March 4, 1969 J. A. STAFFORD 3,430,712

WELL TOOL POSITION INDICATOR

Filed June 29, 1967 Sheet 1 of 2

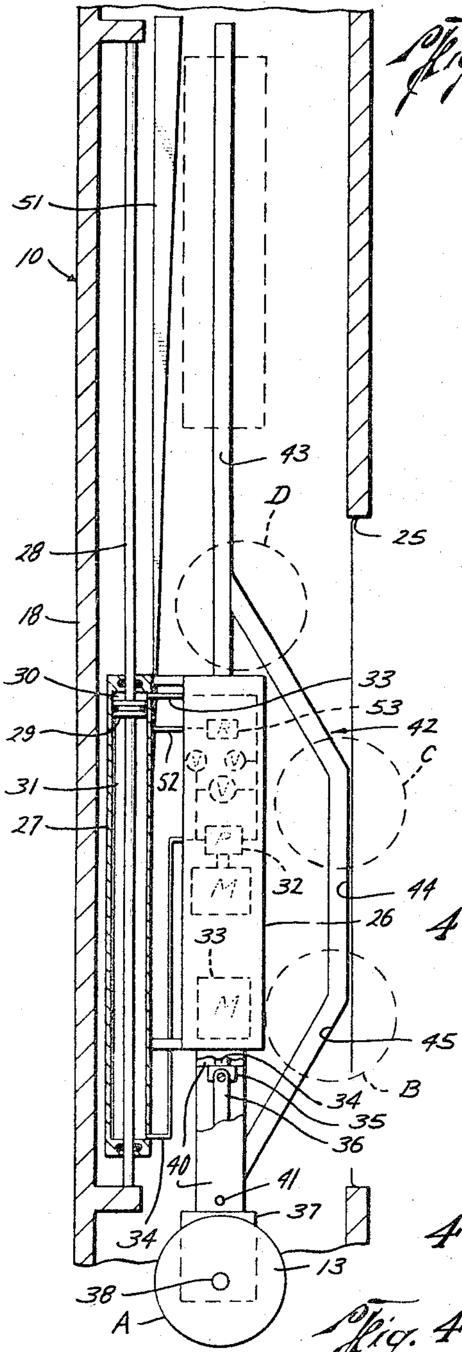

Fig. 2

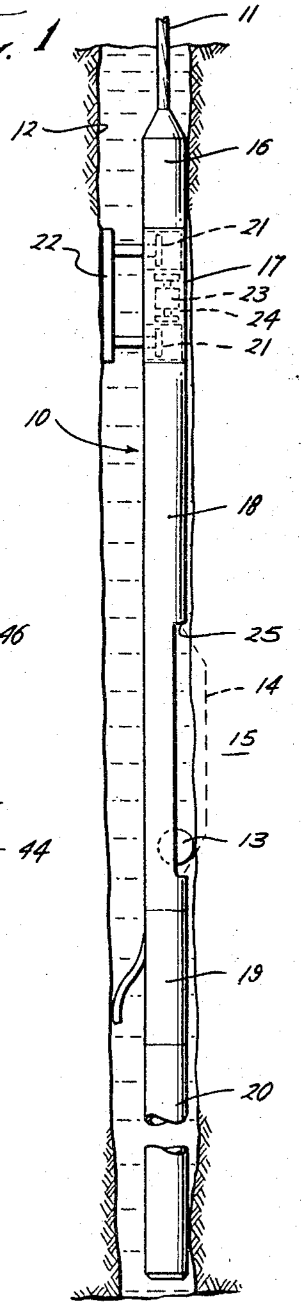

Fig. 1

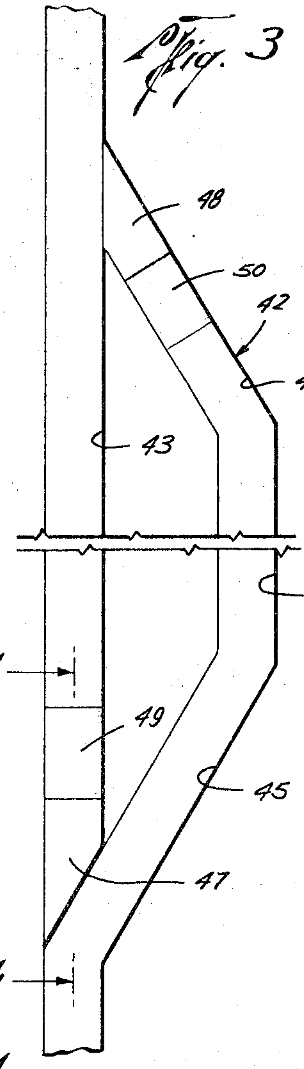

Fig. 3

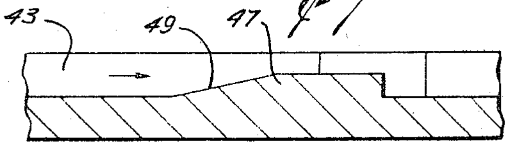

Fig. 4

John A. Stafford
INVENTOR.

BY
ATTORNEY

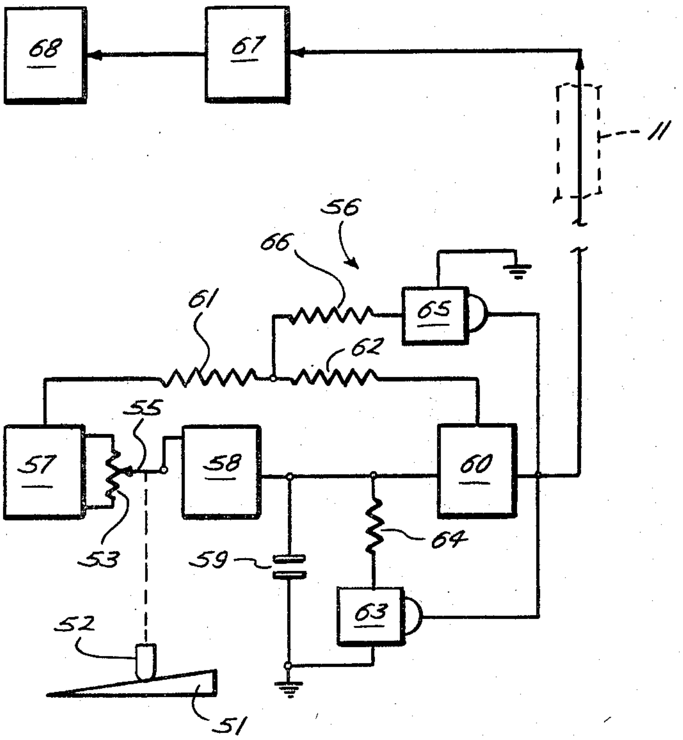

Fig. 5

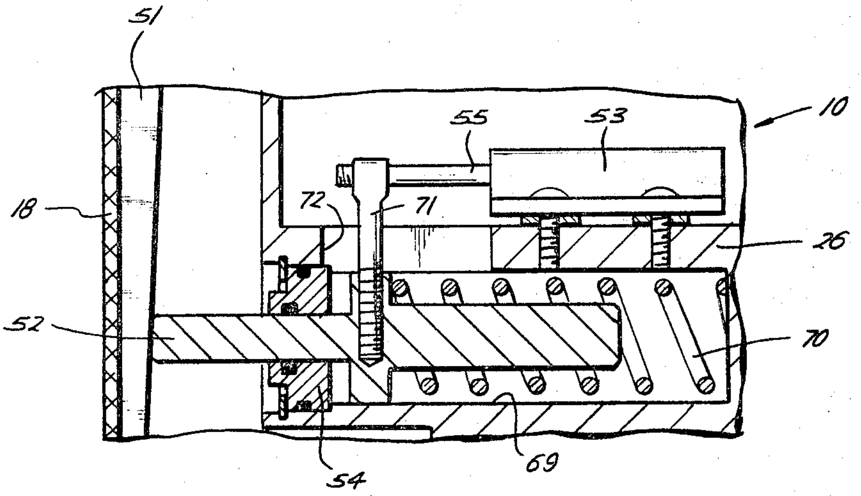

Fig. 6

John A. Stafford
INVENTOR.

BY
ATTORNEY

United States Patent Office

3,430,712

Patented Mar. 4, 1969

3,430,712

WELL TOOL POSITION INDICATOR

John A. Stafford, Houston, Tex., assignor to Schlumberger Technology Corporation, Houston, Tex., a corporation of Texas

Filed June 29, 1967, Ser. No. 649,951
U.S. Cl. 175—40 8 Claims
Int. Cl. E21b *41/00, 47/12, 49/02*

ABSTRACT OF THE DISCLOSURE

The particular embodiment described herein as illustrative of one form of the invention is directed to a position indicator for borehole apparatus used to obtain and collect a sample from earth formations traversed by the borehole. To accomplish this, the disclosed tool includes cutting wheels that are arranged to be extended and make cuts along the face of an adjacent formation as a carrier supporting the wheels is moved longitudinally. An electrical control on the carrier is varied as it moves along a particularly arranged surface on the tool to produce electrical signals characteristic of the relative position of the carrier to the fixed position of the tool.

Accordingly, as will subsequently become more apparent, the present invention pertains to new and improved monitoring means for determining at the surface the positions of relatively movable portions of a well tool; and, more particularly, this invention relates to control means for providing an indication at the surface of the progress of a core-slicing tool as it cuts away samples of earth formations from the wall of a previously drilled borehole.

Heretofore, formation samples have usually been obtained from previously drilled boreholes by explosively propelling into the adjacent wall of a borehole one or more tubular bodies or so-called "bullets" having appropriately arranged forward cutting edges. As these bullets penetrate the borehole wall, a generally cylindrical core of the formation material is driven into each bullet so that, when the bullets are subsequently retrieved, the cores in each will be recovered at the surface for examination. Typical of such core-taking bullets are those shown in Patent Nos. 2,678,804, 2,923,530, 3,072,202 and 3,220,490.

It is recognized of course that although such core-taking bullets have been highly successful, the most ideal arrangement would be to obtain a continuous sample of an earth formation from along a substantial vertical interval of a borehole. Heretofore, this has not been commercially feasible at least from boreholes that have been previously drilled.

One tool as shown in Patent No. 3,173,500 has been proposed, however, in which a pair of rotatable outwardly-converging cutting wheels are cooperatively arranged to be extended outwardly to cut their way into an adjacent formation. Then, as they are slowly raised, the cutting wheels will cut an elongated wedge-shaped formation sample out of the borehole wall. This sample is caught by the tool and returned to the surface. This tool is not arranged, however, to provide indications at the surface of the progress of the cutting wheels.

Accordingly, it is an object of the present invention to provide new and improved position-establishing means for providing a signal at the surface of the progress of a core-slicing tool as it cuts away elongated samples from earth formations.

This and other objects of the present invention are obtained with a core-slicing tool having fixed support means cooperatively carrying cutting means thereon and arranging on one of these means a variable electrical control having a laterally-movable actuator and on the other means a control surface having variable lateral dimensions along its longitudinal length. By positioning the control actuator on the control surface, as the cutting means move relative to the support means, the electrical characteristics of the electrical control will be varied in accordance with the relative positions of the actuator as it moves along the control surface. Appropriate circuit means are provided to respond to the resulting changes in electrical characteristics of the control and transmit a signal to the surface that is representative of the corresponding positions of the cutting means in relation to the support. This signal is, therefore, monitored to determine the positions of the cutting means during the course of a sample-taking operation.

The novel features of the present invention are set forth with particularity in the appended claims. The operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings, in which:

FIGURE 1 depicts a core-slicing tool with control means arranged in accordance with the present invention in a borehole and in position to obtain an elongated sample;

FIGURE 2 is a schematic representation of the intermediate portion of the tool shown in FIGURE 1;

FIGURE 3 is a schematic representation of a groove system that may be employed with the tool shown in FIGURES 1 and 2;

FIGURE 4 is a partial cross-sectional view taken along the lines 4—4 in FIGURE 3;

FIGURE 5 is a schematic representation of the electronic circuit for use in determining the operating position of the cutting wheels in the tool shown in FIGURES 1 and 2; and

FIGURE 6 depicts one manner of mounting an electrical control for use in the present invention.

Turning now to FIGURE 1, a core-slicing tool **10** arranged for use with the present invention is shown suspended from a cable **11** in a borehole **12** and in position for cutting means, such as a pair of similar cutting wheels **13**, to cut away an elongated prismatic or wedge-shaped sample **14** from the adjacent wall of an earth formation **15**. As seen in FIGURE 1, the tool **10** is preferably comprised of a number of tandemly connected housings **16–20** suitably arranged for enclosing the various components of the tool.

It will be appreciated, of course, that to better understand the present invention the general arrangement and operation of the tool **10** as a whole should be first described. Although the following description is believed to be sufficient, copending applications Ser. Nos. 649,929, 649,976 and 649,952 filed simultaneously herewith more fully describe those other portions of the tool **10**.

The upper housing **16** preferably encloses suitable circuitry for locating the tool **10** at a desired position in the borehole **12** as well as for controlling the various components in the tool and transmitting information and power through the various conductors in the suspension cable **11**. The circuitry preferably employed with the cutting means of the present invention is fully described in a copending application Ser. No. 649,978 filed simultaneously herewith.

The next lower housing **17** preferably include suitable longitudinally spaces, hydraulically actuated pistons **21** for selectively extending a wall-engaging member **22** on the rear of the tool **10** laterally against one side of the borehole **12** to shift the forward face of the core-slicing tool in the opposite direction. To make the wall-engaging member **22** selectively operable from the surface, a hydraulic pump **23** and chamber **24** (shown in dashed lines) are arranged to extend and retract the wall-engaging member by pumping hydraulic fluid into the piston chambers either behind or ahead of the pistons **21**. By maintaining an increased hydraulic pressure behind the pistons **21**, the wall-engaging member **22** will, of course, urge the forward face of the tool **10** against the opposite wall of the borehole **12** with a corresponding force.

The intermediate housing **18** of the tool **10** supports the cutting wheels **13** that are respectively mounted in converging vertical planes and arranged to rotate about independent, outwardly diverging axes themselves lying generally in the same horizontal plane and intersecting each other at a suitable angle. A longitudinal opening **25** is provided along the forward wall of the housing **18** diametrically opposite from the wall-engaging member **22**. The cutting wheels **13** are suitably arranged and sized in relation to one another so that, when extended, their converging peripheral edges will pass through the housing opening **25** and all but come together at about the point of intersection of the three aforementioned planes. Thus, by moving the wheels **13** in unison in a generally vertical direction, the generally wedge-shaped or triangular prismatic sample **14** will be cut from the adjacent formation **15**.

To gain entrance for the cutting wheels **13** into the formation **15**, means (to be subsequently described) are provided for advancing the wheels outwardly and upwardly through the housing opening **25** to their outermost lateral position. Then, after a longitudinal cut of a predetermined length has been made, the cutting wheels **13** are returned along an upwardly inclined path and back through the housing opening **25** until they are fully retracted. The cutting wheels **13** then return to their original starting position while still fully retracted.

The lower housing **20** of the tool **10** is arranged to receive a plurality of core samples and keep them segregated from one another. Generally speaking, the housing **20** is arranged in such a manner that a plurality of compartments therein (not shown) will be sequentially positioned to each successively receive a formation sample, as at **14**, as the tool **10** is operated. In this manner, the tool **10** can be employed on a single trip in the borehole **12** to recover a large number of formation samples that will be separately disposed in the compartments in a predetermined order.

Turning now to FIGURE 2, a schematic representation is shown of the intermediate housing **18** of the tool **10** in which the cutting wheels **13** are confined. In general, the cutting wheels **13** are operatively mounted below an enclosed housing or enclosure **26** that is, in turn, secured to two parallel tubular members **27** (only one shown). These tubular members **27** are each slidably disposed about substantially longer, paralleled longitudinal rods **28** (only one shown) that are secured only at their upper and lower ends to the tool housing **18** and spaced away from the rear wall thereof. The opposite ends of these tubular members **27** are slidably sealed around the elongated rods **28**. A piston member **29** (only one shown) is fixed at an intermediate position on each of the elongated rods **28** and slidably sealed relative to the internal bore of its associated tubular member **27** to define therein separate upper and lower fluid-tight chambers **30** and **31**.

Accordingly, it will be appreciated that developing a higher fluid pressure in the upper hydraulic chambers **30** than that in the lower hydraulic chambers **31**, the tubular members **27** and enclosure **26** secured thereto will be moved upwardly along the elongated rods **28** relative to the tool housing **18**. Similarly, by imposing a higher pressure in the lower hydraulic chambers **31** than that in the upper hydraulic chambers **30**, the enclosure **26** will travel downwardly along the rods **28**.

To develop such higher pressures in the chambers **30** and **31**, a suitable reversible hydraulic pump **32** is mounted within the enclosure **26**. Fluid lines **33** and **34** are respectively connected between the hydraulic chambers **30** and **31** and the pump **32**. By selecting a motor-driven pump **32** and filling the chambers **30** and **31** with a suitable hydraulic fluid, the pump can be selectively operated from the surface to transfer fluid between the hydraulic chambers to accomplish the desired travel of the enclosure **26** along the elongated rods **28**.

By arranging a typical bellows or piston (neither shown) at a convenient point in a wall of the enclosure **26**, the hydraulic fluid in the enclosure and chambers **30** and **31** will be maintained at a pressure at least equal to the hydrostatic pressure of fluids or so-called "mud" in the borehole **12**. In this manner, by "pressure-balancing" the hydraulic system relative to the borehole hydrostatic pressure, the hydraulic pump **32** needs only to develop a pressure sufficient to overcome the weight of the enclosure and whatever friction that may be encountered in moving the cutting wheels **13** and the enclosure **26**.

To power the cutting wheels **13**, an electric motor **33** is also fitted into the enclosure **26** and its shaft **34** connected to the cutting wheels by suitable power-transmission means, such as a universal joint **35** which is connected by way of another shaft **36** to a right-angle gear drive **37** having outwardly diverging wheel shafts **38** at an angle to one another. By locating the cutting wheel motor **33** in the enclosure **26**, it will also be pressure-balanced in the same manner as the motor for the pump **32**. Similarly, by enclosing the shafts **34** and **36** and universal joint **35** in an oil-filled tube (not shown) that is fluidly sealed at its opposite ends to the enclosure **26** and gear drive **37** and in fluid communication with each, the power-transmission means will also be completely pressure-balanced.

A pair of depending arms **40** disposed on opposite sides of the protective tube are connected at their lower ends to the gear drive **37** and pivotally connected at their upper ends to the enclosure **26** so as to pivot about an axis lying generally in the same horizontal plane as the pivotal axis of the universal joint **35**. Outwardly-biased pins **41** (only one seen in FIGURE 2) near the free ends of the pivoted arms **40** are slidably disposed in a labyrinth-like system of grooves **42** (only one system seen in FIGURE 2) formed in the interior side walls of the intermediate housing **18** on opposite sides of the longitudinal opening **25** therein. As will subsequently become apparent, these groove systems **42** are so arranged that upward longitudinal travel of the enclosure **26** from its full-line position to its dashed-line position shown in FIGURE 2 will be effective (through the coaction of the guides **41** in their respective groove system) to direct the cutting wheels **13** along the path A–B–C–D depicted in FIGURE 2. Then, upon downward travel of the enclosure **26** back to its full-line position shown in FIGURE 2, the groove systems **42** and guides **41** will direct the cutting wheels **13** along the path D–A toward their initial position.

As seen in FIGURE 3, the groove systems **42** are each arranged in a closed loop having two parallel longitudinal portions **43** and **44** of unequal length and spaced apart from one another. The shorter grooves **44** are connected at their opposite ends to the longer grooves **43** by oppositely directed inclined grooves **45** and **46** which respectively intersect the longer grooves at longitudinally spaced intermediate points.

Accordingly, as the cutting wheels **13** move along the path A–B, they will be moving upwardly and outwardly as they cut their way into the formation **15**. Then, as the cutting wheels **13** move upwardly from their position at B to their position at C, they will be cutting along a straight path of a length determined by the vertical height of the shorter grooves **44**. Upon reaching their position at C, the cutting wheels **13** will be retracted as they move further upwardly and cut their way toward their position at D. Thus, once the cutting wheels **13** have reached the position at D, a prismatic sample, as at **14**, with tapered ends will have been cut out of the formation **15** and dropped into the core-receiving housing **20** therebelow.

The groove systems **42** must, of course, be arranged to insure that the guide pins **41** are diverted into the lower inclined grooves **45** as the enclosure **26** moves upwardly. Similarly, when the enclosure **26** has reached its uppermost position (as shown in dashed lines in FIGURE 2), it is necessary that the guide pins **41** be prevented from re-entering the upper grooves **46** so that the cutting wheels **13** can proceed from their position at D and directly back to their initial position at A.

Accordingly, means are provided to direct the guide pins **41** in a predetermined direction around the circuitous groove systems **42** but prevent these pins from moving in the opposite direction. As seen in FIGURES 3 and 4, an abutment **47** is provided in the lower end of each of the longer grooves **43** for preventing the guide pins **41** from entering the longer grooves as they move upwardly. To facilitate the passage of the guide pins **41**, the faces of the abutments **47** are extended along the line of the downwardly facing wall of the lower inclined grooves **45** as shown in FIGURE 3. Similarly, to insure that the guide pins **41** will not re-enter the upper end of the upper inclined grooves **46** as the enclosure **26** is returned downwardly, an abutment **48** (similar to those at **47**) is located across the entrance to the upper end of each of the upper inclined grooves **46**. Here again, to facilitate the passage of the guide pins **41**, the faces of the abutments **48** are made as a continuation of the right-hand (as viewed in FIGURE 3) side walls of the longer grooves **43**. The height of each abutment, as at **47**, is made less than the total depth of its associated groove **43** and an inclined ramp or surface, as at **49** (FIGURE 4), is provided from the bottom of the groove **43** up to the upper surface of the abutment, with this inclined surface rising in the direction from which the guide pin **41** is intended to be coming in that groove. Thus, as the spring-biased guide pins **41** approach the inclined surfaces **49**, for example, they can retract sufficiently to move up the inclined surfaces **49** of the abutments **47** as the enclosure **26** is moved downwardly. Once the guides **41** reach the abrupt faces of the abutments, the springs biasing the guides will urge them outwardly to return them to their normal extended position. The inclined surfaces **50** (FIGURE 3) on the lower ends of the upper abutments **48** in the grooves **46** will, of course, function in the same manner.

Motion-translating means (not shown) are arranged in the housing **19** coupled immediately below the intermediate tool housing **18** for rotating the several compartments of the sample receiver in the housing **20** therebelow sequentially into position to receive successive formation samples, as at **14**, as they are freed by the cutting wheels **13** and to segregate these samples from one another. Since a complete description of this sample receiver is not essential to a full understanding of the present invention, suffice it to say that these sample-receiving compartments are basically comprised of a plurality of upright tubes (not shown) that are equally spaced about an axial shaft (not shown) journalled at its opposite ends in the housing **20**, with these tubes being adapted to be successively rotated about the longitudinal axis of the housing into position to receive one of the formation samples **14**. The upper ends of these tubes are, of course, open and their lower ends are closed. The motion-translating means in the housing **19** are arranged to rotate the sample-receiving tubes into their respective positions in response to the longitudinal travel of the enclosure **26**. For further details, complete descriptions of the motion-translating means in the housing **19** and the sample receiver in the housing **20** are found in the aforementioned copending application Ser. No. 649,976 filed simultaneously herewith.

Turning now to the present invention, as best seen in FIGURE 2, to provide indications at the surface representative of the longitudinal positions of the cutting wheels **13** in relation to the housing **18**, a control surface with variable lateral dimensions, such as an elongated tapered ramp **51**, is secured to the housing in a convenient position that parallels the elongated rods **28**. This tapered ramp **51** is suitably arranged to contact the outer end of a laterally movable actuator **52** that is connected to an electrical control, such as a so-called "linear" potentiometer **53**, in the enclosure **26**, with the actuator extending through a suitable fluid seal **54** (FIGURE 6) in the enclosure wall.

Thus, at all longitudinal positions of the enclosure **26** in relation to the housing **18** and the tapered ramp **51**, the actuator **52** will assume corresponding lateral positions that are directly related to the distance between the particular point where the actuator is in contact with the ramp and either end of the ramp. It will be recognized, of course, that the resistance between the moving contact **55** (FIGURE 5) and one end of the potentiometer **53** will vary in accordance with the movement of its actuator **52**, with the resistance at any given time being directly related to the longitudinal distance between the present position of the enclosure **26** and its initial position as shown in FIGURE 2. Since the ramp **51** is uniformly tapered in a longitudinal direction, this resistance will, of course, vary at a constant rate as the enclosure **26** moves in either direction in relation to the housing **18**. It should be realized, however, that the control surface on the ramp **51** can be shaped to develop other patterns of lateral displacement of the actuator **52**. For example, pronounced irregularities such as a depression or a bump could be arranged at one or more predetermined positions on the ramp **51** to provide characteristic variations in the resistance of the potentiometer **53**. These interruptions in the otherwise constant rate of change of the resistance of the potentiometer **53** could be employed to designate, for example, that the enclosure **26** has reached its position where the cutting wheels **13** are fully extended as well as where the cutting wheels are about to retract. Similarly, other patterns of the control surface could be devised to signal when the enclosure **26** was at a predetermined longitudinal position.

The varying resistance of the potentiometer **53** as the enclosure **26** moves may be used in various manners to provide a signal at the surface. Although the resistance could just as well be measured directly at the surface, it is preferred, however, to use electronic means **56** such as shown in FIGURE 5 to provide an indication of the present position of the cutting wheels **13** at any given time. Inasmuch as this circuit **56** is more fully explained in a copending application Ser. No. 649,978 filed concurrently with the present application, it is believed necessary only to describe this circuit only so far as to show its general relation to the present invention.

In general, therefore, the circuit **56** seen in FIGURE 5 is arranged to provide repetitive electrical pulses at the surface that have a pulse rate representative of the present longitudinal position of the cutting wheels **13** in relation to the housing **18**. As the cutting wheels **13** change position in relation to the housing **18**, the rate of these pulses will also change to provide a detectable indication at the surface characteristics of the new position of the cutting wheels.

To accomplish this, the potentiometer **53** is connected across a constant-voltage power supply **57** and its movable contact **55** is connected to the input of a typical so-called "constant-current" amplifier **58** to provide a voltage-divider circuit with an output voltage directly related to the relative position of the movable contact. Since the input impedance of the amplifier **58** is constant, the current applied to its input will be directly related to the output voltage of the voltage-divider circuit.

The current amplifier **58** desirably has a high output impedance so that the output current of the amplifier will also be constant for any one position of the movable contact **55**. Thus, as the input current to the amplifier **58** is varied by the potentiometer **53**, the output current from the amplifier will vary accordingly, but will be constant for any single position of the movable contact **55** and, thus, be directly related to the present position of the actuator **52** on the ramp **51**. A capacitor **59** connected across the output terminals of the amplifier **58** is charged by this output current, with the rate at which this capacitor is charged being, of course, directly proportional to the magnitude of the output current from the amplifier.

The capacitor **59** and amplifier **58** are connected to the input of a typical voltage comparator **60**. A reference voltage for the comparator **60** is derived from the constant-voltage power supply **57** by way of a pair of serially-connected resistors **61** and **62**. The comparator **60** will generate a DC output signal whenever the input signal thereto equals the reference voltage which energizes a normally-open gate **63** arranged to shunt the capacitor **59** through a resistor **64**. The discharge rate of the capacitor **59** will, therefore, be a function of the values of the resistor **64** and the capacitor.

The output signal from the comparator **60** also energizes a normally-open gate **65** which then connects the junction between the resistors **61** and **62** through a relatively low-value resistor **66** to ground. Closing of the gate **65** will, therefore, decrease the reference voltage being applied to the comparator **60**. Thus, each time the voltage on the capacitor **59** reaches the initial reference voltage of the comparator **60**, an output signal is developed by the comparator which continues until the capacitor has been discharged (by the resistor **64**) to reach a voltage equal to the now-lower reference voltage of the comparator. At this time, the output signal of the comparator **60** ceases and re-opens the gates **63** and **65** thus restoring the reference voltage to its initial value.

It can be seen, therefore, that this intermittent operation will produce pulses from the voltage comparator **60**. The "on" time of these pulses is substantially related to the time required for the capacitor **59** to be discharged from a voltage equal to the "high" reference voltage initially applied to the comparator **60** to a voltage equal to the "low" reference voltage applied thereto. This time is, of course, a function of the capacitance of the capacitor **59**, the resistance of the resistor **64**, and the differential between the "high" and "low" reference voltages. The "off" time of the pulses is, however, a function of the magnitude of current charging the capacitor **59**. Thus, it can be seen that the frequency or pulse rate of the pulses will be proportional to the output current from the amplifier **58** and, therefore, to the position of the movable contact **55**.

The string of output pulses from the comparator **60** are transmitted through the suspension cable **11** to a suitable pulse-rate detector **67** at the surface. The varying DC output of the pulse-rate detector **67** is connected to an indicator, such as a voltmeter **68**, which is suitably calibrated to provide an indication of the present position of the cutting wheels **13**. Thus, in the operation of the present invention, when the cutting wheels **13** are in one position, the pulse output of the voltage comparator **60** will be at a rate characteristic of this position. As the cutting wheels **13** move up or down, this pulse rate will correspondingly change to provide a different indication on the position indicator **68** at the surface.

Turning now to FIGURE 6, one arrangement is shown for mounting the control or potentiometer **53** within the enclosure **26**. The potentiometer **53** is a typical fluid-tight, so-called "linear" potentiometer which has a rectilinearily movable contact **55**. To protect the potentiometer contact member **55** from damage, the potentiometer **53** is completely confined in the enclosure **26** and the actuator **52** movably disposed in a lateral bore **69** spaced from and parallel to the central axis of the potentiometer. As previously mentioned, the actuator **52** is fluidly sealed relative to the wall of the enclosure **26** by the fluid seal **54**. The actuator **52** will, of course, be pressure-balanced since the pressure of the hydraulic fluid in the enclosure is maintained equal to that of the fluids in the borehole **11**. A spring **70** between the actuator **52** and the rear of the bore **69** maintains the actuator in engagement with the ramp **51**.

To operate the potentiometer **53**, a rigid connecting member **71** is disposed in an opening **72** between the bore **69** and the forward end of the potentiometer **53**. The connecting member **71** is secured at its opposite ends to the actuator **52** and the distal end of the movable contact member **55** so that lateral movement of the actuator as it moves along the tapered ramp **51** will cause a corresponding movement of the contact member.

Accordingly, it will be appreciated that the present invention has provided means for determining at the surface the relative positions of two relatively movable portions of a well tool during the course of their movement in relation to one another. By employing the principles of the present invention, a signal is provided at the surface from which the operation of a well tool such as the disclosed core slicer can be monitored.

While a particular embodiment of the present invention has been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. Apparatus for obtaining samples of earth formations traversed by a borehole comprising: support means adapted for suspension in a borehole; formation-sampling means on said support means and adapted for travel relative thereto between longitudinally-spaced positions; and means for signaling the longitudinal position of said formation-sampling means relative to said support means including a control surface extending longitudinally along one of said two first-mentioned means and having varying lateral dimensions along its length, an electrical control on the other of said two first-mentioned means, and means operatively arranged between said control surface and said electrical control for lateral movement by said control surface to vary the electrical characteristics of said electrical control in accordance with the relative longitudinal positions of said control surface and said laterally-moving means.

2. The apparatus of claim **1** wherein said electrical control is a variable resistance element.

3. The apparatus of claim **1** wherein said lateral dimensions of said control surface vary uniformly in relation to the longitudinal dimensions of said control surface.

4. The apparatus of claim **3** further including: a distinctive lateral irregularity on said control surface at a predetermined location.

5. The apparatus of claim **1** further including: electrical conductor means connected to said support means and extending to the surface of the earth; means on said apparatus for connecting said electrical control to said electrical conductor means; and indicating means at the surface of the earth connected to said electrical conductor means and responsive to variations in said electrical characteristics of said electrical control to signal the relative longitudinal positions of said formation-sampling means and said support means.

6. The apparatus of claim **5** wherein said lateral dimensions of said control surface vary uniformly in relation to the longitudinal dimensions of said control surface.

7. The apparatus of claim **6** wherein said control surface is on said support means and said electrical control is on said formation-sampling means.

8. The apparatus of claim **7** wherein said electrical control is a variable resistance unit.

References Cited

UNITED STATES PATENTS

2,500,785	3/1950	Arutunoff	175—78
2,599,405	6/1952	Mennecier	175—40
3,173,500	3/1965	Stuart et al.	175—78 X
3,225,828	12/1965	Wisenbaker et al.	166—55

DAVID H. BROWN, *Primary Examiner.*

U.S. Cl. X.R.

175—78