Aug. 24, 1943. L. C. MILLER 2,327,658

METHOD OF AND MEANS FOR ORIENTING TOOLS IN WELL BORES

Filed Dec. 12, 1939 3 Sheets-Sheet 1

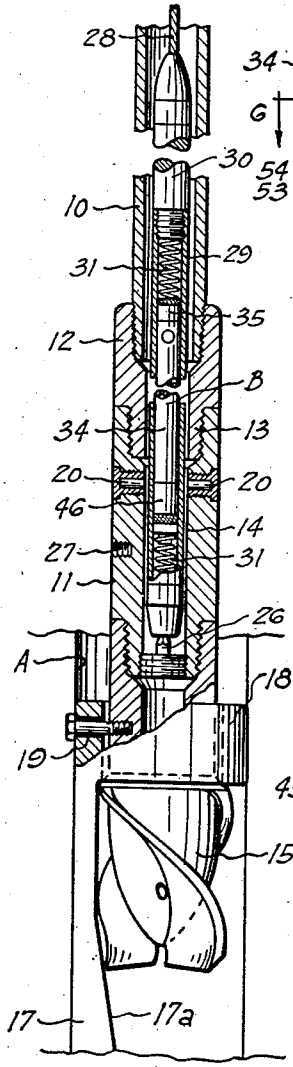
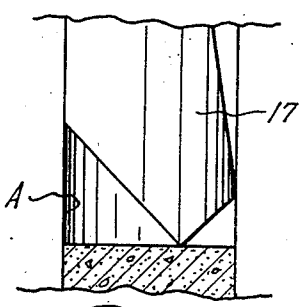


Fig. 1.



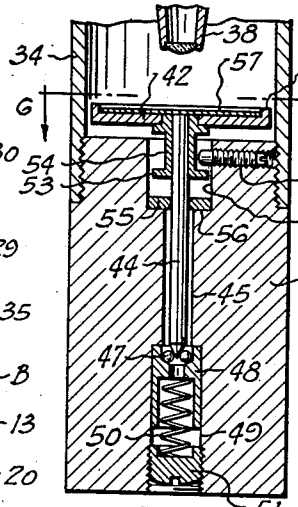


Fig. 5

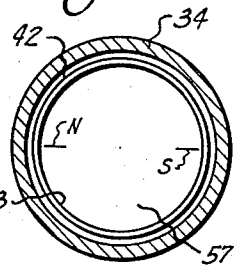


Fig. 6.

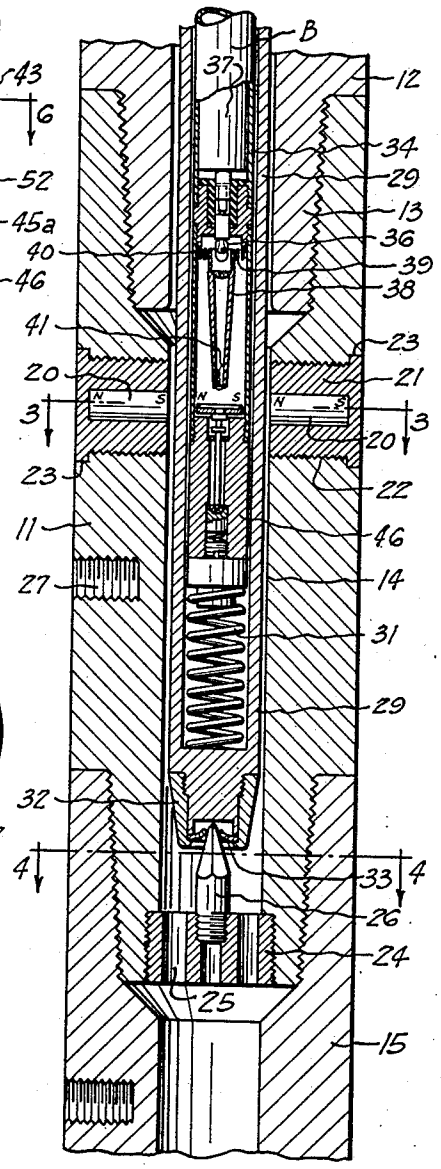


Fig. 2.

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Aug. 24, 1943. L. C. MILLER 2,327,658

METHOD OF AND MEANS FOR ORIENTING TOOLS IN WELL BORES

Filed Dec. 12, 1939 3 Sheets-Sheet 2

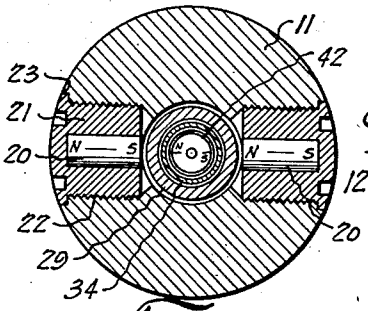


Fig. 3.

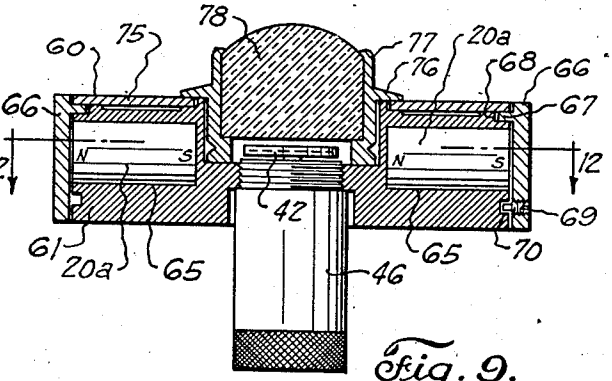


Fig. 9.

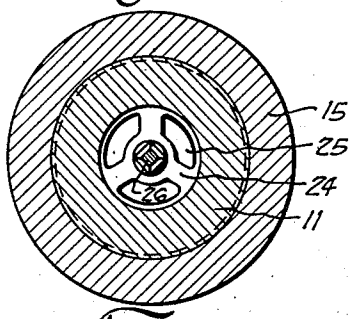


Fig. 4.

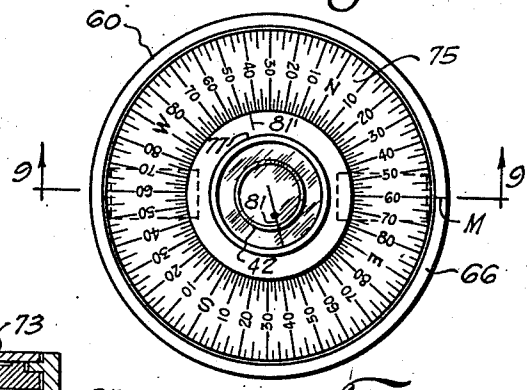


Fig. 7.

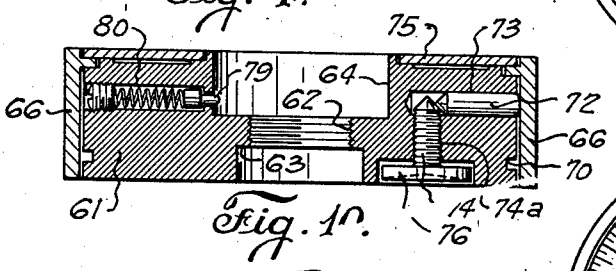


Fig. 10.

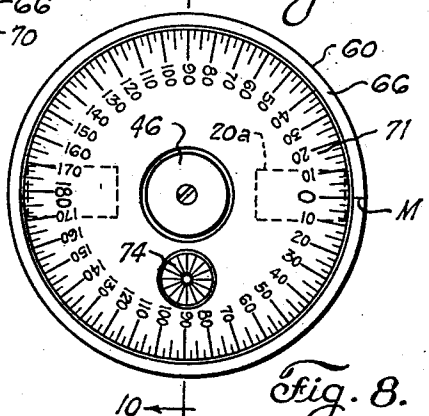


Fig. 8.

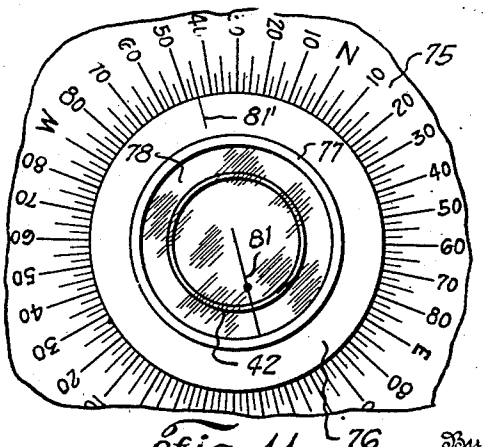


Fig. 11.

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Aug. 24, 1943. L. C. MILLER 2,327,658

METHOD OF AND MEANS FOR ORIENTING TOOLS IN WELL BORES

Filed Dec. 12, 1939 3 Sheets-Sheet 3

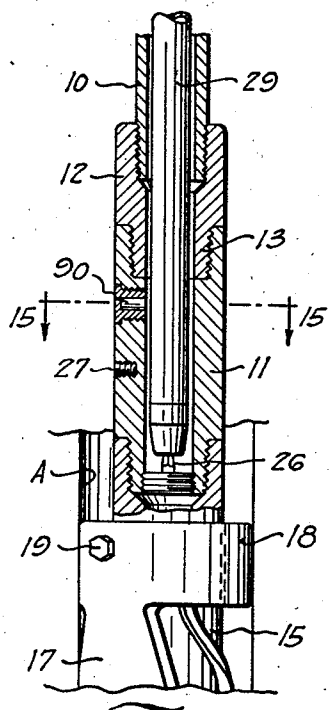


Fig. 13.

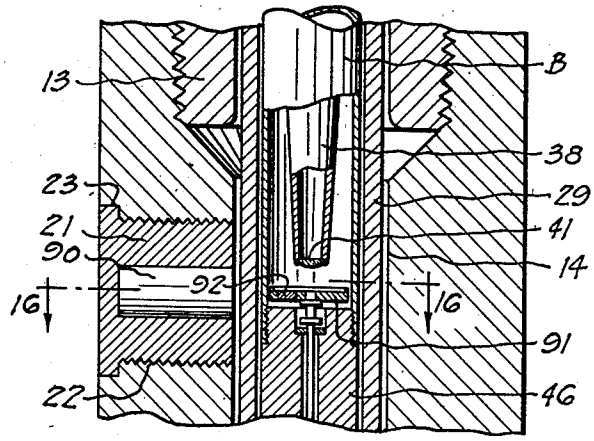


Fig. 14.

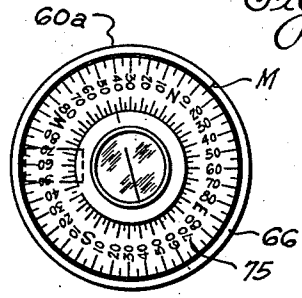


Fig. 17.

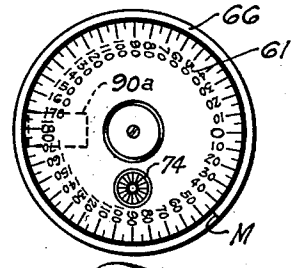


Fig. 18.

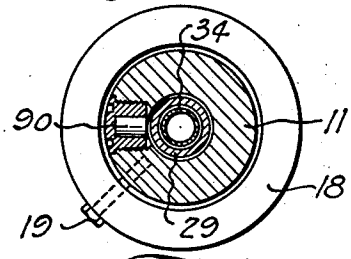


Fig. 15.

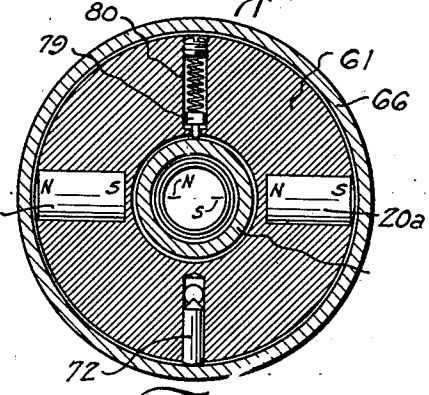


Fig. 12.

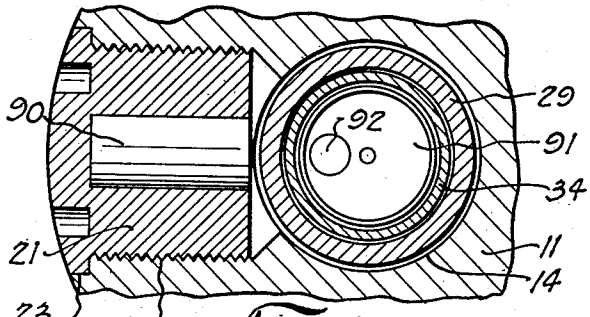


Fig. 16.

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UNITED STATES PATENT OFFICE

2,327,658

METHOD OF AND MEANS FOR ORIENTING TOOLS IN WELL BORES

Leonidas C. Miller, Dallas, Tex., assignor of one-half to Eastman Oil Well Survey Company, Dallas, Tex., a corporation of Delaware, and one-half to Eastman Oil Well Survey Corporation, Long Beach, Calif., a corporation of California

Application December 12, 1939, Serial No. 308,801

12 Claims. (Cl. 255—1.6)

This invention relates to new and useful improvements in methods of and means for orienting tools in well bores.

As is well known, many wells, particularly those produced by rotary drilling, deviate very considerably from the vertical and such deviation may cause the lower end of the bore to completely miss the oil-bearing locality or stratum. After deviation of the bore begins, little can be done to control the drilling from the surface so as to straighten said bore and, therefore, it has become the practice to insert a whipstock in said bore, said whipstock having an inclined guiding surface which directs the drill in a desired direction. Obviously, when a whipstock is employed, it is essential that said whipstock be properly oriented to assure that a proper correction of the direction of the bore hole will be made.

Whipstocks are not only employed in straightening well bores which have deviated from the vertical, but are also used in directing a bore hole in a predetermined direction, which practice is generally known as directional drilling. In directional drilling, the bore hole is started from the surface at a laterally displaced position and the drilling is deflected by means of oriented whipstocks to cause the bore to finally arrive at the desired point in the sub-surface formation. In addition to whipstocks, there are other tools which require orientation in the bore hole in the carrying out of drilling operations.

It is one of the objects of this invention to provide an improved method of orienting a tool within a well bore, whereby said tool may be located in a predetermined azimuthal position in the bore.

An important object of the invention is to provide an improved orientation method which includes surveying the bore hole to determine the direction of inclination or deviation from the vertical of the bore, then lowering a tool to be oriented into the bore and recording the position of the tool relative to the azimuthal position of the low side of the bore hole, whereby such record, taken with the inclination or deviation previously obtained, indicates the azimuthal position of the tool within the bore.

Another object of the invention is to provide an improved method for orienting a tool within a well bore, wherein the tool is secured to the lower end of a drill pipe in a known relation and is lowered into the bore, after which a recording instrument is lowered through the pipe to record the azimuthal position of the low side of the hole relative to the pipe and tool, whereby such record provides accurate information as to the azimuthal position of the tool within the bore; such information making possible the accurate rotation of the pipe to locate the tool in the desired azimuthal position.

A particular object of the invention is to provide an improved apparatus for orienting a tool, such as a whipstock, within a well bore including a sub adapted to be connected to a drill pipe and having a magnetic element mounted therein, together with a recording instrument having a position indicator arranged to co-act with the magnetic element so as to locate the indicator in a predetermined position within the sub, said instrument having means for recording the low side of the bore hole on said position indicator, whereby the low side of said hole with relation to the azimuthal position of the magnetic element in the sub may be determined; said sub having the tool to be oriented secured thereto in known relation to the magnetic element in said sub, thus permitting an accurate determination of the azimuthal position of the tool by a determination of the position of the magnetic element relative to the low side of the bore.

Another object of the invention is to provide an improved apparatus, of the character described, wherein the record made by the recording instrument need not be developed, as is the case where photographic film is employed, thereby making possible an instantaneous and accurate reading at the location or at the well bore and a rapid orientation to properly position the tool.

A further object of the invention is to provide an improved apparatus for orienting devices within a well bore, wherein the recording instrument may be lowered and raised through the drill pipe on a wire line or cable and also wherein the indicator of the instrument is positioned within the drill pipe in a predetermined manner by means of co-acting magnetic elements, whereby the relation of the indicator to the pipe may be readily determined at the surface by means of a suitable reading device and also whereby the recording on said indicator, which recording is representative of the azimuthal position of the low side of the hole, may be determined in degrees from the azimuthal position of the magnetic element mounted in the drill pipe.

Still another object of the invention is to provide an improved reading device for use with an orienting apparatus, of the character described, which is constructed so that an instantaneous and accurate determination of the azimuthal position of the tool to be oriented in the bore, may be had.

A construction designed to carry out the invention will be hereinafter described, together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings, in which an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, illustrating a drill stem having a whipstock secured thereto and showing the improved orienting apparatus, constructed in accordance with the invention in position within the drill stem,

Figure 2 is an enlarged, transverse, vertical sectional view of the orienting apparatus secured to the lower end of the drill stem,

Figure 3 is a horizontal, cross-sectional view, taken on the line 3—3 of Figure 2,

Figure 4 is a horizontal, cross-sectional view, taken on the line 4—4 of Figure 2,

Figure 5 is an enlarged transverse, vertical sectional view of the position indicator which is mounted within the apparatus,

Figure 6 is a horizontal, cross-sectional view, taken on the line 6—6 of Figure 5,

Figure 7 is a plan view of the reading device,

Figure 8 is a view similar to Figure 7 and showing the opposite side of said device,

Figure 9 is an enlarged, transverse, vertical sectional view, taken on the line 9—9 of Figure 7,

Figure 10 is an enlarged, transverse, vertical sectional view taken on the line 10—10 of Figure 8, and

Figure 11 is an enlarged plan view of the central portion of the reading device showing the indicator mounted therein, when a reading is taken.

Figure 12 is a horizontal, cross-sectional view taken on the line 12—12 of Figure 9,

Figure 13 is a view partly in elevation and partly in section showing a slightly modified form of the invention,

Figure 14 is an enlarged, transverse, vertical sectional view of the modified structure,

Figure 15 is a horizontal, cross-sectional view, taken on the line 15—15 of Figure 13,

Figure 16 is a horizontal, cross-sectional view, taken on the line 16—16 of Figure 14,

Figure 17 is the view similar to Figure 7, illustrating the reading device used with this form of the invention, and

Figure 18 is a view similar to Figure 17, showing the underside of the reading device.

In carrying out the improved method, it is first necessary to make a directional survey of the bore hole at the point at which the tool is to be set so as to determine the direction of inclination of the hole at such point. This may be done by any suitable instrument, either a gyroscopic or a magnetic instrument, and such instrument may be lowered into the drill stem on a wire line or cable for the purpose of making the initial survey. An instrument, which is generally known to the trade as a single shot surveying instrument may be employed. By means of the instrument, the degree of inclination or deviation from the vertical, as well as the direction of such inclination, may be determined. For example, the instrument may show that the bore hole inclines N. 45 E., or it may show any other reading in accordance with the inclination and direction of the bore hole.

After this information is obtained by the initial directional survey of the bore hole by any suitable instrument, the drill stem 10 (Figures 1 and 2) is lowered into the well bore A. In carrying out the invention, an elongate cylindrical sub 11, which is preferably constructed of a nonmagnetic material, is coupled to the lower end of the drill stem 10 by means of a suitable coupling collar 12. The collar threads onto the lower end of the drill stem and is provided with a nipple 13 which is threaded into the upper enlarged end of the bore 14 of the sub 11. A drill bit 15 is secured to the lower end of the sub 11 being screw-threaded thereon and said bit may be of any suitable type, a drag bit being illustrated. With this arrangement, it will be obvious that the sub 11 is interposed between the lower end of the drill stem and the drill bit 15.

A whipstock 17, or other tool to be oriented, is provided with the collar 18, which is preferably made integral with its upper end. This collar surrounds the drill bit 15 and is secured thereto by means of a shear pin 19. It is noted that the shear pin is preferably located in vertical alinement with the angular face 17a of the whipstock. When the drill stem is lowered through the well bore A, it will be obvious that the whipstock, as well as the drill bit, are lowered therewith. A rotation of the drill stem will impart a rotation to the whipstock, whereby said whipstock will be oriented in the hole in the desired manner. After the shear pin has been broken, the drill bit 15, sub 11 and drill stem 10 may move downwardly through the collar 18 of the whipstock and upon such movement, the bit is guided by the angular face 17a of said whipstock. It is noted that this construction, just described, is general practice and forms no part of the present invention.

A pair of magnetic elements or bars 20 are mounted in the wall of the sub or sleeve 11, such elements being preferably constructed of a magnetic material having a high coercive force, such as one of the aluminum-nickel-cobalt alloys. As is clearly shown in Figures 2 and 3, the magnets are disposed diametrically opposite each other within the sub and are located nearer the upper end thereof. Each magnet is axially mounted within a collar 21 which is threaded into a radial opening 22 provided in the sub. The collar is preferably constructed of a nonmagnetic material and has the magnet pressed or otherwise secured therein. An external annular flange 23 is formed on the collar and engages within a recess in the wall of the sub to limit the inward movement of the collar. In this manner, each magnet is retained in position within the sub and yet may be removed for replacement by merely unscrewing the collar from the opening 22. By observing Figure 2, it will be seen that the inner end of the magnet is exposed within the bore 14 of the sub. It is noted that since the collars 23 are of a nonmagnetic material, the body of the sub 11 may be either nonmagnetic or magnetic, as desired.

A spider 24 is threaded into the extreme lower end of the bore 14 of the sub and is, of course, provided with vertical ports 25 extending therethrough. A pin 26 is threaded into the upper portion of the spider 24 and is disposed axially therein, the upper end of the pin being preferably tapered or pointed, as is clearly shown in Figure 2. The pin 26 is thus located within the lower end of the bore 14 of the sub.

As shown in the drawings, the shear pin 19, which secures the whipstock to the drill bit 15 is located in the same vertical plane as one of

the magnetic elements 20. Of course, in making up the threads, when the drill bit 15 is secured to the sub, said pin 19 may become misalined with the magnetic elements in a vertical plane and in such instance, the number of degrees of such misalinement is recorded, whereby the operator knows at all times the relative position of the shear pin and the magnetic elements 20. Since the shear pin is disposed in the same vertical plane as the angular face 17a of the whipstock, the operator is thus advised of the relative position of such angular face 17a with relation to the magnetic elements 20 of the sub. If desired, a radial opening of threaded recess 27 may be formed in the body of the sub 11 immediately below one of the magnetic elements and this opening may receive the shear pin 19, in which case, the whipstock would be secured directly to the sub instead of to the drill bit. In this instance, the angular face 17a of said whipstock would at all times be alined in a vertical plane with the magnetic elements 20.

After the assembly, as above described, is lowered into the well bore A, a suitable recording instrument B is arranged to be lowered by means of a wire line or cable 28 downwardly through the drill stem and into the bore of the sub 11. This instrument may be similar to the one which is fully disclosed in my co-pending application filed May 18, 1939, Serial No. 274,329. The instrument is housed within an elongate shell 29 which has its lower end closed, the upper end of said shell being also closed by a cable socket 30. A pair of coil springs 31 are disposed at each end of the instrument B within the shell 29 so as to absorb shock as the instrument is lowered downwardly into position through the drill stem. The lower end of the shell 29 has a collar 32 secured thereon and this collar carries a disk 33, which is constructed of lead or other soft material. The disk 33 has a small opening at its center to permit equalization of pressures thereacross. When the device is lowered through the drill stem and into the bore 14 of the sub 11, this lead disk 33 is adapted to engage and be punctured by the pointed upper end of the axial pin 26 within the lower end of the bore 14, whereby the opening therein is enlarged. The pin not only serves to stop the shell 29 in its proper position within the sub, as will be explained, but also in puncturing the disk 33 to enlarge the small opening indicates to the operator, after the removal of the instrument, that said instrument was properly located within the sub. If desired, the lead disk could be omitted.

The instrument B includes an elongate casing or tubular housing 34 which has its upper end closed by a suitable cap member 35. An electric lamp 36 is mounted intermediate the ends of the housing 34 and is supplied with current by a dry cell battery or batteries 37 which are located within the housing between the lamp 36 and the cap 35. A suitable timing mechanism (not shown) is also mounted in the housing above the batteries 37 and such mechanism is arranged to close the electrical circuit to the lamp 36 at a predetermined time. Such timing mechanism forms no part of the present invention and any suitable mechanism which will close an electrical circuit, may be employed.

An elongate, tapered, or conical tube or plumb-bob 38 is mounted within the housing 34 immediately below the electric lamp 36. The upper end of the tube or plumb-bob is enlarged and is gradually tapered or reduced at its lower end as is clearly shown in Figure 2. The upper end of the tube is mounted, by means of a cardan suspension 39, within an annular flange 40 which is provided within the housing 34. In this manner, the tube is mounted or suspended so as to undergo a universal movement within the housing 34 and, therefore, said housing may be inclined from the vertical and said tube will always remain in a vertical plane.

A projection lens 41 is mounted in the reduced lower end of the tube or plumb-bob 38 and when the lamp 36 is illuminated, the light rays pass downwardly through the tube 38 and are projected through the lens 41. The projection lens acts to direct the light rays onto the upper end of a position indicator disk 42, and this disk is mounted within the lower portion of the housing 34.

The disk 42 is constructed of a suitable metal which is capable of being magnetized and as is clearly shown in Figure 5, said disk is provided with a peripheral, up-turned flange 43. The disk is secured to the upper end of a stem or shaft 44 which extends downwardly through an axial bore 45 which is provided within a block or plug 46. The plug is screw-threaded into the lower end of the housing 34 and closes said lower end. The lower end of the stem 44 is tapered or pointed and rests upon bearings 47 which are supported within a bearing race 48, the latter being insertable within a counterbore 49 of the plug. The bearing race 48 is held in position within the counterbore by a coil spring 50 which, in turn, is retained by a plug 51 which closes the lower end of said counterbore. Upper displacement of the stem and disk from within the bore 45 is prevented by a retaining screw 52 which is threaded radially through the body of the plug or block 46. The inner end of the retaining screw extends into the enlarged upper end 45a of the bore 45, said inner end being confined between the flanges 53 and a collar 54 which is secured to the upper end of the stem and on which the disk 42 is mounted. For centering the stem 44 within the bore 45, a suitable bearing ring 55 is seated on the angular shoulder 56 which is formed between the bore 45 and the enlarged upper end 45a thereof.

Obviously, the metallic disk 42 is mounted to freely rotate within the lower portion of the housing 34 below the elongate tube or plumb-bob 38. The disk 42 is magnetized so as to be attracted by the magnetic elements 20, whereby when the disk is located opposite said elements, the same is rotated to a predetermined relative position therein. In other words, the point N in Figure 6 on the disk will be attracted to one of the magnetic elements 20, while the point S, which is diametrically opposite the point N, will be attracted by the other element 20. Therefore, whenever the disk 42 is positioned opposite the magnetic elements 20, the disk will always assume the same relative position therein due to the attraction of the magnet to the magnetized material of the disk 42.

The provision of the peripheral flange or lip 43 on the disk 42 forms a recess in the top of said disk and this recess is arranged to receive a disk 57, which disk is preferably constructed of a photographic printing out proof paper. Of course, the invention is not to be limited to this particular type of paper, as any light sensitive paper or material, capable of being developed by exposure to light, may be employed. The center

of this paper disk 57 represents the true vertical plane and when the elongate tube or plumb-bob 38 and the housing 34 are disposed in a true vertical plane, the light from the lamp 36 is directed exactly onto the center of the disk 57. When the tube 38 assumes a position at an angle with relation to the housing due to the inclination of the housing, the light rays are directed onto the disk off-center of said disk. Manifestly, the difference between the center of the disk and the point at which the light rays focus thereon is representative of the number of degrees which the housing inclines off of the vertical.

When the disk is placed in position below the plumb-bob, the paper on which the disk is constructed is unexposed. When it is desired to take a reading, the circuit to the electric lamp 36 is closed to illuminate said lamp and the light rays from said lamp pass through the lens 41 and are concentrated at a given point on the disk 57. If both the plumb-bob or tube 38 and the housing were in a true vertical position, the light beam would be concentrated on the center of disk 57. This beam striking the surface of the disk results in an exposure of said surface, which brings out a dot at the disk. The lamp 36 is illuminated for a sufficient length of time to expose or print out that portion of the disk on which the light beam is concentrated. If the outer housing 34 is at an inclination from the vertical, due to the inclination of the sub 11, it will be manifest that the tube or plumb-bob 38 will be swung with relation to the housing 34, with the result that the light beam from the lamp 36 will be directed onto a point which is off-center of the disk 57. The position of the dot will, of course, be in accordance with the angle of inclination and said dot will be representative of the azimuthal position of the low side of the hole. It is noted that the dot is on that side of the disk opposite the direction of inclination of the bore hole, that is, if the hole inclines toward the north, the dot is formed 180 degrees off of north, or south. Thus, the dot is 180 degrees off of the true direction in which the bore hole inclines.

In carrying out the improved method, a directional survey of the bore hole A is first made at the point of setting of the tool by means of a suitable surveying instrument (not shown). As has been pointed out, a single-shot surveying instrument may be employed and it will be assumed that such survey shows that the direction of inclination or deviation of the well bore at the point at which the tool is to be set is N. 45 W. After the above directional survey is completed, the drill stem 10, having the sub 11, drill bit 15 and whipstock 17 secured thereto, is lowered through the well bore to the position at which it is desired to set the whipstock. As has been pointed out, the magnetic elements are mounted within the sub 11 and one of said elements is disposed in the same vertical plane as the angular face 17a of the whipstock, whereby the operator knows the relative position of the angular face of the whipstock with relation to the sub 11.

After the drill stem 10 and its associate parts have been lowered into the well bore, the instrument B, which is mounted within the housing 29, is lowered through the bore of the stem into position within the sub 11 by means of the cable 28. As explained, the lower end of the shell 29, having the lead disk 33 thereon, strikes the axially disposed pin 26 within the lower end of the bore 14 of the sub. The pin serves to puncture or rupture the disk 33 and at the same time halts further downward movement of the shell and of the instrument B. The length of the shell and the disposition of the indicating disk 42 therein is such that when the lower end of the shell 29 is resting on the pin 26, said disk 42 is located opposite the magnetic elements 20, as is clearly shown in Figure 2. The metallic disk 42, as has been explained, has the paper recording disk 57 mounted therein. As soon as the disk 42 moves opposite the magnetic element 20, said disk is attracted by the magnetic elements so as to position the disk with the point N adjacent one of the magnetic elements and the point S adjacent the other magnetic element. The direction of rotation of the disk will depend upon the magnetism of the elements. After a predetermined length of time, the timing mechanism within the upper portion of the housing 34, which mechanism has not been shown, automatically closes the electrical circuit to the lamp 36 to illuminate the same. Illumination of the lamp will cause the light rays to pass downwardly through the tube 38 and lens 41 and onto a given point of the recording paper disk 57. Since the bore A is inclined from the vertical, the sub 11, as well as the shell 29 within said sub, are also inclined from the vertical. Such inclination will have caused the plumb-bob or tube 38 to be inclined within, and relative to, the wall of the housing 34 and shell 29, whereby the light rays passing through said plumb-bob are directed onto a point which is off-center of the disk 57.

The light rays striking the disk 57 will result in a development of the particular point on which they are concentrated and with the result that a dot will appear on the paper. This dot will be a predetermined number of degrees off-center of the disk 57, in accordance with the particular inclination of the sub and housing. After the dot has been formed on the paper disk, it is manifest that said dot will be representative of the azimuthal position of the low side of the hole and will be exactly 180 degrees from the direction in which the hole inclines. The instrument B is then removed from the bore of the sub and is pulled upwardly through the drill stem 10 by means of the cable 28.

At the surface, the instrument B is removed from the shell 29, after which the plug or block 46, which is threaded into the lower end of the housing 34 of the instrument, is removed therefrom. This block carries the disk 42 and removal of the plug results in a removal of the disk from the housing. After such removal, the plug is mounted in a reading device 60, wherein the relative position of the dot formed on the recording disk 57 with relation to the position of the whipstock, may be determined. The reading device 60 may take various structural forms, but it is preferable that the same be constructed as shown in Figures 9 to 12 of the drawings.

As illustrated, the reading device 60 includes a circular block or body 61 which is provided with an axial threaded opening 62. The lower portion of the opening 62 is enlarged to form an annular shoulder 63 and when the plug 46 is threaded into the opening 62, an external shoulder on said plug will abut the shoulder 63, as is clearly shown in Figure 9. When the plug is threaded into the opening of the body 61, the disks 42 and 57 are located within the enlarged upper end 64 of the opening.

The body 61 is formed with a pair of diametrically opposed cavities or recesses 65 and a pair of magnetic elements 20a, which are con-

structed in the same manner as the magnetic elements 20 within the sub 11, are disposed therein. As is clearly shown in Figure 9, the magnetic elements 20a are located on opposite sides in opposed relation and are in horizontal alinement with the metallic disk 42. Thus, when the plug 46 is mounted within the body 61, the disk 42 is disposed adjacent the magnetic elements 20a, whereby said elements serve to move the disk 42 to exactly the same position that said disk assumed within the sub 11 due to the attraction of the magnetic elements 20. Thus, it might be said that the magnetic elements 20a are comparable with the magnetic elements 20 in the sub, the sub being represented by the circular body 61.

A ring 66 encloses the periphery of the body 61 and this ring is formed with an inwardly directed, annular flange 67 at its upper end. The flange engages within a recess 68 formed in the upper peripheral portion of the body 61, whereby said ring is rotatably mounted or supported on the body. As an additional support and guide for the ring 66, a pin 69 is threaded through the ring and has its inner end riding within an annular groove 70 formed in the outer surface of the body 61 at the lower end thereof.

The ring 66 is representative of the collar 18 on the whipstock 17 and said ring has a suitable mark M (Figures 7 and 8), which mark is representative of the angular face 17a of said whipstock. Since the body 61, which carries the magnetic elements 20a, is representative of the sub 11 and the ring 66, which carries the mark M is representative of the ring 18, it is manifest that the relative positions of the sub and the whipstock may be indicated by rotating the ring around the body. The underside of the body 61 carries a suitable dial 71 which has graduations thereon, such graduations indicating degrees from zero to 180. The zero indication is opposite one of the magnetic elements 20a, while the 180 indication is alined with the other magnetic element. If the face 17a of the whipstock is in the same vertical plane as one of the magnetic elements 20 in the sub, the ring 66 is rotated with relation to the body so as to align the mark M with the magnetic element 20a which is representative of the element 20 with which the whipstock is alined. As illustrated, the mark is alined with the element 20a carrying the zero indication (Figure 8). For locking the body 61 to the ring 66 to prevent rotation of the parts after the setting has been made, a friction lock pin 72 is provided. This pin (Figure 10) is mounted within a lateral recess 73 formed in the body 61 and has its inner end beveled. This beveled end is adapted to be engaged by the beveled inner end of a threaded locking screw 74, which extends upwardly through a suitable opening 74a provided in the body 61. The outer end of the screw has a suitable head 76 made integral therewith, whereby the operator may readily rotate the screw 74. It is manifest that when the screw 74 is rotated to move the same inwardly, the beveled inner end of said screw coacts with the beveled inner end of the locking pin 72, to move said pin outwardly into engagement with the inner surface of the ring 66. By tightening the screw 74, a frictional engagement between the pin 72 and the ring 66 is set up, whereby rotation of said ring relative to the body 61 cannot be accomplished.

A dial ring 75 overlies the upper surface of the body and is mounted within a suitable recess provided therefor. Said dial ring is rotatable within the recess and is confined against upward displacement by an annular flange 76 which is formed on a collar 77. The collar 77 is rotatably mounted within the upper end 64 of the central opening of the body 61 and said collar carries a suitable lens 78, which lens overlies the disks 57 and 42, which are located in the lower portion of the opening 64. Upward displacement of the collar 77 is prevented by a spring-pressed pin 79 which is mounted within an opening 80 formed in the body 61 (Figure 10). The lens 78 has a radial hairline 81 which extends radially from the center to one edge thereof. An indicator line 81' is formed on the upper surface of the flange 76 and is a continuation of the hairline, said indicator line being disposed exactly 180 degrees from, or exactly diametrically opposite, the outer end of the line 81, so that the line terminates adjacent the dial ring 75. The dial ring is marked off and carries the four points of the compass north, east, south and west. The spaces between each compass point are graduated or divided into degrees.

In using the reading device, the body 61 is first adjusted relative to the ring 66, whereby the magnets 20a within the body are alined with the mark M on the ring. As has been explained, the circular body 61 represents the sub 11, while the mark on the ring 66 represents the tool or whipstock 17 which is to be set. As shown in Figure 1, the angular face 17a of the tool is alined with one of the magnets 20 in the sub and, therefore, one of the magnets within the body 61 is alined with the mark M on the ring 66 of the reading device. After such adjustment, the locking screw 74 is moved inwardly so as to frictionally lock the body 61 to the ring to prevent accidental disarrangement of these parts.

After the reading has been taken within the sub, the instrument B is disassembled by removing the plug 46 from the lower end thereof and screwing said plug into the opening 62 within the body 61. This disposes the recording disk 57, on which the dot representative of the azimuthal position of the low side of the hole is displayed, below the lens 78. The lens and collar 77 which carries said lens, are then rotated so as to accurately align the dot with the hairline 81 on said lens. Manifestly, this disk 57 assumes the same relative position within the body 61 that said disk assumes within the sub 11 because of the magnetic elements 20a which are disposed within the body in the same manner as the magnetic elements 20 located within the sub. The position of the magnetic elements with relation to the tool is, of course, known and has been prearranged by the adjustment of the body 61 relative to the ring 66. By noting the number of degrees between the hairline 81 and the mark M on the ring 66, the exact number of degrees between the position of the tool and the azimuthal position of the low side of the hole may be determined. The indicator line 81' which is 180 degrees from the outer extremity of the hairline, or opposite the dot which represents the low side of the hole, is indicative of the direction in which the hole inclines.

As has been explained, assuming that the original directional survey of the bore hole A indicated the inclination at said hole as being N. 45 W., then the dial ring 75 is rotated to align the point N. 45 W. with the indicator line 81'. The hairline 81 is of course, in vertical alinement

with the dot on the recording disk 57. This indicates that the hole inclines in a direction N. 45 W. and then by taking the reading opposite the tool mark M, the exact azimuthal position of the tool is indicated. As shown in Figure 7, the position of the tool in this case is N. 60 E. If this is the position at which the setting of said tool is to be made, no further step need be taken. However, if it is desired to change the position of the tool, the drill stem 10 may be rotated a predetermined number of degrees to locate the tool in its proper position.

From the foregoing, it will be obvious that a simple and accurate orienting method is provided. The use of the printing out proof paper disk 57 eliminates the necessity of the development of any film and, therefore, an immediate and accurate reading may be had. The use of the reading device, obviates the necessity of any calculation as the dial 75 gives an accurate visual indication of the exact azimuthal position of the tool. The term "azimuth" or "azimuthal position" has acquired in oil well surveying a very broad meaning, the same as has the term "orienting," which originally meant turning to the east, but now is accepted as meaning turning in any direction. Azimuth is used in oil well surveying to designate substantially any angular direction from a particular point. It is noted that the reading device simulates the various elements which are located within the well bore and the provision of the magnets makes possible the movement or positioning of the indicator disk to the exact relative position within the reading device as said disk assumes within the bore of the sub 11. It is pointed out that if the well tool is not in the same vertical plane as the magnets 20 within the sub, then the difference in degrees between the position of said tool and one of the magnetic elements 20 is compensated by a relative rotation of the ring 66 on the body 61. In other words, if the tool is located 30 degrees out of alinement with one of the magnetic elements 20 in a vertical plane, then the line M on the ring 66 is disposed 30 degrees from the magnet having the indication zero in alinement therewith. In such case, the body and ring would, of course, be locked in the correct position in the same manner as has been explained. Although a particular reading device for carrying out the purpose of the invention has been disclosed, it is manifest that various types of devices for accomplishing the results could be devised and the invention is not to be limited to the particular construction details of the reading device described. The invention has been described as being employed for setting a whipstock within the well bore, but, obviously, it could be employed for orienting any other tool or device, such as a coring device, knuckle joint or deflecting tool. The illumination of the lamp 36 within the instrument B has been described as controlled by suitable timing mechanism (not shown) within said instrument but any suitable switch arrangement, either manually or automatically operated, could be used without departing from the invention.

In Figures 1 to 12, a pair of magnetic elements 20 have been shown and described as co-acting with the magnetized indicating disk 42. However, it would be possible to omit one of the elements 20, in which case only a single magnet would be depended upon to rotate the indicating element to its predetermined position within the sub. In the case where only the single magnet is employed, only a single magnet would be provided in the reading device 60.

It is not always necessary to employ a magnetized indicating disk 42. In Figures 13 to 18, a slightly modified form of the invention is shown. In this form a single magnet 90 is mounted in the sub 11, being substituted for the magnets 20. The magnet 90 may be of any suitable construction and could be a duplicate of one of the magnets 20. The magnetic disk 42 is eliminated and in place thereof a nonmagnetic disk 91 is substituted therefor. The disk 91 is mounted in substantially the same manner as the disk 42 and is preferably constructed of brass, or other nonmagnetic material. An insert 92 is mounted at one side of the nonmagnetic disk 91 and this insert is of a material which is capable of attraction by the magnet 90; such a material would be soft steel.

When the disk 91 is lowered into the bore of the sub along with the instrument B, it will be manifest that the magnet 90 will attract the steel insert 92, whereby the disk is rotated so that said insert is adjacent the magnet, as is clearly shown in Figure 16. Thus, the disk will always be caused to assume a predetermined position within the bore of the sub 11. The disk 91 carries the recording disk 57, which is constructed of the printing out paper and the operation of this form is substantially the same as the first form hereinbefore described.

When the single magnet shown in Figures 13 and 14 is used, together with the nonmagnetic disk 91, the reading device 60*a* is substituted for the reading device 60, shown in Figures 9 to 11. The device 60*a* is substantially the same in construction as the device 60 with the exception that only a single magnet 90*a* is provided. The adjustment of the reading device is made in exactly the same manner as has been described.

It is noted that in Figures 13 and 15, the shear pin 19, which secures the whipstock to the drill bit, is illustrated as out of vertical alinement with the magnet. Before a reading is taken in the device 60*a*, the body 61 of the reading device is adjusted relative to the ring 66 so as to compensate for the misalinement of the shear pin with the magnet.

The magnets 20 and 90 have been illustrated as mounted in a special sub 11, which is interposed between the drill stem 10 and the drill bit 15. It is particularly pointed out that the invention is not to be limited to the use of the sub 11, as said magnets could be mounted either in the drill stem 10 or in the body of the drill bit 15. In such case, the instrument B would be moved into position opposite the magnets and the operation would be the same.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

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

1. The method of orienting a tool within a well bore including, lowering the tool into the bore on a hollow drill stem which drill stem carries a magnet, lowering within the drill stem an instrument having an indicating element which is arranged to co-act with the magnet so as to assume a predetermined position with relation to the stem, recording on the element the angular position of the low side of the bore relative to the

stem, withdrawing the instrument from the drill stem, causing the recording element to assume the same relative position within a reading device as said element had assumed within the drill stem, said device having an indication representative of the position of the tool, determining the difference between the position of the low side of the hole as indicated by the recording element, and the position of the tool as indicated by the reading device to ascertain the position of the tool within the bore relative to the low side of the bore, and then rotating the drill stem to move the tool into the desired position.

2. In combination, a hollow drill stem, a tool carried by the drill stem and disposed in a predetermined position in a vertical plane relative thereto, an instrument arranged to be lowered through the drill stem and adapted to occupy a predetermined final longitudinal position therein, said instrument containing a rotatable indicating element and means for recording the inclination of the instrument from the vertical to indicate and record the position of the low side of the hole on said element, and magnetic means mounted in the drill stem and co-acting with the indicating element to rotate said element to a predetermined position relative to the stem, whereby the indication of the position of the low side of the hole is recorded relative to the drill stem and tool carried thereby.

3. In combination, a hollow drill stem, a tool carried by the drill stem and disposed in a predetermined position in a vertical plane relative thereto, an instrument arranged to be lowered through the drill stem and adapted to occupy a predetermined final longitudinal position therein, said instrument containing a rotatable indicating element having a light sensitive medium thereon, a plumb bob above the medium and means for directing light rays through the plumb bob onto the medium and thereby develop a portion of the medium in accordance with the position of the plumb bob, whereby such developed portion of said medium indicates the angular position of the low side of the bore hole, and magnetic means mounted in the drill stem and co-acting with the indicating element to rotate said element to a predetermined position relative to the stem, whereby the indication of the angular position of the low side of the hole is recorded relative to the drill stem and tool carried thereby.

4. The method of orienting a tool within a well bore which includes lowering into the well bore the tool to be oriented which is provided with a tubular stem having a locating element, then lowering into said stem an instrument having therein a movable indicating element and provided with means for making an index and means for locating the index, locting said movable indicator with respect to said locating element, then making an index on said indicating element, then withdrawing the instrument from the well bore and causing said indicating element to assume the same relative position with a location element as it did in the well bore, then determining with respect to the locating element and the index the degree of orientation necessary for rotating the tool, and then rotating the stem in accordance with the ascertained information.

5. The method of orienting a tool within a well bore which includes, lowering the tool into the well bore, then lowering into the well bore an instrument having movable means for assuming a location with respect to said tool and also having index means movable with said movable means, together with means responsive to a deflection of said instrument to the vertical for making an index on said index means, then making an index on said index means, then withdrawing the instrument from the well bore, then causing the movable means to assume a location simulating the location of said means with respect to the tool, then determining the degree of variance between said assumed location and the index, and then rotating said tool in accordance with the ascertained information.

6. The method of orienting a tool in a well bore which includes, lowering into the well bore a tool having a hollow stem provided with a magnet, lowering into the stem an instrument having a rotatable support subject to being magnetically positioned when brought into the field of said magnet and carrying an index medium, said instrument also having means for making an index on said medium disposed to assume a position with respect to the low side of the bore, arresting said instrument in such position as to cause the magnet to position the rotatable support and its index medium, making an index on said medium with respect to the low side of the bore and located with respect to the magnet, then withdrawing said instrument from the well bore, magnetically positioning the support and its medium to locate the index with respect to a known point, then calculating in degrees the amplitude of rotation necessary to orient the tool, then rotating the tool in accordance with the ascertained information.

7. The method of orienting a tool within a well bore, which includes, a string including a tubular stem having a locating element and having a tool attached thereto, recording the degree of variation between the direction in which the tool faces and the locating element on a reading instrument, lowering said string into the well bore, then lowering into the tubular stem an instrument having means for making an index with respect to said locating element and the low side of the inclination of said well bore, then making an index, then withdrawing said instrument from the well bore, then placing said index means in the reading instrument which has a locating element and compensating means to set up the degree of variation between the direction of the tool and the locating element of the tubular stem, said second instrument also having markings representative of degrees, setting the reading instrument to position the locating element thereof in accordance with the previously made record of variance, then determining the degrees of orientation necessary to position the tool, and then rotating the drill stem in accordance with ascertained information.

8. A well surveying instrument including, a casing, a rotatable support in said casing, means on the support for transversely carrying a removable index medium, means for making an index mounted to suspend above said medium on an axis constant to the vertical when said casing is deflected from the vertical, and means for causing said suspended means to make an index on said medium after a predetermined lapse of time, a casing within which the instrument is arranged to be inserted, and means carried by said casing co-acting with the rotatable support for holding said support stationary while said index is being made.

9. In combination, a hollow drill stem, a tool carried by the drill stem and disposed in a pre-

determined position in a vertical plane relative thereto, an instrument arranged to be lowered through the drill stem and adapted to occupy a predetermined final longitudinal position therein, said instrument containing a rotatable indicating element and means for recording the angular position of the low side of the hole on said element, said element being magnetized so as to be subject to magnetic influence, and magnetic means mounted in the drill stem and disposed opposite the rotatable element when the instrument is in position within the stem, whereby the element is rotated to a predetermined position relative to the stem so that the indication of the angular position of the low side of the hole is recorded relative to the drill stem and tool carried thereby.

10. In a well survey apparatus the combination of, a tubular stem adapted to be located in a well and having a locating element in its bore, an impaling member in the bore of said stem below said locating element, an instrument adapted to be lowered into the stem having an index member for coacting with said locating element, and a medium carried on the lower end of the instrument positioned to be impaled on said member when the instrument is lowered into the stem to cause the instrument to be sustained with its index member substantially opposite the locating element and to record by the impaling thereof the desired positioning of said instrument.

11. In a well survey apparatus the combination of, a tubular stem adapted to be disposed in a well and having a locating element in its bore, marking means in the bore of the stem below the locating element, an instrument adapted to be lowered into the stem having an index member for co-acting with the locating element, and additional marking means mounted on the lower end of the instrument co-acting with the marking means when the instrument is lowered into the stem to cause the instrument to be sustained with its index member in proper position relative to the locating element and to record the desired positioning of the element.

12. In combination, a hollow drill stem, a tool carried by the drill stem and disposed in a predetermined position in a vertical plane relative thereto, an instrument arranged to be lowered through the drill stem and adapted to occupy a predetermined final longitudinal position therein, said instrument containing a recording element movable independently of the instrument and means for recording the inclination of the instrument from the vertical to indicate and record the position of the low side of the well bore on said element, and means mounted in the drill stem and co-acting with the recording element to cause said element to assume a predetermined position within the stem, whereby the position of the low side of the bore is recorded relative to the drill stem and the tool carried thereby.

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