Sept. 20, 1949. J. S. SWEARINGEN 2,482,224

CLINOMETER FOR WELL BORES

Filed Nov. 30, 1940 5 Sheets-Sheet 1

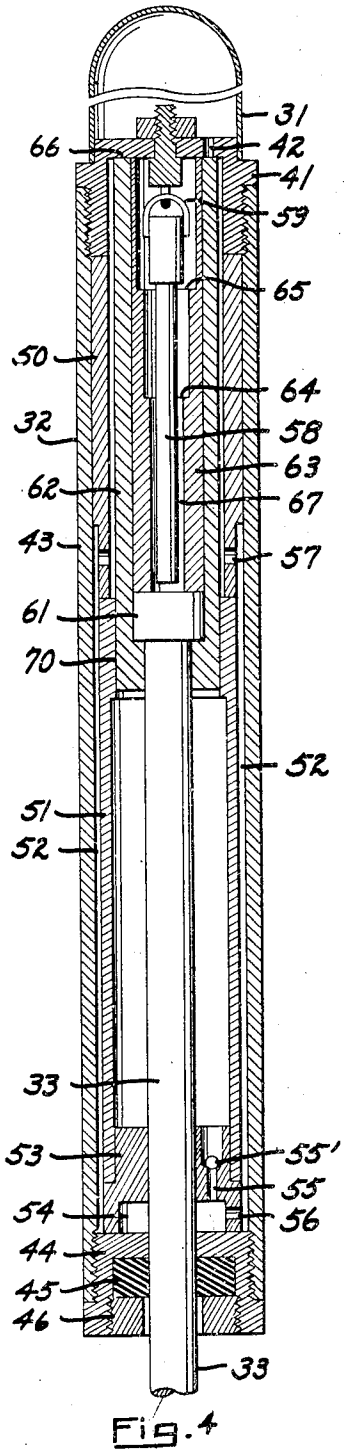


Fig. 4

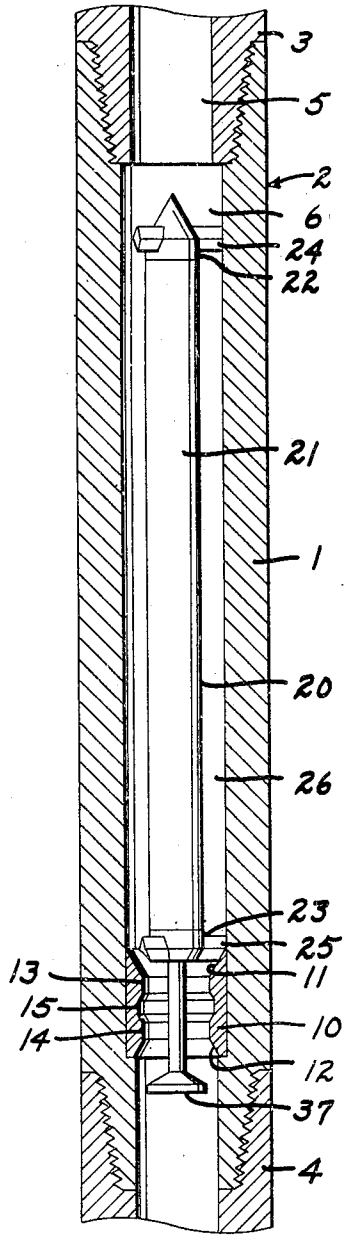


Fig. 1

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Sept. 20, 1949. J. S. SWEARINGEN 2,482,224

CLINOMETER FOR WELL BORES

Filed Nov. 30, 1940 5 Sheets-Sheet 2

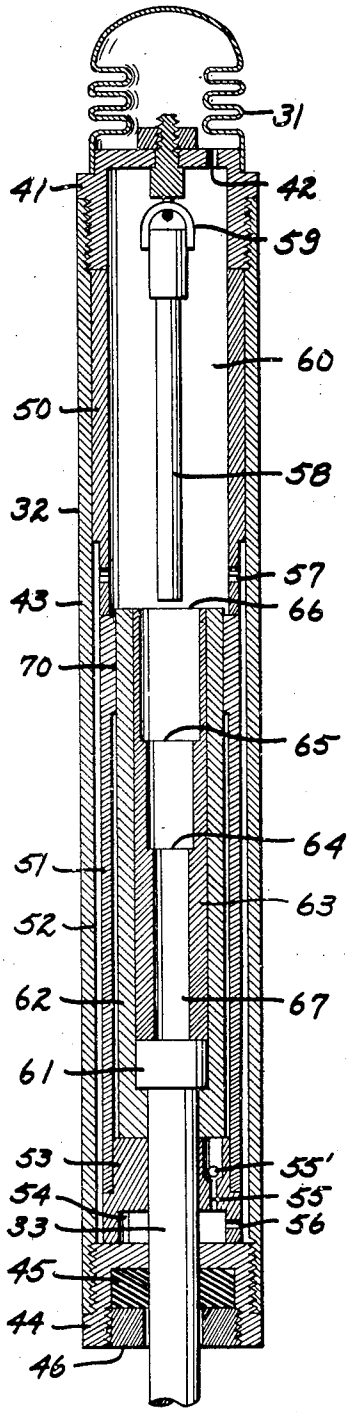


Fig. 3.

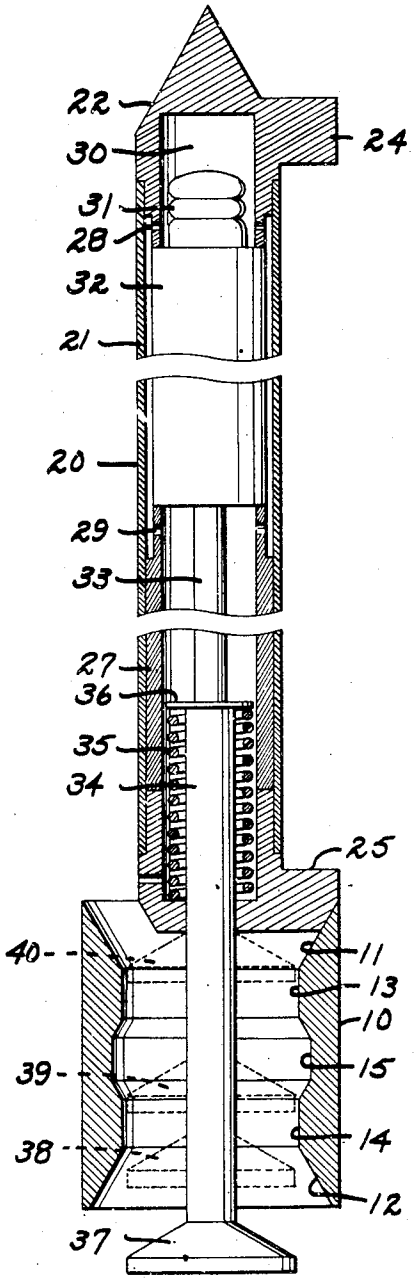


Fig. 2

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Sept. 20, 1949. J. S. SWEARINGEN 2,482,224

CLINOMETER FOR WELL BORES

Filed Nov. 30, 1940 5 Sheets-Sheet 3

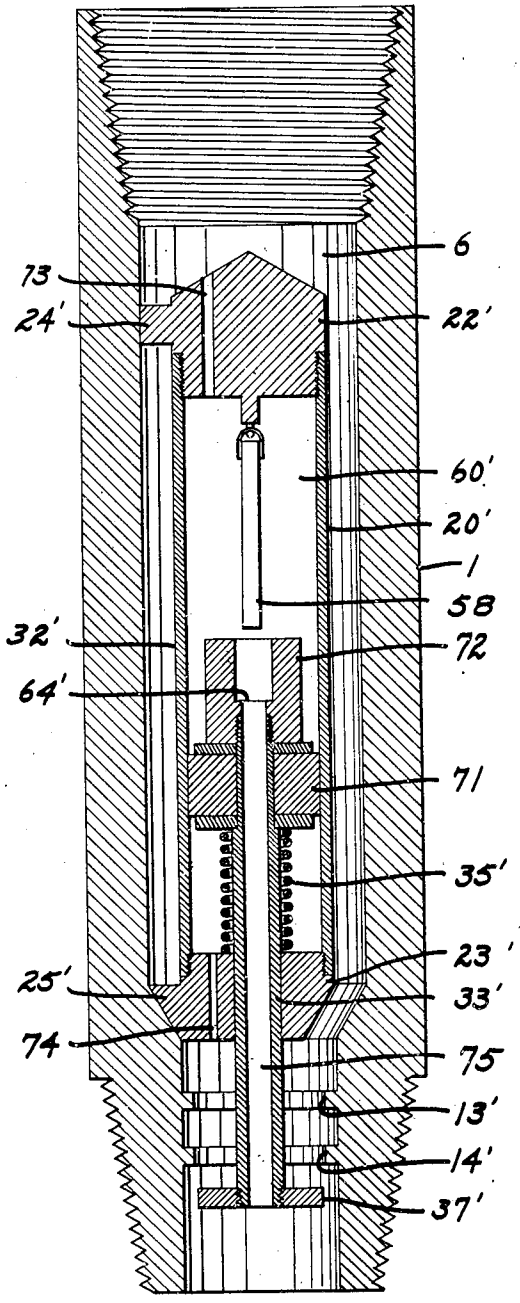


Fig. 5

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CLINOMETER FOR WELL BORES

Filed Nov. 30, 1940 5 Sheets-Sheet 4

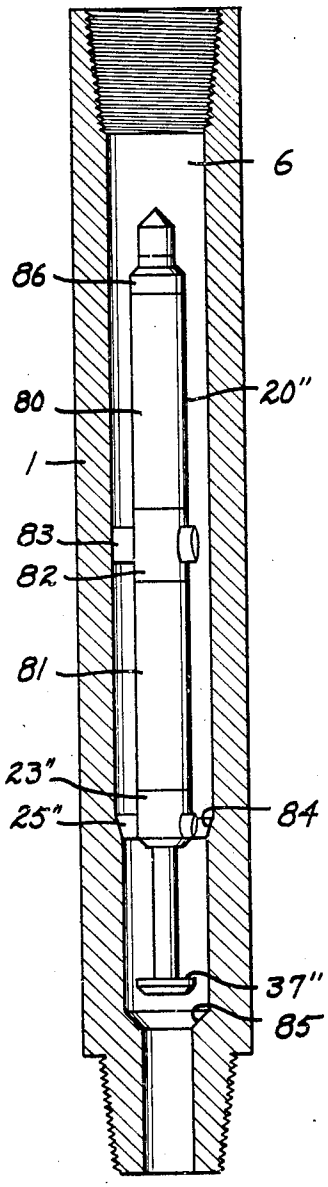


Fig. 6

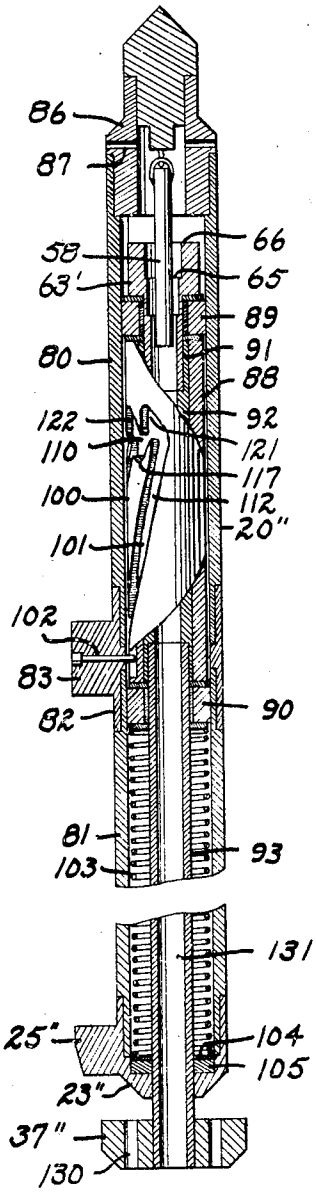


Fig. 7

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Sept. 20, 1949. J. S. SWEARINGEN 2,482,224

CLINOMETER FOR WELL BORES

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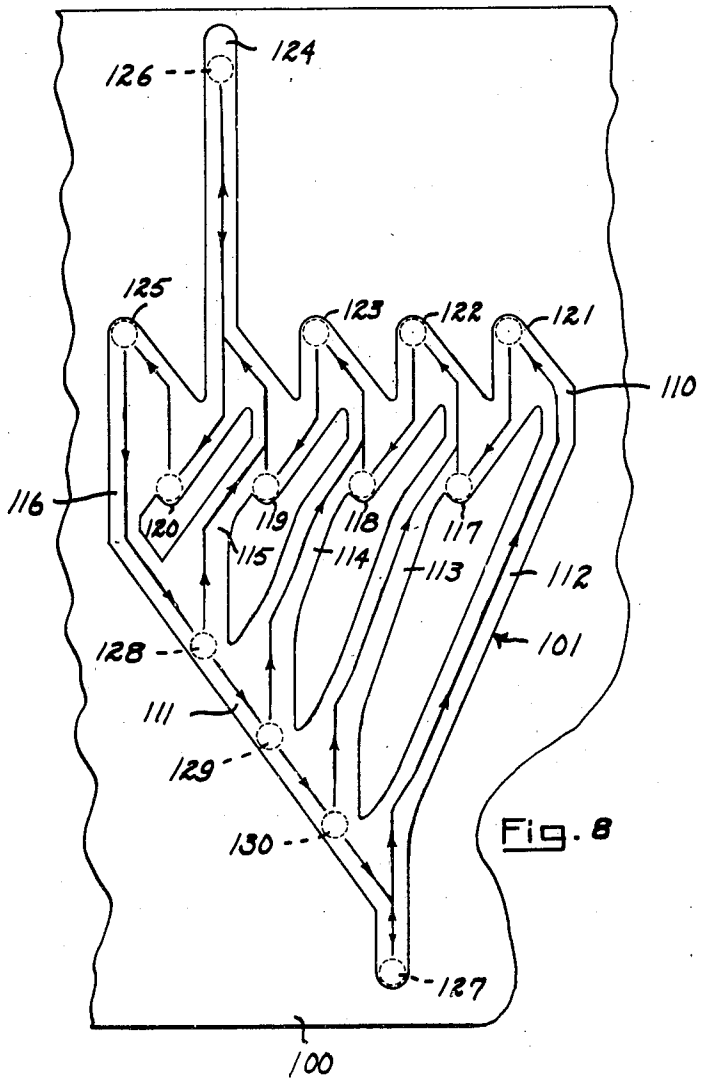


Fig. 8

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Patented Sept. 20, 1949

2,482,224

UNITED STATES PATENT OFFICE

2,482,224

CLINOMETER FOR WELL BORES

Judson S. Swearingen, Southton, Tex., assignor, by mesne assignments, to Robinson Tool Company, Houston, Tex., a corporation of Missouri

Application November 30, 1940, Serial No. 367,911

4 Claims. (Cl. 33—205)

1

This invention relates to the drilling of wells by the rotary method and particularly to a device for indicating at any time during drilling operations the departure of the well bore from the vertical.

In the drilling of wells by the rotary method and the subequent production of such wells it is highly desirable that the well bore be straight throughout its length and also that the axis of the bore be vertical. During drilling operations it has been proposed to utilize well surveying equipment to provide information regarding the departure of sections of the well from the vertical. Such procedure requires that a round trip of a well surveying instrument into and from the well be made whenever an observation is desired, an operation which is time consuming and expensive and which therefore dictates that considerable hole must be drilled between trips of the surveying instrument. If there is progressive inclination of the section of the hole which is produced between trips of the surveying instrument corrective drilling operations are less effective than they would be if the driller were apprized of conditions at the instant inclination began. Furthermore if such section of inclined hole is to be rectified it is necessary to plug back and to sidetrack the hole in order to provide a continuous straight bore.

It has also been proposed to provide an indicating device which throttles or even entirely cuts off the circulation of the drilling fluid so that the changes in pumping conditions indicates to the driller that inclination of the hole at the drill bit has been initiated. When such condition is indicated, drilling is discontinued and steps are taken toward the straightening of the hole. Such a device is disclosed in Patent No. 1,854,208 issued to Lynch et al., April 19, 1932.

The present invention is directed to an improved construction for providing, and it is a primary object of the invention to provide, a simple and efficient instrumentality for indicating at any time during drilling the departure and amount thereof of the well bore from the vertical.

Another object is to provide such an indication without substantially interfering with the circulation of drilling fluid and continued drilling.

Still another object is to provide an indication of the amount of inclination of the bore at any given level.

A further object is to obtain information of inclination of a well bore without removing the drill string and drill bit from the bore.

A further object is to enable straightening of

2

the bore as soon as departure from the vertical is begun.

Still another object is to provide a construction which includes an assembly which, when the circulation of fluid is discontinued, moves upwardly to a position determined by the amount of inclination of the hole. The device is such that upon resumption of the circulation of the drilling fluid, the assembly will move downwardly and produce pulsation in the column of drilling fluid so that pumping conditions are varied in such a manner as to indicate the inclination of the bore hole.

The foregoing objects together with other objects will be apparent from the following description taken in connection with the accompanying drawings in which:

Fig. 1 is an assembly view showing a section of drill pipe equipped in accordance with the invention;

Fig. 2 is an enlarged view partly in section showing the construction of the indicator unit of Fig. 1 and the relative position of such unit with the throttling collar;

Fig. 3 is a sectional view through the pendulum chamber of Fig. 2 with parts in their relative positions when fluid is pumped through the drill pipe during drilling;

Fig. 4 is a view similar to that shown in Fig. 3 but shows the relative position of parts when the inner assembly is moved to its uppermost position;

Fig. 5 is a vertical sectional view through a modified form of the invention;

Fig. 6 is an assembly view similar to that shown in Fig. 1 but illustrating a further embodiment of the invention;

Fig. 7 is a sectional view through the indicator unit shown in elevation in Fig. 6;

Fig. 8 is a developed view of the cam constituting an element of the construction of Figs. 6 and 7.

In Fig. 1 an embodiment of the invention is shown as comprising a tubular member 1 such as a coupling in the drill pipe 2 or a portion of a drill pipe section but is preferably the drill collar which is connected to the adjacent sections 3 and 4 of a drill stem having the passage 5 for drilling fluid which is pumped during drilling in a manner well known in the art. The bore 6 within the member 1 is slightly larger than the passage 5 and has a throttling collar 10 mounted therein at its lower end. This collar has tapered areas 11 and 12 at its opposite ends. Such areas merge inwardly into spaced annular ridges 13 and 14,

there being an annular groove 15 intermediate such ridges.

An inclination unit 20 is mounted in the bore 6 and comprises a housing 21 closed at its opposite ends by cap members 22 and 23 which have outwardly extending arms 24 and 25 of which the latter engage the tapered surface 11 whereby the entire assembly is supported in desired position within the member 1.

It is to be noted that the unit 20 is of smaller diameter than the bore 6 and hence there is provided a passage 26 through the member 1 and drilling fluid may therefore be pumped downwardly through the drill pipe 2 as is well known in the art of drilling wells by the rotary method. As above indicated the member 1 is preferably the drill collar so that the assembly just generally described is in proximity to the drill bit on the lower end of the drill pipe 2 so that any deviation of the bit from the vertical may be readily indicated at the instant such deviation takes place.

As best seen in Fig. 2 the cap member 22 is provided with a chamber 30 which receives an expansible member 31 attached to the upper end of the pendulum chamber 32 from which projects a valve stem 33. The pendulum chamber 32 is spaced from the walls of the tubular member 20 and is held in position by its engagement with the lower end of the cap member 22 and the upper end of a sleeve 27 which engages the lower cap member 25. The upper cap member 22 and the sleeve 27 are reduced in cross section at their adjacent ends and provided with breather openings 28 and 29 respectively so that expansion and contraction of the expansible member 31 may take place in a manner and for a purpose that will be more fully apparent.

The valve stem 33 has an enlarged portion 34 which extends through the bottom of the cap member 25 and a compression spring 35 engages a flange 36 on the stem whereby the stem is constantly urged upwardly so that the valve 37 at the lower end of the stem will move in succession to the positions indicated in dotted outline at 38, 39 and 40.

In Figs. 3 and 4 which show the detailed construction of the pendulum chamber 32 it will be noted that the member 31 is attached to the head 41 and that an opening 42 leads from the interior of such head to the interior of the expansible member. A tubular member 43 is attached to the head 41 at its upper end and to a plug 44 at its lower end, such plug member having an opening to pass the valve stem 33 and being provided with a packing 45 and a gland member 46 whereby the chamber is entirely enclosed and adapted to contain a suitable fluid, such as lubricant, so that the parts therein to be more fully described may operate entirely within such fluid.

A cylinder assembly comprising upper and lower sleeves 50 and 51 are secured within the pendulum chamber, the sleeve 51 being of slightly smaller diameter than the tubular member 43 whereby there is provided an annular chamber 52 between such members. The sleeve 51 is attached at its lower end to a plug 53 through which the valve stem 33 passes. This plug has a counterbore 54 at its lower end and a passage 55 leads from the interior of the cylinder assembly to such counterbore. The passage 55 is enlarged at its upper end to receive a ball valve 55' so that the passage and valve cooperate to act as an upwardly opening check valve. A radial passage 56 in the plug member 53 permits fluid

from the chamber 60 to flow by way of passages 57, 52 and 56 to the passage 55 and thence to the nether side of the piston assembly which will now be described.

The valve stem 33 has a head 61 at its upper end and such head is engaged by a piston assembly which comprises an outer piston member 62 and an inner stepped sleeve 63 having a press fit therein so that the valve stem and the piston assembly move as a unit. The stepped construction of the sleeve 63 provides annular shoulders 64 and 65 and an upper end surface 66.

Mounted within the chamber 60 and above the piston assembly just described is a pendulum 58 which is attached by means of a universal joint 59 to the cap member 41 in coaxial alinement with such piston assembly.

It seems apparent that when the piston assembly is in the position shown in Fig. 3 the pendulum is free to move within the chamber 60 and will remain in a vertical position even though the remainder of the unit be inclined from the vertical. If the housing is inclined and the piston assembly is moved upwardly, such movement will be arrested at a position, which is determined by the amount of inclination, by the engagement of the pendulum 58 with one of the surfaces 64, 65 or 66. If the entire unit is in a vertical position the pendulum will obviously enter the axial bore 67 in the piston assembly. It is intended that the physical dimensions of the parts of the unit will be such that a predetermined change in inclination, as for example one degree, will determine whether the pendulum will engage a given one of the stepped surfaces or the one adjacent thereto.

In Fig. 4 the device is shown with the parts thereof in the relative positions assumed when the piston assembly has been moved to its uppermost position while the entire unit remains vertical.

In the operation of the device as above described it will be assumed that such device constitutes a portion of a drill pipe and that drilling operations are in progress. Under such circumstances the flow of drilling fluid through the member 1 impinges upon the valve member 37 and holds the entire piston assembly in a downward position as shown in Figs. 1, 2 and 3. When an observation is to be made pumping of fluid past the unit 20 is stopped or the rate of pumping is reduced sufficiently that the piston assembly moves upwardly under the influence of the spring 35.

As such movement takes place the liquid within the housing 32 flows from the chamber 60 through the opening 57, the passages 52 and 56 to the chamber 54. This liquid lifts the valve 55' in the passage 55 thereby admitting such liquid to the nether side of the piston assembly. Attention is directed to the fact that volumetric changes within the housing 32 will be compensated by movement of the confined fluid through the passage 42 into the expansible member 31 as indicated in Fig. 4.

If the unit 20 is in a vertical position the piston assembly will rise and the pendulum 58 will enter the bore 67 therein. At the same time the valve member 37 is lifted to the position indicated at 40 in Fig. 2.

When pumping is resumed in the drill pipe 2 the pump fluid will impinge upon the valve 37 and hence the valve and piston assembly will begin to move downwardly against the force exerted by the spring 35. At the same time the ball valve

55' will seat within the passage 55 and hence the movement of the valve and piston assembly will be restricted since liquid within the housing 32 can by-pass the piston assembly only by virtue of the leakage between such assembly and the surrounding cylinder as indicated at 70. It is intended that the downward movement from the position shown at 40 in Fig. 2 to the terminal position shown at 37 will take place over an interval of time as for example from fifteen to twenty seconds although it is to be understood that the invention is not confined to such timing interval. During this interval the valve moves successively through the positions shown at 39 and 38 and while such valve is passing the annular ridges 13 and 14 there will be throttling of the pump liquid and accordingly pulsations transmitted to the pump will indicate to the driller that the valve is passing these restricted areas.

For the assumed condition two impulses will be transmitted to the pump and the driller will thus be apprised of the fact that the unit 20 was in a vertical position when pumping was discontinued. If, however, the unit had been slightly inclined so that the pendulum 58 engaged the shoulder 64, the valve member 37 would have been held in the position indicated at 39 and when pumping was resumed a single impulse would indicate that the unit was inclined an amount necessary to cause such limit of movement of the piston and valve assembly. In a similar manner a larger inclination would cause the pendulum 58 to engage the surface 66 and in such event no throttling would take place when pumping was resumed, and such fact would indicate that a material departure from the vertical had taken place.

It is to be understood that when a small inclination is shown to have taken place corrective steps may be applied as for example by decreasing the pressure applied at the drill bit, a practice by which it is possible to correct small departures from the vertical while drilling. If, however, a considerably larger inclination is noted it may be necessary to withdraw the entire drill string and bit from the bore hole and utilize special bits which have been designed to straighten the well bore.

The embodiment shown in Fig. 5 operates in a manner similar to that just described but this embodiment is such that the drilling fluid pumped through the body 1 may also pass to the interior of the housing 32' within which a piston 71 is mounted upon a tubular valve stem 33' to which is attached the valve member 37'. The piston 71 is secured in place upon the valve stem 33' by means of a cup member 72 into which the pendulum 58 is intended to enter as above explained. The piston and valve assembly is urged upwardly by means of the compression spring 35'.

Passages 73 and 74 in the cap members 22' and 23' permit the ingress and egress of fluid as the piston assembly moves within its housing 32'. It is to be noted also that the passage 73 is larger than the passage 74 and permits pumped fluid to move downwardly through the bore 75 in the stem 73' and in this manner sedimentation within the chamber 60' is avoided.

It is also to be noted that the cup 72 as illustrated has but a single shoulder 64' but it is to be understood that the inner surface of the cup 72 may be stepped in any desirable manner and that furthermore the annular ridges shown as 13' and 14' may be of any desired number so that the pulsations set up in the pumped fluid will indicate the inclination of the unit 20' at the time pumping was discontinued for the purpose of making an observation.

In the embodiment illustrated in Figs. 6, 7 and 8 and housing unit 20'' comprises two pieces of tubing 80 and 81 which are joined at their inner ends by the spider 82 having outwardly extending arms 83 which engage the inner walls of the member 1. The arms 25'' on the lower cap 23'' engage a tapered shoulder 84 on the interior of the member 1 so that the entire assembly is held in position within the member and with the valve 37'' normally held in spaced relation with the valve seat 85. The upper end of the tubing 80 is closed by a cap 86 having radial openings 87 to admit fluid to the interior of the composite housing. The pendulum 58 is suspended from an axial projection on the cap 86.

A piston assembly generally referred to as 88 is movable within the housing and comprises spaced pistons 89 and 90 mounted upon a central shaft 91 which includes the tubular sleeve 92 and the valve stem 93. A rotatable cam 100 is positioned between the pistons 89 and 90 and has a cam slot 101 into which projects the end of a pin 102 in the spider 82. This cam is adapted to rotate about the sleeve 92 and, by virtue of its slot construction 101, to serve a function that will more fully appear.

A compression spring 103 beneath the piston 90 engages an annular plate 104 in the bottom of the housing and such plate surmounts packing 105 whereby a seal is maintained about the valve stem and the entire piston and valve assembly is urged upwardly within the housing an opening 106 in the wall of the tubing 80 permits ingress and egress of fluid to and from the chamber about the spring 103. A stepped sleeve or cup 63' passes through the upper piston 89 and secures the upper end of the piston assembly in assembled relation. This sleeve 63' serves the same purpose as the sleeve 63 shown in Fig. 3 and above described.

The operation of the embodiment of Figs. 6 and 7 will be made apparent by further reference thereto and to Fig. 8 which shows a development of the cam 100 showing in detail the configuration of the cam slot 101. From this development it will be seen that the slot 101 has a generally transverse portion 110 at its upper end and a lower inclined portion 111, these portions being interconnected by intermediate slots 112 to 116 inclusive which respectively include upwardly facing ledges 117, 118, 119 and 120. Above the slots 112 to 116 and in staggered relation therewith are pockets 121 to 125 inclusive lying in a common plane except for the pocket 124 which extends upwardly for a sufficient distance that the piston and valve assembly move downwardly so that the valve 37'' engages it seat when the pin 102 assumes the position 126.

Normally the cam 100 is urged upwardly by the spring 103 so that the pin 102 assumes the position indicated at 127. As drilling fluid begins to flow downwardly around the valve 37'' the piston and valve assembly is caused to move downward until the cam follower pin 102 has taken the position 121. When the assembly is in this position the valve member 37'' is held above the valve seat as indicated in Fig. 6. When the fluid pump is turned off or the rate of pumping is decreased sufficient that the piston and valve assembly moves upwardly under the influence of the spring 103, the cam follower pin 100 moves through the cam groove to the ledge 117. When drilling fluid

is again caused to flow the cam moves in a manner that the pin 100 enters the pocket 122.

This process is repeated through positions 118, 123 and 119. The next downward movement of the piston and valve assembly will move the valve 37'' downward until it seats upon the seat 85 and the follower pin 100 will then have assumed the position indicated at 126. In this position the flow of drilling fluid will be retarded as all fluid must pass through the restricted openings 130 in the valve member 37'' or through the openings 87 in the cap 86 and thence through the bore 131 in the piston and valve stem assembly. This restriction of flow of drilling fluid can be observed at the surface as an increase of fluid pressure.

When the operator observes that the valve 37'' has closed, the valve is released by stopping the flow of fluid for a short interval of time thus allowing the follower pin 102 to assume the position 120. Pumping is then again resumed and the plunger and valve assembly will be stopped by the engagement of the pin 100 in the pocket 125 and in this manner the valve member 37'' will be held off its seat as drilling proceeds normally.

The movement of the cam 100 through the steps just indicated is retarded by the fluid entrapped within the chamber about the spring 103. This retardation of movements permits the pumped fluid to flow past the valve member 37'' for a considerable period of time, as for example five or ten seconds after pumping is resumed. When fluid is not flowing a similar lapse of time is required for the spring 103 to force the piston and valve assembly upward to a new position.

When the follower pin 102 is in position 125 the instrument is ready to make a deviation measurement the next time the pump is stopped. When the pump is stopped the piston assembly moves upwardly. If the hole is materially inclined, say in excess of three degrees the pendulum 58 will engage the annular surface 66 of the cup 63' causing the upward movement of the cam to stop with the follower pin 102 in position 128. Thence on the next downward movement of the cam 100 when the pumping of fluid is resumed, the cam will move downward so that the pin again assumes the position 126, a condition which indicates the large inclination of the assembly.

If the inclination of the hole has exceeded two degrees but is less than three degrees the cam 100 on leaving position 125 will proceed upward until the follower pin 102 reaches the position 129 at which point the assembly is stopped by the pendulum coming into contact with the shoulder 65 in the cup 63'. Subsequent turning on and off of the fluid pump will move the cam through positions 123, 119 and thence to position 126 which provides an indication of the inclination of the unit 20''.

In a similar manner a deviation of, for example, between one and two degrees will cause the pendulum 58 to stop the upward movement of the assembly when the cam pin is at position 130. As already pointed out the amount of inclination will thereafter be indicated by the number of times the pumping is started and stopped before the valve 37'' is again seated upon the seat 85.

Position 125 is provided in order that there may always be an idle position which can be used for drilling. If the driller wishes he need not go through the complete cycle above outlined every time a pipe connection is made. If he proceeds to drill in the customary manner he will find that the fluid pump will labor every fourth connection or every 120 feet of drilling if standard 30 ft. pipe lengths are used and if the deviation of the hole is less than one degree. The labor of the pump is relieved by stopping and starting the pump at which time the cam pin 102 moves to the position 125 If the hole assumes a deviation of between one and two degrees this event will take place every third connection or every 90 ft. of drilling.

It seems apparent that if the deviation is greater than two and less than three degrees laboring of the pump will occur every second connection or every 60 ft. of drilling while if the deviation is greater than three degrees such laboring of the pump will occur every 30 ft. of drilling. The driller is thus automatically informed when the bore deviates from the vertical and may also ascertain the approximate amount of the deviation.

Attention is directed to the fact that, since ordinary drilling fluids are inclined to jell in the absence of agitation, circulation is provided through the unit 20'' by the openings 87 and the central bore 131 through the piston and valve assembly. In this manner the fluid around the pendulum 58 is kept in agitation so that it will not jell and interfere with the free movement of the pendulum. Although a specific preferred embodiment and modifications thereof have been disclosed herein it is intended that the invention shall not be limited thereto as the invention broadly comprehends the provision of a simple and efficient device for indicating, at any time during drilling, the departure and amount thereof of a well bore from the vertical.

What is claimed is:

1. In a device of the class described, an elongated member having a bore therein, an inclination unit mounted in said bore, said unit comprising a housing, there being a passage for fluid between the member and housing, a piston within said housing, a stepped cup movable with said piston, a pendulum suspended in the housing for engagement with the stepped cup when the member is inclined, spring means normally urging the piston and cup toward the pendulum, a stem attached to the piston and extending outwardly through the housing, a valve member on said stem to move the stem outwardly when fluid is forced through the bore, and restricted areas in said bore to produce variable throttling of the fluid as the stem moves outwardly.

2. A device for indicating vertical deflection comprising, a tubular member, an inclination unit mounted therein, said unit comprising a housing of smaller diameter than the bore of said member to provide a passage therebetween, a stepped member movable longitudinally of and having leakage clearance with said housing, a pendulum suspending in the housing and engageable by said stepped member, spring means normally urging said stepped member towards the pendulum, a stem attached to the stepped membr and sealably extending outwardly through the housing, a body of fluid within said housing to lubricate the enclosed elements and to resist external pressure on the housing, an enlargement on said valve stem exteriorly of the housing, and restricted areas in the bore of said tubular member proximate said enlargement to produce variable throttling of the fluid passing through the tubular member.

3. A device for indicating vertical deflection comprising, a tubular member, an inclination unit

mounted therein, said unit comprising a housing of smaller diameter than the bore of said member to provide a passage therebetween, a stepped member movable longitudinally of said housing, a pendulum suspended in the housing and engageable by said stepped member, spring means normally urging said stepped member towards the pendulum, a stem attached to the stepped member and sealably extending outwardly through the housing, a body of fluid within said housing to lubricate the enclosed elements and to resist external pressure on the housing, means comprising leakage clearance between the stepped member and the housing for restricting the movement of the stepped member from said pendulum, an enlargement on said stem exteriorly of the housing, and restricted areas in the bore of said tubular member proximate said enlargement to produce variable throttling of the fluid passing through the tubular member.

4. A device for indicating vertical deflection comprising, a tubular member, an inclination unit mounted therein, said unit comprising a housing of smaller diameter than the bore of said member to provide a passage therebetween, a stepped member movable longitudinally of said housing, a pendulum suspended in the housing and engageable by said stepped member, spring means normally urging said stepped member towards the pendulum, a stem attached to the stepped member and sealably extending outwardly through the housing, a body of fluid within said housing to lubricate the enclosed elements and

to resist external pressure on the housing, a by-pass for said fluid past said stepped member, a check valve in said by-pass operable to freely by-pass fluid as said member moves toward the pendulum, an enlargement on said stem exteriorly of the housing, and restricted areas in the bore of said tubular member proximate said enlargement to produce variable throttling of the fluid passing through the tubular member, and means exposed to the fluid interiorly and exteriorly of the housing and adapted to alter the volume of the chamber within the housing to compensate for the volumetric change produced by movement of the stem.

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