July 12, 1938. L. W. ROGERS 2,123,344

MEANS FOR USE IN THE ROTARY DRILLING OF BORE HOLES

Filed March 18, 1937 2 Sheets-Sheet 1

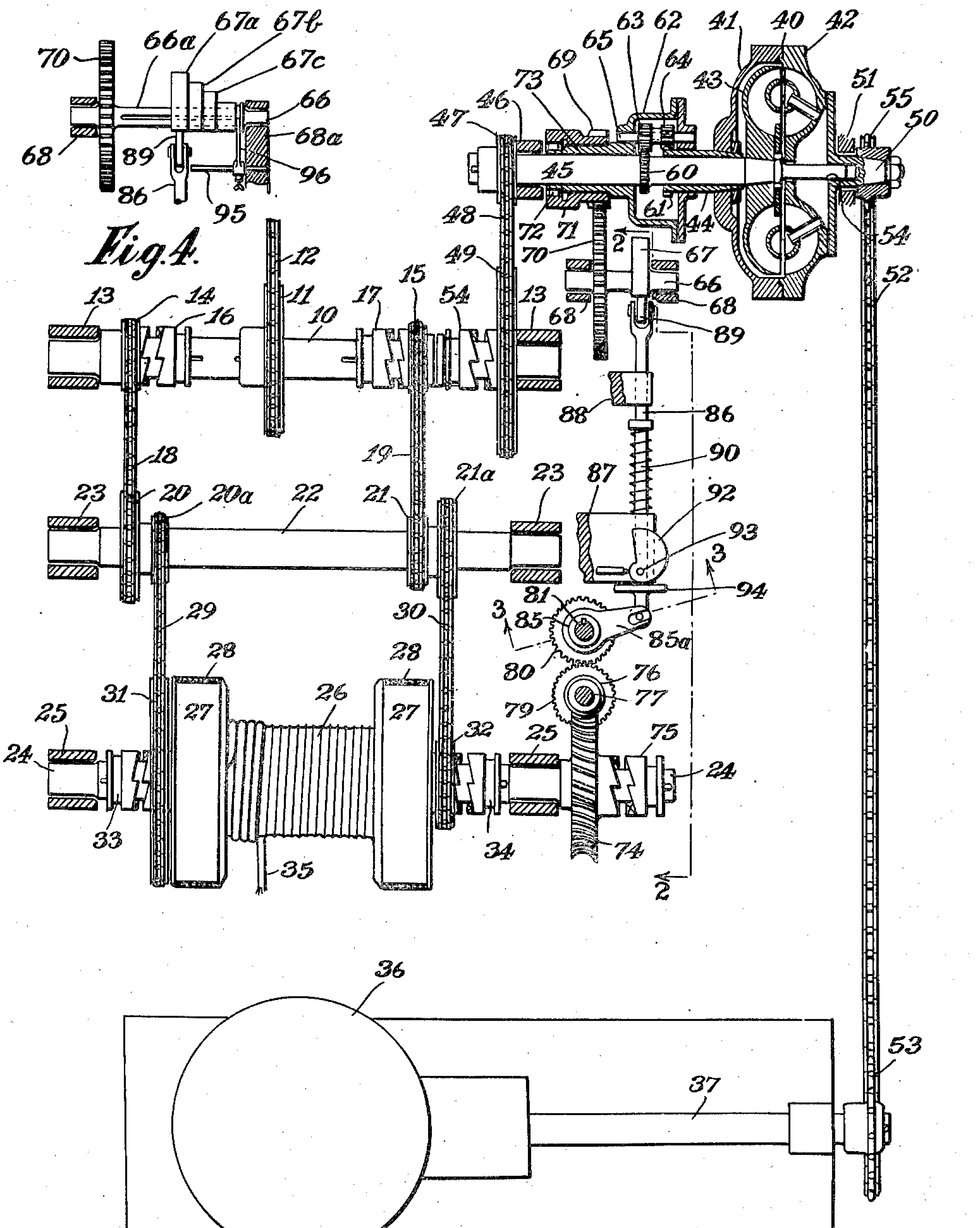

Fig.4.

Fig.1.

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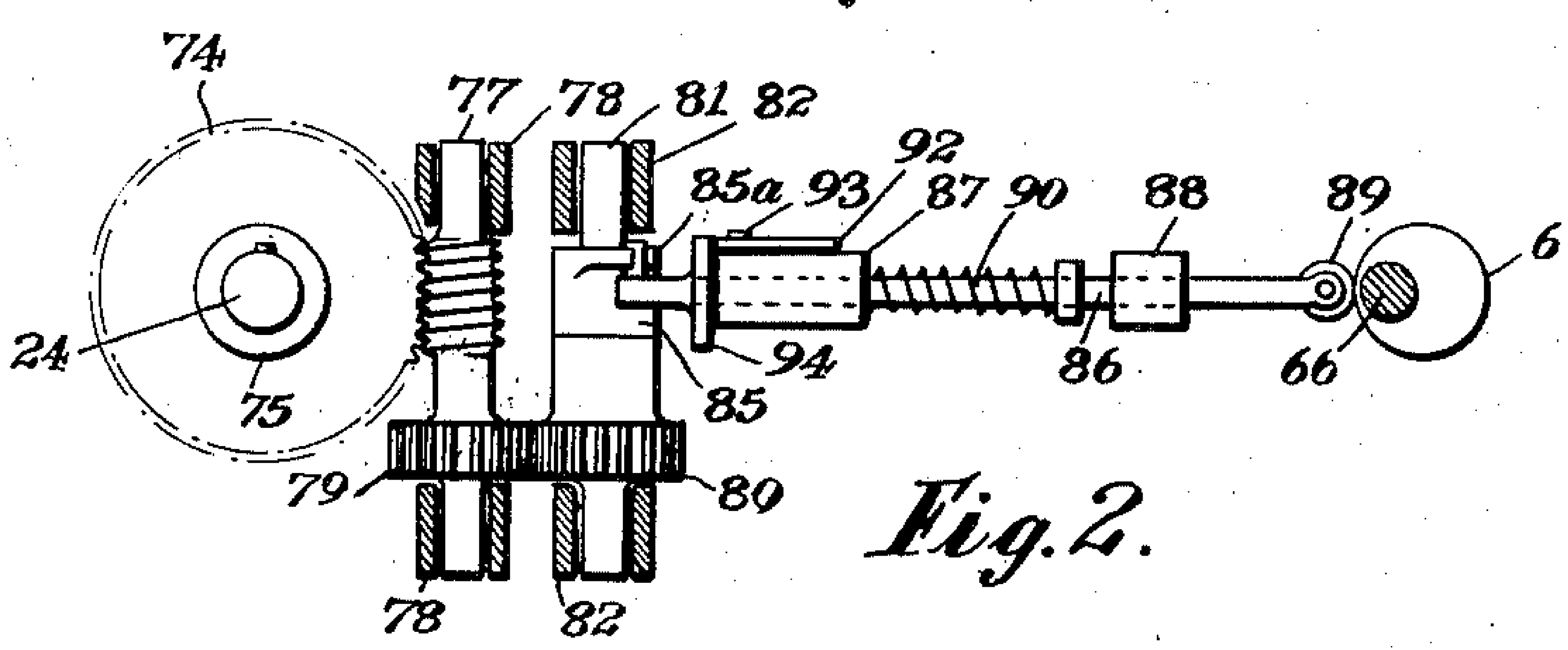


Fig. 2.

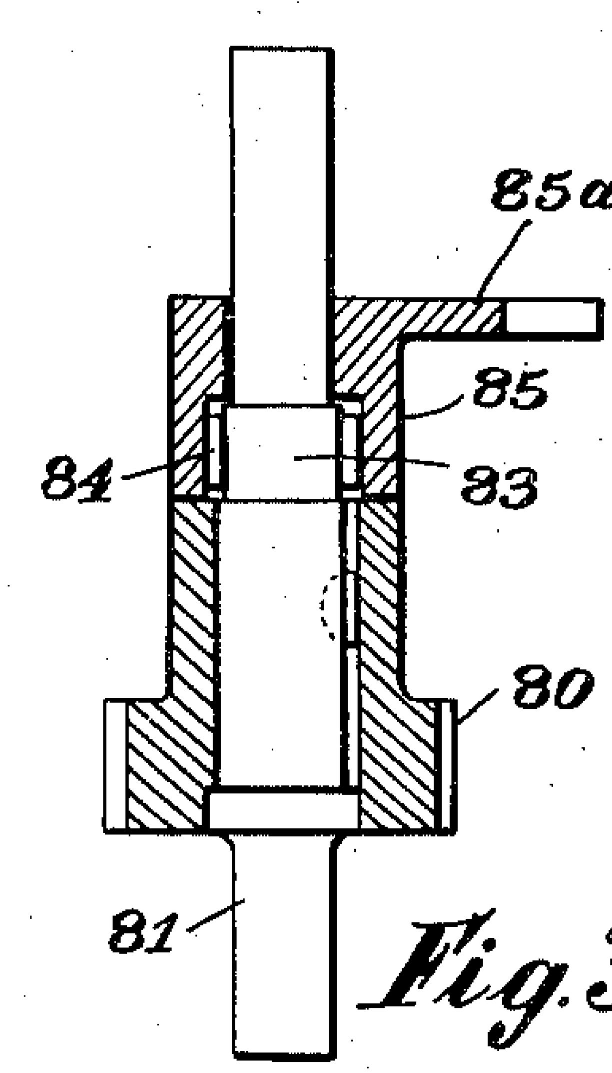


Fig. 3.

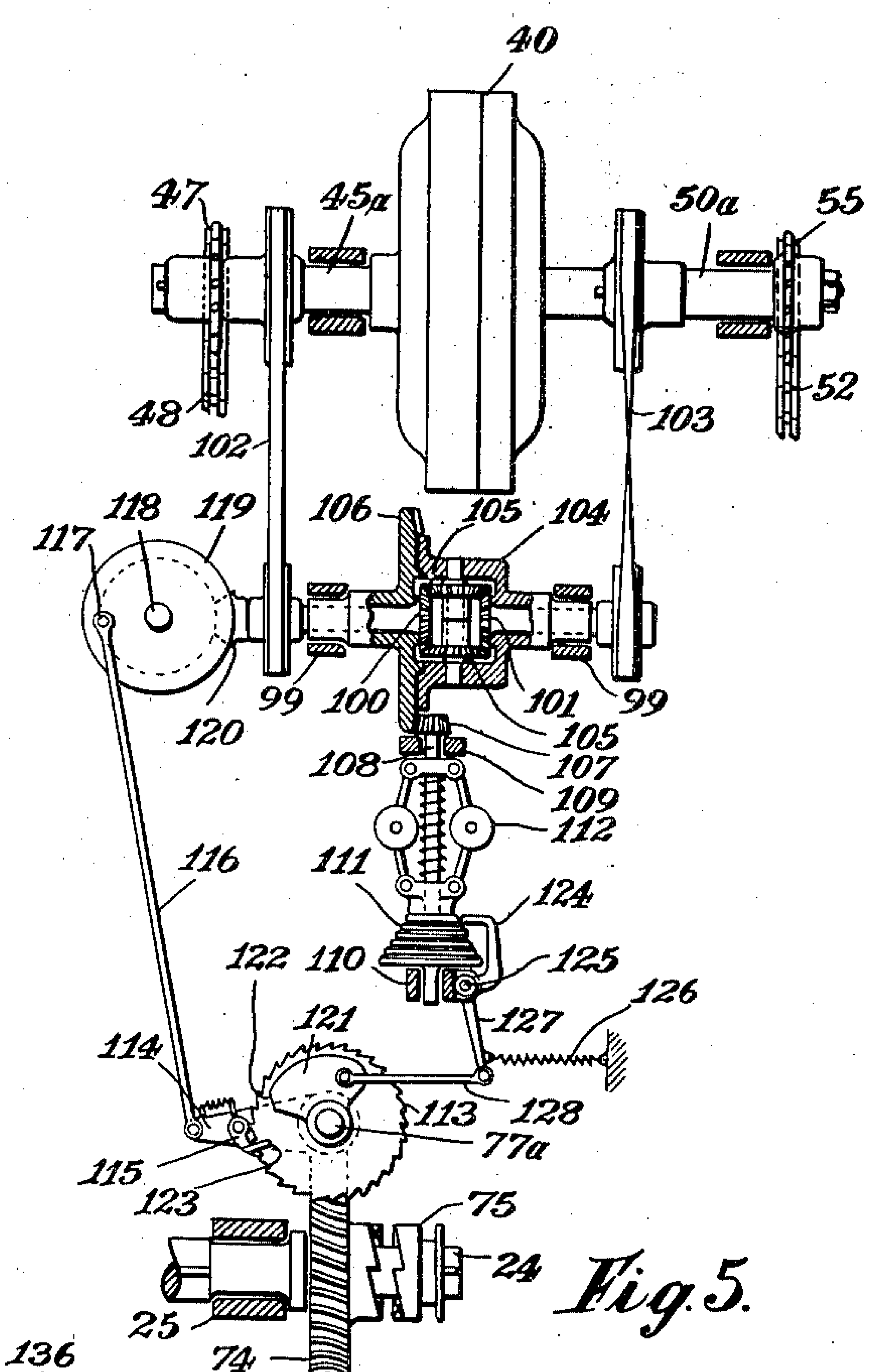
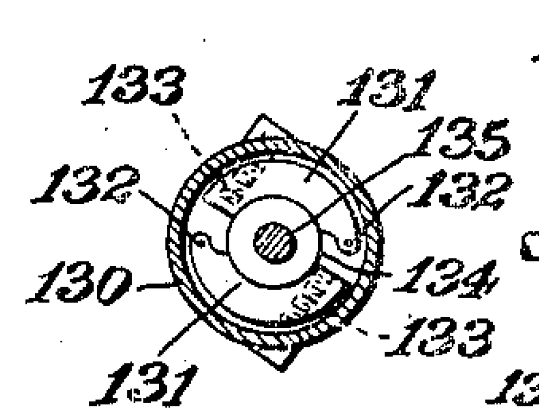


Fig. 5.



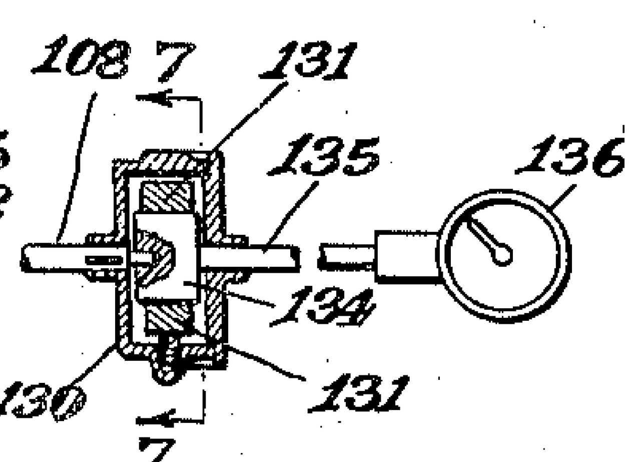


Fig. 7. Fig. 6.

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Patented July 12, 1938 2,123,344

UNITED STATES PATENT OFFICE

2,123,344

MEANS FOR USE IN THE ROTARY DRILLING OF BORE HOLES

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Application March 18, 1937, Serial No. 131,602
In Great Britain March 19, 1936

16 Claims. (Cl. 255—19)

This invention is concerned with the rotary drilling of bore holes and relates to power transmission systems for imparting rotary motion to the drilling bit or other boring tool, in which the vertical pressure operating on the tool is regulated in accordance with the resistance encountered by the tool.

In rotary drilling installations as at present generally employed, the tool is fixed to the lower end of a string of drill pipes. The upper end of this string is supported by a cable which is fixed to the drum of a winch. The pressure on the drilling tool is controlled by the winch which is raised or lowered under manual control for the purpose of varying the fraction of the total weight of the drill pipes which acts on the drilling tool. In the system there is incorporated a weight-indicator showing the tension in the cable, from which an indication of the pressure on the drill can be calculated.

In regulating the vertical advance of the string of drill pipes various factors have to be taken into account, such as the rotary speed of the table which imparts rotation to the string, the hardness of the stratum being penetrated, the depth and diameter of hole being drilled, the dimensions of the string of drill pipes, and the pressure on the drilling bit. This latter is derived from the reading on the weight-indicator during drilling, subtracted from the reading on the weight-indicator when the drilling tool is off the bottom of the bore hole.

It has been observed for some time past that this method of working leaves much to be desired, for the operator controlling the drilling process is dependent solely on the guidance afforded by the weight-indicator. The use of a weight-indicator is unsatisfactory in many respects, chiefly in that it is not capable of accurately indicating sufficiently small increases or decreases in weight. Even if it be supposed that by reference to the weight-indicator the weight on the bit be held constant at a value considered necessary, there is no means of knowing whether this weight, in conjunction with the speed of rotation and other conditions, is placing a safe or a dangerous torque on the drill pipes. A dangerously high torque may easily arise without any change of formation owing to such a condition as a caving formation, the accumulation of cuttings above the bit, or a crooked bore hole. Changes in formation will also give rise to unknown and varying drill-pipe torque. There is the further disadvantage that an error on the driller's part in allowing too much weight to bear upon the bit may at any time result in the immediate fracture or dangerous straining of the drill pipes.

It has been proposed to overcome this difficulty by providing a three-part differential mechanism connecting the driving engine, the rotary table and the winch drum, and so arranged that an increase of torque on the drilling bit causes the drum to exert an increasing force tending to raise the drill string. Such systems suffer from the disadvantage that they require frequent adjustment to compensate for the increasing weight of the drill string as the borehole becomes deeper and are therefore liable to failure if this adjustment is not correctly made.

It has also been proposed to couple the driving engine directly to the rotary table and to employ speed-responsive mechanism for regulating the rate of speed of the drill string in dependence on the speed of the driving engine. Such a system does not protect the drill string against sudden overloads, and cannot be used with a constant speed engine, such as a synchronous electric motor.

The present invention has for its object the provision of improved equipment whereby the aforementioned disadvantages may be obviated and the risk of damage and breakages in the drill string considerably reduced.

This invention includes the use of a hydraulic coupling of the kinetic type, and takes advantage of two characteristic features of such couplings, namely their ability to limit the torque that can be transmitted through them, and the variation in relative speed of their hydraulic elements that follows a variation in torque transmitted.

Accordingly a further object of the present invention is to provide improved drilling equipment in which the rotary movement is imparted to the tool through a hydraulic coupling of the kinetic type which serves to limit the torque that can be transmitted to the tool, the rate at which the tool is lowered being controlled in dependence on the relative speed of the impeller and runner of the hydraulic coupling, which varies with the torque transmitted to the tool.

According to the present invention, the improved apparatus comprises a driving member adapted to rotate continuously, and means for imparting rotary motion to a string of drill pipes, which means are connected to said driving member through a hydraulic coupling of the kinetic type which serves to limit the torque which can be transmitted to the drill pipes, said apparatus also comprising a feeding mechanism which can be engaged to feed said drill pipes at a rate which is independent of the gravitational load imposed by the drill pipes on the feeding mechanism, and a control device responsive to variations in the relative speed of the impeller and runner of said hydraulic coupling, due to variation in the torque on said drill pipes, and capable of regulating the feeding mechanism so as to reduce the rate of feed in consequence of an increase in said relative speed.

Thus the improved apparatus may comprise a mechanical differential gear having three elements movable relatively to one another, of which two are connected respectively to the impeller and runner elements of said hydraulic coupling, and the third of which serves to control said feeding means. The ratios of the elements of this differential gear may be such that as the slip in the hydraulic coupling increases from zero, the speed of the third element decreases until at a predetermined value of slip this speed becomes zero, a driving connection being provided between this third element and the feeding means. Alternatively, the third element of the differential gear may be arranged to drive a speed-responsive mechanism which controls the velocity ratio of a power transmission system connecting a continuously running driving member and said feeding means.

The arrangement in either case is preferably such that, when there is no slip in the hydraulic coupling, the feeding means are actuated at their maximum rate, and when the slip attains a particular value, between 5 and 20 per cent., the feed stops.

The feeding means preferably include a mechanical speed-reducing gearing, such for example as a worm gear, so arranged as to have sufficient frictional restraint as to be irreversible.

The invention will be further described by reference to the constructional examples shown in the accompanying diagrammatic drawings, in which

Fig. 1 is a plan view, part in section, of one form of the improved rotary drilling apparatus,

Fig. 2 is an elevation of a detail, taken on the line 2—2 in Fig. 1,

Fig. 3 is a sectional elevation, to a larger scale, of a detail, taken on the line 3—3 in Fig. 1,

Fig. 4 is a plan of an alternative form of a part of the apparatus shown in Fig. 1,

Fig. 5 is a plan view, part in section, of a portion of an alternative form of the improved rotary drilling apparatus,

Fig. 6 shows a speed indicator and a centrifugal clutch, in section, for driving the same, and

Fig. 7 is a section on the line 7—7 in Fig. 6.

The arrangement shown in Figs. 1 to 3 is an adaptation of a known design of draw works, which will be briefly described. A lay shaft 10, mounted in bearings 13, 13, is driven by an engine (not shown) through a chain 12 engaged with a sprocket 11, a friction clutch being interposed if the engine is of the internal-combustion type. Sprockets 14 and 15 are journalled on the shaft 10 and can be engaged alternatively therewith by slidable jaw-clutch members 16 and 17. The sprockets 14 and 15 are coupled respectively by chains 18 and 19 to sprockets 20 and 21 keyed to an intermediate shaft 22 mounted in bearings 23. A cable drum 26 is fixed to a drum shaft 24 supported in bearings 25. Journalled on the drum shaft 24 are two sprockets 31 and 32 coupled respectively by chains 29 and 30 to sprockets 20a and 21a fixed to the shaft 22. Slidable jaw clutch members 33 and 34 enable the sprockets 31 and 32 respectively to be alternatively coupled to the drum shaft 24. The drum carries a cable 35 which supports the drill string. By selecting alternative combinations of clutch positions, four hoisting speeds are obtained. Brakes 28 acting on drums 27 are employed to control the running out of the cable. The cable passes through a block and tackle supporting the drill string, to which rotary motion is imparted by a rotary table 36 driven by a shaft 37.

The adaptation, according to the present invention, involves the provision of a hydraulic coupling 40 in the power transmission system between the engine and the rotary table 36, the Föttinger type coupling here shown being of known kind with torque-limiting features whereby the maximum torque that it can transmit is limited to a value not greatly exceeding the normal working torque.

The coupling 40 is provided with a rotating casing 41 which is attached to the periphery of the runner 42 and shrouds the impeller 43, this casing being fixed to a sleeve 44 journalled on a driving shaft 45 to which the impeller is fixed The runner 42 is fixed to a driven shaft 50 supported in a bearing 51, and the driving shaft is supported in a bearing 46 and in a counterbore 54 in the driven shaft. A sprocket 47 keyed to the driving shaft can be coupled to the lay-shaft 10 through a chain 48, a sprocket 49 journalled on the shaft 10, and a slidable jaw clutch member 54 adapted to couple the sprocket 49 to the shaft 10. A sprocket 55 fixed to the driven shaft 50 is coupled by a chain 52 to a sprocket 53 fixed to the shaft 37 geared to the rotary table.

A differential gear system comprises a spur gear wheel 60 fixed to the driving shaft 45, a larger spur gear wheel 61 fixed to the sleeve 44, and a planet cage 62 journalled on the driving shaft and the sleeve, the planet cage carrying two planet wheels 63 and 64 fixed together co-axially and journalled on a pin 65 in the cage. The planet wheel 63 meshes with the gear wheel 60 on the driving shaft and the planet wheel 64 with the gear wheel 61 on the sleeve. With this arrangement, with zero slip in the coupling 40, the cage 62 will rotate in the direction of rotation of the driving shaft 45 at the same speed as this shaft. Since the gear wheel 61 is of larger diameter than the gear wheel 60, the cage 62 will slow down as the slip in the coupling increases, until at a certain value of the slip the cage will come to rest. When the slip exceeds this value the cage will rotate in the reverse direction. The mechanism for feeding the drill pipes is connected to the planet cage 62, as will be shortly described. If it is desired, for example, that the rate of feed of the drill pipes should be zero at 10 per cent. slip in the coupling, the gear wheels and planet wheels may have the following number of teeth; gear wheel 60, 36 teeth; gear wheel 61, 38 teeth; planet wheel 63, 19 teeth; planet wheel 64, 18 teeth.

The cage 62 is drivably connected to a shaft 66, carried in bearings 68, through a spur-wheel reduction gearing 69, 70 in series with which is a free wheel comprising wedging rollers 72 disposed between a hollow shaft 73 forming part of the cage 62 and a hollow boss 71 of the pinion 69, which is journalled on the shaft 73. This free wheel is arranged to transmit motion when the cage 62 rotates in the direction of rotation of the driving shaft 45, and to run free when the cage rotates in the reverse direction. A cam 67 is fixed to the shaft 66.

A worm wheel 74 journalled on the drum shaft 24 can be coupled to this shaft by a slidable jaw-clutch member 75. The worm wheel 74 engages with a worm 76. The pitch of the worm thread is such that the worm 76 cannot be driven by the worm wheel 74; that is to say the gear system is irreversible. The worm 76 is integral with a shaft 77 carried in bearings 78 (Fig. 2) and the shaft 77 is drivably connected, by spur gearing 79, 80, with a shaft 81 carried in bearings 82.

On the shaft 81 (Fig. 3) is formed the driven part 83 of a free wheel having wedging rollers 84. The driving part 85 of this free wheel includes an arm 85*a* by which it is rotated backwards and forwards by means of one end of a cam follower 86 which is slidably fitted in bearings 87 and 88. The other end of the cam-follower 86 is provided with a roller 89 constrained to bear on the cam 67 by a spring 90. As the cam follower 86 is moved by the cam 67 away from the cam shaft 66, the free wheel drives the worm gearing 74, 76 in such a direction that the worm wheel rotates in the same direction as the winch drum is rotated to lower the drill string. As the cam follower 86 approaches the cam shaft 66 under the action of the spring 90, the free wheel runs free.

This apparatus operates as follows. All clutches being disengaged except 54, which drives the hydraulic coupling, the rotating drill pipes are lowered under control of the brakes 28 until the bit is lightly engaged with the bottom of the bore hole. The clutch 75 is now engaged so as to couple the winch drum 26 to the worm wheel 74, and the brakes 28 are released. The torque imposed on the drum shaft 24 by the weight of the drill pipes is now absorbed by the irreversible worm gear. Each time the cam 67 revolves, the drill pipes are lowered by equal distances. The number of times per minute that the drill pipes are lowered by this distance is regulated by the speed of the cage 62 of the differential gear, and hence by the slip in the coupling 40 which in turn is determined by the resistance met by the drilling tool. When the torque load on the drill pipes is low, the slip in the coupling is correspondingly low, and the cage 62 rotates only slightly slower than the shaft 45. Hence the drill pipes are lowered at nearly the maximum rate of feed. If the torque load increases to such a value that the slip in the coupling is 10 per cent., the cage 62 comes to rest and the feed ceases. If the slip exceeds 10 per cent., the free wheel 71, 72, 73, overruns and the cam 67 remains stationary.

The distance that the drill pipes are lowered at a time may be regulated by an adjustable stop 92 pivoted at 93 to the bearing 87, this stop cooperating with a collar 94 on the cam follower 86 to limit the extent of its travel on its return stroke under the action of the spring 90. Thus to shorten this distance, the stop 92 is so positioned that the cam follower does not press against the cam during the whole period of rotation of the latter.

Fig. 4 shows an alternative arrangement of adjusting the amount of lowering of the drill pipes at a time. A series of cams 67*a*, 67*b*, 67*c* of progressively varying lift, and fixed together, are splined on to the cam shaft 66*a* and are arranged to be slidably movable in the axial direction of the cam shaft under the control of a yoke 96 adjustably mounted on a rod 95 fixed to the part 68*a*. The cams are so arranged that in one part of the whole assembly the surfaces lie on a line parallel to the axis of the cam shaft. By moving the assembly along the cam shaft, the stroke of the cam follower may be varied.

In the alternative design shown in Fig. 5, parts omitted from the drawings may be identical with the corresponding parts in Fig. 1. The input and the output shafts 45*a* and 50*a* of the hydraulic coupling 40 are drivably connected, for example by means of belts 102, 103, one of which is crossed, respectively to the two sun elements 100 and 101 of a bevel type differential gear mounted in bearings 99. The gear ratios between the shafts of the coupling and the sun elements of the differential gear are the same. The third element of the differential gear is constituted by a planet cage 104 having journalled within it planet pinions 105 each meshing with the two sun wheels. The cage 104 is fixed to a crown wheel 106 which meshes with a bevel pinion 107 fixed on a governor shaft 108 which is mounted in bearings 109 and 110. This shaft carries a spring-loaded ball governor 112, which moves a sleeve 111 along the governor shaft as the balls move under the action of centrifugal force. The differential gear is arranged so that the speed of the third element 104, compounded from the speeds of the first and second elements 100, 101 is zero when the first and second elements are rotating at the same speed in opposite directions.

On the worm shaft 77*a* is keyed a ratchet wheel 113. A crank arm 114 is journalled on the worm shaft 77*a* and carries a pawl 115 which can engage with the teeth of the ratchet wheel 113. The crank is moved backwards and forwards through an arc of a circle by means of a rod 116 connected to a second crank 117 fixed on a shaft 118 rotated preferably by the main prime mover or by an auxiliary motor. As shown the crank 117 comprises a crown wheel 119 meshing with a bevel pinion 120 fixed to the differential gear shaft that is rotated by the driving side of the hydraulic coupling. Also journalled on the worm shaft 77*a* and positioned adjacent to the ratchet wheel 113 is a sector 121 having a bevelled corner 122. On the pawl is fixed a trip projection 123, and the radius of the sector 121 is such that, when the arm 114 is moved alongside the sector 121, the trip projection 123 slides up the bevelled corner 122 of the sector and so disengages the pawl 115 from the teeth of the ratchet wheel 113. Thus the position of the sector controls the effective stroke of the ratchet crank 114 on the ratchet wheel.

The movement of the sector is controlled by the governor 112. To this end the sliding sleeve 111 on the governor shaft is formed as a stepped truncated cone or equivalent step-motion device. An arm 124 of a lever pivoted at 125 to the part 110 is pressed against the cone 111 by means of a spring 126 acting on the other arm 127 of this lever, which is connected by a link 128 to the sector 121. When the slip in the coupling 40 is zero, the parts are in the configuration shown, the sector 121 being then in such a position that the pawl 115 engages with the ratchet wheel 113 at the beginning of the working stroke of the ratchet crank 114. When the slip in the hydraulic coupling is the maximum desirable, say 10 per cent., for any feeding motion to be permitted, the governor balls are apart, and the cone moves the lever 124, 127 so that the sector 121 is in a position whereby the pawl 115 engages with the ratchet wheel 113 only at the end point in the stroke of the ratchet crank; and in consequence the drill pipes are lowered at the lowest rate. At a slightly higher slip the feed is stopped entirely. The steps on the truncated cone are so arranged that as the arm 124 moves from one step to the next, the sector moves to cause the pawl to engage with one less or one more tooth on the ratchet wheel.

The ratios of the differential gear and its drive mechanism may be such that the rate of feed is maintained at the maximum value until the slip of the hydraulic coupling reaches a certain value, for example 3 per cent.

The governor shaft 108 may be arranged to drive a speed-indicator 136 (Fig. 6) for giving a visual indication of the slip, and the drive to the speed-indicator may include a centrifugal clutch arranged to interrupt the transmission to the speed-indicator at, say, 50 per cent. overspeed, i. e. 15 per cent. slip in the hydraulic coupling, to guard the speed-indicator from damage due to excessive speed. The clutch shown in Figs. 6 and 7 includes a drum 130 fixed to the governor shaft 108 and having two arcuate masses 131 pivoted therein on pins 132. Springs 133 urge these masses radially inwards into contact with a driven element 134 journalled in the drum and fixed to the speedometer drive shaft 135. At normal speeds the friction between the parts 131 and 134 constrains the shafts 108 and 135 to rotate in unison. At excessive speeds the masses 131 overcome the force of the springs and disengage from the element 134.

In place of the irreversible worm gear which controls the unwinding of the winch, any other gear train may be used which is so arranged that the primary element thereof is not driven by the gravity load imposed by the drill pipes. For example a normal spur gear train may be employed, a brake being provided capable of exerting sufficient braking power to prevent the feeding system from being driven by the load, but capable of allowing the system to be driven by the free wheel or the ratchet mechanism. Thus the brake may operate on the shaft on which the ratchet wheel is keyed.

I claim:

1. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling being of the kinetic type in which the slip between said elements increases with increase of torque transmitted therethrough and thus serving to limit the torque that can be applied to the drill pipes, a feeding mechanism which can be engaged to feed said drill pipes at a rate which is independent of the gravitational load imposed by said drill pipes on said feeding mechanism, and a control device, responsive to variations in the relative speed of said coupling elements, and capable of regulating said feeding mechanism so as to reduce the rate of feed of the drill pipes in consequence of an increase in said relative speed.

2. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving automatically to reduce the speed of rotation of said drill pipes in consequence of increase in torque applied thereto, and means for feeding said drill pipes including a variable gearing for varying the rate of feed of said drill pipes and operatively associated with said hydraulic coupling elements so as to reduce the rate of feed of said drill pipes automatically in consequence of an increase in torque on said drill pipes.

3. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, and means for feeding said drill pipes including a cable drum, a driving member, a variable-speed gear mechanism connected between said cable drum and said driving member, and an element controlling the ratio of said variable-speed gear mechanism and operatively connected with said hydraulic coupling elements in such manner that an increase in the relative speed of said coupling elements causes a decrease in the speed of said cable drum.

4. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element coupled to said driving member and a runner element drivably connected to said means for rotating the drill pipes, a winch for feeding said drill pipes, gearing for unwinding said winch, and means functioning in response to variations in slip between said impeller and runner elements for actuating said gearing at a rate which is a maximum when said slip is substantially zero, and which falls progressively to zero as said slip rises to a predetermined value between 5 and 20 per cent.

5. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member, and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a mechanical differential gear having three co-operating elements movable relatively to one another, two of said elements being connected respectively to said impeller and runner elements, and means for feeding said drill pipes including a control device operatively connected with the third element of said differential gear for reducing the rate of feed automatically in response to increase of slip between said impeller and runner elements.

6. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill

pipes, a mechanical differential gear having three co-operating elements movable relatively to one another, two of said elements being connected respectively to said impeller and runner elements, and the ratios of said gearing being such that the speed of its third element decreases as the relative speed of its first and second elements in one sense increases, and means, drivably connected with said third element, for feeding said drill pipes.

7. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a mechanical differential gear having three co-operating elements movable relatively to one another, two of said elements being connected respectively to said impeller and runner elements, means for feeding said drill pipes, associated with a variable-rate driving mechanism having a control member, and a speed-responsive device drivably coupled to the third element of said differential gear and serving to actuate said control member for reducing the rate of feed with increase in slip between said impeller and runner elements.

8. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling being capable of slipping to an increasing extent as the torque applied to said drill pipes rises, a winch for lowering said drill pipes including mechanical speed-reducing gearing having sufficient frictional restraint as to be irreversible, and means responsive to variation in slip in said hydraulic coupling for driving the higher-speed end of said speed-reducing gearing at a rate varying with the torque imposed on the drill pipes.

9. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a winch for lowering said drill pipes including an irreversible gearing, variable-rate gear mechanism having a control member and connecting said irreversible gearing to said driving member, and means associated with said hydraulic coupling for actuating said control member to reduce the rate of descent of the drill pipes in response to increase in relative speed of said impeller and runner elements.

10. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a winch for lowering said drill pipes including an irreversible gearing, and a mechanical differential gearing having three co-operating elements rotatable relatively to one another and drivably connected respectively with said impeller and runner elements and said irreversible gearing, the ratios of said differential gearing being such that, when the relative speed of said impeller and runner members is the minimum, the lowering speed of said winch is the maximum, and when said relative speed increases to a predetermined value substantially lower than the absolute speed of said impeller, said winch stops.

11. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a winch for lowering said drill pipes including an irreversible gearing, a mechanical differential gearing having three co-operating elements rotatable relatively to one another, two of which are drivably connected respectively with said impeller and runner elements, the ratios of said gearing being such that the speed of its third element decreases as the slip between said impeller and runner elements increases, an oscillating member actuated by said third element, and a unidirectional driving device connecting said oscillating member with said irreversible gearing.

12. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element connected to said driving member and a runner element connected to said means for rotating the drill pipes, said coupling serving to limit the torque that can be applied to the drill pipes, a winch for lowering said drill pipes including an irreversible gearing, a member adapted to oscillate continuously, a unidirectional coupling having a driven element connected to said irreversible gearing and a driving element connected to said oscillating member by means including a control member operable for varying the stroke of said driving element, and a device responsive to the relative speed of said impeller and runner elements and operatively connected with said control member for reducing the speed of said winch as a result of increase in said relative speed.

13. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic slip coupling of the kinetic type having an impeller element coupled to said driving member and a runner element drivably connected to said means for rotating the drill pipes, a mechanical differential gear having three co-operating elements rotatable relatively to one another, two of which are drivably connected respectively with said impeller and runner elements, the ratios of said gearing being such that the speed of the third of said differential gear elements is substantially zero when the slip between said impeller and runner elements is zero, a speed-indicator, and a clutch connecting said third ele-

ment to said speed-indicator and arranged to disengage automatically when the speed of said third element exceeds a predetermined value.

14. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element coupled to said driving member and a runner element drivably connected to said means for rotating the drill pipes, a winch for feeding said drill pipes, irreversible gearing for unwinding said winch, a unidirectional coupling connected with said irreversible gearing and having a driving member, and means for oscillating said driving member at a frequency varying automatically and inversely with the slip between said impeller and runner elements and for stopping said driving member when said slip exceeds a predetermined value.

15. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic coupling of the kinetic type having an impeller element coupled to said driving member and a runner element drivably connected to said means for rotating the drill pipes, a winch for feeding said drill pipes, irreversible gearing for unwinding said winch, a unidirectional coupling connected with said irreversible gearing and having a driving member, and means for oscillating said driving member with an amplitude varying automatically and inversely with the slip between said impeller and runner elements and for stopping said driving member when said slip exceeds a predetermined value.

16. Apparatus for use in the rotary drilling of bore holes, comprising a driving member adapted to rotate continuously, means for imparting rotary motion to a string of drill pipes, a hydraulic slip coupling of the kinetic type having an impeller element coupled to said driving member and a runner element drivably connected to said means for rotating the drill pipes, a winch for feeding said drill pipes, including an irreversible gearing, a mechanical differential gear having three co-operating elements rotatable relatively to one another, two of which are drivably connected respectively with said impeller and runner elements, the ratios of said differential gearing being such that the third element thereof rotates at the maximum speed in one direction when the slip in said hydraulic coupling is zero and said third element comes to rest when said slip rises to a predetermined value substantially less than 100 per cent., and a driving connection between said third element and said irreversible gearing, said driving connection including a free-wheel device capable of overrunning when said third element rotates in the other direction.

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