

April 25, 1933.

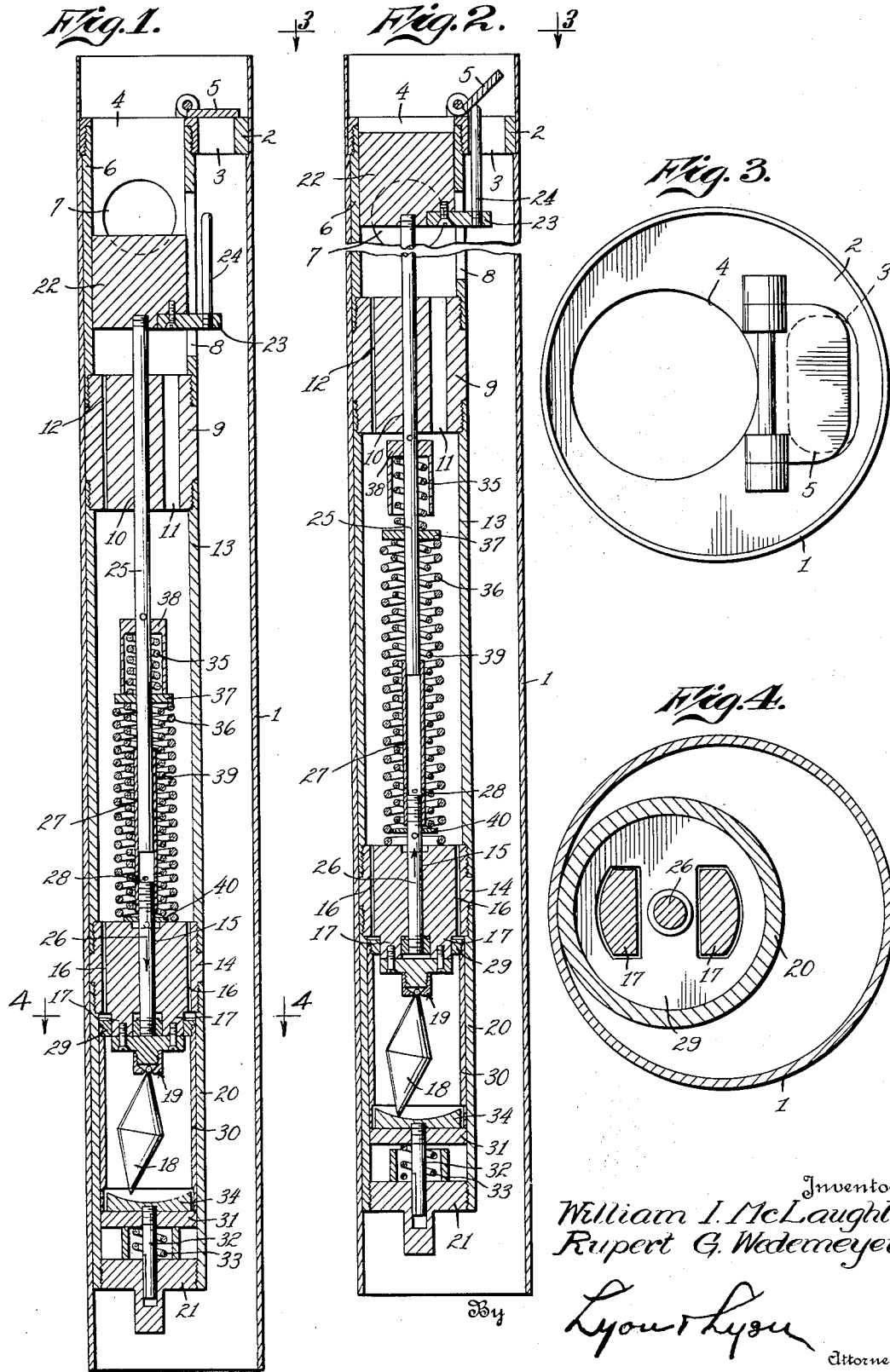
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1,905,299

INSTRUMENT FOR RECORDING INCLINATION

Filed Nov. 3, 1930

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 5.

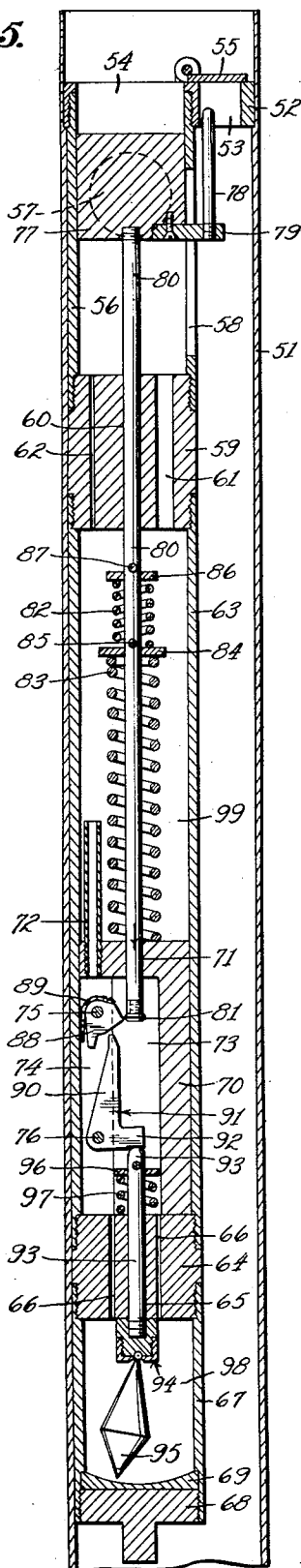
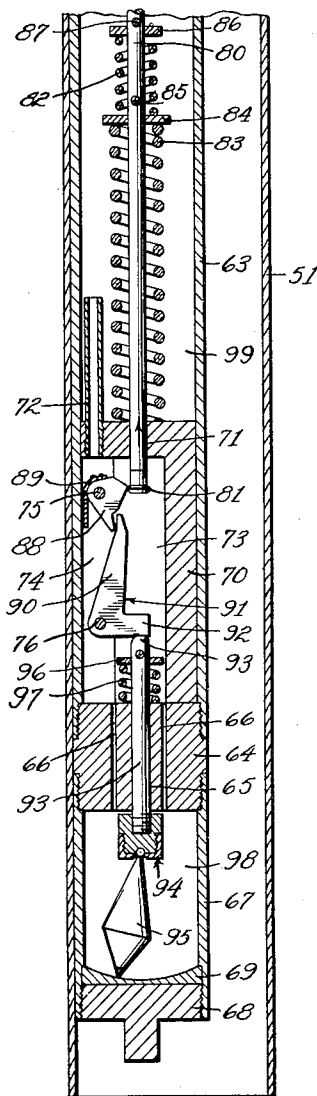


Fig. 6.



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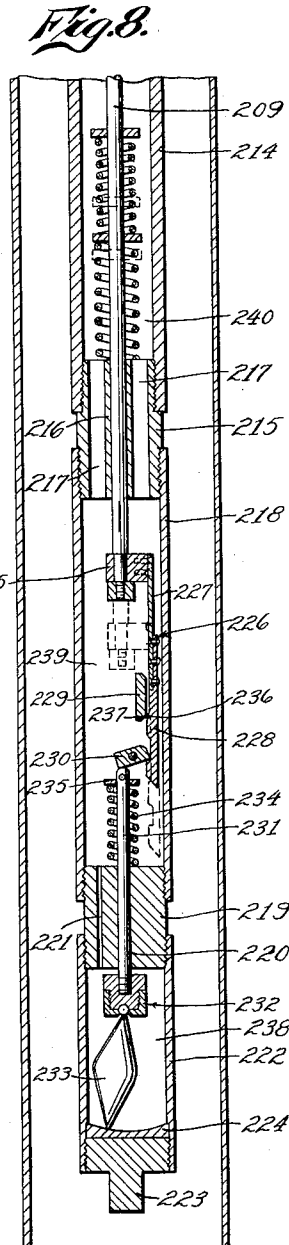
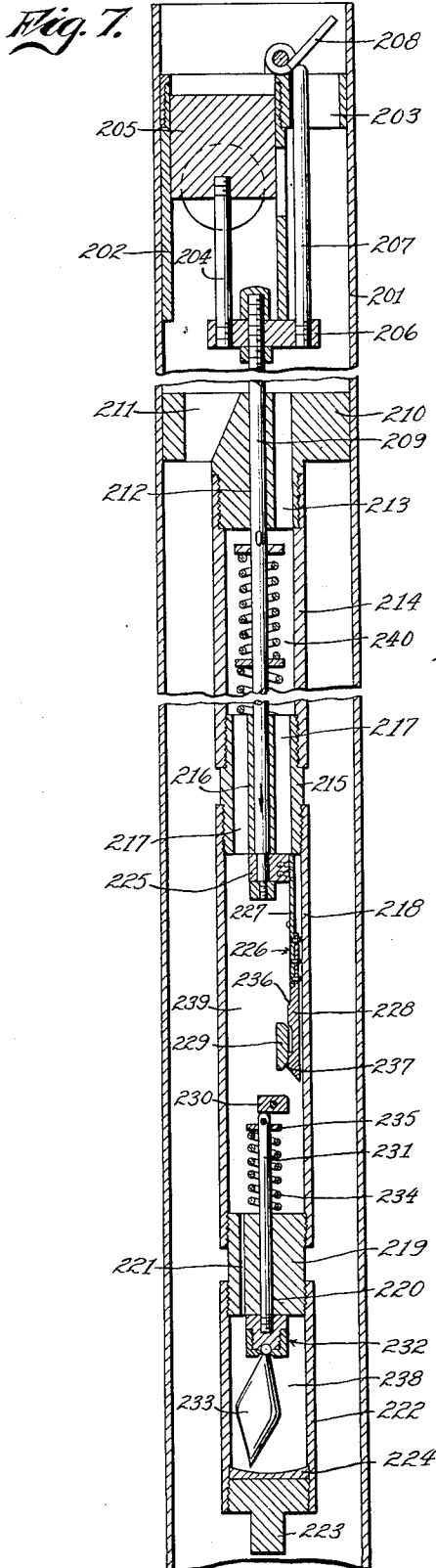
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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INSTRUMENT FOR RECORDING INCLINATION

Application filed November 3, 1930. Serial No. 493,056.

This invention relates to an instrument for recording the inclination of the drill pipe in the drilling of oil wells and more specifically relates to an instrument adapted to be mounted in the drill collar or pipe during the drilling operation and to be actuated by the pressure of the drilling fluid or mud to record the inclination of the drill pipe.

In the drilling of oil wells the use of drill pipe and the forcing of a drilling fluid such as mud down through the drill pipe to wash out the cuttings is so common and so thoroughly understood by those skilled in the drilling art that further description is deemed unnecessary.

An instrument as described in these specifications and as illustrated in the accompanying drawings, as will be appreciated by those skilled in the art, is applicable for a great many different uses, but for the purpose of illustration the invention, will be described and illustrated as adapted to oil well surveying.

In drilling oil well bores, it is desirable to drill a straight hole which will be perpendicular to the normal surface of the earth. However, in the course of drilling the well, the drilling tool is often deflected, or, as commonly termed, "drifts" from its true course. The driller can operate the drilling tool to bring the well bore back to its true course, providing he knows of approximately the locality of the "drift". It is, therefore, the principal object of this invention to provide an instrument which may be mounted in the drill pipe and arranged whereby the instrument may be actuated to record the inclination of the drill pipe where and when deemed necessary.

To withdraw the drill pipe requires considerable time and labor and is, therefore, expensive and consequently the drill pipe is run as long as possible before being withdrawn and it is, therefore, important to provide an instrument which may be actuated any number of times to check the inclination of the drill pipe during a single run.

It is a further object of this invention to provide an instrument which may be actuated any number of times during a single run of

the drill pipe to record the inclination thereof.

It is a further object of this invention to provide an instrument which when mounted in the drill pipe will not materially interfere with or stop the flow of drilling fluid pumped through the drill pipe.

It is a further object of this invention to provide an instrument which will permit the normal filling and draining of the drill pipe during the running-in and withdrawal of the drill pipe.

It is a further object of this invention to provide an instrument which will permit the running-in and withdrawal of the drill pipe without causing the instrument to be actuated.

It is a further object of this invention to provide an instrument which may be actuated responsive to the pressure of the drilling fluid.

It is a further object of this invention to provide an instrument having an oil seal and pressure equalizing means for the plumb-bob chamber.

It is a further object of this invention to provide an instrument having a replaceable recording disc.

Further objects and advantages will appear in the specifications and drawings.

This invention consists in the novel parts and combinations of parts to be described hereinafter, all of which contribute to produce an efficient and easily operated instrument for recording the inclination of the drill pipe. A preferred embodiment of the invention is described in the following specifications and illustrated in the drawings, while the full scope of the invention is pointed out in the appended claims.

In the drawings:

Figure 1 is a longitudinal view of the invention illustrating the position of the operating parts of the instrument during the time the drilling fluid is being pumped through the drill pipe, and further illustrating the recording disc moved out of engagement with the plumb-bob.

Figure 2 is a view similar to Figure 1, illustrating the position of the operating parts of

the instrument when the drilling fluid pumps have been stopped and the pressure thereof dissipated from the drill pipe and also illustrating the recording disc moved into recording engagement with the plumb-bob.

Figure 3 is a plan view, taken substantially on line 3—3 of Figure 2, looking in the direction of the arrows.

Figure 4 is a sectional view, taken substantially on line 4—4 of Figure 1, looking in the direction of the arrows.

Figure 5 is a longitudinal sectional view of the instrument illustrating a modified form of the actuated means and illustrating the position of the parts when the drilling fluid pumps have just been started, causing the parts to be moved downward and also illustrates the plumb-bob held out of engagement with the recording disc.

Figure 6 is a fragmental view of Figure 5 illustrating the relative position of the parts when the drilling fluid pumps have just been stopped and therefore the parts are moving upward causing the bob to be forced into recording engagement with the recording disc.

Figure 7 is a longitudinal sectional view of the instrument illustrating a further modified form of the actuating means and illustrating the relative position of the parts when the drilling fluid pumps are at rest and further illustrating the bob held out of engagement with the recording disc.

Figure 8 is a fragmental view of Figure 7, illustrating in broken lines the relative positions of the parts when the drilling fluid pumps are operating, and further illustrating in full lines the bob in recording engagement with the recording disc resulting from the return of the operating parts to their normal position, as illustrated in Figure 7.

In the preferred embodiment of the invention, as illustrated in the drawings, and especially in Figures 1 to 4, inclusive, a suitable supporting tube 1 is provided. The supporting tube 1 may be of any suitable size for retaining the instrument and aligning the instrument within the inner bore of the drill pipe or collar, (not shown). For convenience and as illustrated in the drawings, the instrument proper has been located off center of the supporting tube 1 but it is also practical to place the instrument in the center thereof. Suitably secured to the upper end of the tube 1 is a valve block 2 having a bypass opening 3 and a large opening 4. Pivottally mounted upon the upper surface of the valve block 2 is a bypass valve 5 arranged in position to close the bypass opening 3. A cylinder 6 may be suitably secured to or formed integral with the valve block 2 and in alignment with the large opening 4, and is provided with ports 7 and a guide slot 8. A cyl-

inder head 9 is secured to the lower end of the cylinder 6 and is provided with a piston rod guide bore 10, a large passage 11 and a relatively small passage 12 and suitably secured to the lower end of cylinder head 9 is an encasing and spacing tube 13. Suitably secured to the lower end of encasing tube 13 is a bearing block 14 having a plunger guide bore 15, two small pressure equalizing passages 16 and two projections 17. A plumb-bob 18 is pivotally suspended on a ball and socket mounting 19 which is secured to the bearing block projections 17. The plumb-bob 18 is enclosed by means of tube 20 which forms a tight joint with bearing block 14 and is sealed at its lower end by means of a removable plug 21.

The parts just described in reality constitute the supporting structure of the instrument and as arranged provide a structure by which the more delicate parts of the instrument may be protected by filling the supporting structure with water, oil or grease so that these parts will not be hindered in their proper functioning by the heavy drilling mud. The supporting structure also provides for equalizing the pressure in the instrument with the pressure of the drilling fluid, the pressure equalizing passages are so arranged that the pressure is equalized from one chamber to the next serially so as to further safeguard the proper functioning of the plumb-bob. The passage 11 is larger in volume than the volume displaced by the action of the piston rod 25 later to be described, in moving into and out of the spring chamber so that no drilling mud will be forced into the spring chamber.

The operating parts include a piston 22 slidably mounted in cylinder 6 and is provided with a rod support 23 which projects through the cylinder guide slot 8 and is provided with an upwardly extending rod 24 adapted, when the piston 22 is at the upper end of the stroke, to engage and hold open the by-pass valve 5 which position is illustrated in Figure 2.

A piston rod 25 is operatively connected with piston 22 and extends through guide bore 10 of cylinder head 9. A plunger 26, in alignment with the piston rod 25, is guided in bore 15 of bearing block 14 and at its upper end is provided with a tube 27 into which the lower end of piston rod 25 is slidably fitted.

As piston rod 25 moves relative to tube 27 it is necessary to vent the tube and for this purpose any suitable means may be used, such as vent holes 28. Connected to the lower end of plunger 26 is yoke 29 which may be guided by the two projections 17 of bearing block 14. The extent of travel of yoke 29 is limited between block 14 and the plumb-bob mounting 19.

Secured to yoke 29 is the operating cylinder

30 which is slidably mounted in the plumb-bob encasing tube 20. There is also slidably mounted in the plumb-bob encasing tube 20 a plunger 31 which is guided by a plunger rod 32 and is yieldably held in engagement with the lower end of operating cylinder 30 by means of spring 33 which is mounted between the plunger 31 and the removable plug 21.

Suitably mounted upon plunger 31 is a recording disc 34 of suitable material such as wood, a soft white metal or brass, on which are scribed circles so that the degree from the vertical may be read. Suitable means are employed for normally and yieldingly retaining the operating parts of the instrument in the position shown in Figure 2. The first portion of these means includes a primary spring 35, a secondary spring 36, an intermediate washer 37 and a washer or collar 38 which is suitably secured on the piston rod 25. The washer or collar 38 may be provided with a sleeve preferably formed integral therewith and arranged to surround spring 35. The sleeve formed upon the collar 38 may be dispensed with and a pin or other means may be positioned in or secured to the piston rod 25 to control the amount of travel of piston rod 25 as illustrated in Figures 5 and 6. By this arrangement of parts, the piston 22 is maintained in the position illustrated in Figure 2.

The primary spring 35 is adjusted to enable the piston 22, when the pump is started, to move a sufficient distance to withdraw rod 24 from holding bypass valve 5 open and to thus permit the bypass valve 5 to close, so that the entire pressure of the drilling fluid or mud will be exerted against piston 22 which will cause piston 22 to exert sufficient force to move downward against the forces of springs 35 and 36, and until a sufficient portion of the port 7 is exposed to take care of the pumped fluid.

The second portion of these means includes the spring 39 surrounding the plunger 26 and positioned between slidable washer 37 and a washer or collar 40 suitably secured on plunger 26. When the piston rod 25 compresses spring 36 spring 39 is likewise compressed until finally spring 39 overcomes the force exerted by spring 33 to shift the recording disc 34 away from the point of the plumb-bob 18. This position of parts is illustrated in Figure 1. When the pumps are stopped, the pressure of the drilling fluid or mud is dissipated and the force exerted by the springs 35, 36, and 39 is sufficient to return piston 22 to its initial position and to cause piston 22 by means of rod 24 to open the bypass valve 5 and also enables spring 33 to again force the recording disc 34 in recording engagement with the point of bob 18.

The operation of the instrument is as follows:

The instrument is placed in the lower end of the drill collar so that the tubing 1 will

hold the instrument and align it within the inner bore of the drill collar. The drill collar is then connected to the drilling tool (not shown) and then the tool, collar and drill pipe are lowered into the well.

During the lowering operation, the instrument is maintained as illustrated in Figure 2, wherein bypass valve 5 is held raised so that the drill pipe may fill through the bypass opening 3 with the drilling fluid or mud contained in the well bore and also wherein the recording disc 34 is held in contact with the plumb-bob 18. As soon as the drill pipe has been run-in the drilling operation is commenced. The pumps are turned on to pump drilling fluid or mud through the drill pipe to the drilling tool. This mud passes through the instrument between the instrument proper and the inside of tube 1. The pressure of the pumped drilling fluid will be sufficient to force piston 22 to lower, thus lowering rod 24 until the bypass plate valve 5 is closed so that the entire pressure of the drilling mud will be exerted against piston 22 thus causing piston 22 to move still further until sufficient area of port 7 is uncovered to permit the pumped fluid to discharge into the inside of tube 1.

The lowering of piston 22 transmits motion through piston rod 25, spring 39 to plunger 26, yoke 29, operating tube 30 which in turn forces plunger 31 down against the action of spring 33 and also plunger 31 carries the recording disc 34 out of engagement with bob 18. The bob 18 is now released so that it may swing freely. When it is desired to take a reading, to determine whether the drilling operation has drifted or inclined from its true course, the rotation of the drill pipe is stopped and the pumps continued in action to maintain the bob 18 free from the recording disc 34 until the bob has had sufficient time to settle into a vertical plane. The pumps are then stopped to allow piston 22 to return to its initial position, as shown in Figure 2, to again permit spring 33 to force plunger 31 and disc 34 into recording engagement with plumb-bob 18.

The drill string may now be removed from the well bore and by referring to the recording disc 34 the driller can observe whether the well is being drilled on its true course, or whether the drilling tool has been deflected or drifted from its true course. Should the driller desire to continue drilling after taking the first reading the drilling is resumed and the pumps are again started as before described.

As soon as the pumps are started plunger 22 is again forced downward and through the mechanism already described forces the recording disc away from bob 18. A second reading may be taken by again stopping the drilling operation, permitting the bob to come to rest, and then stopping the pump as

before described, and upon completion of the reading, the drilling may be again resumed.

When it is necessary to raise the drill pipe 5 to change the tool, a new recording disc 34 can be inserted in place of the old one. The readings on the old disc may be entered in the log and the disc filed away for future reference.

10 In the modified form of the invention illustrated in Figures 5 and 6, there is suitably secured adjacent the upper end of supporting tube 51 a valve block 52 having the bypass opening 53 and opening 54, and pivotally 15 mounted upon the upper surface thereof is bypass valve 55 positioned to close opening 53. A cylinder 56 is suitably secured in opening 54 and is provided with ports 57 and guide slot 58. The cylinder head 59 is secured to the lower end of cylinder 56 and is 20 provided with a piston rod guide bore 60 and passages 61 and 62. A spacing tube 63 is secured to the lower end of head 59 and to the lower end thereof is secured bearing 25 block 64 having plunger rod guide bore 65 and two small pressure equalizing passages 66.

Secured to the lower end thereof is the plumb-bob enclosing tube 67 which is tightly 30 sealed at its lower end by the removable plug 68. A recording disc 69 made of wood, brass or any other suitable material, is securely held adjacent the lower end of the plumb-bob enclosing tube 67 by any suitable means 35 such as in the present instance by the removable plug 68. The recording disc 69 may be inscribed with concentric circles indicating degrees from the vertical. Suitably mounted in spacing tube 63 adjacent bearing 40 block 64 is the guide block 70 which is provided with a piston rod guide bore 71, a pressure equalizing tube 72, an enlarged central bore 73, a longitudinal slot 74, and extending transversely of slot 74 is the cam 45 lever pivot pin 75 and the bob actuating lever pivot pin 76.

Having described the stationary elements which in reality form the framework of the instrument proper, the operating elements 50 will now be described in relation thereto:

Slidably mounted in cylinder 56 is piston 77 and to enable the piston to actuate the bypass valve 55 a rod 78 is suitably mounted upon piston 77 by rod support 79. Operatively 55 connected to piston 77 is a piston rod 80 which passes through the guide bores 60 and 71 and has positioned upon its lower end an operating cam surface 81. To yieldably maintain piston 77 in the upper end 60 of cylinder 56 in position so that rod 78 holds open the bypass valve 55, two springs are provided. The primary spring 82 is of less strength than the secondary spring 83 to permit a relatively light pressure of the drilling 65 ing fluid to actuate piston 77 to withdraw

rod 78 so that bypass valve 55 may close passage 53 to divert the entire volume and pressure of the pumped drilling fluid to act upon piston 77 to force piston 77 downward 70 against the action of the secondary spring 83 a sufficient distance to uncover sufficient area of ports 57 and slot 58 to permit the pumped drilling fluid to pass through the instrument.

To provide for the action of springs 82 75 and 83 just described, any suitable arrangement may be used, in the present instance, spring 83 is mounted around piston rod 80 and abuts at one end against guide block 70 and at the other end against the slidable 80 washer 84 limited in its move by any suitable means, such as pin 85.

As will be noted in Figure 6, pin 85 is not in engagement with washer 84 but upon the downward movement of piston 80, due 85 to pressure acting upon piston 77, pin 85 is brought into engagement with washer 84 and upon further downward travel of piston rod 80 compression of spring 83 takes place. The 90 primary spring 82 is positioned surrounding piston rod 80 and acting between washer 84 and washer or collar 86 suitably secured to the piston rod 80 as in this instance by pin 87.

When the piston rod 80 is forced downward cam surface 81 engages the cam surface 95 of cam lever 88. As is clearly shown in Figure 5 a further movement of cam 81 forces cam lever to rotate about its pivot 75 in a clockwise direction until cam 81 has passed by. A cam lever spring 89 returns 100 lever 88 to its normal position. When the pressure of the drilling fluid is released, piston 77, piston rod 80 and cam 81 are moved upward due to the tension of springs 82 and 105 83. The cam surface 81 in its upward course, again engages cam lever 88, but this time, as will be noted from Figure 6, cam lever 88 is swung in a counterclockwise direction causing one arm of lever 88 to engage arm 110 90 of bell crank lever 91 which is pivoted upon pin 76. Arm 92 of lever 91 extends in position to engage the plumb-bob actuating plunger 93. The plunger 93 extends through and is guided in bore 65 of bearing block 64 115 and upon the lower end thereof is a pivotal mounting, such as the ball and socket joint 94 of plumb-bob 95.

Secured, adjacent the upper end of plunger 93, is a collar or washer 96 acted upon by 120 spring 97, which normally yieldably holds bob 95 out of engagement with the recording disc 69. When plunger 93 is engaged and forced downward by arm 92 of lever 90, spring 97 is compressed and bob 95 is forced 125 into recording engagement with disc 69. The position of the parts just described is illustrated in Figure 6. When cam 81 passes above lever 88, spring 89 returns lever 88 to its normal position and likewise spring 130 97 returns lever 91 to its normal position and

at the same time lifts bob 95 from contact with disc 69.

In the form of the invention just described, it will be seen that the bob is only momentarily forced into recording engagement with the recording disc and this action takes place only after the pumps have been started and then shut off. Like in the previous form of the invention, any number of readings may be taken where and when deemed necessary by the driller.

Like in the previous form of the invention, it is desirable to fill the plumb-bob chamber 98 the central bore 73 and chamber 99, also passages 61, 62, 72 and 66 with water, oil, grease or other suitable fluid, for keeping the mechanism and chambers free from the drilling fluid or mud and to permit the equalization of pressure inside and out, passage 62 should be of greater volume than that volume displaced by piston rod 80 so as to prevent the mud from working into chamber 99.

In the modification of the invention illustrated in Figures 7 and 8, it will be noted that the instrument proper is mounted substantially concentric with the supporting tube 201, whereas cylinder 202 and passage 203 are positioned as in the previous figures. A piston rod 204 transmits the motion of piston 205 to crosshead 206, through crosshead 206 to valve rod 207 positioned to actuate the bypass valve 208 and also through crosshead to plunger 209.

Suitably mounted in supporting tube 201 is the supporting member 210 having one or more fluid passages 211, a plunger guide bore 212 and a pressure equalizing passage 213. The supporting member 210 is also provided with a section of reduced diameter to which tube 214 is suitably secured. A guide block 215 is secured to the lower end of tube 214 and is provided with a plunger rod guide bore 216 and one or more pressure equalizing passages 217. A second tube 218 is suitably secured to the lower end of guide block 215 and secured to the lower end of said tube is bearing block 219 having a plumb-bob plunger and guide bore 220 and the pressure equalizing passage 221. A plumb-bob enclosing tube 222 is secured to the lower end of bearing block 219 and is sealed at its opposite end by the removable plug 223. A recording disc 224 of wood, brass, or other suitable material, is firmly held in tube 222 by means of plug 223 or other suitable means.

Plunger 209 extends through the guide bores 212 and 216 of members 210 and 215, respectively, and is yieldingly maintained in its upper position, as illustrated in Figure 7, by substantially the same arrangement of springs as shown in the previous figures. Upon the lower end of plunger 209 is mounted block 225 to which is suitably secured a spring latch 226 comprising a flat spring 227

and the latch member 228. Secured to tube 218 is a guide member 229 for controlling the action of latch member 228. Pivotaly mounted in tube 218 is lever 230 having one end positioned to be engaged and rotated in a counterclockwise direction by latch member 228 upon its upward travel, as illustrated in Figure 8, and positioned whereby its opposite end engages and actuates the plumb-bob plunger 231 when rotated by latch member, as above stated. The plumb-bob plunger 231 is guided in and extends through bearing block 219 and is provided at its lower end with a suitable pivotal, or ball and socket, mounting 232 for the plumb-bob 233. The bob 233 is normally held out of engagement with the recording disc 224 by means of spring 234 positioned between bearing block 219 and washer 235 suitably secured adjacent the upper end of plunger 231.

In operation, when the pumps are started spring latch is lowered to the position indicated in broken lines in Figure 8, through the elements already described. When the pumps are shut off and the pressure dissipated, the spring latch 226 moves upward, latch member 228 engages lever 230, as illustrated in Figure 8 in full lines.

Lever 230 is rotated counterclockwise and due to its operative relation with the bob plunger 231 the bob 233 is forced into engagement with the recording disc 224 thus recording the inclination of the drill pipe. Upon further movement upward of spring latch 226 the inclined surface 236 of latch member 228 contacts with a similar inclined surface 237 of guide member 229 to force latch member 228 laterally to disengage it from lever 230.

The instrument may be caused to actuate any number of times during the drilling operation by stopping the rotation of the drill pipe to permit bob 233 to seek the true vertical plane and then by stopping the drilling fluid pumps and as the pressure of the drilling fluid dissipates the bob is actuated to record upon the disc the inclination of the instrument and thus the inclination of the drill pipe from its true course.

The structure of the instrument provides three separate chambers, namely the bob chamber 238, actuating mechanism chamber 239 and spring chamber 240. Communicating between bob chamber 238 and actuating mechanism chamber 239 is the pressure equalizing passage 221 and between chamber 239 and the spring chamber 240 there are one or more pressure equalizing passages 217, and finally passage 213 equalizes the pressure in chamber 240 with the pressure surrounding the exterior of the instrument.

Before the instrument is mounted in the drill collar or pipe the chambers and equalizing passages are all filled with water, oil or other fluid to prevent the intrusion of the

drilling fluid into the instrument. Passage 213 should be of greater volume than that volume displaced by the plunger 212 when moved in or out of the instrument proper.

5 Having fully described my invention, it is to be understood that I do not wish to be limited to the details herein set forth, but my invention is of the full scope of the appended claims:

10 I claim:

1. An instrument for measuring inclination including the combination of a pivotally mounted plumb-bob, a recording disc, a piston slidable to uncover a fluid passage, a spring means opposed to said piston, and means associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

2. An instrument for measuring inclination including the combination of a pivotally mounted plumb-bob, a recording disc, a bypass means, a piston slidable to uncover a fluid discharge passage and arranged to actuate said bypass means, a spring means opposed to said piston, and means associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

3. An instrument for measuring inclination including the combination of a pivotally mounted plumb-bob, a recording disc, a bypass valve, a cylinder having a discharge port, a piston slidably mounted in said cylinder and arranged to open and close said discharge port and operative to actuate said bypass valve, a differential spring means opposed to said piston whereby said piston may be moved by a relatively low pressure to close said bypass valve and whereby said piston may be moved a further distance by a higher pressure to uncover said cylinder discharge port, and means associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

4. An instrument for measuring inclination including the combination of a pivotally mounted plumb-bob, a recording disc, a cylinder having a bypass means and a discharge port, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or close said discharge port, a primary spring means opposed to said piston and arranged to permit a relatively low pressure to move said piston to close said bypass means, a secondary spring means opposed to said piston and arranged to permit a greater pressure to further move said piston to open said discharge port, and means associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

5. In an instrument for measuring inclination, a fluid seal therefor including the combination of a supporting structure having a plurality of chambers adapted to be filled

with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof.

6. In an instrument for measuring inclination, a fluid seal therefor including the combination of a supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof and whereby the volume of the port communicating with the exterior is of greater capacity than the volume of fluid displaced in said chamber during the operation of the instrument.

7. An instrument for measuring inclination, including the combination of a supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof, a plumb-bob pivotally mounted in one of said chambers, a recording disc, and means responsive to changes in fluid pressure for forcing said bob and disc to and from recording engagement.

8. An instrument for measuring inclination including the combination of a supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof, a plumb-bob pivotally mounted in one of said chambers, a record disc, a cylinder formed in said supporting structure and having a bypass means and a discharge port, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or close said discharge port, a spring means mounted in serial chambers and opposed to said piston, and means extending through said chambers associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

9. An instrument for measuring inclination including the combination of a supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof, a plumb-bob pivotally mounted in one of said chambers, a recording disc associated therewith, a cylinder formed in said supporting structure and having a bypass means and a discharge port, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or close said discharge port, a primary spring means opposed to said piston and arranged to permit a relatively low pressure to move said piston to close said bypass means, a secondary spring means also opposed to said piston and arranged to permit a further movement of said piston when a greater pressure is exerted thereagainst to open said dis-

charge port, and means associated with said piston for yieldingly forcing said bob and disc to and from recording engagement.

10. An instrument for measuring inclination including the combination of a piston slidable to uncover fluid passages, a spring means opposed to said piston, a pivotally mounted plumb-bob, a recording disc, and means operatively connecting said piston and said disc.

11. An inclination recording instrument including the combination of a pivotally mounted plumb-bob, a recording disc, means for yieldingly holding said bob and disc in recording engagement, and means actuated by fluid pressure for releasing said bob and disc from recording engagement.

12. An inclination recording instrument including the combination of a pivotally mounted plumb-bob, a recording disc, means to yieldingly hold said bob and disc in recording engagement, and means operated by fluid pressure to actuate said yieldable holding means to release said bob and disc from recording engagement.

13. An inclination recording instrument including the combination of a pivotally mounted plumb-bob, a recording disc, means for yieldingly holding said bob and disc in recording engagement, and means responsive to a predetermined fluid pressure for releasing said bob and disc from recording engagement.

14. An inclination recording instrument including the combination of a pivotally mounted plumb-bob, a recording disc, a spring to yieldingly hold said bob and disc in recording engagement, a piston actuated by pressure fluid to release and hold released said bob and disc from recording engagement.

15. In an instrument for recording inclination, an operating mechanism for actuating a recording disc to and from recording engagement with a pivotally suspended plumb-bob including the combination of a piston slidably mounted in the instrument, a piston rod associated with said piston, a first spring means associated with said piston rod, a recording disc supporting means, and a second spring means operatively arranged between said piston rod and said disc supporting means.

16. In an instrument for recording inclination, an operating mechanism for actuating a recording disc to and from recording engagement with a pivotally suspended plumb-bob including the combination of a piston slidably mounted in the instrument, a piston rod associated with said piston, a first spring means associated with said piston rod, and a second spring means operatively arranged between said piston rod and said disc supporting means, and a third spring means for yieldingly urging the re-

cording disc into engagement with the plumb-bob.

17. An inclination recording instrument including the combination of a plumb-bob chamber filled with a suitable fluid, a pressure equalizing chamber likewise filled with a suitable fluid, a pressure equalizing passage serially connecting said chambers with the exterior thereof, a plumb-bob suitably mounted in said bob chamber, a recording disc also suitably mounted in said bob chamber, means for yieldingly holding said bob and disc in recording engagement, and means actuated by fluid pressure for releasing said bob and disc from recording engagement.

18. An inclination recording instrument including the combination of a plumb-bob chamber filled with a suitable fluid, a pressure equalizing chamber filled with a suitable fluid, pressure equalizing ports serially connecting said chambers with the exterior thereof, a plumb-bob suitably mounted in said bob chamber, a recording disc suitably mounted in said bob chamber, means for yieldingly holding said bob and disc in recording engagement, and means operated by fluid pressure to actuate said yieldable holding means for releasing said bob and disc from recording engagement.

19. An inclination recording instrument including the combination of a pivotally mounted plumb-bob, a recording disc associated therewith, means for yieldingly holding said bob and disc apart, and means actuated upon the release of the fluid pressure for forcing said bob and disc into recording engagement.

20. In an instrument for recording inclination adapted to be actuated responsive to changes in fluid pressure comprising the combination of a supporting structure, a cylinder formed therein and having a bypass means and a fluid discharge means, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or close said discharge means, a spring means operatively opposed to said piston, a recording disc suitably supported in said structure, a plumb-bob pivotally mounted within said structure and associated with said disc, means for yieldably holding said bob out of recording engagement with said disc, a bob actuating means operatively associated with said piston and arranged as said piston returns to its uppermost position to engage and actuate said bob holding means to force said bob into recording engagement with said disc and upon further upward movement of said piston to automatically disengage from said bob holding means.

21. In an instrument for recording inclination an operating mechanism for actuating a plumb-bob to and from recording engagement with a recording disc including

the combination of a piston slidably mounted in the instrument, a piston rod associated with said piston and having a head, a spring means associated with said piston rod, a first lever means positioned to be engaged and rotated by said piston rod head, a second spring means arranged to yieldably retain said first lever means in operative position, a second lever means positioned to be engaged and rotated by said first lever means when said first lever means rotates in one direction, a plumb-bob supporting means positioned to be engaged and operated by said second lever means, a third spring means arranged to yieldingly retain said bob supporting means in operative engagement with said second lever means.

22. In an instrument for recording inclination including the combination of a suitable supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof, a cylinder formed in said structure and having a bypass means and a discharge port, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or close said discharge port, a piston rod associated with said piston and having a head, a spring means mounted in the upper of said chambers associated with said piston rod, a first lever means operatively mounted in the intermediate of said chambers positioned to be engaged and rotated by said piston rod head, a second spring means mounted in the upper of said chambers arranged to yieldingly retain said first lever means in operative position, a second lever means operatively mounted in the intermediate of said chambers positioned to be engaged and rotated by said first lever means when said first lever means rotates in one direction, a plumb-bob supporting means positioned to be engaged and operated by said second lever means, a third spring means arranged to yieldingly retain said bob supporting means in operative engagement with said second lever means, a plumb-bob pivotally suspended from said bob supporting means in the lowermost of said chambers, and a recording disc mounted in said lowermost chamber within the operating range of said plumb-bob.

23. In an instrument for recording inclination including the combination of a suitable supporting structure having a plurality of chambers adapted to be filled with a suitable fluid and having pressure equalizing ports serially connecting said chambers with the exterior thereof, a cylinder formed in said structure and having a bypass means and a discharge port, a piston slidably mounted in said cylinder and arranged to actuate said bypass means and to open or

close said discharge port, a piston rod associated with said piston and having a spring latch, a spring means mounted in the upper of said chambers and associated with said piston rod, a lever means operatively mounted in the intermediate of said chambers and positioned to be engaged and rotated by said spring latch, a plumb-bob supporting means positioned to be engaged and operated by said lever means, a second spring means arranged to yieldingly retain said bob supporting means in elevated position, a plumb-bob pivotally suspended from said bob supporting means in the lowermost of said chambers, and recording disc mounted in said lowermost chamber within the operating range of said plumb-bob.

24. In an instrument for recording inclination an operating mechanism for actuating a plumb-bob to and from recording engagement with a recording disc including the combination of a piston slidably mounted in the instrument, a piston rod associated with said piston and having a spring latch, a spring means associated with said piston rod, a lever means positioned to be engaged and rotated by said spring latch, a plumb-bob supporting means positioned to be engaged and operated by said lever means, and a second spring means arranged to yieldingly retain said bob supporting means in elevated position.

25. In an instrument for recording inclination a bypass means including the combination of a supporting structure having a cylinder and a bypass port, a piston slidably mounted in said cylinder, a valve means operatively arranged to close said bypass port, and means associated with said piston for actuating said valve means.

26. An instrument for measuring inclinations including the combination of a piston slidable to uncover fluid passages, a spring means opposed to said piston, a pivotally mounted plumb-bob, a recording disc, and means operatively connecting said piston and said bob.

27. In an instrument for recording inclination including the combination of a valve means responsive to fluid pressure, an enclosing structure, a plumb-bob pivotally mounted therein, a recording disc slidably mounted in said structure, means for resiliently urging said disc into engagement with said bob, and means operatively connecting said valve means and said disc, and arranged to actuate said recording disc to and from recording engagement.

Signed at San Francisco this 29th day of October, 1930.

WILLIAM I. McLAUGHLIN.
RUPERT G. WEDEMEYER.