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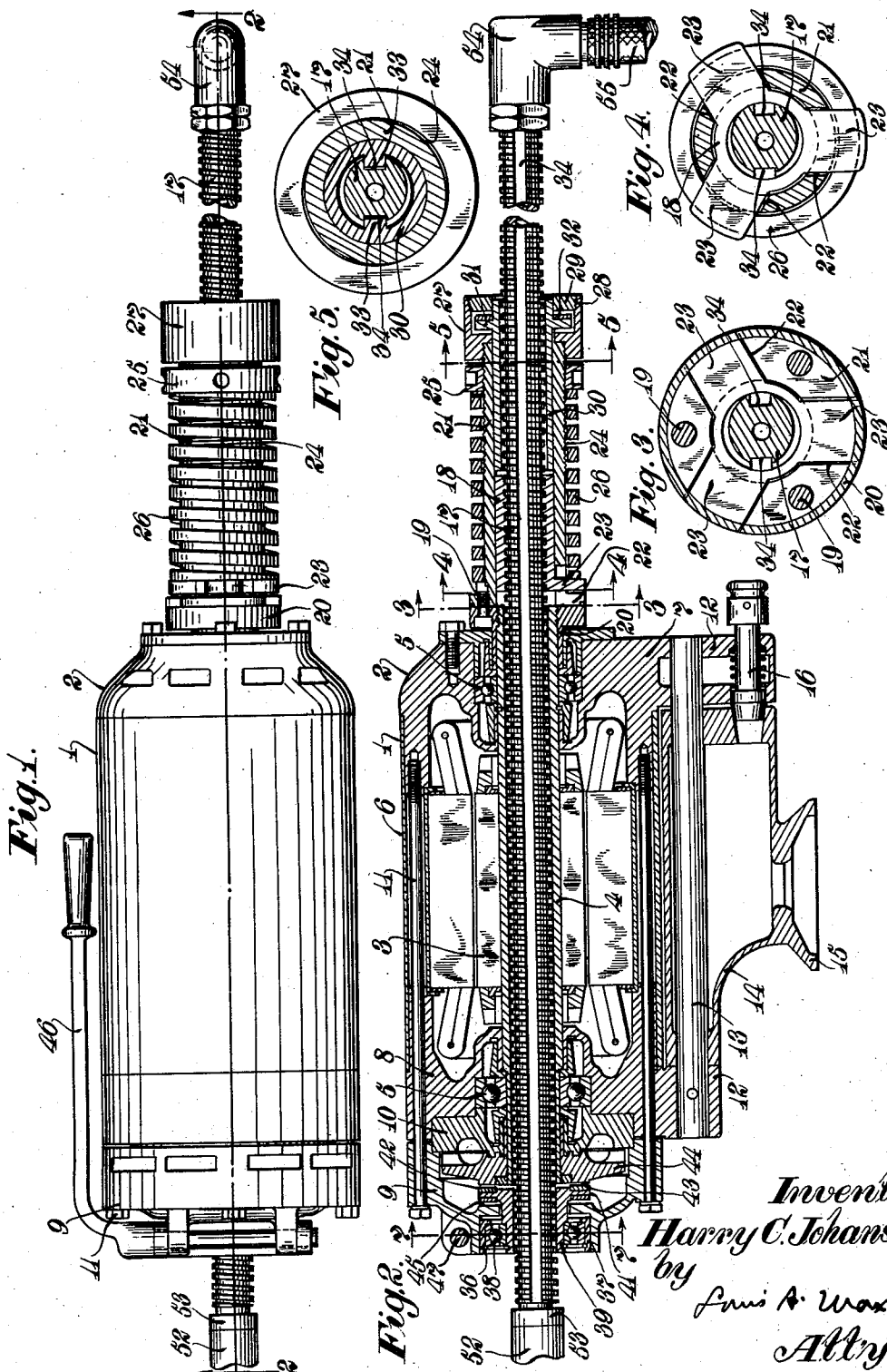
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DRILLING APPARATUS

Filed Aug. 2, 1940

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

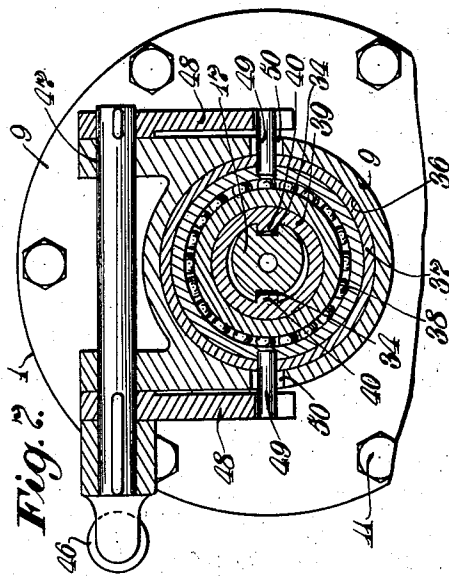


Fig. 6.

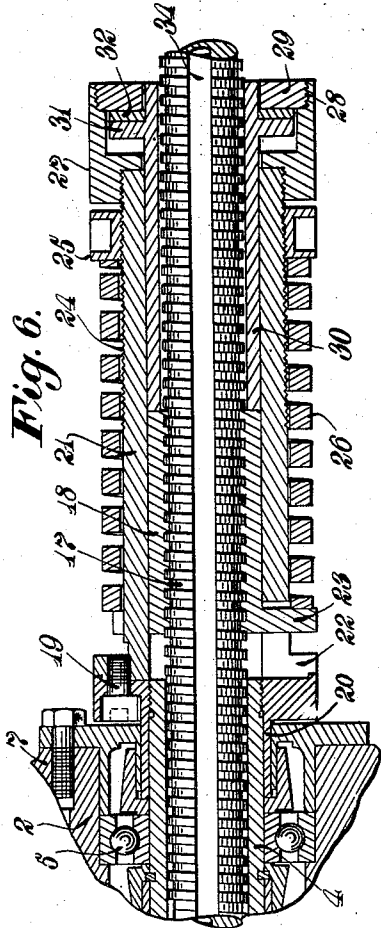
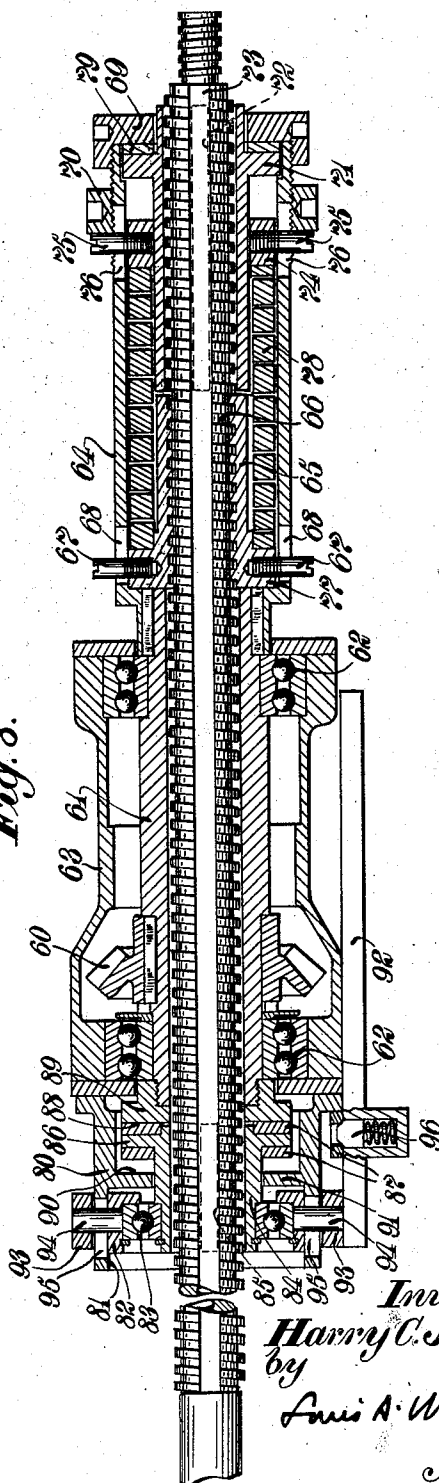


Fig. 8.



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DRILLING APPARATUS

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23 Claims. (Cl. 255—47)

This invention relates to drilling apparatus, and more particularly to improvements in a drilling apparatus of the high speed, rotary, diamond core type.

An object of the present invention is to provide an improved rotary drilling apparatus. Another object is to provide an improved drilling apparatus having an improved automatic feeding mechanism for the drill bit. A further object is to provide an improved drilling apparatus having an improved feeding mechanism whereby the feed is controlled automatically in accordance with the requirements of the work. Yet another object is to provide an improved feeding mechanism whereby the load changes on the drill bit automatically effect control of the feeding mechanism. A further object is to provide an improved feeding mechanism whereby the combined action of the resistance to penetration of the work by the drill bit and the resistance to rotation of the drill bit automatically effects control of the feeding pressure of the bit. Yet another object is to provide an improved automatic feeding mechanism wherein the feeding pressure builds up to a predetermined amount and then remains constant until feeding movement of the drill bit takes place, and wherein on feeding movement of the drill bit the feeding pressure varies between a predetermined minimum feeding pressure and the predetermined maximum pressure in accordance with the resistance to the angular and rectilinear movement of the bit. A still further object is to provide an improved automatic feeding mechanism of the screw and nut type whereby the drill bit is fed in an improved manner. A still further object is to provide an improved automatic feeding mechanism whereby variations in feeding pressure automatically effect control of the rate of feed. Another object is to provide an improved drilling mechanism in which the rotation of the bit is controlled automatically in accordance with the variations in feeding pressure. These and other objects and advantages of the invention will, however, hereinafter more fully appear.

In the accompanying drawings there are shown for purposes of illustration two forms which the invention may assume in practice.

In these drawings

Fig. 1 is a plan view of a drilling apparatus within which an illustrative form of the invention is embodied.

Fig. 2 is a view in longitudinal vertical section taken substantially on line 2—2 of Fig. 1.

Fig. 3 is a cross sectional view taken on line 3—3 of Fig. 2.

Fig. 4 is a cross sectional view taken on line 4—4 of Fig. 2.

Fig. 5 is a cross sectional view taken on line 5—5 of Fig. 2.

Fig. 6 is an enlarged sectional view taken in the plane of Fig. 2, showing parts in a different position.

Fig. 7 is a cross sectional view taken on line 7—7 of Fig. 2.

Fig. 8 is a view in longitudinal vertical section, similar to Fig. 2, illustrating a modified form of the invention.

In the illustrative embodiment of the invention shown in Figs. 1 to 7, inclusive, the invention is embodied in a rotary drilling apparatus of the high speed type especially designed for use in drilling hard rock or similar materials, and is preferably of the type known as a diamond core drill. Various features of the invention may, however, be embodied in drilling apparatus of various other types.

The drilling apparatus comprises a reversible rotary motor 1, herein preferably of the high speed electric type, although motors of other types obviously may be employed if desired. The motor has a casing 2 and a rotor 3, the latter fixed to a tubular shaft 4 journaled in ball bearings 5, 5 suitably supported within the motor casing. The motor casing consists of an outer cylindrical shell 6, a rear head 7, a front head 8, a front cap 9 and an inner head plate 10 interposed and clamped between the front cap and front head, and the motor casing elements are held in assembled relation by tie bolts 11. The motor casing has depending lugs 12, 12 provided with aligned bores within which is fixed a pivot pin 13, the latter being pivotally mounted in a bore in a trunnion support 14 provided with a swivel plate 15. The motor casing may be swung laterally about the pivot pin relative to the trunnion support for a purpose to be later explained, and a releasable plunger lock 16 is provided for holding the parts in the position shown.

Now referring to the improved means for rotating and feeding the drill bit, it will be noted that extending centrally through the tubular motor shaft 4 is a rotatable feed screw 17 having its threads engaging the threads of a rotatable feed nut 18. Secured by screws 19 to a flanged sleeve 20 in turn threadably secured to the rear end of the motor shaft 4 is a tubular member or sleeve 21, and this sleeve 21 has three mutually spaced longitudinal slots 22. Projecting lat-

erally through the sleeve slots are lug-like arms 23 integral with the feed nut 18 for holding the latter against rotation relative to the motor shaft but permitting limited longitudinal movement of the feed nut relative to the sleeve 21. The sleeve 21 is exteriorly threaded at 24, and engaging the threads is an adjustable annular nut or collar 25, while surrounding the sleeve 21 and interposed between the annular nut 25 and the feed nut arms 23 is a relatively heavy coil spring 26 which constantly urges the feed nut 18 toward its foremost position within the sleeve 21. By adjusting the nut 25 relative to the sleeve, the tension of the coil spring 26 may be varied as desired. Threaded on the rear end of the sleeve 21 is a cap 27 in turn having threaded therein at 28 an end plate 29. Arranged within the sleeve bore is a sleeve-like body 30 of a collar 31, and fixed to the latter is a friction clutch plate or washer 32. The collar body is splined to the feed screw 17 and has splines 33 engaging longitudinal splineways 34 on the screw.

When the parts are in the position shown in Fig. 6, the friction clutch plate 32 frictionally engages the front face of the end plate 29 so that the feed screw, feed nut, sleeve and collar rotate together as a unit. When the friction clutch plate 32 is released from the end plate and assumes the positions shown in Fig. 2, the feed nut 18 may rotate relative to the feed screw 17 to effect relative axial movement between the feed nut and the feed screw. The purposes of these functions will hereinafter be more fully described.

Arranged within the front cap 9 of the motor casing and slidably mounted in a bore 36 in the cap is a sleeve-like support 37 for a ball bearing 38 in which is journaled a sleeve 39 having splines 40 engaging the splineways 34 of the feed screw. The sleeve 39 has a collar 41 having secured thereto at its opposite faces friction plates or washers 42. The sleeve 39 is shiftable axially with the sliding support 37 to move the friction plates selectively into engagement with a friction surface 43 on a member 44 secured to the front end of the motor shaft 4 or with a friction surface 45 on the front cap 9 of the motor casing. It will thus be seen that the sleeve 39 may be engaged with the element 44 for rotation therewith or held stationary with the motor casing, and by properly adjusting the pressure on the friction plate the sleeve 39 may be rotated at variable speeds. The means for shifting the sleeve 39 comprises a lever 46 pivotally mounted at 47 on the front cap 9 of the motor casing and having shipper arms 48 engaging pins 49 secured to the sliding support 37. The pins 49 project laterally through longitudinal slots 50 in the front cap 9, as shown in Fig. 7.

A conventional drill rod 52 is coupled at 53 to the front end of the feed screw 17, and the drill rod has coupled to its outer end a usual drill bit, which is herein preferably an abrasive bit known as a diamond bit. Cleansing water may be supplied to the drill bit through the drill rod and feed screw which are herein hollow, and the rear end of the feed screw carries a conventional detachable water swivel 54 through which water may be supplied to the feed screw from a supply hose 55.

In Fig. 8 a modified embodiment of the invention is shown. In this modified construction, which is essentially the same as that above described, the reversible driving motor (not shown)

is located out of alignment with the feed screw, and the motor power shaft drives through a bevel pinion a bevel gear 60 keyed to a tubular drive shaft 61 which corresponds to the motor power shaft of the embodiment of the invention above described. The drive shaft 61 is suitably journaled in ball bearings 62, 62 suitably supported within a casing 63. Keyed to the rear end of the shaft 61 is a sleeve 64 having arranged therein a feed nut 65 engaging a feed screw 66, the latter extending centrally within the shaft 61. The feed nut is movable axially within the sleeve and has pins 67 projecting radially through longitudinal slots 68 in the sleeve so that while the sleeve and nut always rotate together such relative axial movement is permitted. Threadedly secured to the rear end of the sleeve 64 is an end plate 69, while threaded on the sleeve and surrounding the latter is an adjustable nut or collar 70. A collar 71 is arranged within the sleeve 64 and has splines 72 engaging splineways 73 on the feed screw. Surrounding the sleeve-like body of the collar 71, but relatively rotatable with respect to the latter, is an annular member 74 carrying pins 75 projecting radially through longitudinal slots 76 in the sleeve 64 and engaging the front face of the nut 70 in the manner shown. Interposed between the annular member 74 and a collar 77 integral with the feed nut 65 is a relatively heavy coil spring 78 which urges the feed nut into abutting engagement with the rear end of the shaft 61. By adjusting the nut 70, the tension of the coil spring may be varied as desired. The collar 71 has secured thereto a friction clutch plate or washer 79 engageable with the front face of the end plate 69. When the feed nut is moved rearwardly against the tension of the spring, it abuts the front end of the sleeve-like body of the collar 71, thereby moving the friction clutch plate 79 into frictional engagement with the end plate 69 and at that time the feed nut, sleeve, collar 71 and feed screw rotate together as a unit. When the friction plate is released from frictional contact with the end plate, the feed nut may be rotated relative to the feed screw, thereby to effect relative axial movement between the feed nut and feed screw. A front head 80 secured to the casing 63 has a bore 81 in which is slidably mounted a support 82 for a ball bearing 83. Journaled within this ball bearing is a sleeve 84 having splines 85 engaging the splineways 73 on the feed screw, and this sleeve has an integral collar 86. Secured to the opposite faces of the collar 86 are friction plates or washers 87 which are selectively engageable with a friction surface 88 formed on a member 89 secured to the front end of the shaft 61 or with a friction surface 90 formed on a flange 91 integral with the front head 80. The means for shifting the sleeve 82 comprises a lever 92 pivotally mounted on the casing head and having shipper arms 93 engaging pins 94 projecting through longitudinal slots 95 in the casing head and secured to the sleeve 82. A spring-pressed plunger lock 96 is provided for holding the lever 92 in its different operating positions. As in the form of the invention above described, a conventional drill rod is coupled to the forward end of the feed screw, and this drill rod carries a conventional drill bit. Attached to the rear end of the feed screw is a conventional water swivel, not shown.

The mode of operation of the improved drilling apparatus is as follows: Prior to the drilling operation the apparatus is set up adjacent the working face with the swivel plate 15 of the trun-

nion support 14 clamped in the saddle mounting of a conventional drill support. The drilling motor is then started to drive positively the feed nut 18 which is in threaded engagement with the feed screw 17 and, as there is little resistance to rotation of the feed screw, the latter may rotate with the feed nut. If the feed screw and nut turn equiangularly there is no feeding movement imparted to the drill bit, but if the rotation of the feed screw is resisted so that its rate of rotation is less than that of the feed nut, then the feed screw will be moved axially relative to the feed nut to feed the drill bit toward the work, or the feed nut will move axially relative to the feed screw and compress the spring 26, or axial movement of the feed screw and the feed nut may take place at the same time in opposite directions. In order to bring the drill bit promptly into engagement with the work, the clutch lever 46 may be manipulated to shift the sleeve 39 forwardly in the casing cap bore 36 and bring the front friction plate 42 into frictional contact with the stationary surface 45 on the casing cap. As a result, rotation of the feed screw 17 will be braked due to its splined connection with the sleeve 39. The feed nut 18 will accordingly rotate relative to the feed screw 17 and, since axial movement of the nut is opposed by the spring 26 and there is substantially no opposition to axial movement of the feed screw, the feed screw will be fed forwardly to effect feed of the drill bit toward the work. When the drill bit engages the work and its rotation is adequately resisted thereby, the operator may release the sleeve 39, and, due to the resistance to feed screw rotation afforded by the work, the feed nut will continue to rotate relative to the feed screw in a direction to effect either a forward feed or an axial movement of the feed nut to compress the spring 26. If the drill is unable to cut its way into the work at a rate equal to the feeding tendency of the screw from the relative rotation between the screw and nut, then the feed nut will move rearwardly along the feed screw and compress the spring 26. After the feed nut moves rearwardly a substantial distance it engages the end of the sleeve-like body 30 of the collar 31 and moves the latter rearwardly to bring the friction plate 32 into frictional engagement with the end plate 29. The feed nut will then be held against further movement to the rear and the feed screw and nut will be locked against relative rotation in a direction to effect increase in the distance between the feed nut and drill bit. Frictional engagement of the plate 32 with the end plate, if the pressure is great enough, causes the collar 31 to rotate at the same rate with the sleeve 21 which drives the feed nut, and, since the collar 31 is splined to the feed screw, the feed screw will be driven through the collar 31 at the same rate as the feed nut. As the drill bit cuts clearance for itself, the spring 26 tends to move the feed nut forwardly, causing the friction plate to tend to be released from frictional contact with the end plate 29. Since the entire forward feeding force is provided by the spring 26 and the resistance to rotation will be only slightly reduced by the cutting of an amount of clearance sufficient to allow slippage between the plate 32 and the end plate 29, there will be, almost as soon as relative slippage between these plates commences, a movement of the feed nut back along the feed screw to reestablish contact under pressure between the plates 32 and 29. Indeed, it is likely

that there may result a nearly continuous cutting of a slight clearance and a nearly continuous rearward movement of the nut so that the feed and drive will be not visibly intermittent. Of course, if the resistance to rotation of the bit were sufficiently reduced, the feed screw might be driven through the feed nut alone without any relative rotation, and if the bit continued to cut a clearance for itself, while resistance to rotation remained reduced, the spring 26 might expand to feed the screw and the drill bit toward the work until a condition requiring normal engagement of forward plate 42 and surface 45 recurred. This would, however, be very unlikely in ordinary circumstances. The operator, by moving the sleeve 39 rearwardly, may bring the rear friction plate 42 into engagement with the surface 43 on the element 44 which rotates with the motor shaft so that the feed screw and nut will be caused to rotate together, and at that time no feed takes place. Thus the feed is always under the operator's control, though feed will not be interrupted until the spring 26 re-expands. It is also to be noted that should there be, for any reason, insufficient resistance to bit rotation, to cause the nut to move back along the screw, resistance can be increased by pressing forward plate 42 against surface 45. To effect feed of the drill bit in the reverse direction, it is only necessary to reverse the drilling motor and retard the rotation of the feed screw.

By releasing the plunger lock 16, the drilling motor may be swung laterally relative to the trunnion support about the pivot pin axis, thereby to move the drill to one side of the drill hole to facilitate changing of drill rods. Prior to the lateral swinging of the drilling motor, the coupling 53 for connecting the drill rod to the feed screw is, of course, disconnected.

The embodiment of the invention disclosed in Fig. 8 operates in substantially the same manner as that above described. In this construction, when the resistance to rotation and penetration of the drill bit are of sufficient magnitude, the feed nut 65 moves rearwardly into end abutting engagement with the sleeve-like body of the collar 71, thereby moving the friction plate 79 into frictional engagement with the end plate 69, so that at that time the sleeve 64, collar 71, feed nut 65 and feed screw 66 rotate together as a unit. When the drill bit cuts a clearance and the spring 78 begins to expand, the spring 78 moves the feed nut forwardly, thereby relieving the frictional contact of the friction plate 79 with the end plate 69 so that the feed nut 65 can again rotate relative to the feed screw to effect an increase in feeding pressure. Also, as in the embodiment of the invention above described, rotation of the splined sleeve 84 may be controlled by the lever 92 so that the operator may effect resistance to rotation of the feed screw, or may effect feed screw rotation with the drive shaft 61. The feed is reversed by reversing the motor.

As a result of this invention it will be noted that an improved drilling apparatus is provided having improved feeding mechanism for the drill bit. It will further be evident that by the provision of the automatic clutch for controlling rotation of the feed nut relative to the feed screw, the feeding of the drill bit is controlled automatically by the combination of the resistance to rotation of the bit and the resistance to penetration of the work by the bit. It will still further be evident that by the provision of the improved

automatic feeding means the feeding pressure on the drill bit increases until it reaches a certain predetermined amount and then the feeding pressure is decreased again only on penetration of the work by the bit. Other uses and advantages of the improved drilling apparatus will be clearly apparent to those skilled in the art.

While there are in this application specifically described two forms which the invention may assume in practice, it will be understood that these forms of the same are shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. A drilling apparatus comprising, in combination, a drill bit, means for rotating said bit, means for feeding said bit toward the work to effect drilling, and means for automatically controlling feed and bit rotation in accordance with the resistance to drilling including a feed and rotation controlling clutch automatically operative through the increased loading thereof when the feeding pressure on said bit reaches a predetermined maximum for preventing further increase in feeding pressure and to effect bit rotation and automatic means for loading said clutch effective to load the same only when the feeding pressure attains a predetermined value.

2. A drilling apparatus comprising, in combination, a drill bit, means for rotating said bit, means for feeding said bit toward the work to effect drilling including relatively rotatable feeding elements, and means for controlling feed and bit rotation including means automatically operative when the feeding pressure on said bit reaches a predetermined maximum for preventing further increase in feeding pressure and for effecting bit rotation at maximum rate, and for effecting bit rotation at a lower rate upon a reduction in feeding pressure below said predetermined maximum.

3. A drilling apparatus comprising, in combination, a drill bit, relatively rotatable, mechanically interengaged elements relative rotation between which effects longitudinal bit movement and rotation of one of which effects bit rotation, and means for driving said elements to effect rotation thereof including means for driving the one of the same which effects bit rotation under the control of the other and controlling means for said last mentioned driving means including means controlled automatically in accordance with the varying resistance to rotation of and penetration by the drill bit and operative to speed up said bit rotating element when such resistance increases for automatically controlling the relative rotation of said elements.

4. A drilling apparatus comprising, in combination, a drill bit, relatively rotatable, mechanically interengaged elements relative rotation between which effects longitudinal bit movement and rotation of one of which effects bit rotation, driving means for said elements including means for driving the other of said elements continuously, and means controlled automatically in accordance with the varying resistances to rotation of and penetration by the drill bit for automatically controlling said driving means to control the relative rotation between said elements, said automatically controlled driving means including means for connecting said elements together for concurrent rotation at the same angular rate

when the resistance to penetration reaches a predetermined maximum.

5. A drilling apparatus comprising, in combination, a drill bit, relatively rotatable, mechanically interengaged feeding elements relative rotation between which effects longitudinal bit movement and rotation of one of which effects bit rotation, driving means for said elements including means controlled automatically in accordance with the varying resistances to rotation of and penetration by the drill bit for automatically controlling the relative rotation of said elements, and manual means associated with one of said feeding elements wholly independently of said automatic controlling means for manually controlling the relative rotation of said elements.

6. A drilling apparatus comprising, in combination, a drill bit, and rotating and feeding means therefor including relatively rotatable feed screw and nut elements and means for driving said elements including means for connecting the same for rotation at equiangular rates, said driving means including a common driving element continuously connected to one of said elements and connectible independently of its connection with said one element with the other, and said driving means further having controlling means controlled automatically in accordance with the varying resistances to rotation of and penetration by said bit for automatically controlling the relative rotation of said screw and nut elements.

7. A drilling apparatus comprising, in combination, a drill bit, means for feeding said bit toward the work to effect drilling including relatively rotatable feeding elements and driving means for one of said elements, a bit rotating element cooperating with one of said relatively rotatable feeding elements, and means controlled automatically in accordance with the variations in the resistances to rotation of and penetration by the bit for automatically effecting rotation of said bit rotating element at the angular speed of that one of said feeding elements with which said bit rotating element does not cooperate, when the resistance to rotation is at the maximum, and at lesser angular speed when the resistance to rotation is below such maximum.

8. A drilling apparatus comprising, in combination, a drill bit, means for rotating said bit and for feeding the same including relatively rotatable feeding elements and driving means for said elements including means for connecting them under predetermined conditions for rotation at equiangular rates, and means controlled automatically in accordance with the load changes on said bit for controlling feeding and embodying means for automatically controlling the relative rotation of said feeding elements providing for a range of relative rotations between zero and the full speed of one of said elements.

9. A drilling apparatus comprising, in combination, a drill bit, means for rotating said bit and for feeding the same including relatively rotatable feeding elements, driving means for said elements, the drive for one of said elements including a friction clutch for controlling the relative rotation of said elements and loadable to connect the same for equiangular rotation, and means controlled automatically in accordance with the load changes on said bit for controlling said feeding means and embodying means for

automatically controlling clutch loading to control the clutch loading pressure.

10. In combination, a feed screw, a feed nut threadedly connected with said feed screw, driving means for said nut providing for bodily movement thereof axially of said feed screw, driving means for said feed screw operatively connectable for drive by said driving means for said nut upon nut movement rearwardly along said screw, and means for exerting a predetermined pressure on said nut to resist rearward movement of the latter.

11. In combination, a feed screw, a feed nut threadedly connected with said feed screw and mounted for axial movement, means for yieldingly pressing said nut in a forward direction with respect to said feed screw, driving means for said nut, driving means for said screw including a clutch, and controlling means for said clutch governed by nut movement.

12. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit, feeding means for said drill bit for applying a feeding pressure to the drill bit, and means for controlling the operation of said feeding means and said rotating means, said feed and rotation controlling means including means operable automatically in accordance with variations in the resistance to drilling to preclude application of feeding pressures in excess of desired values to said drill bit and to control bit rotation by increasing the rate thereof automatically as resistance to drilling increases.

13. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit and for applying a feeding pressure to the drill bit, and means for controlling the operation of said rotating and feeding pressure applying means, said last mentioned means being adapted to operate automatically in accordance with variations in the resistance to drilling to preclude application of feeding pressures in excess of desired values to said drill bit and to control bit rotation, said means for rotating said drill bit and for applying a feeding pressure to it including relatively rotatable feeding elements and said controlling means including a clutch for controlling the relative rotation between said feeding elements and engageable to effect a connection between them for rotation at the same angular rates and for controlling bit rotation.

14. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit and for applying a feeding pressure to the drill bit, and means for controlling the operation of said rotating and feeding pressure applying means, said last mentioned means being adapted to operate automatically in accordance with variations in the resistance to drilling to preclude application of feeding pressures in excess of desired values to said drill bit and to control bit rotation, said means for rotating said drill bit and for applying a feeding pressure to it including relatively rotatable feeding elements and said controlling means including a clutch for controlling the relative rotation between said feeding elements, said clutch being operative to connect said feeding elements for concurrent rotation at the same angular rate when the feeding pressure on the drill bit reaches a predetermined amount.

15. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit at different rates, means for feeding said drill bit toward the work, and means asso-

ciated with said bit rotating and feeding means for automatically interrupting feed of the bit when the resistance to drilling reaches a predetermined amount and for automatically effecting bit rotation at maximum rate when said predetermined amount is reached.

16. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit, means for feeding said drill bit toward the work, and means associated with said bit rotating and feeding means for automatically interrupting feed of the bit when the resistance to drilling reaches a predetermined amount and for simultaneously increasing the rate of bit rotation when said predetermined amount is reached, said automatic means embodying means for interrupting bit rotation when the resistance to drilling drops below said predetermined amount and for again automatically effecting forward feed of the drill bit.

17. In a drilling apparatus, the combination comprising a drill bit, means for rotating said drill bit, means for feeding said drill bit toward the work, and means associated with said bit rotating and feeding means for automatically interrupting feed of the bit when the resistance to drilling reaches a predetermined amount and for automatically effecting bit rotation when said predetermined amount is reached, said automatic means embodying means for decreasing the rate of bit rotation when the resistance to drilling drops below said predetermined amount and for again automatically effecting forward feed of the drill bit, said feeding means including relatively rotatable feeding elements and said automatic means including a clutch for controlling the relative rotation of said feeding elements.

18. In a drilling apparatus, mechanically interengaged, relatively rotatable elements one of which is adapted to rotate a drill bit and to advance or retract the same, means for driving the other of said elements, and clutch means engageable by axial movement of said last mentioned element for connecting said elements together to interrupt feed when the resistance to drilling attains a predetermined value.

19. In a drilling apparatus, relatively rotatable feed screw and feed nut elements, means for positively rotating said feed nut element, said feed screw element adapted to support a drill bit, and means operative automatically upon the development of a predetermined resistance to rotation for driving said feed screw element at the same angular rate as the feed nut element to interrupt feed.

20. In a drilling apparatus, mechanically interengaged relatively rotatable feeding elements operative upon relative rotation to effect feed, one of said elements operative to support and rotate a boring implement, means for rotating the other of said elements, and means operative automatically when the feeding pressure on the boring implement reaches a predetermined amount for connecting said elements for rotation at equal angular rates.

21. In a drilling apparatus, relatively rotatable screw and nut elements, one constituting a rotating member for a drill bit, means for exerting a yielding pressure on the other of said elements in a feeding direction, means for rotating said last mentioned element providing for limited axial movement thereof, and means governed by the axial movement of said last

mentioned element for rotating the other of said elements.

22. In a drilling apparatus, relatively rotatable screw and nut elements one constituting a rotating member for a drill bit, a driving member with which the other of said elements is connected in slidable but non-rotatable relation, means yieldingly resisting the sliding of said last mentioned element in one direction, and means for connecting the other one of said elements with said driving member including a friction

clutch and means actuated by the sliding of said slidable element for loading said friction clutch.

23. In a drilling apparatus, a feed screw, an associated feed nut, means for continuously rotating said feed nut, means including a clutch for rotating said feed screw, and means automatically controlled by relative axial movement between the feed nut and the feed screw upon increased resistance to advance of the latter for loading said clutch to effect feed screw rotation.

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