Dec. 24, 1940. R. H. CARR ET AL 2,225,683

APPARATUS FOR USE IN CONNECTION WITH EARTH BORING

Filed Dec. 3, 1937 4 Sheets-Sheet 1

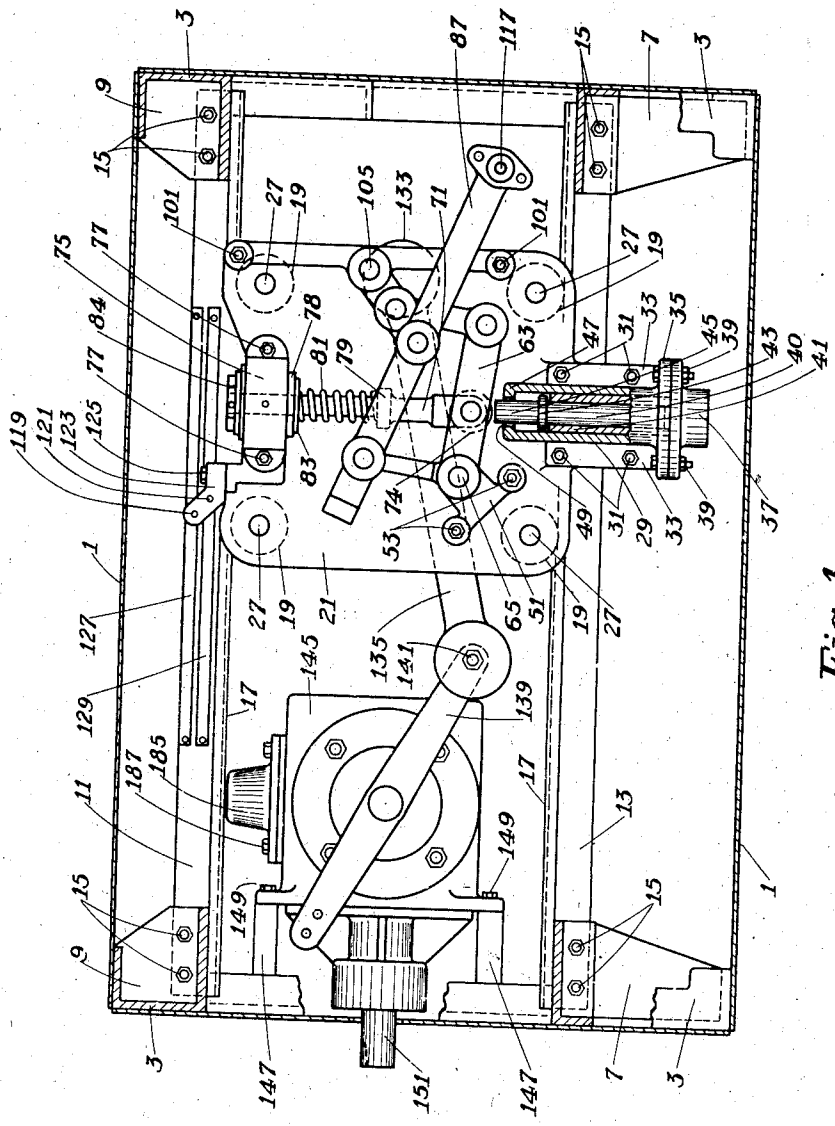


Fig. 1

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APPARATUS FOR USE IN CONNECTION WITH EARTH BORING

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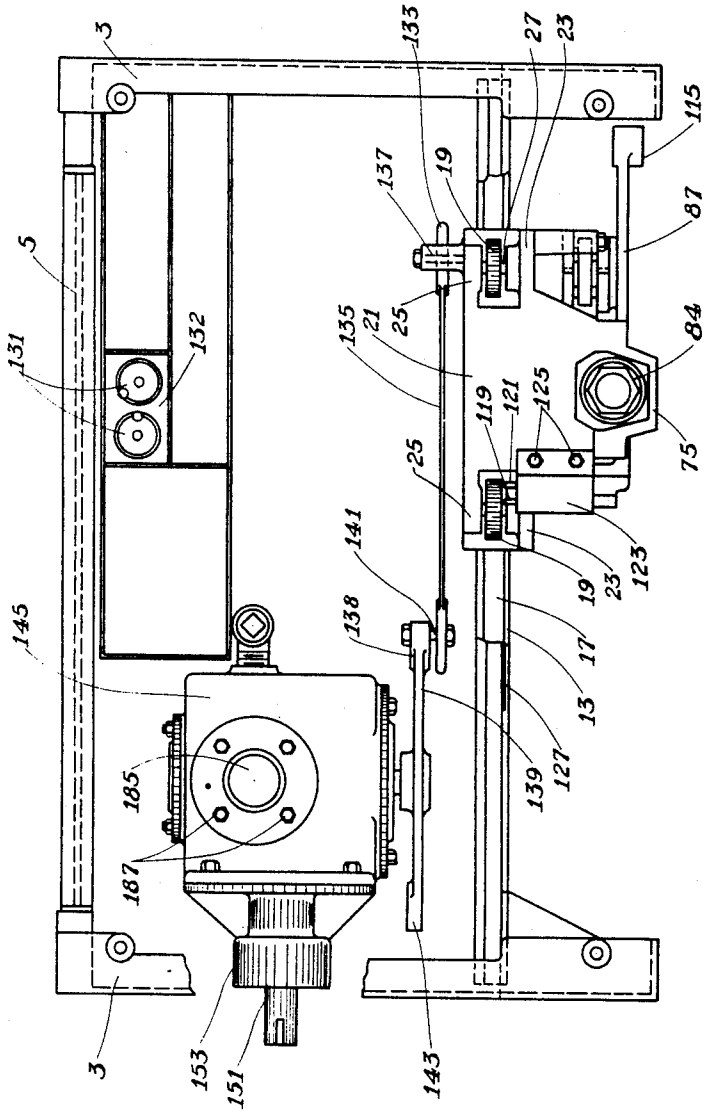


Fig. 2

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APPARATUS FOR USE IN CONNECTION WITH EARTH BORING

Filed Dec. 3, 1937 4 Sheets-Sheet 3

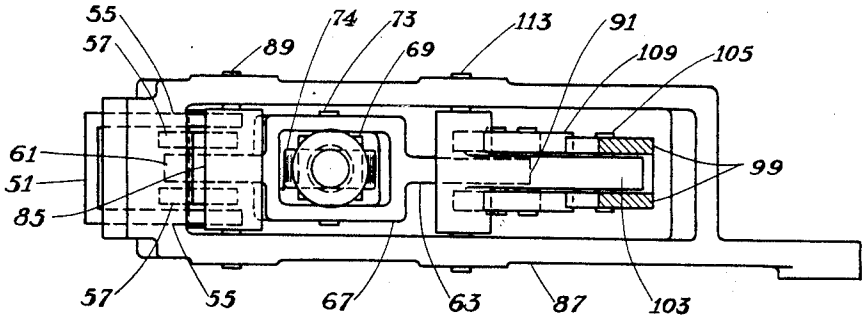


Fig. 4

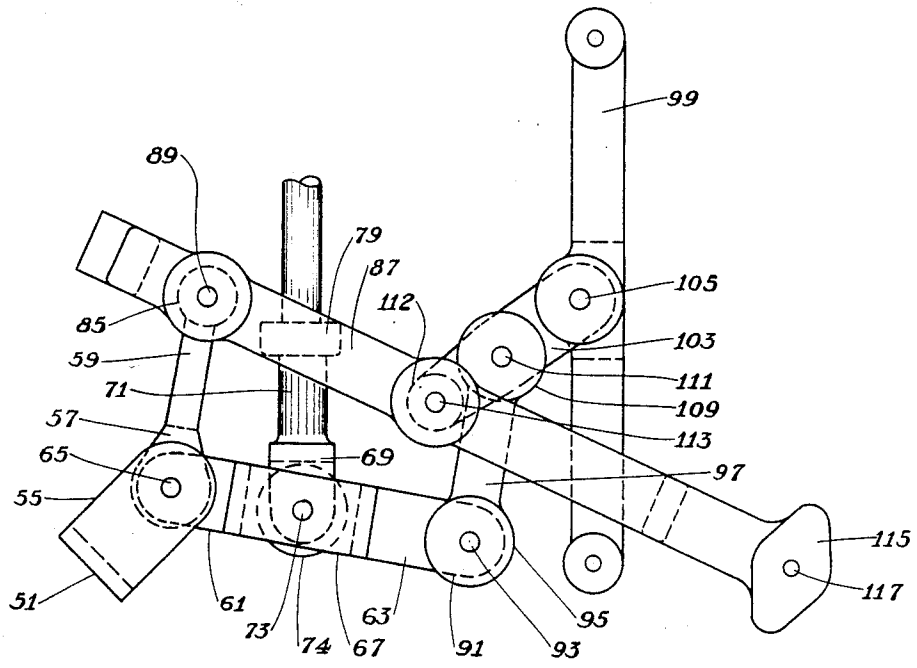


Fig. 3

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APPARATUS FOR USE IN CONNECTION WITH EARTH BORING

Filed Dec. 3, 1937 4 Sheets-Sheet 4

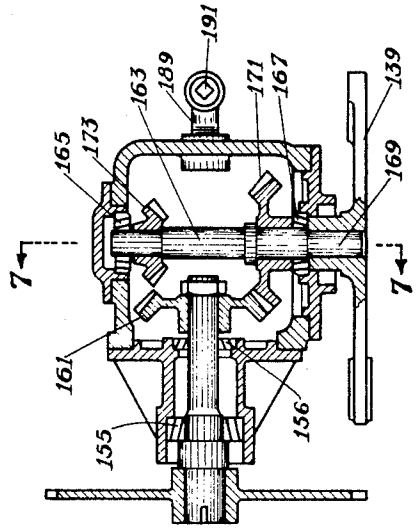


Fig. 6

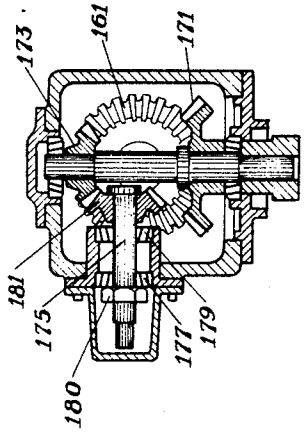


Fig. 7

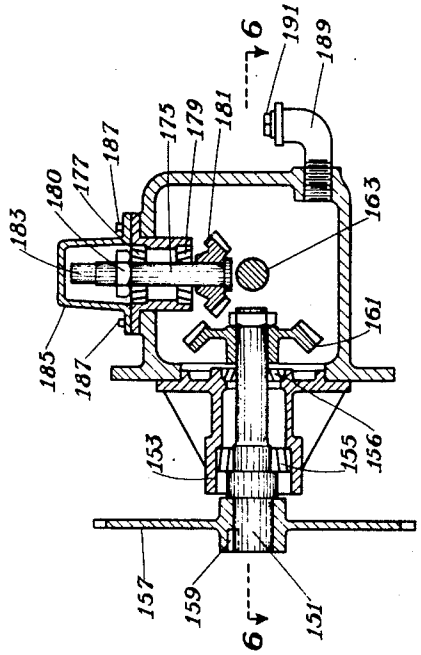


Fig. 5

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Patented Dec. 24, 1940

2,225,683

UNITED STATES PATENT OFFICE

2,225,683

APPARATUS FOR USE IN CONNECTION WITH EARTH BORING

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Application December 3, 1937, Serial No. 177,962

10 Claims. (Cl. 73—30)

This invention relates to apparatus for controlling well drilling operations and is more particularly concerned with indicating and recording apparatus for enabling control of percussion well drilling operations.

Present day oil well drilling requires the use of extremely long strings of drilling tools because of the great depths that it is necessary to drill to find oil. During operation the line and drilling tools are continually stretching and contracting due to the elasticity thereof. In percussion drilling, in order to get maximum efficiency, a definite relationship should exist between the motion of the walking beam and the natural period of the line of drilling tools.

The rapidity with which percussion drilling can be effected depends on the force of the blow struck by the drilling tools at the bottom of the hole plus the number of blows struck in a given time; and secondarily on the extent of freedom of the bottom of the hole from the accumulation of loose material which has been broken from the formation by the drilling operation.

The force of the blow being struck by the tools on the bottom of the hole is dependent upon a number of factors and adjustments such as weight of the tools, tension of the line, length and speed of the stroke, and the condition of the hole.

The present means of determining the proper adjustments for the most effective blow and rate of speed and length of stroke, is to feel the shock of the drilling cable and other component parts of the rig. The operator relies on sensory impressions and as the hole becomes deeper and the elasticity of the cable absorbs more of the shock, it becomes increasingly difficult for the operator to determine proper adjustments. At present there is no practical means of readily determining the amounts of loose cuttings in the bottom of the hole and to what extent they affect the force of the blow, or the action of the tools in relation to the motion of the drilling beam or mechanism. The current procedure is to arbitrarily drill a given distance between bailing operations.

The object of the invention is to provide a sensitive instrument to determine continuously the stress in the drilling cable, with the instrument synchronized with the drilling motion in such a manner as to describe a visual stress diagram and which instrument may be connected to a conventional stress recording instrument. By observing the characteristics of this diagram and changes of line stress, the operator will be enabled to make adjustments with a higher degree of precision and reliability than when the sense of feeling solely is relied upon. In this manner the proper relationship between walking beam motion and the period of the string can be established.

When the drill hole begins to mud up or an excess of loose cuttings occurs in the bottom of the hole, the drilling string produces a characteristic stress diagram and the shape of the diagram indicates this condition. Therefore, the device which is the subject of the invention makes it possible to determine when this condition exists. Likewise, mudding up of the tools produces a characteristic stress diagram. Mudding up causes increased line stress at certain points of the stroke and thus can be detected from the stress diagram.

In fishing for tools lost in a drill hole, it is customary to slowly lower the fishing string into the hole. When the fish is touched, the stress on the line decreases and this will appear immediately by the change in the shape of the stress diagram.

Likewise, when the drilling tools break, the weight on the line and therefore the stress becomes less and this can be detected from the stress diagram.

The characteristics of the stress diagram are different for hard and soft formations. For example, when drilling in a soft formation such as clay, the tools penetrate and the line has very little or no tendency to bounce, whereas in rock formation when the tools strike, the tools bounce and the bounce is recorded by the stress diagram.

Thus, by becoming familiar with the stress diagrams which are produced by these conditions, a trained operator can immediately detect what type of condition is being met with in the well.

One of the objects of the invention is to provide means for obtaining a visual diagram whereby to aid the operator in maintaining proper adjustments for delivering the greatest number of blows of greatest impact.

Another object of the invention is to provide means for determining when the hole is beginning to mud up or the accumulation of loose cuttings in the bottom of the hole begins to lessen or destroy the effectiveness of the drilling tools and thereby indicating the necessity for bailing out the hole.

A still further object is to provide means to

indicate accident to tools, such as broken pins or joints.

Still another object is to provide means for indicating whether or not the tools are mudding up.

A further object is to provide means for showing contact between tools or other objects to be fished out of the well, and the fishing or recovery tools. If the object to be fished out has sufficient weight the instrument will show when a hold has been made on the fish.

Another object is to provide means for indicating changes in well formation, as from hard to soft or vice versa, and to produce a permanent record thereof.

Another object is to provide a mechanism of sensitivity equalling a precision instrument, yet so constructed that it is rugged enough to operate continuously with a minimum of lubricating and other attention.

Another object is to provide a long life mechanism giving two straight line motions at right angles to each other, the one motion proportional to a mechanical movement and the other motion proportional to a pressure change.

Other objects of the invention will become apparent from the following detailed description and the accompanying drawings, of which

Figure 1 is a front elevational view, with the front cover of the casing removed, of apparatus in accordance with this invention.

Figure 2 is a plan view of the device shown in Figure 1 with the top cover of the casing removed.

Figure 3 is an elevational view of a portion of the apparatus shown in Figure 1.

Figure 4 is a plan view of the apparatus shown in Figure 3.

Figure 5 is a vertical sectional view of the gear box forming part of the apparatus shown in Figures 1 and 2.

Figure 6 is a horizontal sectional view taken on the line 6—6 of Figure 5; and

Figure 7 is a vertical sectional view taken on the line 7—7 of Figure 6.

Referring more particularly to Figures 1 and 2, the numeral 1 indicates a rectangular casing preferably made up of sheet metal such as steel or aluminum, fastened to suitable rectangular or square end frames 3 of steel, aluminum or other suitable metal. The rectangular end frames 3 are held in spaced relation by means of the tie bar 5, which is fastened to the two end frames intermediate the top and bottom thereof and at the rear end thereof by means of bolts (not shown). The end frames 3 are preferably cast with suitable brackets or abutments 7, adjacent the lower forward corners thereof, and 9, adjacent the upper forward corners thereof, and these brackets are drilled with holes to enable the horizontal tracks 11 and 13 to be fastened between the upper brackets 9 and lower brackets 7 by means of suitable nuts and bolts 15. The tracks 11 and 13 assist in holding the end frames 3 in spaced relation. The tracks 11 and 13 are each formed with a longitudinal groove 17 in which the wheels 19 of a vertical carriage frame 21 are adapted to ride.

As appears from Figure 1, the tracks 11 and 13 are in the same vertical plane with the grooves 17 facing each other and are vertically spaced apart a distance sufficient to permit the wheels 19 of the carriage frame 21 to ride therebetween. The frame 21 is preferably formed of cast metal, preferably aluminum or aluminum alloy, in order to lessen the weight of the apparatus. Each corner of the carriage is bifurcated as shown at 23 and 25 (Figure 2) and a shaft 27, preferably press-fitted in holes drilled through the bifurcations. The wheels 19 are mounted on the shaft 27 by means of ball bearings, between the arms of each bifurcation. The wheels 19 are adapted to fit into the grooves 17 of the tracks 11 and 13 and ride therein.

A cylinder housing 29 is mounted on the carriage frame 21 at the lower end thereof and centrally thereof by means of the bolts and nuts 31 passing through flanges 33 formed integrally with and extending sidewise from the cylinder housing 29, and through the lower portion of the carriage frame 21. The bottom of the cylinder housing 29 is formed integrally with the flange 35 and is bolted to a flanged coupling 37 by means of the nuts and bolts 39. A slidable plunger 40 is snugly mounted in a cylinder 41 which in turn is mounted in the housing 29. The coupling 37 preferably has a passageway centrally thereof, preferably of larger diameter than the plunger 40 but smaller than the outside diameter of the cylinder 41. The plunger 40 has an integral collar 43 formed therewith intermediate the ends thereof and between the upper ends of the housing 29 and cylinder 41, which collar is adapted to form a limit stop for the plunger 40, the upper movement being limited by contact with the upper end 47 of the cylinder housing 29 and the lower movement by contact with the upper end of the cylinder 41. Through an opening 49 in the upper end of housing 29 extends the upper portion 45 of plunger 40 to operate the light carrying mechanism shown in Figures 3 and 4. Leakage of oil is prevented by means of a snug fit between plunger 40 and cylinder 41.

Referring more particularly to Figures 1, 3 and 4, a bracket 51 is rigidly mounted on the front face of the carriage frame 21 at the lower left hand corner thereof by means of bolts 53. The bracket 51 has a bifurcated arm 55 and between the elements of the arm is pivotally mounted on sealed and lubricant packed ball bearings carried by pin 65, the bifurcated end 57 of an arm 59 and the end 61 of a second arm 63. The arm 63 is bifurcated at 67 intermediate the ends thereof and the lower end 69 of rod 71 is pivotally mounted between the elements of the bifurcation by means of the shaft 73. The arm 63 is pivotally mounted on ball bearings intermediate the ends thereof and carried on the pin 73 which is a free moving pivot. Also carried by arm 63 is a ball bearing mounted roller 74 which bears on plunger 40.

A bracket 75 is mounted on the upper part of the carriage frame 21, directly in line with the rod 71. The bracket is fastened to the carriage frame by means of nuts and bolts 77 (Figure 1). A swivel bearing 78 is mounted in the bracket and held in place thereby. A collar 79 is formed integrally with the rod 71, intermediate the ends thereof and a coil spring 81 is mounted on the rod 71 between the collar 79 and spring follower 83. The spring follower 83 has a male thread which fits into swivel bearing 78. The spring follower is properly bored and machined to receive the upper end of rod 71 and to permit it to slide therein. The rod 71 is in vertical alignment with the plunger 40 and is adapted to be actuated thereby. The lower end of the rod 71, carried on ball bearing roller 74, is in contact with the upper end of plunger 40. The upper portion 84 of spring follower 83, which extends above the swivel bearing 78, is provided with a hexagon or

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other suitable shaped head to enable it to be turned by a wrench in order to adjust the tension of coil spring 81.

The other end 85 of the arm 59 is pivotally connected with one end of the arm 87 by means of the pin 89. Between the pin 89 and the arm 87 is inserted sealed and lubricated ball bearings to reduce friction and wear. The pin 89 is a free moving pivot. It will be seen from Figure 4 that the arm 87 is bifurcated between the ends thereof and the elements of the bifurcation are spaced apart horizontally a sufficient distance to permit the remaining arms and rods to lie therebetween.

The other end 91 of the arm 63 is fastened by means of the movable pin 93 to one end 95 of an arm 97. As appears from Figure 4, the end 95 of the arm 97 is bifurcated and the end 91 of the arm 63 is fastened to the end 95 of the arm 97 between the elements of the bifurcation. Between the end 95 of arm 97 and end 91 of arm 63 are ball bearings.

An elongated vertical bracket 99 is rigidly fastened to the right hand side of the carriage frame 21 by means of the nuts and bolts 101. Bracket 99 is spaced from the frame 21 to enable it to pass through arm 87 and also to enable arm 103 to be pivotally fastened to bracket 99 by means of pin 105 at the point where bracket 99 is bifurcated. Arm 103 pivots on pin 105 on ball bearings mounted in bracket 99.

The other end 109 of the arm 97 is bifurcated and pivotally fastened to the arm 103 intermediate the ends thereof by means of the pin 111. The arm 103 is mounted between the elements of the bifurcation of the arm 97. The other end 112 of the arm 103 is pivotally fastened to the arm 87 intermediate the ends thereof and between the elements of the bifurcation by means of the pin 113. The end 109 of arm 97 and the end 112 of arm 103 are mounted on ball bearings on pins 111 and 113. Both pins 111 and 113 form movable pivots.

Thus, all pivots are ball bearing mounted. It will be seen that the only two fixed pivots are the pins 65 and 105. The linkage shown and described is so arranged as to cause the end 115 of the arm 87 to move along a vertical line when motion is imparted to the rod 71. A light socket 117 is mounted on the end 115 of the arm 87 into which a small electric light bulb is adapted to be screwed. The socket 117 is adapted to be connected by suitable wires (not shown) to contact points or brushes 119 and 121 (Figure 1), which are formed in a suitable insulating material in the form of a bracket 123 fastened to the carriage frame 21 by means of the bolts 125. The brushes 119 and 121 are adapted to contact elongated copper bars 127 and 129 respectively which are fastened to the track 11 and insulated therefrom. The bars 127 and 129 are connected by suitable wires to the batteries 131 adapted to set in a compartment 132 in the bottom, rear portion of the casing; or any other suitable source of electric current may be used.

Referring again to Figures 1 and 2, one end 133 of a connecting rod 135 is pivotally mounted on a pin 137 screwed or press-fitted into the carriage frame 21 at the right side thereof, intermediate the lower and upper ends and extending horizontally from the back face thereof. The other end of the crank arm is pivotally fixed to one end 138 of a crank arm 139 by means of pin 141. The other end of the crank arm 143 is suitably weighted for counterbalancing purposes. Both connections of the connecting rod are ball bearing mounted.

Referring more particularly to Figures 1, 2, 5, 6, and 7, a gear box 145 is suitably mounted by means of bolts 149 in the casing 1 on brackets 147 preferably cast as part of the left side frame 3. A shaft 151 extends horizontally into the gear box through the housing 153 in which is mounted bearings 155 and 156. To the outer end of the shaft 151 is keyed a sprocket 157 by means of key 159. On the inner end of the shaft 151 is fastened a gear 161 which is adapted to rotate with the shaft. A horizontal shaft 163 in the same horizontal plane as the shaft 151 but running perpendicular thereto is mounted in the gear box in the bearings 165 and 167. One end 169 of the shaft 163 extends outside the gear box and the crank 139 is keyed thereto or otherwise rigidly mounted on the shaft. A gear 171 is rigidly mounted on the shaft 163 inside the gear box adjacent one end of the shaft and is adapted to engage the gear 161. A second gear 173, smaller than the gear 171, is mounted on the shaft 163 adjacent the other end thereof. This gear does not engage the gear 161. A vertical shaft 175, mounted in bearings 177 and 179 and held in place by retaining nut 180, extends into the gear box and has a gear 181 rigidly mounted on the inner end thereof. The gear 181 is adapted to engage the gear 173. The upper end 183 of the shaft 175 extends through an opening in the upper part of the gear box. The opening is closed by a cap 185 secured to the box by means of bolts 187. A suitable pipe 189, having a cap 191, is screwed into the lower portion of the gear box in order to permit introduction of lubricant.

The apparatus just described is used in the following manner. A sprocket is placed on the driving shaft of a well drilling rig and the sprocket 157 is connected to the driving shaft sprocket by means of a chain. The coupling 37 at the lower end of the housing 29 is connected by means of a flexible line to a dynamometer head fastened to the end of the walking beam and from which the drilling string is suspended in a manner similar to that shown and disclosed in application of Carr et al., Serial No. 90,784, now Patent No. 2,163,665 or the patent to Francis W. Lake, No. 1,739,724.

The rotation of the drive shaft causes rotation of the shaft 151 and in turn the crank 139. As the crank rotates it causes the carriage to move backward and forward on the tracks 11 and 13. At the same time the variation in tension on the string of drilling tools will be imparted to the plunger 40 through the dynamometer head thereby raising or lowering the plunger 40 and the rod 71 against the tension of the spring 81. Through the linkage heretofore described, the end 115 of the arm 87 will be moved up and down along a vertical line Since the motion of the carriage as imparted by the drive shaft and the variation in the tension of tools at each portion of the stroke of the string are imparted simultaneously to the apparatus, the light bulb 117 will define or trace the outline of an indicator card showing the tension at any point in the stroke of the drilling tools.

In order to observe the path defined by the light bulb 117, a window of frosted glass is placed in the casing immediately in front of the light bulb. The frosted glass window should be of sufficient size so that the light bulb 117 will not move out of vision during any portion of its

movement. A window approximately ten inches square is satisfactory. Thus, the operator is enabled to continuously watch the path of the light bulb, and by checking it against a perfect indicator card, he can determine how effective the drilling operation is. Preferably a perfect indicator card should be painted, etched or otherwise placed on the frosted glass window in order to more easily enable the operator to compare the outline traced by the light bulb with the perfect indicator. If the light bulb deviates from the card the operator will know by the particular deviation whether to lengthen or shorten the drilling string or whether to decrease or increase the speed of the drive shaft.

In order to obtain a permanent record of the drilling operation, the cap **185** may be removed from the gear box and a suitable recording device (not shown) may be fastened to the upper end **183** of the shaft **175**. This recording device may be likewise fastened to the dynamometer by a suitable line and a permanent chart can thus be obtained of the stresses in the drilling or other line during each point in the stroke thereof.

Instead of using a chain drive from the driving shaft to operate the device, the shaft **151** may be connected directly to the walking beam, and instead of turning the crank **139** through a complete revolution, the crank may oscillate back and forth; or the gear box may be dispensed with entirely and suitable connections from the walking beam or the drive shaft of the drilling rig to the crank arm **139** made in order to oscillate the arm. However, the chain drive has been found to be most practical since it enables performance of the well drilling or other operation without interference on the part of the indicator mechanism and does not necessitate disconnecting each time the tools are pulled or the hole is bailed.

The entire casing containing the device shown and described may be approximately three to four feet long by one and one-half to two feet wide and the same height. The apparatus may weigh approximately one hundred fifty pounds so that it may be easily conveyed from place to place.

It will be seen that novel apparatus has been provided for indicating conditions existing during percussion drilling and for continuously recording conditions during the entire drilling or other operation, thereby enabling the operations to be controlled at all times to obtain the maximum efficiency in drilling.

What is claimed is:

1. Apparatus for use in connection with well drilling in which the well drilling apparatus is driven by a drive shaft, comprising a track, a carriage adapted to move in opposite directions along said track, means connecting said drive shaft to said carriage, said means including means for converting rotary to reciprocating motion, a free-ended arm pivotally mounted on said carriage, a plurality of links connected at one point to said arm and at another point to a reciprocable rod, and means for operating said rod by means of fluid pressure, which is proportional at all times to the tension on the drilling string of the well drilling mechanism.

2. Apparatus in accordance with claim 1 including an electric bulb fixed to the end of said arm, contact points fixed to said carriage and connected by wires to said bulb, contact bars fixed to said track in contact relation with said points, electrical connections from said contact bars to a source of electric current and a screen in front of said bulb.

3. Apparatus for use in connection with oil producing comprising an indicator, mechanical means for imparting straight line motion to said indicator, fluid pressure means for imparting straight line motion to said indicator in a direction perpendicular to said first mentioned straight line motion, said means for imparting said first mentioned straight line motion comprising a crank connected through gears to a chain drive.

4. Apparatus for use in connection with well drilling operations in which the well drilling apparatus is driven by a shaft having a sprocket mounted thereon comprising a movable carriage mounted on tracks, an indicator mounted on said carriage in such manner as to move in a straight line perpendicular to the direction of motion of said carriage on said tracks, means for oscillating said carriage on said tracks, said oscillating means comprising a crank connected to said carriage, a crank shaft upon which said crank is mounted, a drive shaft, said crank shaft being geared to said drive shaft, a sprocket mounted on said drive shaft adapted to be connected by a chain to said first mentioned sprocket and fluid pressure means for imparting motion to said indicator.

5. Apparatus of the character described comprising a track, a carriage slidably mounted thereon, means for moving said carriage in opposite directions along said track, a free-ended arm pivotally mounted on said carriage, separate means for moving the free end of said arm only perpendicular to and simultaneously with the movement of said carriage, the free end of said arm being capable of motion only perpendicular to movement of said carriage when said carriage is at rest.

6. Apparatus of the character described comprising a track, a carriage slidably mounted thereon, means for moving said carriage in opposite directions along said track in which the means for moving the carriage along the track comprises a drive shaft having a gear mounted thereon, a second shaft having a gear mounted thereon and adapted to mesh with said first mentioned gear, a crank mounted on said second shaft and a rod connecting said crank to said carriage, a free-ended arm pivotally mounted on said carriage, separate means for moving said arm in such manner as to cause the free end thereof to move along a straight line.

7. Apparatus of the character described comprising a track, a carriage slidably mounted thereon, means for moving said carriage in opposite directions along said track in which the means for moving the carriage along the track comprises a drive shaft having a gear mounted thereon, a second shaft having a gear mounted thereon and adapted to mesh with said first mentioned gear, a crank mounted on said second shaft and a rod connecting said crank to said carriage, a free-ended arm pivotally mounted on said carriage, separate means for moving said arm simultaneously with the movement of said carriage, the free end of said arm being capable of moving only perpendicular to movement of said carriage.

8. Apparatus for indicating well drilling operations, in which the well drilling apparatus is driven by a shaft which is operatively connected to a sprocket, said sprocket is operatively connected connected by means of a chain to a second sprocket, and said second sprocket is mounted on a second shaft, said first mentioned appa-

ratus comprising a third shaft adapted to be rotated through a set of gears by said second mentioned shaft, a crank mounted on said third mentioned shaft, said crank being connected to an indicator in such manner as to impart straight line motion thereto and means for imparting straight line motion to said indicator in a direction perpendicular to said first mentioned straight line motion by fluid pressure proportioned to the stress in the string of drilling tools.

9. Apparatus of the character described comprising a pair of tracks, a carriage having rollers mounted thereon and adapted to roll on the tracks, means for moving said carriage in opposite directions along said tracks in which the means for moving the carriage along the tracks comprises a drive shaft having a gear mounted thereon, a second shaft having a gear mounted thereon, and adapted to mesh with said first mentioned gear, a crank mounted on said second shaft and a rod pivotally connecting said crank to said carriage, a free-ended arm pivotally mounted on said carriage, and separate means for moving said arm in such manner as to cause the free end thereof to move along a straight line independently of the motion of said carriage.

10. Apparatus of the character described comprising a track, a carriage slidably mounted thereon, means for moving said carriage in opposite directions along said track, a free-ended arm pivotally mounted on said carriage, separate means for moving the free end of said arm in only a direction perpendicular to the motion of said carriage comprising a piston mounted in a cylinder and a series of interconnected links connected at one point to said arm and at another point to said piston, and means for applying fluid pressure to said cylinder in order to operate said piston.

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