

March 9, 1943.

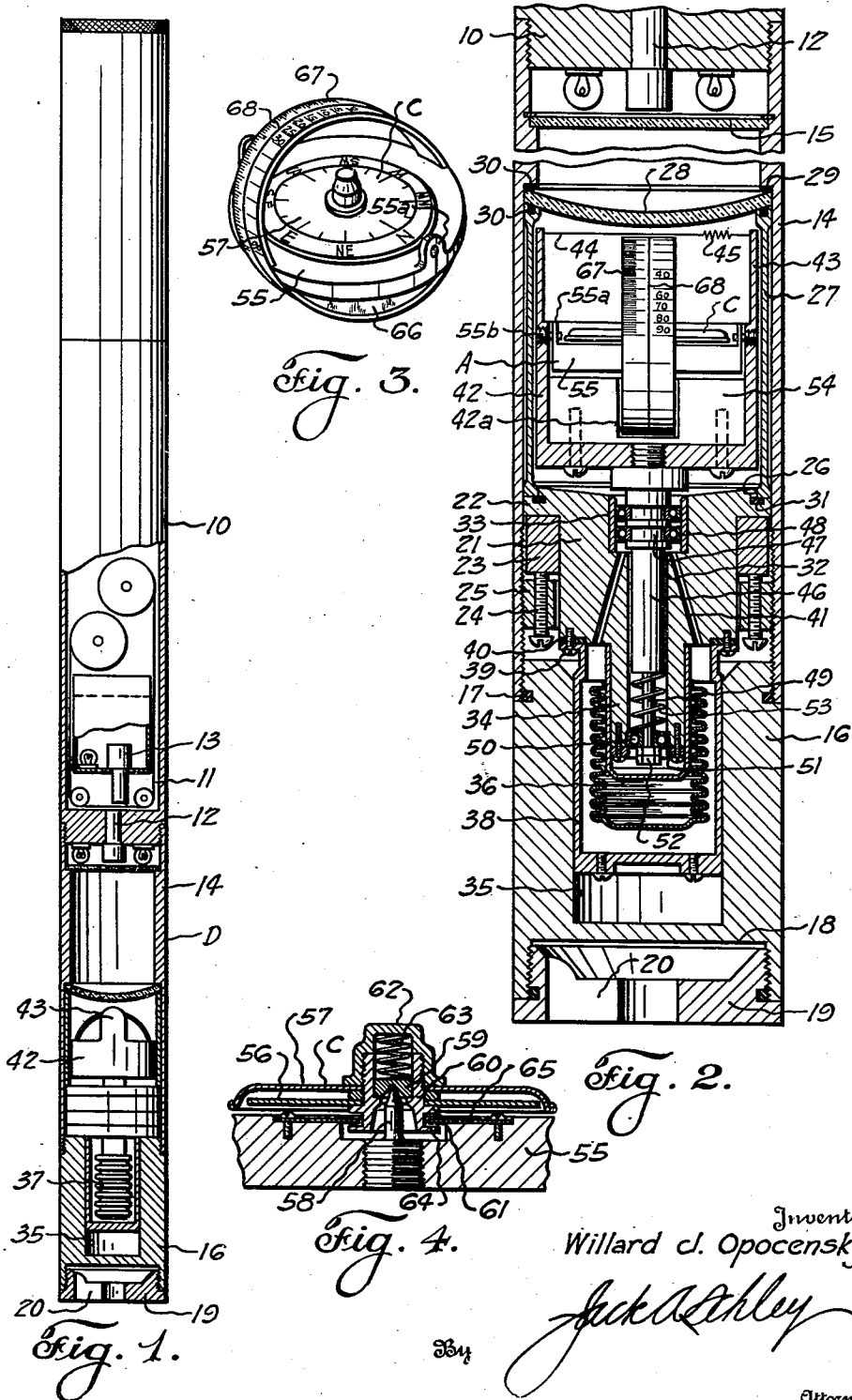
W. J. OPOCENSKY

2,313,168

INCLINATION AND DIRECTIONAL DEVICE FOR BORE HOLES

Filed April 25, 1940

3 Sheets-Sheet 1



March 9, 1943.

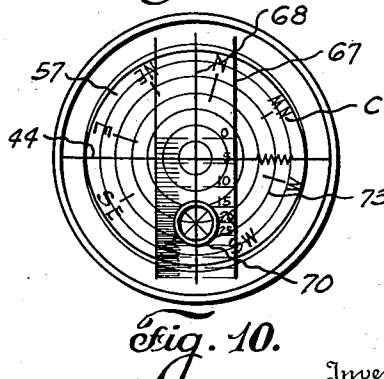
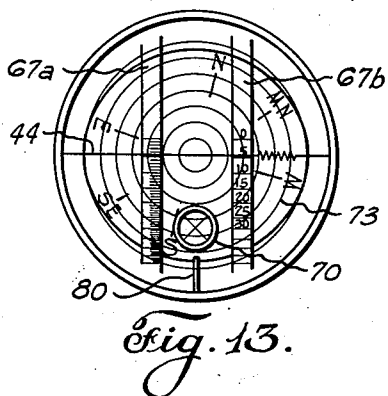
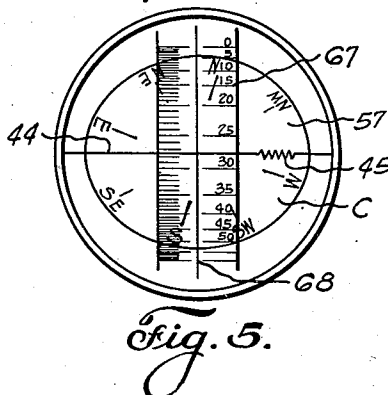
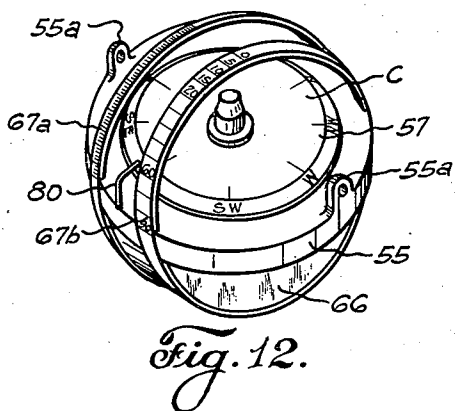
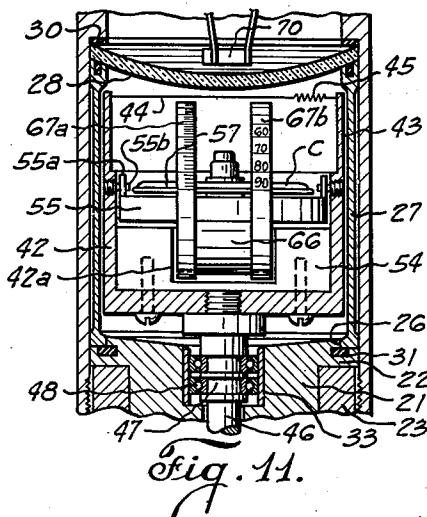
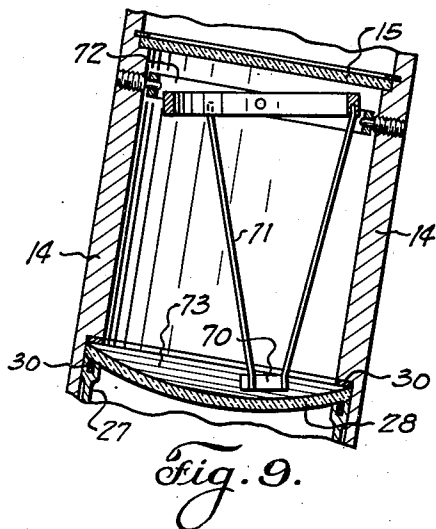
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INCLINATION AND DIRECTIONAL DEVICE FOR BORE HOLES

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3 Sheets-Sheet 2



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INCLINATION AND DIRECTIONAL DEVICE FOR BORE HOLES

Filed April 25, 1940

3 Sheets-Sheet 3

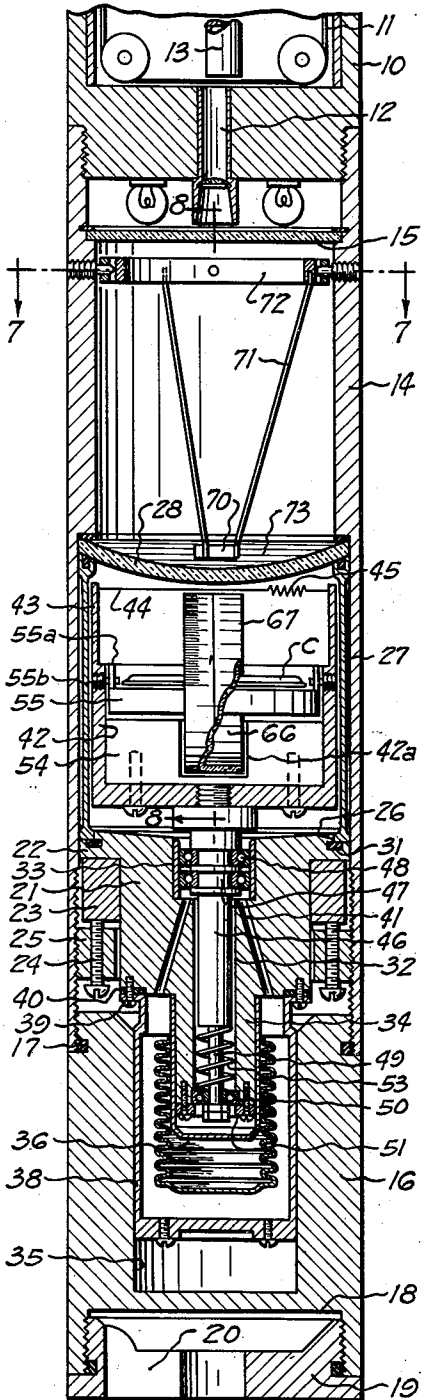


Fig. 6.

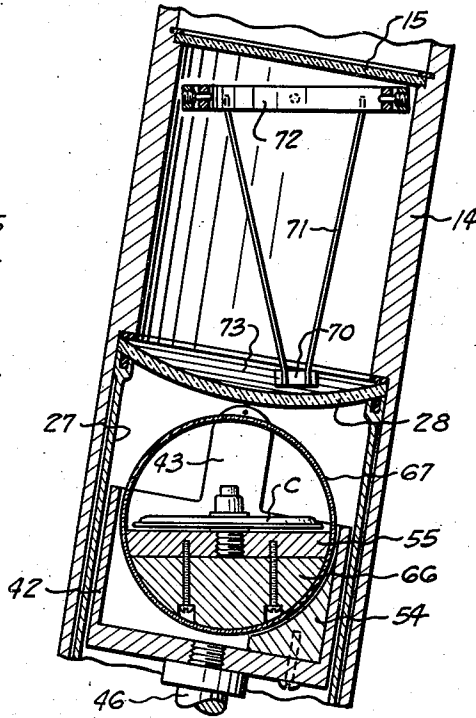


Fig. 8.

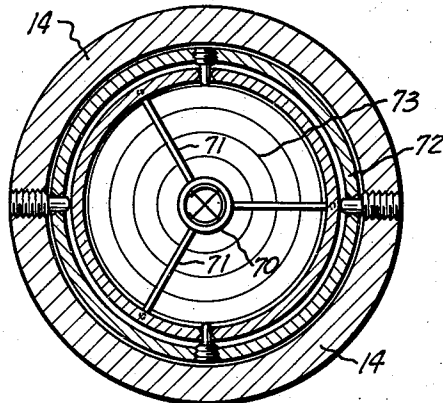


Fig. 7.

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UNITED STATES PATENT OFFICE

2,313,168

INCLINATION AND DIRECTIONAL DEVICE
FOR BOREHOLES

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Application April 25, 1940, Serial No. 331,518

16 Claims. (Cl. 33—205.5)

This invention relates to new and useful improvements in inclination and directional devices for bore holes.

This invention is filed as a continuation-in-part of my copending application, filed March 6, 1939, Serial No. 260,073.

One object of the invention is to provide an improved device which is adapted for use with well survey instruments and which has means for accurately determining and indicating the inclination, and the direction of such inclination, of the bore hole from the vertical.

An important object of the invention is to provide an improved device for determining and indicating the inclination of a well bore, wherein a pair of indicating elements are mounted within a housing which is arranged to be lowered into the well bore, one of said elements being mounted so as to be maintained in a true horizontal position regardless of the inclination of the housing, with the other element being mounted to undergo movement relative to said first element and being controlled in its movement and position by the inclination of the housing, whereby the relative positions of the two elements indicates the inclination of said housing and therefore, the inclination of the bore within which the housing is lowered.

Another object of the invention is to provide an improved inclination and directional device, wherein the two indicating elements which indicate the inclination are associated with a compass; the disposition of the parts being such that all of the same may be simultaneously photographed, whereby the relative positions thereof are indicative not only of the inclination but also of the direction of such inclination, and also whereby a direct reading is obtained from the photograph or record, thereby obviating the necessity of using a straight edge or other tool.

A particular object of the invention is to provide an improved device, of the character described, having a plumb bob or other element mounted therein in addition to the other indicating elements, whereby an accurate indication of small degrees of inclination of the bore from the vertical, may be obtained.

A further object of the invention is to provide an improved device for indicating inclination and direction of inclination of a well bore, which includes a rotatable weighted element which automatically rotates to a predetermined position in accordance with the low side of the bore, together with a compass and indicating element which are mounted so as to remain in a horizon-

tal plane at all times, whereby the relative position of said weighted element to said compass and indicating element indicates the angle and direction of inclination of the bore.

Still another object of the invention is to provide a device, of the character described, wherein the angle unit, as well as the compass proper are mounted in an improved manner whereby these parts and their associate elements are protected from excessive shock or jar as the device is moved through the well bore.

A still further object of the invention is to provide an improved inclination and directional device for use with a well surveying instrument which device comprises a single or unitary assembly rotatably supported within a housing, said support including non-magnetic bearings whereby efficient operation of the unit and accurate readings as to inclination and direction are assured.

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 section and partly in elevation, illustrating an inclination and direction device, constructed in accordance with the invention and showing the frame mounted within a well surveying instrument,

Figure 2 is an enlarged, transverse, vertical, sectional view of the device.

Figure 3 is an isometric view of the compass mounting,

Figure 4 is an enlarged transverse, vertical, sectional view taken through the compass,

Figure 5 is a plan view of the photograph or record which is made, showing the various positions of the indicating element of the device,

Figure 6 is a view similar to Figure 2, showing a slightly modified form of the invention,

Figure 7 is an enlarged, horizontal, cross-sectional view, taken on the line 7—7 of Figure 6,

Figure 8 is a transverse, vertical, sectional view of the upper portion of the device shown in Figure 6, taken on the line 8—8 and illustrating the housing inclined so as to show the action of the plumb bob,

Figure 9 is a transverse, vertical, sectional view, of the upper portion of the device in Figure 6, with the outer housing of said device inclined,

Figure 10 is a view similar to Figure 5, show-

ing the photograph or record which is made by the modified form of the invention illustrated in Figures 6 to 9,

Figure 11 is a transverse, vertical, sectional view of a slightly modified form of indicating means associated with the compass,

Figure 12 is an isometric view of this form of the invention, and

Figure 13 is a view, similar to Figures 5 and 10 and showing the record or photograph which is produced by the indicating element shown in Figures 11 and 12.

In the drawings, the numeral 10 designates a well survey instrument, which may be of any suitable construction. The instrument houses photographic equipment which includes a traveling film 11 which passes over a lens 12 which is mounted in the lower portion of the instrument case, as is clearly shown in Figure 1. A second lens 13 may be positioned over the film 11 and is adapted to photograph a clock (not shown). The upper portion of the instrument 10 has the usual batteries and timing mechanism (not shown) mounted therein. It is noted that the construction of the well survey instrument, as well as the construction of the photographic equipment and its associate parts is subject to variation and forms no part of the inventive concept of the present application.

In carrying out the invention, a device D for indicating the inclination and direction of inclination of a bore hole, is secured to the lower end of the instrument 10. This device includes an outer shell or housing 14 which has its upper end threaded onto the lower end of the case of the instrument 10. The lens 12 projects into the upper portion of the housing 14 and a flat window 15 is mounted within said housing immediately below the lens 12. The lower end of the housing 14 is closed by a plug 16 which is threaded thereinto, as is clearly shown in Figure 2. A suitable gasket ring 17 is mounted adjacent the threads of the plug 16 so as to form a fluid tight seal between said plug and the housing 14. The extreme lower end of the plug 16 may be recessed as shown at 18 to receive an inverted cap 19 and this cap may be provided with a key slot 20, whereby when the instrument is lowered into an outer protective casing (not shown) the slot may cooperate with an aligning element on said casing to properly dispose the instrument therein. If desired, the cap member 19 may be omitted and the lower portion of the plug 16 may be made flat.

A supporting block 21 is mounted within the lower portion of the housing 14 and is formed with an external annular flange 22 at its upper end. The flange 22 rests upon a clamping ring 23 which is supported within the housing by means of adjusting screws 24, the latter being threaded through a supporting ring 25. The ring 25 is provided with threads on its exterior surface and said threads engage the internal thread formed at the lower portion of the housing 14. The upper end of the flange 22 of the supporting block 21 is formed with an annular recess or groove 26 which is located at its peripheral portion. This recess is adapted to receive the lower end of a sleeve 27 which extends upwardly therefrom within the housing 14. The upper end of the sleeve 27 engages the peripheral portion of a curved window 28, which window is confined between the upper end of the sleeve and an internal shoulder 29 which is provided within the housing. Suitable gaskets 30

may be disposed on each side of the peripheral portion of the window 28 and a similar gasket 31 may be interposed between the lower end of the sleeve and the flange 22 of the supporting block 21, whereby a fluid tight seal between these engaging parts is obtained.

From the above, it will be seen that the supporting ring 25, together with the adjusting screws 24 provides a means for supporting the block 21, sleeve 27 and curved window 28. When the screws 24 are moved upwardly, the clamping ring 23 which engages beneath the flange 22 of the block 21, moves the assembly upwardly, whereby the window 28 is clamped between the upper end of the sleeve 27 and the shoulder 29. Also, the supporting block 21 is confined against longitudinal movement within the housing 14.

The supporting block 21 is formed with an axial bore 32, which is enlarged or counter-bored at its upper end, as indicated at 33. A depending collar 34 extends downwardly from the block 21, surrounding the bore 32 and this collar extends into an enlarged axial bore 35 which is formed within the plug 16. A relatively thin sleeve element 36 is secured to the outer surface of the collar 34 and has its lower end closed so as to close the lower end of the bore 32 of the block 21. A Sylphon bellows 37 surrounds the sleeve 36 and has its upper end rigidly secured thereto. The lower end of the bellows is, of course, closed and air under pressure is confined within the interior of the bellows and is constantly urging said bellows towards an expanded position. An annular shell 38 extends downwardly within the bore 35 of the plug 16 and surrounds the bellows 37, being spaced therefrom, as is clearly shown in Figure 2. The upper end of the shell 38 is flanged and is secured to the underside of the supporting block 21 by means of screws 39. A suitable packing gasket 40 is interposed between the flange of the shell and the underside of the block so as to provide a fluid tight seal at this point.

The interior of the shell 38 provides a chamber for receiving a suitable damping fluid and this chamber communicates with the space above the supporting block 21 through ports or passages 41, whereby the damping fluid may be introduced into the space above the block and may flow downwardly into the chamber formed by the shell 38. In operation, the interior of the sleeve 27, as well as the interior of the chamber formed by the shell 38 is entirely filled with the damping fluid and obviously, such fluid is subject to contraction and expansion under varying temperature conditions. When this fluid becomes heated due to an increased temperature, the expansion of the fluid is compensated by the bellows 37, which bellows will of course be collapsed in accordance with the expansion of the fluid. Similarly, if the fluid is cooled, the bellows 37 may expand to fill up the space which has been left by the contraction of the fluid. Thus, the bellows 37 provides a means for compensating for the expansion and contraction of the fluid under varying temperature conditions.

An indicating assembly A is mounted within the sleeve 27 above the supporting block 21 and this assembly includes a rotatable collar 42. This collar is formed with upwardly extending lugs or ears 43 which are disposed diametrically opposite each other. An indicating wire or other element 44 has its ends secured to the ears 43 so as to extend transversely across the collar 42 and this wire may have a coiled spring 45 con-

nected therein so as to hold said wire taut at all times. The collar 42 has the upper end of a rotatable shaft 48 secured thereto and this shaft extends downwardly into the bore 32 of the supporting block 21. The upper portion of the shaft 48 is formed with annular groove 47, whereby lateral bearings 48 may be interposed between said shaft and the counter-bore 33 of the bore 32. It is pointed out that the outer races of the bearings 49 are slidable vertically within the counter-bore, whereby the entire shaft may undergo a limited vertical movement relative to the bore 32. The lower end of the shaft 48 is formed with an axial depending pin 49 which extends downwardly through thrust bearings 50 mounted in the lower end of the bore 32, such thrust bearings being retained within the bore by means of a retaining ring 51. The pin extends through the bearings 50 and has suitable nuts 52 secured thereon. A coil spring 53 is interposed between the lower end of the shaft 48 and the upper end of the bearings 50 and exerts its force to urge the shaft in an upward direction within the bore 32. The strength of the spring is sufficient to lift the shaft and the collar 42 fastened thereon and normally the parts are in the position shown in Figure 2. The purpose of the spring 53 is to yieldably mount the collar and shaft so that when the device is lowered into the well any jar or shock is taken or absorbed by said spring, whereby the collar and its associate parts are not subjected to such shock or jar.

From the above, it will be seen that the collar 42 is freely rotatable within the housing 14 and said collar has a suitable weight 54 mounted therein at one side thereof. The provision of the weight within the collar will cause said collar to rotate because the weight will always seek the low side of the well bore as the device is lowered therethrough. The weight is shown as located exactly 90° from the plane in which the indicating wire 44 extends.

A compass unit is mounted within the upper portion of the collar 42 and includes a circular plate 55 which is provided with upwardly extending ears 55a, the latter being disposed diametrically opposite each other. The ears 55a are pivotally mounted on pins 55b which extend inwardly from the upper end of the collar 42 and thus, it will be seen that the plate 55 may undergo a swinging movement relative to the collar 42. A compass C is mounted on the plate 55 and as is clearly shown in Figure 4, includes the usual magnetic needle 56 and compass card 57, which card carries the usual indications thereon. It is noted that the peripheral edge portion of the card is curved downwardly, so that the indications on said card are clearly visible from an angle.

The mounting of the compass on the supporting plate 55 is such as to prevent shock or jar affecting the compass and includes a pivot pin 58 which is mounted within the plate 55 and extends upwardly therefrom. A jewel bearing 59 engages the upper end of the pin 58 and is mounted within a collar 60. The compass needle and compass card are secured to the collar 60, being clamped thereon between a flange 61 and a cap member 62. A coil spring 63 is mounted within the cap member 62 and urges the jewel bearing 59 downwardly onto the pin 58 at all times. However, the bearing is yieldable with relation to the pin and such mounting prevents undue shock or jar being transmitted to the compass needle 56 and the compass card 57. For preventing upward displacement of the collar 60 and its associate parts,

from the pivot pin 58, the lower end of said collar is formed with an annular groove 64 which has the inner end of a retaining element 65 engaged therein. As is clearly shown in Figure 4, the element 65 permits a limited upward movement of the collar 60 but prevents displacement thereof from the pin 58.

Since the compass C is mounted on the plate 55, which plate is capable of a swinging movement within the collar 42, it is manifest that said compass is also capable of a movement relative to said collar. Therefore, when the housing 14 is lowered into an inclined well bore and the collar 42 is inclined in accordance with the inclination of the housing, the compass C may remain in a horizontal plane, regardless of the inclination of the collar 42 with respect to the vertical. For assuring that the compass and its supporting plate 55 remain in a true horizontal plane, a weight 66 is secured to the underside of the plate 55.

An indicating ring 67 surrounds the plate 55 and the compass C, being disposed in a vertical plane, as is clearly shown in Figure 2. This indicating ring is preferably of a transparent material and has a central indicating line 68 displayed thereon. In addition to the indicating line 68, the transparent ring 67 is provided with graduations or indications which are representative of degrees. The diameter of the ring 67 is such that its periphery is disposed contiguous or adjacent to the wire 44, which wire is carried by the collar 42. In order to permit the ring 67 to extend completely around the supporting plate, the weight 54 which is mounted within the collar 42 may be provided with a groove or recess 42a, through which the ring 67 extends. The ring is rigidly secured to the supporting plate 55 so that when said plate swings with relation to the collar 42, the ring 67 is rotated relative to the collar and to the indicating wire 44. Since the compass C is of the magnetic type, it is preferable that all of the parts of the device be constructed of a nonmagnetic material and it is particularly important that the bearings 48 and 50 be of such nonmagnetic material.

In the operation of the device, the assembly, as shown in Figure 1 is suitably mounted within a protective casing (not shown) which is adapted to be lowered through the well bore by means of a cable, or other suitable element. So long as the instrument is maintained in a truly vertical position, the housing 14 is also in such position and the parts are as shown in Figure 2. The bottom of the rotatable collar 42 is in a substantially horizontal plane, as is the compass unit. At this time, the zero indication on the transparent ring 67 is below the indicating wire 44 of the collar 42. Of course, the compass needle 56 which is controlled by the magnetic influences of the earth, assumes a position indicating azimuth.

As the casing 14 is inclined, due to the inclination of the bore hole through which the same is lowered, the collar 42 is rotated, such rotation being caused by the disposition of the weight 54 at one side of said collar. As the collar 42 rotates due to the weight 54 seeking the low side of the hole, the supporting plate 55 and compass C are maintained in substantially a horizontal plane, swinging on the pivot pin 55b. Therefore, the supporting plate, compass C and transparent indicating ring 67 are maintained in substantially the same position as the parts assumed while the casing was lowered through the vertical portion of the bore. However, since the collar 42 has

been inclined and rotated, the indicating wire 44 has moved to a different position relative to the periphery of the indicating ring 67. Thus, when all of the parts were in a vertical position, as shown in Figure 2, the zero indication of the ring 67 is opposite wire 44, but upon the inclination and rotation of the collar 42, the indicating wire 44 has moved opposite another indication on the indicating ring 67. The indications or graduations on the ring 67 are graduated so as to be representative of degrees and therefore, if the inclination of the bore hole is 27° off of vertical, then the wire moves opposite the indication 27 on the ring 67, thereby indicating the angle of inclination.

The weight 54 which is mounted within the collar 42 has its central portion alined with the central indicating line 68 of the transparent ring 67 and thus, the position of the weight with relation to the transparent ring 67 is known. Also, since the ring 67 is rigidly mounted on the supporting plate, said ring always maintains a given position with relation to the plate. The compass card 57 which is below the ring 67 will, of course, be rotated in accordance with the magnetic influences of the earth. Therefore, the relative position between the indications on the compass card and the central indicating line 68 on the indicating ring 67 will show the azimuthal position of the weight 54. Since it is known that the weight will always seek the low side of the hole, the determination of the azimuthal position of the weight will indicate the direction in which the hole is inclined. Thus, it will be seen that the relative position of the indicating wire 44, with respect to the indicating ring 67 will indicate the angle of inclination, while the relative position of the compass card to the weight 54 will indicate the direction of such inclination.

The device is lowered through the well bore to various positions therein and at each position, the camera equipment within the instrument 10 may be actuated by a suitable timing mechanism (not shown) to photograph the positions of the various indicating elements, such photograph being recorded on the film 11 which travels through the housing 10. The photograph, which is taken of these various indicating elements, will be as shown in Figure 5. By observing this figure, it will be seen that the indicating wire 44 has assumed a position relative to the periphery of the ring 67, which shows that the angle of inclination is substantially 27° from the vertical. Since the ring 67 is transparent, the entire surface of the compass card 57 is visible therebeneath and the position of the indicating line 68 on the ring 67, which line is representative of the location of the weight 54 with relation to the compass card is recorded. The relative positions of the line 68 with relation to the card illustrates the direction of inclination of the bore hole.

It is apparent that the arrangement above described, will efficiently indicate the number of degrees from vertical up to 90° but if the inclination is greater than 90°, the device is ineffective. It has also been found that if the bore hole inclines from the vertical a small number of degrees, as for example 3° or 4°, then the rotation of the collar 42 is so slight that it is difficult to obtain an accurate measurement of this inclination. In order to make the device adaptable for accurately recording a small variation or inclination in the bore hole from the vertical, the construction shown in Figures 6 to 10 may be employed. In this form of the invention, a plumb

bob is mounted within the housing 14 above the curved window 28 and below the flat window 15. This plumb bob includes a collar 70, which is suspended by means of wires, or other supporting element 71 from a gimbal ring arrangement 72. As is well known, the gimbal ring arrangement includes a pair of rings which are so pivoted to each other that the plumb bob 70 may undergo a universal movement within the housing 14. The collar of the plumb bob overlies the upper surface of the curved window 28 and said window is provided with a plurality of concentric lines 73, each being representative of one degree. When the device is in a true vertical position, as shown in Figure 6, the collar 70 of the plumb bob will be alined with the center of the curved window 28. However, when the housing 14 is inclined from the vertical, due to being lowered in an inclined bore, the universal mounting of the plumb bob causes the collar 70 thereof to move to a point off center of the window 28, as is shown in Figures 8 and 9. Thus, when a picture is taken, the position of the plumb bob with relation to the center of the window 28 is recorded, as shown in Figure 10. The relation of the image of the plumb bob to the center of the window 28 indicates the number of degrees which the housing 14 inclines and therefore, illustrates the angle of inclination of the bore. The plumb bob is of course interposed between the camera equipment and the other indicating elements and when a photograph is taken, all of the elements are photographed or recorded on the film, as is clearly shown in Figure 10. This form of the invention, as has been explained, is particularly adapted to accurately indicate the angle of inclination, when such angle is of a very low degree.

In the forms of the invention shown in Figures 1 to 10, the indicating ring 67 has been shown and described as being transparent. The construction of the ring of transparent material makes it possible for the ring to overlie the compass card and yet obtain a photograph of said card. However, it might be desirable to form the indicating ring 67 of a nontransparent material, and in such case, the ring would be made in two pieces, as illustrated in Figures 11 to 13. The two piece ring includes a ring 67a and a ring 67b, which are secured to the supporting plate 55 and have their peripheries immediately below the indicating wire 44. In order to indicate the relative position of the weight 54 of the collar 42 with respect to the supporting plate 55 and compass, a separate indicating element 80 is secured to the plate 55 (Figure 12) and takes the place of the central indicating line 68 in the first form. Manifestly, the operation of this form of the invention will be exactly the same and the photograph or record which is made will be as shown in Figure 13. The only difference between the device shown in Figures 11 to 13 and the other devices is that the indicating ring is made up of two narrow rings 67a and 67b, both of which are not transparent.

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. An inclination and directional indicating device including, a housing, an element mounted within the housing and arranged so as to main-

tain a fixed position relative to the longitudinal axis of the housing whereby said element assumes the same inclination from the vertical as said housing, an indicating means carried by said element, an arcuate member pivotally mounted within the element, means for maintaining said member in the same plane regardless of the inclination of the housing and element, whereby, when said element is inclined from the vertical, the position of the indicating means carried by said element is moved relative to the arcuate member to indicate the angle of such inclination from the vertical, and photographic means within the housing above the element for photographing the relative positions of the indicating means and element.

2. The combination with a well surveying instrument of an inclination and directional indicating device including, a housing, a supporting block mounted within the housing, an indicating assembly mounted on the block and including means for indicating the inclination of the housing and means for indicating the direction of such inclination, means for confining a damping liquid around the indicating assembly, compensating means mounted on the block and exposed to the confined liquid for compensating for expansion and contraction of the liquid under various temperature conditions, and means for protecting the compensating means from the pressure in the well outside the housing whereby said compensating means is not affected by said well pressure.

3. The combination with a well surveying instrument of an inclination and directional indicating device including, a housing, a supporting block mounted within the housing, an indicating assembly mounted on the block and including means for indicating the inclination of the housing and means for indicating the direction of such inclination, means associated with said assembly for yieldably mounting the same whereby shocks and jars are absorbed and said assembly is not subjected thereto, means for confining a damping liquid around the indicating assembly, compensating means mounted on the block and exposed to the confined liquid for compensating for expansion and contraction of the liquid under various temperature conditions, and means for protecting the compensating means from the pressure in the well outside the housing whereby said compensating means is not affected by said well pressure.

4. An inclination and directional indicating device including, a housing, an element mounted within the housing and arranged so as to maintain a fixed position relative to the longitudinal axis of the housing whereby said element assumes the same inclination from the vertical as said housing, an indicating means carried by said element, an arcuate member pivotally mounted within the element, means for maintaining said member in the same plane regardless of the inclination of the housing and element, whereby when said element is inclined from the vertical, the position of the indicating means carried by said element is moved relative to the arcuate member to indicate the angle of such inclination from the vertical, and a plumb bob mounted so as to undergo universal movement within the housing and arranged to hang vertically so as to be axially aligned with the center of the housing when the same is in a vertical position, said plumb bob being swung to an off-

center position when the housing is inclined to indicate the angle of such inclination.

5. An inclination and directional indicating device including, a housing, an element mounted within the housing and arranged so as to maintain a fixed position relative to the longitudinal axis of the housing whereby said element assumes the same inclination from the vertical as said housing, an indicating means carried by said element, an arcuate member pivotally mounted within the element, means for maintaining said member in the same plane regardless of the inclination of the housing and element, whereby when said element is inclined from the vertical, the position of the indicating means carried by said element is moved relative to the arcuate member to indicate the angle of such inclination from the vertical, a plumb bob mounted so as to undergo universal movement within the housing and arranged to hang vertically so as to be axially aligned with the center of the housing when the same is in a vertical position, said plumb bob being swung to an off-center position when the housing is inclined to indicate the angle of such inclination, and means within the housing for recording the position of the plumb bob with relation to the housing, and also for recording the position of the indicating means relative to the arcuate member.

6. An inclination and directional indicating device including, a housing, an element rotatably mounted axially within the housing, means secured to the element for rotating the same to a predetermined position upon the inclination of the housing and element, indicating means carried by the element, an arcuate member pivotally mounted within the element in a predetermined relation, means for maintaining the element in a horizontal plane regardless of the inclination of the element from the vertical, whereby the position of the indicating means relative to the member is varied in accordance with the inclination of said element from the vertical to indicate the degree of such inclination, a compass unit associated with the arcuate member for indicating the position of said member relative to azimuth and thereby indicating the direction of the inclination of the element, and a plumb bob mounted so as to undergo universal movement within the housing and arranged to hang vertically so as to be axially aligned with the center of the housing when the same is in a vertical position, said plumb bob being swung to an off-center position when the housing is inclined to indicate the angle of such inclination.

7. An inclination and directional indicating device including, a housing, an element rotatably mounted axially within the housing, means secured to the element for rotating the same to a predetermined position upon the inclination of the housing and element, indicating means carried by the element, an arcuate member pivotally mounted within the element in a predetermined relation, means for maintaining the element in a horizontal plane regardless of the inclination of the element from the vertical, whereby the position of the indicating means relative to the member is varied in accordance with the inclination of said element from the vertical to indicate the degree of such inclination, a compass unit associated with the arcuate member for indicating the position of said member relative to azimuth and thereby indicating the direction of the inclination of the element,

a plumb bob mounted so as to undergo universal movement within the housing and arranged to hang vertically so as to be axially aligned with the center of the housing when the same is in a vertical position, said plumb bob being swung to an off-center position when the housing is inclined to indicate the angle of such inclination, and photographic means within the housing for photographing in one photograph the position of the plumb bob relative to the center of the housing and also the relative positions of the indicating means, arcuate member and compass unit to each other.

8. An inclination and directional indicating device including, a housing, an element mounted within the housing and arranged so as to maintain a fixed position relative to the longitudinal axis of the housing whereby said element assumes the same inclination from the vertical as said housing, an indicating means carried by said element, a pair of relatively narrow non-transparent arcuate members pivotally mounted within the element, and means for maintaining said members in the same plane regardless of the inclination of the housing and element, whereby when said element is inclined from the vertical, the position of the indicating means carried by said element is moved relative to the arcuate members to indicate the angle of such inclination from the vertical.

9. An angle unit for well surveying instruments, comprising a case, a yoke in the case, a shaft depending from the yoke, means journaling said shaft in the case, a plate pivotally mounted in the yoke, a compass card mounted on the plate, a weight on one side of the yoke, a weight on the bottom of said plate, and an arcuate, transparent ring mounted on the plate, a fixed wire above the ring, said ring being calibrated to indicate inclination of the hole, an orientation line on said ring extending circumferentially thereof, said shaft being journaled for vertical movement in the case, and spring means bearing against the shaft and holding said shaft in raised position.

10. An angle unit for well survey instruments, comprising a case, a yoke in the case, a shaft depending from the yoke, means journaling said shaft in the case, a plate pivotally mounted in the yoke, a compass card mounted on the plate, a weight on one side of the yoke, a weight on the bottom of said plate, and an arcuate, transparent ring mounted on the plate, a fixed wire above the ring, said ring being calibrated to indicate inclination of the hole, an orientation line on said ring extending circumferentially thereof, said shaft being journaled for vertical movement in the case, and spring means bearing against the shaft and holding said shaft in raised position, and means yieldably mounting the compass card on the plate.

11. An angle unit for well surveying instruments, including a case, a yoke journaled in the case, a weight on one side of said yoke, a compass plate pivotally mounted in the yoke, a weight on the bottom of said plate, a compass card mounted on the plate, and an arcuate ring mounted on said plate, said ring being calibrated to indicate the inclination of the hole, a fixed index wire above said ring, a transparent pane mounted in the case above said unit, the space below said pane and about said yoke and compass card being filled with a liquid, a temperature and pressure responsive device emersed in the liquid, and means for protecting the tempera-

ture and pressure responsive device from the well pressure outside the case.

12. An angle unit for well surveying instruments, including a case, a yoke journaled in the case, a weight on one side of said yoke, a compass plate pivotally mounted in the yoke, a weight on the bottom of said plate, a compass card mounted on the plate, and an arcuate ring mounted on said plate, said ring being calibrated to indicate the inclination of the hole, a fixed index wire above said ring, a transparent pane mounted in the case above said unit, the space below said pane and about said yoke and compass card being filled with a liquid, a temperature and pressure responsive device emersed in the liquid, and means yieldably mounting said yoke in the case whereby shock on the case may be absorbed.

13. An angle unit for well surveying instruments, comprising a case, a head mounted in the case, a yoke, a shaft depending from the yoke, said shaft being journaled in the head, a counterweight on one side of the yoke, a compass plate pivotally mounted in the yoke, a compass card mounted on the plate, an arcuate, transparent ring mounted on the plate, said ring extending over the compass card, and said ring being calibrated to indicate inclination of the hole, an index wire fixedly mounted above the ring, a transparent pane mounted in the case above the yoke, the space below said pane and above said yoke being filled with a liquid, and means yieldably mounting said shaft in the head.

14. An angle unit for well surveying instruments, comprising a case, a head mounted in the case, a yoke, a shaft depending from the yoke, said shaft being journaled in the head, a counterweight on one side of the yoke, a compass plate pivotally mounted in the yoke, a compass card mounted on the plate, an arcuate, transparent ring mounted on the plate, said ring extending over the compass card, said ring being calibrated to indicate inclination of the hole, an index wire fixedly mounted above the ring, a transparent pane mounted in the case above the yoke, the space below said pane and above said yoke being filled with a liquid, means yieldably mounting said shaft in the head, and means yieldably mounting the compass card on the plate.

15. An angle unit for well surveying instruments, comprising a case, a head mounted in the case, a yoke, a shaft depending from the yoke, said shaft being journaled in the head, a counterweight on one side of the yoke, a compass plate pivotally mounted in the yoke, a compass card mounted on the plate, an arcuate, transparent ring mounted on the plate, said ring extending over the compass card, said ring being calibrated to indicate inclination of the hole, an index wire fixedly mounted above the ring, a transparent pane mounted in the case above the yoke, the space below said pane and above said yoke being filled with a liquid, means yieldably mounting said shaft in the head, a temperature and pressure sensitive cup depending from the head, said angle unit having a space around said cup, said space being open to the space about said yoke.

16. An angle unit for well surveying instruments, comprising a case, a head mounted in the case, a yoke, a shaft depending from the yoke, said shaft being journaled in the head, a counterweight on one side of the yoke, a compass plate pivotally mounted in the yoke, a com-

pass card mounted on the plate, an arcuate, transparent ring mounted on the plate, said ring extending over the compass card, said ring being calibrated to indicate inclination of the hole, an index wire fixedly mounted above the ring, a transparent pane mounted in the case above the yoke, the space below said pane and above said yoke being filled with a liquid, means yieldably

5 mounting said shaft in the head, a temperature and pressure sensitive cup depending from the head, said angle unit having a space around said cup, said space being open to the space about said yoke, and means yieldably mounting the compass card on the plate.

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