United States Patent [19]

Delestrade et al.

[11] **3,891,038**

[45] **June 24, 1975**

[54] **DEVICE FOR MEASURING THE POSITION AND SPEED OF A BORING TOOL**

[75] Inventors: **André Delestrade**, Viroflay; **Roger Marce**, Fourqueux, both of France

[73] Assignees: **Compagnie Francaise des Petroles; Compagnie Generale d'Automatisme**, both of Paris, France

[22] Filed: **June 19, 1974**

[21] Appl. No.: **480,798**

[30] **Foreign Application Priority Data**

June 28, 1973 France 73.23712

[52] **U.S. Cl.** **175/7**; 73/151.5; 175/45; 175/27; 254/172

[51] **Int. Cl.** **E21b 47/02**

[58] **Field of Search** 175/5, 7, 27, 40, 45; 73/151, 151.5; 254/172, 173

[56] **References Cited**

UNITED STATES PATENTS

3,001,396	9/1961	Cleveland	175/5 X
3,511,476	5/1970	Horton	254/172 X
3,522,727	8/1970	Calhoun	73/151.5
3,643,504	2/1972	Rundell	73/151.5
3,721,293	3/1973	Ahlstone	175/27
3,746,102	7/1973	Griffin et al.	175/27
3,747,402	7/1973	Branham et al.	73/151
3,777,560	12/1973	Guignard	73/151.5
3,785,445	1/1974	Scozzafava	175/5
3,791,628	2/1974	Burns	254/172

Primary Examiner—Frank L. Abbott
Assistant Examiner—Richard E. Favreau
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn and Macpeak

[57] **ABSTRACT**

Device making it possible to know, at the time of boring an oil well at sea, the depth of the hole, the position of the tool and its advancing speed; these characteristics are calculated according to the measurements of the paying out of the active end of the cable passing through a block supporting a combination of rods, of the weight at the hook of the combination of rods, of the movement in relation to the structure of the boring tower, of the axis of the upper pulley of the block and of the paying out of the support cables of a tubular part connecting the head of the well to the bottom of the water or craft.

14 Claims, 3 Drawing Figures

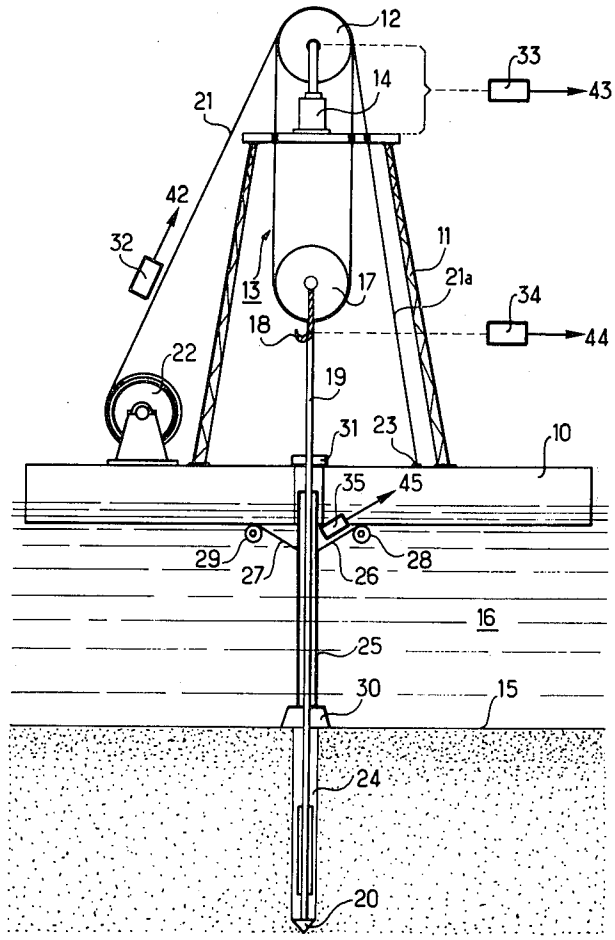


FIG.1

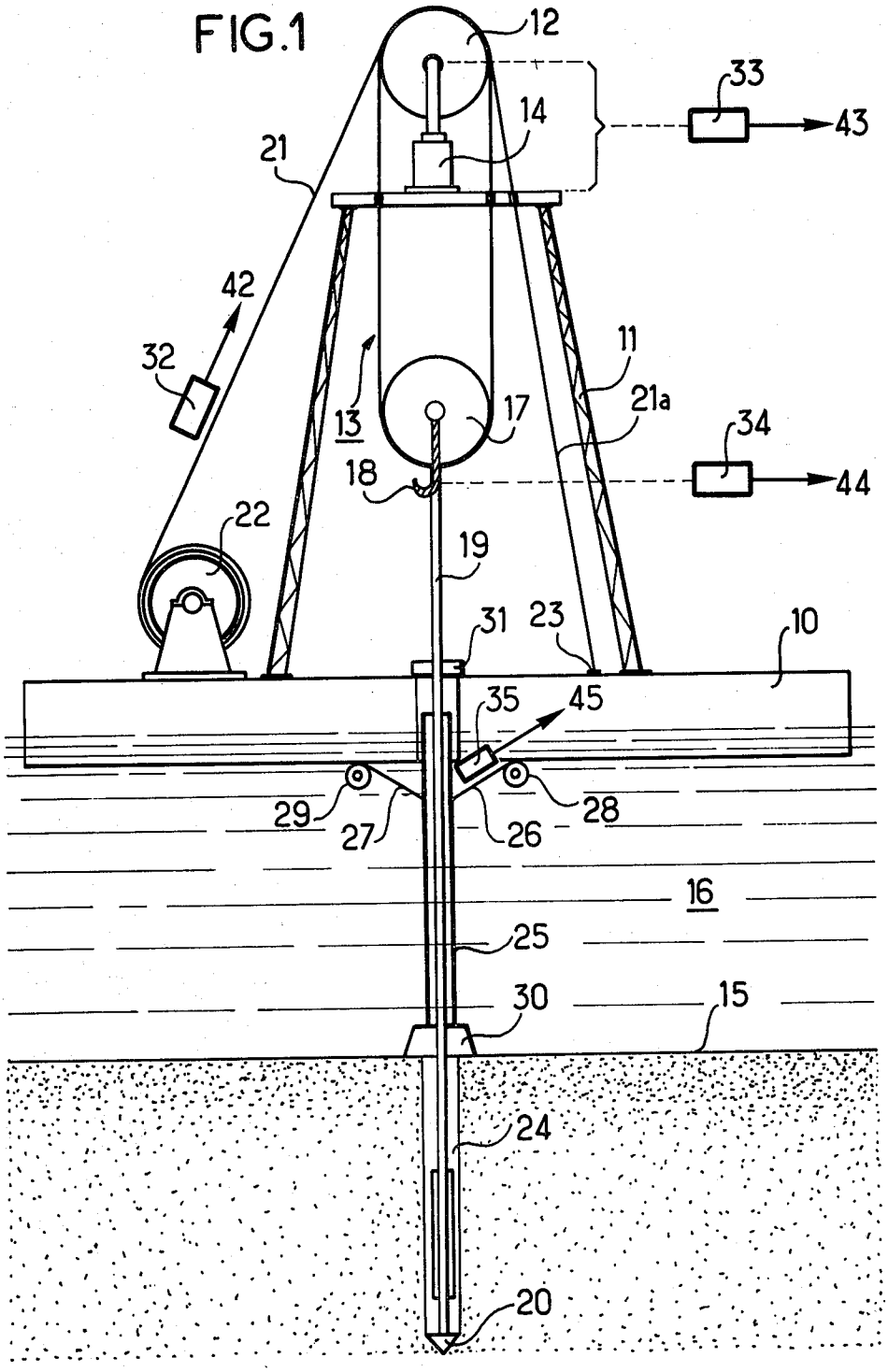
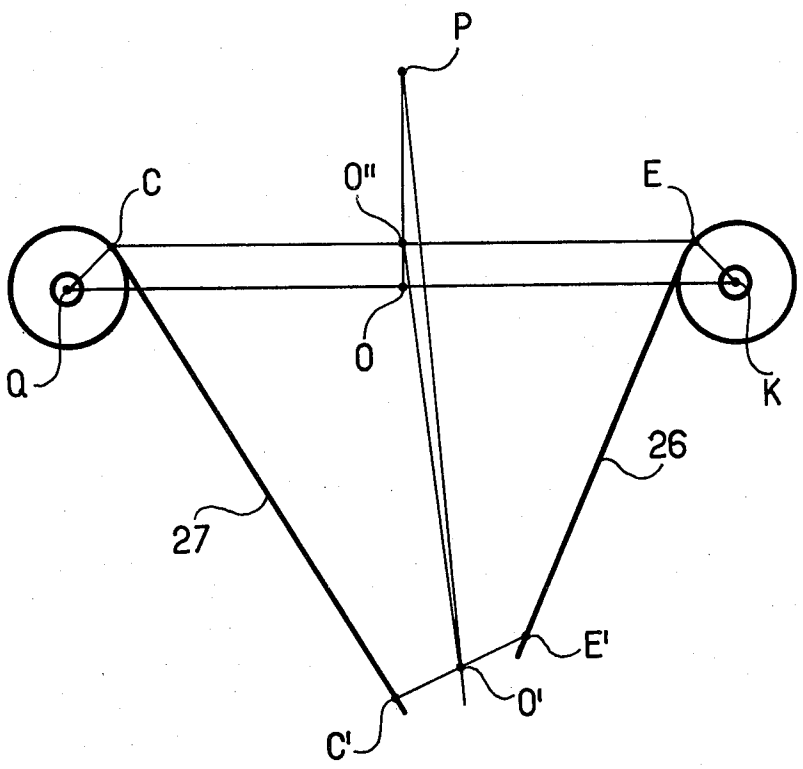

12
33
43
14
21
42
32
11
21a
13
17
34
44
18
22
19
31
23
10
35
45
29
27
26
28
16
25
30
15
24
20

FIG. 2



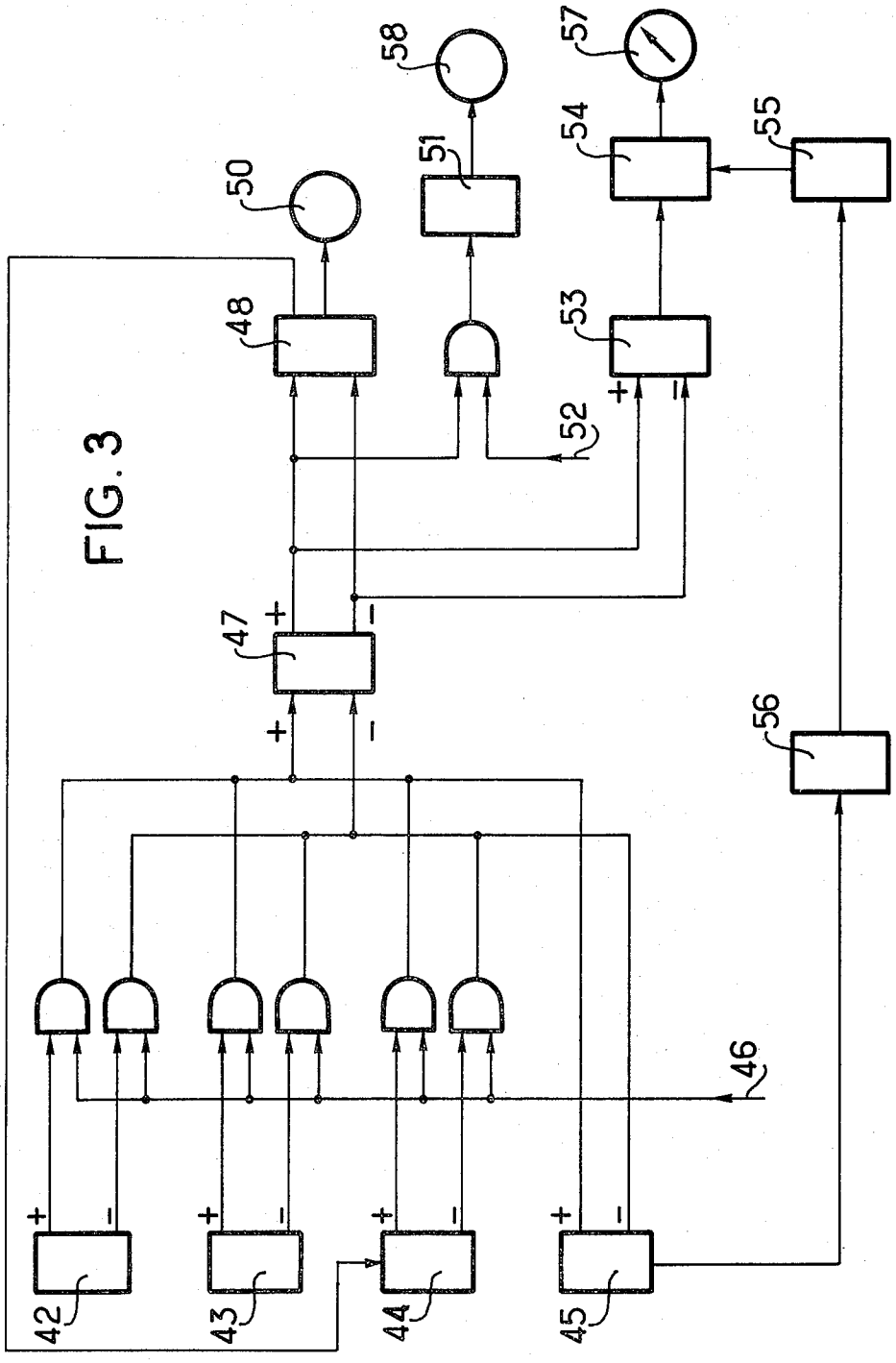


FIG. 3

DEVICE FOR MEASURING THE POSITION AND SPEED OF A BORING TOOL

The present invention has for its object a device making it possible to measure accurately various parameters which it is interesting to know when boring a well, for example, an oil well; these parameters are, for example, the depth of the hole, the position of the tool and the penetration speed of the tool during its boring work.

When the boring is effected on land, the determining of these parameters is fairly easy, since it is situated on a system of fixed references in relation to the hole; but when drilling at sea, based on a floating craft, this becomes more complicated, for it is situated on a mobile reference because of the tide, the waves, the imperfect anchoring of the craft.

The invention makes it possible, on a basis of data received at the surface, to know the speed of penetration of the drilling tool, its position and the depth of the hole.

In such a drilling system, the floating craft supports a boring tower (derrick) which itself supports a block system from whose lower pulleys is suspended, by means of a hook, a line of rods at the end of which is placed the boring tool. For the lubricating of the boring tool, sludges are sent down the inside of the rods and they rise by the annular passage limited by the walls of the the well and the outer surface of the line of rods. It is therefore necessary to provide, between the top of the well situated at the bottom of the water and the floating craft a pipe making it possible to ensure the continuity for the guiding of these sludges.

In general, this part is a tubular part (called a RISER) which extends the well up to the inside of the floating craft. That tubular part is fixed to the bottom of the water by an anchoring system and it is kept just about vertical by at least two cables fixed in the vicinity of the top of that tubular part and passing on guide pulleys, situated in a fixed position inside the craft, then fixed to winches also situated in a fixed position inside the craft. The line of rods passes through a fixed point of the craft. In the particular case of boring by means of a line of rods driven in a rotating movement, that fixed point is constituted by the rotary.

The present invention has for its object a device for measuring the position of a drilling tool for boring a well and the boring speed, the said tool being placed at one end of the combination of rods suspended from the hook of a block, the said block being arranged at the top of a derrick situated on a floating craft and the said combination of rods passing constantly through a fixed point of the craft, a cable passing through on the block having a first end connected to a winch and a second end connected to a fixed point of the craft, an element for the compensation of the vertical variations in the position of the craft in relation to the bottom of water connecting the two upper pulleys of the block to the derrick or the lower pulleys to the hook, a tubular part being arranged round the line of rods between the opening of the well and the craft, that part being anchored to the bottom of the water, its upper part being held by means of at least two cables stretched by winches placed in a fixed position in the craft, characterized in that it comprises a first signal generator sending out a signal which is characteristic of the length of the cable unwound, a second signal generator sending out a signal which is characteristic of the elongation of the compensation element, an element for measuring the force exerted on the hook on the block, combined with a third signal generator receiving a data item relating to the total length of the line of rods and sending out a signal which is characteristic of the elongation of the rods, coming from the resultant of their own weight and of the reaction of the bottom of the hole on the tool, a circuit for measuring the length separating the top of the tubular part from the fixed point through which the rods pass, combined with a fourth signal generator sending out a signal which is characteristic of that length, a treating circuit fed by the four signals, in which is calculated a magnitude proportional to the algebraic resultant of the variations in the length of the cable unwound, of the elongation of the line of rods, of the length of the distance which separates the top of the tubular part from the fixed point through which the rods pass and of the elongation of the compensator, that magnitude being representative of the position of the tool.

According to a particular embodiment of the present invention, the device is characterized in that it comprises a first pulse generating providing a counting pulse when the cable passing on the block has been wound off the winch by a given quantity and a reverse counting pulse when the cable has been wound onto the winch by the same quantity, a second pulse generator providing a counting pulse when the upper pulleys of the block fall by a given quantity and a reverse counting pulse in the contrary case, an element for measuring the force exerted on the hook of the block by the line of rods, combined with a third pulse generator, receiving a data item relating to the total length of the line of rods and supplying a counting pulse when the force exerted on the hook has increased by a given quantity, corresponding to an elongation of the length of the line of rods because of the resultant of its own weight and of the reaction of the bottom of the hole on the tool and a reverse counting pulse when the force exerted on the hook has decreased by the same quantity, a circuit for measuring the length separating the height of the tubular part from the fixed point through which the rods pass, combined with a fourth pulse generator providing a counting pulse when that length has decreased by a given quantity and a reverse counting pulse in the contrary case, a processing circuit comprising a first counter and reverse counting pulse in the contrary case, a processing circuit comprising a first counter and reverse counting counter receiving the pulses provided by the four pulse generators and whose contents are thus representative of the position of the tool.

With reference to the accompanying diagrammatic drawings, an example of the implementing of the invention, having no limiting character will be described.

FIG. 1 shows diagrammatically an elevation view of an installation for boring at sea, comprising the means set forth in the invention.

FIG. 2 shows a detail of the installation.

FIG. 3 is a block diagram of the electronic calculating circuits in the case of an example comprising pulse generators and counting and reverse counting units.

FIG. 1 shows diagrammatically a boring assembly comprising a floating platform **10** on which rests a structure constituting a boring tower or derrick **11**. The upper pulleys **12** of a block **13** are supported by that

structure, by means of a compensator **14** making it possible to compensate the vertical movements of the floating craft, the upper pulleys of the block thus remaining at a more or less constant height in relation to the bottom **15** of the expanse of water **16**; the lower pulleys **17** of the block **13** bear a hook **18** which supports a line of rods **19** at the end of which is placed a boring tool **20.** A cable **21** passes over the block and is fixed on the one hand to a winch **22** and on the other hand to a fixed point **23** of the structure.

The well **24** constituted by the boring hole is artificially extended up to the inside of the floating craft by fixing vertically to the bottom of the water and in the extension of the boring hole a tubular part **25** (called a RISER) through which passes the line of rods; at the upper portion of the said part are fixed two cables **26,** 27, or wires; the wire **26** is connected to a winch **28** having constant tension and the wire **27** is connected to a winch **29** having constant tension. The two winches are arranged symmetrically to each other in relation to the axis of the tubular part **25**; a concrete mass **30** keeps the part **25** on the bottom **15.** The line of rods **19** is driven in a rotating movement by means, for example, of a rotary **31** which constitutes a fixed point through which the rods pass in relation to the craft.

The various elements for measuring the parameters are the following;

1. A device **32** for measuring the unwinding of the cable **21.** That device is of a known type, for example, such as that described in the application for the first certificate of addition to French Pat. No. 1,533,960.

That device comprises a pulse generator **42** providing a counting pulse each time the cable **21** has unwound by a given length in a given direction and a reverse counting pulse when the cable has unwound by the same length in the reverse direction. That length, chosen at random, is a multiple of the length of fall or rise of the tool and the ratio between these lengths depends directly on the number of pulleys of the block.

2. A device **33** for measuring the position of the shaft of the upper pulleys of the block. It comprises, for example, a rack which is fixed in relation to the structure of the floating craft and combined with a toothed wheel. A pulse generator **43** sends out a counting pulse each time the distance between the shaft of the pulleys **12** and a fixed point of the craft has varied by a given length and a reverse counting pulse in the contrary case.

That distance varies, indeed, for the following reasons: The upper pulleys of the block are fixed to the derrick by means of the compensation system which comprises the constant pressure cylinders. When the ship, subsequent to the pounding due to the swell, has a tendency to fall, the effort on the hook tends to decrease because of the increase in the reaction of the ground on the tool; the cylinders then take effect to raise the upper pulleys of the block in order to bring the effort on the hook back to its original value. The cylinders take effect in the reverse direction when the craft has a tendency to rise.

3. A device **34** for measuring the elongation of the line of rods due to the resultant of its own weight and to the reaction of the ground on the tool.

That device comprises a sensor of the effort on the hook **18** which may be a strain gauge situated either on the hook or the fixed end **21***a* of the cable **21**; it is combined with an analog-to-digital convertor transforming the measuring of the sensor into a digital value. A pulse generator **44** develops a counting pulse each time the elongation of the rods reaches a certain value. The generator takes into account, according to HOOK's law, of the physical characteristics of the rods (cross-section, Young's modulus, etc.) of the above digital value, representing the effort on the hook and the total length of the line of rods. According to a preferred embodiment, the said data item concerning the total length is developed by the processing circuit itself, as will be seen hereinafter. A reverse counting pulse is developped every time the line of rods is shortened by that same length.

4. A device **35** measuring the length separating the top of the tubular part **25** from the rotary **31.** It comprises two sensors for the unwinding of the wires **26** and **27** and a function generator calculating the said length on a basis of the length of the ends of the wires **26** and **27** between the winch and the tubular part, by the length of the unwinding of each of these ends and by the respective positions of the winches **28, 29** and of the rotary **31.** The device **35** is connected with a pulse generator **45** providing counting pulses and reverse counting pulses each time that length varies by a given quantity in one direction or another, according to the movements of the craft in relation to the axis of the hole, due more particularly to the effects of the swell, of the tide, and of the differences in the anchoring positions.

FIG. **2** shows the geometrical configuration of the device making it possible to calculate the distance separating the top of the tubular part **25** from the fixed point through which the rods **31** pass, by measuring the unwinding of the cables **26** and **27** and based on the constants of the system: the tubular part **25** is connected to the craft by means of at least two cables **26** and **27** stretched by winches making it possible to lengthen and shorten these cables according to the movements of the craft, the variations in length of the said cables causing the appearance of a signal which is representative of the variations in the distance between a fixed point of the craft and the head of the well at the bottom of the water.

By way of an example, the cables are stretched at a constant tension and pass over guide pulleys. These pulleys comprise signal generators (coded) pulses or signals) applied to a function generator whose output provides the said signal which is representative of the variations in distance. Operation is as follows in the case where the cables are two in number: FIG. **2** shows two pulleys whose respective centres are Q and K, separated in practice, by about 4 m; the radius R of the pulleys is in the order of 0.5 m. The boring rods pass through a fixed point P, which is usually the centre of the drive rotary, situated vertically to the middle O of QK at about 2 m from that point. The cables wound on the pulleys up to C and E are rectilinear in the portions CC′ and EE′, the points C′ and E′ being diametrically opposite on the tubular part, the middle of C′E′ being designated by O′. In practice, the angle formed by PO′ and PO exceeds 4° only less than 4 percent of the time and never reaches 8°. On the other hand, E′ C′ having a value in the order of 0.8 m, it may be assumed that the axis of the line of rods does not pass far from the point O′. The distance OO′ varies normally between 6 and 14 m. In these conditions, it may be shown that it is possible to effect the following three approximations:

Replace P O′ by the sum P O″ + O″O′, calling the middle of C E, O, the angle P O″ O′ being almost flat;

Neglect the movement of the points C and E on the pulleys, this being the equivalent, more particularly if the pulleys are assumed to be mobile, of merging the involutes of the circle described by C′ and E′ with circles;

Admit that the projecting of C′ E′ on C E is equal to C′ E′.

These approximations being made, the calculation of the length P O′ may be effected simply by calculating the middle O′ O″ of the quadrilateral CC′E′E and adding thereto a constant quantity P O″. Moreover, the second approximation justifies the replacing of the direct measuring of the lengths CC′ and EE′ by a measuring of the rotating of the corresponding pulleys.

And the result obtained is:

$$PO' = \frac{[2\,(\overline{CC'}^2 + \overline{EE'}^2) - \overline{EC}^2 + 2\,\overline{EC} \times \overline{E'C'}]^{1/2}}{2} + O''P$$

Of course, instead of measuring the lengths of the cables which hold the tubular part, separate cables having no holding function may be used.

The sensors for the unwinding of the wires **26** and **27** measure angles *a* and *b* of the rotation of the guide pulleys whose respective centres are Q and K and, R being the value of the radius of the pulleys, the result obtained is:

$CC' = Ra +$ constant

$EE' = Rb +$ constant

In the case where the tubular part is held by more than two cables, the calculating of the distance PO′, which is more complicated, is nevertheless of the same type and is possible with similar approximations.

FIG. **3** shows a block diagram of the electronic circuit for using the measurements. It comprises the pulse generators **42, 43, 44** and **45**; each of these generators has two outputs, the one providing the counting pulses, the other providing the reverse counting pulses. The first outputs are marked with the + sign, the second, with the − sign.

The outputs of the generators **42** to **44** are connected to a first input of an AND circuit a second input of which is connected to a device supplying a signal **46** when the line of rods **19** is effectively linked to the hook **18.** In the manoeuvring phases such as addition of rods, where the linkage (line of rods) is made fast with the craft and disconnected from the hook, it is evident that the position of the tool is influenced neither by the winch nor by the compensator. It remains on the other hand independant from the position of the craft in relation to the bottom, measured on the RISER. The manoeuvres are effected usually with the tool slightly raised and no longer touching the bottom of the hole; the generator indicating the elongation of the linkage may also be disconnected.

The counting and reverse counting outputs are sent onto an anti-coincidence circuit **47** which also comprises two outputs, the one for the counting pulses and the other for the reverse counting pulses.

The outputs of the circuit **47** are sent to a counting and reverse counting unit **48.** A display element **50** is connected to the counter **48.**

The data item supplied by that element **50** is the position of the boring tool. For this to be so, it is necessary, for example, that:

The generator **42** supply counting pulses when the sensor **32** indicates a slackening of the cable;

The generator **43** supply counting pulses when the upper pulleys of the block fall in relation to the derrick;

The generator **44** supply reverse counting pulses when the weight on the hook decreases;

The generator **45** supply reverse counting pulses when the distance between the top of the tubular part and the rotary increases.

It is quite evident that the compensating element **14,** instead of connecting the upper pulleys of the block to the derrick, could quite well connect the hook **18** to the lower pulleys **17** of the block, in which case the generator **43** would supply counting pulses when the lower pulleys rise in relation to the hook, that is, when there was an elongation of the compensation element.

In the case of an example comprising, not pulse generators, but signal generators sending out a signal which is characteristic of the measured magnitude, it is quite clear, inasmuch as concerns the compensator, that its elongation can always be added algebraically, on condition that it be taken with the appropriate sign. If the compensator connects the pulley to the derrick, the positive sign corresponds to the falling of the pulleys in relation to the derrick. If, on the contrary, it connects the pulley to the hook, the positive sign corresponds to the rising of the pulleys in relation to the hook.

The output of the counter **48** is connected to an input of the generator **44** to supply it with the data item of the total length of the combination of rods (linkage) required for determining the elongation of the latter.

The positive output of the circuit **47** is connected to a counter **51** provided with a display device **58** by means of a first input of an AND circuit having two inputs and whose second input receives a signal **52** when the tool bores to indicate permanently the depth of the bored hole.

A counter and reverse counting counter **53** is connected to the outputs of the anti-coincidence circuit **47.**

The outputs of that counter are connected to a divider circuit **54** which receives a time data item from a clock **55.**

The divider thus effects a quotient which is representative of the vertical movement speed of the tool.

For several consecutive measurements of that speed to be taken in comparable conditions, arrangements are made for the clock to send out its data only at instants corresponding to passes through a given value and in a determined direction of the value of the length measured by the computer combined with the generator **45.**

For that purpose, a synchronizing circuit **56** calculating, at the instants indicated, control pulses for the clock is formed.

The contents of the divider are displayed by a visual display element **57.**

What is claimed is:

1. In a device for measuring the position of a boring tool supported through a line of rods by supporting means situated on a floating craft, said supporting means including a tackle adapted to hoist and lower said boring tool in response to winding and unwinding of a first cable on a winch fixed on said craft, means for compensating for variations in the vertical position of

said floating craft in relation to the bottom of the water, and a tubular member surrounding said line of rods between the opening of a well being bored and said craft, the lower end of said tubular member being adapted to be anchored to the bottom of the water, said tubular member being further held near its upper end by means of at least two second cables which are stretched by their associated winches fixed on said craft, the improvement comprising:

first signalling means associated with said first cable for providing a first signal representative of motion of said first cable along its length;

second signalling means associated with said compensating means for providing a second signal representative of the variation in the vertical position of said craft in relation to the bottom of the water;

third signalling means associated with said second cables for providing a third signal representative of the relative vertical positions of said tubular member and said craft; and

processor means responsive to said first, second and third signals for providing a signal indicative of the position of said boring tool.

2. In a device for measuring the position of a boring tool supported through a line of rods by a supporting means situated on a floating craft, said supporting means including a tackle adapated to hoist and lower said boring tool in response to winding and unwinding of a first cable on a winch fixed on said craft, a hook member connecting the upper end of said line of rods to said tackle, said line of rods constantly passing through a fixed point on said craft during the hoisting and lowering operation, means for compensating for variations in the vertical position of said floating craft in relation to the bottom of the water, and a tubular member surrounding said line of rods between the opening of a well being bored and said craft, the lower end of said tubular member being adapted to be anchored to the bottom of the water, said tubular member being further held near its upper end by means of at least two second cables which are stretched by their associated winches fixed on said craft, the improvement comprising:

first signalling means associated with said first cable for providing a first signal representative of motion of said first cable along its length;

second signalling means associated with said compensating means for providing a second signal representative of the variation in the vertical position of said craft in relation to the bottom of the water;

third signalling means associated with said second cables for providing a third signal representative of the vertical distance between the upper end of said tubular member and said fixed point on said craft;

fourth signalling means associated with said hook member for measuring the force exerted on said hook member and for providing a fourth signal representative of the elongation of said line of rods;

processor means responsive to said first, second, third and fourth signals for providing a signal indicative of the position of said boring tool.

3. The device according to claim **2,** wherein said first signalling means includes:

a pulse generator adapted to provide a counting pulse when said first cable has been unwound by a first predetermined length and to provide a reverse counting pulse when said first cable has been wound by the same length.

4. The device according to claim **2,** wherein said compensating means is provided on said supporting means to support the upper pulleys of said tackle for vertical movement relative to said supporting means; and said second signalling means includes:

a pulse generator adapted to provide a counting pulse when said upper pulleys have fallen by a second predetermined length relative to said supporting means and to provide a reverse counting pulse when said upper pulleys have risen by the same length.

5. The device according to claim **2,** wherein said third signalling means includes:

a pulse generator adapted to provide a counting pulse when the vertical distance between the upper end of said tubular member and said fixed point on said craft decreases by a second predetermined length and to provide a reserve counting pulse when the distance increases by the same length.

6. The device according to claim **2,** wherein said fourth signalling means includes:

a sensor for measuring the force exerted on said hook member due to the resultant of the weight of said line of rods and the reaction of the bottom of said well on said boring tool;

means responsive to said processor means for providing information on the total length of said line or rods;

means responsive to said sensor and said means for providing the total length information for calculating the elongation of said line of rods; and

a pulse generator responsive to said calculating means for providing a counting pulse when the elongation of said line of rods exceeds a second predetermined length and for providing a reverse counting pulse when said line of rods is shortened by the same length.

7. The device according to claim **2,** further comprising:

fifth signalling means for providing a signal indicating the initiation of the boring operation by said boring tool;

means responsive to said fifth signalling means and to said processor means for providing a signal indicative of the depth of the well bored.

8. The device according to claim **2,** further comprising:

time means for providing a time data; and

means responsive to said time means and to said processor means for providing a signal indicative of the penetration speed of said boring tool.

9. In a device for measuring the position of a boring tool supported through a line of rods by a supporting means, situated on a floating craft, said supporting means including a tackle adapted to hoist and lower said boring tool in response to winding and unwinding of a first cable on a winch fixed on said craft, a hook member connecting the upper end of said line of rods to said tackle, said line of rods constantly passing through a fixed point on said craft during the hoisting and lowering operation, means for compensating for variations in the vertical position of said floating craft in relation to the bottom of the water, said compensating means being provided on said supporting means to support the upper pulleys of said tackle for vertical

movement relative to said supporting means, and a tubular member surrounding said line of rods between the opening of a well being bored and said craft, the lower end of said tubular member being adapted to be anchored to the bottom of the water, said tubular member being further held near its upper end by means of at least two second cables which are stretched by their associated winches fixed on said craft, the improvement comprising:

a first pulse generator responsive to said first cable for providing a counting pulse when said first cable has been unwound by a first predetermined length and for providing a reverse counting pulse when said first cable has been wound by the same length;

a second pulse generator responsive to said compensating means for providing a counting pulse when said upper pulleys have fallen by a second predetermined length relative to said supporting means and for providing a reverse counting pulse when said upper pulleys have risen by the same length, said second predetermined length being equal to the length of the fall and rise of said tackle caused by the unwinding and winding of said first cable by said first predetermined length;

a third pulse generator responsive to said second cables for providing a counting pulse when the vertical distance between the upper end of said tubular member and said fixed point on said craft decreases by said second predetermined length and for providing a reverse counting pulse when the vertical distance increases by said second predetermined length;

a sensor for measuring the force exerted on said hook member due to the resultant of the weight of said line of rods and the reaction of the bottom of said well on said boring tool;

a fourth pulse generator responsive to said sensor for providing a counting pulse when the elongation of said line of rods due to its weight exceeds said second predetermined length and for providing a reverse counting pulse when said line of rods is shortened by the same predetermined length; and

a first counter responsive to said counting and reverse counting pulses from said pulse generators for providing a signal indicative of the position of said boring tool.

10. The device according to claim **9**, further comprising:

first gate means for allowing said counting and reverse counting pulses to pass from said pulse generators to said first counter only while said line of rods is linked to said hook member.

11. The device according to claim **9**, further comprising:

an anti-coincidence circuit provided between said pulse generators and said first counter.

12. The device according to claim **9**, further comprising:

a second counter responsive to said counting and reverse counting pulses from pulse generators;

second gate means for allowing said counting and reverse counting pulses to pass from said pulse generators to said second counter, said second counter providing an indication of the depth of the well bored.

13. The device according to claim **9**, further comprising:

a third counter responsive to said counting and reverse counting pulses from said pulse generators;

time means for providing a time data; and

means responsive to said third counter and said time means for providing an indication of the penetration speed of said boring tool.

14. The device according to claim **13**, further comprising:

means operative to actuate said time means each time the distance between the upper end of said tubular member and said fixed point on said craft varies by a third predetermined value.

* * * * *