

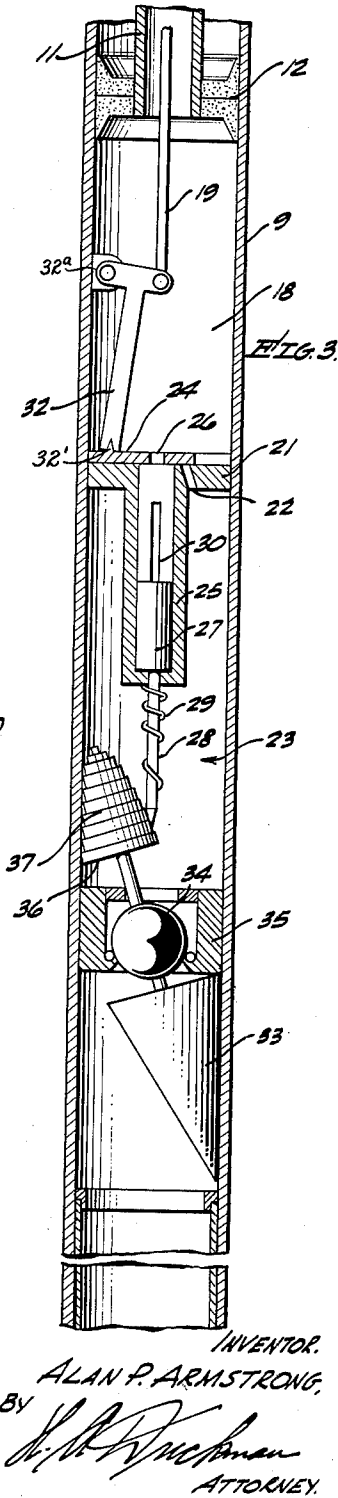
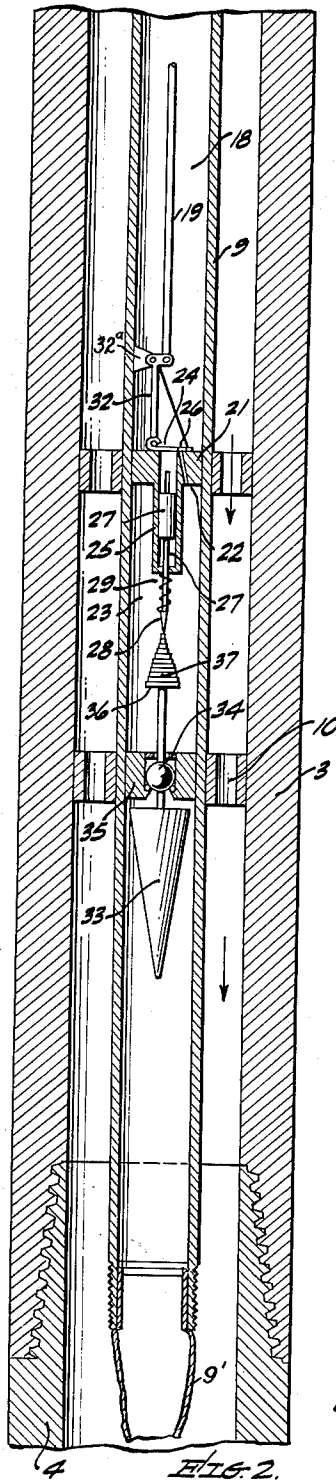
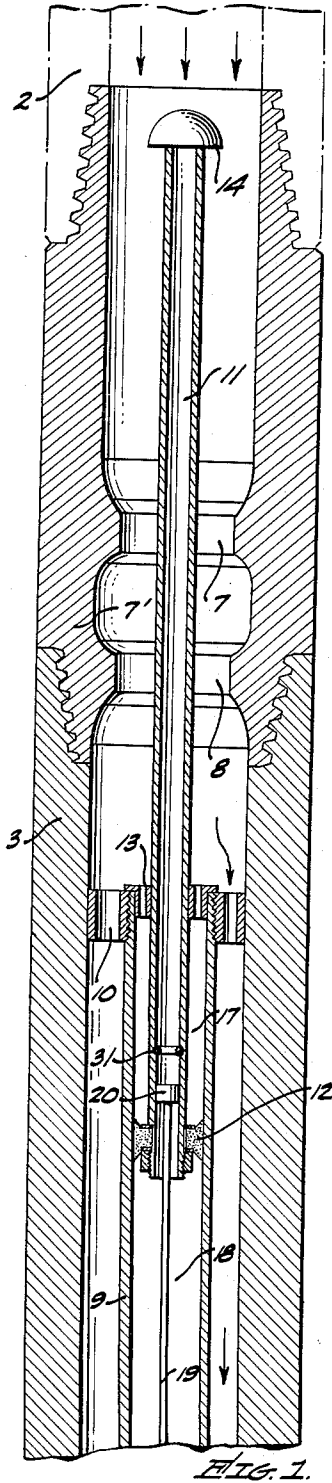
Feb. 12, 1963

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BORE HOLE DECLINOMETER

3,077,233

Filed April 20, 1959

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

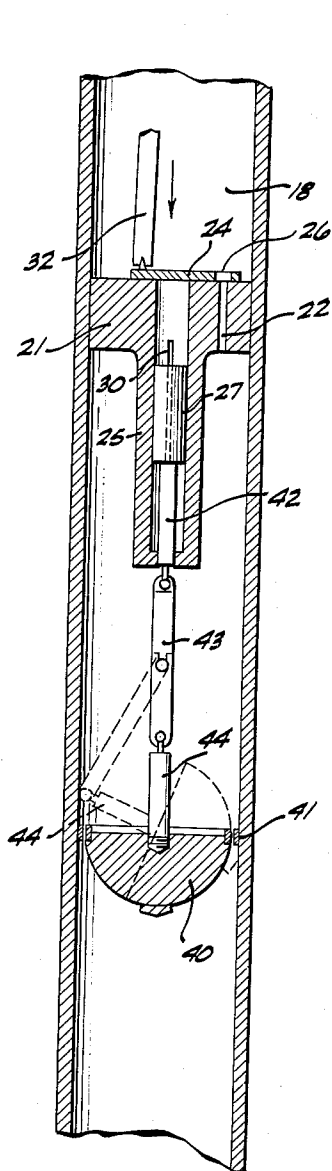


FIG. 4.

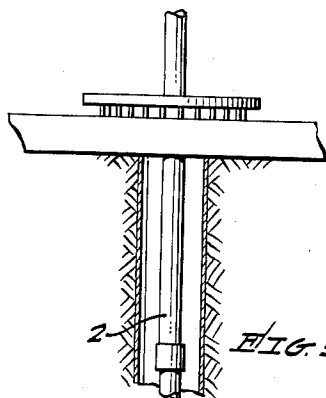


FIG. 5.

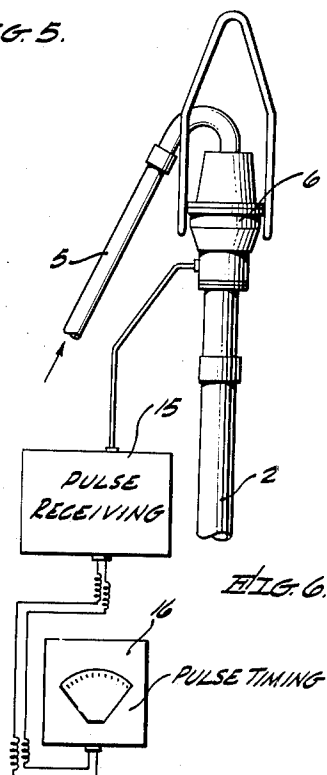
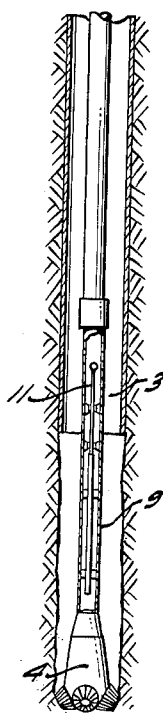
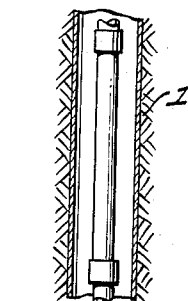


FIG. 6.

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3,077,233

BORE HOLE DECLINOMETER

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Filed Apr. 20, 1959, Ser. No. 807,500

6 Claims. (Cl. 175-45)

This invention relates to a bore hole declinometer which will determine the amount of deviation of the bore from the vertical by means of pulses or surges which are introduced into the mud stream flowing into the bored hole from the surface; said impulses being recorded at the surface by suitable instruments for determining pressure variations. My invention consists primarily of an indicating assembly which is mounted in the tool string immediately above the drilling bit. This indicating assembly produces pressure pulses in the drilling mud stream which are proportional in duration to the angular deviation from the vertical of the bored hole. There is also a pressure recording instrument at the surface which records the duration of pressure pulses in the drilling mud, this recording instrument being calibrated and readable in degrees of declination of the bored hole from the vertical.

An object of my invention is to provide a bore hole declinometer which will indicate the amount of declination of the bored hole from the vertical, this reading being obtained at the surface of the ground while the drilling of the well continues, and without the necessity of removing the drill string or bit from the well.

A further object of my invention is to provide a novel bore hole declinometer which is activated by fluid pulses introduced into the mud stream by means of a mechanism actuated by the mud stream, this mechanism introducing readable surges or pulses in a flowing mud stream in the bore of a well while the drilling operation of the well continues.

It is to be understood that my invention can also determine, record, or indicate other information at the bottom of a well other than declination, such other information consisting of bottom hole temperatures, pressures, acidity, etc.

Still another object of my invention is to provide a novel bore hole declinometer which will reposition and reactivate itself after each angular reading produced thereby, and without the necessity of removing the declinometer from the bored hole.

Other objects, advantages and features of invention may appear from the accompanying drawing, the subjoined detailed description and the appended claims.

In the drawings:

FIGURE 1 is a fragmentary vertical sectional view of the upper portion of my declinometer.

FIGURE 2 is a fragmentary vertical sectional view of the lower portion of my declinometer.

FIGURE 3 is a fragmentary longitudinal sectional view of the pendulum control mechanism of my declinometer.

FIGURE 4 is a fragmentary longitudinal sectional view of a modified form of pendulum mechanism.

FIGURE 5 is a diagrammatic view of my declinometer in position in a well.

FIGURE 6 is a diagrammatic view of the recording apparatus at the surface of the well.

Referring more particularly to the drawing, casing or open hole 1 forming the bore of the well extends from the surface to the bottom of the well, all of which is usual and well known in the art. During the digging of the bore 1 a tool string 2, consisting of pipe, extends from the surface to a drill collar 3, and a bit 4 is attached to the bottom of the drill collar again in the usual and well known manner. The tool string 2 is threaded to the upper end of the drill collar 3, again in the usual and

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well known manner. In rotary drilling, drilling mud is pumped through a pipe 5 and thence into a swivel head 6 which is mounted on the upper end of the drill string 2. This drilling mud flows under considerable pressure to the bit 4 and then flows upwardly in the bore 1 and back to the surface. Any pulse or wave in the stream of drilling mud within the drill string 2 would, therefore, be transmitted back to the surface and could be there received as a pulse, and also various pulses which are separated from each other could be timed. The drill collar 3 is provided with a plurality of necks or constrictions 7-8, etc., adjacent the upper end thereof. In this instance, two such constrictions or necks are shown and these are spaced vertically a known distance for the purpose of producing a pulse or wave in the column of drilling mud within the drill string 2, as will be further described. A cylinder 9 is concentrically mounted in the collar 3 and is fixedly held in this position by means of a plurality of spiders or rings 10. A cap or closure 9' is secured to the lower end of the cylinder 9. This cap 9' is preferably formed of a flexible material. A tubular piston rod 11 extends into the top of the cylinder 9 and this tubular rod has a piston 12 thereon which closely fits within the cylinder 9. A guide 13 is mounted on the upper end of the cylinder 9 and surrounds the piston rod 11. A head 14 is provided on the upper end of the piston rod 11 and this head is somewhat smaller in diameter than the necks 7 and 8. As the head 14 passes through the necks 7 and 8 it will materially restrict the flow of drilling mud which is passing downwardly through the collar 3 and will thus create a surge or pulse during the time that the head 14 is positioned within a neck 7 and 8. The necks 7 and 8 being spaced vertically with a bulge 7' between the necks, will cause a different time interval to be recorded as the head moves from 7 to 7' than from 7' to 8; the time varying with the downward speed of the head 14 as it is pushed downwardly by the flow of drilling mud within the drill string 2. The varying speed of the head 14 is accomplished by the flow of fluid through a certain port and orifice, as will be subsequently described. Since the rod 11 is tubular it will tend to float upwardly in the column of drilling mud whenever that mud is quiescent, that is, when the mud pumps are not operating and when there is no flow of mud within the drill string 2.

At the surface, whenever a pulse is produced by movement of the head 14 through a neck 7 or 8 and the bulge 7', this pulse will be received in a suitable pressure receiving instrument 15, which instruments are well known in the art. Once the pulse is received the timing of the pulses is recorded by the pulse timing instrument 16. Thus it is possible to receive a pulse produced within the drill string 2 by movement of the head 14 downwardly as described, but also to time the pulses produced in the restrictions 7 and 8 and the bulge 7'. While I have only shown two such restrictions, it is obviously possible to provide additional space restrictions if it is found desirable or necessary.

The drilling mud will move into the chamber 17 above the piston 12 to push this piston downwardly within the cylinder 9. The space or chamber 18 below the piston 12 is filled with oil and serves as a control means, as will be further described. A rod 19 extends into the bottom of the tube 11 and is formed with a head or guide 20 at its upper end which slides freely within the tube 11.

A transverse wall 21 in the cylinder 9 defines the lower wall of the chamber 18. A fixed orifice 22 extends through the wall 21 into another chamber 23 within the cylinder 9 and below the chamber 18. A slide valve 24 is mounted on the wall 21 and when this valve is moved transversely of the wall it will open and close the orifice or port 22. In one position of the valve 24, as shown

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in FIG. 2, the port 22 is open. In another position of the valve, as shown in FIG. 3, this port is closed. A metering cylinder 25 depends from the wall 21 and the bore of this cylinder extends upwardly through the wall 21 to the valve 24, substantially as shown. The port 26 in the valve 24 will permit oil to flow from the chamber 18 either through the orifice 22 or into the calibrating cylinder 25, depending on the position of the valve. A cylindrical plunger 27 within the cylinder 25 is provided with a pin 28 which projects through the bottom of the cylinder 25. A coil spring 29 is attached at one end to the pin 28 and tends to pull the pin and the plunger 27 upwardly in the cylinder 25. An elongated slot or control orifice 30 extends through the wall of the cylinder 25, and the plunger 27 controls the opening through the orifice 30 and thus determines the rate of flow of oil through that orifice. When the control tube 11 is pushed downwardly by the circulating mud a soft rubber O-ring 31 on the inside of the tube 11 will engage the head 20, pushing the rod 19 downwardly to swing the lever 32 which is pivotally attached to the valve 24, by means of a pin 32' on the valve 24, which pin enters a hole in the bottom of the lever 32 thus moving the port 26 over the calibrating cylinder 25 and permitting the oil in the chamber 18 to pass first into the cylinder 25 and then out through the calibrated opening 30. The pressure of the oil in the chamber 18 will also move the plunger 27 and the pin 28 downwardly against the tension of the spring 29. The downward movement of the plunger 27 will variably open the calibrating orifice 30, thus determining the rate of flow of the oil from the chamber 18 into the lower chamber 23 and thus controlling the rate of downward movement of the piston 12 as well as the head 14, and thereby determining the time of movement of the head 14 from the neck 7 to the bulge 7' and the neck 8. The lever 32 is pivotally mounted on the lug 32^a projecting inwardly from the cylinder 9.

The maximum downward movement of the plunger 27 and the pin 28 is controlled as follows: A weight 33 is mounted on a ball joint 34, which joint is positioned within a transverse wall 35 within the cylinder 9. A cone 36, which has peripheral steps 37 thereon, is also attached to the ball 34 and extends upwardly into the chamber 23. The cone 36 with its surface steps is immediately below the pin 28, and the weight 33 will swing the cone 36 to one side, depending upon the inclination of the bored hole from the vertical. When the pin 28 is now driven downwardly by pressure of the oil within the chamber 25 the pin will strike one of the surface steps 37 to limit further downward movement of the plunger 27 and thus determine the maximum opening of the orifice 30 for the particular inclination of the bored hole. It will thus be evident that the different inclinations of the tool in the bored hole will variously position the cone 36 to stop the pin 28 and the plunger 27 in a corresponding position, thus adjusting the orifice 30 and varying the time of movement of the head 14 from the neck 7 to the neck 8. This time interval between successive pulses received by the instrument 15 at the surface will be recorded on the time mechanism 16 and this time element in turn can be translated into degrees of declination of the bored hole.

After the declination of the hole has been determined as stated above, the flow of drilling mud into the well is stopped. Since there is no mud flow, the piston 12 will be stationary; also there will be no oil pressure in the chambers 18 and 23. The oil in the chambers 18 and 23 has a lower specific gravity than the mud column on the outside of the cylinder 9 and, consequently, the piston 12 and hollow rod 11 will be floated upwardly in the mud column. Since the tube 11 is hollow it will float upwardly in the mud column to its original position shown in FIG. 1, and at the same time the spring 29 will push the plunger 27 upwardly to substantially close the

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orifice 30. At the same time the rod 19 will also be pulled upwardly due to the friction of the head 20 within the tube 11, and also by engagement with the compressible rubber stop 31. Thus shifting the valve 24 to the position where the ports 22 and 26 are aligned, as shown in FIG. 2, and thus returning the parts to a starting or position of zero declination. This is usually accomplished by moving the bit 4 off of bottom and permitting the drilling string to hang vertically in the well. If the declination is excessive, further movement of the bit vertically or further drilling ahead might correct the deficiency and, if not, the bit can be removed and a whipstock inserted which is usual and well known in the art.

A modification of the pendulum mechanism is shown in FIG. 4 wherein a weighted hemispherical pendulum 40 is mounted in a gimbal ring 41. The plunger 27 has a pin 42 depending therefrom and this pin is pivotally attached to a link 43. The other end of the link 43 is pivotally attached to a post 44 which rises from the weight 40. Thus as the hemisphere 40 moves in the ring 41 the plunger 27 will be pulled downwardly to expose the orifice 30 in the same manner as previously described.

In Operation

Assuming that the bit 4 is being rotated by the drill string 2 in the normal manner and is drilling ahead with drilling mud circulated through the drill string 2, the drilling mud will be under considerable pressure and this drilling mud will pass downwardly through the string 2 and thence into the top of the cylinder 9 and will press against the top of the piston 12. The tube 11 will thus be moved downwardly, as well as the head 14 on the upper end of this tube. When the head 14 enters the neck 7 a surge or pulse is created in the drilling mud which is transmitted to the top of the drilling string 2 and will be received by the mechanism 15. As the head 14 moves from 7 to 7' this time interval will be recorded on the instrument 16. The rate of movement of the head 14 during this interval is determined by the size of the port 22. The initial downward movement of the tube 11 will cause the soft O-ring 31 to engage the head 20 and will push the rod 19 downwardly to shift the valve 24 from a position to open the port 22 to a second position to open the cylinder 25. When the orifice 30 is now open the rate of movement of the head 14 will be changed and, consequently, the time interval of movement of the head 14 from 7' to 8 will be different than the time interval from 7 to 7'. This latter time interval is again indicated on the instrument 16 and can be calibrated to indicate declination of the hole. The downward movement of the piston 12 has pushed oil in the chamber 18 downwardly and this oil first passes through the port 22 until it is shifted into the cylinder 25. The first action of the incoming oil into the cylinder 25 is to push the plunger 27 downwardly to open the orifice 30 and permit the incoming oil to flow into the chamber 23. Meantime, if there is some inclination in the bored hole the pendulum 33 will swing the cone 36 to one side, exposing the steps 37 thereon to the pin 28. Downward movement of the plunger 27 will push the pin 28 downwardly until it engages one of the steps 37; thus limiting further downward movement of the plunger 27 and limiting the exposed portion of the orifice 30. This constriction of the orifice 30 will limit the rate of movement of the piston 12 and thus regulate the movement of the head 14 from the neck 7 to the neck 8. This time interval is recorded in the timing mechanism 16 and can be translated into the declination of the hole which determines the position of the pendulum 33 and the cone 36. After a reading has been taken and the amount of declination of the hole determined, the flow of drilling mud will be stopped and the bit 4 is raised off of bottom so that the drill string 2 hangs vertically in the

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well. The drilling mud having been stopped, there is no pressure on the piston 12, which relieves pressure in the chambers 18 and 23. The spring 29 now moves the plunger 27 upwardly, releasing the pendulum 33 so that it in turn can again hang vertically. The tube 11 will now float upwardly in the mud stream and will also pull the rod 19 upwardly to shift the valve 24 through the link 32 so that the ports 22 and 26 are aligned, as shown in FIG. 2. The tool is now ready for continued drilling and a repetition of declination indication.

Having described my invention, I claim:

1. In a bore hole declinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole declinometer, said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on said piston rod, said head being movable past said constrictions to create a pulse in the drilling mud, and pulse receiving means at the surface of the bore hole, and a means to retard the downward movement of said piston and piston rod, a cylinder in said drill collar, said piston being slidably mounted in said cylinder, the drilling mud bearing against one side of the piston, a wall in the cylinder, said wall separating said cylinder into upper and lower chambers, said wall having a fluid port extending therethrough to permit flow of a fluid from the upper to the lower chamber, pivotally mounted weighted means sensitive to the declination of the bore hole, and valve means connected to and operable by said weighted means controlling the size of said fluid port, stepped shoulders on the weighted means engaged by the valve means, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

2. In a bore hole declinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole declinometer, said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on said piston rod, said head being movable past said constrictions to create a pulse in the drilling mud, and pulse receiving means at the surface of the bore hole, and a means to retard the downward movement of said piston and piston rod consisting of a universally mounted weight, a head on the weight, a plurality of spaced stop shoulders on the head, said drill collar having a fluid port therein positioned above said head, valve means movable over said port to constrict the port and reduce fluid flow therethrough, said last named valve means being engageable with and movable relative to any of the stop shoulders to permit movement of the valve means over said port and vary the opening thereof, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

3. In a bore hole declinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole declinometer, 75

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said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on said piston rod, said head being movable past said constrictions to create a pulse in the drilling mud, and pulse receiving means at the surface of the bore hole, and a means to retard the downward movement of said piston and piston rod consisting of a cylinder fixedly mounted in said drill collar, said piston being slidably mounted in said cylinder, the drilling mud bearing against one side of the piston, a transverse wall in the cylinder separating said cylinder into upper and lower chambers, said wall having a metering cylinder therein, a plunger in the metering cylinder, said metering cylinder having a metering orifice extending through a wall thereof, said plunger being movable over the metering orifice to control the size thereof, and pivotally mounted weighted means sensitive to the declination of the bore hole, and spaced stop means on said weighted means engageable by said plunger to limit the movement of the plunger relative to the metering orifice, and control fluid flow therethrough, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

4. In a bore hole declinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole declinometer, said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on said piston rod, said head being movable past said constrictions to create a pulse in the drilling mud, and pulse receiving means at the surface of the bore hole, and a means to retard the downward movement of said piston and piston rod consisting of a cylinder fixedly mounted in said drill collar, said piston being slidably mounted in said cylinder, the drilling mud bearing against one side of the piston, a transverse wall in the cylinder separating said cylinder into upper and lower chambers, said wall having a metering cylinder therein, a plunger in the metering cylinder, said metering cylinder having a metering orifice extending through a wall thereof, said plunger being movable over the metering orifice to control the size thereof, a universally mounted weight in said cylinder, a head on the weight, a plurality of spaced stop shoulders on the head, and means projecting from said plunger, said means on the plunger being engageable with any of the stop shoulders to control the size of the fluid port, and control fluid flow therethrough, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

5. In a bore hole declinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole declinometer, said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a tubular piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on

said piston rod, said head being movable past said constrictions to create a pulse in the drilling mud, and pulse receiving means at the surface of the bore hole, a second rod extending into said tubular rod and slidable therein, a cylinder fixedly mounted in the drill collar, said piston being slidably mounted in said cylinder, the drilling mud bearing against one side of the piston, a transverse wall in the cylinder separating said cylinder into upper and lower chambers, said wall having an orifice therein connecting said upper and lower chambers, valve means in said wall adapted to open and close said orifice, actuating means connecting said valve means and the second rod whereby said valve means is operated, a metering cylinder on said wall, said valve means being movable to connect said upper cylinder and the metering cylinder, said metering cylinder having an orifice therein extending through a wall thereof, a plunger in the metering cylinder, said plunger being movable over the metering orifice to control the size thereof and control fluid flow there-through, a pendulum in said cylinder, and means on the pendulum engageable by the plunger to limit the movement of said plunger in the metering cylinder, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

6. In a bore hole inclinometer a drill string in the bored hole, a bit on the lower end of said drill string; a drill collar in said drill string above said bit, said drill collar comprising the housing for a hole inclinometer, said drill string having a column of drilling mud therein, said drill collar having a plurality of superposed constrictions therein, a tubular piston rod mounted in said drill collar for vertical movement therein, a piston on said piston rod to be acted upon by the drilling mud to force the piston rod downwardly in the drill collar, a head on said piston rod, said head being movable past said con-

strictions to create a pulse in the drilling mud; and pulse receiving means at the surface of the bore hole, a second rod extending into said tubular rod and slidable therein, a cylinder fixedly mounted in the drill collar, said piston being slidably mounted in said cylinder, the drilling mud bearing against one side of the piston, a transverse wall in the cylinder separating said cylinder into upper and lower chambers, said wall having an orifice therein connecting said upper and lower chambers, valve means in said wall adapted to open and close said orifice, actuating means connecting said valve means and the second rod whereby said valve means is operated, a metering cylinder on said wall, said valve means being movable to connect said upper cylinder and the metering cylinder, said metering cylinder having an orifice therein extending through a wall thereof, a plunger in the metering cylinder, said plunger being movable over the metering orifice to control the size thereof and control fluid flow therethrough, a pendulum in said cylinder, a head on the pendulum, a plurality of spaced stop shoulders on the head, and means projecting from said plunger, said means on the plunger being engageable with any of the stop shoulders to control the movement of the plunger over the metering orifice, the opening of the fluid port by the valve means being approximately proportional to the tilt of the weighted means, a second port in said wall, a second valve means controlling the second port, and means coupling the second valve means and said piston rod to actuate the second valve means as the piston rod moves vertically.

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