April 29, 1969 R. L. ALDER 3,440,730

CENTRIFUGALLY CONTROLLED SIGNALLING DRIFT APPARATUS

Filed Sept. 28, 1966 Sheet 1 of 2

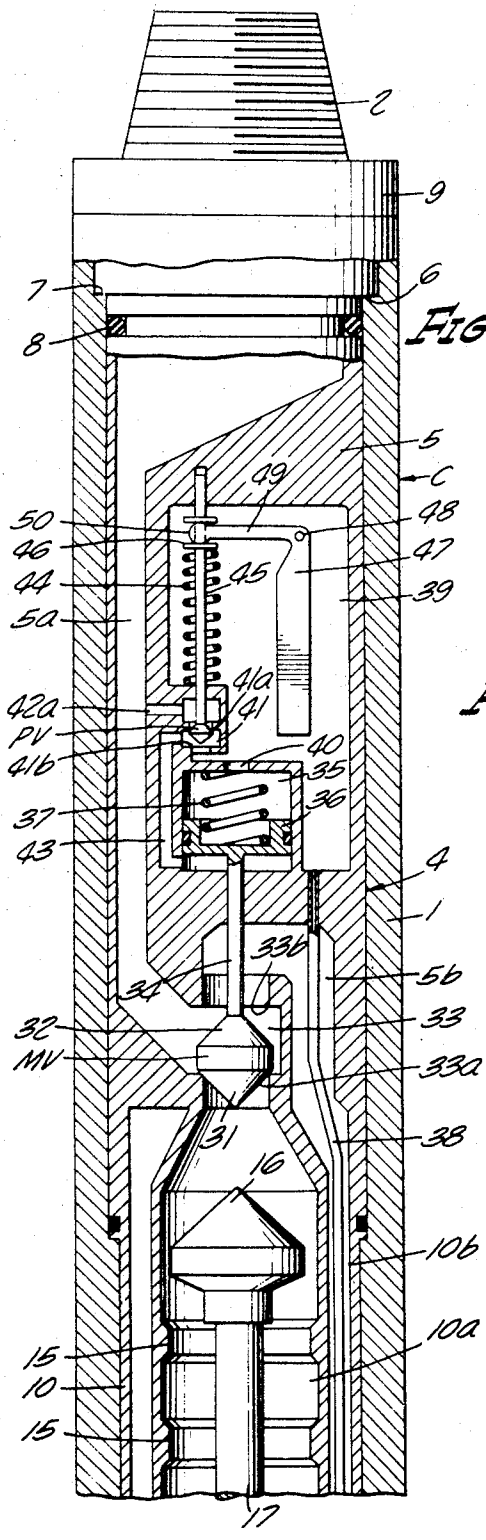


FIG. 1A.

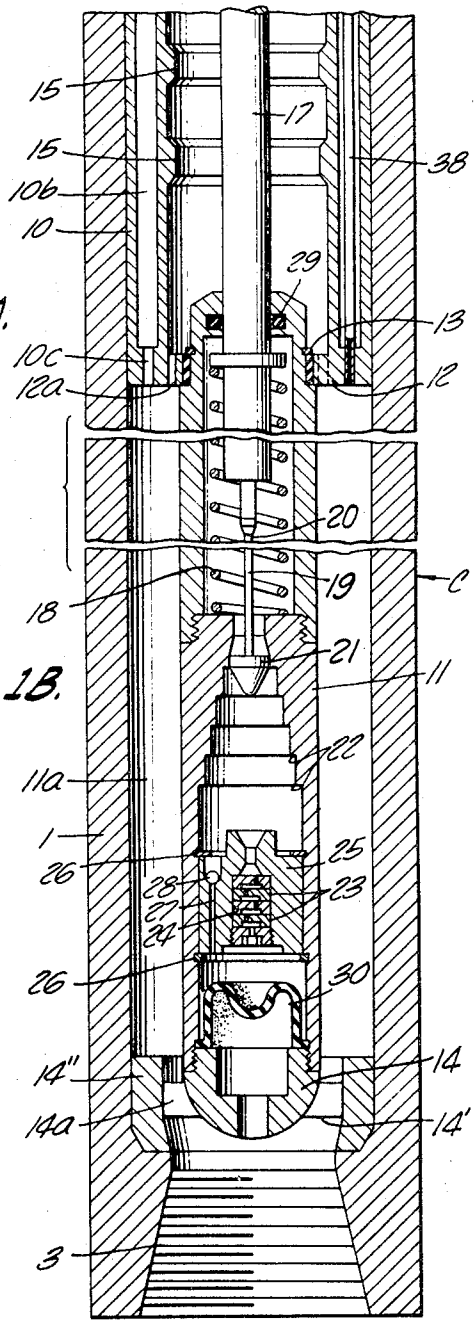


FIG. 1B.

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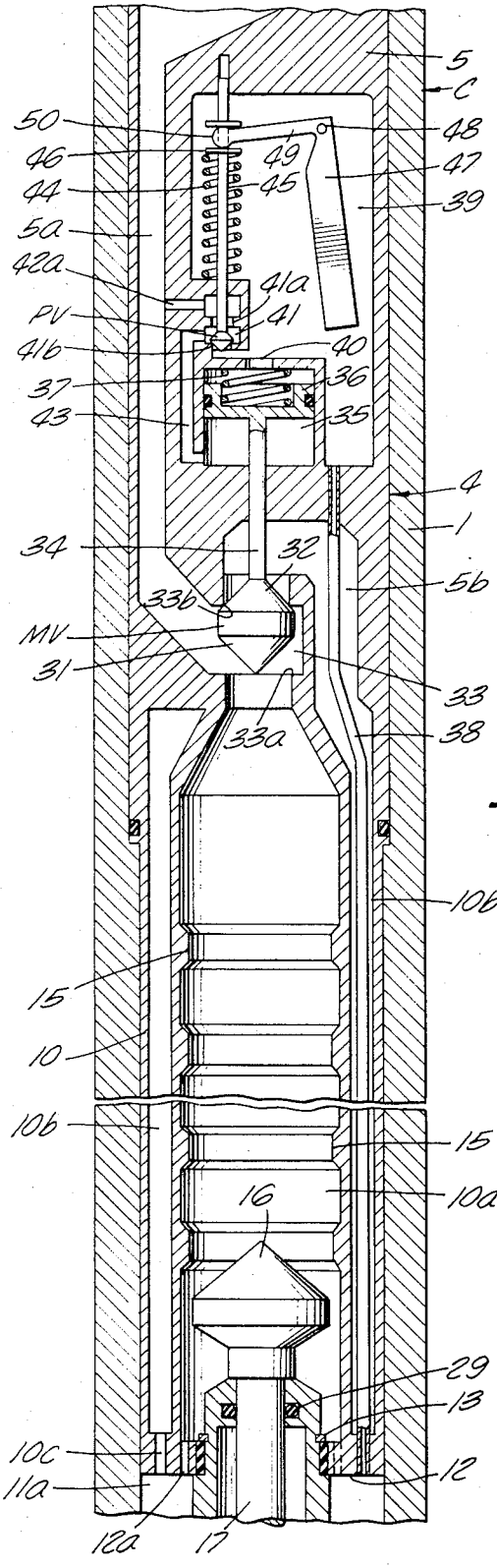


FIG. 2.

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3,440,730

CENTRIFUGALLY CONTROLLED SIGNALLING DRIFT APPARATUS

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Int. Cl. E21b 47/024
U.S. Cl. 33—205 10 Claims

ABSTRACT OF THE DISCLOSURE

A signalling drift indicator for use in drilling bore holes into the earth, in which a drilling fluid flow responsive knob moves longitudinally in a main flow passage having pulse rings therein for producing pressure pulses in the drilling fluid indicative of the angular disposition of the drill string relative to vertical, the knob being on an instrument shaft, movement of which is limited by a pendulum engageable with axially spaced annular stop shoulders of progressively smaller diameter to determine the number of pressure pulses, and in which flow of fluid through the main flow passage is diverted to a bypass flow passage to allow movement of the shaft in response to operation of a centrifugally controlled valve.

The present invention relates to signalling drift indicators for use in the drilling of bore holes or wells through or into the earth, and more particularly to centrifugal force controlled signalling drift apparatus which is responsive to the rotation of a well drilling string to actuate means whereby the generation of pressure pulses or signals indicative of the angle of the drill string adjacent the lower end thereof will be initiated.

Signalling drift indicators of the general type here involved are shown in patents heretofore issued to F. M. Varney et al., Patent No. 2,435,934, Sept. 10, 1948, J. A. Varney, Patent No. 2,762,132, Sept. 11, 1956, and R. L. Alder et al., Patent No. 3,176,407, dated Apr. 6, 1965, as well as in the pending application for Letters Patent filed July 1, 1966, Ser. No. 562,146 in the name of R. L. Alder. As will be recognized from these prior inventions, pressure pulses or signals may be produced in the stream of drilling fluid adjacent the drill bit and detected or recorded at the earth's surface as an indication of the angle of the lower end of the drill string from vertical, such signals being generated in a number which is either directly or inversely related to the angularity of the drill string adjacent the bit, or more precisely at the location in the drill string of the signal producing means. Such devices are of substantial benefit to the proper control of the weight to be applied to the drill bit in order to maintain the desired directional control over the progression of the drilling operation, as well as being of substantial benefit to the driller in determining relative bit efficiency, i.e., whether the bit should be changed to enable increased penetration rate at a given depth in the light of the time required to make a "round trip" of the drill pipe to change bits, all as is now well known in the art.

Heretofore, in the use of devices of the general type discussed above, it has been the practice to cause operation of the signal producing means in response to the cessation and resumption of the circulation of drilling fluid. In such devices, cessation of drilling fluid circulation allows the upward travel of a flow pressure responsive head or knob through a series of restrictions, and resumption of drilling fluid circulation causes the downward travel of the knob through a number of the restrictions related to the angle of the drill string, or more precisely the drill collar sub, in which the knob is disposed. Means are included in such devices which are operative in response to gravity to limit upward travel of the knob in a particular relation, direct or inverse, to the angle of the sub. However, in certain wells where heavy cuttings are encountered interruption to the circulation of drilling fluid is undesirable except when absolutely necessary, i.e., when a new length of drill pipe must be added. Moreover, when air is employed as the drilling fluid, substantial variation in air flow occurs when circulation is resumed and a period of time is required to establish a uniform flow of air at a uniform pressure. Effective operation of the signal producing means of the general type here involved, however, required heretofore the cessation of drilling fluid circulation, and in order for the signals produced in the drilling fluid column to be sensibly detected at the earth's surface a reasonably steady pressure must be established before the fluctuations or signals produced downstream can be reasonably detected and/or recorded with certainty. Thus, those prior devices which require the cessation of circulation or which are used in air drilling fluid operations are subject to the objection that either (1) their use is practically limited to readings of angularity made following addition of a length of drill pipe if intermediate cessation of drilling fluid circulation is hazardous, or (2) the signals may tend to be erratically detected in air drilling operations when the air circulation has not reached a substantially steady state following its resumption when the signals are produced below the surface of the earth.

An object of the present invention, therefore, is to provide means whereby the pressure pulse producing means of a signalling drift indicator may be operated to cause the creation of signals or pulses in the pressure of the stream of drilling fluid, without interrupting the continuity of such circulation.

Another object is to provide means for initiating operation of the subsurface signal producing means during continued drilling fluid circulation by halting rotation of the drill string. In accomplishing this objective means are provided responsive to the cessation of rotation of the drill string to initiate operation of the signal producing means by allowing the pulse generating means to assume a state determined by the angle at which the drill string is disposed responsive to the cessation of drill string rotation, the pulse generating means being caused to function to generate pulses in the stream of drilling fluid upon the resumption of rotation of the drill string, circulation of drilling fluid being maintained throughout the operation or being re-established prior to resumption of drill string rotation in the case that rotation and circulation have both been ceased, as when a length of drill pipe is to be added to the drill string.

In accordance with the next proceeding object, a more specific objective of the invention is to provide an instrument adapted to be installed in a drill string and having means for generating a number of pulses in the stream of drilling fluid without necessitating that circulation of the drilling fluid be interrupted, the instrument including a by-pass passage whereby the drilling fluid is allowed to bypass that portion of the pulse generating means which in prior devices has moved upon interruption to the circulation of drilling fluid to a position relative to cooperative means to cause the generation of the relevant number of signals or pulses, so that the instrument of the invention responds in the same fashion as it would had drilling fluid circulation been interrupted; the instrument including valve means for controlling the flow of drilling fluid through the bypass passage or through a main flow passage in response to specific manipulation of the drill string, i.e., more specifically the interruption and resumption of drill string rotation.

In accomplishing the foregoing objects, the instrument is provided with main and bypass flow passages and the movable member of the pulse generating means is disposed so as to be contacted by fluid flowing through the main flow passage and being biased to move by an internal main spring when fluid flow is diverted to the bypass passage, a main control or bypass valve being provided and being movable between a first, normal position closing the main flow passage and a second position closing the bypass passage when the instrument is stationary and rotating, respectively, under the control of a centrifugally operated pilot valve and under the influence of the drilling fluid pressure.

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

In the drawings:

FIG. 1A is a view showing the upper portion of a drill collar sub broken away to expose in longitudinal section an instrument embodying the invention, with the parts shown in a static condition and the main flow passage closed;

FIG. 1B is a downward extension of FIG. 1A; and

FIG. 2 is a view showing the centrifugal force responsive pilot valve means shifted and the main flow passage open, with the bypass passage closed, responsive to the downward flow of drilling fluid.

Like reference characters in the several views of the drawings and in the following description designate corresponding parts.

Referring first to FIGS. 1A and 1B, there is illustrated a length of drill collar C in the form of an elongated tubular body or sub **1** provided at its upper end with a threaded pin **2** and at its lower end with a threaded box **3** whereby the body **1** is adapted to be installed in a drill string adjacent or just above a drill bit. Disposed within the body **1** is the pressure signal producing instrument generally denoted at **4**.

In the illustrative embodiment the instrument **4** includes an upper flow control section including a body section **5** having a shoulder **6** at its upper end projecting outwardly to seat on an internal shoulder **7** in the body **1**. A sealing ring **8** is provided below the shoulders **6** and **7** to prevent flow of drilling fluid outside of the body **5**. The pin **2** at the top of the drill collar C is formed on a cap **9** adapted to be removably secured to the body **1** by threads (not shown) to allow access to the body **1**.

Below the body section **5** of the instrument **4** is a pulse ring section **10**, and beneath the pulse ring section **10** is a shaft supporting and pendulum section **11**. The pulse ring section **10** includes a tubular member having at its lower end a spider mount **12** into which the upper end of the shaft support and the pendulum section **11** extends, the latter being retained in the spider mount by a retaining ring **13**. At its lower end, the section **11** is threadedly connected to a cup-shaped member **14** which is connected by spider arms **14'** to a bottom support ring **14''** which bottoms in the body **1** of drill collar C and centralizes the lower end of the instrument.

A main flow passage extends through the instrument and includes a passage **5***a* in section **5**, a passage **10***a* in the pulse ring section **10**, and passages **12***a* in spider mount **12** the latter opening to the annular space **11***a* outside the rod support and pendulum section. This annular space leads to openings **14***a* in the bottom support **14**. Thus, fluid may be circulated downwardly through the instrument's main flow passage during a well drilling operation so as to remove cuttings from the bottom of the well caused by rotation of the drill string and the rotary bit thereon, and carry such cuttings up the annulus outside the drill string, all as well known in the art.

The pulse ring section **10** of the instrument includes a number of axially spaced pulse rings **15** constituting restrictions in the main flow passage **10***a*. Reciprocable in the passage **10***a* is a knob **16** which is supported at the upper end of a shaft **17** projecting from the upper end of the shaft supporting section **11** and normally biased upward by an internal main spring **18**. Fluid pressure acting on the knob **16** during circulation of drilling fluid through the main flow passage **10***a* biases the knob **16** and shaft **17** downward against the force of the spring **18**.

Means are provided within the shaft supporting and pendulum section **11** of the instrument for limiting upward movement of the shaft **17** a distance related to the angle of drift of the drill collar C and the well from vertical, so that upward movement of knob **16** through pulse rings **15** will be correspondingly limited. As seen in FIG. 1B, this means comprises a pendulum **19** pivotally supported beneath shaft **17** by bail means **19** and having a head **21** providing a shoulder which is selectively engageable with one of a plurality of axially spaced annular stops **22** of progressively diminishing diameter. It will be recognized the angular disposition of the drill collar C relative to the pendulum **19**, which being gravity responsive will depend vertically from its pivot, will determine which stop **22** will be engaged by pendulum head **21**, and that while in the structure shown the permitted upward travel of the pendulum and the shaft is inversely related to the angular disposition of the body, i.e., the greater the angle the less the travel, the assembly may include a coding system for enabling a direct relationship between angle and extent of shaft travel, as disclosed in the aforesaid R. L. Alder et al. Patent No. 3,176,407.

In either event, downward movement of the knob **16** responsive to flow of drilling fluid through main flow passage **10***a* will cause the production of a pressure pulse in the stream of fluid, which pulse constitutes a signal detectable at the earth's surface for purposes of indicating the angle of the drill collar C. In order that the pulses will be of sufficient duration as to be easily discriminated from normal pressure variations in the fluid, the clean body of oil in the pendulum section **11** is displaced through an orifice assembly including a number of orifice discs **23** which are disposed in a passage **24** in a combined disc support and pendulum seat **25** which is mounted in the section **11** between rings **26**. A bypass passage **27** and a downwardly closing check valve **28** are provided in the support **25** for allowing relative freedom of upward movement of instrument fluid in section **11** through support **25** during upward movement of shaft **17**.

This clean oil or instrument fluid is retained in the section **11** by means of a seal ring **29** at the upper end of section **11** and engaged with the shaft **17** and by a pressure equalizing divider below the support **25**. The divider in the illustrative embodiment is in the form of a diaphragm **30**, but a free piston may also be employed.

The instrument as thus far described in respect of the pulse ring, a knob means for producing pulses, and the gravity responsive means for determining the extent of movement of the knob, is typical of instruments of this general type which are operated in response to the cessation of drilling fluid circulation to allow upward knob movement and the resumption of drilling fluid circulation to cause downward knob movement and resultant pulse generation. Thus, a reading of the angle at which drilling is progressing may be had at least each time circulation is interrupted during the addition of a length or string of drill pipe. If additional readings are to be had with prior devices, circulation of drilling fluid must be interrupted between the periods during which new drill pipe is being added to the string. However, under some drilling conditions it is desirable to maintain continuous circulation as much as possible. When air is employed as a drilling fluid moreover, a substantial period of time is required to regain a stable flow and pressure condition following interruption to the circulation of air. Therefore, in accordance

with the present invention means are provided for enabling the taking of a reading of the angle without interrupting the circulation of the drilling fluid, such means functioning response to specific drill string manipulation.

In addition to the main flow passages **5***a* and **10***a* through the instrument, as previously described, the present instrument is provided with a bypass flow passage **5***b* in section **5** and, in communication therewith or as an extension thereof, a bypass passage **10***b* in the section **10**, the passage **10***b* opening at the lower end of section **10** into the main passage **11***a* through openings **10***c*.

Valve means are provided for either allowing flow of drilling fluid through the main passages or through the bypass passages in response to manipulation of the drill string. Specifically, such valve means includes a main valve MV and a pilot valve PV. The main valve MV includes a head having opposing seating surfaces **31** and **32** and is disposed in a valve passage **33** which communicates through a seat **33***a* with the main passage **10***a* and through a seat **33***b* with the bypass passage **10***b*. This valve head is provided with actuator means including a stem **34** which extends into a chamber **35** provided in the instrument section **5**. Within this chamber **35** is a valve actuating piston **36** and a spring **37** which acts on the piston to bias the valve downward to effect engagement of seating surface **31** with seat **33***a*.

Means are also provided for admitting to the chamber **35** above the piston **36** and under static drill pipe conditions beneath the piston **36**, the fluid pressure in the main passageway at a location downstream from the valve MV. This means includes a tube **38** or other suitable passage means which extends through the bypass passage **10***b* and communicates at its lower end with the lower main passage **11***a* and at its other end with a chamber **39** in instrument section **5**. The downstream pressure present at the lower end of tube **38** is thus present in chamber **39** and finds access to valve actuator chamber **35** through a port **40**. Thus, there is a constant downwardly acting force tending to cause closure of bypass passage **10***a* by the main valve MV, which force is that supplied by spring **37** and the downstream pressure acting on the piston **36**.

Pilot valve means including the pilot valve PV are provided for admitting to valve actuator chamber **35** below piston **36** either downstream pressure from chamber **39** or pressure from a location in the main passage **5***a* upstream from the source of downstream pressure, so that there will exist a net force acting on piston **36** to move the valve MV to the position shown in FIG. 1A at which seat **33***a* is closed or to move the valve MV to the position shown in FIG. 2 at which the seat **33***b* is closed. Thus, the pilot valve PV is disposed in a chamber **41** which communicates through a passage circumscribed by a seat **41***a* which leads to a port **42***a* constituting an inlet from main passage **5***a* upstream of the valve MV, and this chamber **41** communicates through a passage circumscribed by a seat **41***b* with the chamber **39**. In addition, a passage **43** leads from chamber **41** to actuator chamber **35** below the piston **36**.

Means are provided for biasing the pilot valve PV into engagement with seat **41***a* comprising a coiled spring **44** disposed about an actuator stem **45** which carries the valve PV and extends through seat **41***a* and upwardly into the chamber **39**, the spring engaging a collar **46** on the stem **45**. Means are also provided for moving the stem **45** against the spring **44** to move the valve PV to the position shown in FIG. 2 to engage seat **41***b* and open seat **41***a*. The latter means is responsive to specific manipulation of the drill collar C, and specifically responds to rotation of the drill collar. Thus, a weight member **47** is provided in chamber **39** and is pivotally mounted so as to normally depend from a support pin **48**, which extends transversely in the body section **5** through the chamber **39**, the weight which engages abutment **46** on the valve stem **45**. Accordingly, upon rotation of the drill collar C during drilling operations, the weight member **47** will be centrifugally forced to swing in the direction causing downward movement of lever arm **49** to force the valve stem and valve PV downward, whereby to engage seat **41***b* and open seat **41***a*.

Operation

In operation, assuming the drill collar to be stationary as shown in FIGS. 1A and 1B and assuming that drilling fluid is flowing downwardly through the main passage **5***a*, such fluid will flow through main valve seat **33***b* and thence downward through bypass passage **5***b* and through ports **10***c* into the main passage **10***a*. Under these circumstances, pilot valve PV engages seat **41***a* under the influence of spring **44**, and main valve MV engages seat **33***a* under the influence of spring **37**, while downstream pressure admitted to chamber **39** through tube **38** is applied to the piston **36** both above the piston through port **40** and below the piston through seat **41***b* and passage **43**. Accordingly, signal knob **16** will be moved upwardly by the action of main spring **18** on shaft **17**, to a position determined, as previously described, by engagement of pendulum shoulder **21** with one of the stops **22** in the pendulum section of the instrument. This conditions the instrument for the subsequent generation of a number of pressure pulses in the stream of drilling fluid indicative of the angular deviation of the drill collar C from vertical.

These signals will be produced pursuant to manipulation of the drill string, namely, upon rotation of the drill collar C. Such rotation will cause swinging of weight member **47** and downward movement of pilot valve stem **45** resulting in the pilot valve PV moving to engage seat **41***b*. This opens passage **43** to communicate with port **42***a* so that drilling fluid pressure derived from the upstream source will be supplied to main valve actuator chamber **35** below piston **36** to provide a force overcoming spring **37** and the pressures tending to hold the main valve MV in the position shown in FIG. 1A. Thus, the main valve MV will be moved to the position shown in FIG. 2 at which drilling fluid flow will be closed off at bypass seat **33***b* and the fluid will flow through main flow passage seat **33***a* into main flow passage **10***a*. Such flow will cause downward movement of knob **16** and a pressure pulse will be produced at each pulse ring **15** through which the knob passes, and such pulses may be detected or recorded at the earth's surface as an indication of angular deviation of the drill collar C.

While the specific details of the invention have been herein shown and described, changes and alterations may be resorted to without departing from the spirit of the invention.

I claim:

1. Signalling drift apparatus comprising: an elongated body adapted to be installed in a well drilling string and having a main flow passage and a bypass flow passage therethrough for the flow of drilling fluid; a drilling fluid flow responsive member exposed in said main flow passage, means for effecting movement of said member in said main flow passage from a first position to another position related to the angular disposition of said body upon interruption of the flow of drilling fluid through said main flow passage, means cooperative with said member for effecting a number of pulses in the drilling fluid stream as said member returns to said first position upon resumption of the flow of drilling fluid through said main flow passage; and valve means responsive to specific manipulation of said body for interrupting flow of drilling fluid through said main passage and diverting said flow through said bypass passage, and for thereafter allowing resumption of flow of drilling fluid through said main flow passage.

2. Signalling drift apparatus as defined in claim **1**, wherein said valve means includes means for actuating said valve means to interrupt flow of drilling fluid through said main flow passage when said body is stationary and

for allowing resumption of said flow of drilling fluid upon rotation of said body.

3. Signalling drift apparatus as defined in claim 2, wherein said means for actuating said valve means includes centrifugal force responsive means.

4. Signalling drift apparatus as defined in claim 1, wherein said valve means includes a drilling fluid pressure actuated main valve and pilot valve means responsive to said specific manipulation of said body for controlling actuation of said main valve.

5. Signalling drift apparatus as defined in claim 1, wherein said valve means includes a main valve, a bypass passage seat and a main flow passage seat engageable by said main valve, and means responsive to said specific manipulation of said body for actuating said main valve into engagement with said bypass passage seat and said main flow passage seat.

6. Signalling drift apparatus as defined in claim 1, wherein said valve means includes a main valve, a bypass passage seat and a main flow passage seat engageable by said main valve, actuator means for said main valve to move the same into alternate engagement with said seats including a chamber in said body, an actuator piston in said chamber, passage means for conducting drilling fluid pressure to said chamber at one side of said piston from a location downstream from said valve means, passage means for conducting fluid pressure to said chamber at the other side of said piston from a location upstream of said valve means, and means responsive to said specific manipulation of said body for preventing communication between said upstream location and said chamber at said other side of said piston.

7. Signalling drift apparatus as defined in claim 6, wherein said means responsive to said specific manipulation of said body includes centrifugal force responsive pilot valve means.

8. Signalling drift apparatus as defined in claim 6, wherein said means responsive to said specific manipulation of said body comprises pilot valve means, said pilot valve means having a valve passage communicating with each of said passage means, a pair of valve seats, and a

pilot valve head engageable alternately with said seats in response to said specific manipulation of said body.

9. Signalling drift apparatus as defined in claim 6, wherein said means responsive to said specific manipulation of said body comprises pilot valve means, said pilot valve means having a valve passage communicating with each of said passage means, a pair of valve seats, a pilot valve head engageable alternately with said seats in response to said specific manipulation of said body, and said means responsive to specific manipulation of said body including means responsive to centrifugal force for moving said pilot valve head into engagement with said seats.

10. Signalling drift apparatus as defined in claim 6, wherein said means responsive to said specific manipulation of said body comprises pilot valve means, said pilot valve means having a valve passage communicating with each of said passage means, a pair of valve seats, a pilot valve head engageable alternately with said seats in response to said specific manipulation of said body, said means responsive to specific manipulation of said body including a stem on said pilot valve head, a spring biasing said stem in one direction to cause engagement of said pilot valve head with one of said seats, an actuator lever engaged with said stem for shifting said stem in the other direction opposing said spring to cause engagement of said pilot valve head with the other of said seats, and a weight member connected to said lever for moving said lever in said directiton opposing said spring responsive to rotation of said body.

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PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,440,730 Dated April 29, 1969

Inventor(s) Robert L. Alder

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

Column 1, line 38, "Sept." should read --Feb.--. Column 4, line 17, "19" should read --20--. Column 5, line 4, after "ing" insert --in--; lines 73 and 74 should be transposed. Column 8, line 29, "directiton" should read --direction--.

SIGNED AND
SEALED

OCT 21 1969

(SEAL)
Attest:

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Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents