in turn, imposed on the well tool for assisting its continued descent through substantially deviated well bore intervals.



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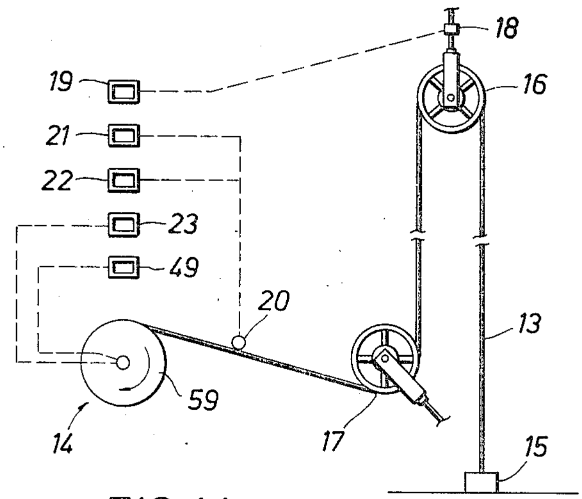


FIG. 1A

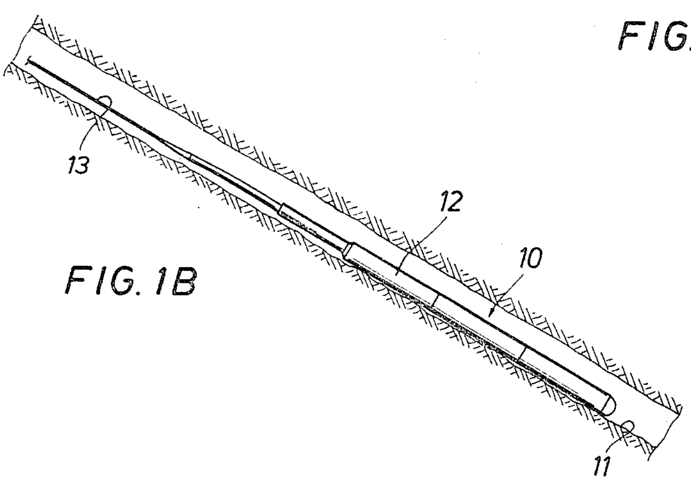


FIG. 1B

FIG. 2

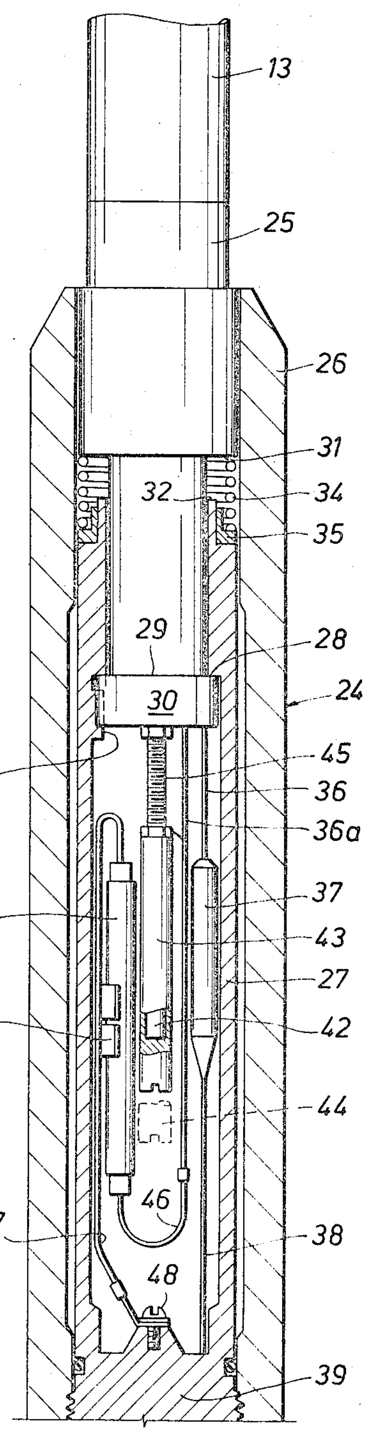
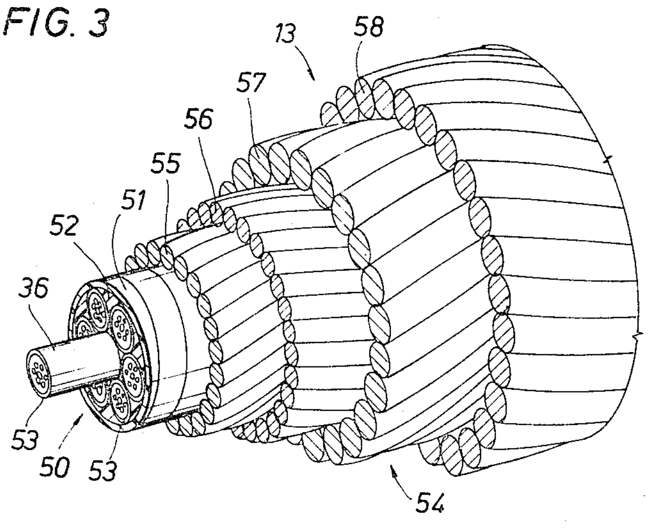


FIG. 3



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ATTORNEY

METHODS FOR FACILITATING THE DESCENT OF WELL TOOLS THROUGH DEVIATED WELL BORES

In some oil fields, it is not at all uncommon to find well bores having highly-slanted intervals therein that may approach angles deviating from the vertical as much as 60° to 80°. It is, of course, all but impossible to simply lower a cable-suspended well tool to the bottom of such highly-deviated well bores. It will be appreciated, therefore, that unless suitable means and techniques are devised for moving cable-suspended well tools through such highly-deviated holes, they cannot be logged or perforated in the usual manner.

Accordingly, it is an object of the present invention to provide new and improved methods for facilitating the descent of cable-suspended well tools through highly-deviated well bores.

It is another object of the present invention to provide new and improved methods for selectively imposing downwardly-directed forces to cable-suspended well bore apparatus for promoting the continued movement of such tools into deviated well bores.

These and other objects of the present invention are accomplished by coupling a well tool that is to be lowered into a well bore having one or more deviated intervals to a relatively-stiff suspension cable that is spooled on a typical powered winch. So long as the well tool continues to descend into the well bore, the cable is allowed to unreel from the winch at a desired speed. Once, however, the descent of the tool is slowed or checked as, for example, when the tool moves into a highly-deviated interval of the well bore, the cable is moved downwardly to reduce tensile forces therein and develop corresponding compressive forces in the lower portion of the cable. In this manner, since at least the lower portion of the cable has sufficient lateral rigidity that it cannot be doubled back onto itself, these downwardly-acting compressive forces will be transmitted to the tool for promoting its further movement.

The novel features of the present invention are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may be best understood by way of the following description of exemplary methods employing the principles of the invention as illustrated in the accompanying drawings, in which:

FIG. 1A depicts a typical arrangement of the surface equipment employed for imposing downward forces to a well tool suspended from a logging cable in a well bore;

FIG. 1B shows a well tool as it may appear while being pushed through a deviated borehole during the practice of the present invention;

FIG. 2 is a cross-sectional view of the upper portion of an exemplary well tool particularly suited for practicing the present invention; and

FIG. 3 is an isometric view, partially in cross section, of a unique suspension cable particularly arranged for the practice of the present invention.

Turning now to FIG. 1B, a well tool **10** such as an electrical logging instrument or other well-completion tool is depicted as it is being moved through a highly-deviated interval of a well bore which, in this instance, is illustrated as being an uncased borehole **11**. Although the specific nature of the well tool **10** is of no consequence to the present invention, it is preferred that the tool include some means, as at **12**, for providing signals at the surface that are at least indicative of whether or not the tool is moving through the borehole **11**. Thus, in one manner of providing such signals, where the tool **10** is a typical logging instrument the signalling means **12** may include a typical radioactivity detector or other measuring device which responds to some characteristic of earth formations. On the other hand, if the tool **10** is a perforator or other completion tool for use in a cased well bore, the measuring device **12** could also be a typical casing collar locator. In any event, the signals produced by the measuring device **12** will vary whenever the tool **10** is moving and, as a result, will provide at least a qualitative indication of the rate of descent of the well tool through the borehole **11**.

The well tool **10** is dependently coupled to the lower end of a uniquely-constructed logging cable **13** which, as will subsequently be explained, is appropriately arranged to withstand substantial axial compressive loads without being doubled back onto itself within the confines of the borehole **11**. As seen in FIG. 1A, the logging cable **13** is spooled in the usual fashion on a powered winch **14** and has previously been directed into the surface casing **15** that customarily lines the walls of the upper portion of the borehole **11**. As is typical the winch **14** is positioned in a convenient location adjacent to the surface casing **15** and the cable **13** is preferably directed into the casing by means of upper and lower pulleys or sheaves **16** and **17** aligned with one another and the winch and respectively supported directly above the casing and to one side thereof. It will be appreciated, of course, that the winch **14** is operatively equipped with brakes and a driving mechanism (neither shown) by which the winch drum may be selectively driven in either rotative direction and at any suitable rotational speed. The upper sheave **16** is typically supported in a derrick (not shown) a strain gage **18** that is coupled to a suitable indicator **19** for measuring the tension forces on the electrical logging cable **13**. As is usual, a calibrated measuring wheel **20** that is frictionally driven by the running portion of the cable **13** is coupled to a totalizer **21** for measuring the length of the cable being reeled onto or off of the winch **14** and a tachometer **22** for indicating the speed of the cable. A suitable instrument **23** is electrically coupled by way of the armored logging cable **13** to the measuring device **12** in the well tool **10**.

Turning now to FIG. 2, the upper portion of the well tool **10** is shown in cross section to illustrate a preferred embodiment of signalling means **24** for indicating when an axial force is being effectively imposed through the suspension cable **13** to the well tool. As illustrated, the lower end of the suspension cable **13** is suitably secured within a cylindrical body **25** that is slidably received within the open upper end of a tubular housing **26** coupled to the upper end of the well tool **10**. To limit the upward longitudinal travel of the cylindrical body **25** in relation to the housing **26**, an elongated sleeve **27** having an inwardly-directed shoulder **28** is secured within the housing to position the shoulder above the upper face **29** of an enlarged-diameter head **30** arranged on the lower end of the cylindrical body. Conversely, downward longitudinal travel of the cylindrical body **25** is limited by an enlarged-diameter shoulder **31** arranged around an intermediate portion of the cylindrical body to engage an upwardly-facing shoulder such as defined by the upper end **32** of the sleeve **27**. To corotatively secure the cylindrical body **25** in relation to the housing **26**, means such as a longitudinal spline-and-groove arrangement, as at **33**, are provided on the enlarged head **30** and internal wall of the sleeve **27**.

Accordingly, it will be appreciated that the cylindrical body **25** is free to travel axially in relation to the housing **26** within the limits provided between the opposed upper shoulders **31** and **32** and the opposed lower shoulders **28** and **29**. For reasons that will subsequently become apparent, the cylindrical body **25** is biased upwardly in relation to the housing **26** by means such as a compression spring **34** coaxially disposed within the tubular housing and yieldably restrained between the shoulder **31** and a ring **35** mounted around the elongated sleeve **27**.

As shown in FIG. 2, the cylindrical body **25** is not fluidly sealed in relation to the housing **26** so that the tubular housing will be filled with the borehole fluids. To prevent the borehole fluids from electrically shorting the various cable conductors, as at **36**, the conductors are appropriately sealed within the cylindrical body **25** and connected, as at **37**, to conductors, as at **38**, leading to the interior of the well tool **10** and brought through typical conductor seals (not shown) sealingly mounted in a transverse partition **39** across the lower end of the tubular housing **26**. Accordingly, inasmuch as the hydrostatic pressure of the borehole fluids will be acting on both sides of the cylindrical body **25**, there will be no unbalanced pressure forces affecting the relative longitudinal position of the cylindrical body in relation to the tool housing **26**. Thus, imposition of a downwardly-directed force through the cable **13** to the cylindrical body **25** will be effective to move the cylindrical body downwardly in relation to the housing **26** against the spring force of the compression spring **34**. Similarly, in the usual situation, the weight of the well tool **10** will be transmitted to the logging cable **13** by means of the opposed shoulders **28** and **29**. Thus, it will be appreciated that so long as the well tool **10** is dependently suspended from the logging cable **13**, the shoulders **28** and **29** will be abutted; and a downwardly-acting force at least as great as the potential spring force provided by the compression spring **34** will be required to shift the cylindrical body **25** downwardly in relation to the tool housing **26** so as to bring the shoulders **31** and **32** into abutment.

Accordingly, it will be appreciated that when the well tool **10** is suspended, the cylindrical body **25** will be at its depicted upper position in relation to the tool housing **26** so that the full weight of the tool is supported by the shoulders **28** and **29**. Similarly, as the tool **10** is moving through a deviated well bore, such as the the borehole **11**, upwardly-directed forces on the housing **26** tending to slow or halt further progress of the well tool **10** will be countered by the longitudinal or axial component of the weight of the well tool. It will be seen, therefore, that when the cylindrical body **25** is elevated in relation to the tool housing **26**, the summation of the downwardly-acting forces on the well tool **10** (such as the longitudinal component of the tool weight) is greater than the downwardly-acting forces on the cylindrical body **25** are equal or greater than the upwardly-directed forces on the tool housing **26** (such as frictional drag) tending to slow or halt the well tool **10** as well as the spring force of the spring **34**, the cylindrical body will be shifted downwardly to bring the shoulder **31** into abutment with the shoulder **32**. Thereafter, so long as these downwardly-acting forces on the cylindrical body **25** predominate, these downwardly-acting forces will be effective for pushing the well tool **10**.

Accordingly, in the preferred manner of providing the signalling means **24** for indicating the position of the cylindrical body **25** in relation to the tool housing **26**, a proximity switch, such as a so-called "reed switch" **40** adapted for remote magnetic actuation, is encapsulated in a suitable pressure-resistant case and secured, as by spring clips **41**, within the elongated sleeve **27**. To actuate the proximity-sensing switch **40**, a magnet **42** is encapsulated in a suitable case **43** and dependently secured below the cylindrical body **25** for movement thereby into and out of the proximity of the switch. In this preferred embodiment, the switch **40** is normally open and the magnet **42** is longitudinally positioned in relation thereto for actuating the switch upon movement of the cylindrical body **25** to its lower position to shift the magnet case **43** to the position shown by the dashed lines at **44**.

To provide means for adjusting the relative longitudinal positions of the magnet **42** and switch **40**, a depending rod **45** supporting the magnet case **43** is preferably threaded so that the magnet case can be screwed upwardly or downwardly along the rod. One lead **46** from the switch **40** is connected to a selected conductor **36*a*** in the logging cable **13** and another switch lead **47** is electrically connected to either another cable connector or to the tool housing **26** as at **48**. Since the armor of the logging cable **13** is electrically connected to the housing **26**, the cable armor will serve as a return path. In this manner, so long as the switch **40** is open, the cable conductor **36*a*** will not be connected to any other cable conductors; and, upon movement of the magnet **42** to its lower position **44**, the switch will close to connect the cable conductor **36*a*** to the tool housing **26**. Thus, by connecting a suitable electrical instrument such as, for example, an ohmmeter **49** between the cable armor and the conductor **36*a*** at the surface, a surface indication will be provided representative of the longitudinal position of the cylindrical body **25** in relation to the tool housing **26**.

Turning now to FIG. 3, an isometric view is shown of a preferred embodiment of the suspension cable **13** to illustrate its unique construction. As fully explained in a copending application Ser. No. 827,186, filed May 2, 1969 the logging cable **13** has a central axial core **50** comprised of a plurality of insulated electrical conductors **36** that are symmetically grouped and encased in a suitable sheath **51** which, for example, may be either braided Nylon strands or spirally-wrapped insulating tape. To give the core **50** a generally cylindrical form, the interstitial spaces between the electrical conductors **36** and the sheath **51** are filled with semiconductive materials such as cotton fillers **52**. To reduce the effects of capacitive coupling between the several cable conductors **36**, the outer surfaces of the insulating sheath **53** of each cable conductor **36** is coated with a thin, electrically-semiconductive film and the cotton fillers **52** and Nylon braid **51** (or spiraled tape) are impregnated with an electrically-semiconductive compound. Thus, in the finished cable core **50**, each insulated conductor **36** is surrounded by a semiconductive film which is electrically connected to the external armor **54** of the logging cable **13**.

To protect the central cable core **50**, the external armor **54** is comprised of a unique arrangement of four concentric layers **55—58** of helically-wound armor strands wound in a particular manner around the central core. The two innermost layers **55** and **56** of the armor **54** are assembled onto the central core **50** in the usual manner. That is to say, the innermost layer **55** of the armor **54** comprises a plurality of metallic strands wound in one so-called "lay" direction about the core **50**, and the second layer **56** of the armor similarly comprises a plurality of metallic strands wound in the opposite "lay" direction about the innermost armor layer. The number, size, and pitch or lay angle of the first and second layers are chosen so that the innermost layer **55** substantially covers the central core **50** and the second layer **56** substantially covers the first layer. As is customary, these inner layers **55** and **56** of the armor **54** perform the usual tension-bearing functions of the cable **13** as well as protect the central cable core **50** from damage.

It will be appreciated, of course, that if the logging cable **13** had only the two inner layers **55** and **56** of armor strands, as is typical for such cables, the cable would have only minimal longitudinal stability for withstanding axial compressive loads. Accordingly, inasmuch as the electrical logging cable **13** must also be capable of transmitting axially-directed compression forces through its lower portion to the well tool **10**, the two outer layers **57** and **58** of the armor **54** are uniquely arranged to laterally stiffen the cable to withstand such compression forces without materially reducing the ability of the cable to be spooled onto the winch **14** and operatively carried over the sheaves **16** and **17**. More significantly, these two outer layers **57** and **58** are uniquely wound in oppositely-directed lays and respectively have a pitch angle in the order of about 35° as compared to only about 18° for the two layers **55** and **56**.

Accordingly, by virtue of the substantial pitch angles of the two outer layers **57** and **58**, the logging cable **13** will be incapable of doubling back on itself within the diameter of a typically-sized well bore. Thus, when compressive loads are imposed on the lower portion of the suspension cable **13**, these loads will initially be transmitted through the cable to the tool **10** and gradually begin bending the lowermost length of the cable into a long helix. However, instead of doubling back on itself as would otherwise be usually expected, the logging cable **13** will continue transmitting axial compressive loads to the tool **10** until it has been helically looped so as to expand the cable loops into engagement with the walls of the borehole **11**. Ultimately, of course, the frictional engagement of the helical loops of the cable **13** with the walls of the borehole **11** will be sufficient to tightly wedge the cable so that further compressive loads cannot be imposed therethrough so long as the loops are against the borehole wall.

With this unusual ability of the logging cable **13** in mind, it will, therefore, be appreciated that as the well tool **10** is progressively moved downwardly through the borehole **11**, axial compressive loads can be imposed thereon by way of the cable.

Thus, in the practice of the present invention, the well tool **10** is lowered into the borehole **11** at, preferably, as high a speed as can be attained by free fall of the well too through the borehole fluids. This of course, means that for most situations, the winch **14** will be allowed to freewheel so that the weight of the well tool **10** and progressively-increasing weight of the logging cable **13** hanging in the borehole **11** will be effective for carrying the well tool to as great a depth as is possible. It will be recognized, of course, that so long as the well tool **10** is moving relatively freely, the switch **40** will remain open. Once the well tool **10** enters a relatively-deviated interval of the borehole **11** as shown in FIG. **1B**, the tool, of course, will ultimately be halted and come to rest in a position such as that illustrated. If the tool **10** does halt, this will be apparent at the surface since the electrical signal provided by the logging device **12** included with the tool will now show an unvarying signal on the instrument **23** in contrast to the usual varying signals that normally occur as the tool is moving.

When the operator at the surfaces has ascertained that the tool **10** has in fact come to rest, in one manner of practicing the present invention, the winch **14** can be powered forwardly (as at **59**) in such a manner as to unreel an additional length of the cable **13**. Inasmuch as the portion of the cable **13** running over the sheaves **16** and **17** and a substantial proportion of its length within the borehole **11** will be under extreme tension, powering of the winch **14** will, in effect, merely reduce this tension load in the major portion of the logging cable. At some point, however, very near to the tool **10**, the tensile load on this lower portion of the cable **13** will be zero so that any further downward force on the cable will induce a compressive force in the portion of the cable therebelow. Thus, the lowermost portion of the cable **13** will instead have an axial compressive load imposed thereon which is, of course, transmitted downwardly, to the slidable cylindrical body **25** in the upper end of the tool housing **26**.

If this compressive load is less than the opposing spring force provided by the compressive spring **34**, a corresponding downwardly-directed force will be transmitted by way of the spring to the tool housing **26** which, hopefully, will be sufficient to move the well tool **10** still further. If, on the other hand, this downwardly-acting compressive load on the logging cable **13** is greater than the opposing spring force provided by the spring **34**, the cylindrical body **25** will move downwardly in relation to the tool housing **26**; and, once the magnet **42** reaches the position **44** opposite the switch **40**, the switch contacts will close and provide an indication at the surface on the ohmmeter **49** that such has occurred This information will, therefore, advise the operator at the surface that a force of at least as great as the spring force of the spring **34** is being applied to the tool **10** for moving it further downwardly in relation to the borehole **11**. If the well tool **10** does in fact begin to move further downwardly, the logging device **12** will again provide varying electrical signals indicative of the different formation materials being passed by the moving well tool. On the other hand, if the downward forces are not sufficient to move the well tool **10**, the steady reading on the instrument **22** provided by the logging device **12** will advise the operator that the tool is not moving. Moreover, the ohmmeter **49** will provide an indication of whether these downward forces are actually being imposed on the tool **10**. Then, the winch **14** can be driven forwardly, as at **59**, to insure that the cable **13** is hanging free which will be indicated by substantial flexing of the portion of the logging cable between the lower sheave **17** and the winch. Once the cable **13** has been significantly flexed in this running portion of the cable, the cable can be pushed downwardly by hand or some cable-pushing device at the surface to impose a maximum load on the tool **10**. It is, of course, impossible to impose further loading through the cable **13** onto the well tool **10** unless the cable is partially respooled onto the winch **14** and then the tool is again relowered in an attempt to gain sufficient momentum to pass the impediment.

It has been found, however, that in actual situations where a borehole, such as at **11**, is substantially deviated, with ordinary suspension cables it has not been possible to get well tools as at **10** to intervals in the borehole beyond the uppermost highly-deviated portions thereof. On the other hand, by employing the new and improved methods of the present invention, a significant aid in facilitating the descent of these well tools is provided by practicing the invention. Usually, by watching the recording instrument **22** connected to the logging device **12**, an operator will be advised that the well tool **10** is beginning to slow. When this is notched, the winch **14** may be powered forwardly, as at **59**, to begin driving the logging cable **13** to supplement to the gravitational and inertial forces moving the well tool **10** downwardly through the borehole **11**. In this manner, by taking advantage of the motional inertia of the well tool **10**, often the added impetus provided by positively driving the winch **14** to impose axial compressive forces on the moving well tool will be sufficient to force the tool along substantially-deviated or nonvertical intervals and on into more-vertical intervals therein.

Accordingly, it will be appreciated that the present invention has provided new and improved methods for facilitating the descent of well tools through highly-deviated well bores. Thus, although changes and modifications may be made in the principles of the invention as set out in the claims, by providing a relatively-stiff logging cable as well as the switching mechanism in the well tool, this well tool may be moved through even highly-deviated boreholes to greater depths than has heretofore been attainable.

I claim:

1. A method for advancing a well tool disposed within a downwardly-inclined well bore interval and suspended therein from a cable having a laterally-stiffened lower portion coupled to the well tool and an upper portion extending therefrom through the well bore to the surface comprising the steps of: moving said upper cable portion downwardly into the well bore to reduce tensile forces therein and develop downwardly-acting compressive forces in said lower cable portion for producing corresponding downwardly-acting forces on said well tool; and moving additional lengths of said cable from the surface into the well bore to produce additional downwardly-acting forces on said well tool for advancing said well tool further downwardly through the downwardly-inclined well bore interval.

2. A method for lowering a well tool suspended within a well bore from a cable having a laterally-stiffened lower portion coupled to the well tool and an upper portion extending therefrom through the well bore and operatively spooled on a powered winch at the surface comprising the steps of: unreeling said cable from said winch to lower said well tool into the well bore; measuring a characteristic representative of the descent of said well tool through the well bore; and, whenever said well slows its descent, powering said winch to unreel additional lengths of said cable into the well bore for reducing tensile forces therein and developing compressive forces in said laterally-stiffened lower portion thereof to urge said well tool on further through the well bore.

3. A method for logging a well bore having a nonvertical interval therein comprising the steps of: dependently coupling a logging instrument to an electrical logging cable having at least a lower portion thereof resistant to lateral bending and an upper portion thereof operatively spooled onto a powered winch adapted to be selectively driven forwardly and reversely for respectively lowering and raising said logging instrument into and out of a well bore to be logged; unspooling said cable from said winch to lower said logging instrument into a well bore to be logged; whenever the descent of said logging instrument is halted, driving said winch forwardly for reducing tensile forces in said upper cable portion and developing compressive forces in said lower cable portion to move said logging instrument through nonvertical intervals of the well bore to greater depths therein; and, after said logging instrument has reached a selected well bore depth, driving said winch reversely to respool said cable back onto said winch for logging the well bore as said logging instrument is returned toward the surface.

4. A method for logging a well bore having a nonvertical interval therein comprising the steps of: dependently coupling a logging instrument to an electrical logging cable having a lower portion thereof resistant to lateral bending and an upper portion thereof operatively spooled onto a powered winch adapted to be selectively driven forwardly and reversely for respectively lowering and raising said logging instrument into and out of a well bore to be logged; unreeling said cable from said winch to lower said logging instrument into a well bore to be logged; whenever the descent of said logging instrument is slowed, driving said winch forwardly for reducing tensile forces in said upper cable portion and developing compressive forces in said lower cable portion to increase the speed of said logging instrument through nonvertical intervals of the well bore; and, after said logging instrument has reached a selected well bore depth, driving said winch reversely to reel said cable back onto said winch fore returning said logging instrument toward the surface.

5. A method for advancing well tool disposed within a downwardly-inclined well bore interval and suspended therein from a cable having a lower portion coupled to the well tool and an upper portion extending therefrom through the well bore to the surface comprising the steps of: moving said upper cable portion downwardly into the well bore to reduce tensile forces therein and develop downwardly-acting compressive forces in said lower cable portion for producing corresponding downwardly-acting forces on said well tool; measuring a characteristic indicative that said downwardly-acting forces are acting on said well tool; and, so long as said characteristic indicates that said downwardly-acting forces are acting on said well tool, moving additional lengths of said cable from the surface into the well bore to produce additional downwardly-acting forces on said well tool for advancing said well tool further downwardly through the downwardly-inclined well bore interval.

6. A method for logging a well bore comprising the steps of: dependently coupling a logging instrument to the lower portion of an electrical logging cable adapted to resist lateral bending and having an upper portion thereof operatively spooled onto a powered winch adapted to be selectively driven forwardly and reversely for respectively lowering and raising said logging instrument into and out of a well bore to be logged; unreeling said cable from said winch to lower said logging instrument into a well bore to be logged; observing at the surface signals produced by said logging instrument for obtaining indications that said logging instrument is descending into the well bore; whenever said signals indicate that the descent of s aid logging instrument is slowed, driving said winch forwardly for reducing tensile forces in said upper cable portion and developing corresponding downwardly-acting compressive forces in said lower cable portion to move said logging instrument further downwardly in the well bore; and, after said logging instrument has reached a selected well bore depth, driving said winch reversely to respool said cable back onto said winch for returning said logging instrument toward the surface.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,554,284 Dated January 12, 1971

Inventor(s) Horace A. Nystrom PAGE - 1

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 20, after "shown)" insert -- by --. Column 3, line 10, after "acting" insert -- axial --; line 28 after "forces" insert -- , if any, --; line 28, after "body" insert -- . Conversely, when the downwardly acting forces on cylindrical body --. Column 5, line 47, after "occurred" inse a period. Column 6, line 9, "notched" should read -- noticed line 11, after "supplement" cancel "to"; line 52, after "well insert -- tool --. Column 8, after line 28, insert claims 7, 8, 9, 10 and 11:

7. A method for logging a well bore comprising the steps of: dependently coupling a logging instrument to an electrical logging cable adapted to withstand axial compress forces without being bent double within the spatial limits of the well bore, said cable being operatively spooled onto a powered winch adapted to be selectively driven forwardly and reversely for respectively lowering and raising said logging instrument into and out of a well bore to be logged; unreeling said cable from said winch to lower said logging instrument into a well bore to be logged; observing at the surface logging signals produced by said logging instrument for obtaining indications that said logging instrument is descending into the well bore; whenever said logging signals indicate that the descent of said logging instrument is slov driving said winch forwardly for reducing tensile forces in said cable and developing corresponding compressive forces

UNITED STATES PATENT OFFICE

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

in the lower portion thereof to facilitate the descent of said logging instrument through the well bore; measuring a characteristic indicative that said compressive forces are acting on said logging instrument; and, so long as said characteristic indicates that said compressive forces are acting on said logging instrument and said logging signals indicate that said logging instrument is descending into the well bore, continue driving said winch forwardly to carry said logging instrument to a selected well bore depth

8. The method of Claim 7 further including the step of; after said logging instrument has reached said selecte well bore depth, driving said winch reversely to respool said cable back onto said winch for returning said logging instrument toward the surface.

9. The method of Claim 7 further including the step of: after said logging instrument has reached said selecte well bore depth, driving said winch reversely to respool said cable back onto said winch for logging the well bore as said logging instrument is returned toward the surface.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,554,284 Dated January 12, 1971

Inventor(s) Horace A. Nystrom Page - 3

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

10. A method for logging a well bore having a non-vertical interval therein comprising the steps of: dependen coupling a logging instrument to an electrical logging cable adapted to resist lateral flexing under compressive loading and operatively spooled onto a powered winch adapted to be selectively driven forwardly and reversely for respectively lowering and raising said logging instrument into and out of a well bore to be logged; unreeling said cable from said wir to lower said logging instrument into a well bore to be logg whenever the descent of said logging instrument is retarded, driving said winch forwardly for reducing tensile forces in said cable; and forcing the upper portion of said cable downwardly for developing corresponding compressive forces : the lower portion thereof to urge said logging instrument toward greater depths in said well bore.

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

11. The method of Claim 10 further including the ste of: after said logging instrument has reached a selected well bore depth, driving said winch reversely to respool sa cable back onto said winch for logging the well bore as sai logging instrument is returned toward the surface.

Signed and sealed this 7th day of March 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Pate