May 25, 1954 J. E. YANCEY 2,679,161

# DEPTH PROGRESS RECORDING APPARATUS FOR WELLS

Filed Nov. 3, 1949 4 Sheets-Sheet 1

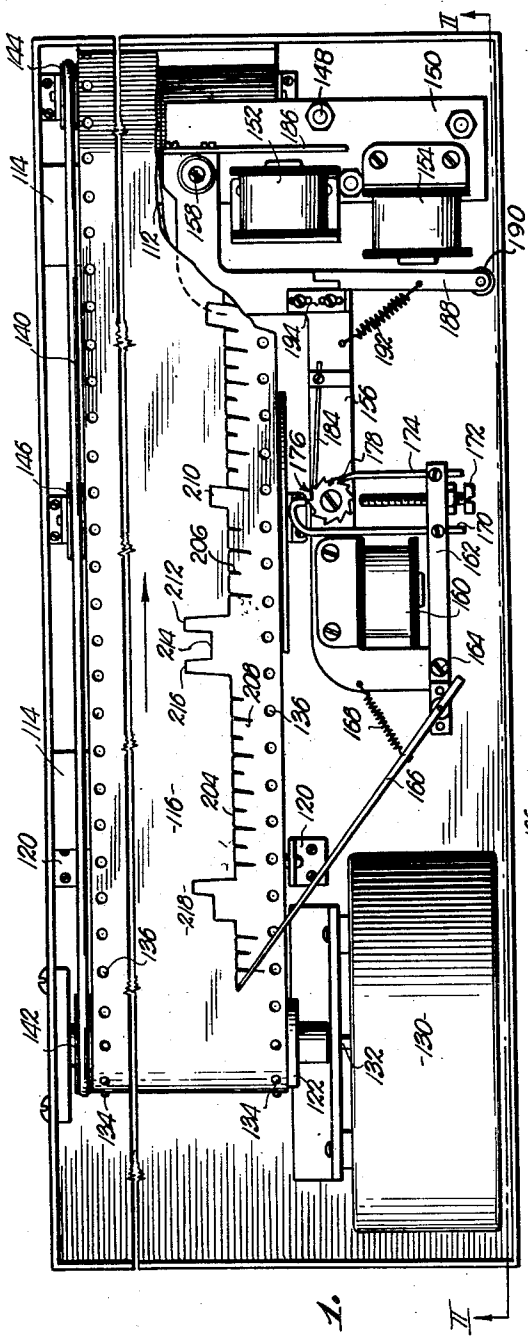

Fig. 1.

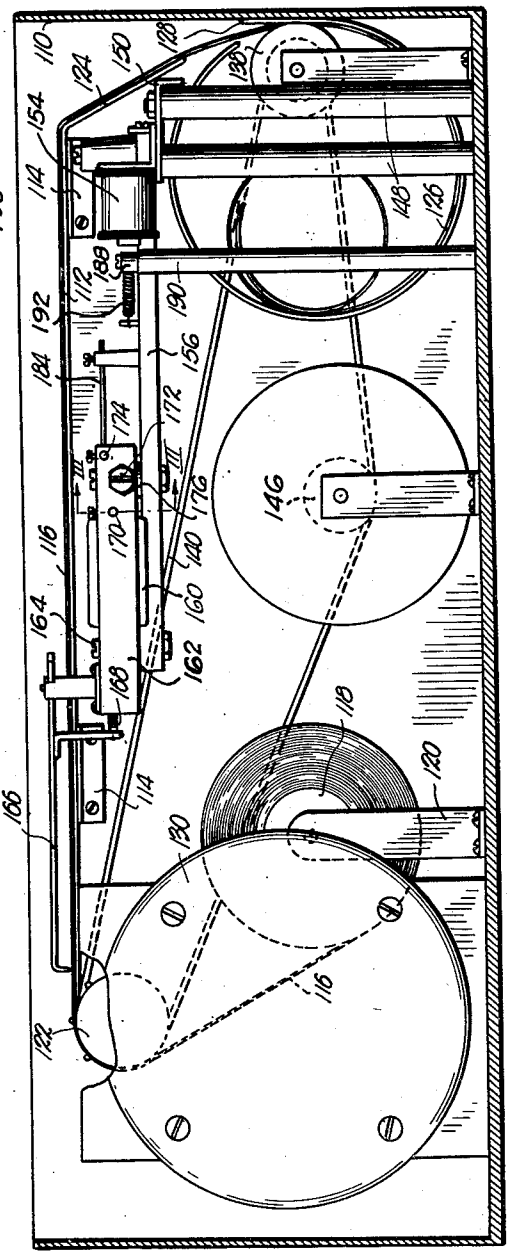

Fig. 2.

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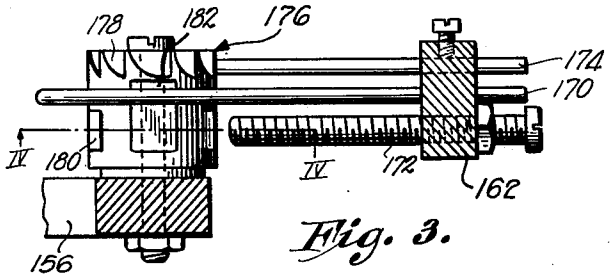


Fig. 3.

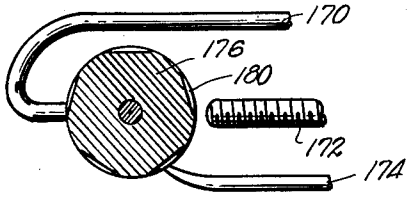


Fig. 4.

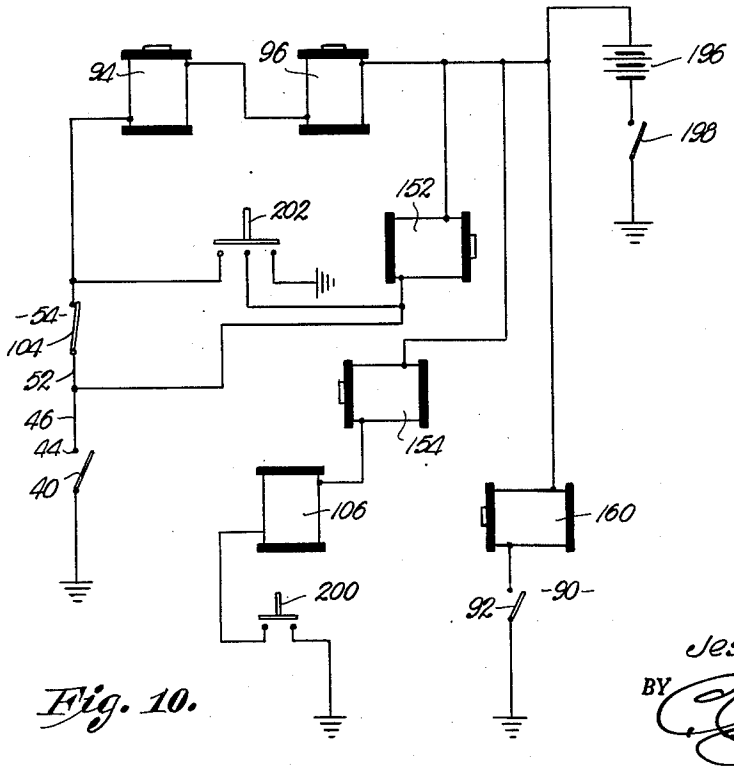


Fig. 10.

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DEPTH PROGRESS RECORDING APPARATUS FOR WELLS

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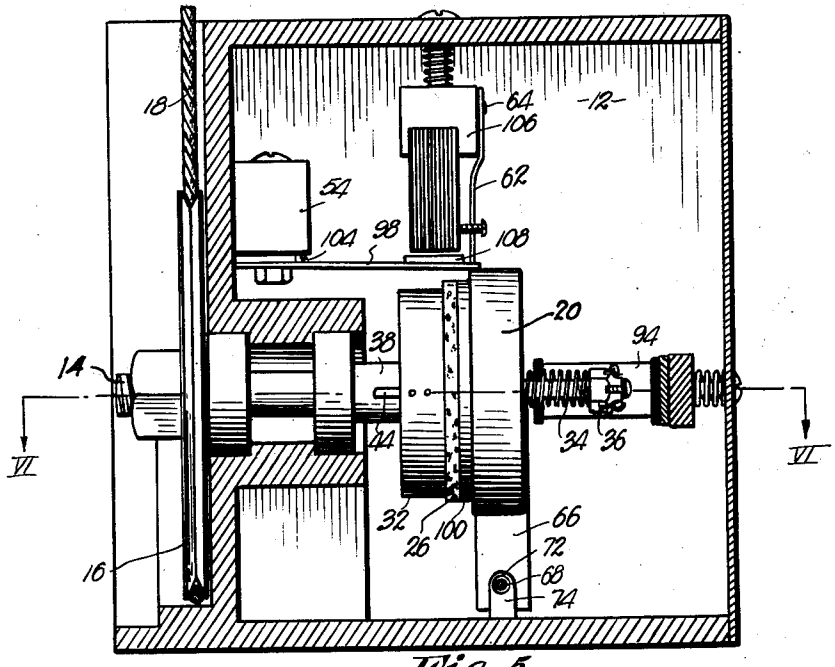


Fig. 5.

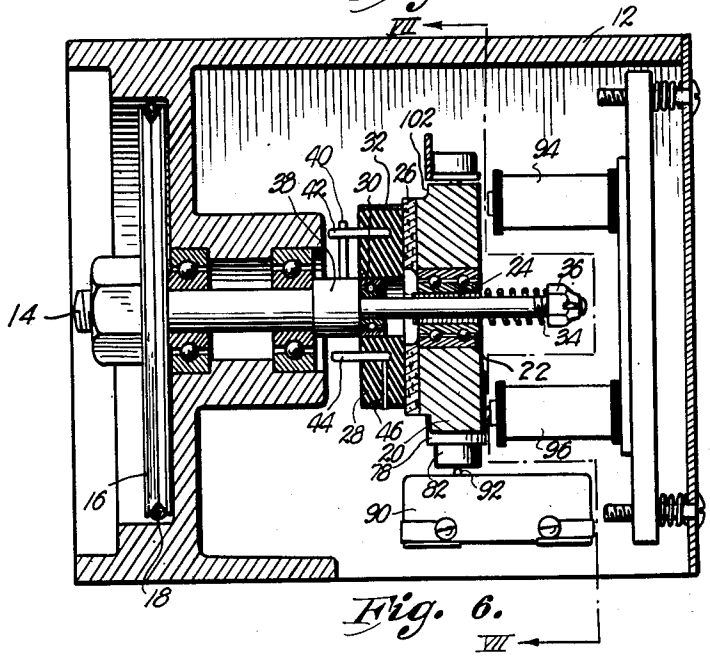


Fig. 6.

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DEPTH PROGRESS RECORDING APPARATUS FOR WELLS

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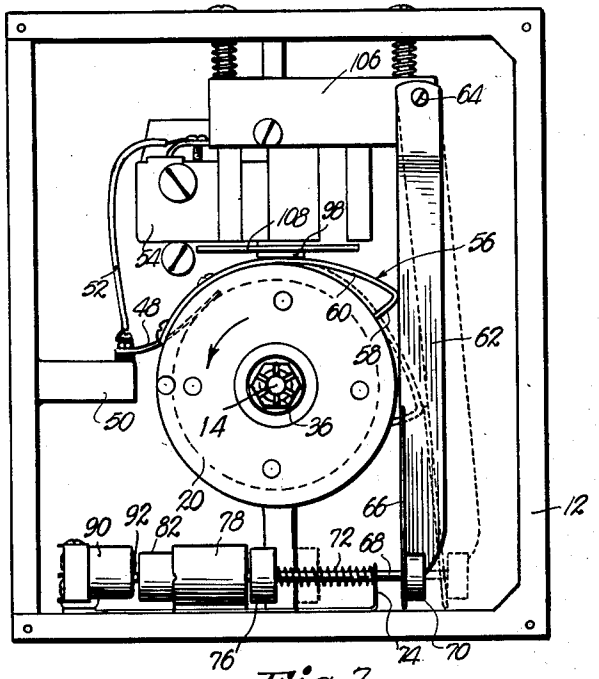


Fig. 7.

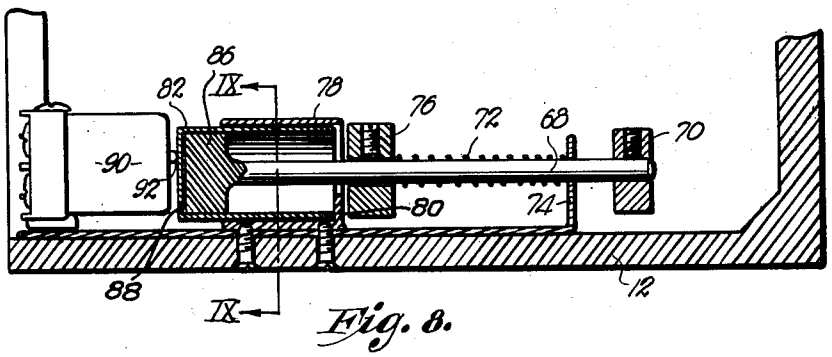


Fig. 8.

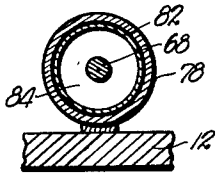


Fig. 9.

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# UNITED STATES PATENT OFFICE

2,679,161

## DEPTH PROGRESS RECORDING APPARATUS FOR WELLS

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Application November 3, 1949, Serial No. 125,291

10 Claims. (Cl. 73—151.5)

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This invention relates to an instrument particularly adapted for use in the drilling of oil wells for recording the progress of the drilling operations whereby to indicate the speed of drilling, the character of the earthen formations through which the drilling takes place; the number of feet drilled within a given period of time; and the time spent in servicing the drilling equipment and other activities necessitating temporary cessation of actual drilling operations.

It is the primary object of the present invention to provide a recording device capable of indicating the above information and including a clock-driven tape provided with a stylus swingably mounted for movement with respect to the path of travel of the tape, there being structure operably interconnecting the stylus and the well drilling equipment for imparting swinging movement to the stylus each time the drilling assembly descends a predetermined distance whereby to indicate on the tape the number of feet drilled in any given period of time.

Another important object of the present invention is to provide structure as above set forth and including limiting or control means for the swinging movement of the stylus for marking the tape to render the same easily read by showing through marks of differing lengths, each foot of drilling, each two foot descent of the drilling assembly and each ten foot progress during a given period of time as determined by the speed of movement of the tape.

Another important object of the present invention is to provide a recorder wherein the stylus is mounted for a secondary swinging movement for indicating on the chart each time the drill is moved from the bottom of the well by lines marked on the tape on one side of the aforesaid footage marks, all movements of the stylus with respect to the tape being automatic and without the necessity of operator attention.

A further object of the present invention is to provide a rotatable member operably interconnected with the well drilling equipment for rotative movement in accordance with the extent of downward movement of the drilling bit, such rotative member being provided with structure to periodically close an electric circuit having a solenoid or like prime mover therein for actuating the stylus and indicating on the advancing tape the fact that the rotative member has progressed a specified distance.

A still further object of the present invention is to provide a novel clutching arrangement so formed as to automatically become inoperable

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from the standpoint of actuating the stylus to indicate drilling progress, the clutch having parts associated therewith for energizing another electrical circuit also provided with an electric prime mover for swinging the stylus in an altogether differing manner whereby to indicate on the chart that the drilling assembly has been moved from the bottom of the well toward a fully withdrawn position with respect thereto.

Other objects of the present invention include the way in which the prime movers for the stylus are controlled for momentary energization; the way in which the stylus is locked on one side of a main indicating line on the tape while the drilling assembly is in an inoperative position; the way in which manual control means is provided for releasing the locking assembly when the drilling operation is resumed; the manner of providing a specially formed combination rotatable cam and ratchet assembly for controlling the swinging movement of the stylus during normal operation; and the way in which a pair of stops or limiting means is provided in connection with the cam to produce the desired markings on the tape as above set forth.

Many other more minor objects including details of construction will be made clear or become apparent as the following specification progresses, reference being had to the accompanying drawings, wherein:

Fig. 1 is a top plan view, parts being broken away showing the stylus and tape assembly of a depth progress recording apparatus for wells made in accordance with the present invention.

Fig. 2 is a vertical, cross-sectional view taken on line II—II of Fig. 1 looking in the direction of the arrows.

Fig. 3 is an enlarged, detailed, fragmentary, cross-sectional view taken on line III—III of Fig. 2.

Fig. 4 is a fragmentary, detailed, cross-sectional view taken on line IV—IV of Fig. 3.

Fig. 5 is a view partially in section and partially in elevation showing the stylus control assembly forming a part of the recorder and adapted for operable connection with the well drilling equipment.

Fig. 6 is a transverse, cross-sectional view taken on line VI—VI of Fig. 5 looking in the direction of the arrows.

Fig. 7 is a vertical, cross-sectional view taken on irregular line VII—VII of Fig. 6 looking in the direction of the arrows.

Fig. 8 is a substantially central, vertical, cross-sectional view through a piston-type switch ac-

tuating mechanism forming a part of the stylus control.

Fig. 9 is a transverse, detailed, cross-sectional view taken on line IX—IX of Fig. 8; and

Fig. 10 is a wiring diagram showing the electrical components of the recorder.

Those skilled in this field are well aware of the imminent need for an accurate and satisfactory automatic recording means capable of logging the formations penetrated particularly in the rotary method of sinking wells where it is difficult to obtain accuracy through conventional method such as coring of the formations. Furthermore, a progress report from day to day is extremely desirable, that will not only indicate the speed at which drilling takes place, but the time consumed in progressing a predetermined distance, which, of course, depends on many factors including the nature of the formations as well as time consumed in repair, servicing and other activities as a consequence of the well drilling operation itself.

While instruments have heretofore been developed capable of indicating such progress, such instruments have not been entirely satisfactory from the standpoint of accuracy and furthermore, have been incapable of recording all of the data that is needed and desired.

The instrument about to be described is entirely automatic and will record all of the aforesaid data for each full day's operation and present a permanent record for the well from the beginning of the drilling thereof until such time as the same is complete and ready for pumping.

The recorder hereof is adapted for the automatic operation and actuation by the well drilling equipment and can easily be coupled therewith in the conventional manner. As is known, such equipment (not shown) includes a derrick having a platform for supporting the usual drilling apparatus having rotary motion imparted thereto through a drive stem or Kelly joint. The derrick has a crown block provided with a plurality of sheaves at the uppermost end thereof and the derrick also supports a hoisting reel and a traveling block, all operably connected with the drill stem for controlling the reciprocable movement thereof.

As rotary movement is imparted to the drilling string that is suspended by tackle construction and swivel means, such string and the bit thereon are permitted to descend within the well in accordance with the progress of the bit. The control assembly of the instant recorder illustrated in Figs. 5 to 9 inclusive, is adapted for operable connection with such drilling equipment in any suitable conventional manner not shown.

A housing, broadly designated by the numeral 12, has a horizontal shaft 14 journaled therein, shaft 14 being provided with a sheave 16. Rotative movement is imparted to the sheave 16 and consequently to the shaft 14 by means of a cable 18 trained therearound and as aforesaid, attached to the well drilling assembly.

As the drilling string descends within the well, sheave 16 is rotated in the direction indicated by the arrow in Fig. 7 and manifestly, as such drilling string is elevated to move the bit thereof from its normal operating position at the bottom of the well, rotative movement is imparted to sheave 16, through cable 18 in a direction opposite to the arrow shown in Fig. 7.

A clutching assembly within the housing 12 is provided on shaft 14 and includes a wheel 20 provided with a bearing 22 for rotatably mounting wheel 20 on shaft 14, bearing 22 having a bushing 24 reciprocable longitudinally on shaft 14.

Wheel 20 is provided with a disc 26 rigidly secured to the normally innermost face thereof and made from any suitable non-conductive, frictional material such as cork. A secondary wheel 28 provided with a bearing 30 for mounting the same on shaft 14 and for rotation with respect thereto, is disposed adjacent the disc 26.

Wheel 28 is formed from a non-conducting material and is provided with a band 32 forming the circumference thereof made from brass or other electrical conductor.

A spring 34 coiled about the shaft 14 and held in place by a nut 36 on shaft 14, bears against the outermost end of bushing 24 and normally holds wheels 20 and 28 biased inwardly with the bearing 30 of wheel 28 against an enlarged boss 38 forming a part of shaft 14. Boss 38 of shaft 14 is provided with an outwardly extending radial pin 40 disposed to contact either of a pair of diametrically opposed outwardly extending pins 42 and 44 mounted on the wheel 28 as the shaft 14 rotates relative to the wheel 28. Pin 44 is connected with the metallic band 32 by means of a conductor 46.

A metallic spring 48 mounted on a bracket 50 within case 12 is biased in wiping engagement with the metallic band 32 and coupled within the electric circuit illustrated in Fig. 10 by a wire 52 joined with an electric switch 54. Corresponding indicating numerals have been used in Fig. 10, but further explanation of the wiring diagram of Fig. 10 will hereinafter appear.

A cam member 56 is mounted on the periphery of the wheel 20 and, as illustrated in Fig. 7 of the drawings, the member 56 is provided with a radial leg 58 and an integral tangential leg 60. An elongated, vertical arm 62 is pivotally mounted for swinging movement on a horizontal axis at 64, arm 62 being provided with a flange 66 adjacent its lowermost end. The uppermost end of the flange 66 is within the path of travel of the cam member 56 and as the wheel 20 rotates in the direction shown by the arrow in Fig. 7, cam 56 will move the arm 62 on pivot 64 to the position shown by dotted lines in Fig. 7. The lowermost end of the arm 62 is bifurcated for slidably receiving a horizontally reciprocable shaft 68 having a head 70 on one end thereof. Consequently, as the arm 62 swings to the dotted line position shown in Fig. 7, shaft 68 will be moved to the dotted line position thereof.

A spring 72 coiled about the shaft 68 is interposed between a bracket 74 for reciprocably mounting shaft 68 and a collar 76 on shaft 68 for yieldably holding the shaft 68 and the arm 62 biased in the normal position shown by full lines in Fig. 7. Bracket 74 secured to the innermost face of the bottom wall of case 12 also mounts a cylinder 78 having the ends thereof open and one end provided with a stop 80.

A cylindrical cup 82 is reciprocably mounted within the cylinder 78 and extends beyond the opposite end thereof. The outermost end of the cup 82 is provided with a wall 84 closing the same. The shaft 68 extends into the open end of the cup 82 in coaxial relationship with cup 82 and with the cylinder 78, shaft 68 being provided with a piston 86 of resilient material having a diameter to provide a relatively tight sliding fit of piston 86 within cup 82.

An air leakage port 88 is provided in the cup 82 adjacent the outermost end thereof.

It is clear that as the arm 62 is swung to the dotted line position shown in Fig. 7, shaft 68 and its piston 86 will likewise be moved to the dotted line position shown in Fig. 7. Movement of the cup 82 however, in such direction is limited by the stop 80 on cylinder 78. As soon as the cam member 56 moves upwardly to clear the uppermost end of the flange 66, arm 62 will return to the normal position shown by full lines in Fig. 7 under influence of the spring 72 and such quick snap-like return movement of arm 62 and the shaft 68, will cause movement of the cup 82 away from the stop 80 because of the air within the cup 82 drawn thereinto by piston 86 through port 88. Cup 82 will immediately return toward the stop 80 as such air escapes from the port 88 until the stop 80 is reached.

Cup 82 serves to close a normally open switch 90 by its end wall 84 engaging plunger 92 of switch 90 as cup 82 is forced away from the stop 80. Consequently, switch 90 is held closed only momentarily by the cup 82 and as the latter returns to the normal position within cylinder 78, spring-loaded plunger 92 will automatically reopen switch 90. Normal rotative motion is imparted to the wheel 20 and its cam 56 to actuate switch 90 as just above described, by rotation of sheave 16 and shaft 14 as the bit of the well drilling assembly progresses downwardly.

It is contemplated that sheave 16 and the wheel 20 rotate one revolution for each foot of downward movement of the drilling bit, consequently switch 90 will be closed each and every time such progress is made. Spring 34 on shaft 14, holding the disc 26 and the wheel 28 in frictional engagement, causes shaft 14 to impart rotative movement to both wheels 20 and 28 when pin 40 contacts pin 42. When however, the sheave 16 and shaft 14 rotate in the direction opposite to the arrow in Fig. 7, pin 40 will be moved into contacting relationship with the pin 44, thereby closing an electric circuit through a pair of solenoids 94 and 96 mounted upon one vertical end wall of the case 12 in attracting relationship to the outermost face of the metallic wheel 20. When the solenoids 94 and 96 are thus energized to attract wheel 20, the latter will move longitudinally with respect to the shaft 14 against the action of spring 34, thereby moving the gripping disc 26 out of engagement with the proximal face of the wheel 28. Continued rotation of the sheave 16 and shaft 14 in such direction will continue to rotate wheel 28 by virtue of pin 40 engaging pin 44, but such counter-rotative movement of the wheel 28 will have no effect upon the retracted wheel 20.

A resilient locking arm 98 mounted at one end thereof immediately below the switch 54, is normally biased against the circumference of wheel 20 as indicated in Fig. 5 and as the wheel 20 is retracted toward the nut 36 by solenoids 94 and 96, arm 98 automatically drops to a position riding upon a circumferential portion 100 of reduced diameter and forming a part of the wheel 20. Such portion 100 presents an annular shoulder 102 facing inwardly and as solenoids 94 and 96 are de-energized, return movement of the wheel 20 under influence of the spring 34 toward the wheel 28, is limited by shoulder 102, contacting the proximal outermost free end of the arm 98. Such movement of arm 98 also causes opening of the switch 54 by permitting downward movement of spring-loaded plunger 104 of switch 54, it being noted in Fig. 5 that the plunger 104 contacts the uppermost face of arm 98. The wheel 20 is unlocked and permitted to return to the normal operating position shown in Figs. 5 and 6 and the switch 54 is closed through the medium of energization of a solenoid 106 mounted within the case 12 above a transverse metallic attracting plate 108 on the arm 98.



The assembly of parts of the recorder that is controlled by the mechanisms just above described, is illustrated in Figs. 1 and 2 of the drawing and further in detail, by Figs. 3 and 4.

A hollow, open top housing 110 is provided with an elongated, substantially horizontal flat table 112 extending longitudinally thereof adjacent its open top, table 112 being supported by a number of brackets 114 secured to one side wall of the housing 110.

A strip of tape 116 is coiled upon a reel 118 rotatably mounted on upstanding brackets 120 on the bottom wall of housing 110 below table 112. Tape 116 is threaded upwardly from the reel 118 about a horizontally rotatable drum 122 adjacent one end of table 112. From drum 122, tape 116 is extended across the uppermost surface of the table 112 and thence downwardly along an apron 124 at the opposite end of table 112.

A hollow cylinder 126 suitably mounted within the housing 110 below the table 112 and adjacent the apron 124, has an opening 128 for receiving the tape 116 as the same is advanced along the table 112 in the direction indicated by the arrow in Fig. 1. The tape 116 is automatically formed into a roll within the cylinder 126 as indicated in Fig. 2.

A suitable clock or other timing mechanism of conventional character and designated by the numeral 130, is rigidly mounted within the housing 110 with its drive shaft 132 parallel with the axis of rotation of drum 122.

A train of gears (not shown) interconnects the drive shaft 132 of timing mechanism 130 with the drum 122 and as drum 122 is thus caused to rotate, tape 116 is advanced along the table 112 by virtue of sprockets 134 on drum 122 and corresponding marginal rows of perforations 136 formed in the tape 116. The tape 116 is held taut on the table 112 through the medium of a frictional roller 138 rotatably mounted in the cylinder 126 and in a position to hold the tape 116 against the cylinder 126 adjacent inlet opening 128.

Roller 138 is driven by the drum 122 through the medium of an endless belt 140, trained about a pulley 142 on drum 122, a pulley 144 on roller 138 and an idler pulley 146 mounted within the case 110 below table 112 to hold belt 140 in a tight condition.

A plurality of standards 148 mounted on the bottom wall of housing 110, carry a horizontal plate 150 on the uppermost end thereof and disposed beneath the table 112 adjacent apron 124. Plate 150 mounts a pair of solenoids 152 and 154 together with a substantially Z-shaped member 156 by means of a pivotal connection 158. Member 156 extends outwardly in a horizontal plane from the bracket 150 and swings on its vertical axis 158 in spaced relationship below the table 112.

Member 156 carries a solenoid 160 adjacent the outermost free end thereof remote from pivot point 158, together with a relatively short metallic arm 162 pivotally secured to the member 156 intermediate its ends as at 164.

An elongated stylus 166 is adjustably secured

to the arm 162 on one side of the pivot point 164, the outermost free end of the stylus 166 being in constant marking engagement with the uppermost face of tape 116. Stylus 166 and the arm 162 are held biased toward one end of their swinging paths of travel by a spring 168 interconnecting the stylus 166 and the member 156.

A substantially J-shaped rod 170, a screw 172 and a spring member 174 are all adjustably mounted on the arm 162 adjacent that end thereof opposite to stylus 166 and all extend in the same direction toward the member 156.

A cam member 176, detailed in Figs. 3 and 4, is rotatably mounted upon the member 156. Cam member 176 has an annular row of ratchet teeth 178 thereon in alignment with the spring member 174, a row of indentations 180, there being five of such indentations 180 illustrated and in alignment with the screw 172, and a single indentation 182 between the teeth 178 and the indentations 180 in alignment with the J-shaped rod 170. As shown in Fig. 3 of the drawings, the single indentation 182 for the J-shaped rod 170, is aligned with one of the five indentations 180. It is noted in Fig. 3 that the indentation 182 is a continuation of one of the indentations 180 and that it extends therefrom, toward the teeth 178, in alignment with the rod 170. All of the indentations 180 and 182 are provided with flat chord-like bottom walls as shown in Fig. 4 of the drawing. The spring member 174 is biased against the teeth 178 and serves to impart rotative movement to the cam member 176 when the arm 162 is swung in one direction toward the cam 176. A second spring member 184 on the member 156 is also biased against the teeth 178 and serves to prevent counter-rotative movement of the cam 176.

Swinging movement is imparted to the member 156 on its pivot point 158 by energization of the solenoid 152. Solenoid 152 attracts a metallic plate 186 secured to that end of the member 156 adjacent pivot point 158. When plate 186 is thus attracted by solenoid 152 to swing the member 156, a latch 188 pivotally mounted upon the uppermost end of a standard 190 is swung to an operative position by spring 192 interconnecting the member 156 and the latch 188. As soon as solenoid 152 is de-energized, spring 192 serves to swing member 156 back toward the normal position shown in Fig. 1 but such return movement is limited by virtue of a stop 194 adjustably mounted on the member 156 in a position to contact the proximal end of latch 188.

Metallic latch member 188 is released from such locked position with respect to the member 156 by energization of the solenoid 154 to attract latch 188 and withdraw the same from its interlocked position with respect to the stop 194.

Solenoids 94, 96, 106, 152, 154 and 160 may all be energized through a suitable source of electrical energy 196, the entire electrical circuit shown in Fig. 10 being initially placed in condition ready for use by closing of manual switch 198. It is seen in Fig. 10 that the solenoid 160 is energized upon closing of the switch 90 and that solenoids 94 and 96 are energized simultaneously upon closing of the switch that includes pins 40 and 44, it being remembered that switch 54 is normally in the closed position shown in Fig. 10. Interengagement of the contact points 40 and 44 also energizes the solenoid 152 simultaneously with the energization of solenoids 94 and 96.

Solenoids 106 and 154 are in a separate circuit and are energized simultaneously through the medium of a manual switch 200. It is also to be noted in Fig. 10 that solenoids 94, 96 and 152 may be energized as desired by the operator irrespective of the condition of contact points 40 and 44 by the closing of a third manual switch 202.

Assuming the well drilling structure to be in an operating condition with the drilling string lowered into the well and with the bit thereof at the lowermost end thereof, the operation of the recorder above described is as follows:

Tape 116 moving at a constant speed and being driven by the timing mechanism 130, has a longitudinal, rectilinear line 204 marked thereon by the stylus 166. Inasmuch as the wheels 20 and 28 are held operably interengaged by the spring 34, downward movement of the drilling string and its bit will progressively rotate the shaft 14, the wheels 20 and 28 and the cam member 56 in the direction of the arrow in Fig. 7. As soon as the bit of the drilling assembly has descended one foot, wheel 20 will have rotated a complete revolution, bringing the cam 56 into operative engagement with the arm 62. Arm 62 will, as above described, actuate the shaft 68 and the cup 82 as cam 56 moves to a position clearing flange 68 and the switch 90 will thereby be momentarily closed.

Referring therefore, to Fig. 10, it is seen that solenoid 160 will accordingly be energized for only a moment and referring next to Fig. 1, it is seen that energization of the solenoid 160 will attract the metallic arm 162. As arm 162 is thus moved toward the solenoid 160 and swings on pivot point 164, the stylus 166 will be shifted or swung with respect to the path of travel of the tape 116. A relatively short oblique mark 206 will then appear upon the tape 116 extending to one side of the rectilinear line 204.

As soon as solenoid 160 is de-energized, spring 168 will return the arm 162 and the stylus 166 to the normal position where stylus 166 is again in a position to mark the line 204. Each time the arm 162 is thus swung by solenoid 160, the spring 174 in engagement with the teeth 178 of cam 176, will impart rotative movement to cam 176. Such step-by-step movement of the cam 176 continues and inasmuch as ten teeth 178 are provided on the cam 176, the latter will rotate a complete revolution each time the drilling bit has progressed ten feet.

The extent of movement of the arm 162 toward the solenoid 160 is governed by the screw 172 coming into contact with the cam member 176, and therefore, the cam member 176 operates as stop means within the path of travel of stylus 166 to limit the extent of swinging movement of stylus 176 in both directions. Since cam member 176 rotates, the extent of movement of stylus 176 is varied. If the cam member 176 is in a position when arm 162 is swung to receive the proximal end of screw 172 at a point thereon between the annular row of indentations 180, then the oblique line 206 will appear on the tape 116. If however, cam 176 is in a position to receive the screw 172 by the latter moving into one of the five indentations 180, then obviously, arm 162 will move closer to the energized solenoid 160 and the extent of travel of stylus 166 will be greater. During such movement of the arm 162 and stylus 166, longer oblique lines 208 will be marked on tape 116 by stylus 166.

Cam 176 is so formed as to cause the presentation of alternate indicating markings 206 and 208 on the tape 116 since the indentations 180

are equally spaced around the cam member 176 and the flat bottom wall thereof is substantially the same as the distance between the indentations 180. Outward swinging movement of the arm 162 away from the de-energized solenoid 160 under influence of the spring 168, is limited by the J-shaped rod 170 having its outermost free end normally in contact with the cam member 176 in alignment with the indentation 182. Consequently, whenever cam 176 is in a position with the indentation 182, aligned with rod 170, arm 162 will swing a greater distance outwardly when solenoid 160 is de-energized.

Such operation will cause the stylus 166 to override to the side of line 204 opposite to indicating marks 206 and 208. Thereafter, while the sheave 16 is revolving for an additional cycle, stylus 166 will produce a relatively short straight line 210 parallel with the line 204. Inasmuch as only one indentation 182 is provided on the cam 176, and further because of the fact that cam 176 completes one revolution for each ten feet, the lines 210 will indicate each ten feet of drilling.

In reading the charted tape 116 therefore, it is seen that the number of feet drilled in a given period of time can easily and quickly be determined by counting the number of markings 210, each indicating a ten foot descent of the drilling bit. Between the ten foot indications 210, each two feet may be counted by virtue of the marks 208 and each one foot of progress is indicated by the marks 206.

Such operation continues as long as the drilling bit remains at the bottom of the well in an operating condition. If however, such bit is withdrawn from the bottom of the well to impart a counter-rotative motion to the sheave 16, then the pin 40 will move from its engaged position with respect to the pin 42 until the same comes into contact with the electrical contact pin 44. As soon as such electrical connection is established, the circuit is closed through solenoids 94, 96 and 152 because of the fact that switch 54 is still in the normally closed position.

Immediately upon the energization of solenoids 94 and 96, wheel 20 will be attracted against spring 34 moving the same out of frictional contact with the wheel 28 and thereby stopping further rotative movement of wheel 20. As soon as wheel 20 clears the spring member 98, the latter will snap into place upon the annular portion 100 and the switch 54 will be opened.

Opening of the switch 54 as seen in Fig. 10, deenergizes solenoid 94 and 96 which releases the wheel 20 whereupon spring 34 moves wheel 20 toward the wheel 28 until the same is stopped by the spring member 98 contacting the annular shoulder 102.

During the time that the drilling string is being retracted and the sheave 16 consequently rotated in a direction counter to its normal rotative movement, contact points 40 and 44 will remain closed and solenoid 152 will continue to be energized. As solenoid 152 attracts plate 186 to swing the member 156, stylus 166 will again be moved to a position on the tape 116 on one side of line 204 opposite to markings 206 and 208. Until such time as the drilling string is again lowered, stylus 166 will produce a straight mark 212 on the tape 116 parallel with the lines 204 and 210, the line 212 being spaced further from line 204 than that of line 210.

As soon as the drilling string is lowered, pin 40 will move away from the pin 44 to break the circuit through solenoid 152, whereupon spring 192 will retract member 156 until the stop 194 comes into contact with latch 188. Since stylus 166 moves only part of its way back toward the line 204, another straight line 214 will be formed on the tape 116 in parallelism with the line 204, but spaced therefrom. If the drilling string is again raised before reaching the bottom of the well, another line 216 comparable to line 212 will be formed on the tape 116. When the operator again lowers the drilling string and decides to permit the bit thereof to return to an operative position at the bottom of the well, switch 200 is closed to energize solenoids 106 and 154. Energization of the solenoid 154 will release the latch 188 and the stylus 166 will return to the normal position for marking line 204.

Energization of the solenoid 106 by closing of the switch 200 will attract the arm 98 and release the wheel 20, whereupon switch 200 is again opened and operation is continued. In the event the operator lowers the drilling string only partially and thereupon decides to continue such lowering of the same to the full operative position without again raising the same to the fully raised position, such operation will be indicated by a diagram 218 on the tape 116.

It is clear from the foregoing that the distance between the alternate markings 206 and 208 indicate the time consumed in drilling each foot and obviously, as such distances are increased, difficulty in drilling is indicated whether the same is caused by relatively hard formations or for other reasons. The lines 212, 214 and 216, as well as the diagram 218, will indicate immediately each and every period of inoperation and the time consumed thereby.

It is clear that the entire recorder is automatic and requires very little operator attention, for as long as the drilling apparatus is in operation, lines 204, 206, 208 and 210 will be automatically marked upon the moving tape 116. The only time the operator must attend to the recorder is after withdrawal of the drilling string and such attention will constitute merely the closing and opening of the manual switch 200.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a recorder, tape advancing mechanism; a swingable member; a stylus swingable on the member and in engagement with said tape; a prime mover for said member and for said stylus respectively; a rotatable assembly; structure operably connected with said assembly for energizing the prime mover for said stylus upon a predetermined number of cycles of rotation of said assembly in one direction; and apparatus operably connected with said assembly for energizing the prime mover for said member upon rotation of said assembly in the opposite direction.

2. In a recorder, tape advancing mechanism; a swingable member; a stylus swingable on the member and in engagement with said tape; a prime mover for said member and for said stylus respectively; a rotatable assembly; structure operably connected with said assembly for energizing the prime mover for said stylus upon a predetermined number of cycles of rotation of said assembly in one direction; and apparatus operably connected with said assembly for energizing the prime mover for said member upon rotation of said assembly in the opposite direction, said prime mover for the stylus being disposed to swing the stylus in a direction with respect to the tape opposite from the direction of swinging

movement of said member by its prime mover with respect to the tape.

3. In a recorder, tape advancing mechanism; a swingable member; a stylus swingable on the member and in engagement with said tape; a prime mover for said member and for said stylus respectively; a rotatable assembly; structure operably connected with said assembly for energizing the prime mover for said stylus upon a predetermined number of cycles of rotation of said assembly in one direction; apparatus operably connected with said assembly for energizing the prime mover for said member upon rotation of said assembly in the opposite direction; and releasable means for limiting the extent of return movement of said member on de-energization of its prime mover.

4. In well drilling equipment having a reciprocable drilling string, a recorder including a rotatable member adapted for connection with and rotation by said drilling string in opposite directions as said string is reciprocated; an electric circuit having a switch; an element mounted for rotation by said member for closing said switch upon a predetermined number of cycles of rotation of said member in one direction; marking structure having a movable stylus provided with an electric prime mover in said circuit whereby movement is imparted to the stylus upon each closing of the switch, said element being releasably connected with said member; means for releasing said element upon rotation of the member in the opposite direction; means for swinging said stylus separate from said first-mentioned movement thereof; and mechanism operably interconnecting said member and said last-mentioned means for swinging the stylus as the member rotates in said opposite direction.

5. A recorder comprising mechanism for continuously advancing a tape at a constant speed; shiftable apparatus having a stylus in marking engagement with said tape; structure for shifting said apparatus in one direction with respect to the path of travel of said tape; a movable member; means operably connected with said member for actuation thereby and coupled with said structure for motivating the latter upon each movement of said member a predetermined distance; means connected with said apparatus for yieldably holding the same biased in the opposite direction; a movable element having stop means within the path of travel of said apparatus in each direction respectively; and means operably interconnecting said apparatus and said element for moving the latter as the apparatus shifts whereby to move the stop means and thereby vary the extent of shifting movement of the apparatus from one end of its path of travel to the opposite end thereof.

6. A recorder for drilling equipment comprising mechanism for continuously advancing an elongated tape at a predetermined, constant speed on its longitudinal axis; a swingable arm; a stylus mounted on the arm in marking engagement with the tape for swinging movement transversely of the tape; an elongated member on the arm; a rotatable cam having a circumferential surface within the path of travel of the member as said arm is swung in one direction, there being a number of equally spaced indentations in said surface of the cam; means on the arm for stepping the cam each time the arm is swung whereby to alternately dispose the indentations for engagement by the member and thereby vary the extent of swinging movement of the arm; electrical means for swinging the arm, the stylus and the member as a unit in one direction; means coupled with the stylus for swinging the same in the opposite direction; an electric circuit for said electrical means; a normally open switch in said circuit; rotatable structure operably coupled with said equipment for rotation thereby in one direction as the drilling bit thereof is advanced; and means mounted on said structure for periodic engagement with the switch as the structure is rotated to close the switch and thereby swing the stylus in said one direction.

7. A recorder for drilling equipment comprising mechanism for continuously advancing an elongated tape at a predetermined, constant speed on its longitudinal axis; a stylus in marking engagement with the tape and mounted for swinging movement transversely of the tape; electrical means for swinging the stylus in one direction; means coupled with the stylus for swinging the same in the opposite direction; an electric circuit for said electrical means; a normally open switch in said circuit; rotatable structure operably coupled with said equipment for rotation thereby in one direction as the drilling bit thereof is advanced; and means mounted on said structure for periodic engagement with the switch as the structure is rotated to close the switch and thereby swing the stylus in said one direction, there being a movable member for limiting the extent of swinging movement of the stylus in said one direction, and means coupling the stylus with said member for moving the latter each time the stylus is swung by said electrical means, whereby to vary the extent of swinging movement of the stylus.

8. A recorder as set forth in claim 7, wherein is provided a rotatable cam member having a plurality of circumferentially-arranged indentations, an element mounted on the stylus for movement toward and away from the member as the stylus is swung, and means on the stylus for stepping the cam member each time the stylus is swung, to alternately dispose the indentations within the path of said element, whereby to vary the extent of swinging movement of the stylus.

9. A recorder comprising mechanism for continuously advancing a tape at a constant speed; shiftable apparatus having a stylus in marking engagement with said tape; structure for shifting said apparatus in one direction with respect to the path of travel of said tape; a movable member; means operably connected with said member for actuation thereby, and coupled with said structure for motivating the latter upon each movement of said member, a predetermined distance; stop means within the path of travel of said apparatus, said stop means being movable to vary the extent of shifting movement of the apparatus in said one direction; and means operably connecting said apparatus and the stop means for moving the latter upon each shifting movement of the apparatus.

10. A recorder comprising mechanism for continuously advancing a tape at a constant speed; shiftable apparatus having a stylus in marking engagement with said tape; structure for shifting said apparatus in one direction with respect to the path of travel of said tape; a movable member; means operably connected with said member for actuation thereby, and coupled with said structure for motivating the latter upon each movement of said member a predetermined distance; movable stop means within the path of

travel of said apparatus for limiting the extent of shifting movement thereof, in said one direction; and means operably interconnecting said apparatus and said stop means, for moving the latter as the apparatus shifts, whereby to vary said extent of shifting movement of the apparatus.

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