Sept. 5, 1933. F. AHLBURG 1,925,223

METHOD AND APPARATUS FOR DETERMINING THE INCLINATION OF A WELL

Filed Jan. 22, 1930 3 Sheets-Sheet 1

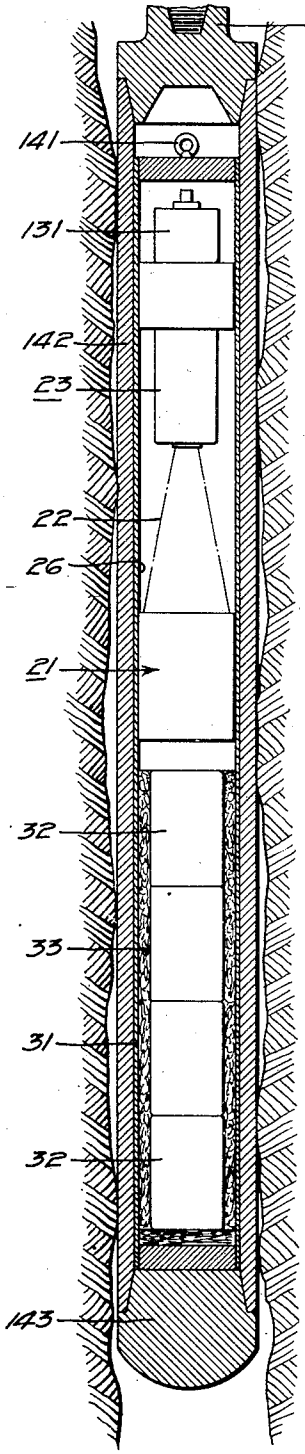

FIG. 1.

FIG. 2.

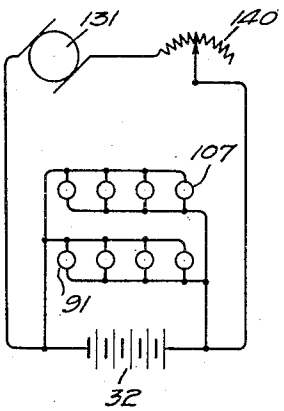

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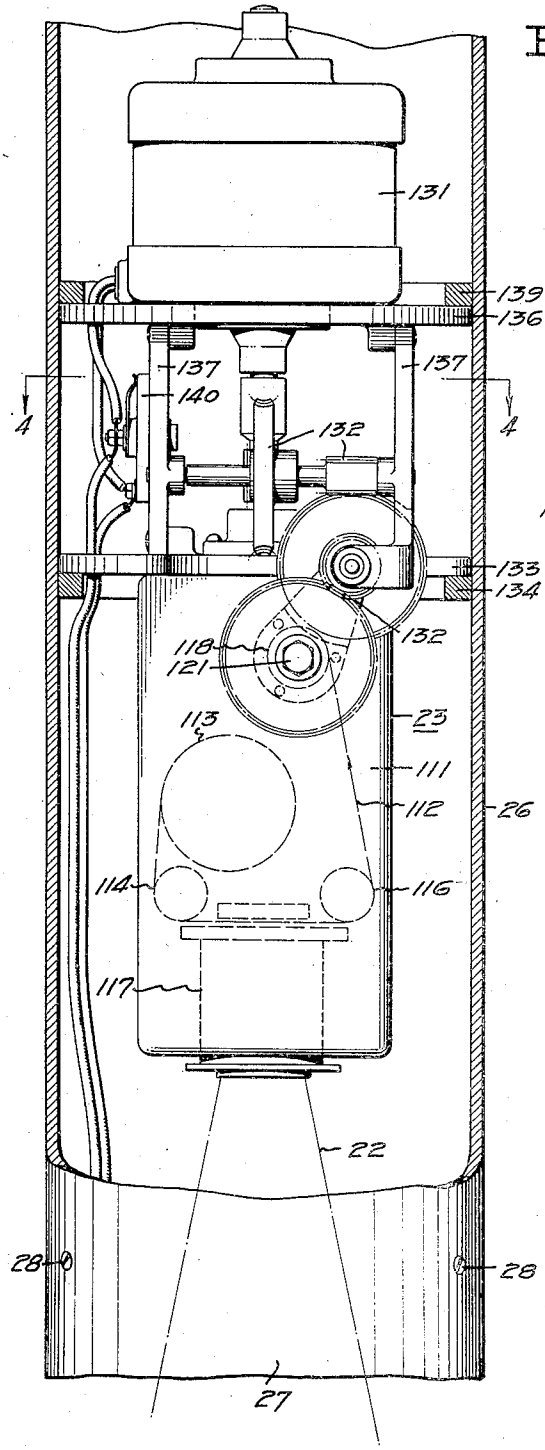
FIG. 3.



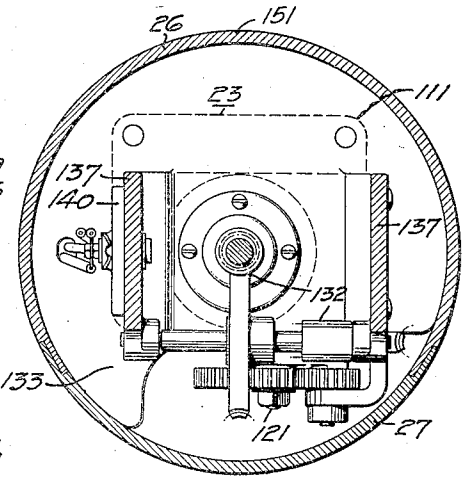


FIG. 4.

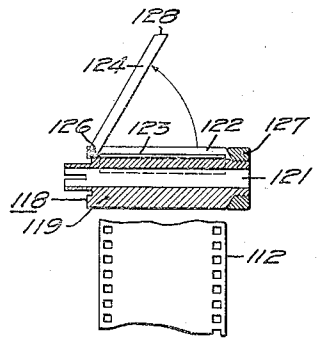


FIG. 5.

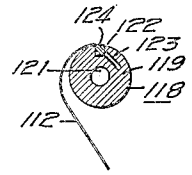


FIG. 6.

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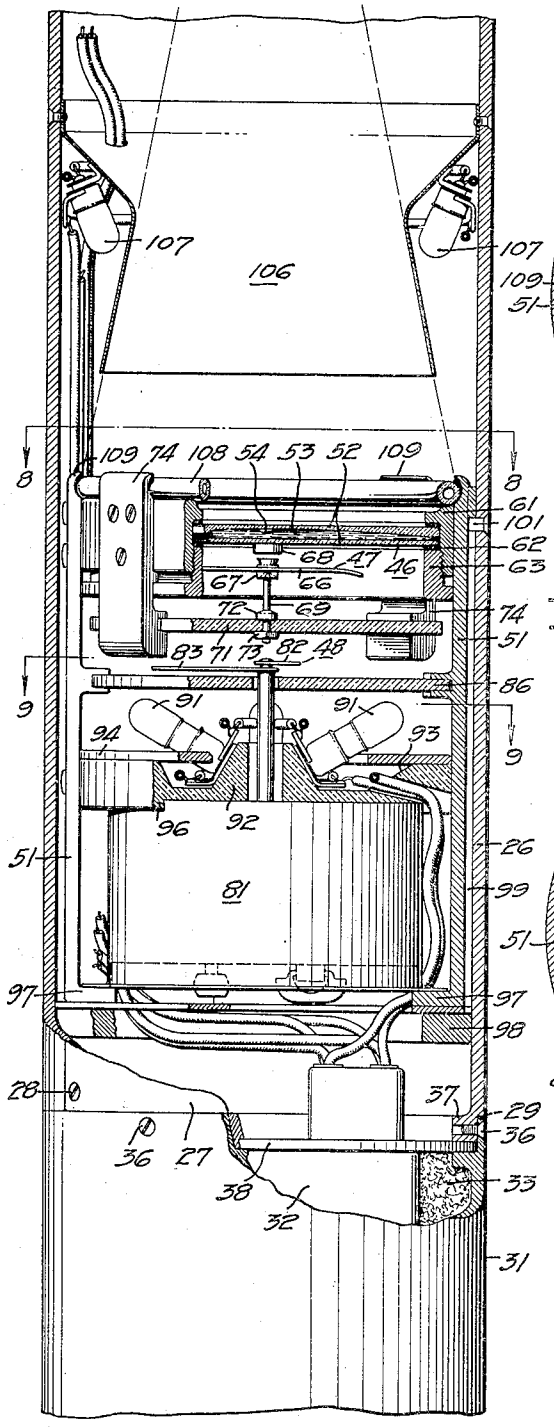


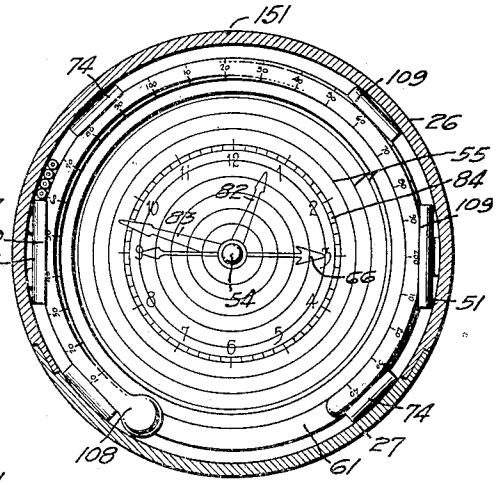


FIG_8_

FIG_7_

FIG_9_

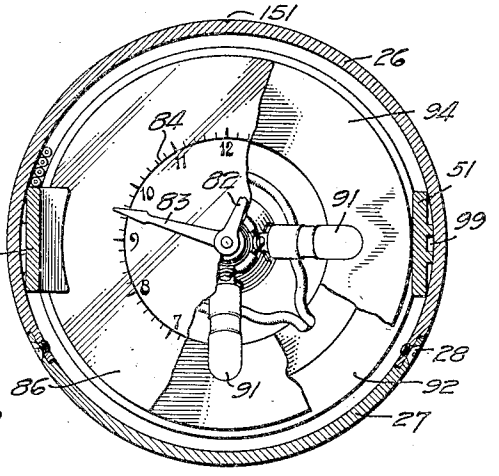
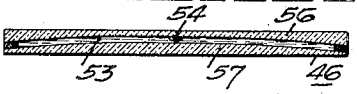


FIG_10_



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Patented Sept. 5, 1933 1,925,223

UNITED STATES PATENT OFFICE

1,925,223

METHOD AND APPARATUS FOR DETERMINING THE INCLINATION OF A WELL

Frank Ahlburg, Los Angeles, Calif.

Application January 22, 1930. Serial No. 422,559

2 Claims. (Cl. 234—5.3)

This invention relates to the determination of the inclination of an oil well from the vertical. In petroleum engineering it is an appreciated fact that deep wells cannot be drilled without giving special attention to overcoming the tendency for the drill to follow off along one of the various strata and so take the course of the well away from the vertical. This results in an increased expense in drilling the well. In some instances adjacent wells have been ruined by being drilled into and non-productive wells have also resulted by reason of missing the oil sand due to departure from the vertical.

In my co-pending application Serial No. 367,758 filed June 1, 1929, I have disclosed a method suitable for determining the inclination of a well from the vertical and suitable apparatus for accomplishing this. However, the method and apparatus disclosed in that application embody certain disadvantages which I propose to overcome by the present invention. Thus, in that application I disclosed an apparatus which, when lowered into the well, recorded the degree of inclination of the well from the vertical and the direction of such degree. However, to coordinate this information with the depth at which the individual records were made, it was necessary to keep a careful check at the surface on the number of individual records which were made and of the depth at which the apparatus was located when they were made so that, when the apparatus was brought to the surface, information as to the particular conditions at any particular depth in the well could be secured by relating the individual records to their corresponding depth. If, for any reason, the apparatus failed to make a record, this fact would not be known and a true coordination would not exist between subsequent records and the depths at which they were made. Accordingly, all doubt as to the accuracy of the method was not removed. It is therefore an object of the present invention to remove this doubt and to provide a method, together with an apparatus suitable for carrying out the method, which enables a ready coordination, of the individual records made of the inclination and the direction of the inclination to the vertical, to the corresponding depth.

Another object of the present invention is to provide an improved apparatus suitable for manufacture and production for the trade for accomplishing a survey of a well with respect to the vertical.

The invention possesses other advantageous features and objects, some of which with the foregoing will be set forth at length in the following description where I shall outline in full a method of my invention as well as that form of apparatus for determining the inclination of a well which I have selected for illustration in the drawings accompanying and forming part of the present specification. In said drawings I have shown one form of apparatus for determining the inclination of a well embodying my invention, but it is to be understood that I do not limit myself to such form since the invention, as set forth in the claims, may be embodied in a plurality of forms.

Figure 1 is a section through the apparatus, illustrating the apparatus as positioned in an oil well.

Figure 2 is a diagram of an electrical circuit employed.

Figure 3 is a side elevational view showing the camera and mechanism for driving the camera.

Figure 4 is a section on the line 4—4 of Figure 3, particularly illustrating the driving mechanism for the camera.

Figure 5 is a section through a device employed for securing the film in position on the camera.

Figure 6 is a cross section through the device shown in Figure 5.

Figure 7 is a section through the recording mechanism, the figure to be taken as a lower extension of the structure shown in Figure 3 to supply a substantially complete section through the apparatus.

Figure 8 is a section taken on the line 8—8 of Figure 7. This view illustrates a record made by the camera.

Figure 9 is a section along the section line 9—9.

Figure 10 is a section through another form of means for indicating the angular deviation of the well.

My invention may be briefly stated as comprising the recording of the direction and degree of deviation of the well from the vertical together with some other indication which will enable the record to be subsequently coordinated with the position at which the record was made in the well. A preferred manner of accomplishing this and one which I have found suitable for use in an oil well is provided by placing the several means in the field of a camera so that a record may be made of their simultaneous indications at the point where it is desired to secure information as to the direction of the deviation and the degree of deviation of the well from the vertical. Thus, as is illustrated diagrammatically in Figure 1, the several indicating means typified at 21 are placed

within the field 22 of a camera 23 so that, upon operation of the camera, light being provided for the purpose, a record will be made of the indication of the several means.

A convenient manner of mounting the several indicating means typified at 21 is to superpose them with respect to each other so that, upon illumination and operation of the camera shutter, they are all photographed simultaneously by the camera. This arrangement of the several indicating means simplifies construction and overcomes other difficulties entailed by the fact that the size of the apparatus is restricted to a relatively small cross sectional size. For convenience in handling the various units I preferably utilize a shell 26 circular in outline and constructed of a non-magnetic material such as brass. This is usually formed with a removable segmental section 27 retained in place by the screws 28 so that this section may be removed to inspect the various units within the casing. The casing is shown divided as at 29 to provide a lower portion 31 within which an electric source of power 32 for the lights and other mechanism, as will be presently described, is carried. Such an electric source of power is conveniently provided by storage batteries which are slipped within the casing and are packed therein with a material 33 such as mineral wool so that they are insulated against heat and are prevented from shifting their position within the casing. The casing 26 and the lower portion 31 thereof are held together by screws 36 which extend into bosses 37 formed upon the casing 26. To protect the units in the casing 26 against spillage of chemical reagents or from fumes, a lead plate 38 is preferably interposed between the two portions of the casing.

The indicating means 21 are preferably superposed with respect to each other and are conveniently formed into a single unit so that their relative position is maintained and so they may be easily handled and readily inspected. A convenient construction is that illustrated in Figures 7, 8 and 9 wherein deviation indicating means 46, direction indicating means 47 and coordinating means 48 are joined together by several strips 51.

As means for indicating the degree of deviation I have employed a plurality of glasses 52 spaced from each other to receive a quantity of liquid 53 such as distilled water. The quantity of liquid between the glasses is sufficient to provide an air bubble 54.

The uppermost glass has a concave face formed thereon so that it may be used to indicate, in conjunction with the air bubble, the deviation from the vertical. I have inscribed a plurality of concentric circles 55 on the glass so related to the concave face of the glass that they indicate certain increments of slope in feet per hundred feet or in percentage.

The size of the air bubble should be relatively large at ordinary temperatures since, when the liquid becomes heated in the well, expansion takes place and the bubble shrinks materially in size. In the form of deviation indicating means illustrated in Figure 10 I have been able to overcome this tendency to some extent by providing one glass having a concave face as at 56 and another glass having a convex face 57 spaced from the concave face but a slight distance. The angularity of the faces 56 and 57 is substantially identical so that but a small quantity of liquid is between them. With a reduction in the quantity of the liquid the total expansion taking place is relatively small and the compression of the air bubble is not as great. The glasses are secured in liquid retaining position by a ring 61 in which they are fitted, a gasket 62 being positioned between the glasses and also between the respective glasses, the ring and a collar 63 which screws into the ring to lock the glasses in position.

Means are provided for indicating the direction of the deviation. As a simple form of means for securing this I preferably employ a magnetic needle 66 pivotally mounted as at 67 and positioned so as to be in the field of the camera as by being positioned beneath the deviation indicating means 46. The needle is preferably prevented from displacement from its pivotal mounting by positioning a pad 68 adjacent to it upon one of the glasses 52 so that upon extreme angular movement away from the horizontal the needle will contact with the pad and be prevented from slipping off its pivot. The pivotal mounting for the needle is constructed by securing, to a plate 71, a pin 69 having a collar 72 formed upon the pin to engage the plate and by nut 73. The plate 71 which is preferably made of glass, is conveniently positioned by securing it to the ring 61 through several short strip members 74 formed to engage the plate and to be screwed onto the ring.

Means 48 are provided for coordinating the indication of the degree of deviation and the direction of deviation means with the depth at which the record is made. While this coordination may be accomplished in various ways by the use of different factors, I prefer to employ such a convenient factor as that of time. In operation, the employment of this agency possesses several advantages among which is that of simplicity. Thus, when the apparatus is prepared initially for service in the well, it is only necessary to note the time at which the first picture is taken (this will presently be described in detail) and to know the interval at which the pictures will subsequently be taken by the camera. The apparatus may then be lowered into the well and, as it is lowered, the length of the drill stem or cable in the well at any one of the instants when the pictures are taken is noted. Subsequently, when the apparatus is withdrawn from the well, the log of the depth at any given time may be readily applied to the records made of the indication of the direction of deviation and the degree of deviation by noting the time at which the record was made. Since the time is directly incorporated into the record and cannot be effaced, complete assurance is had that, dependent upon the accuracy of the log at the surface, the record is in agreement with conditions within the well. Accordingly, I employ a clock mechanism 81 capable of indicating the time through hour hand 82 and minute hand 83 in accordance with the graduations 84 provided upon plate 86. This clock mechanism per se does not constitute any portion of my invention. However, I do not wish by this to be said to disclaim the employment of a clock in the environment herein shown, but what I do disclaim is the particular assemblage of shafts, gears, springs, bearings, etc. to provide a clock structure. The plate 86 is also carried by the strips 51 so that the graduations 84 are positioned beneath the plate 71 which carries the direction indicating means.

Means are also provided for illuminating the several indicating means so that the camera

may photograph them. Such means are provided by lights 91 carried on a fibre disc 92, likewise positioned between and carried by the strips 51. The disc is preferably cut away as at 93 so that the lights are angularly positioned to throw their illumination upward. To facilitate the illumination a collar 94 is positioned adjacent the lights and upon the disc so that a reflecting surface is provided thereon which is effective to throw the light upwardly. Since the illuminating means are provided below the plate 86, this plate is formed of suitable material which will pass the light. I prefer to employ a translucent material rather than one which is entirely transparent, in order to secure better photographic exposures.

The disc 92 is also formed with a shoulder 96 thereon which abuts against the clock mechanism 81 to retain it in position in conjunction with arm portions 97 formed on the strips 51. The structure confined by the strips 51 is adapted to be slipped within the casing 26 and to be supported therein by a collar 98 secured to the casing. The correct relative positioning of the assemblage within the casing is secured by providing a keyway 99 in one of the strips 51 so that a screw 101 is effective to guide the assemblage into position. The screw 101 may also be moved relative to the casing so that the assemblage is jammed within the casing and so prevented from moving in the casing.

Means are provided for furnishing a supplementary illumination of the several indicating means so that the lights 91 do not appear in the photograph as points or definite regions of light. This is accomplished by positioning a reflector 106 in the casing above the indicating means so that lights 107 are effective to illuminate the several means without their illumination passing directly to the camera. This supplementary illumination is also effective to enable the camera to secure a clear record of the indication of certain temperature responsive means which I preferably include, since much information can be gained from temperature conditions within the well. Such temperature indications can be secured by a thermometer 108 secured in the extending fingers 109 provided upon the strips 51 and the short strip members 74.

It is believed that temperature indications above the normal at a given depth in a well are indicative of the nearness of oil sands and particularly of gas strata. Careful checking up of these excessive temperatures may prevent gas blowouts and subsequent damage or destruction of the well as proper preparations can be taken before entering the strata. The fact that less information is at present available upon this point is largely due to inability to secure a proper record within a well. In accordance with my invention this can be easily and conveniently secured at the time the well is surveyed.

As a means for recording the indication of the degree of deviation from the vertical, the direction of deviation and the factor coordinating this information with the depth in the well, I preferably employ a camera 111 such as a moving picture camera which is capable of taking a succession of photographs upon a continuous film. The camera mechanism, as with the clock mechanism, constitutes in itself no portion of this invention, the particular lenses, shutters, and other devices being secured from those skilled in that art. In practice I prefer a camera as is shown in Figure 3 wherein a film 112 is unwound from a reel 113 to pass over rollers 114 and 116 adjacent to exposing mechanism 117 which includes a shutter to record photographically the indication of the degree of deviation, the direction of deviation and the coordinating factor such as the time. The film passes from the roller 116 to the winding reel 118.

I have found that the winding reels available with present camera structures have been particularly unreliable and I have accordingly evolved the novel structure shown in Figures 5 and 6. This structure includes a body 119 adapted to be placed upon a shaft 121 of the camera and to be driven thereby. A slot 122 is formed in the body and is provided with an angular cut 123 leading out from it into the body. The film is carried over the body 119, through the slot 122 into the cut 123, in which position it is locked by securing a member 124 in the slot 122. This securing is conveniently accomplished by hinging the member 124 as at 126 and securing the free end of the member by a nut 127 screwed upon the body to engage face 128 on the member 124 and force the member down to lock the strip of film securely in place. With this structure I have never had any difficulty from unwinding of the film or from lack of securing of the film.

In operation, I prefer that the film be moved continuously with respect to the mechanism 117 at such a rate that a fresh portion is available for the taking of a picture after a certain interval of time has passed. To accomplish this I provide a power source 131 such as an electric motor capable of being driven by the storage batteries constantly for several hours. Since the motor normally operates at a relatively high speed it is desirable to interpose reduction gearing 132 between the motor and the shaft 121 so that the film is moved at the desired speed. In one apparatus the motor operated at 2200 R. P. M. and the interval between the taking of the pictures was 3½ minutes. Since one revolution of the shaft 121 was sufficient to move the film to a different position wherein a fresh portion of the film was provided, the reduction gearing 132 was capable of giving a reduction of 7700 to 1.

The camera, motor and reduction gearing are positioned in the casing so that the camera is correctly related to the means which are to be photographed. A convenient construction for this is provided by fastening the camera to a circular plate 133 adapted to just fit within the casing and to be supported upon a ring 134 secured to the casing. The motor is carried on another circular plate 136 spaced from and supported upon the circular plate 133 by the plate members 137. The provision of the several plates provides a box like structure within which the reduction gearing 132 may be conveniently mounted.

To ensure that the motor and camera do not move relative to the casing, I provide another ring 139 removably fastened to the casing upon the top of the plate 136 so that the motor and camera are retained between it and the ring 134. It is advisable to support the units against displacement in any direction since, under working conditions, forces tending to rotate the units occur as well as other forces tending to make them move upwardly relative to the casing.

The circuits employed for actuation of the lights and motor are preferably as shown in Figure 2. The several groups of lights are respectively connected in parallel to the batteries 32

while the motor is separately connected to the batteries and is capable of being controlled by rheostat 140. This rheostat, conveniently positioned upon the plate members 137, serves to enable the interval to be varied within which a fresh portion of a film will be brought into position before actuation of the shutter mechanism occurs. This manner of operating the apparatus is preferable to that in which the carrying out of the various operations is confined to a relatively short period of time by means of contact mechanism. I have found that under operating conditions in the well, contact mechanisms are apt to get out of order and, since this fact is not known until the apparatus is withdrawn from the well, it is most undesirable for it is then necessary to repeat the making up of the drill stem and inserting the apparatus again to complete the survey of the well.

In conducting a survey of a well to determine its position relative to the vertical, the apparatus is assembled within the casing 26 and the operation of the apparatus initiated by connecting the motor and the lights to the batteries so that the motor is running and the lights are illuminated. The time at which the shutter mechanism opens to take a particular exposure or picture is noted through a suitable peep hole into the camera (not shown) and this time made note of. I have found it expedient to warm the apparatus, particularly the camera lens, before inserting it into the well so that moisture does not condense to fog and so impair the photography.

The assembled apparatus is lowered by means of the handle 141 into outer casing 142. This outer casing is constructed of a heavy non-magnetic material of sufficient strength to resist the pressure conditions met in the well. A material suitable for this purpose is manganese bronze. The lower end of the casing 142 is closed by a plug 143, in this instance shown as being rounded off. However, the plug may be adapted to have other instruments connected to it or lengths of the drill stem. The upper end of the casing is joined to a drill stem 146 or to some manner of connection so that the apparatus may be lowered into the well.

Having noted the time at which the shutter mechanism is operated to take a picture, the apparatus is then lowered into the well until the point is reached at which it is desired to begin the survey. Thus, if a well has reached a depth of 6,000 feet and its position has been previously surveyed to 5,000 feet, it is desirable to ascertain the position of the well as drilled between these depths. Such a determination may be made for the purpose of ascertaining if the well is vertical or, if it is not desired to drill vertically, if the well is being drilled at the angle and, in the direction of the structure which it is desired to reach. Accordingly, the drill stems are made up successively, the length of each being noted as it is put into the well, until a depth of 5,000 feet is reached. Then, the operator at the surface notes the time at which the 5,000 foot level is reached and holds the apparatus there steady until the time has passed for the taking of a picture. The number of pictures taken prior to the reaching of the level at which it is desired to begin operations, in this instance the 5,000 foot level, is immaterial since the 5,000 foot record is definitely coordinated by means of the time with this depth. Thus if the depth is reached at 4 o'clock and a picture is taken at two minutes after four it is necessary to wait until after this time. In operation, an independent timing mechanism may be set up at the surface to ring a bell one minute before a picture is taken and a second bell when the picture is being taken. In this way the operators will be advised as to the operations of the apparatus many thousand feet below them.

After the initial picture has been taken, further drill stems are added and the apparatus lowered for say another hundred feet. The apparatus is then held there steady, so that equilibrium is established in the apparatus, until after the time has passed for the taking of another picture. The actual depth at that time is noted and the record made there is readily coordinated subsequently with the actual depth by means of the time. These operations are continued until the survey has been made to the 6,000 foot depth whereupon the apparatus may be withdrawn directly or check records made as the apparatus is taken up by withdrawing it at intervals. The pictures or film exposures are taken automatically and at substantially regular intervals because the motor for the camera operates at a constant speed and continuously.

Upon reaching the surface, the camera unit is withdrawn from the apparatus, the film removed and developed. It is only necessary to run through the developed film and find the photograph showing the clock hands indicating the time when initial one was made, two minutes past four. That photograph will then be a record of the position of the several indicating means at that time. The other pictures are similarly coordinated with the depth at which they are taken.

From the relative position of the bubble with respect to the compass needle, the direction of the deviation can be ascertained with respect to the magnetic north. Applying the correction for the deviation of the magnetic north from the true north, the actual deviation in direction can be had with a fair degree of accuracy while the relative position between the bubble and the several etched lines upon the glass 52 show how much the well is deviating from the vertical. In that record shown in Figure 8, the bubble would indicate that the well was following a true vertical position. However, for each one of the lines which the bubble traversed outwardly an indication would be had of a certain degree of slope. In this respect I have found it convenient to employ a glass etched so that each one of the lines indicated an increase in the slope from the vertical of 2%. In wells deviating badly from the vertical I have found it expedient at times to employ two apparatuses or more in tandem, one of the apparatuses being capable of indicating minor variations in slope, say between zero and 10% and the other capable of indicating between zero and 30% so that a complete record might be had of the course of the well.

The device of my invention may also be employed under conditions where interferences are present which affect the compass so that it does not give a true indication. Such a condition is when the apparatus is employed within the casing of the well. Under such a condition, it being desired to survey the cased portion of the well, the device of my invention may be employed by determining the direction of inclination by other means than with the magnetic compass needle. Thus, by positioning the apparatus in a predetermined manner with respect to the well and then lowering it into the well, the amount of

rotation of the means employed for lowering the apparatus being noted as the lowering takes place, the cased portion of the well may be surveyed.

In practice I have positioned the casing 26 so that the figure 12 on the clock dial was toward the north. This is facilitated by providing a cut 151 on the casing 26 opposite the numeral and another cut in the same relative position on the outer casing 142. The apparatus is assembled, the cut on the outer casing being toward the true north. As the apparatus is lowered, the degree of rotation taking place is made note of so that at any given depth the position of the numeral 12 which has been empirically taken as indication of the true north may be correctly ascertained subsequently.

After the end of the casing is past, an observation of the twist of the drill stem need not be made since the compass will then ordinarily function correctly.

I claim:

1. An apparatus for ascertaining the inclination of an oil well comprising means for indicating the degree of inclination, means for indicating the direction of inclination, concentrically positioned means for indicating the time, and automatic means for photographically recording the indications of each of said means at spaced intervals within the well, the recording being accomplished by a simultaneous exposure of each of said means to the photographic recording means.

2. In an earth well exploration apparatus comprising a structure adapted to be lowered into an earth well which structure carries photographic recording means together with direction indicating means capable of being photographed by the aid of a source of light to form a permanent record, the combination of inclination indicating means comprising a pair of light transparent lenses formed to afford an inner concave chamber, said chamber containing a liquid and a level indicating bubble.

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