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APPARATUS FOR ORIENTING TOOLS

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1. This invention relates to the drilling of wells and has particular reference to an apparatus for orienting a tool, particularly a whipstock, designed to guide a drill in a definite direction as is necessary, for example, in straightening a crooked well.

As is well known, many wells, particularly those produced by rotary drilling, deviate very considerably from the vertical at even moderate distances from the surface, such deviations being apparently due to lack of uniformity in the soil through which the drill is passing, and being particularly noticeable in the case of rotary drilling, since the rotation of the drill stem appears to promote the production of a tortuous hole. If a bore hole deviates to a substantial degree from the vertical, it may entirely miss the locality which is believed to contain oil. Once a bore hole begins to deviate from the vertical, little can be done in the way of control of the drilling from the surface to cause it to become vertical. Accordingly, it is the practice to insert within the bore hole a whipstock having a guiding surface at an angle with the axis of the bore hole to direct the drill in the desired direction to reach its objective. Obviously it is necessary to properly orient the whipstock to insure that a proper correction of the direction of the bore hole will be made.

The orientation of whipstocks is also useful where it is desired to direct a bore hole in a predetermined direction, as may occur, for example, where theerrick cannot be conveniently set up directly over the point which it is desired that the bore hole should reach. In such cases, the hole may be started from the surface at a laterally displaced location and may be deflected by means of oriented whipstocks to cause it to finally arrive at the desired point.

The orientation of a whipstock necessarily involves a knowledge of the path of a bore hole, so that a preliminary survey must be made to find direction and position of the lower end of the hole.

2. It is the object of the present invention to provide means whereby a whipstock may be lowered upon a hollow drill stem, without the necessity for carrying out drill stem orientation, and its position determined, the drill stem rotated to bring it into a predetermined azimuthal position, the position checked, and the whipstock then set and released from the drill stem. While the invention has been and will be described particularly with reference to whipstock setting, it will be clear that the invention is applicable to the proper orientation of any other tool which is to be located in a predetermined azimuthal position in a bore hole.

Detailed objects of the invention will be apparent from the following description read in conjunction with the accompanying drawing, in which:

Figure 1 is a sectional view showing a drill stem supporting a whipstock and having located there-in a position checking instrument;

Figure 2 is an enlarged fragmentary sectional view of the position checking instrument;

Figure 3 is a plan view of a photographic record made by the use of the preferred type of instrument;

Figure 4 is a fragmentary view showing a possible modification of a portion of the checking instrument if the whipstock is being oriented where the slope of the bore hole deviates substantially from the vertical;

Figures 5 and 6 are enlarged fragmentary sectional views of the lower portion of the drill stem shown in Figure 1 having modified forms of whipstocks associated therewith; and

Figure 7 is an elevation of the lower portion of a drill stem embodying an alternate form of the present invention.

In carrying out the improved method, it is first necessary to make a complete directional survey of the bore hole. This should be done by the use of an instrument which is not subjected to tortuosity errors. Both gyroscopic and magnetic instruments would satisfy the requirement for avoidance of errors due to tortuosity, but the only type of instrument which is fully reliable is a gyroscopic one, due to the errors caused in magnetic readings by mineral deposits or the presence of magnetic bodies artificially present in the bore hole. An accurate survey with no errors due to tortuosity or magnetism may be made by the type of instrument described in the patent to Williston and Nichols, No. 1,660,038, dated May 22, 1924. This instrument photographically records the position of a gyroscope and bubble at short intervals of time corresponding to relatively short distances along the path of a bore hole. Such instrument may be lowered either on a wire line or a drill stem for the purpose of making the initial survey.

In general, magnetic instruments are fairly satisfactory for approximate results. Magnetic compasses are usually sufficiently accurate, since usually only slight local disturbances of the earth's magnetic field, if any, occur, to permit the setting of whipstocks to a degree of accuracy which can be expected of the results of the whipstock in
deflecting a drill. Accordingly, although for the initial survey a gyroscopic instrument is most desirable since it will determine to a high degree of accuracy the actual path of the bore hole, nevertheless there is employed, in accordance with this invention, the indication of a magnetic compass to determine the position of the whipstock. If the hole however, has a substantial slope from the vertical where the whipstock is being set, the indication of azimuthal position independent of any magnetic disturbing influence may be determined by means of a modification of the non-magnetic instrument described herein. Such instrument, however, gives indeterminate results where the bore hole is vertical.

Referring to Figures 1 and 2 there is illustrated therein a drill stem 2, the lower portion of which takes the form of a non-magnetic catcher 4 to which there is attached a bottom plug 8 and a drill bit 7. Secured to the outer side of the lower portion of the drill stem is a whipstock or other tool 6 which has its upper portion in the form of a sleeve 3 which is attached to the lower end of the drill stem by means of a shear pin 3 which may be sheared when it is desired to fix the whipstock in final position in the well 10. The whipstock may be of any suitable type designed to be finally held in position either by penetration of the soil or by cementing.

An instrument designed to indicate the position of the whipstock is arranged to be lowered into the non-magnetic catcher 4. This instrument may comprise an outer casing 8 carried by a line 10. The instrument contains a pair of magnetic compasses and, consequently, it must be of non-magnetic construction to the extent of any parts which might affect the readings. This remark applies to the protective casing and the lower portion of the suspension means which may consist of a spacer between the casing and suspension line proper. The catcher 4 and any associated parts must be non-magnetic to a sufficient extent beyond the compasses so that their readings will not be affected. In the form of the invention shown in Figure 1, the whipstock is of demagnetized steel and has set in the upper portion thereof a pair of magnets 48 and 48′. These magnets are arranged, for example, with the north pole end of the magnet 48 turned inwardly and the south pole end of the magnet 48′ turned inwardly so that the effect of the earth's field on the lower compass in the instrument is negligible.

One form of the position recording instrument is illustrated in Figure 2. This instrument is provided with a sidewall opening slot into which there may be inserted and from which there may be extracted, a sensitized film disc 16. This disc comprises sensitized celluloid or other transparent or translucent material, preferably reinforced at its edges by a metallic ring. A threaded lower support 16 may be rotated and thereby axially moved by a knob 20 to uncover the slot 14 so that the film may be dropped in place from a light-tight receptacle through a light-tight connection with the slot. Upon reverse movement of the knob 20, the supporting member 16 moves upwardly, closing off the slot and causing the film disc 16 to contract with a ring 22 which locates it in proper focal relationship to the camera lenses 24 and 36.

The former lens 24 is designed to project upon the film an image of the lower indicia carrying surface of a compass float 25 guided by a vertical wire 26 in a chamber 30 containing a damping liquid, which chamber is provided with a glass bottom 32. The compass 26 is designed to indicate the direction of the earth's field and is hence necessarily used due to any magnetic disturbances either by the lower compass 38, the permanent magnets 48 and 48′, or any of the parts of the instrument. This result is achieved by locating it sufficiently remote from any disturbing influences. Errors in the reading of this compass can only be due to errors occasioned by disturbances of the earth's magnetic field due to ores or the like. Such disturbances are, in general, relatively small, and considering the fact that a whipstock can only deflect a drill bit in a predetermined direction within certain limits of error, the indications of a compass of this type are sufficient for the present purpose. The compass is illuminated by bulbs 34, which, together with other bulbs 42, are energized at suitable times.

The lower lens 36 projects upon the film the image of a lower compass 38 contained within a glass topped chamber 40. The bottom of the chamber forms a light-tight closure between the upper and lower portions of the instrument. The bulbs 42 are designed to illuminate the compass 38, one end of which may be differentiated from the other end by difference in light reflecting properties. The compass 38 need not be very delicately mounted, since this compass is designed to be affected by the strong magnetic field of the permanent magnets 48 and 48′.

Located below the compass 38 and accessible through an opening in the side of the instrument is a time switch 44 of any conventional type which is designed to so set that a predetermined time will elapse after setting before the circuit through the lamps 34 and 42 is closed. The switch then maintains the circuit closed for a sufficient period to produce an exposure and thereafter breaks the circuit with the result that a single exposure of a particular film 16 will be produced, giving a superimposed picture of the indications of the two compasses. Current for operating the lamps may be supplied by batteries contained in the lower portion 46 of the instrument.

The type of record which is produced is indicated in Figure 3, which illustrates the disc 16 after development. The markings 27 at the end produced by the upper compass 26, while the markings 39 is produced by the lower compass 38.

In carrying out the improved method, there is located within the instrument a sensitized film 16 and when the instrument is ready for lowering, the time switch 44 is set so that the exposure will not be made until the instrument is in its final position. The instrument in its protective casing is then lowered into the drill stem, which carries the whipstock at the vertical location where it is to be fixed. When the instrument reaches the bottom of the drill stem and rests in its final position within the catcher 4, the lower compass 38 will be located directly opposite the permanent magnets 48 and 48′, which consequently will hold it in a fixed position. Since the position of the magnets 48 and 48′ relative to the face of the whipstock will have been previously noted, it will be clear that the compass 38 will occupy a predetermined position relative to the whipstock.

At the same time, when the instrument is in its lowestmost position, the compass 25 will be located away from disturbing influences in the non-magnetic catcher and will attain a position determined by the direction of the earth's magnetic field.
The instrument is permitted to remain in its lowered position until the time for making an exposure has expired and is then drawn to the surface, opened, and the sensitized disc withdrawn and developed. From the superimposed images of the two compasses, the azimuthal position of the whipstock may be directly determined and the drill stem may then be rotated a sufficient amount to bring the whipstock into a predetermined position. In so rotating the drill stem, it is desirable to move it up and down to avoid frictional drag on the lower end, which may be lower end to be rotated through an angle less than the predetermined angle of rotation of the upper end. Before finally fixing the whipstock in position, the instrument 12 may be again lowered with a second film and exposure made, and the instrument brought to the surface and opened, whereupon an examination of the new record will determine whether the whipstock has been located in the desired position. If not, suitable correction may be made and the process repeated. Finally, the whipstock may be fixed in the desired position in any well known field.

Instead of direct indication of the azimuth by means of the compass 25 which, as noted above, may be subject to errors due to magnetic inhomogeneity of the earth, the azimuth may be indirectly indicated by taking advantage of data from the preliminary survey, giving the direction of slope of the bore hole where the whipstock is being set. A modified type of apparatus for this purpose can be provided by substituting the parts indicated in Figure 4 for the upper part of the instrument indicated in Figure 2. This substitution consists essentially of a box level 31 containing a bubble 53 for the compass 26. The image of the bubble is focussed by the lens 24', corresponding to lens 24, upon the film through the glass bottom of the box level, the bubble being illuminated by lamps 34' corresponding to 33. The course of the box level may, if desired, be marked with indicia showing the central point.

From the superimposed records of the bubble and lower compass fixed by the permanent magnet, and from the preliminary survey data, it is obvious that the azimuthal position of the whipstock may be ascertained, since the direction represented by the relationship of the image of the bubble to the center of the film is dependent upon the direction of maximum inclination given by the preliminary survey data. If the preliminary survey was made with an accurate gyroscopic instrument, it is obvious that the location of the position of the whipstock will be entirely independent of any irregularities of the earth's magnetic field. The only failure of the type of arrangement illustrated in Figure 4 occurs where the bore hole is so nearly vertical that the direction of the bubble relative to the center position cannot be ascertained with any degree of accuracy. The ease of determining this to a high accuracy increases, of course, with the deviation of the bore hole from the vertical. If a level independent of the illustrated bubble, or an equivalent pendulum or the like, is used for indicating the azimuth, it is, of course, unnecessary to provide a non-magnetic catcher. It would only be necessary to provide non-magnetic parts immediately surrounding the permanent magnets 48 and 48' so that their field could influence the lower compass.

In view of the inherent inaccuracy of deflection of a drill by a whipstock, it would not generally be economical to use an expensive gyroscopic compass instead of the upper magnetic compass which is sufficiently accurate for the purpose.

In Figure 5 there is shown a modification of the present invention in which there is employed a non-magnetic whipstock. In this modification, the whipstock has been lowered the instrument described in connection with Figure 2, having the compass needle 38 positioned adjacent to the cylindrical upper portion 52 of the whipstock. The whipstock is attached to the lower portion of the drill stem by means of the cylindrical portion 54, and a magnetized material 56. This strip may be composed of any of a number of well known materials which retain magnetism to a high degree. The upper end of the strip 58 may be, for example, of north polarity and the lower end of south polarity, and there will be thereby induced in the cylindrical portion 62 of the whipstock of magnetic field such disposition and strength as to effectively position the compass needle 38 irrespective of the presence or direction of the earth's magnetic field.

In the modification of the invention shown in Figure 6, the cylindrical upper portion 60 of the whipstock which is made of a magnetic material is partially cut away in order to provide the upper portion 62 adjacent to the compass 38. In this modification, the whipstock itself is magnetized, and the result will be that one end of the compass needle 38, depending upon the polarity of the upper portion 62 of the whipstock 60, will be attracted to and point toward the upper portion 52 of the whipstock.

In the modification of the invention shown in Figure 7, there is provided a non-magnetic cylindrical catcher 70 which has been cut on the diagonal line 72 and associated therewith in matching arrangement is the magnetic whipstock 74. The whipstock 74 is affixed to the non-magnetic catcher sleeve 70 by means of shear pins 76 and 78 and is of the type which remains permanently in the bore hole. It will be noted that the upwardly extending portion 80 of the magnetic whipstock is adjacent to the compass needle 38, and it is being of magnetic material may be sufficiently magnetized to attract one pole of the compass 38.

It will be seen that these various modifications of the invention all provide for the indication of the relative position of the instrument with respect to the whipstock which is attached to the lower end of the drill stem. The modifications shown in Figures 6 and 7 have been described as employing magnetized whipstock extension portions in order to attract a predetermined pole of the compass 38. It will be apparent that in these forms there could be alternately used with either magnetized or demagnetized whipstocks an eccentric compass in place of the symmetrical compass 38. An eccentric compass would obviously always have its pole of greatest length from its center of rotation attracted toward the upper portion of the magnetic whipstock which then could be either magnetized or demagnetized.

The whipstock shown in Figures 1, 5 and 6 are of the type which may be adapted to be retrieved if desired. This type of whipstock is well known in the art and need not be described herein. In all of the modifications of the invention described herein, however, the whipstock is employed as representative of any one of a variety of well
known tools used within a bore hole, and is provided with means for attracting the compass contained within the instrument which is lowered into the drill stem.

What is claimed is:

1. In combination, a hollow drill stem, a tool carried by the drill stem and detachably connected thereto adjacent to the lower end thereof whereby the tool may be positioned within the well and the drill stem detached therefrom, an instrument arranged to pass through the drill stem and arranged to occupy a predetermined final longitudinal position in the drill stem adjacent to the tool, the instrument containing means for checking azimuthal position including a magnetic compass, and means carried by the tool adapted to be in a position in the immediate vicinity of one of the compasses when the instrument is in said final position in the lower section whereby the last named compass is caused to give an indication of the position of the tool relative to the instrument both when the tool is attached to or when it is detached from the drill stem.

2. In combination, a hollow drill stem having a non-magnetic lower section, a tool carried by the drill stem and detachably connected thereto adjacent to the lower end of the non-magnetic section whereby the tool may be positioned within the well and the drill stem detached therefrom, an instrument arranged to pass through the drill stem and arranged to occupy a predetermined final longitudinal position in the non-magnetic lower section, the instrument containing a pair of magnetic compasses and means for recording the indications of the compasses, and means carried by the tool adapted to be in a position in the immediate vicinity of one of the compasses when the instrument is in said final position in the lower section whereby the last named compass is caused to give an indication of the position of the tool relative to the instrument both when the tool is attached to or when it is detached from the drill stem.

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