Sept. 13, 1932. I. ROMAN 1,877,593

METHOD AND APPARATUS FOR SURVEYING BORE HOLES

Filed July 3, 1930

Fig. 1.

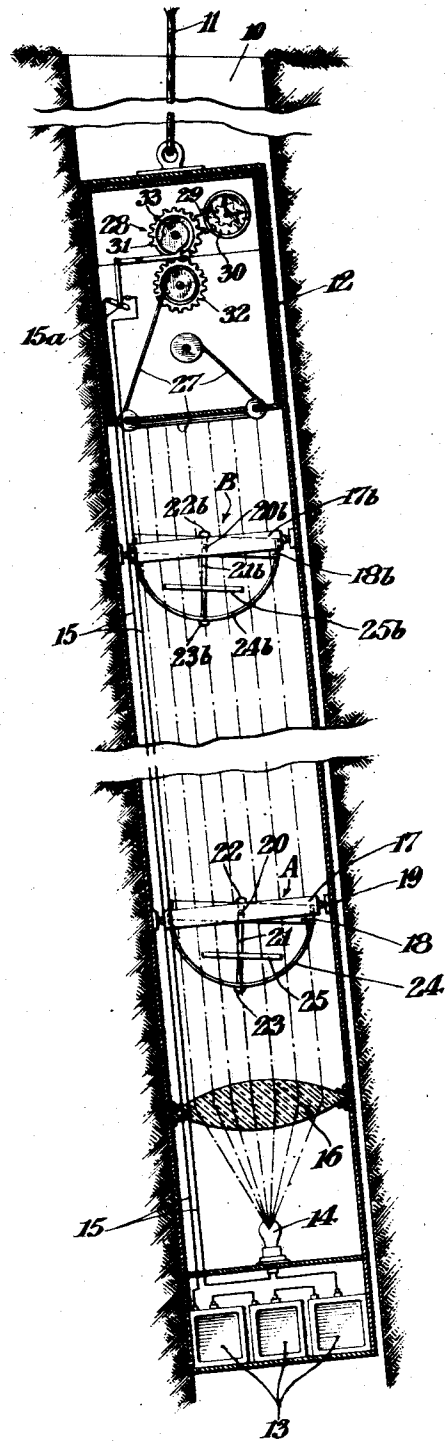
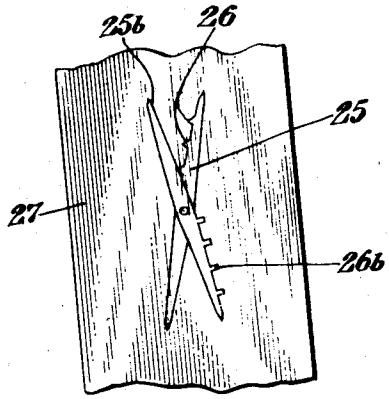


Fig. 2.



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METHOD AND APPARATUS FOR SURVEYING BORE HOLES

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This invention relates to a method and apparatus for surveying bore holes and particularly to a method and apparatus for surveying bore holes for oil and gas wells.

An object of the invention is to provide a simple, accurate, inexpensive and efficient method and device for measuring the straightness and the degree of deviation from the vertical of a hole bored into the ground; and, while the invention is intended particularly for use in oil and gas wells, it may be used in any kind of wells, such as artesian wells. In drilling wells to great depths for the purpose of producing gas, oil, etc., the intention is to drill the holes straight down so that they descend vertically into the earth,—but in practice straight boring has been found extremely difficult, and holes are often very crooked and will deviate hundreds of feet after drilling to depths of three or four thousand feet. As a consequence, the hole may have deviated so that its bottom is located beneath adjacent property, or when effort is made to locate wells within 200 or 300 feet of each other to completely cover an oil-bearing territory, the exploration is uncertain and may have left part of the territory completely untouched, as well as causing great unnecessary expense. The herein described invention eliminates this uncertainty as to the exact location of the bottom of the hole and all unnecessary expense in drilling.

An apparatus by means of which my method may be used comprises a casing which may be lowered into the hole by means of a cable and containing therein a mechanism whereby is photographed or otherwise recorded the position of two compass needles located near opposite ends of the casing and so mounted as to come to rest in a vertical position. From the relative positions of these two compass needles on the photograph, the angle between the true vertical and the direction of the bore hole may be easily deduced, and the direction of the bore hole calculated. The method of my invention consists in recording the respective positions of these needles at the top of the hole, where the true north is known, and then lowering the casing the length of the distance between the two needles, and again recording the respective positions of the needles, and repeating this operation the entire depth of the hole. By this means, any deflection of a needle due to interference with the normal magnetic field, by the presence of ore bodies or by other causes, may be checked against the present position of the other needle, or against the position of the same needle at an earlier or later reading and on making proper allowance for such deflection, the actual direction of the bore hole may be determined.

In the accompanying drawing, Fig. 1 is a vertical section through an apparatus embodying the invention, the apparatus being shown in a well hole, and Fig. 2 is a fragmentary portion of a photographic film containing images of the magnetic needle.

In Fig. 1, 10 indicates the hole or bore in the earth into which, by means of the cable 11, the tube or shell 12 is lowered. The tube 12 is preferably made 50 or 100 feet long and small enough to fit the hole at all times and so that its direction as it lies suspended in the hole will be the same as that of the hole itself at the point at which the tube is suspended. In the lower end of the tube are carried the batteries 13, which effect the illumination of the incandescent lamp 14, being connected thereto by the electrical leads 15. The electrical leads 15 are likewise connected to a switch 15*a*, actuated by a driving clock 30, to be later referred to, which closes the electrical circuit at regular intervals of time, thereby illuminating the lamp 14. Positioned in the tube above the lamp 14, is the condensing lens 16, through which pass the rays of light from the lamp 14 in parallel beams.

Located beyond the lens and near the lower end of the tube, a magnetic compass, A, is suspended, being mounted in the gimbals 17 and 18, the outer of which 17, is perpendicularly pivoted to the axis in the walls of the tube 12 at the points 19, and the inner of which, 18, is pivoted at right angles thereto in the sides of the outer gimbal at the points 20. The inner gimbal in turn supports the spindle 21, which is vertically pivoted in the jeweled bearings 22 and 23, the lower bearing 23 being connected to the inner gim-

bal 18 by means of the narrow arms 24. On the spindle 21 is fixedly mounted a compass needle 25 having saw teeth 26 which serve to identify the needle from its companion needle 25*b* on the photograph.

At the upper end of the tube 12, a second magnetic compass, B, is suspended, likewise mounted in gimbals and similar in all respects to the first compass above described, except that its needle has notched teeth 26*b* to distinguish it from the first needle. The two needles are constantly pointed to the magnetic north, except as one or both is deflected by other magnetic forces, but as a check on this deflection is provided by this invention, the true north can be easily ascertained at any time. And as the spindles 21 and 21*b*, supported in gimbals, constantly seek a vertical position, due to gravity, it is thereby possible to calculate the angle between the true vertical and the actual direction of the tube 12 and the bore hole, from the respective recorded positions and the lengths of the two compass needles on the photographic film.

Above the indicating mechanism, near the top of the tube 12, a camera film 27 or means for making a photographic record is arranged, driven by the clock mechanism 28, and appropriate gears 29, 30, 31, 32 and 33. The same clock mechanism 28, attached to the electrical leads 15, also actuates the switch 15*a* and closes the electrical circuit which provides the brief illumination at regular intervals of time of the lamp 14.

The lamp 14, the point of intersection of the two axes of rotation of the gimbals 17 and 18, and 17*b* and 18*b* and the center point of the camera film 27 are preferably positioned in the direct line of the axis of the tube 12, so that the axis of the camera coincides with the direction of the bore hole at any point of observation.

The above described mechanism is made use of, as follows: The driving clock 28 is set in motion, and is so adjusted that the electrical circuit is closed for a brief interval of time at regular intervals as desired, as every two minutes, for instance. The closing of the circuit illuminates the lamp 14 momentarily, and the beam of light passing in parallel rays through the condensing lens 15, causes the compass needles 25 and 25*b* to cast a shadow of their position upon the camera film 27, and a photographic record is made thereon. Fig. 2 is a reproduction of a section of the photographic film showing a record of the relative position of these needles. The film 27 is driven by the driving clock 28 at intermittent rate, such that a new portion of the film will be exposed to each illumination of the lamp 14.

Since the light rays from the lamp 14 pass in parallel beams in the same direction as the axis of the tube 12, and likewise of the bore hole 10, and since the spindles 21 and 21*b* maintain a constant vertical position due to the force of gravity and consequently the needles 25 and 25*b* attached thereto maintain a constant horizontal position, it will be seen that the relative positions both in angularity, space and length of the needles 25 and 25*b* appearing upon the photograph becomes a means of measuring the degree of deviation of the tube 12 and the bore 10 from the true vertical and the direction in which the deviation takes place at the particular point measured. If the axis of direction of the tube and the bore hole are vertical, the shadows of the two needles, of course, will coincide, and will photograph as a single needle, except for the variations in the teeth and variations from the normal magnetic field of the earth. But when there is a deviation from the vertical of the tube and bore hole, and since the direction of the needles 25 and 25*b* are either kept constant, in the true north, or the degree of deflection from the true north due to interference, may be easily ascertained by means of this invention, measurements between the lines forming the needles, and the length of these lines become measurements by simple algebraic relation of the angular deviations of the bore hole from the vertical.

The method of my invention is as follows: A photographic or other record is made of the respective positions of the compass needles 25 and 25*b* at the top of the ground, where the true north is known, and then the casing 12 is lowered into the bore hole 10 the length of the known distance between the two compasses, A and B, in the casing, the top compass B now being at the position the lower compass A was in a moment before at the previous recording, and the respective position of the two needles is again recorded. This operation is repeated down the entire depth of the hole at these same distances, two recordings being taken at each level, one when the lower compass A is at that point, and the second when the upper compass B reaches the same level. If the magnetic field remains uninterfered with the entire distance down the bore hole, the two needles, 25 and 25*b*, will constantly point to the north, and any departures from an identical shadow cast by the two needles will clearly indicate a deviation of the bore hole from the vertical. But if the magnetic field is interfered with by the presence of magnetic ore bodies or other forces, and results in a deflection of the needles from the true north, departures from identical shadows cast by the two needles would not represent deviations of the bore hole from the vertical, and consequently allowance must be made for such deflections of the needles from the true north. Any such deflections of the needles from the true north are detected by means of my invention, which

consists in checking the positions of each needle, first, against the position of the other needle at the same moment, and second, against the position of the same needle at an earlier or later recording. When the differences between the respective shadows cast by the needles are due only to the deviation of the bore hole from the vertical, the shadows although separate, would still be parallel since they both face to the true north. But when the differences between the respective shadows are due to the presence of ore bodies or other interferences with the magnetic field, there will be a level somewhere along the bore hole where the ore body would affect one needle but not the other, and the needles then will lose their parallelism and will point in different directions. By noting when the needles first begin to point in different directions, proper allowance can be made for the deflection of the needles from the true north, and the actual deviation of the bore hole from the vertical precisely calculated. In this way miscalculation due to the deflection of both needles from the true north, when both are under the influence of the same interfering force, can be avoided, even through both needles be in parallel alinement.

Since the apparatus is lowered into the bore holes by means of the cable 11, it is possible to determine at any time its distance into the bore hole, and by taking a series of observations at specific distances starting from the top of the hole and going to the bottom, it is thus possible to obtain a complete log of the direction of the entire hole, and to determine the deviation of any point in the hole with reference to the top. The driving clock 30 is set in synchronism with another clock or watch in the hands of the operator located at the top of the bore hole. By observation of his clock or watch he will know the precise time at which these intervals of photographing occur and can arrange to have the apparatus located at the proper point in the bore hole at that time by simply lowering the apparatus to the point in question sufficiently in advance and allowing it to remain stationary during the period of photographing.

It is apparent, of course, that various modifications may be made in the method of my invention, and in the structure of the device utilizing my method, without in any way departing from the spirit of the invention as defined in the appended claims. The method and apparatus may also be used in other ways than those specifically described.

I claim:

1. A method of surveying bore holes by use of two magnetic compasses definitely spaced one above the other, which comprises recording the relative positions of the needles at one level, lowering the two compasses a distance equivalent to the distance between the two compasses, and again recording the relative position of the needles.

2. A method of surveying bore holes by use of two magnetic compasses definitely spaced one above the other and supported for constant vertical position of axis, which method comprises recording the relative positions of the needles at one level, lowering the two compasses a distance equivalent to the distance between the two compasses, and again recording the relative position of the needles.

3. A method of surveying bore holes by use of two magnetic compasses definitely spaced one above the other and supported for constant vertical position of axis which method comprises photographically recording the relative positions of the needles at one level, lowering the two compasses a distance equivalent to the distance between the two compasses, and again photographically recording the relative position of the needles.

In testimony whereof, I have signed by name to this specification.

IRWIN ROMAN.