March 19, 1968 Z. S. WYSZYNSKI 3,374,484

APPARATUS FOR INDICATING AND RECORDING BOREHOLE DRILLING

Filed Oct. 26, 1964 2 Sheets-Sheet 1

FIG. 1

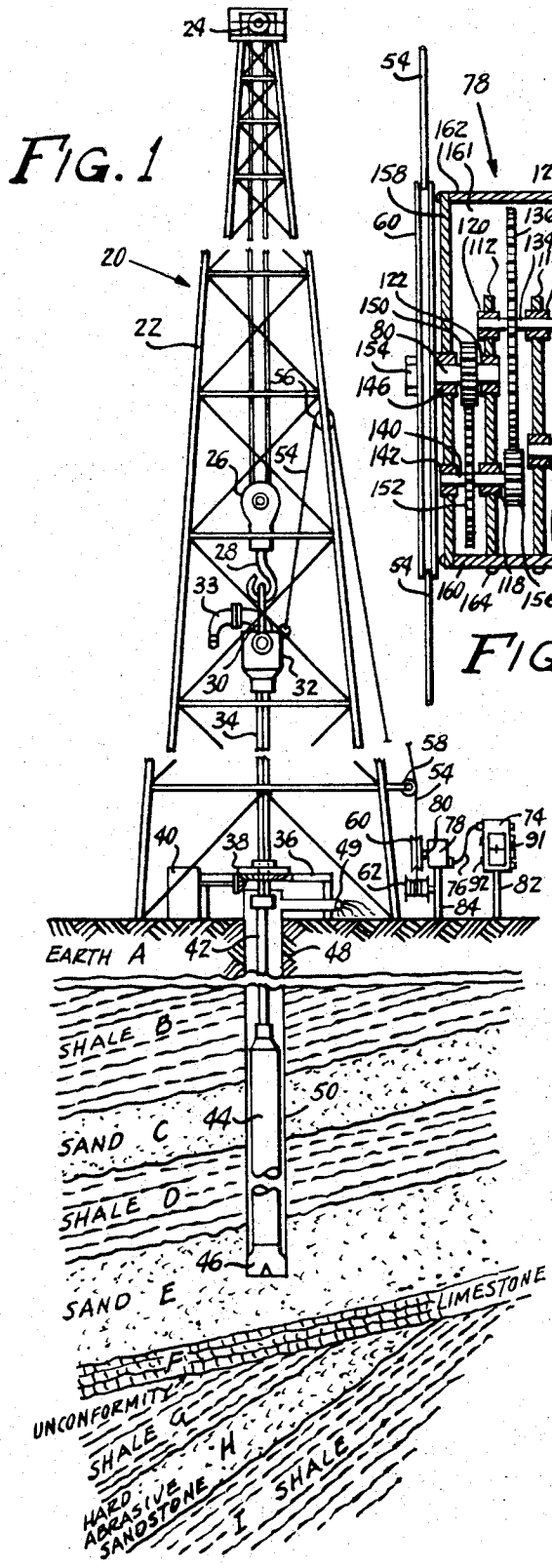

FIG. 3

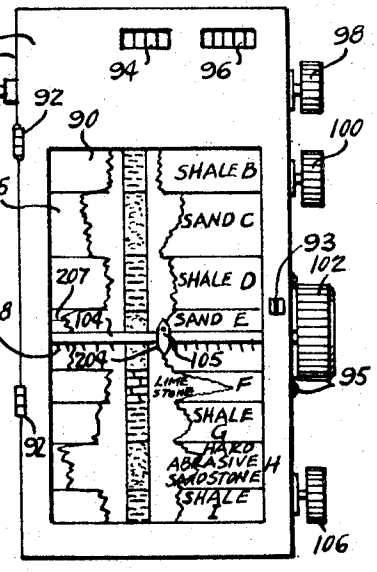

FIG. 4

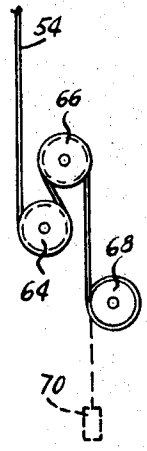

FIG. 2

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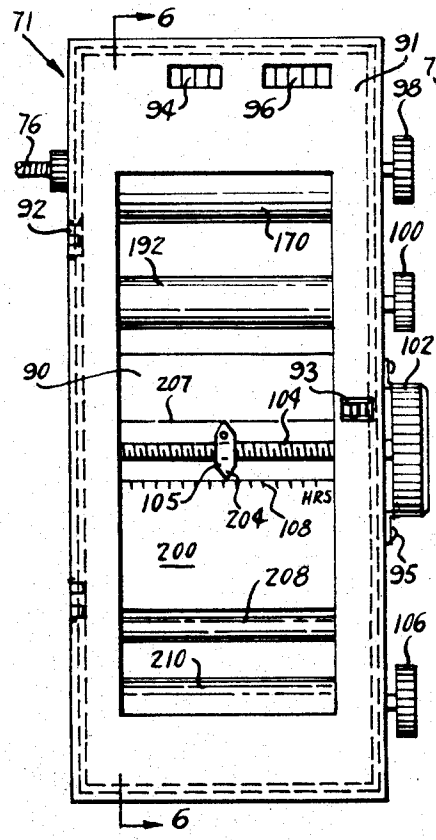

FIG. 5

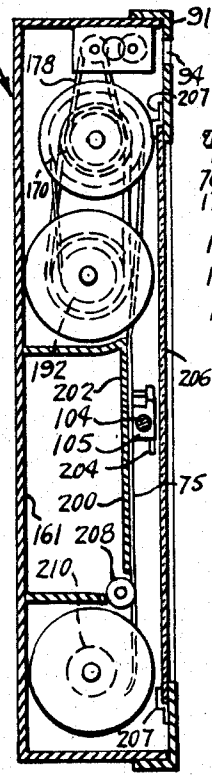

FIG. 6

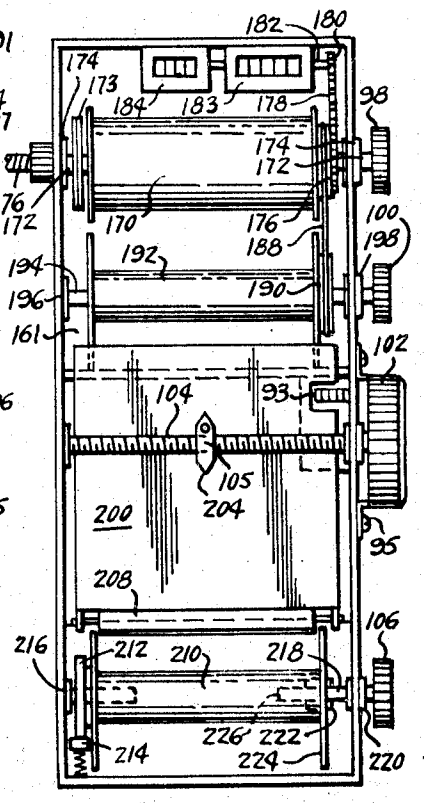

FIG. 7

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APPARATUS FOR INDICATING AND RECORDING BOREHOLE DRILLING

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4 Claims. (Cl. 346—14)

This invention applies to any type of borehole drilling and relates particularly, to the method and means of indicating to the driller the exact progress the drilling bit is making in the hole in relation to the earth strata being drilled and permits the driller to anticipate changes in earth strata as affecting his operation of the drilling bit and rig.

The important advantage of the inventioin is that heretofore the driller had to operate more or less blindly in controlling the instantaneous behavior of the drill bit inasmuch as it is difficult to operate the complicated machinery of the modern rig, especially on the more difficult jobs and at the same time keep track of the anticipated formation changes.

This invention eliminates the above difficulties and provides the driller, tool-pusher, engineer or whoever might be interested in watching the actual progress of the bit in the hole, with a continuous picture graph of substantially all downhole geological data and conditions. This is accomplished by providing, on the rig floor or other suitable place in front of the driller's position an observable indicating instrument which is the subject of this invention and which consists of a continuous log indicating apparatus housed in a box or cabinet enclosure of a suitable shape, made of steel, aluminum or other metal, wood or plastic with a front cover or door having suitable viewing apertures therein containing glass, Plexiglas or other desired transparent materials in the front cover of the display apparatus. The support means for the indicating apparatus may be a tripod, legs or any other suitable support means as desired to be juxtaposed before the driller's position at the rig. Inside the box-like enclosure are mounted a plurality of rollers, such as in a roll-film photographic camera, adjacent each end of the box. These rollers or reels are mounted on shafts in proper support bearings therefor, and the rollers cooperate with each other to hold and display a continuous tape or roll of material, such as plastic, parchment, paper or the like, suitable for containing thereon an electric log (or any other formation log) that may be chosen to be as closely representative of the anticipated formations as possible that are to be drilled in the subject well. On this log, there has also been superimposed thereon a composite log or graph scale designated in feet of depth for each earth formation in advance of the commencement of drilling of a prospective well in accordance with the best available geological and engineering data and information accumulated from previous drilled wells of the area. Also included on the composite log at various designated depths of the prospective graph are warnings, recommendations and other important data intended to alert the driller to various drilling difficulties and operational problems to be met ahead of the drill bit at various depths of earth strata in drilling a prospective borehole.

The primary object of this invention is to provide the driller, as operator of the drilling rig, of whatever type, with a continuous method and indicating means for observing the progress of the bit in a borehole while drilling, and to instantly relate back the depth of the bit to the type, thickness and character of geological formation being drilled at a certain depth at a particular past, present or future time as desired.

Another object of the invention is to provide the driller

with an indicating apparatus, operated by the drill string, which contains therein a composite graph or log graduated in feet of depth which automatically corresponds to the instantaneous depth of the drill bit at any particular time during the drilling of a borehole.

A further object of the invention is to provide a recording device comprising a pre-selected or prepared formation log tape to display to the driller the drilled depth of a borehole and the anticipated formations of the earth at various depths of penetration by the drilling rig.

A further object of the invention is to provide a programming and program-indicating method and apparatus.

Another object of the invention is to provide an indicating device operated by the drill string, including a clock-driven stylus which automatically indicates drilling time for a particular depth in a borehole.

A further object of the invention is to provide a ratio means of interconnecting a log indicating apparatus to an instrument drive line of the drill string of a drilling rig to designate the measured depth of drill penetration in a borehole.

Another object of the invention is to provide a simple mechanical programming device including a prepared strata formation log and indicating means for predicting drilling manipulations and providing instructions for operation of a drilling rig for a new borehole.

A further object of the invention is to provide a method for automatic operation of a drilling rig during drilling of a new borehole.

Still other objects of the invention reside in the combination of elements, arrangements of parts, features of construction, all as will be more fully pointed out hereinafter and disclosed in the accompanying drawings, wherein there is shown a preferred embodiment of this inventive concept.

In the drawings:

FIGURE 1 shows an elevational view of a preferred embodiment of the invention for a conventional drilling rig comprising an indicating programming method and apparatus for use in borehole drilling;

FIGURE 2 shows in elevation one arrangement of securing the end of the instrument line about the driving sheave of the gear box of FIGURE 3;

FIGURE 3 is a sectional view of one type of speed reduction gear box interconnecting the logging apparatus of FIGURE 2 with the drilling rig of FIGURE 1;

FIGURE 4 is an elevational view of the indicating and logging apparatus used in the programming method and apparatus for borehole drilling of this invention;

FIGURE 5 is an enlarged view of the front door means of the indicating logging apparatus of the invention;

FIGURE 6 is a sectional view of the logging apparatus of FIGURE 5, taken substantially on lines 6—6, as shown; and

FIGURE 7 is a front view of the indicating log tape apparatus of FIGURE 5 with the front panel or door removed.

Like reference numerals represent like parts in the drawings.

Referring to FIGURE 1, reference numeral **20** represents a generalized view of the drilling rig comprised of a derrick **22**, a crown block **24**, traveling block **26** suspended by cables from block **24** and contains a hook means **28**, attached clevis means **30** to a rotary swivel **32** and conduit **33** secured to a kelly or grief stem **34** reciprocatably passing through a platform or table **36**, further comprising rotary gear **38** suitably attached to a conventional prime mover **40** for rotation of the grief stem **34**. The grief stem **34** is connected in a conventional manner to a drill pipe or rods **42** connected to a drill collar **44** secured to rotary drilling bit means **46**. The drill string

comprising the rod members 42, drill-collars member 44 and bit 46 is surrounded by an upper casing 48 which is connected to conduit 49 and terminates in an open drill hole 50 through the different strata of the earth, as shown in FIGURE 1.

Swivel connection 32 is connected in any suitable manner to instrument line 54. Instrument line 54 passes over sheaves 56 and 58 of the derrick 22 and passes around drive sheave 60 and is further attached to a spring wound actuated drum means 62 which allows reciprocatable motion of instrument line 54 similar in operation to that of a conventional spring wound drum of the conventional window blind type, or alternatively line 54 may be passed over sheaves 64, 66 and be attached to a spring wound drum 68 or may, if desired, be attached to a weight 70, as shown in FIGURE 2, which allows instrument line 54 to be kept taut at all times during the drilling operation which permits accurate programming of the drilling of a log tape in the indicator programmer 74 which is connected by suitable flexible shaft or other linkage means 76 to gear box 78 to be actuated by sheave 60 through shaft 80. In this manner, instrument line 54 actuates the programmer 74 supported on support 82 juxtaposed to the driller's position for viewing during the drilling operations. Likewise, gear box 78 and drum means 62 are supported by support 84, as shown in FIGURE 1. Door 91 is secured by hinges 92 to enclosure 71, see FIGURES 5 and 6.

Furthermore, FIGURE 1 shows, in detail, an example of the various earth strata as associated with drilling information programmed on the log tape 75 as displayed in similar detail in window 90 in door 91 of FIGURE 4. In FIGURE 1 bit means 46 has drilled shale strata B, sand C, shale D and partially penetrated through sand E by conventional drilling methods, as understood by those skilled in the art. Limestone strata F and the shale G, hard abrasive sandstone H and shale I shows the driller what kind of earth strata are yet to be drilled, as predicted by log means 75 of FIGURE 4. Log means 75 may comprise any composite number of logs or drilling guidance material or operational instructions as to the drilling of the new borehole obtained from previous drillings and studies or take any programmed form, as desired, within the purview of this invention.

FIGURES 4 and 5 disclose a frontal view of the log indicator-programmer 74 connected to linkage means 76 operably secured to gear box 78. The indicator-programmer 74 contains window apertures 94 and 96 in front door 91 opposite two indicating counters to be viewed by the driller. Door 91 has a latch means 93 therefor for securing the door in tightly closed position. Manual knobs 98, 100 and 106 are operably connected to tape or log bearing rollers within log programmer 74. Clock means 102 is operably connected by suitable worm linkage means 104 to drive stylus 105 to indicate the number of units of drilling time used on an indicia scale 108 during drilling of a borehole. Stylus 105 may be of a conventional single or multiple stylus means, as desired.

Referring to FIGURE 3, gear box 78, may be structurally made in any conventional manner, as desired, containing therein supports 110 and 112. Support 110 operably carries shaft bearings 114 and 116. Support means 12, likewise carries shaft bearing 118, 120 and 122. Side 124 of gear box 78 supports shaft bearings 126 and 128. Shaft means 130 fixedly carries gear 132 and is rotatably supported in bearings 116 and 128. Shaft 130 is preferably connected to linkage means 76 by conventional coupling 132. Shaft 134 is rotatably carried in bearings 120 and 126. Shaft 134 fixedly carries gear means 136 and gear 138. Gear 132 operably contacts gear 138. Shaft 140 is rotatably supported in bearings 118 and 142, as shown. Gear 150 is fixedly carried by shaft means 80 in bearings 122 and 146. Shaft 140 fixedly carries gear 152 which operably engages the gear teeth of gear 150. Gear 150 is fixedly secured by conventional

screw, key or other conventional means to shaft 80 and further secured thereon by nut 154, as shown, is the drive sheave 60.

Gear 156 is fixedly secured to rotatable shaft 118 by conventional means and is operably engaged by the gear teeth of gear 136.

All gears fixedly secured to the rotating shafts of gear box 78 may be fixedly secured thereon by conventional screw, key or other means, as desired.

Gear box 78, may be formed of sides 124, 158, bottom 160, back 161 and top 162 held together by screw means 164, or by other conventional means, as desired.

The gear box 78 contains conventional gear train means, as shown, designed as to provide the correct ratio of rotational movement between the input shaft and the output shaft, or shafts, as desired. Gear box 78 may use and type of gears therein. The input shaft of the gear box is actuated by the instrument line 54 in different arrangements as shown in FIGURES 1 and 2. One such arrangement consists of a large diameter drive wheel, mounted on the outside extension of the input shaft. The circumferential surface of the pulley or sheave 60 is grooved and/or lined with suitable friction material to accept a light steel wire or cable, which is wrapped around the wheel one or more times as desired. One end of this line extends for about 100 feet upwards, passes over a sheave 56 mounted in derrick 22 of the drilling rig 20 and then continues downwards to the uppermost part of the active drill stem (the gooseneck of the rotary swivel 32 is the most suitable point of attachment), and is attached thereto by any suitable conventional method. The opposite end of the drive line extends downwards and is counter-balanced as indicated in FIGURE 2, or by one of several conventional methods, well known in the art, to prevent the line from riding loose on the drive wheel during rapid and fast movements of the drill stem, and of the drive line.

Any desired overall gear ratios may be employed in the gearing and drive mechanisms to provide for suitable synchronized strip log chart movements with the drill stem. For example, one, two, five and ten inches of chart movement for each 100 feet of drill stem movement. Suitable multiple gear trains may be utilized for quick exchange of ratios in gear box 78, or gear box limits can be exchanged to suit required ratios.

Referring to FIGURES 6 and 7, programmer 74 is comprised of internal roller 170 carried by shaft 172 rotatably mounted in bearing 174. Shaft 172 is operably coupled by a conventional pneumatic or spring actuated friction clutch 173 to shaft or linkage means 76 at one end and connected to knob 98 by a conventional selective release knob means, similar to the knobs on the paper roller or platen of a typewriter, so that reel or roller 170 cannot be actuated manually until knob 98 is engaged with roller 170. This prevents any accidental misalignment of the paper strip log 75 in the programmer 74 as regards the position of the bit in the well bore. Before knob 98 will turn shaft 172 of reel 170, knob 98 has to be pressed or pulled, as desired.

On the one end of roller 170 is mounted a double grooved pulley sheave 176. One groove of pulley 176 is adapted as a sprocket drive to receive a chain means 178 which drives positively pulley 180 fixedly connected to shaft 182 that mutually drives recording counter means 183 and 184 as shown in FIGURE 7. Counter 183 records the total footage drilled from the beginning of drilling operations, while an additional conventional trip type counter 184 gives the footage drilled by one particular drill bit or for a particular drill operator. While only two counters 183 and 184 are shown, other counters may be added to designate other drilling data, as desired. The other groove of pulley 176 is adapted to receive spring belt 188 which drives pulley means 190 secured to spool or tape take-up roller 192 fixedly carried by shaft 194 rotatably secured in bearings 196 and 198 of a recorder and programmer means 74.

Platen **200** is conventionally secured to enclosure **71** and supports log tape means **75** against pointer or pen means **202** of stylus **105**. Indicator pointer **204** of stylus **105** registers drilling time on indicia scale **108** which may be viewed through transparent panel means **206** of window **90** the latter being supported on the door means **91** by any suitable angle means **207**. Platen means **200** carries in suitable bearings tape roller **208**, as shown in FIGURES 6 and 7, to permit log tape means **75** to travel freely over the platen from storage roller **210**. Roller **210** has attached at one end a small brake drum **212** which coacts with a spring actuated brake **214** of felt or the like which insures that spool or roller **210** has proper tension on the log tape **75** as it unrolls therefrom uniformly, as needed, which is necessary for the proper operation of the drilling programmer **74**. One end of spool **210** is rotatably supported by shaft or pin means **216** secured to the side structure of programmer enclosure **71**. The other end of spool means **210** is supported on reciprocatable shaft **218** rotatably carried by bearing **220** in the side structure of programmer enclosure **71**, as shown. Shaft **218** is fixedly secured to knob means **106** and it intermediately carries a detent pin means **222** which coacts with a bayonet socket detent **224** and the end **226** of shaft **218** is received by the other end of tape spool **210** which permits the interchange of tape spools **210**, as desired, for drilling operations.

Thus, manually operated knob means **98**, **100** and **106** at the outside extensions of the shafts of the programmer **74** may be made like the knobs on the paper roller or platen of a typewriter, which provide an easy means of reeling the log tape **75** on and off the reels and of adjusting its relative position on the reels and in positioning the desired portion of the log which is exposed to view in the window like aperture **90** of the box enclosure **71**. The take-up reel **192** is driven by a steel spring type of belt drive **188** which allows it to apply slight tension to the log tape or paper chart **75** being reeled onto that reel, while preventing damage to the paper strip resulting from an excessive tension, in which case the belt slips.

Therefore, there is provided a mechanical means for transporting the log from the bottom or storage reel to the top reel and take-up reel. This mechanism is connected by any suitable linkage means through gear box **78** and is driven by the instrument line **54** from the descending drill stem. The mechanism for transporting the strip log chart or tape in the indicator box **71** consists of a rubber or similarly surfaced roller **170** of a desired size, over whose surface the strip log is threaded and which is mounted in such a manner that a maximum required wrap-around by the log tape is achieved to assure a slip-free drive. Roller **170** is driven by an air or mechanically actuated friction clutch with over-load declutching mechanism from shaft **76**, as well as, with a conventional manual de-clutching control of a typewriter platen type to be operated occasionally by the driller. Drive shaft **76** connects clutch **173** with the gear box **78** which may be either an integral part of the instrument enclosure **71**, or a separate unit connecting the instrument line to the instrument box, as desired. Rollers **170**, **192** and **210** are covered by rubber, or the like, to insure proper contact of each roller or spool with log tape **75**.

As the drill bit penetrates the earth formations, its downward movement is transmitted through either a suitable mechanical, electrical, hydraulic, pneumatic means, or the like, by drive and gear speed reduction system actuated by a suitable linkage therefor. The drive roller **170** of the instrument turns and moves the log at a speed proportional to the vertical movement of the drill stem in the well bore in any one of the above chosen ratios, as desired.

Thus, the movement of the log **75** indicates to the driller at all times the constant movement and the instantaneous position of the drilling bit relative to the log of geological formation being drilled.

A further refinement of this device includes a vertical pointer, mounted on the screw traveling horizontal bar **104**, which is being moved from one side of the window to the other by the action of clock or time mechanism **102**, suitably mounted and geared, thus indicating to the observer the time elapsed since the start of operation, in this particular case, the time of the bit on bottom while actually drilling the borehole. Attached to the pointer **204** and moving with it is a stylus for indicating or graphing the progress of the pointer across or along the log, thus providing a simple means of recording the rate of the drilling.

Both the log transporting mechanism and the clock **102** are stopped, either manually by the driller, or automatically, by conventional means, each time the drill stem reaches a certain lowermost position and remains out of action while the incidental work, such as adding a length of drill pipe, making a round trip to change the bit, and the like, is being performed during the drilling of the borehole. Thus, both the recording and indicating log tape **75** and the clock driven pointer are restarted again when the drilling bit touches the bottom of the drill hole and begins the proper drilling action. The pointer **204** and stylus **105** of the time or clock indicator travels the width of the log or any portion thereof in a specified period of time predetermined by the clock setting, such as for example, 8, 12, or 24 hours, and after reaching the extreme maximum position, is returned instantly to the starting position, either manually or by any conventional automatic trip mechanism, well known in the art. For example, when stylus **105** reaches the right end of worm **104** of FIGURE 4, stylus **105** may contact or actuate a conventional switch similar to switch **15** of FIGURE 6, of U.S. Patent No. 2,390,178, issued Dec. 4, 1945, to return stylus **105** to the left end of worm **104**, if desired. Thus, the movement of the log chart or tape **75** is directly actuated and is proportional in length of travel to the traverse position of the bit **46** in the earth strata. Moreover, the time indicated on the clock means **102** and that added on the counter or scale **108** is the net time used to actually drill the borehole. It is accordingly, within the purview of this invention to provide the "down time" or nondrilling operation, if desired, by conventional recording means, well known in the art.

While the spring belt means **188** has been found to be satisfactory as a driving means between pulleys **176** and **190** of roller means **170** and **192**, respectively, it is to be understood, that a more positive drive means, such as, a conventional gear drive with clutch or chain and sprocket means may be used as a drive means, if desired, between roller means **170** and the depth recording counter means within the purview of this invention.

Additional refinements may be incorporated in certain instrument box-like enclosures of this invention by providing an additional set of reels holding a transparent tape, paper, acetate, or other similar material which will form an overlay over the formation strip log **75**. On this overlay tape which will also be driven synchronously with the underlaying log, many drilling functions and drilling instructions may be recorded using suitable existing recording methods, well known to those skilled in the art. Also, the recently developed electric-log-as-you-drill curves may be superimposed or graphed on the overlay strip. Therefore, the drilling rate of earth penetration curve or other desired information may be also drawn on the overlay strip by a suitable double stylus **105** cooperating with stylii drawing the other desired functions during the drilling operation.

The programmed log material on log tape **75** may be presented to the driller in sequence of the drilled earth strata or in any other order desired.

In the operation of this method of drilling the following steps are necessary for the proper and safe operation of the drill rig:

The driller places an engineered and prepared com-

posite programming tape in mechanical programmer **74** and properly adjusts the change gears in gear box **78** to synchronize the drilling depth of travel of the scaled log tape **75** with that of instrument line **54** and drill bit **46** after which all knobs and tape spools are properly adjusted and engaged with the tape rollers, and stylus **105** is either manually or automatically adjusted at the proper end of worm drive **104** to record the drilling time on indicia scale **108**. Then door **91** is secured by latch **93** and the driller is ready for the drilling operation by watching the programmed tape **75** and its instructions as it slowly passes a horizontal line **207** inscribed on window pane **206** adjacent the upper end of pointer or stylus **105**, during drilling operations, as best shown in FIGURES 4 and 5 by actual earth stratum or sand E of FIGURE 1 which corresponds to sand E stratum on log tape **75** of FIGURE 4. Programmed drilling instructions to the driller for each or only for certain separate strata of the earth (although not shown for clarity) are displayed on log tape **75** insuring safe and economical drilling operation of the drilling rig during a present drilled strata and an anticipated strata as the drill bit descends, and operating the drilling rig as programmed drilling steps of operation of the drill rig as the drill bit **46** bores through each earth strata, as shown in earth A, shale B, sand C, shale D, sand E, limestone F, shale G, hard abrasive sandstone H and shale I, of FIGURES 1 and 4.

It is a well known fact for those skilled in the art, that each earth stratum has a different designated rate of drill bit descent therethrough and this fact is utilized in the present novel method. If the log tape **75** of FIGURE 4 is at variance with the earth strata of FIGURE 1, the driller may use correction operational steps by immediately referring to the strata on log **75** having the rate of drill bit descent corresponding to the rate of descent of the bit through the strata in question as operational steps to adjust the speed of drill rotation, fluid pressure used, and properly adjust the weight on the bit, and the like, to insure proper economical and safe operation of the drill rig to prevent the possible hazard of ruining, losing or getting a drill bit fastened in the borehole.

From the foregoing it will be seen that there is herein provided an improved indicating and programming method and apparatus for borehole drilling which accomplishes all the objects of this invention, and others, including many advantages of great practical utility and commercial importance.

It should be understood, of course, that the foregoing disclosure relates to only a preferred embodiment of the invention and that it is intended to cover all changes and modifications of the example of the invention chosen for the purposes of the disclosure, which do not constitute departures from the spirit and scope of the invention set forth in the appended claims.

I claim:

1. An indicating and programming apparatus for operation of a drill rig for boreholed drilling comprising means for advancing a programmed log tape means at a speed relative to the travel of a drilling bit in a borehole; clock means, shiftable apparatus having a stylus and indicator pointer adapted to be driven by said clock means to contact and uniformly travel across and along the log tape registering the units of time consumed by selective drilling operations for a borehole on an indicating scale overlying said log tape means, indicator counter means driven by the log tape means and adapted to record the number of feet of earth strata drilled in a given period of time; and coupling means operatively connecting the counter means to said means for advancing said log tape with an instrument line operatively connected to a swivel of a drill string.

2. A mechanical programmer in combination with a drill rig for borehole drilling comprising an enclosure having therein display openings, tape receiving and displaying rollers actuated by elastic belt means connected to an input shaft driven by an instrument line connected to a drill string and one of said rollers, log tape means adapted to be received by said rollers and displayed in one of said openings, platen means cooperating with said tape and said rollers, drill registering depth means operatively driven by one of said rollers, clock means, and shiftable apparatus means in said enclosure selectively driven by said clock means including a stylus and indicator pointer to contact and uniformly travel across and along the display of said log tape and register in one of said openings the drilling time to drill a bore hole, and clutch means interconnecting said input shaft with one of said rollers to selectively operate the programmer.

3. A mechanical programmer in combination with a drill rig for borehole drilling as in claim **2**, wherein said rollers include selectively manually engaging and disengaging means for interchange of said log tape means, and for adjusting its position relative to the reference datum line.

4. A mechanical programmer in combination with a drill rig for borehole drilling as in claim **3**, wherein one end of said rollers includes a spring biased braking means adapted to adjust the tension of said log tape means as it passes one of said display openings.

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