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EARTH BORE SURVEY INSTRUMENT

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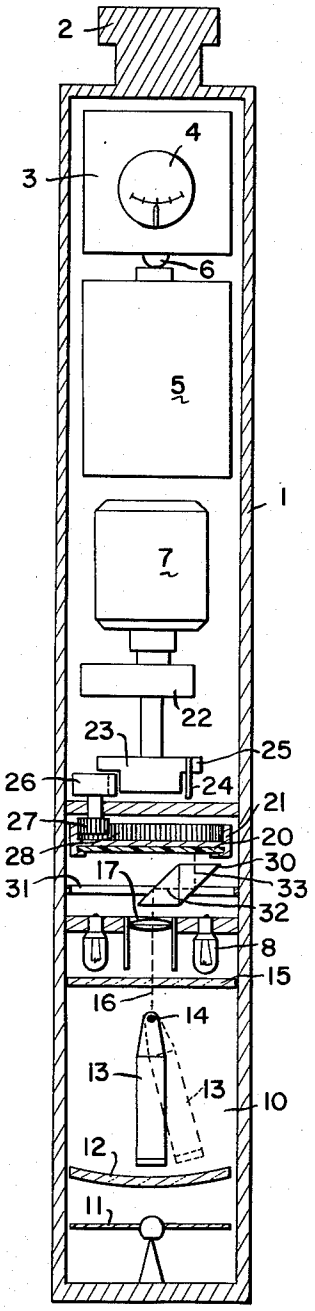


FIG. 1.

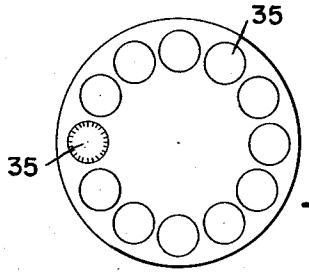


FIG. 2.

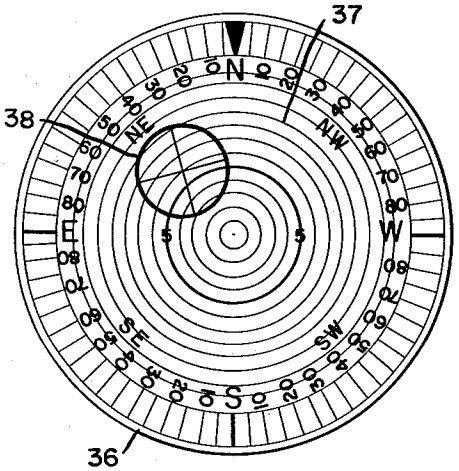


FIG. 3.

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EARTH BORE SURVEY INSTRUMENT

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This invention relates to earth bore survey instruments and more particularly to an instrument primarily designed for ascertaining the degree of inclination of the axis of the bore from the vertical, or what is commonly called drift, and the relationship of the direction of the "drift" to north.

Under certain bore hole conditions, the drill pipe becomes stuck in the bore hole during the drilling process if for any reason circulation and/or drill pipe movement are stopped even for relatively short intervals. With conventional instruments for ascertaining drift and drift direction, commonly called "single shots," the actuating timer or clock in the instrument and a hand watch commonly called the "surface watch" are equipped with similar dials indicating elapsed time from a maximum of, for example, 60 minutes to zero minutes and the mechanisms in the instrument watches are arranged to allow for some interval as a safety factor after the zero minutes indication is reached before causing electrical or mechanical actuation of the photographic apparatus within the instrument. These watches are synchronized to the degree necessary to conform with the safety factor. When it is desired to operate the instrument in the well, or as it is called "to take a picture," the two watches are set to run the amount of time (plus allowance for miscalculations, etc.) it is estimated will be required to allow the instrument in its outer protective barrel to reach the bottom of the bore hole. The instrument, in its outer barrel, is dropped or run into the bore hole on a wire line and, depending on the method used, circulation and/or some movement of the drill pipe are maintained even after the instrument is thought to be on bottom until a minute or so before the surface watch indicates zero (0) minutes at which time circulation and/or movement of the drill pipe are stopped. Theoretically the dial of the instrument watch and the dial of the surface watch will have reached zero at exactly the same time and there will occur a safety interval during which circulation and/or pipe movement are stopped and before the instrument is actuated to take the "picture."

The stoppage of circulation and drill pipe movement is continued until it is estimated that the picture cycle is completed, at which time circulation and/or pipe movement is resumed. Ordinarily from 2 to 5 minutes of complete stoppage is allowed although this time period has, in some instances, been reduced to one minute. With bore holes becoming smaller and deeper and with holes being bored under more adverse conditions, manufacturers and operators have attempted to reduce the interval of stoppage by better synchronization of the watches and by reducing the safety interval allowed. However, it can be seen that with the conventional instrument and surface watch regardless of how well the watches are synchronized some safety interval must be allowed and that as the overall interval is reduced the entire operation becomes more critical and more maintenance is required.

Numerous structures have been designed, such as so-called "jar switches," which actuate automatically when the lower end of the instrument's outer barrel strikes bottom and those which are actuated by varying the mud pressure, etc. None of these designs have been of sufficient success to warrant extensive use, principally because actuation thereof, except in clean shallow holes,

does not necessarily occur when the instrument has reached bottom and it is not always possible to tell the exact moment the assembly reaches bottom and when circulation and/or movement of the pipe should be stopped. In some cases, so-called "multiple shot" instruments which run continuously for several hours and take a succession of pictures at regularly spaced intervals have been used by running them into the bore hole in any conventional manner, waiting a sufficient length of time to be sure they are on bottom, and then stopping circulation and movement for a sufficient interval for one good picture. This procedure will work but is not entirely satisfactory because a trained man must load the strip film into the machine, operate the machine, unload and develop the film, etc., and the wet film is difficult to handle and the crew need the information immediately in order to determine what to do next.

A primary object of this invention is to provide an improved and slightly modified single shot directional survey instrument whereby automatically a plurality of pictures, instead of just one, may be taken in continuous chronological sequence on the usual single sensitized disc. By having such an instrument, stoppage of circulation and/or movement merely for the time required for one of the multiplicity of picture cycles, at any time during the entire period during which the multiplicity of pictures are being exposed, will result in one good picture. Thus the interval of complete stoppage is the minimum required to expose a single picture and exact synchronization of the surface and instrument watches is not required nor need there be provision for a safety interval.

Another object of the invention is to provide an improved earth bore survey instrument which will take a multiplicity of pictures but which, so far as the operator is concerned, functions with the same accessories and in the same manner as the conventional single shot instrument.

A further object of the invention is to produce an instrument of the type defined wherein the multiplicity of pictures taken on the single film disc are positioned thereon in reduced size adjacent the periphery of the film or at any spaced portions of the film.

Yet another object of the invention is to provide an instrument of the type defined wherein each image forming the basis of each picture is reduced in size and then is deflected to different portions of the film disc by conventional means such as mirrors or prisms interposed in the path of travel of the image to the film.

The construction designed to carry out the invention will be hereinafter described, together with other features and objects thereof, and will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof wherein an example is shown and wherein:

FIGURE 1 is an elevational view, partly in section and partly in schematic form, illustrating this invention;

FIGURE 2 is a top view of a single shot disc depicting recordings thereon; and

FIGURE 3 is a top view of one of the recordings of the disc of FIGURE 2.

First of all, it should be mentioned again that the principle and structure necessary to carry out this invention may be adapted and incorporated in most all tyes of presently commercialized single shot directional survey instruments. As is well known, by means of such an 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 is directed North 45 degrees East and deviates from the vertical by 5 degrees, or it may show any other reading in accordance with the inclination and direction of the bore hole. One suitable type of com-

mercial single shot instrument to which this invention may be adapted is the "Eastman Type A" manufactured by Eastman Oil Well Survey Company of Denver, Colorado, the assignee of the present invention. In any event, it is to be understood that this invention is applicable to all types of single shot instruments and the disclosure illustrated herein is only illustratory.

Further, to more properly and clearly disclose this invention, the drawings only include those parts, many in schematic form, that are necessary for an understanding of the invention. However, it is to be understood that in actuality the instrument would include the usual construction, such as the timing device, a battery section, a camera section and the angle unit section containing the compass and angle unit. Furthermore, there would be provided the usual slug trap arrangement permitting access to the film disc and the angle unit would be positioned within a thermally expandable fluid to take care of temperature deviations. It is believed that if one skilled in this field bears in mind the usual construction and apparatus included in a single shot instrument, some of which is disclosed schematically herein, and considers the detailed parts emphasized herein and shown, it will be entirely apparent as to how the presently commercialized single shots may be modified to incorporate this invention.

Referring in particular to the drawing, **1** represents the casing or outer barrel for the instrument, having at the top thereof a means **2** used for suspending the instrument within the well bore. Represented at **3** is a standard watch timer having a dial **4** which is wound and synchronized with the usual surface watch whereby, after a predetermined time, the watch will cause through means including the dry battery **5**, with which it is in contact at **6**, to actuate and start operation of a motor **7** and light sources **8**. The angle unit of the instrument is shown at **10** in the embodiment illustrated and includes a standard compass **11** suitably mounted and containing the usual indicia thereon, a glass ring **12** having preferably engraved or otherwise marked therein a plurality of spaced rings, and the pendulum unit **13** pivotally suspended at **14** whereby it may readily assume the inclination from the vertical corresponding with that of the bore. Numeral **15** merely depicts the glass plate completing the angle unit housing and, as is well known, the direction and degree of inclination of the axis of the bore from the vertical is determined by taking a picture of the locations with respect to one another in the bore of pendulum **13**, glass ring **12** and compass **11**. The image of the picture to be taken is normally directed to the film disc, as shown by the dotted line **16**. Thus, the apparatus described is identical with many commercial single shot instruments and the particular construction shown is a modification of the Eastman "A" type single shot, but a similar modification could be made of other currently manufactured single shots of the photographic type.

A photographic sensitized film disc is shown at **20** and this disc is supported in a holder **21**, the holder **21** being modified from the standard type in the sense that it is made to be rotatably mounted within the casing **1** and, of course, any movement of holder **21** results in corresponding movement of disc **20**. To accomplish the rotation of holder **21**, the motor **7** through reduction gearing **22** drives a suitable Geneva mechanism **23**. The mechanism **23** may be of any numerous types and, as shown, includes a pin **24** extending from wheel **25** whereby during each rotation of the wheel **25** the pin **24** will move element **26** in Geneva fashion to drive gear **27** a predetermined amount. Gear **27** is the pinion for gear **28** with which it meshes and which is an integral of holder **21** and as a matter of fact forms part of the outside surface thereof. Thus, it can be seen that once the motor **7** is operated, the disc **20** is indexed, stopped, indexed, etc., or in other words, the disc **20** is moved predetermined amounts at predetermined time intervals. As shown, the disc holder **21** or slug trap has been modified from the conventional to the extent that it is free to rotate under the control of the Geneva mechanism, but it is to be understood, although not shown, that it is still free to operate for receiving, holding and releasing the sensitized disc in a conventional manner. Further, it is to be understood that the means for causing indexed movements of disc **20** could be accomplished by other structure, such as by the use of step switches.

The image **16** is directed through a ray concentration lens **17** (for the purpose of reducing the size thereof) and interposed in the path of travel of image **16** to the disc is a light deflecting or bending means **30** which is suitably supported within the casing **1** by any means **31**. It should be mentioned that standard single shot instruments generally incorporate a lens similar to **17**, but not of the same focal length as there is no necessity of reducing the size of the image. As shown, the deflecting means **30** includes two prisms whereby each small or reduced image **16** is directed twice at right angles through paths **32** and **33**. The deflecting element directs the image to the disc **20** adjacent the peripheral edge thereof, as distinguished from the axial center. It is to be understood that the means for projecting or deflecting the image may be accomplished by various different combinations of lenses and different type of prisms or by the use of mirrors. Furthermore, there are available prisms which function partially as linses and thus elements **17** and **30** could be combined in a single prism. As should be apparent, the disc **20** is rotated to receive different images, but instead the disc **20** could remain fixed in the sense that it is in presently made single shot instruments and the deflecting means could be arranged to rotate.

So far as the operator is concerned, the present instrument is operated in exactly the same manner as in taking a picture with a conventional single shot and by synchronizing the surface watch with the watch **3**, the operator attempts to stop circulation and/or movement of the drill pipe at the middle of the over-all period during which the instrument is exposing pictures.

In the particular construction shown, the multiplicity of pictures, by referring particularly to FIGURE 2, are arranged in a circle, each picture **35** constituting a reduced image of the angle unit apparatus. Arranging the pictures around the disc **20** in a substantial circle and near the peripheral edge thereof, as illustrated in FIGURE 2, is only illustratory as they could take the form of a spiral, a zig zag or other arrangement, depending upon the deflecting system. FIGURE 2 also shows some twelve pictures, but it might be found desirable, for cost and simplicity, to use fewer pictures or in other cases to cover a longer interval by using more pictures. Assuming that the construction is designed for taking twelve pictures, it probably would be desirable to use an exposure interval of about 10 seconds and an indexing interval of the disc **20** of 3 seconds, which would then provide an over-all interval for taking pictures of 2 minutes and 36 seconds. It will be noted that as each indexing interval is brief, preferably between 2 and 3 seconds as compared to the exposure cycle of 10 seconds, no visible picture or smear will result during indexing. Thus, it has been found satisfactory to maintain lights **8** energized throughout the picture taking instead of causing the lights to be operated in synchronism with the indexed movements of disc **20**, although an arrangement for causing on and off action for the lights **8** could be incorporated if desired.

In the operation, when contact is made in the timer **3**, the battery **5** causes the motor **7** to begin operation and the light source **8** to be operated. At this time, supposedly, the instrument is within the bore somewhere adjacent to where the reading is desired and the lights **8** remain lighted throughout the taking of all pictures. It can be seen that the disc **20** is rotated at predetermined intervals of time, whereupon the different portions of the disc are exposed in chronological sequence to different images to provide the recordings **35**, these images of the

angle unit equipment being different, depending upon movements in the bore of the instrument after the timer has gone off. All pictures 35 exposed while mud is being circulated and/or the drill pipe is in motion, before and after the total stoppage interval for the exposure of the true and desired recording, will be blurred and faulty, as is true with conventional instruments under similar conditions. Only the pictures 35 exposed during the period of total stoppage will be clear and distinct. When the over-all exposure period is completed, the instrument, of course, is brought to the surface and the disc 20 is unloaded and developed in the conventional manner and the good picture or pictures are either projected or enlarged in a magnifying reader.

In FIGURE 3 one of the pictures 35, namely that identified as 36, has been shown as developed and markings 37 are those caused by the glass ring 12, marking 38, including the cross hair lines therewithin, is that caused by the position of pendulum 13 and the remaining markings constitute indicia from the compass. From analyzing this reading, it can be seen that the bore within which the instrument is run is deviating 6 degrees from the vertical and is directed substantially Northeast.

As explained in connection with the embodiment illustrated, during the period contact is made the light source 8 is on and the motor 7 through the gear train and Geneva device is alternately stopping and indexing the sensitized disc exactly 12 times until it is returned to its original starting position. Preferably, the operator stops circulation and/or drill pipe movement for the time necessary to take one good picture at approximately the midpoint of his contact period or about the time the 6th or 7th exposure is being taken. He may then re-establish circulation and/or drill pipe movement and if the instrument was run on a wire line the operator may start to pull it out and if the instrument was dropped to a landing plate he may start to "come out of the hole."

Thus far the principles of this invention have been explained with reference to recording information as to drift and the direction thereof relative to north. Also to obtain such information reference has been made to the use of a compass 11 and pendulum 13. It is to be understood that not only may the angle unit parts be varied, but also the principles of this invention may be utilized for recording other information.

The foregoing disclosure and description of the invention is illustrative and 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 is claimed is:

1. An earth bore survey instrument for ascertaining the degree of inclination of the axis of the bore from the vertical and the direction of the axis of the bore relative to north comprising a casing adapted to enter the bore, a single sensitized film disc, means for supporting the disc for rotative movement within the casing, a compass centered within the casing having indicia markings thereon, a pendulum-like element pivotally suspended and centered within the casing, a light source for illuminating the compass and element and exposing the record disc to the complete picture images thereof, means interposed in the path of travel of each image to reduce the size of each image and means disposed between said reducing means and said disc to direct each image from the center of the casing to the peripheral edge of said disc to provide for exposing a plurality of said images in chronological sequence on different portions of the disc, means for operating said light source, and means for causing indexed rotative movements of said disc during predetermined intervals of time of light operations to expose a different portion of said disc to each directed image.

2. An instrument as defined in claim 1 wherein the means for directing each reduced image from the center of the casing comprises light deflecting means interposed in the path of travel of each image to the disc member.

3. An instrument as defined in claim 2 wherein the means for reducing each image comprises a concentration lens interposed in the path of travel of each image to the deflecting means.

4. An instrument as defined in claim 2 wherein the means for causing indexed movements and the means for operating the light source are operated in synchronism.

5. An instrument as defined in claim 3 wherein the light deflecting means comprises a pair of prisms each designed to deflect the images once reduced substantially 90 degrees from the center of the casing to the periphery of said film disc.

6. An instrument as defined in claim 4 wherein the means for causing indexed movements includes means for intermittently stopping the disc for exposure under controlled periods of time.

7. An earth bore survey instrument comprising a casing adapted to enter the bore, a single sensitized film element supported within the casing, bore information means carried in the center of said casing and adapted to be recorded on said element, a light source within the casing for illuminating the bore information means and exposing the element to complete picture images thereof, means for operating said light source, means mounted within the casing for reducing the size of each image and means disposed between said reducing means and said element for deflecting each reduced image away from the axial center and towards the peripheral edge of said element, and means for causing relative rotative movement of said sensitized film, element and said deflecting means during predetermined intervals of time of light operation to advance a different portion of said sensitized film element for exposure to each directed image.

8. An earth bore survey instrument according to claim 7 wherein the means for directing each reduced image from the center of the casing comprises light deflecting means.

9. An earth bore survey instrument according to claim 8 wherein the means for reducing each image comprises a concentration lens.

10. An earth bore survey instrument according to claim 7 wherein the means for causing relative rotative movement of said sensitized film element and said deflecting means is characterized by means for causing alternate stopping and rotative movement of said film element under controlled periods of time whereby a separate portion of the film element is exposed to each image.

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