

June 15, 1971

R. G. TAYLOR, JR

3,584,386

PENDULUM RELEASE MECHANISM FOR SIGNALLING DRIFT INDICATORS

Filed June 24, 1968

6 Sheets-Sheet 1

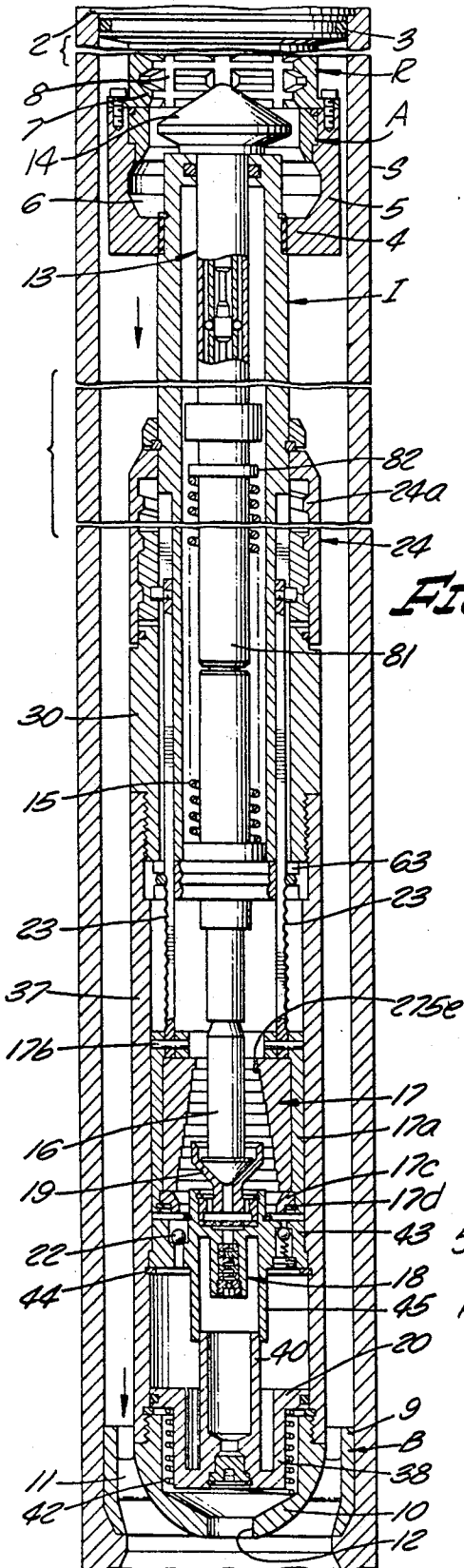


FIG. 1.

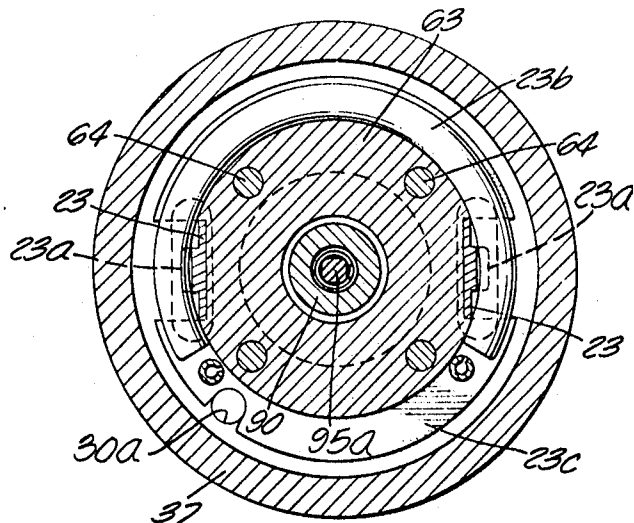


FIG. 3.

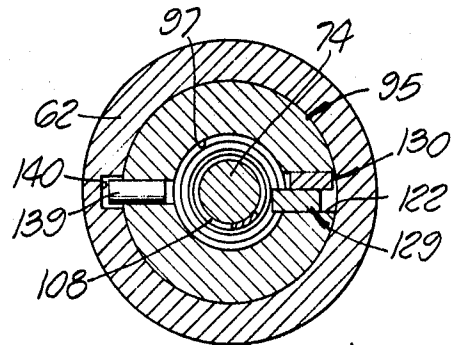


FIG. 4.

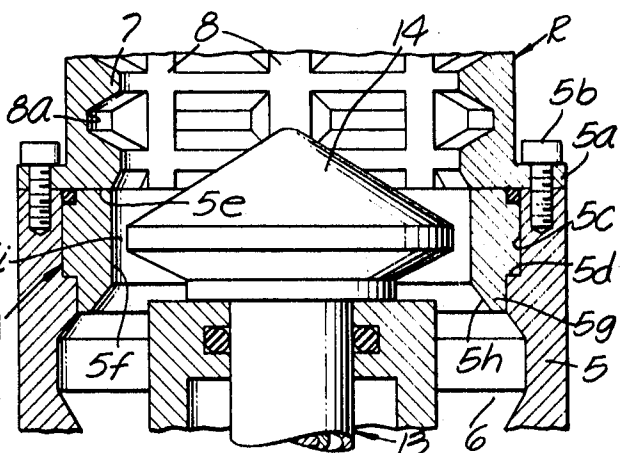


FIG. 5.

INVENTOR.
RAYMOND G. TAYLOR, JR.
BY *b. G. Stallings*
ATTORNEY

June 15, 1971

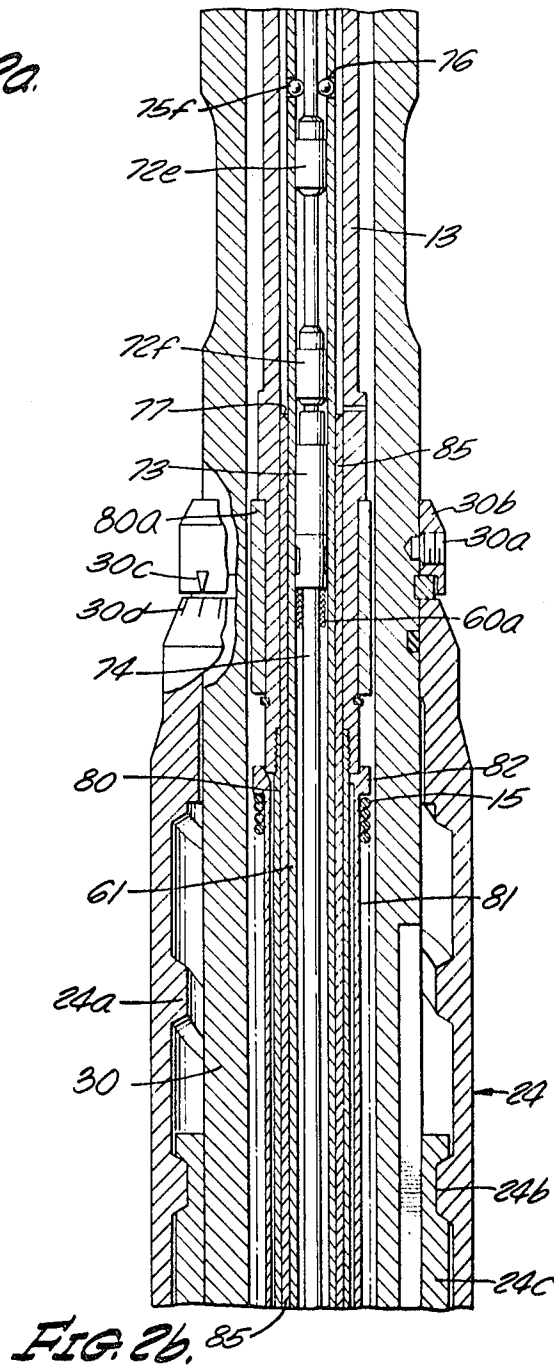
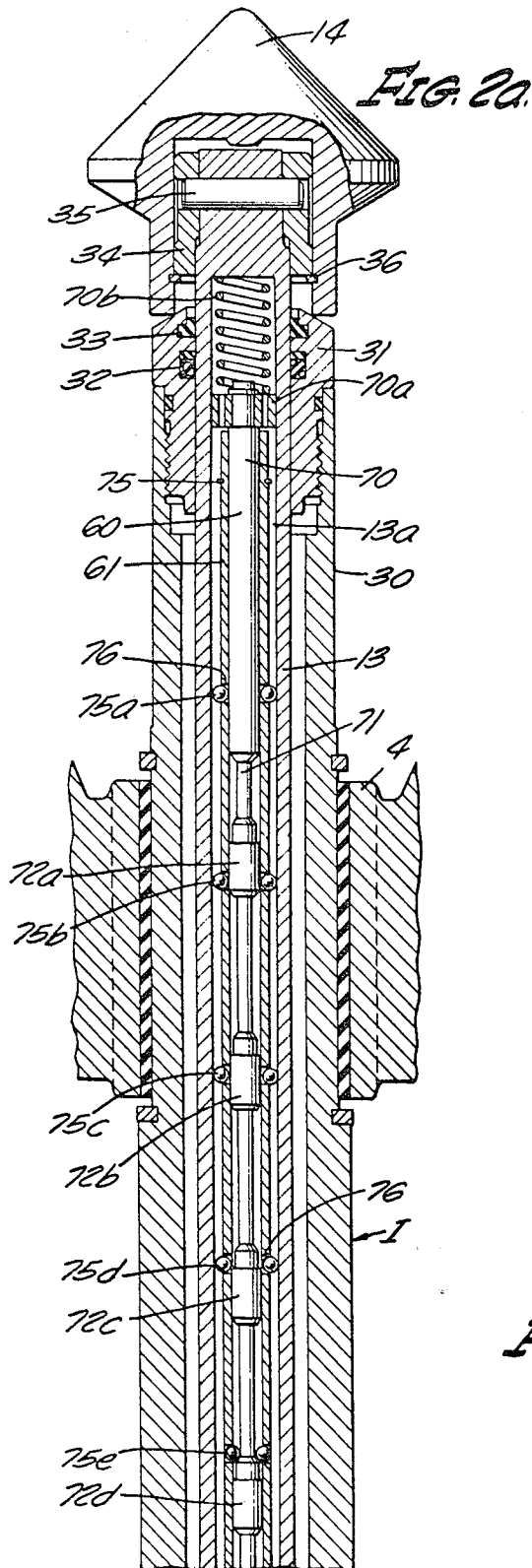
R. G. TAYLOR, JR

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PENDULUM RELEASE MECHANISM FOR SIGNALLING DRIFT INDICATORS

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INVENTOR
RAYMOND G. TAYLOR, JR.
BY *b. g. Stallings*

ATTORNEY

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R. G. TAYLOR, JR

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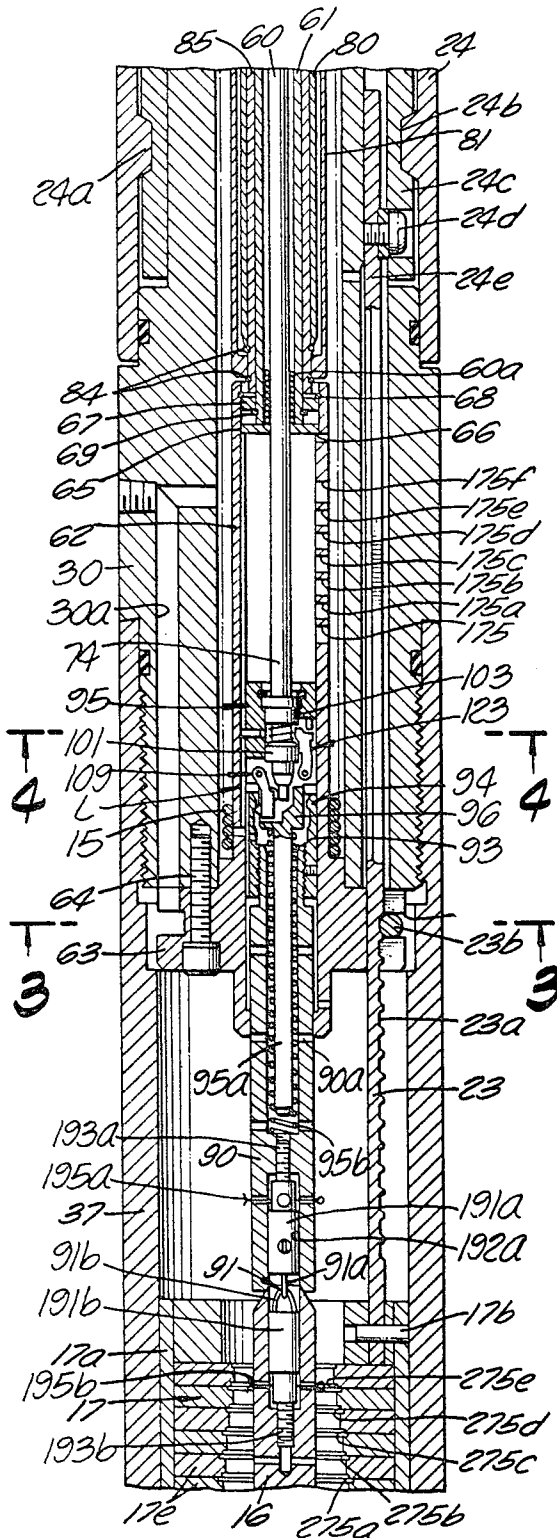


FIG. 2C.

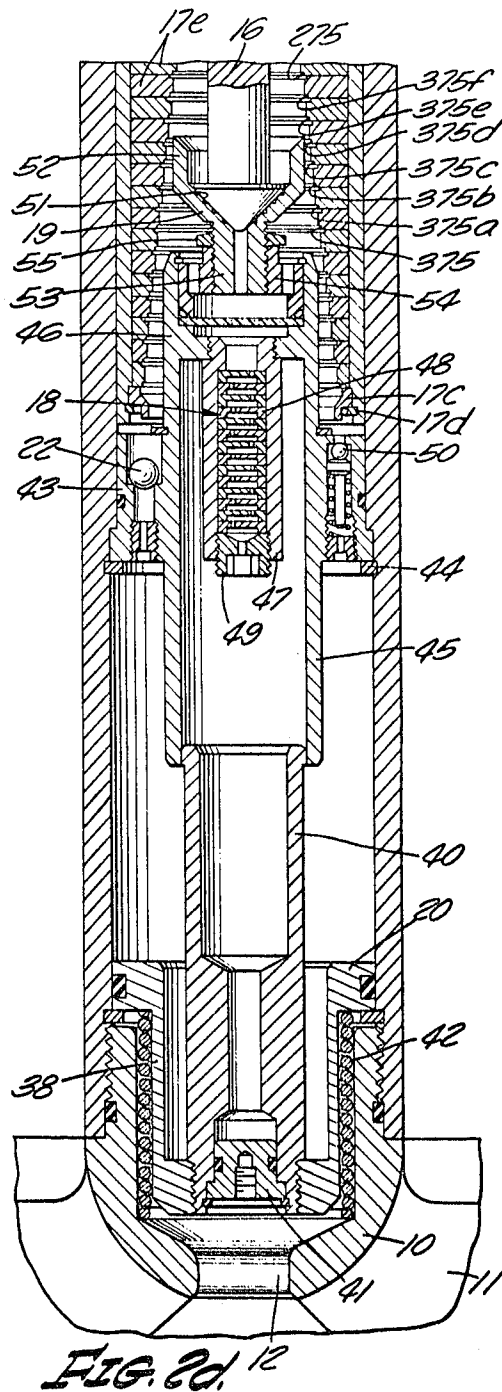


FIG. 2d.

INVENTOR
RAYMOND G. TAYLOR, JR.

BY *b. g. Stallings*

ATTORNEY

June 15, 1971

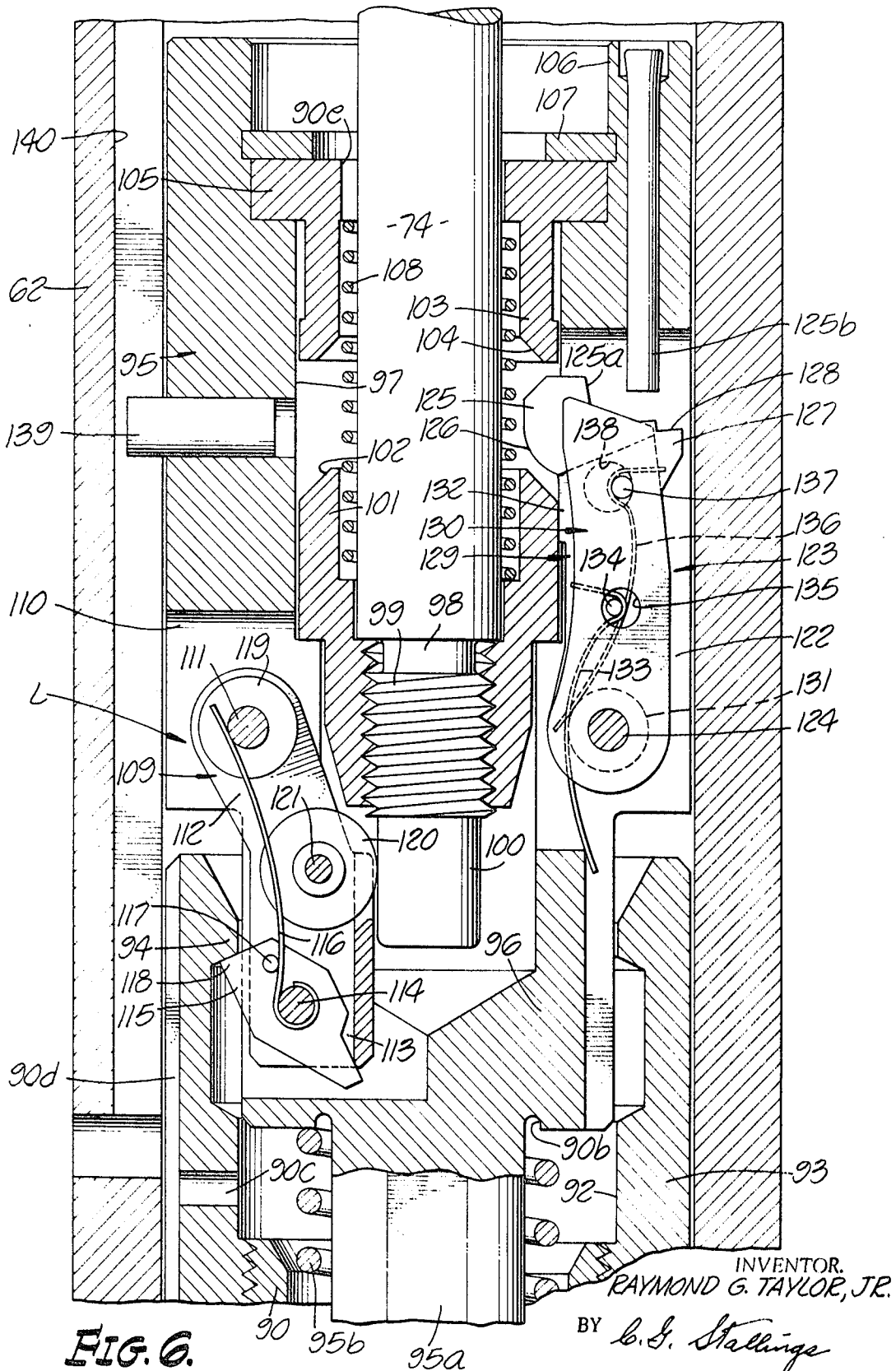
R. G. TAYLOR, JR

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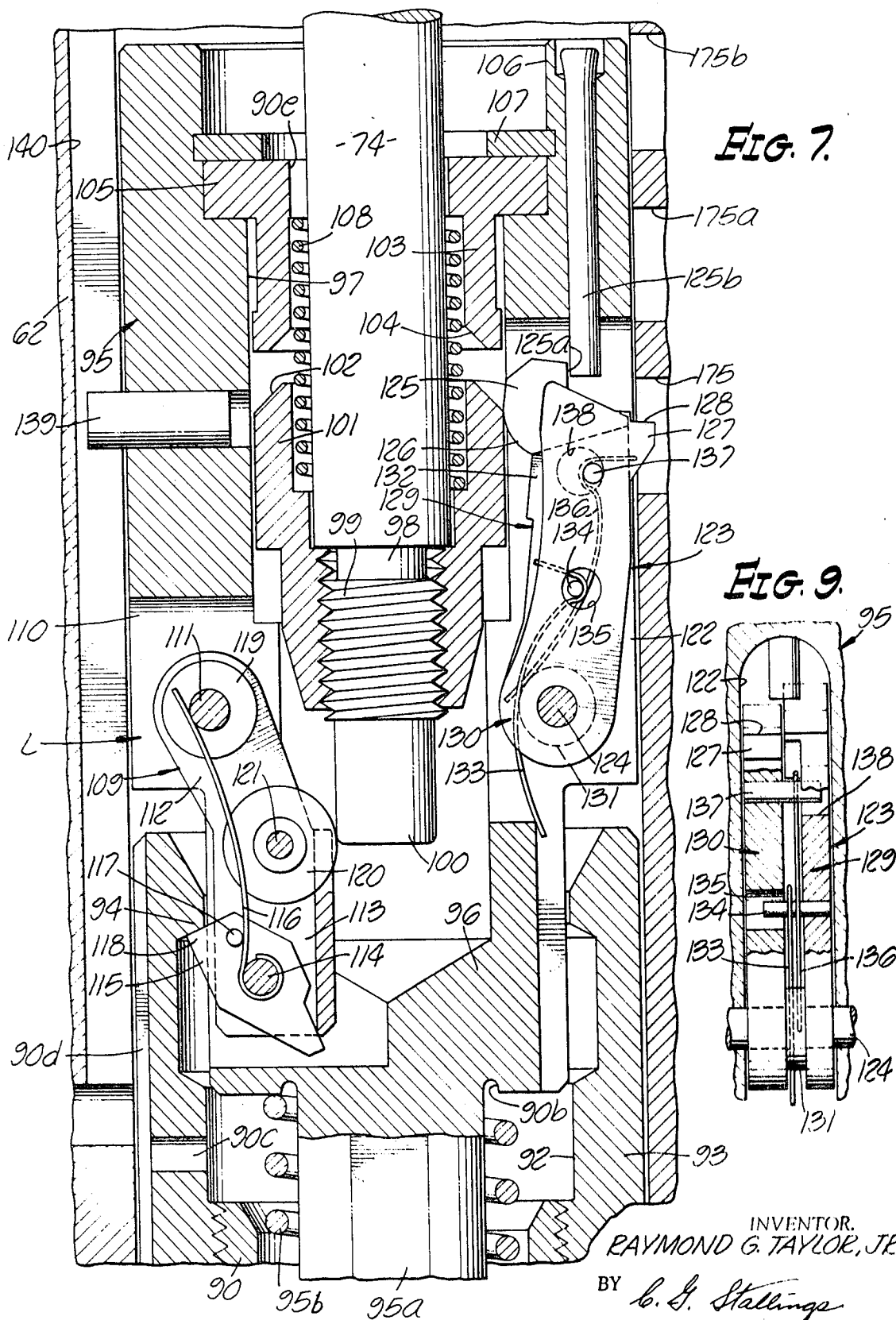
R. G. TAYLOR, JR

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INVENTOR.
RAYMOND G. TAYLOR, JR.
BY *b. S. Stallings*
ATTORNEY

June 15, 1971

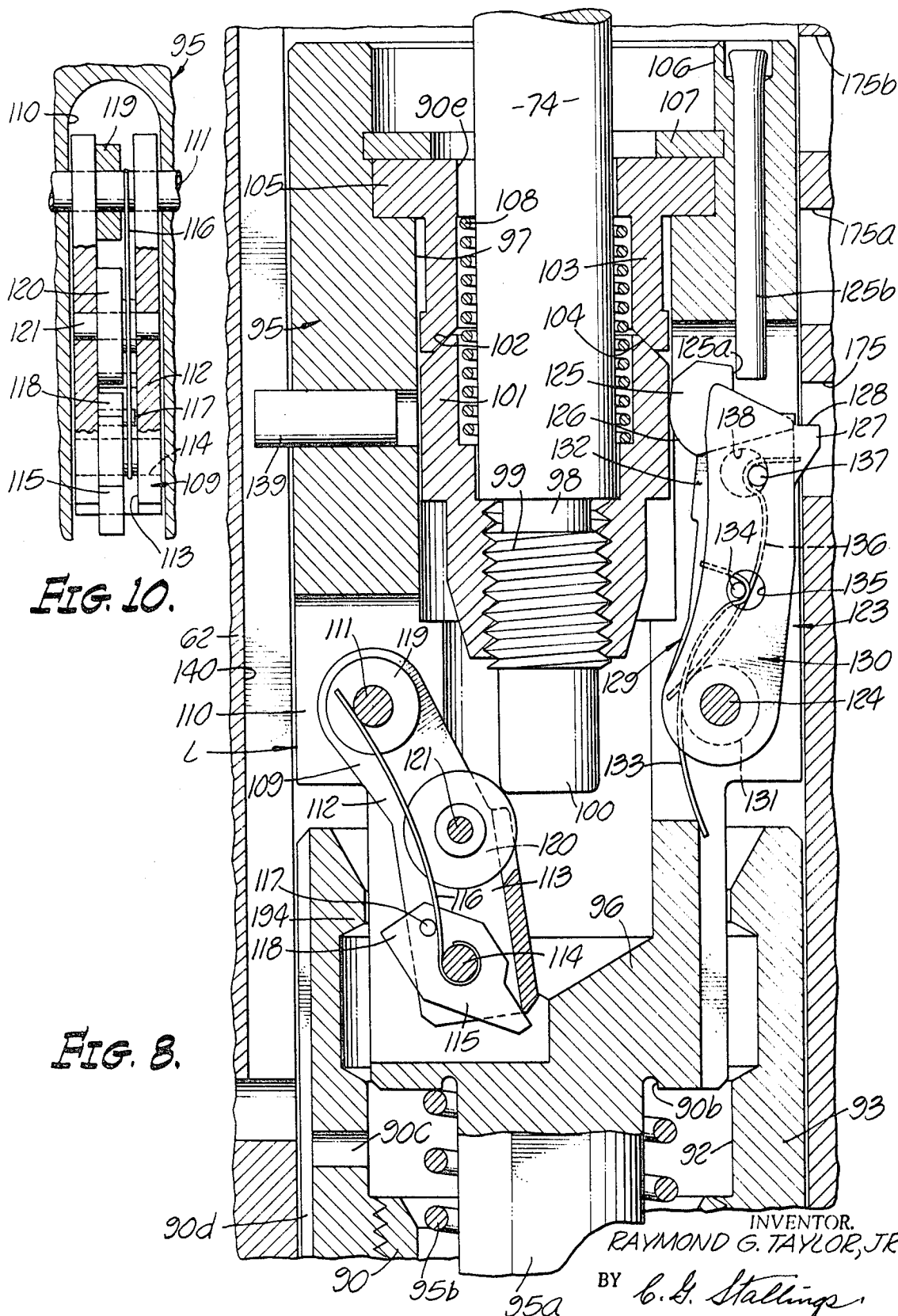
R. G. TAYLOR, JR

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PENDULUM RELEASE MECHANISM FOR SIGNALLING DRIFT INDICATORS

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INVENTOR.
RAYMOND G. TAYLOR, JR.

BY *b. S. Stallings*

ATTORNEY

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PENDULUM RELEASE MECHANISM FOR SIGNALLING DRIFT INDICATORS

Raymond G. Taylor, Jr., Santa Monica, Calif., assignor
to Byron Jackson, Inc., Long Beach, Calif.

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U.S. Cl. 33—205

16 Claims

ABSTRACT OF THE DISCLOSURE

Signalling apparatus for producing pressure pulses in the stream of well drilling fluid in which the fluid flows through a pulse ring assembly having axially spaced rings cooperative with a knob reciprocable through said rings to provide restricted flow paths productive of the fluid pressure pulses in the drilling fluid stream in a number representative of the disposition of the well drilling string in the well bore in the vicinity of the drill bit, and in which a pendulum determines the extent of movement of said knob, and a releasable latch structure connects the pendulum to a selectively positionable coding rod which cooperates with stop balls to limit such movement of the knob, the releasable latch structure including a first member or catch to limit movement of the coding rod in one direction and a second member or latch for releasing the pendulum so that the latter may return to a starting position.

BACKGROUND OF THE INVENTION

Field of the invention

In general, signalling drift indicators of the type here involved are adapted to be disposed in a drill collar sub above the drill bit of a well drilling string. The instrument includes an elongated housing containing clean oil, and internal pressure is balanced with external pressure by a floating divider at the lower end of the instrument. At the upper end of the housing is a pulse ring attachment through which drilling fluid flows during drilling. Reciprocable in the upper end of the housing is a shaft having a knob which passes upwardly through the pulse rings upon extension of the shaft from the housing and which, responsive to flow of drilling fluid, will force the shaft downward within the housing. As the knob passes downwardly through the pulse rings it cooperates with them to provide restrictions to flow. Such movement is retarded so that the successive restrictions cause distinct pressure pulses which will travel through the column of fluid to the earth's surface, where the signals may be recorded. Gravity responsive means are provided in the housing for limiting shaft extension in accordance with the angle from vertical at which the housing is disposed when the circulation of drilling fluid is halted. Thus, the pressure pulses recorded at the surface are indicative of the angle of the well in the region of the drill string sub in which the instrument housing is installed.

Such apparatus may include a coding system including a rod, stop members selectively expandable by the rod, and a stop carried by the shaft and engageable with the expanded stop members. The coding rod is controlled by the gravity responsive means so that the ultimate travel of the shaft and thus the knob through the pulse rings is directly related to the angle of the instrument. Such an instrument therefore produces a pulse for each increment of the total angle which the instrument may measure.

In the use of this type of instrument it has been determined that desirably the gravity responsive means or pendulum and the coding system should be protected from excessive loading or abuse during shipment or use of the instrument.

DESCRIPTION OF THE PRIOR ART

Pendulum release means have been provided as more particularly disclosed in the pending application for Letters Pat. of the U.S. of Robert L. Alder, Ser. No. 562,146, filed July 1, 1966, now Pat. No. 3,457,654 issued July 29, 1969, whereby during shipment the pendulum may remain spring biased into engagement with a protective pendulum seat, and during use the pendulum will also return to its seat after engagement with a pendulum stop to cause operation of the pendulum release mechanism.

However, the outside dimensions of signalling drift indicators are governed by the size of the bore in the drill collar sub in which the instrument is disposed during use, so that there remains between the instrument housing and the drill collar bore wall sufficient annular clearance to enable adequate drilling fluid flow during the usual drilling operations. Therefore, instruments of the type here involved are inherently of very limited outside diameter, and, accordingly, the operating mechanisms contained within the instrument must be quite small.

In the pendulum release mechanism of the above mentioned application for patent there is a combined catch and latch for determining the extent of upward movement of the coding rod and thus the extent of upward movement of the knob, and for releasing the pendulum from its connection to the coding rod. This combined catch and latch is normally maintained in latched relation to the pendulum by a spring, and a cam surface on the combined catch and latch is engaged by a cam surface on a member movable upon upward movement of the coding rod under the influence of another spring. The combined catch and latch element is adapted to be moved to a position at which simultaneously the catch is positioned to determine the upward movement of the coding rod and the latch is released. Due to the extremely small size of the various components and due to the existence of inherent tolerances in the manufacture and assembly of such components, a major problem inherent in the release mechanism of the above-identified application is the lack of certainty that the combined catch and latch will be effectively operated so as to simultaneously perform both functions. Moreover, the releasable latch mechanism must maintain the connection between the coding rod and the pendulum until the pendulum is stopped by engagement with a selected stop element and, in order to assure the maintenance of this connection, the spring which holds the latch latched must have sufficient force to prevent inadvertent release. This same spring force must be overcome by the camming of the catch to a position at which it may function to limit upward movement of the coding rod. Accordingly, the establishment of a proper balance between this spring force and the effective camming action under the influence of still another spring which urges the coding rod in a direction to effect the camming action poses still another problem which is difficult of solution.

Damage to the latch mechanism or faulty operation thereof as a consequence of variable conditions of use also pose problems in the operation and maintenance of the instrument. For example, if the drill string in which the instrument is disposed should be forcibly reciprocated for the purpose of spudding through a bridge in the well bore, the releasable latch mechanism may be subjected to unusual forces in opposite directions which may be destructive of the latch mechanism if the combined catch and latch is not properly positioned with respect to the stop tube within the instrument with which the catch element is engageable to limit the extent of upward travel of the knob. In other circumstances, excessive fluid pressure differentials may be imposed across the instrument causing the rapid transfer of hydraulic fluid within the

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instrument, which fluid is normally employed to retard downward movement of the knob during normal signalling operations. In such a small instrument where the available fluid pasageway between the components is inherently restricted, the tendency of the fluid to pass rapidly through the components may impose substantial hydraulic forces on the components causing deformation or destruction thereof.

SUMMARY

With the foregoing in mind, the present invention provides apparatus for producing signals in the stream of drilling fluid in which a pressure responsive knob is normally held in a lowermost position by the flow of drilling fluid but is movable upwardly through pulse rings when the flow of drilling fluid is interrupted so that, upon resumption of drilling fluid flow, pressure pulses will be produced in the fluid stream indicative of the disposition of the instrument within the well bore, wherein gravity responsive pendulum means and cooperable stops are provided to limit the upward movement of the knob to an extent dependent on the angle of the instrument in the well bore and wherein novel releasable latch means are provided for allowing the return of the pendulum to a protective seat therefor following release of the latch means.

More specifically, the apparatus includes releasable latch means for releasably connecting the gravity responsive pendulum to a member which moves upwardly with the knob of the instrument, and a separate catch being provided cooperable with a stationary portion of the instrument to establish the extent of the upward movement of the knob, the catch being positioned to limit the extent of such movement before the latch is released.

In this connection, the catch is not only separate from the latch but also the catch is a compound assembly of relatively movable parts, one of which is adapted to be cammed outwardly to an operative position and the other of which is spring biased outwardly to an operative position so that, in the event of camming of the first catch part outwardly at a location at which the second catch part is incapable of moving to the operative position, the catch assembly will effectively collapse, resuming its normal condition when free to do so.

In the present instrument, moreover, the latch is also a compound assembly comprising a latch holder and a latch element, the latch holder being normally held in a latching position by a member which is moved relative to the latch holder during movement of the instrument knob upwardly, and this member releasing the latch holder for movement to a position at which the latch is released after movement of the catch to its operative position. In such a construction release of the latch is insensitive to the magnitude of the force of a spring tending to hold the latch in engagement, and positive lifting of the pendulum is assured without requiring special balancing of the forces acting to release the latch, on the one hand, and the forces tending to hold the latch engaged, on the other hand.

In order to prevent damage to the instrument as a result of excessive pressure differential across the instrument housing tending to cause rapid transfer of hydraulic fluid within the housing, the releasable latch mechanism is provided with passageways therethrough allowing the free transfer of fluid between the releasable latch components.

An object of the invention, accordingly, is the provision of a signalling drift indicator for use in determining the angular disposition of a well drilling string in the vicinity of the drill bit, wherein, notwithstanding the necessary small diameter of the drift indicator instrument, the instrument is rendered trouble-free and certain in

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its use, thereby minimizing the costly and time-consuming maintenance of the instruments.

Other objects and advantages of the invention will be hereinafter described or will become apparent to those skilled in the art, and the novel features of the invention will be defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary view, partly in vertical section and with certain parts shown in elevation, illustrating a drift indicator instrument installed in a drill collar sub, the shaft being in its down position and the pendulum being on its seat;

FIG. 2a is an enlarged fragmentary detail view in longitudinal section showing the upper end of the instrument of FIG. 1, minus the pulse ring assembly, and showing the upper portion of the coding system;

FIG. 2b is a downward extension of FIG. 2a, showing the upper actuating means for the angle adjuster and showing the intermediate portion of the coding system;

FIG. 2c is a downward extension of FIG. 2b, showing the lower portion of the angle adjuster, and showing the lower portion of the coding system including the pendulum release means;

FIG. 2d is a downward extension of FIG. 2c, showing the pendulum seat, with the pendulum seated thereon, and showing the lower instrument support and the internal-external pressure balancing divider and the instrument fluid transfer restrictor and bypass;

FIG. 3 is an enlarged transverse sectionial view, as taken on the line 3—3 of FIG. 2c;

FIG. 4 is an enlarged fragmentary transverse sectional view, as taken on the line 4—4 of FIG. 2c;

FIG. 5 is an enlarged fragmentary view in vertical section illustrating the pulse tube mounting and flow restricting bushing;

FIG. 6 is an enlarged fragmentary view in vertical section, showing the pendulum release mechanism with the latch engaged and the catch retracted;

FIG. 7 is a view corresponding to FIG. 6 but showing the catch projected outwardly for engagement with a catch stop and the latch engaged;

FIG. 8 is a view corresponding to FIGS. 6 and 7 but showing the latch released following outward projection of the catch;

FIG. 9 is a detail view, partly in side elevation, with parts broken away, showing the catch means of the releasable latch mechanism; and

FIG. 10 is a detail view, partly in side elevation, with parts broken away, showing the latch means of the releasable latch mechanism.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, it will be seen that the drift indicator assembly of the invention is installed in a sub or length of drill collar S which is, as customary, adapted to be mounted in a string of drill pipe so as to conduct drilling fluid downwardly through the drill collar sub S to the bit, not shown, and the fluid then flowing upwardly outside of the drill string to the earth's surface. This assembly comprises an instrument housing generally denoted I having at its upper end a pulse ring sleeve R and at its lower end a bottom support B whereby the housing I is supported top and bottom in the sub S, and drilling fluid may flow through the sub S about the housing I.

The pulse ring sleeve R has an enlarged end flange 2 which shoulders and is sealed in a seat 3. At its lower end (FIG. 5) the pulse ring sleeve R has an outwardly extended flange 5a which seats upon the upper end of a cylindrical support 5 which is connected to a central hub 4 and provides windows 6 so that fluid may pass through the sleeve R. The hub 4 is suitably mounted on the upper end of the instrument I so as to support the pulse ring sleeve R thereabove, this mounting being pref-

erably like that more specifically described in the application for U.S. Letters Pat. Ser. No. 561,637, filed June 29, 1966. The flange 5a of the pulse ring sleeve R is removably connected to the tubular member 5 by suitable means, such as fasteners 5b. Within the cylindrical member 5 is a bore 5c providing an inwardly projecting shoulder 5d, this shoulder 5d and the lower end 5e of the pulse ring sleeve R defining an annular space for reception of a replaceable bushing A. This bushing A may be suitably hardened or composed of erosion-resistant material so that its inner cylindrical wall 5f is resistant to the erosive effects of drilling fluid flowing therepast. At its lower end the bushing A is provided with a downwardly extended lip 5g having an outwardly flaring or beveled surface 5h leading into the cylindrical member 5. Within the sleeve R is a series of axially spaced pulse rings 7, each of which is adapted to cause a pressure pulse in the fluid stream passing therethrough, as will hereinafter appear. Between the rings 7 are axially extended and angularly spaced ribs 8 forming abutments in the spaces between the ribs, these abutments extending substantially to the inner annular surfaces of the rings 7 from the circumferentially extended walls 8a between the pulse rings 7. The diametrical distance between the walls 8a is, in the illustrative embodiment, greater than the diameter of the cylindrical wall 5f of the bushing A for reasons which will hereinafter become apparent, but the wall 5f has a selected diameter which in some cases may be substantially equal to the diameter of walls 8a.

Bottom support B has an outer rim 9 and a hub 10 on which the rim 9 is supported by webs 11 forming therebetween flow passages at the lower end of housing I. A port 12 is provided in the hub 10 so that fluid finds access to the housing I at its lower end.

The housing at its upper end has reciprocally mounted therein and extensible therefrom a shaft 13 having at its outer extremity a head or knob 14. Within the housing I is a spring 15 which normally biases shaft 13 upwardly out of the housing I, thereby causing the head 14 to be moved upwardly through the pulse rings 7. However, the flow of drilling fluid downwardly through the pulse ring sleeve R will cause the head 14 to move downwardly, and the flow of fluid downwardly through the annular space 5i between the knob and the bushing A will provide a pressure differential acting on the knob 14 to hold the same in its lowermost position in abutting engagement with the upper end of the instrument I. Thus, during circulation of drilling fluid the shaft 13 and knob 14 will remain as shown in FIG. 1, but when such circulation is halted, the shaft will be forced outward and the head will move upward through the rings 7. Such circulation of drilling fluid is automatically ceased each time an additional length of drill pipe is to be added at the earth's surface, and otherwise as desired. When circulation is resumed, a pressure pulse is caused as the knob 14 passes through the rings 7 due to the restriction in flow area, and such pulses are detectable at the earth's surface by a typical pressure gauge or pressure recorder.

In order that the upward movement of the shaft 13 will be limited in accordance with the angle at which the housing I is disposed, gravity responsive means including a pendulum generally denoted at 16 is adapted to selectively engage pendulum stop means 17 as the pendulum moves upwardly. In order to retard downward movement of the shaft 13 so that, as previously indicated, the resultant pressure pulses will be distinct and adequately spaced, means generally indicated at 18 are provided for retarding fluid displacement through the pendulum seat 19. At the lower end of the housing I is a divider piston 20 shiftable to balance internal fluid pressure and external drilling fluid pressure and so as to enable the transfer of fluid through the retarding means 18 as the shaft 13 displaces fluid downwardly and the upward transfer of fluid through a check valve 22 as the shaft 13 is urged upwardly.

In order to change the relationship between the stop means 17 and the pendulum 16, means are provided for shifting the stop means axially in housing I. In this connection the stop means 17 is connected by rods 23 to adjuster means 24.

Referring now more particularly to FIGS. 2a through 2d, the details of the structure will be more fully explained.

The instrument housing I includes an upper tubular section 30 having an upper shaft guide 31 threadedly mounted therein. Shaft guide 31 has a seal and wiper means 32 and 33, respectively, engageable with the shaft. At the outer extremity of the shaft, the knob 14 is supported by means of a knob bushing 34, a pin 35 connecting the bushing to the shaft, and a snap ring 36 retaining the knob on the bushing.

As seen in FIG. 2c, the upper housing section 30 is threaded to a lower housing section 37 to the lower end of which is connected the hub 10 of bottom support B, as shown in FIG. 2d. Within the lower housing section is the divider piston 20 which has a skirt 38 adapted to extend into the hub 10. Mounted in the skirt 38 is a hollow piston guide stem 40, at the lower end of which is a filler plug 41, whereby the housing may be filled with clean oil or the like. A spring 42 seated in hub 10 is provided to normally bias the piston 20 upward, but essentially the piston 20 serves to apply pressure to the internal fluid equal to external fluid pressure and to move axially to allow extension of the shaft 13 from the housing.

Disposed above the piston 20 in lower housing section 37 is an orifice block 43, retained in place by a lock ring 44 and having a downwardly extended guide tube 45 slidably receiving the piston guide stem 40 of the piston. Supported by an upwardly extended tubular part 46 on the block 43 and within guide tube 45 is an orifice disc support 47 having therein a stack of orifice discs 48 retained in place by a ported plug 49. At one side of block 43 is an upwardly opening ball check valve 22 and at another location in the block 43 is a downwardly opening spring loaded relief valve 50. Thus, the orifice block, the valve 22 and the orifice discs 48 constitute means for retarding downward flow of housing fluid through the block 43, while enabling comparatively free upward flow of housing fluid, as the shaft is extended from the housing and forced back into the housing during operation of the instrument. The valve 50 serves to relieve pressure in the event that such relief may be necessary.

The block 43 also supports the aforementioned pendulum seat 19. This seat 19 comprises a conical center 51 having an upstanding guide skirt 52. The seat center has a ported stem 53 and means are provided for adjustably supporting the stem 53 and hence the seat 19 within the upper end of block part 46. Such means in the illustrative embodiment comprise a spider 54 in which the stem 53 is threaded, and a lock 55 engageable with the spider.

The pendulum 16, as shown in FIG. 2d, is adapted to seat in the pendulum seat 19, when, as shown in FIG. 2a, the shaft 13 is in the downward position. The shaft is connected to the pendulum by means which (1) allow upward movement of the shaft a distance inversely related to the upward travel of the pendulum, and (2) by means which, upon the pendulum reaching the upper limit of its travel, will cause release of the pendulum so that it will be freed to return to its seat.

The first-mentioned means includes a longitudinally extended coding rod 60 which is reciprocally disposed in a tubular guide and stop ball support 61. The guide 61 is connected to and essentially constitutes a portion of the upper housing section 30, and, as best seen in FIG. 2c, the guide is supported at its lower end in a coding rod stop tube 62 which is formed as an upward extension of a block 63 which in turn is secured as by fasteners 64 to the lower end of the upper housing section 30.

More specifically, the guide 61 seats at its lower end on a washer 65 which shoulders at 66 in the upper end of the tube 62; and, in upwardly spaced relation to the washer 65, is a second washer 67 fastened in the tube 62 by lock ring 68, the lower end of the guide 61 extending through washer 67 and having a lock ring 69 which engages beneath the washer 67. Thus it is apparent that while the guide 61 is assembled with the tube 62 prior to connection of the block 63 to the lower end of housing section 30, means are provided so that the ultimate assembling of these components results in the guide 61 being rigidly and concentrically supported within the upper housing section 30.

The coding rod 60 previously referred to is composed of an upper end section 70 slidably disposed within the guide 61. Beneath the upper end 70 is an axially spaced series of reduced stem sections 71 and thimbles 72a, 72b, 72c, 72d, 72e and 72f. Beneath the lowermost thimble 72f is a connector 73 which connects the upper coding rod section 70 to a connecting rod or lower coding rod section 74, the latter extending downwardly through the guide 61 and the guide supporting washers 65 and 67 into the coding rod stop tube 62. At its upper end, coding rod section 70 has a centralizing guide 70a secured thereto and slidably engaged in the shaft 13, this guide being perforated to permit bypass of fluid within the instrument. Above the guide 70a is a coil spring 70b freely disposed in shaft 13 so as to engage and bias the coding rod downward when the shaft is in its downward position, as shown in FIG. 2a. As shown in FIGS. 2b and 2c, there is another coil spring 60a which surrounds the lower coding rod section 74 within rod guide 61 and engages at its upper end with connector 73 and at its lower end with the support washer 65 for tube 62. This spring 60a is adapted to normally bias the coding rod 60 upward when the shaft 13 moves upwardly. It is the purpose of the thimbles 72a-72f depending upon the extent of upward movement of the coding rod, as will be more fully explained hereinafter, to selectively hold in an outwardly projected position a set of stop projections which more specifically are composed of sets of balls. In the illustrative embodiment, there are 6 sets of such balls respectively designated from top to bottom, as viewed in FIGS. 2a and 2b, 75a, 75b, 75c, 75d, 75e and 75f, adapted to be moved outward by thimbles 72a-72f, respectively. The balls are disposed in openings 76 in the rod guide 61 so that the latter also constitutes a ball support. The sets of balls are cammed outward upon engagement by the respective thimbles 72a-72f into annular space 13a defined by the guide 61 and the shaft 13. Within the shaft 13 (see FIG. 2b) is a stop 77 which defines the bottom of the just-mentioned annular space 13a, and essentially this stop forms a portion of the shaft 13 which will limit upward movement of the latter, under the influence of spring 15, upon engagement with one of the sets of stop balls 75a-75f, or upon engagement with a stop ring 75 carried by tube 61 in spaced relation above stop balls 75a (FIG. 2a), thus selectively limiting upward movement of the knob 14 with respect to the pulse ring sleeve R.

Essentially the stop shoulder 77 is a portion of the shaft 13, but in the specifically shown structure the shaft 13 incorporates means for allowing freedom of upward movement of the shaft independently of the stop shoulder 77 in order to relieve the stop shoulder and stop balls from excessive loading in the event of back flow of drilling fluid through the drill collar S, as well as during running of the drill string into the well bore following the changing of drill bits. Accordingly, as shown in FIGS. 2b and 2c, the shaft 13 is reduced in diameter at the point of its connection with a downwardly extended shaft extension 80. If desired, the shaft 13 may be provided with an enlarged sleeve 80a above the shaft extension 80 to stabilize the shaft assembly within the body section 30. Concentrically disposed about the downward shaft ex-

tension 80 is a spring coupling sleeve 81 having an upper outwardly projecting flange 82 engaged by the upper end of a shaft biasing spring 15. The lower end of the latter abutting, as shown in FIG. 2c, with the block 63. The just-mentioned flange 82 also abuts with the larger diameter upper shaft section so that the shaft 13 is biased upwardly. At its lower end the spring coupling sleeve 81, as seen in FIG. 2c, is connected between a pair of snap rings 84 with an internal sleeve 85 which is disposed within the downward shaft extension 80. Thus it will be seen that the shaft extension 80 is free to move upwardly relative to the spring coupling sleeve 81 and the connected internal sleeve 85, but the spring 15 acts to bias the shaft 13 upwardly through the intermediary of the spring coupling sleeve 81 and internal sleeve 85, the latter having at its upward extremity the above-mentioned stop shoulder 77. Therefore, the extent of upward movement of the shaft 13 and the knob 14 under the influence of the spring 15 is limited by the stop 77, even though the shaft may be free to move further upwardly in response to the influence of fluid flow through the drill collar S.

Thus it will be apparent that if the balls 75f be cammed into the path of stop 77, the shaft 13 will be limited in its upward travel under the influence of spring 15 to a position at which the knob 14 is disposed between the lowermost and the next above pulse ring 7. As the shaft 13 is allowed further increments of upward movement then the knob 14 will correspondingly be allowed further upward movement, a distance equal to another pulse ring per increment of shaft movement. Thus if the stop 77 is allowed to pass all the sets of stop balls 75f through 75a but engages stop ring 75, the knob 14 will be allowed to travel a distance equal to the spaces between 7 pulse rings as a result of which downward movement of the knob caused by drilling fluid flow will cause the production of 7 pressure pulses or signals which will travel through the column of drilling fluid to the earth's surface for detection or recordation as an indication of the angle at which the housing 30 is disposed within the well bore. As previously described, the gravity responsive pendulum and the cooperative pendulum stop means 17 serve to limit upward movement of the coding rod 60 so as to cause the projection of the appropriate set of stop balls 75a through 75f to limit upward movement of shaft 13. However, as mentioned above in accordance with one of the objectives of the invention, shaft 13 is releasably connected to the pendulum as will now be described and as is more particularly illustrated in FIGS. 2c, 3 and 4.

In the present construction the coding rod 60 is releasably connected to the pendulum 16 so that the shaft 13 is also releasably connected to the pendulum, as best seen in FIGS. 6, 7 and 8.

Slidably disposed within the block 63 is a pendulum support in the form of a hollow rod 90, to the lower end of which the pendulum is freely universally connected as by a pair of bails 91. At its upper end the rod 90 is provided with a seat 92 formed within a cup-like female connector member 93 which has, at its upper end, an internal latch shoulder 94.

The releasable latch means of the invention, generally denoted at L, are disposed within the coding rod stop tube 62 and in the pendulum support rod 90 for cooperative releasable coengagement with the shoulder 94 of the connector 93; and a number of vertically spaced stop shoulders, respectively designated 175, 175a, 175b, 175c, 175d, 175e and 175f, are provided in the coding rod stop tube 62 by the provision of axially spaced lateral openings therein. More particularly, the releasable latch means L includes a latch body 95 having a reduced lower section 96 adapted to be received in the seat 92 of the connector member 93. Depending from the lower section 96 of the latch body 95 is a stem 95a which extends downwardly into the pendulum support 90, a coiled compression spring 95b being disposed about the stem 95a, seating at its lower

end at the lower end of the bore in the pendulum support 90 and at its upper end engaging the lower end 96 of the latch body 95 to normally bias the latch body 95 upwardly from the seat 92 in the connector 93. This latch body 95 also has a bore 97 therein into which the lower end of the connecting rod section 74 of the coding rod 60 extends. At its lower end the connecting rod section 74 has a downwardly extended shank 98 provided with a threaded section 99 and a further downwardly extended cylindrical terminal section 100. Threadedly mounted on the threaded section 99 of the connecting rod section 74 is a cam member 101 having a cylindrical portion disposed about the connecting rod section 74 and provided at its upper end with an inclined cam surface 102. In the bore 97 of the latch body 95 is a cam stop member 103 having a downwardly facing end surface 104 which is adapted to be engaged by the upper end of the cam member 101 to limit upward movement of the latter during operation of the latch means L. The cam stop member 103 has an upper flange 105 seating in an enlarged bore 106 in the latch body 95 and retained therein as by a suitable lock ring 107, the connecting rod section 74 extending upwardly through the cam stop member 103. A coiled compression spring 108 is interposed between the cam stop member 103 and the cam member 101 and serves to normally bias the cam member 101 and the connecting rod section 74 downwardly to the position shown in FIG. 6.

A latch unit 109 is carried by the latch body 95 in a radially opening, longitudinally extended slot 110, a pivot pin 111 extending through the latch unit 109 and the slot 110 so as to pivotally support the latch unit. The latch unit 109 includes a latch holder 112 pivotally mounted on the pivot pin 111 and having an outwardly opening channel 113 at its lower end in which is pivotally mounted on a pivot pin 114 a latch dog 115. A spring 116 is provided, the spring being connected at one end to the latch dog pivot pin 114 and extending upwardly therefrom so as to engage at its upper end the pivot pin 111 for the latch holder 112, the latch dog 115 having a spring engaging pin 117 engageable by the spring 116 between the ends of the spring so as to normally bias the latch dog 115 in a direction to effect projection of an angular latching end portion 118 to a position beneath the latch shoulder 94 of the connector member 93. A spacer 119 may be provided about the pivot pin 111 to maintain the spring 116 in proper position. Intermediate the ends of the latch holder 112 it is provided with a roller 120 rotatably supported on a shaft 121 and projecting inwardly from the holder 112 for rolling contact with the lower extremity 100 of the connecting rod section 74. Thus, as seen in FIG. 6, the lower extremity 100 of the connecting rod section 74 engages the roller 120 so as to maintain the latch holder 112 in a position at which the latching dog 115 is in latched coengagement with the latch shoulder 94 of the connector member 93, and the latch holder 112 will be held in that position until, during use of the instrument to produce signals as mentioned above, the coding rod 60 and its connecting rod section 74 move upwardly following interruption in the flow of drilling fluid downwardly past the knob 14 of the instrument.

In angularly spaced relation to the slot 110 of the latch body 95, and in the illustrative embodiments in diametrically spaced relation to the slot 110, the latch body 95 is provided with another longitudinally extended slot 122 in which is disposed a catch unit denoted at 123, the catch unit 123 being pivotally supported at its lower end on a pin 124 extending through the slot 122. At its upper end the catch unit 123 has an inwardly projecting ear 125 provided with an arched surface 126 adapted to be engaged by the cam surface 102 of the cam member 101 whereby to effect outward movement of the upper end of the catch unit 123 about the pivot pin 124 when the cam member 101 moves upwardly. The catch unit 123 also includes at its upper end an outwardly extending stop lug 127 provided with an angular seat 128, whereby, when the catch unit

123 is caused to swing outwardly by the cam member 101 the stop lug 127 will be caused to project into underlying relation to one of the stop shoulders 175-175f provided in the coding rod stop tube 62. As best seen in FIG. 9, the catch unit 123 is a compound assembly comprising a first catch part 129 and a second catch part 130, each of which is pivotally connected to the pivot pin 124, a spacer or washer 131 being disposed about the pin 124 and serving to maintain the space between the lower ends of the catch parts 129 and 130 and to prevent cocking of these parts on the pin 124. The ear 125 of the catch unit 123, having cam surface 126 thereon, is formed on the catch part 129; and extended downwardly beneath the cam surface 126 is a longitudinally extended stop surface 132 which is adapted to abut with the cam member 101 to limit inward movement of the catch unit 123. The stop lug 127 of the catch unit 123 is provided at the upper end of the second catch part 130. Means are provided for biasing the catch part 129 inwardly about the pivot pin 124 and the catch part 130 outwardly about the pivot pin 124. Such means comprises a first spring 133 having one end looped about a pin 134 which is carried by and projects from the catch part 129 into an enlarged opening 135 in the catch part 130, the spring extending downwardly between the catch parts and engaging at its lower end with the spacer 131. A second spring 136 at one end is looped about a pin 137 carried by the catch part 130 and projecting into an enlarged opening 138 in the catch part 129, the lower end of the spring 136 extending past one side of the above-mentioned pin 134 in engagement therewith, and the lower extremity of the spring 136 anchoring against the spacer 131. Thus, the spring 136 not only provides a force acting on pin 134 to bias the catch part 129 inwardly to normally maintain engagement between the stop surface 132 and the cam member 101, but this spring 136 also serves to bias the pin 137 carried by the catch part 130 into engagement with the outer side of the opening 138 in the catch part 129 so as to normally resiliently hold the catch part 130 in a position of maximum outward projection. This position of maximum outward projection of the catch part 130 is such that the stop lug 127 thereon is spaced slightly inwardly from the inside wall of the coding rod stop tube 62. However, it will be noted that when the cam member 101 moves upwardly the cam surface 102 thereon will engage the cam surface 126 on the catch part 129 to bias this catch part outwardly about the pivot pin 124, and, if the stop lug 127 is opposite an opening below any of the stop shoulders 175-175f in the coding rod stop tube 62, the lug 127 will move into such opening. However, if such outward movement of the lug 127 occurs when it is opposed by the inner wall of the coding rod stop tube 62 at the location intermediate any of the openings of the stop shoulders 175-175f, then the lug 127 will engage the inside wall of the coding rod stop tube 62 and the spring 136 will allow outward movement of the catch part 129 relative to the immovable catch part 130, the catch unit 123 therefore effectively collapsing in a lateral direction so as to protect the catch unit 123 against damage under these circumstances.

In order to establish and maintain a proper relative angular relationship between the latch body 95 and the coding rod stop tube 62 so that the catch unit 123 is in alignment with the openings beneath the stop shoulders 175-175f, cooperative key and slot means are provided including a key 139 carried by the latch body 95 and projecting radially therefrom into an elongated keyway 140 formed internally of the coding rod stop tube 62 (as seen in FIG. 4).

Means are provided for adjusting the bail connection between the pendulum support 90 and pendulum 16, thus, as best seen in FIG. 2c, the bails 91 comprising an upper bail wire 91a and a lower bail wire 91b, each formed to provide a loop coengaged with the other. The bail 91a is mounted in a support 191a which extends into a bore 192a in the lower end of the pendulum support 90. The support

191a has at its inner end a threaded stem 193a for adjustably positioning the support 191a in the bore 192a. The position in which the support 191a is to be fixed may be determined and fixed by insertion of a suitable locking element such as a cotter pin 195a or the like. In a similar fashion, the bail 91b is mounted in the support 191b. In addition, this latter support has a threaded end 193b engaged in the pendulum 16 so as to adjust the position of support relative to the pendulum 16. As in the case of support 191a, support 191b may be fixed in adjusted position by a cotter pin 195b which extends through the support 191b. By virtue of this adjustable pendulum supporting structure, the relationship of the pendulum 16 to the connecting rod pendulum support 90 may be adjusted to maintain a stable but substantially friction-free universal connection between the support 90 and the pendulum 16 so that the pendulum 16 may freely swing relative to the support 90 to any desired angular disposition relative to the stop means 17 and so that upward movement of the pendulum 16 will be arrested at a precise position representative of the angular disposition of the housing I.

It will be noted, as seen in FIGS. 1, 2c and 2d, that the stop means 17 comprises a supporting sleeve 17a connected to the above-described adjuster rods 23 by means of pins 17b. Adjacent the bottom of sleeve 17a is a stop ring retainer 17c held in place by a snap ring 17d. Intermediate the retainer 17c and the upper end of the sleeve 17a is a series of angular stop shoulders of progressively diminishing diameter. Preferably such shoulders are provided on a series of stacked stop rings 17e. In the illustrative embodiment there is an upper stop shoulder 275e (FIG. 2c) provided by the uppermost stop ring 17e and progressing downwardly are stop shoulders 275d, 275c, 275b, 275a and 275 of progressively increasing diameter. Thus, if upward movement of the pendulum 16 is arrested by stop shoulder 275e, lug 127 of the catch unit 123 will engage with the stop at 175e in coding rod stop tube 62 and balls 75e (FIG. 2a) will be caused to project into the path of stop 77 (FIG. 2b) of the shaft 13. The same relationship exists between each of the stop shoulders 275 through 275d, catch stops 175 through 175d and stop ring 75 and balls 75a through 75d so that, while the upward travel of the pendulum 16 will be inversely related to the angular deviation of the instrument housing I, the permitted upward travel of the coding rod 60 and hence the permitted upward travel of the shaft 13 will be directly related to the angular deviation of the housing I from a vertical disposition, and a single pressure signal will be induced in the drilling fluid stream for each increment of angular deviation.

As indicated above, the range of angular deviation at which the instrument may respond is adjustable in response to rotation of the housing part 24 relative to the upper housing 30, whereby to axially shift stop ring supporting sleeve 17a relative to the pendulum 16. As seen in FIGS. 2b and 2c, the housing part 24 is provided with an internal thread 24a. This internal thread 24a engages in a helical groove 24b in a connector sleeve 24c disposed within part 24 and slidably mounted on the upper housing section 30. Referring to FIG. 2c, it will be noted that the sleeve 24c is connected by means of a fastener 24d to a collar 24e from which depend the above-noted rods 23 which extend downwardly through block 63 (see FIG. 3) and are connected to the pins 17b.

The angular disposition of the part 24 relative to the upper housing section 30 thus determines the relative axial disposition of the stop rings 17e in the lower housing section 37. In this manner in the extreme lowermost position of axial adjustment, rings 17e will be disposed for engagement of stop shoulders 275 through 275e by the pendulum 16, but in the event that the instrument is to be adjusted for detection of angular deviation ranging between say 3½ and 7 degrees, if shoulders 275 through 275e represent detection of angles ranging between 0 to 3½ degrees, the part 24 may be adjusted to move the stop shoulders

upwardly so that a second set of stop shoulders 375 through 375f may be disposed for engagement by the pendulum 16. It will also be understood that the range of adjustment of the stop shoulders provided by rings 17e may be such that any combination of stop shoulders 275e through 375 may be availed of for the purpose of detecting angular deviation within any selected range of the maximum range for which the instrument is adapted by provision of stop rings 17e of different diameters.

In order to fix the selected range, the rods 23 are provided with a series of axially spaced depressions 23a with which engage detent means 23b which, in the illustrative embodiment, comprises a spring ring disposed about the block 63 in a groove 23c, as best seen in FIG. 3. On the upper housing section 30 is fixed, as by fastener 30a (FIG. 2b), a collar 30b having a suitable index means 30c which, in relation to graduations 30d on the upper end of the rotatable part 24, will serve to indicate the relative axial disposition of the stop ring support sleeve 17a within the lower housing section 37. By virtue of this construction, the instrument may be preset so as to detect angular deviation ranging from 0 degree deviation through any selected range of the entire capability of the instrument. For example, either from 0 to 3½ degrees or 2 degrees to 5½ degrees, etc.

In the use of the instrument the hydraulic fluid contained within the instrument housing is caused to transfer through the means 18 for retarding fluid displacement through the pendulum seat as the shaft moves inwardly with respect to the instrument housing, and during outward movement of the shaft fluid is caused to pass through the check valve 22. The transfer of fluid during normal usage of the tool is at such a rate that normal clearances between the components permits sufficient flow as to impose no significant fluid flow or pressure differential problems on the components. However, if the knob 14 should be subjected to a sudden pressure surge within the drill collar sub tending to rapidly force the shaft 13 inwardly, then the relief valve 50 is adapted to open to allow the rapid transfer of fluid through the components within the instrument housing. However, as previously indicated, the instrument of necessity is of small diameter and the clearance spaces between the components inherently are restricted. Thus, passage means are provided for allowing the rapid transfer of fluid through and past the latch mechanism L under these circumstances. In this connection, a passage 30a, as seen in FIGS. 2c and 3, extends between the lower end of the upper housing section 30 below the threaded connection thereof with the lower housing section 37 and the annular space between the coding rod stop tube 62 and the housing section 30 in which the main spring 15 is disposed. Additionally, the pendulum support 90 is provided with a suitable number of axially spaced lateral ports 90a leading from the housing section 37 into the space in which the spring 95b is disposed; and the depending stem 95a of the latch body 95 is, as seen in FIG. 3, preferably of a non-circular cross-sectional configuration so as to provide adequate fluid flow space between the outer periphery of the rod 95a and the spring 95b. At the juncture of the rod 95a with the lower end section 96 of the latch body 95, moreover, suitable cross grooves 90b are provided leading to lateral ports 90c in the connector member 93 in which the latch body 95 seats, the exterior of the connector member 93 being provided with vertical grooves 90d to facilitate the flow of fluid upwardly between the connector member 93 and the inside wall of the coding rod stop tube 62. The lateral slots 110 and 122 in which the latch unit 109 and the catch unit 123 are respectively disposed afford substantial fluid flow paths allowing the upward flow of fluid therethrough into the space in which the spring 108 is disposed between the cam member 101 and the cam stop member 105. The cam stop member 105 may be provided with passages 90e at its inner periphery to allow for the free

flow of fluid through the cam stop member into the coding rod stop tube 62, the openings beneath the respective stop shoulders 175-175f allowing the free flow of fluid within the stop tube 62 into the annular space in which the main spring 15 is disposed.

These various fluid passageways as just described prevent the application of damaging hydraulic forces to the components of the pendulum release mechanism L in the event that the operating conditions produce a substantial differential pressure across the relief valve 50 in the block 43 causing the relief valve to be opened allowing the sudden flow of fluid downwardly through the upper housing section 30 into the lower housing section 37 above the floating piston 20.

It may be that the rapid flow of fluid through the pendulum release mechanism L will occur in an upward direction at such velocity as to effect outward pivotal movement of the catch unit 123 to an extent greater than the catch unit would be cammed outwardly by the cam member 101, while the stop lug 127 is adjacent one of the openings beneath the stop shoulders 175-175f, thereby tending to overstress the springs 133 and 136 of the catch unit 123. In this connection it will be understood that in an instrument having the small diameter referred to above, the catch unit will be very small, and the springs 133 and 136 will also be of very small size susceptible of irreparable damage if overstressed. In order to prevent the excessive outward movement of the catch unit 123 it is therefore provided with an upwardly extended and projection 125a which, more particularly, is at the upper end of the catch part 129, this projection being adapted for abutting engagement with a stop 125b extended downwardly from the upper wall of the latch body 95 which defines the slot 122 in which the catch unit is pivotally disposed.

In use, the instrument as described above operates so as to indicate to the person controlling the progression of a well drilling operation the angle at which the drill collar string immediately above the drill bit is disposed each time the driller stops the drilling operation so that an additional length of drill pipe may be added to the drill string. This indication is derived inherently due to the fact that the circulation of drilling fluid is temporarily arrested. During the period that such circulation is halted, the shaft 13 and the knob 14 will move upwardly through a number of pulse rings representative of the angular disposition of the drill collar S above the drill bit. In addition, if the driller so desires he may intermittently halt the circulation of drilling fluid so as to derive, at will, an indication of the angular disposition of the drill string above the drill bit.

If it is assumed that the instrument is conditioned by the adjuster means 24 to operate on the stop rings 17e, having stop shoulders 275 through 275e thereon, and the drill string in which the instrument is disposed is at the maximum angle, say $3\frac{1}{2}$ degrees from vertical when the circulation of drilling fluid is arrested, then the knob 14 will allow upward movement of the coding rod 60, the pendulum release means L and the pendulum 16 until the pendulum engages and is stopped from further upward movement by the stop shoulder 275. The main spring 15 biases the shaft 13 upwardly, but the coding spring 60a biases the coding rod 60 upwardly effecting upward pull on the pendulum release means L to move it and the pendulum upwardly. When the upward movement of the pendulum is arrested by engagement of the pendulum with the stop shoulder 275, upward movement of the connector member 93 is arrested; but the coding rod spring 60a continues to move the coding rod 60 and its lower connector rod section 74 upwardly so as to cause corresponding upward movement of the cam member 101 of the pendulum release means L. As the cam member 101 moves upwardly it will cause outward pivotal movement of the catch unit 123 by the opposing cam surfaces 102 and 126 on the cam member and on the catch unit so

as to cause movement of the stop lug 127 into a position beneath the stop 175 provided in the coding rod stop tube 62, as seen in FIG. 7. At this time the latch unit 109 is still engaged beneath the shoulder 94 of the connector member 93 due to the engagement of the lower end 100 of the connecting rod section 74 with the roller 120. Continued upward movement of the coding rod 60 then moves the lower end 100 of the connecting rod section 74 past the center of the roller 120 so that the latch unit 109 is no longer restrained against the shoulder 94 of the connector member 93 (as seen in FIG. 8). At this time the spring 95b which is interposed between the section 96 of the latch body 95 and the bottom of the bore in the pendulum support 90 will exert a downward force on the pendulum support 90 to move the pendulum downwardly away from the latch body 95, the connector member 93 serving as a guide within the block 63 and the pendulum being forced back into firm seating engagement with the pendulum seat 19.

Following release of the latch unit 109 and seating of the pendulum 16, the cam member 101 will be prevented from substantial further upward movement by coengagement with the cam stop and, thus, upward movement of the coding rod 60 will be limited to an extent dependent upon which of the stop rings 17e is engaged by the pendulum 16. If, as pointed out above, the upward movement of the pendulum was arrested by the stop shoulder 275, then the coding rod 60 will move upwardly a distance calculated to allow all of the stop balls 75a through 75f to be freed for inward movement relative to the coding rod 60 and the shaft stop 77 will be free to move upwardly about the guide tube and stop ball support 61 into engagement with the stop ring 75 adjacent the upper end of the tube 61, this being the maximum extent of permissible upward movement of the shaft 13 and the knob 14.

Thus, upon resumption of the circulation of drilling fluid the knob 14 will be caused to move downwardly through seven of the pulse rings 7 causing 7 pressure pulses or signals detectable at the surface of the earth and indicative that the instrument is disposed at an angle of at least $3\frac{1}{2}$ degrees relative to vertical, or $\frac{1}{2}$ degree per pressure pulse.

At the point in these operations at which the circulation of drilling fluid is arrested and the upward movement of the shaft 13 is arrested by engagement of the shaft stop shoulder 77 with the selected balls 75a through 75f, or with the ring 75, the latch means will have been released and the pendulum will be on its seat, but upon resumption of circulation of drilling fluid the downward movement of the shaft 13 and the resultant downward movement of the coding rod 60 will cause the latch means to again be engaged with the pendulum support 90, providing that the coding rod 60 moves downwardly a sufficient distance to assure that the latch dog 115 will re-engage the latch shoulder 94, as shown in FIG. 6. The forces resisting such downward movement of the coding rod 60 and the latch means 95 include the opposing force of the spring 95b within the pendulum support 90 which urges the latch body 95 upwardly, the spring 60a within the coding rod tube 61 which acts upwardly on the coding rod, the main spring 15 and the spring 70b interposed between the upper end of the coding rod 60 and the shaft 13. Therefore, in order to be certain that sufficient downward force on the knob 14 is provided in response to the pressure differential acting on the knob 14, the above described replaceable bushing A is selected to provide a diameter of the wall 5f thereof which will cooperate with the outer periphery of the knob 14 to provide an annular gap or flow passage 5i related to the proposed rate of drilling fluid flow in the drilling operation.

While the specific details of an illustrative embodiment of the invention have been herein shown and described, changes and alterations may be resorted to with-

out departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a signalling apparatus adapted to be installed in a well drilling string for producing pressure signals in a stream of well drilling fluid indicative of the disposition of the drilling string in a well bore, said apparatus comprising: an elongated housing, a shaft having a free end projecting from an end of said housing, biasing means in said housing for moving said shaft from an inner position longitudinally outward with respect to said housing, cooperable gravity responsive means and first stop means spaced longitudinally in said housing for limiting such movement of said shaft, said free end of said shaft having a surface responsive to the flow of drilling fluid for moving said shaft inwardly with respect to said housing against said biasing means, pressure pulse producing means for producing said signals during inward movement of said shaft, releasable means connecting one of said cooperable gravity responsive means and first stop means to said shaft and operable to release said one of said cooperable gravity responsive means and first stop means from said shaft, second stop means operable independently of said releasable means to limit outward movement of said shaft, and means responsive to engagement of said gravity responsive means with said first stop means during outward movement of said shaft for so operating said second stop means prior to the operation of said releasable means and for thereafter operating said releasable means.

2. Signalling apparatus as defined in claim 1, wherein said releasable means includes a latch body, said second stop means including a catch unit carried by said latch body and movable with said shaft, stationary stops spaced along the path of said catch unit, and means movable relative to said catch unit and said latch body to move said catch unit into a position for engagement with one of said stops.

3. Signalling apparatus as defined in claim 1, wherein said releasable means includes a latch body, said second stop means including a catch unit carried by said latch body and movable with said shaft, stationary stops spaced along the path of said catch unit, and means movable relative to said catch unit and said latch body to move said catch unit into a position for engagement with one of said stops, and said latch means includes a latch unit shiftably carried by said latch body and a connector member connected to said one of said gravity responsive means and first stop means and releasably engageable by said latch unit, said means movable relative to said catch unit including means for holding said latch unit engaged with said connector member until said catch unit has been positioned for engagement with one of said stops.

4. Signalling apparatus as defined in claim 3, wherein said latch unit includes a roller revolvably engageable with said means movable relative to said catch unit.

5. Signalling apparatus as defined in claim 3, wherein said means movable relative to said catch unit includes a cam member, said catch unit having a cam surface engageable by said cam member responsive to movement of said cam member, and said means for holding said latch unit engaged with said connector member includes a portion of said cam member.

6. Signalling apparatus as defined in claim 3, wherein said means movable relative to said catch unit includes a cam member, said catch unit having a cam surface engageable by said cam member responsive to movement of said cam member, and said means for holding said latch unit engaged with said connector member includes a portion of said means movable relative to said catch unit and a roller on said latch unit.

7. Signalling apparatus as defined in claim 1, wherein said second stop means includes an elongated member having longitudinally spaced stop shoulders thereon, and

a catch unit movable relative to said stop shoulders responsive to outward movement of said shaft, and means for moving said catch unit into engagement with one of said stop shoulders upon engagement of said gravity responsive means with said first stop means to limit such movement of said shaft.

8. Signalling apparatus as defined in claim 7, wherein said catch unit comprises a first catch part and a second catch part, means pivotally supporting said catch parts in side by side relation for movement to a position for engagement with said stop shoulders, spring means biasing said first and second catch parts away from said position, spring means biasing said second catch part toward said position, and means for limiting relative movement of said catch parts by said last mentioned biasing means, whereby said catch parts are relatively pivotally movable to allow collapse of said catch unit.

9. Signalling apparatus as defined in claim 8, wherein said means for limiting relative movement of said catch parts includes a pin on one part and an enlarged opening in the other part, said pin projecting into said enlarged opening, and said last mentioned spring means being disposed between said parts and engaged with said pin.

10. Signalling apparatus as defined in claim 8, wherein said means for limiting relative movement of said catch parts includes a pin on one part and an enlarged opening in the other part, said pin projecting into said enlarged opening, and said last mentioned spring means being disposed between said parts and engaged with said pin, said other part also having a pin and said one part also having an enlarged opening into which the last mentioned pin projects, said spring means for biasing said catch parts away from said position being disposed between said parts and engaged with the last mentioned pin.

11. Signalling apparatus as defined in claim 1, wherein means are provided for connecting said releasable means to said gravity responsive means and to said shaft, said gravity responsive means comprising a pendulum and said first stop means comprising a plurality of annular stop rings spaced axially of one another, said releasable means including a pendulum support having a connector provided with a latch shoulder, a latch body movable upon movement of said shaft relative to said connector, said latch means including a latch unit pivotally mounted on said latch body for movement into and out of engagement with said latch shoulder, an element movable in said latch body from a position engaged with said latch unit to hold said latch unit in engagement with said latch shoulder to a position enabling release of said latch unit from said shoulder, said second stop means including a plurality of stationary stop shoulders and a catch unit pivotally mounted on said latch body for movement into and out of a position engageable with one of said stop shoulders and cooperative cam surfaces on said element movable in said latch body and on said catch unit for moving said catch unit into said position as said element moves toward said position enabling release of said latch unit.

12. Signalling apparatus as defined in claim 11, including roller means interposed between said element movable in said latch body and said latch unit.

13. Signalling apparatus as defined in claim 11, wherein said latch unit comprises a latch holder pivotally mounted on said latch body, said holder having a latch dog pivotally carried thereby, and a spring carried by said latch holder and engaged with said dog for biasing said dog to a position for latching engagement with said latch shoulder.

14. Signalling apparatus as defined in claim 11, wherein said catch unit comprises a pair of catch parts pivotally mounted on said latch body, one of said parts having one of said cooperative cam surfaces thereon, the other of said parts having a lug projecting therefrom for engagement with said stop shoulders, and means for allowing collapse of said parts.

15. Signalling apparatus as defined in claim 11, wherein said means for connecting said releasable means to said

shaft comprises coding means for allowing outward movement of said shaft to an extent inversely related to the extent of upward movement of said shaft.

16. Signalling apparatus as defined in claim 11, wherein means are provided for imposing a greater inward force on said shaft when said shaft is in said inner position than the force applied to said shaft to move said shaft inwardly during production of said signals.

References Cited

UNITED STATES PATENTS

3,457,654 7/1969 Alder ----- 33—205

5 LEONARD FORMAN, Primary Examiner
S. L. STEPHAN, Assistant Examiner

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,584,386 Dated June 15, 1971
Inventor(s) R.G. TAYLOR; JR.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, line 3, cancel "pending".
Col. 5, line 3, after "1966" insert --, now Patent
No. 3,526,041, issued September 1, 1970--.
Col. 5, line 48, cancel "Fig." and insert --Figs.--; after
"1" insert --and 5--.
Col. 5, line 51, cancel "automatically".
Col. 6, line 38, cancel "an" and insert --the aforementioned--;
line 59, cancel "Fig." and insert --Figs. 1,--; after
"2a" insert --, and 5--.
Col. 8, line 3, cancel "a" and insert --the--.
Col. 9, line 17, after "end" insert --102--.
Col. 10, line 43, after "62" insert --(Fig. 6)--;
line 47, after "124" insert --(Fig. 7)--;
line 50, after "opening" insert --(Fig. 8)--;
line 56, after "the" (first occurrence) insert
--then--.
Col. 11, line 6, cancel "the" (second occurrence) and insert
--a--;
line 64, after "to" insert --the stop means 17 by--.
Col. 12, line 30, cancel the comma (,) and insert --I;--;
line 31, after "shaft" insert --13,--;
line 47, cancel "30a" and insert --30e--;
line 74, cancel "105" and insert --103-- (2 places)
Col. 13, line 30, cancel "and" and insert --end--.
Col. 14, line 23, cancel "and," and insert --104;--;
line 58, cancel "95" and insert --L--;
line 61, after "rod" insert --guide--.
Col. 16, line 20, cancel "one" (first occurrence) and insert
--on--.

Signed and sealed this 20th day of June 1972.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents