

Oct. 6, 1942.

P. McSHANE

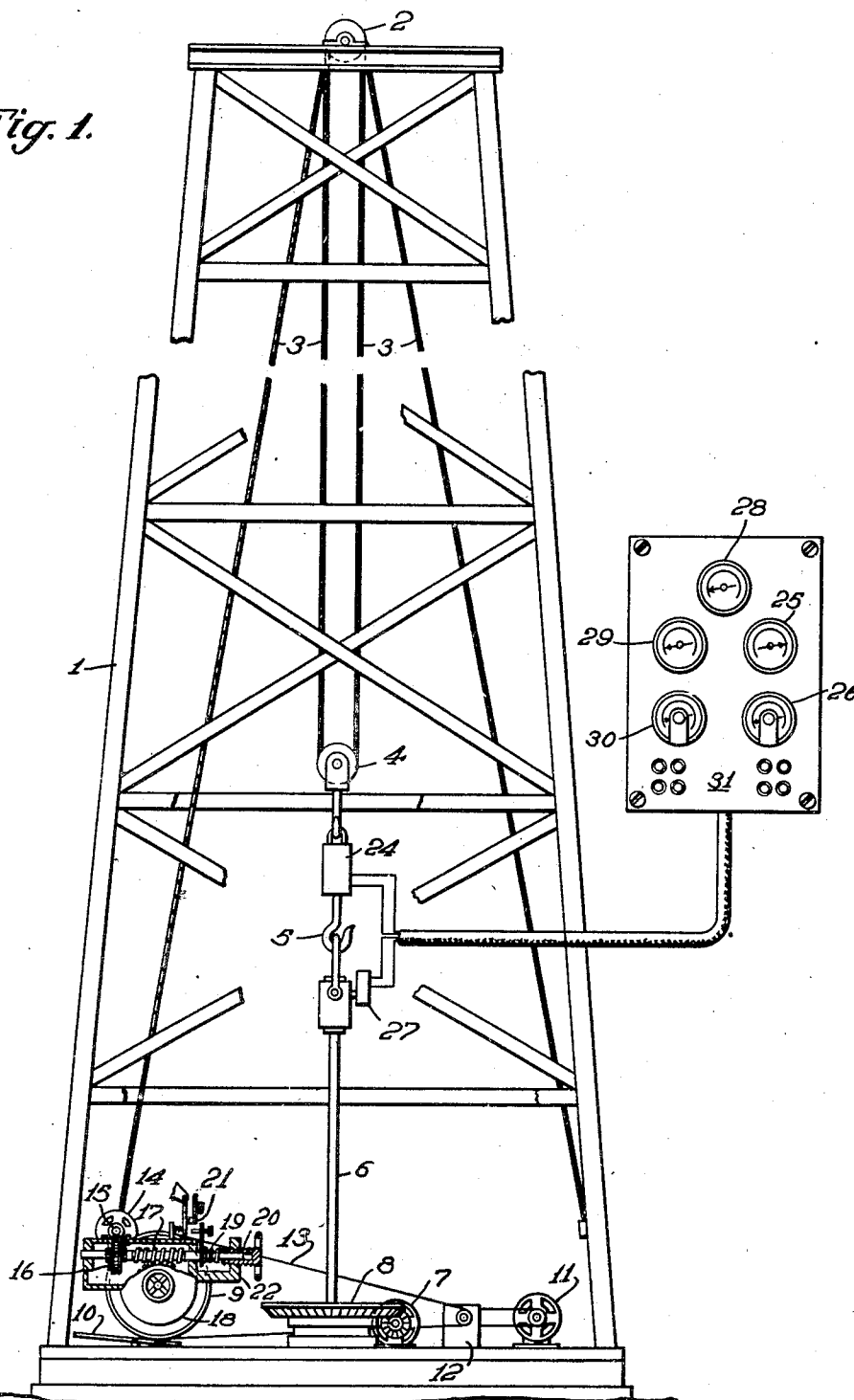
2,298,222

AUTOMATIC FEED FOR ROTARY WELL DRILLS

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2 Sheets-Sheet 1

Fig. 1.



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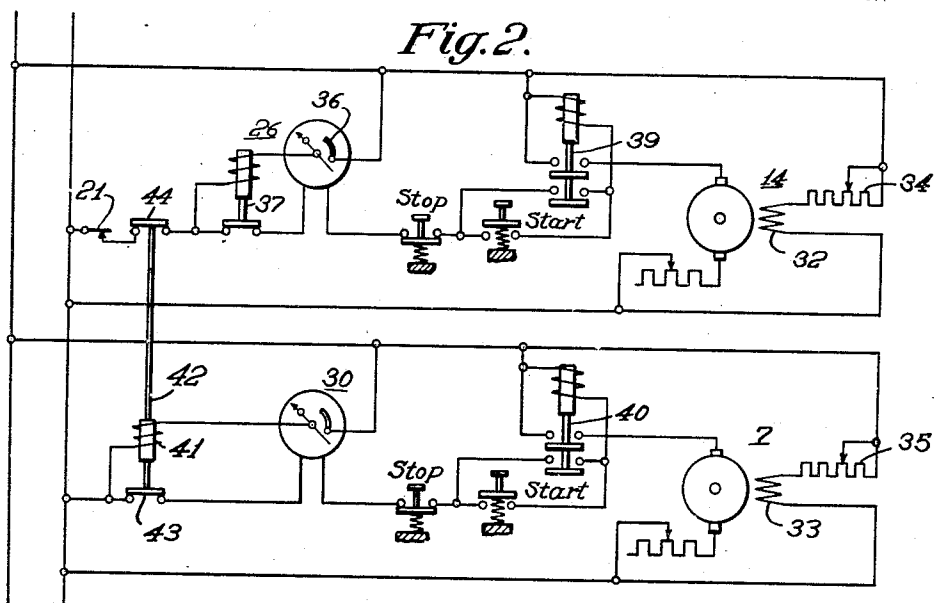
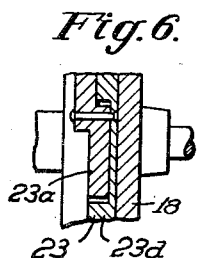
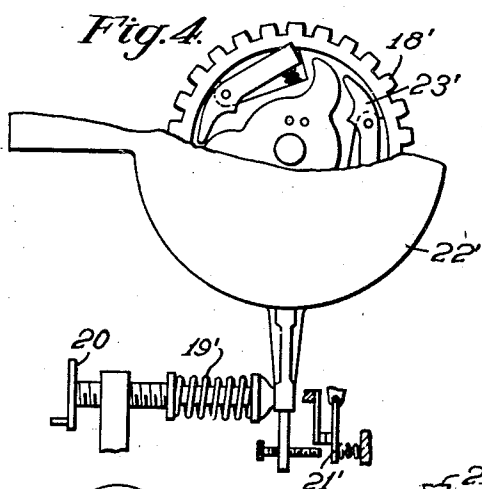
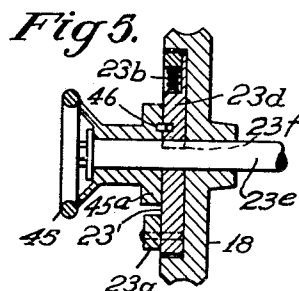
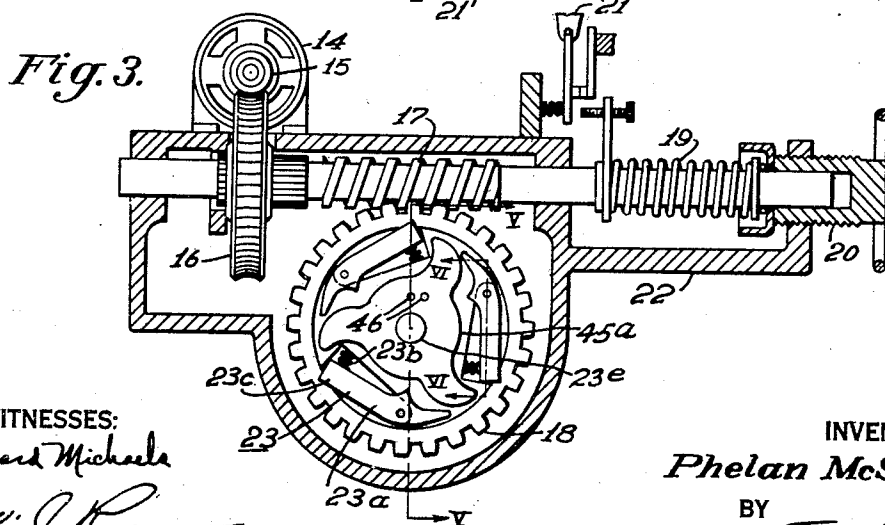
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2 Sheets-Sheet 2



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2,298,222

AUTOMATIC FEED FOR ROTARY WELL
DRILLS

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Application March 7, 1940, Serial No. 322,795

3 Claims. (Cl. 255—19)

My invention relates to rotary well drilling apparatus.

A general object of my invention is to provide apparatus operating in such a way that the pressure of the tool on the bottom of the hole can be automatically limited to a definite predetermined amount, an amount that will not be exceeded.

A further object of my invention is to provide means whereby the torque applied to the grief stem (Kelly or rotary table) will be automatically limited to a predetermined amount.

Other objects and advantages will become more apparent from a study of the following specification when considered in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic showing of an oil well drilling apparatus embodying the principles of my invention;

Fig. 2 is a diagrammatic showing of an electric control system for carrying out the method of drilling in accordance with my invention;

Fig. 3 is a sectional showing of a feeding mechanism for the drill including a switch which is responsive to the weight of the drill string which is included in Fig. 1;

Fig. 4 is a modified showing of the feed mechanism for accomplishing the same function as may be accomplished by the apparatus shown in Fig. 3;

Fig. 5 is a sectional view taken along the line V—V of Fig. 3; and

Fig. 6 is a sectional view taken along the line VI—VI of Fig. 3.

My invention broadly contemplates the use of any device whatever, that will be affected by the weight of the drill stem, irrespective of the location of the weight responsive device and to the use of any device whatever which is responsive to the torque of the grief stem so long as these devices are used in the manner hereinafter set forth.

The weight responsive means in accordance with the broadest aspects of my invention may be hydraulic, such as shown in the Dyer Patent 2,015,634, the Hild Patents 2,003,078 or 2,003,079, or arrangements such as are shown in the Dillon et al. Patent 2,005,889. The weight responsive means, however, will in no case be used to accomplish the same results set forth in the patents just listed.

A preferred weight responsive means consists of an electric strain gauge located in the tool string supporting means, such as the hook shank, tail rope or other suitable locations.

A preferred torque responsive device consists

of a strain gauge or an electric responsive device that will be affected by current supplied to a motor used to drive the rotary table and thus causes said device to respond when the torque required to rotate the table equals a predetermined amount.

The use of the devices mentioned, in combination with semi-automatic means to control the descent of the tool and its rotation are to be arranged to provide the new and desirable method of drilling hereinafter described more in detail.

A study of the patents hereinbefore mentioned and other art, indicates that the inventors in the past strove to provide means to maintain a constant torque on the drill stem and constant pressure on the tool, although they did not actually accomplish these, particularly under varying conditions of earth structure. The principle of operation of most somewhat similar prior art devices is based on the thought that when the weight on the suspending means exceeds a certain predetermined amount, the tool should be permitted to descend. Obviously, the actual torque on a tool or the pressure on the bottom, or both, is not definitely limited or controlled by such scheme. Another outstanding disadvantage of devices such as shown in the prior art is that when the weight responsive means initiates feeding of the drill stem there is great danger of overfeeding, resulting in dulling too fast, and thus producing crooked holes, or the destruction of the tool, or the twisting of the drill string, or producing two or more of these undesirable results. Furthermore, in prior art devices, if the drill should happen to go through a very soft earth formation, its rate of feed would increase considerably, and if a layer of rock or other hard formation were suddenly encountered thereafter, then the drill tool, due to its excessive feeding rate at the moment of encounter, might be ruined and the string twisted causing considerable damage. Even just before the drill tool touches bottom, due to the absence of "weight on bottom," there is great danger of overfeeding at the moment of encounter with bottom, which is detrimental to the tool.

I propose to feed the tool at a constant rate, a rate suitable to the formation being drilled. The rate of feed is selected by the operator, and not automatically subject to change by changing earth conditions.

Should the rate of feed be such as to tend to cause the weight on bottom to exceed a predetermined amount, further downward motion of the tool would be automatically arrested. Ob-

viously the pressure on the bottom would not necessarily be constant nor would the torque be constant, but in no case would the torque or weight on bottom be exceeded. That they not be exceeded, is of prime importance.

In operation, should feeding cease, the operator would alter the setting so as to reduce the rate of feed, increase mud pressure, increase speed of drill rotation, or perhaps decide to replace the bit. It is clear that with the rate of bit rotation and weight on bottom properly adjusted, maximum rate of drilling would result. It is also clear that should the character of the formation or the condition of the bit change, or the rate of penetration decline, so as to cause the pressure to tend to exceed the weighted pressure on the bottom, further downward motion of the bit would cease. Similarly, should the type of formation or the condition of the bit cause an increase in torque beyond the desired predetermined amount, feeding would cease.

Reflection will disclose that with the methods proposed by the prior art devices, should the conditions just mentioned occur, weight on the suspending means would not be exceeded, but weight on the bottom and the torque would most certainly be exceeded.

I provide a means whereby the operator can adjust his apparatus so that drilling may proceed at maximum rate, with the full assurance that weight on the bottom and the torque impressed on the drill rotating parts will not be exceeded. Only with this knowledge can the operator proceed with the full assurance that disaster will not overtake him.

Referring more particularly to Fig. 1, numeral 1 denotes a derrick having mounted thereon, a crown block 2 which supports cables 3 which, together with the block 4, forms a pulley for lifting hook 5 and the drill string 6 supported thereby. Motor 7 is used for rotating gear 8 which, in turn, rotates the drill string 6. Cables 3 are wound on a drum 9 which may be held against rotation by means of brake lever 10. When it is desired to lift the drill string 6 to replace the tool or alter the length of the string, or the like, motor 11 is operated which drives through a speed changing or transmission device 12, and is effective to rotate the drum by means of the belt 13 or other suitable coupling means. The detail structure of the speed changing device 12 does not form any part of the present invention. Therefore, it is believed that it would be sufficient to state that it is merely for the purpose of changing the speed ratio so as to make the hoisting speed of the drill string selective.

When the drill string is resting on the bottom of the well and is not ready for drilling, the rotation thereof, as described before, is effected by motor 7 as it is during actual drilling. The feeding movement of the drill string, however, is effected by the rotation of the feed motor 14 (see particularly Fig. 3) through a worm 15 which drives a worm wheel 16, which in turn, drives a worm 17, driving a worm wheel 18. There is an overhauling tendency of the drum due to the suspended weight on the hook, which tendency is overcome due to the self-locking action of the worm and worm wheels.

Assume that the drill string is in operation and that it is being fed and rotated by motors 14 and 7, respectively, and assume further that a very hard rock formation is encountered there-

by increasing the weight (on bottom), that is, the weight resting upon the tool. The suspended weight on the hook will now decrease, thereby decreasing the overhauling tendency of the drum. However, the suspended weight on the hook or overhauling tendency is counterbalanced by spring 19 (see Fig. 3), the amount of counterbalance being adjustable by nut 20. In other words, worm 17 is slidable longitudinally in either direction. The tension of spring 19 tends to slide worm 17 to the left, whereas, with increasing suspended weight, worm 17 will tend to slide towards the right by virtue of the overhauling tendency of the drum. Thus, when the suspended weight in the hook has decreased to a predetermined value (depending upon adjustment of nut 20), thereby decreasing the overhauling tendency, the spring 19 will effect opening of contact members 21, which contact members interrupt energization of motor 14, as shown more clearly in Fig. 2, thereby stopping the feed. The frame structure 22 in Fig. 3 is rigidly mounted on a stationary support on the derrick floor or other stationary structure. Worm wheel 18 drives drum 9 through a one-way clutch 23. The clutch 23 connecting the worm wheel 18 with the drum 9 comprises a plurality of pawls 23a which are normally biased by springs 23b into engagement with ratchet teeth 23c formed in the body of the worm wheel 18, the pawls 23a being pivotally mounted on the plate 23d. The plate 23d is connected to the shaft 23e by means of a suitable key 23f for the purpose of transmitting forces back and forth between the worm wheel 18 and the shaft 23e in a manner to be described. The drum 9 is provided with suitable connections (not shown) securing the same to the shaft 23e for rotation therewith.

By reason of the arrangement of the pawls 23a with respect to the ratchet teeth 23c, it will be apparent that the unwinding force transmitted to the drum 9 by the tension of the cable 3 will tend to rotate the shaft 23b, clutch plate 23 and gear 18 in a clockwise direction as viewed in Fig. 3. Such rotation of the gear 18 is prevented by the worm 17 and unwinding of the drum 9 is had only upon operation of the worm 15 to permit movement of the gear 18 in a clockwise direction. Upon reversal of the motor 14, the pawls 23a will cooperate with the notches 23c to transmit counterclockwise movement of the gear 18 to the clutch 23 and shaft 23f, in order to rotate the drum 9 and reel the cable 3 thereon.

When it is desired to release the clutch 23, the wheel 45 (see Fig. 5) is slightly rotated in a clockwise direction to move the part 45a, as viewed in Fig. 3, into engagement with the pawls 23a for the purpose of moving such pawls in a clockwise direction about their pivot points against the action of the springs 23b and out of engagement with the recesses 23c. The disengagement of the pawls 23a with the notches 23c frees the operation of the drum 9 from control of the gear wheel 18 and the worm 17. Spring-pressed pin and slot combinations 46 are provided for holding the plate member 45a in a fixed position with respect to the plate 23d. It will be noted that gear 18 and plate 45a are journaled for rotation about the shaft 23e and the member 23d operates to clutch the gear 18 to the shaft 23e.

Fig. 4 shows a modification of the device illustrated in Fig. 3. In Fig. 4, casing 22' is used which encases worm wheel 18' and clutch 23', all corresponding to elements 22, 18 and 23, respec-

tively, of Fig. 3. Also, spring 19', nut 20', and switch 21' correspond to elements 19, 20 and 21 of Fig. 3. The outstanding difference between the device in Fig. 4 and that in Fig. 3 is that in Fig. 4 casing 22' is adapted to oscillate about its axes (which coincides with the axes of worm-wheel 18'). In other words, the spring 19' tends to rotate casing 22' counter-clockwise, whereas the suspended weight of the drill string tends to rotate it clockwise. Again as in Fig. 3, switch 21' is opened in response to a decrease in the suspended weight on hook 5 due to increase of the weight on the bottom of the drill string.

Referring again to Fig. 1, numeral 24 denotes a compound strain gauge which may be of the magnetic type, as described in the copending application of Lamberger and Langer, Serial No. 296,596, filed September 26, 1939, entitled "Weight indicators for rotary drilling," which is useful to indicate the amount of strain of a portion of the drill string as the result of the suspended weight hanging thereon and in this manner, will indicate either the total suspended weight by means of a suitable connected ammeter such as 25, and the weight on the bottom by another ammeter 26, the latter ammeter having a zero calibration when the total of said weight of the drill string is suspended on the hook, that is, when the drill string has not reached the bottom of the well. Of course, after the drill 2 has touched bottom and begins to drill into the earth, the total suspended weight, as indicated by meter 25, will show a decrease, while the weight on bottom, as indicated by meter 26 will show an increase. In other words, the pointers on these meters always rotate in opposite directions, assuming that the zero position in both meters is at the extreme left. The circuit details of such compound strain gauge and meters are clearly disclosed in the copending application referred to, and since they do not form part of the present invention, further description is deemed unnecessary. It will be apparent, further, that any other suitable means may equally be used for indicating total weight, and weight on bottom, such as a hydraulic pressure responsive means instead of the strain gauges shown. A single type magnetic strain gauge 27 similar in construction to that shown by the Dillon Patent 2,005,889, or the copending application of Lamberger and Langer, Serial No. 268,500, filed April 18, 1939, entitled "Oil well strain gauges," is used in conjunction with the mud flow going through the drill string 6. In other words, a suitable bellows or diaphragm responsive to mud pressure (not shown) may be used to cause relative movement between the magnetic structures of strain gauge 27, which relative movement is recorded by a mud pressure meter 28. Other types of meters, however, may be used, although perhaps with less efficiency, in order to keep check on the drilling process present, such as a tachometer or voltmeter 29 which is suitably geared to the drill table or to motor 7 to denote the speed of rotation of the drill string 6. The torque meter or ammeter 30 is connected in the energizing circuit of motor 11, as shown more clearly in Fig. 2. A plurality of switches 31 shown below the meters, may be used for selectively starting or stopping or altering the speed of the mud pump motor, the motor 11, the motor 14, and in the event that reversal of motor 14 is desired, they may also accomplish that function. My invention does not contemplate any specific switching

means for such purposes except those that are well known in the art.

Referring more particularly to Fig. 2, the feed motor 14 and the drill rotating motor 7 are shown with their respective field windings 32 and 33 and speed adjusting resistors 34 and 35, respectively. The weight on bottom meter 26 has an arcuate segment 36 (which is preferably adjustable in a circumferential direction), which makes contact with the movable pointer when a predetermined weight on bottom has been attained, thus effecting operation of relay 37 which, in turn, effects interruption of the circuit which energized motor 14. In series with a meter 26 are the contact members 21 described in connection with Figs. 1 and 3, which are also responsive to weight on bottom. The use of these meters makes it possible for the operator to know exactly what is going on during the drilling operation. For instance, if he sees the weight on bottom increasing, he knows a harder earth formation is being encountered so he will likely decrease the feeding rate even before the maximum attainable weight on bottom valve is reached. It will be obvious that either meter 26 and its associated parts or contact members 21 and their associated parts may be eliminated because they are both for the same purpose, namely, to effect interruption of the feed motor circuit when a predetermined weight on bottom has been attained. The reason for including both such means in the same circuit in Fig. 2 is in the interest of safety so that in the event one of the switches or switch operating means becomes ineffective, the other will act as an emergency or aiding means so as to insure interruption of the circuit upon attainment of a predetermined weight on the bottom. Likewise, a torque meter or ammeter 30 similar to meter 26 in construction will, upon registering a predetermined value of torque, effect operation of relay 42, which will interrupt the energizing circuits of motors 7 and 14 and stop the rotation of the drill string thereby. After motor 14 has stopped because of excessive weight on bottom responsive to the closing of contacts of meter 26, the operator will then readjust the value of resistor 34 to pick a more suitable speed for the feed motor 14. In other words, he will decrease the speed and rate of feed of motor 14 to a value which is more appropriate for the earth formation encountered. He will select the highest rate of speed possible but not one which is so high as to cause the contacts of meter 26 to close. After resistor 34 has been readjusted, the "start" push button is depressed, thereby actuating relay 39, which closes two circuits, one which bridges the "start" push button effecting interlock thereof and the other which closes the armature circuit of motor 14. Of course, when the operator wishes to stop the feed motor 14 for any reason whatsoever, he depresses the "stop" push button. It will be apparent that before the operator restarts the feed motor 14, he will be sure by noting the readings of the weight on bottom meter 26, that the weight on bottom has decreased to a safe value. Even if he failed to do this, the motor would not start because of the interruption of the circuit by contact members 21 or by the contact members of meter 26. In actual operation, if the weight on bottom is excessive, motor 7 may be allowed to continue rotation until sufficient drilling action (without feeding of the drill string) has taken place, so as to drill away the earth's formation encountered so as to relieve the pressure on the

tool, that is, the weight on the bottom. After this has been done, the operator will depress the "start" push button for motor 14 so as to effect feed at the new rate which feed will be of constant value, but of a value lower than previously. Likewise, in motor 7, after it has been stopped because of excessive torque indicated by a meter 30, can be restarted by depressing its corresponding "start" push button which actuates relay 40 in a manner similar to relay 39. When meter 30 has completed a circuit through actuating coil 41 as the result of excessive torque, relay 42 will open contact members 43 and 44, thus interrupting the circuits through both the feed motor 14 and the table or tool rotating motor 7. Of course, motor 7 will not be restarted until the excessive torque has been removed either by decreasing the rate of feed of motor 14 or by raising the drill string slightly by means of motor 11.

The various features of my invention may be summarized as follows:

1. In operation the drill string and tool are lowered in the customary manner until the tool is within a few inches of the bottom and is so held by means of the drum brake, until the ratchet clutch heretofore mentioned is placed in engagement. The drum brake is then released by operating lever 10.

2. The rotary table which is mechanically coupled to gear 8 is then caused to rotate.

3. The compression of the spring 19 associated with the feeding device is then adjusted by nut 20 to the weight of tool value, which the operator does not wish to exceed. The rate, of feed, is also adjusted, by adjusting the speed of feeding motor by resistor 34. The feed motor 14 is then started by depressing its "start" push button.

4. The tool will now descend at the rate selected and on contacting bottom, drilling will proceed.

5. Should the rate of feed selected be such as to cause the usual weight indicating device to indicate a tendency toward a weight value greater than that which the operator desires, he may slow down the rate of feed motor rotation.

Should the opposite tendency be indicated, the rate of feeding may be conveniently increased by increasing the speed of the feed motor.

Should the operator neglect or fail to observe the indications of the weight indicating instruments and the weight on the tool equal, the value for which the feeding device is adjusted, feeding will be automatically stopped.

6. In addition to the feeding device, means for selecting and limiting the torque which may be applied to the grip stem is contemplated.

This device may be a torque limiting device such as a strain gauge in case of engine-driven rigs, or a contact making (or breaking) ammeter, if an electric motor is used to drive the draw-works.

7. The one way clutch means will permit the operator to hoist the tool off the bottom without declutching the feeding mechanism. Ordinarily, he would stop the feed motor after he had hoisted the tool off bottom.

I do not claim, nor do I desire to provide, an automatic means of maintaining a constant pressure on the tool or torque on the Kelly, for the very simple reason that the same tool pressure and the same torque on the Kelly is not suitable for all formations, and formations change without notice. On the other hand, it is certain that there is a torque value for a given string that should not be exceeded irrespective of the formation, and a pressure on a given tool that should never be exceeded, and that they not be exceeded is the function of my device.

I claim as my invention:

1. In a well drilling apparatus having a drill string which supports a drill tool, a cable supporting said string, a drum upon which said cable is partially wound, means for feeding said drill string downwardly at a constant rate of speed, including a motor which is coupled to drive said drum through gearing means, said gearing means including a spring biased switch operating member which is differentially responsive to the torque of said motor and the suspended weight of said drill string, and an electrical switch for controlling operation of said motor and operated by said operating member so as to effect stopping of said motor upon occurrence of a decrease in the suspended weight of said drill string from a predetermined weight.

2. In a well drilling apparatus having a drill string which supports a drill tool, a cable supporting said string, a drum upon which said cable is partially wound, means for feeding said drill string downwardly at a constant rate of speed, including a motor which is coupled to drive said drum through gearing means, said gearing means including a spring biased switch operating worm gear adapted for reciprocating motion and which is differentially responsive to the torque of said motor and the suspended weight of said drill string, and an electrical switch for controlling operation of said motor and operated by said operating worm gear so as to effect stopping of said motor upon occurrence of a decrease in the suspended weight of said drill string from a predetermined weight.

3. In a well drilling apparatus having a drill string which supports a drill tool, a cable supporting said string, a drum upon which said cable is partially wound, means for feeding said drill string downwardly at a constant rate of speed, including a motor which is coupled to drive said drum through gearing means, said gearing means including a spring biased switch operating casing surrounding said gearing means which casing is adapted for slight oscillatory movement and which is differentially responsive to the torque of said motor and the suspended weight of said drill string, and an electrical switch for controlling operation of said motor and operated by said operating casing so as to effect stopping of said motor upon occurrence of a decrease in the suspended weight of said drill string from a predetermined weight.

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