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METHOD FOR ORIENTING DRILL STEMS

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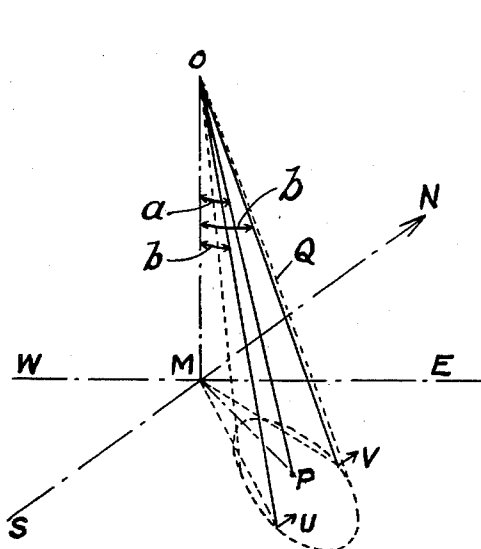


FIG. 3.

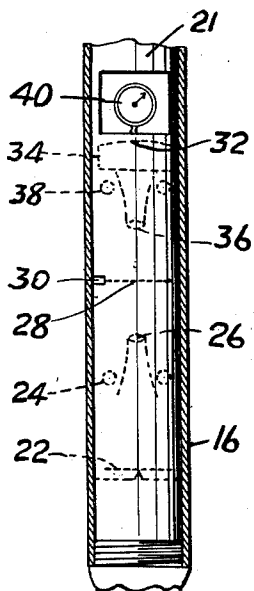


FIG. 2.

FIG. 1.

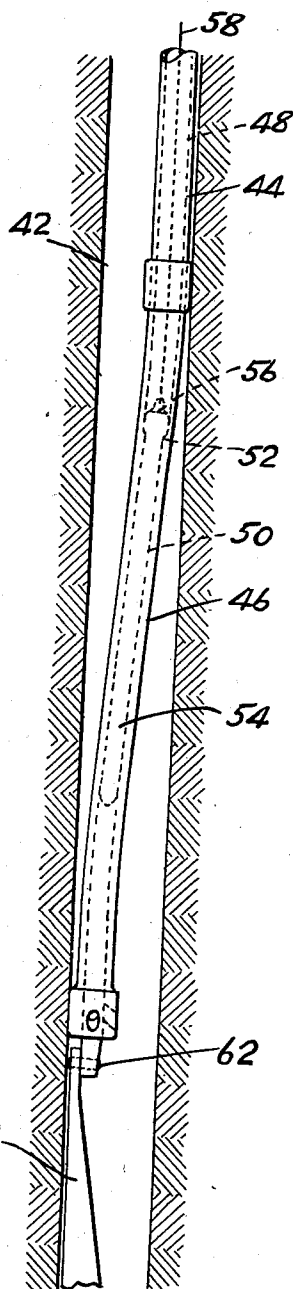
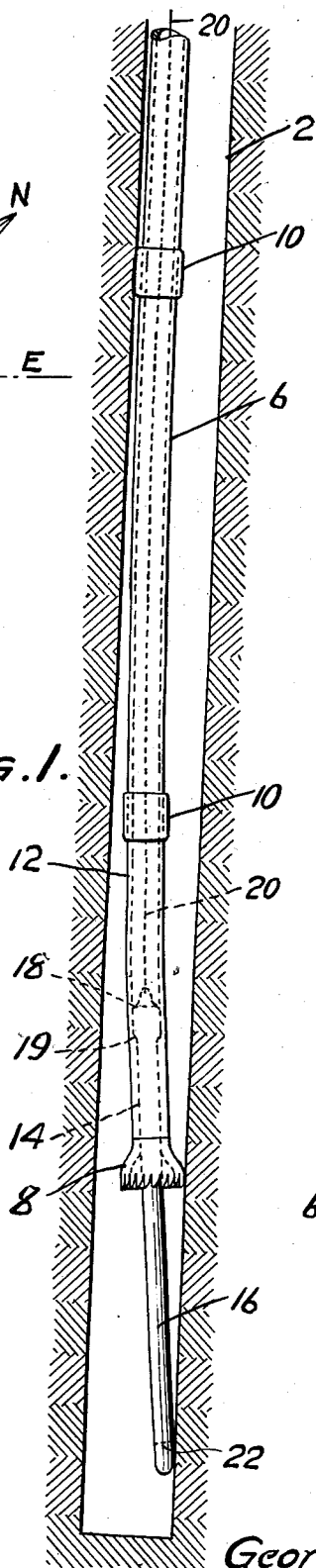


FIG. 4.

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## UNITED STATES PATENT OFFICE

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## METHOD FOR ORIENTING DRILL STEMS

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10 Claims. (Cl. 255—1)

This invention relates to a method for orienting drill stems and, more specifically, to a method of directional drilling which has as part of its procedure the orientation of a drill stem.

5 The orientation of the lower portions of drill stems within a bore hole is important for various purposes. For example, in setting of whipstocks or directional drilling tools, the whipstock or other tool is lowered into the bore hole in an  
10 arbitrary position, or perhaps with an attempt to get it in a predetermined position by so-called drill stem orientation. Orientation by the latter method is never absolutely certain because of the possibility that in lining up the drill stem  
15 lengths there may have occurred accumulation of errors which would result in substantial deviation of the tool from the assumed position. Accordingly, in either case, it is desirable to check the orientation of the lowermost portion  
20 of the drill stem by means of a well surveying instrument. This may be accomplished in various fashions. For example, the inside of the lowermost portion of the drill stem may be provided with a key adapted to engage a groove  
25 in a well surveying instrument, or vice versa, with the result that when the well surveying instrument is lowered within the drill stem it will be brought into a predetermined relationship with the stem. Alternatively, mechanical complica-  
30 tions may be avoided by the use of the method and apparatus described in Hyer Patent 2,120,670, dated June 14, 1938.

It is the broad object of the present invention to provide an improved method for orienting  
35 the lower portion of a drill stem for any of the various purposes for which such orientation is usually practiced.

A further object of the invention is concerned with the orientation of a drill stem the lower  
40 portion of which is deflected at an angle relative to the major portion of the drill stem in order to produce deflected drilling of the bore hole. By forcing the lower end of a drill stem having  
45 such a deflected portion into the bottom of a hole and then rotating the drill stem, the latter will, if sufficiently flexible, bore a hole away from the axis of the original hole in the direction of eccentric penetration of the bit into the bot-  
50 tom. By the use of the improved method, a drill stem of such character may be oriented to properly produce drilling in the desired direction.

The above and other objects of the invention, particularly relating to details, will become ap-  
55 parent from the following description, read in

conjunction with the accompanying drawing, in which:

Figure 1 is a diagrammatic sectional view showing within a sloping bore hole the lower end of a drill stem which is deflected relatively  
5 to the major portion of the drill stem for directional drilling purposes, and which is shown in the position occupied during the determination of its orientation;

Figure 2 is a fragmentary vertical section  
10 showing the type of well surveying instrument used in the practice of the method;

Figure 3 is a perspective diagram illustrating the matters which must be taken into account in determining the orientation of the drill stem;  
15 and

Figure 4 is a view similar to Figure 1, but illustrating the applicability of the invention to the orientation of a whip-stock or similar tool  
20 carried by a drill stem.

Referring first to Figure 1, there is shown therein a bore hole 2 which is sloping with respect to the vertical and which it is desired to deflect in a different predetermined direction. The deflection of this hole is accomplished by  
25 the use of a flexible drill stem 4 which, in its upper portions, is straight, but which at its lower portion, as indicated at 6, is deflected laterally so that its lower portion is at a predetermined angle with respect to its upper portion  
30 when no load is imposed upon it. At its lower end, the drill stem carries the usual bit 8, which, in the present case, is, as is also the drill stem, of substantially less diameter than the bore hole. The drill stem is made up of sections in the usual  
35 fashion, coupled as indicated at 10, and is hollow as is usual for the circulation of mud. The bore through the drill stem is indicated at 12 and is provided with a lower portion of reduced diameter, as indicated at 14, to closely engage  
40 a well surveying instrument 16 so as to align the instrument when it projects beyond the bit 8, as illustrated in Figure 1, with the lowermost portion of the drill stem which, as stated heretofore, is at a predetermined angle with respect  
45 to the upper straight portions of the stem. The instrument 16 is provided with an enlarged head indicated at 18 adapted to seat upon a shoulder indicated at 19, where the reduced and enlarged portions of the drill stem bore join each other.  
50 The well surveying instrument is adapted to be lowered through the drill stem upon a wire line indicated at 20.

In the case of the modification of Figure 1, it is assumed that the drill stem and drill bit are  
55

made throughout of magnetic material so that a magnetic well surveying instrument could not be operated within the drill stem to give indications of azimuth. In such case, it is necessary that a magnetic surveying instrument project beyond the bit in order that its compass may be beyond the influence of the magnetic materials of the drill stem and bit. A type of surveying instrument which may be used and which is of the type illustrated in said Hyer patent may comprise within the outer protective casing the instrument proper, indicated at 21. In this instrument, which, together with its outer casing, must be of non-magnetic material, there is located a compass 22, the image of which may be projected upon a film indicated at 28 by means of a lens system 26, illumination of the compass being effected by means of lamps 24. The film, which may be in the form of a disc, can be inserted in the instrument through the slot 30 in conventional manner, as indicated in said Hyer patent. The instrument also contains a level 34 containing a bubble 32, the image of which may be projected by lens system 36 upon the film 28. The bubble is illuminated by lamps 38. Exposure is made at the proper time under the control of a switch the closure of which is effected by means of a clock mechanism indicated at 40. Since this type of apparatus is illustrated in the Hyer patent, it need not be further described.

The operation of the apparatus of Figures 1 and 2 may now be described. The bore hole will have been preliminarily surveyed at at least the lower portion thereof to determine the inclination and the direction of inclination of that portion. The drill stem carrying the bit 8 is lowered in arbitrary position within the bore hole, and after touching bottom may be lifted a predetermined distance as indicated in Figure 1. The surveying instrument 16 containing a sensitized film and with its timing apparatus set to make an exposure after the instrument comes to rest will then be lowered within the drill stem on the wire line 20 until it enters the reduced portion of the bore indicated at 14 and seats at 19. The portion of the surveying instrument containing the magnetic compass will then be substantially below the bit and unaffected thereby so as to take up a position corresponding to the magnetic field of the earth. The timing apparatus is so adjusted that an exposure will be made only after the position of rest of the instrument is reached. Following the making of the exposure, the instrument 16 is then removed from the drill stem, opened, and the film developed to secure a record of the inclination of the portion of the drill stem adjacent the bit.

From this data the orientation of the lower portion of the drill stem to determine in which direction the deflected portion is extending may be determined. To understand how this may be accomplished, reference may be made to Figure 3, which is a perspective view indicating at N, E, W and S, the points of the compass, and at OM the direction of the vertical. In this vector diagram, assume that OP represents the direction of the bore hole. In such case, since the angle which the lower portion of the drill stem makes with the upper portion is known, it will be evident that the vector representing the direction of the lower portion of the drill stem must lie through O in the cone which has as its axis OP and which has a half vertical angle at its apex equal to the angle which the lower portion

of the drill stem makes with the upper straight portion. The intersection of this cone Q with the horizontal plane will be an ellipse, indicated in dotted lines.

There are two elements of this cone which will make, with respect to the vertical, the angle of inclination indicated by the surveying instrument, for example, OU and OV, which make the same angle  $b$  with the vertical. However, the direction of inclination of these two elements will be substantially different. For example, with respect to the north the angle of one is NMU and the angle of the other NMV. The azimuth record of the well surveying instrument will indicate which is the vector representing the direction of the deflected end of the drill stem.

Thus, having obtained the direction of deflection of the end of the drill stem, the drill stem may be rotated to cause the deflection to lie in the proper direction. This may be accomplished by rotating the drill stem while moving it up and down to make sure that resistance to turning does not affect the resulting orientation. Thereafter, the drill stem is lowered to force the bit 8 into the soil at the bottom of the hole and rotation may then be imparted to the drill stem for the purpose of causing the bit to bore a deflected extension of the hole. The considerations involved in the nature of the drill stem and the operations for boring the deflected hole are set forth in Ragland Patent 2,114,476, dated April 19, 1938. As pointed out therein, the drill stem should be flexible so that the new direction of boring may be taken thereby. Above the bit there may be provided a reaming tool, as indicated in said patent.

Instead of projecting the well surveying instrument beyond the drill bit if it is of magnetic type, there may be provided in the deflected portion of the drill stem a non-magnetic sub within which the instrument may be aligned with that portion of the drill stem and in which it may make its record of its position with respect to the earth's field without interference by the magnetic materials of the other portions of the drill stem. Alternatively, a small gyroscopic instrument may be used without any precaution as to the magnetic nature of the stem.

Instead of lowering the surveying instrument through the drill stem after the drill stem is made up, it may be located within the lower portion of the drill stem and lowered with the drill stem as the stem is made up. Suitable delay in the making of the record must then be provided to insure that it will have reached the bottom of the hole before the record is made. If the casing is provided with a spear head, the instrument may then be withdrawn by lowering an overshot on a wire line to engage the spear head.

The method is applicable generally for the orientation of tools carried by drill stems, as will be obvious from a consideration of Figure 4, which illustrates a further applicable of the invention. In this case, it is desired to set a whipstock within a bore hole 42. For this purpose, there is lowered within the bore hole a drill stem 44, which has adjacent its lower end a section of non-magnetic material, indicated at 46 within which a magnetic surveying instrument is ultimately located. The drill stem is provided with the usual bore, indicated at 48, while the section 46 is provided with a smaller bore 50 for the snug reception of a surveying instrument 54 which is provided with an enlarged head, in-

licated at 56, designed to be arrested by a shoulder 52 at the junction of the wider and narrower portions of the bore. The well surveying instrument 54 is adapted to be lowered and raised by means of a cable, indicated at 58.

At the lower end of the section 46 there is secured a whipstock 60 by means of a rivet 62 which may be sheared off in the usual fashion to leave the whipstock in the hole after it is properly oriented. A whipstock is shown merely as an example of a type of tool which may be oriented by the improved method.

In the practice of the method illustrated in Figure 4, the whipstock may be lowered to the desired level with or without drill stem orientation, so that it may or may not be approximately in its final desired position. The well surveying instrument is then lowered into the section 46 which, it will be noted, makes a predetermined known angle with the straight portion of the drill stem located above it. In the bore of this section the instrument is permitted to make a record and is then withdrawn and the record examined. Knowing the angle that the section 46 makes with the straight portion of the drill stem, it is obvious that the record will give the information of the type described previously so that the orientation of the whipstock or other tool may be determined, the whipstock being, of course, originally lined up with the direction of slope of the section 46. Following a determination of the orientation of the whipstock it may then be turned by manipulation of the drill stem to the desired position and then fixed in the hole in conventional fashion, by shearing off the rivet 62 by downward pressure. The drill stem may then be withdrawn and drilling resumed.

In the event that a gyroscopic instrument is used, it will be unnecessary to have the section 46 of non-magnetic material. The bore in this case, however, must have a known angle of inclination with respect to the straight portions of the drill stem so as to give the necessary data for determining the orientation.

What I claim and desire to protect by Letters Patent is:

1. The method of effecting directional drilling of a bore hole comprising determining the slope and direction of slope of a bore hole adjacent the bottom thereof, lowering into the bore hole a hollow drill stem the lower end of which carries a drilling tool and is deflected at a known angle with respect to the major portion of the stem, locating said tool substantially above the bottom of the hole, lowering within the drill stem a magnetic well surveying instrument, containing a compass and means for indicating slope, to a position wherein the instrument extends in the direction of the lower deflected end of the drill stem and projects beyond the tool to carry the compass within the instrument beyond the magnetic influence of the tool, producing a record of the inclination and direction of inclination of said instrument, removing the instrument from the drill stem, determining the slope and direction of slope of the deflected end of the drill stem, turning the drill stem to locate its deflected end in a desired direction, and lowering the tool to the bottom of the hole and drilling therewith.

2. The method of effecting directional drilling of a bore hole comprising determining the slope and direction of slope of a bore hole at the location where deviation from its direction is to be effected, lowering into the bore hole a hollow drill stem the lower end of which carries a drill-

ing tool and is deflected at a known angle with respect to the major portion of the stem, locating said tool in a portion of the hole adjacent said location and having a free portion of the hole therebeneath, lowering within the drill stem a magnetic well surveying instrument, containing a compass and means for indicating slope, to a position wherein the instrument extends in the direction of the lower deflected end of the drill stem and projects beyond the tool to carry the compass within the instrument beyond the magnetic influence of the tool, producing a record of the inclination and direction of inclination of said instrument, removing the instrument from the drill stem, determining the inclination and direction of inclination of the deflected end of the drill stem, turning the drill stem to locate its deflected end in a desired direction, and then drilling with said tool.

3. The method of effecting directional drilling of a bore hole comprising determining the slope and direction of slope of a bore hole at the location where deviation from its direction is to be effected, lowering into the bore hole a hollow drill stem the lower end of which carries a drilling tool and is deflected at a known angle with respect to the major portion of the stem, lowering within the drill stem a well surveying instrument, containing means for indicating inclination and means for indicating azimuth, to a position where the instrument extends in the direction of the lower deflected end of the drill stem, producing a record of the inclination and direction of inclination of said instrument, removing the instrument from the drill stem, determining the inclination and direction of inclination of the deflected end of the drill stem, turning the drill stem to locate its deflected end in a desired direction, and drilling with said tool.

4. The method of orienting a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where orientation is to be effected, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where orientation is to be effected is deflected at a known angle with respect to the major portion of the stem, lowering within the drill stem a well surveying instrument containing inclination indicating means and azimuth indicating means to a position wherein the instrument extends in the direction of said deflected portion of the drill stem, producing a record of the inclination and direction of inclination of said instrument, removing the instrument from the drill stem, determining the inclination and direction of inclination of the deflected portion of the drill stem from the record of said instrument, and turning the drill stem to locate its deflected portion in a desired position.

5. The method of determining the orientation of a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where such determination is to be made, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where such determination is to be made is arranged to position a well surveying instrument at a known angle of deviation from the axis of the hole, causing a record of inclination and direction of inclination to be made by an instrument so positioned, removing the instrument from the drill stem, and determining the inclination and direction of the positioned instrument from its record.

6. The method of determining the orientation of a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where such determination is to be made, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where such determination is to be made is arranged to position a well surveying instrument at a known angle of deviation from the axis of the hole, lowering within the drill stem a well surveying instrument to be positioned at said known angle, causing a record of inclination and direction of inclination to be made by said instrument while so positioned, removing the instrument from the drill stem, and determining the inclination and direction of the positioned instrument from its record.

7. The method of orienting a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where orientation is to be effected, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where orientation is to be effected is arranged to position a well surveying instrument at a known angle of deviation from the axis of the hole, causing a record of inclination and direction of inclination to be made by an instrument so positioned, removing the instrument from the drill stem, determining the inclination and direction of the positioned instrument from its record, and turning the drill stem to locate it in a desired position.

8. The method of orienting a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where orientation is to be effected, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where orientation is to be effected is ar-

anged to position a well surveying instrument at a known angle of deviation from the axis of the hole, lowering within the drill stem a well surveying instrument to be positioned at said known angle of deviation, producing a record of the inclination and direction of inclination of said instrument while so positioned, removing the instrument from the drill stem, determining the inclination and direction of the positioned instrument from its record, and turning the drill stem to locate it in a desired position.

9. The method of determining the orientation of a portion of a drill stem within a bore hole comprising determining the slope of a bore hole at the location where such determination is to be made, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where such determination is to be made is arranged to position a well surveying instrument at a known angle of deviation from the axis of the hole, causing a record of inclination to be made by an instrument so positioned, removing the instrument from the drill stem, and determining the inclination and direction of the positioned instrument from its record.

10. The method of determining the orientation of a portion of a drill stem within a bore hole comprising determining the slope and direction of slope of a bore hole at the location where such determination is to be made, lowering into the bore hole a hollow drill stem which at the portion which is positioned at the location where such determination is to be made is arranged to position a well surveying instrument at a known angle of deviation from the axis of the hole, causing a record of inclination to be made by an instrument so positioned, removing the instrument from the drill stem, and determining the inclination and direction of the positioned instrument from its record.

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