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APPARATUS FOR LOCATING A ZONE OF LOST CIRCULATION

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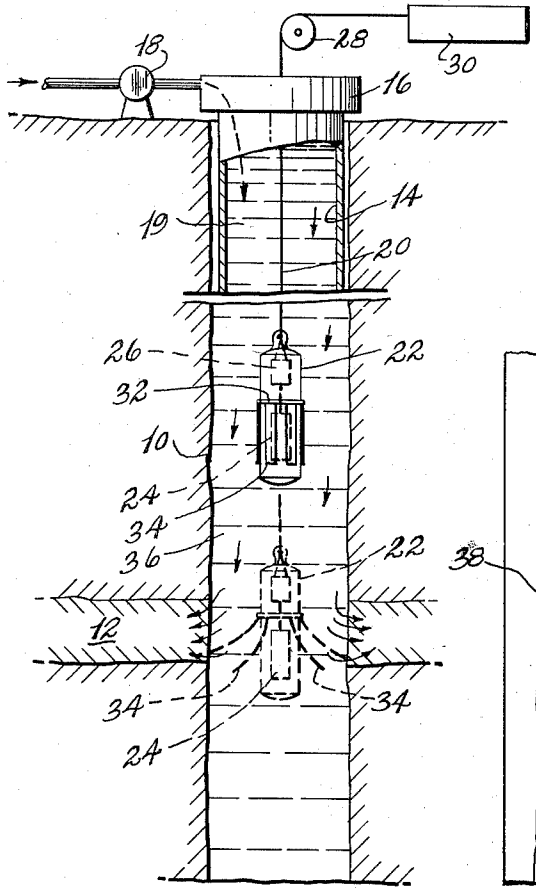


Fig. 1.

Fig. 2.

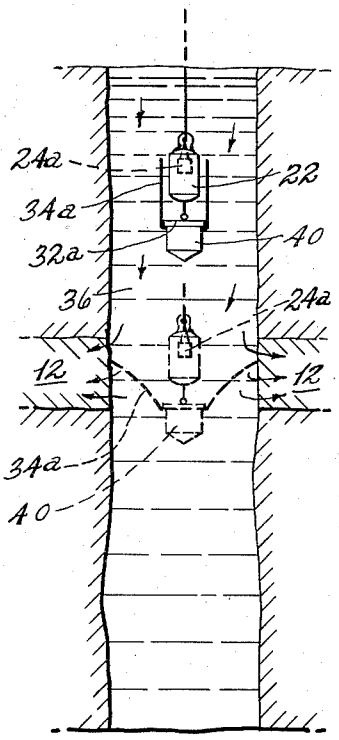


Fig. 3.

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2,835,819

APPARATUS FOR LOCATING A ZONE OF LOST CIRCULATION

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This invention relates to the subsurface exploration of earth formations and more particularly to a method and an apparatus for locating a permeable zone traversed by a well or bore hole into which zone the drilling fluids used in the drilling of the well pass, and are lost. The principal object of the invention is the provision of such a method and an apparatus which is simple in use and construction and by means of which a zone of lost circulation can be accurately located.

In rotary drilling operations, a fluid, usually drilling mud, is circulated down through the drill pipe and the bit and back to the surface on the outside of the drill pipe. The purpose of this mud is, as is well known, to carry the bit cuttings out of the hole, lubricate and cool the bit, and help support the formations drilled while preventing formation fluids from entering the bore hole by overbalancing the formation fluid pressure. There are cases when, in the drilling of a well bore hole, a formation has been traversed by the hole which is so porous that the drilling fluid or at least a large part of it will pass into the formation from the hole and thereby be lost. Such a zone or formation is frequently called a "zone of lost circulation" and in practically all cases it is necessary to find the zone so that remedial steps can be taken. In many cases the formation may hold the drilling mud for some time, or in other words, the mud will not pass into the formation. Later, however, the formation may break down or fracture when the drilling mud weight is increased. Once the formation has been accurately located, steps may be taken to cure the situation, such as by adding fibrous or flaky material in the form of shredded wood fiber, etc., to the mud in an effort to plug off the formation taking the mud. This method has proven moderately successful in some cases but has failed in many others. At the present time it is believed that the best method of correcting the situation is to squeeze off the zone taking the mud with cement or a high gel mud. It is the principal purpose of this invention to provide a method and means for locating the depth of the porous formation so that the exposed surface of the formation can be plugged or sealed off in some suitable manner.

In accordance with one embodiment of the present invention, the hole is preferably maintained substantially full of drilling mud as by pumping additional mud into the top of the well to make up for that which is lost by passing into the porous formation. A device is then lowered through the liquid in the bore hole, this device comprising essentially a detector of penetrative radiation and a source of such radiation, which source is normally held in close proximity to the detector but arranged so that it will move away from the detector when the zone of lost circulation has been reached. The source of radiation is in the form of one or more flexible strips or streamers which are attached at one end near the detector in a manner such that while the detector is passing down through the upper portion of the hole above the zone of lost circulation, the streamers will

remain close to the detector. The output of the detector is recorded at the surface in correlation with the depth of the instrument in the bore hole and when the device reaches the proximity of the porous zone of lost circulation, the streamers will tend to follow the movement of the fluid in the hole in passing radially outwardly into the formation and in so doing, the radiation source will, of course, move away from the detector and thus provide a fairly sudden decrease in the recorded output thereof. This sudden decrease in the recorded response apprises the operator that the instrument has reached the depth of the porous zone.

For a better understanding of the invention, reference may be had to the accompanying drawing in which

Fig. 1 is a vertical sectional elevation through a portion of a bore hole traversing a porous zone, i. e., a zone of lost circulation;

Fig. 2 is a section of a log or record which would be made with the apparatus shown in Fig. 1; and

Fig. 3 is a view somewhat similar to Fig. 1 but in which a modified form of detecting apparatus is illustrated.

Referring to the drawing, particularly to Fig. 1, a bore hole **10** is shown as having traversed a porous formation **12** into which drilling fluid from the bore hole has passed and has been lost. The upper portion of the bore hole is shown as provided with the casing **14** closed at the top by means of a suitable casing head **16**. A pump **18** is connected to the casing head so that drilling mud or any other suitable fluid **19** can be pumped into the bore hole to make up for that which is being lost in the zone **12**. Shown as suspended within the bore hole on a conductor cable **20** is a sealed instrument housing **22** containing a detector **24** of penetrative radiation, the output of which passes to a suitable preamplifier **26** which is connected in turn to the lower end of the cable **20**. The cable **20** passes over a suitable cable measuring device **28** which serves to indicate or record continually the depth of the instrument as it passes through the bore hole. The cable passes to a suitable amplifying and recording device **30** by means of which a record or log, preferably on a moving tape, is made of the output of the detector **24** as it passes through the hole.

Shown as surrounding the instrument housing **22** is a band **32** to which is attached a plurality of flexible strips or streamers **34**. These streamers are attached to the band at the upper end and will therefore hang normally downwardly along the side of and close to the housing **22**. As will be observed, in this position the streamers **34** are also in fairly close proximity to the detector **24**. The streamers **34** are made radioactive as by impregnating them or coating them with a radioactive substance to the radiation from which the detector will respond.

In operation, the instrument **24** is lowered through the bore hole as shown in solid lines in Fig. 1. In this embodiment it is assumed that the instrument is being lowered quite slowly through the bore hole or that the formation **12** is so porous or so permeable that the fluid **19** being pumped in by means of the pump **18** passes downwardly through the hole more rapidly than the detecting instrument. Thus, the radioactive streamers **34** will remain close to the detector housing and to the detector and, as indicated in the upper portion of Fig. 2, the record will indicate a fairly high detector output. When, however, the instrument reaches the proximity of the formation **12**, as is shown in dotted lines in Fig. 1, the fluid **36** being pumped into the casing head and downwardly through the hole will enter the formation **12** as is indicated by the plurality of arrows. The flexible

radioactive streamers 34 tend to follow this motion of the fluid 36 and therefore swing outwardly from the instrument 22 towards the walls of the porous formation 12. In the position shown in dotted lines, the streamers are considerably farther away from the detector 24 than they were before the instrument reached the depth of the zone 12 and therefore the output of the detector 24 will be reduced fairly suddenly due to the greater distance between source and detector and the absorbing effect of the liquid therebetween. This reduction in detector output is indicated on the record strip of Fig. 2 at the point 38 and when the operator notes this indication on the record, he will know that the instrument has reached the zone 12. Knowing the depth of the instrument in the hole at that time, as indicated or measured by the device 28, he will have accurate knowledge as to the position of the zone of lost circulation and steps can then be taken to cure the situation as by cementing the exposed walls of the formation.

In Fig. 3 a modification is shown in which the radiation detector 24*a* is disposed within a smaller housing 22*a* and the lower end of this housing is attached to a weight 40 which is sometimes necessary to pull the instrument downwardly through the surrounding mud fluid 36. A band 32*a* is attached to the upper portion of the weight 40 and a plurality of flexible strips or streamers 34*a* are attached at one end to this band in a manner similar to that described hereinbefore with reference to Fig. 1. As shown in solid lines in Fig. 3, the flexible radioactive strips 34*a* extend upwardly in fairly close proximity to the radiation detector 24*a*. In this position the detector output will be relatively high, as indicated in the upper portion of Fig. 2, due to the closeness of the radioactive strips 34*a*. However, when the device reaches the proximity of the porous formation 12, the strips 34*a* will tend to follow the movement of the fluid 36 as it passes into the walls of the formation, and they will, therefore, leave the proximity of the detector. When this occurs, the detector output will decrease suddenly as indicated at 38 in Fig. 2, and the operator will know that the instrument has reached the depth of the zone of lost circulation. This modified form is useful where the detecting instrument is to be lowered more rapidly than the surrounding mud fluid 19.

Obviously many other modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, but only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. An apparatus for locating a permeable formation traversed by a well bore hole containing fluid and into which formation said fluid is passing, comprising a weight member suspended from a cable and adapted to be passed through the fluid in the hole, means attached to said weight member and movable substantially laterally with respect thereto in accordance with changes in the direction of movement of the fluid in the hole and means including a source of radiation and a detector responsive thereto for indicating the occurrence of relative movement between said first means and said weight member.

2. An apparatus for locating a permeable formation traversed by a well bore hole containing fluid and into which formation fluid from the bore hole is passing, comprising a radiation detector adapted to be passed through the bore hole suspended from a conductor cable, means for indicating the depth of said detector in the bore hole, means for indicating the output of the detector, and at least one flexible, radioactive streamer normally disposed close to said detector in movable relation therewith, the arrangement being such that as the detector passes through the bore hole said streamer will remain close to the detector until the detector reaches the proximity of said formation when the flow of fluid into the formation will cause the streamer to move away from the detector, thus providing a sudden decrease in the output of the detector and thereby an indication of the depth of said formation.

3. An apparatus as described in claim 2 including a weight member attached to said detector.

4. An apparatus as described in claim 2 in which a plurality of said flexible radioactive streamers are disposed around said detector in the form of a fringe.

5. An apparatus for locating a permeable formation traversed by a well bore hole containing fluid and into which formation fluid from the bore hole is passing, comprising a sealed instrument housing adapted to be passed through the bore hole suspended from a conductor cable, a radiation detector disposed in said housing, means for indicating the depth of said housing in the bore hole, means at the surface connected through said cable to said detector for recording the output of the detector, and at least one flexible element attached to the exterior of said housing and adapted normally to extend substantially vertically close to the housing and in close proximity to the detector therein, said element containing a radioactive substance, the arrangement being such that as the instrument passes through the bore hole said radioactive element will remain close to the detector until the instrument reaches the proximity of said formation when the flow of fluid into the formation will cause the element to move away from the detector, thus providing a sudden decrease in the recorded output of the detector and thereby an indication of the location of said formation.

6. An apparatus as described in claim 5 in which a plurality of said flexible radioactive elements are disposed around said instrument housing in the form of a fringe.

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