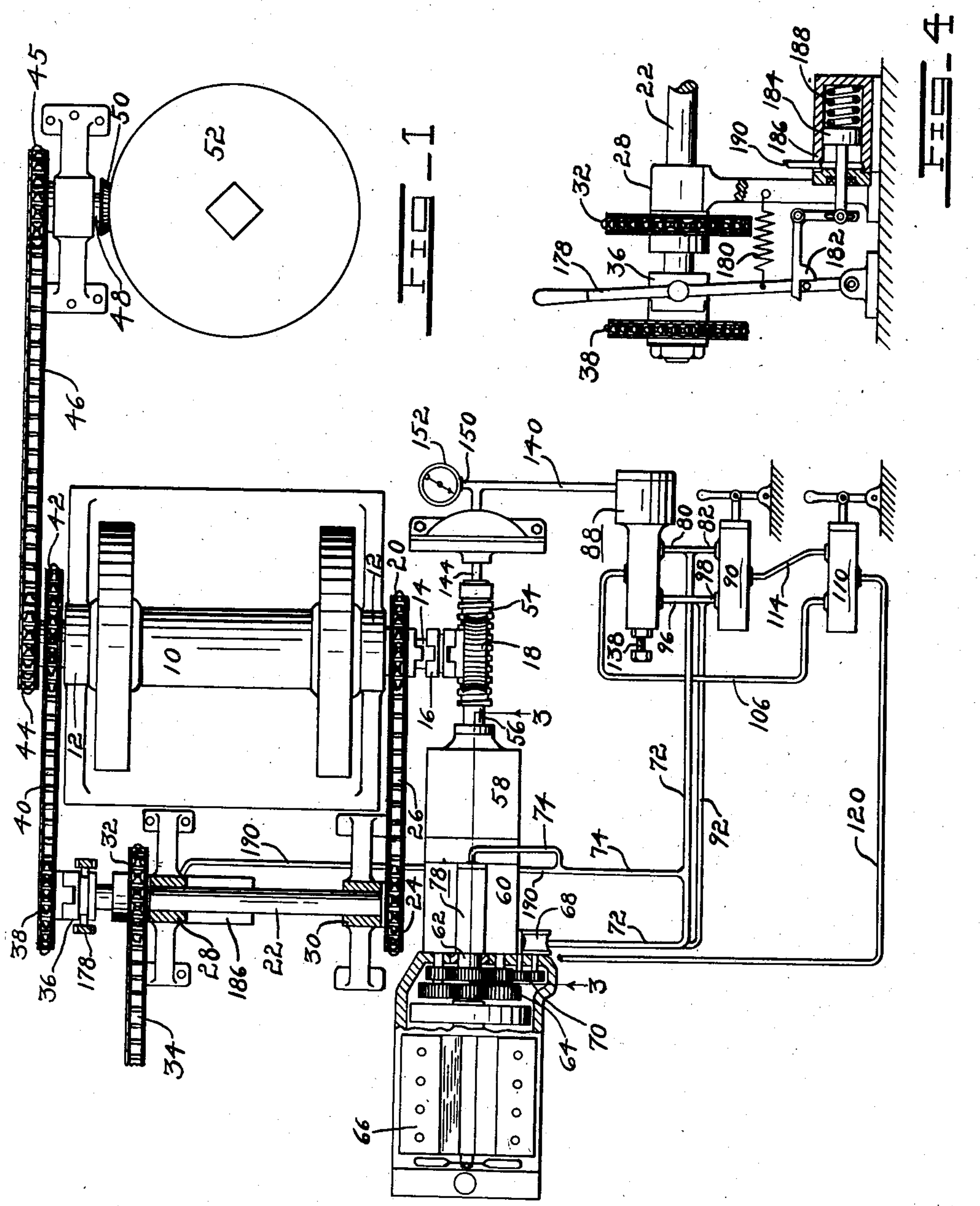
March 1, 1938. E. L. ROSE ET AL 2,109,782

POWER TRANSMISSION

Filed Aug. 25, 1936 3 Sheets-Sheet 1



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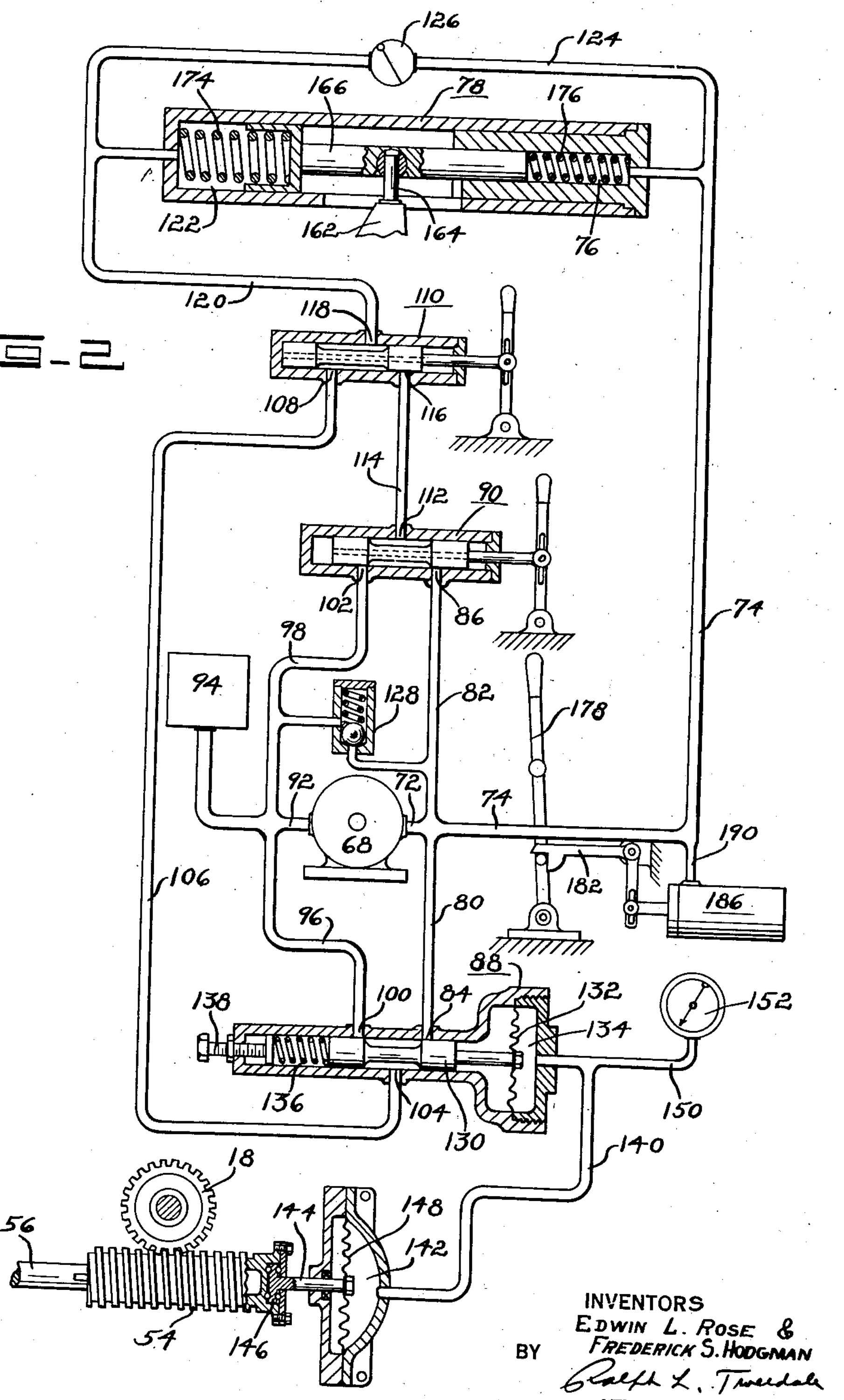
3 Sheets-Sheet 2

FIG-2



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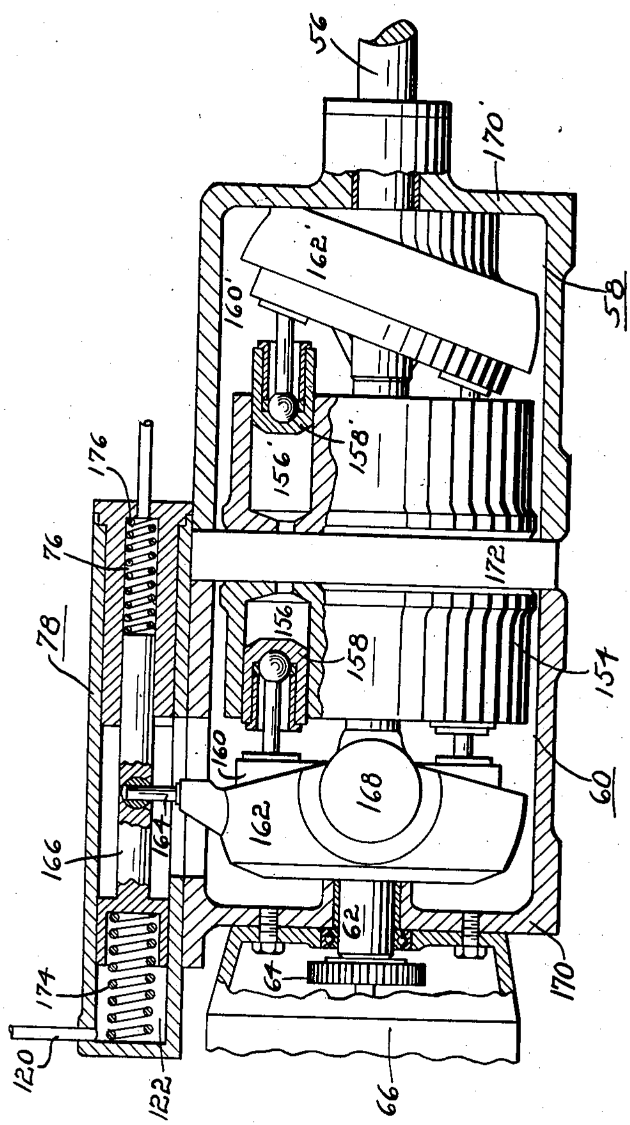

FIG. 2

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POWER TRANSMISSION

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19 Claims. (Cl. 255—19)

This invention relates to power transmissions and particularly to transmissions of the hydraulic type comprising a fluid pump and fluid motor either or both of which may be provided with mechanism for varying its displacement in order to vary the speed ratio between the prime mover which operates the pump and the load device which the motor operates. The invention is illustrated as adapted for use in a well drilling rig of well-known type in which a string of drill stem is caused to revolve by a rotary drilling head while a portion of the weight of the string rests upon the earth formation at the bottom of the hole being drilled, the remainder being suspended on a block and falls mounted in a drilling derrick and connected to a draw-works drum.

It is desirable in such drilling operations to maintain at a constant value that portion of the weight of drill string which rests upon the earth formation at the bottom of the hole and to be able to readily adjust such weight to different values as different formations are encountered. Various systems have been proposed for automatically regulating the weight on the drill stem in such a manner. Systems of this character as heretofore constructed have utilized either the energy of the drill stem itself for feeding the same into the hole as required; such, for example, as systems wherein a friction or fluid brake is automatically regulated to maintain a constant tension on the draw-works drum, or have utilized an expensive and cumbersome power operated feed system such as a steam or electric powered feed controlling apparatus. Devices of the latter class are not only expensive in first cost and in operation but are open to other objections in that they require specially trained operators or are incapable of use in fields where an adequate water supply is not available.

It is an object of the present invention to provide a well drilling rig whereby the weight of the drilling bit on the earth formation at the bottom of the hole may be maintained at a constant but adjustable value and which incorporates simple, reliable and inexpensive apparatus capable of operation in any locality by untrained operators.

A further object is to provide a well drilling rig of this character including a feed controlling device which may be energized from a small prime mover independently of the principal source of power for the draw-works and other apparatus usually associated with drilling rigs of the rotary type and which small prime mover may preferably comprise a small internal combustion engine of the type used in motor vehicles which are readily available at low cost.

It is a further object to provide a feed controlling apparatus for a well drilling rig wherein a hydraulic variable speed power transmission is incorporated for transmitting power between a substantially constant speed prime mover and the drawworks drum, whereby the speed of rotation of the drum may be precisely controlled automatically to maintain a predetermined constant weight on the drill bit and whereby also the operation of the draw-works may be controlled manually as desired to either raise or lower the drill string at any speed within the power capacity limits of the prime mover.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a prefered form of the present invention is clearly shown.

In the drawings:

Fig. 1 is a plan view partly in section of a well drilling rig showing a preferred form of the present invention.

Fig. 2 is a diagrammatic view of the hydraulic circuits incorporated in the apparatus illustrated in Fig. 1.

Fig. 3 is a vertical cross section on line 3—3 of Fig. 1 showing a hydraulic transmission forming part of the apparatus.

Fig. 4 is a fragmentary detail of a portion of the apparatus.

Referring now to Fig. 1 there is illustrated a draw-works having a drum 10 journalled in bearings 12 and adapted to have wound thereon a cable by which a drilling string may be supported from a derrick, not shown, in the usual manner. The drum 10 is keyed to a shaft 14 on which is splined a slidable clutch member 16 which may be engaged either with a worm wheel 18 as shown in Fig. 1, or with a sprocket 20. The sprocket 20 is driven from a counter shaft 22 by means of a sprocket 24 and chain 26. The shaft 22 is journalled in bearings 28 and 30 and has keyed thereon a sprocket 32 which is driven by means of a chain 34 from a suitable prime mover, not shown, through the medium of any suitable multiple speed transmission mechanism. Splined to the shaft 22 is a clutch member 36 slidable to engage a sprocket 38 loosely journalled on the shaft 22. Sprocket 38 drives by a chain 40 a sprocket 42 loosely mounted on the shaft 14, the sprocket 42 being rigidly secured to a sprocket 44 which drives a sprocket 45 by means of a chain 46.

The sprocket 44 is keyed to a shaft 48 which carries a bevel pinion 50 meshing with a bevel gear on the under side of a rotary table 52, whereby the drill stem may be given a rotary movement independent of the vertical movement imparted to it by the draw-works drum 10, as is well-known in the art. The apparatus thus far described is represented as typical of the usual well drilling apparatus and, per se, forms no part of the present invention.

The worm wheel 18 is adapted to mesh with a worm 54 which is splined to a shaft 56 forming the output shaft of a fixed displacement rotary fluid motor 58. Motor 58 is hydraulically connected to a variable displacement pump 60 to form therewith a variable speed hydraulic transmission which is illustrated as of the well-known "Waterbury" type, shown in Fig. 3. The pump 60 has an input shaft 62 which is connected by means of reduction gearing 64 to the crankshaft of an internal combustion engine prime mover 66. An auxiliary fixed displacement pump 68 of small capacity is driven from the reduction gearing 64 by gearing 70.

Referring now to Fig. 2, pump 68 has an outlet conduit 72 which connects by means of a conduit 74 with the small cylinder 76 of a differential piston fluid motor 78. The conduit 72 has branches 80 and 82 communicating with ports 84 and 86 of a pressure responsive pilot valve 88 and a manually operable control valve 90 respectively. The return side of the pump circuit includes a return conduit 92 connected with an expansion tank 94 as well as with the interior of the casings of the pump 60 and the motor 58. Branches 96 and 98 communicate with ports 100 and 102 of the valves 88 and 90 respectively. Valve 88 has a third port 104 communicating by means of a conduit 106 with a port 108 of a manually operable selector valve 110, while valve 90 similarly has a third port 112 communicating by means of a conduit 114 with a port 116 of the valve 110. A third port 118 of the valve 110 communicates by a conduit 120 with the large cylinder 122 of the fluid motor 78. A conduit 124 connects the conduits 74 and 120 and has disposed therein a check valve 126 opening toward the conduit 74. The usual relief valve 128 is provided between the outlet 72 and the inlet 92 of the pump 68 for the purpose of limiting the pressure developed in the conduit 72.

The valve 88 includes a movable valve member 130 which is secured at one end to a flexible diaphragm 132 forming a movable wall of a chamber 134 formed in the right-hand end of the body of the valve 88. A spring 136 abuts against the opposite end of the member 130 and can be adjusted by means of an adjusting screw 138. The chamber 134 communicates by a conduit 140 with a chamber 142 formed adjacent the end of the worm 54. The latter carries at its right-hand end a shaft 144 with respect to which the worm 54 is free to rotate by means of ball bearings 146. The shaft 144 is secured to a flexible diaphragm 148 forming a movable wall of the chamber 142. The conduit 140 includes a branch 150 leading to a pressure gauge 152 for indicating the pressure existing in the conduit 140.

Referring now to Fig. 3 wherein the internal mechanism of the variable speed transmission is illustrated; the pump 60 includes a revolving cylinder barrel 154 within the bores 156 of which pistons 158 are reciprocated by the motion of a socket ring 160 which revolves in a tilting box 162. The tilting box 162 carries a stud 164 having a pivoting and sliding connection with the differential piston 166 of the fluid motor 78. The socket ring 160 is caused to revolve with the shaft 62 by a universal joint connection, not illustrated, while the cylinder barrel 154 is keyed to the shaft 62. The tilting box 162 is mounted for oscillatory movement on its trunnions 168 in the casing 170 of pump 60. When the tilting box 162 and consequently the socket ring 160 are tilted about the trunnion 168 and shaft 62 is caused to revolve, the pistons 158 are reciprocated in the bores 156 due to the inclination of the plane in which the socket ring 160 rotates to the plane of the cylinder barrel 154, the stroke of the pistons 158 being determined by the angular setting of the tilting box 162. As the pistons 158 are reciprocated, fluid is caused to be drawn into the cylinders 156 through one arcuate port, not shown, in the valve plate 172 and to be expelled from the cylinders 156 through the opposite arcuate port in valve plate 172.

The fluid motor 58 is similar in construction to the pump 60 except that the socket ring 160′ is journalled in a fixed angle box 162′ rigidly secured to the casing 170′ of the motor 58. Fluid delivered from the pump 60 through the valve plate 172 is admitted to the cylinders of the motor 58 causing the socket ring 160 and the shaft 56 to revolve while on the return stroke of the pistons in the motor 58, the fluid is returned to the pump through the valve plate 172. Customary replenishing and relief valves, not shown, are incorporated in the valve plate 172 for the purpose of maintaining the working circuit filled with fluid at all times and for preventing building up of excessive pressures and undue overloading of the machine. The construction and operation of hydraulic transmissions of this character are well-known in the art so that further description thereof is unnecessary.

In operation assuming the drill string to have been run into the hole and the apparatus arranged for drilling operation, the clutch member 16 having been adjusted to engage the worm gear 18 as illustrated in Fig. 1, and the clutch member 36 having been adjusted to engage the sprocket 38, the rotary table 52 is driven from the principal power source of the drilling rig through chain 34, sprocket 32, shaft 22, clutch 36, sprocket 38, chain 40, sprockets 42 and 44, chain 46, sprocket 45, shaft 48 and bevel pinion 50. With the prime mover 66 running at a substantially constant speed, the shaft 56 will be caused to turn at a speed determined by the position of the tilting box 162 which is in turn governed by the position of the differential piston 166. Fluid under pressure delivered by the auxiliary pump 68 is transmitted through the conduit 74 to urge the piston 166 to the left in Fig. 2. The position of the movable member 130 of the valve 88 is determined by the pressure existing in the chamber 134 which in turn is determined by the reactive force exerted by the worm wheel 18 on the worm 54.

Assuming the cable to be wound on the drum in a direction in Fig. 2, such that the weight of the drill stem tends to turn the worm wheel 18 counter-clockwise, this weight consequently urges the worm 54 to the right thus increasing the pressure in the chambers 142 and 134. Assuming that the operations are started with the drill bit suspended a short distance above the bottom of the hole, the full weight of the drill string will be imposed on the draw-works drum 10 so that the consequent thrust on the worm 54 overcomes the force of the spring 136, permitting the valve 130 to move to the left and completely opening a passage between the ports 100 and 104. The piston is thereby caused to move to the left under the fluid pressure exerted in cylinder 76, the fluid in cylinder 122 being exhausted through the conduit 120, port 118, port 108, conduit 106, ports 104 and 100 and conduit 96 to the return side of the system. The tilting box 162 thereby rotates in a counter-clockwise direction to the limit of its movement causing shaft 56 to revolve in a direction to rotate the worm wheel 18 and the drum 10 counter-clockwise in Fig. 2, thus lowering the drill string into the hole.

As soon as the drill bit touches the bottom of the hole, a portion of the weight of the drill string is supported on the earth so that the thrust of the worm 54 to the right in Fig. 2 is reduced. As soon as the reduced thrust reaches a value such that the spring 136 can overcome the thrust of the worm 54, the movable valve member 130 moves to the right sufficiently to close the port 100. Should the rate of downward feed of the drill stem be too great at this time, the thrust of the worm 54 is further reduced, thus permitting the valve member 130 to move further to the right and open the port 84 to communicate with the port 104. Fluid under pressure is thereby admitted to the cylinder 122 through conduit 80, ports 84, and 104, conduit 106, ports 108 and 118, and conduit 120 causing the piston 166 to move to the right thus moving the tilting box 162 in a direction to decrease the stroke of the pistons 158.

As soon as the speed of the shaft 56 has been reduced sufficiently so that the downward movement of the drill stem is equal to the rate at which the drill bit "makes hole", the thrust on the worm will come to a balance with the thrust exerted by the spring 136, thus permitting the valve 130 to move into the position shown in Fig. 2. Thereafter the drill string will be fed downwardly at the same rate so long as the bit "makes hole" at the same speed. As soon as any change occurs in the rate at which the bit "makes hole", the thrust of the worm 54 correspondingly changes, causing the valve 130 to make the required adjustments in the rate of feed of the drill stem.

If for any reason, such as a failure of the principal power supply of the drilling rig, it should be necessary or desirable to control the vertical movement of the drill string manually, the selector valve 110 is shifted to the right in Fig. 2, thus connecting conduit 120 with the valve 90 through conduit 114. The speed and direction of the draw-works drum 10 may thereafter be controlled by operating the valve 90. Thus, if it is desired to decrease the speed in a downward direction or to increase the speed upwardly, the valve 90 will be moved to the right in Fig. 2, admitting fluid under pressure from the conduit 82, through ports 86 and 112, conduit 114, ports 116 and 118, conduit 120 to the cylinder 122. The piston 166 thereby moves to the right so long as valve 90 is held to the right. Conversely, if the valve 90 is moved to the left, piston 166 moves to the left, exhausting fluid from cylinder 122 through conduit 120, ports 118 and 116, conduit 114, ports 112 and 102, and conduit 98 to the return side of the system.

If for any reason the auxiliary prime mover 66 should fail, it is desirable to prevent damage to the rig being caused thereby. For this purpose springs 174 and 176 are provided in the cylinders 122 and 76 respectively. Whenever the piston 166 is to the right of mid-position, that is, whenever the draw-works drum is being driven in a hoisting direction by the auxiliary prime mover 66, if any failure of the prime mover 66 should occur, the pressure in conduit 74 will drop substantially to zero. Under these conditions spring 176 moves the piston 166 to the left to mid-position, thus bringing the hydraulic transmission to a safe position where the weight of the drill string cannot cause the fluid motor 58 to overhaul, even though the worm drive 18—54 be of the overhauling type. The check valve 126 permits fluid to pass from cylinder 122 to the conduit 74 for this purpose. Obviously, if the worm drive be of the non-overhauling type this mechanism may be dispensed with.

If a failure of prime mover 66 should occur while the drill string is being fed downwardly during drilling operations, it is desirable to prevent continued turning of the table 52 so as to prevent a "twist-off". For this purpose the clutch 36 has its operating lever 178 biased to the right in Fig. 4 by a spring 180 and is held in clutch engaging position by a latch 182. A piston 184 mounted in a cylinder 186 is biased to the left by a spring 188 and connected to the latch 182. The cylinder 186 is in communication with conduit 74 by a conduit 190. The construction is such that the latch 182 is maintained in engagement with the lever 178 only when pressure of a predetermined magnitude exists in conduit 74. Whenever the pressure falls below this point the latch 182 is tripped by the spring 188 thus permitting spring 180 to disengage clutch 36 and interrupt the rotation of table 52.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, and means whereby said controlling member may control operation of said motor.

2. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, and means whereby said controlling member may control operation of said motor, and additional manually controlled means for varying the speed ratio of the power transmission independently of the controlling member.

3. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, means whereby said controlling member may control operation of said motor, addi-

tional manually controlled means for varying the speed ratio of the power transmission independently of the controlling member, and means for selectively rendering the transmission subject to control either by the controlling member or by the manually controlled means.

4. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, and means whereby said controlling member may control operation of said motor.

5. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, means whereby said controlling member may control operation of said motor, and additional manually controlled means for varying the speed ratio of the power transmission independently of the controlling member.

6. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, means whereby said controlling member may control operation of said motor, additional manually controlled means for varying the speed ratio of the power transmission independently of the controlling member, and means for selectively rendering the transmission subject to control either by the controlling member or by the manually controlled means.

7. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, additional means for driving said draw-works drum independently of said prime mover, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a motor for varying the speed ratio of the power transmission, means whereby said controlling member may control operation of said motor, and means for selectively connecting said draw-works drum to be driven either by the power transmission or by said additional driving means.

8. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, and means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum.

9. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, and additional manually controlled means for varying the speed ratio of the power transmission independently of the torque imposed on the draw-works drum.

10. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, additional manually controlled means for varying the speed ratio of the power transmission independently of the torque imposed on the draw-works drum, and means for selectively rendering the power transmission subject to control either by the torque responsive means or by the manually controlled means.

11. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, and means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum.

12. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, and additional manually controlled means for varying the speed ratio of the power transmission independently of the torque imposed on the draw-works drum.

13. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission including a variable displacement pump and a fluid motor operable thereby connected in driving relation between the prime mover and the draw-works drum, means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, additional manually controlled means for varying the speed ratio of the power transmission independently of the torque imposed on the draw-works drum, and means for selectively rendering the power

transmission subject to control either by the torque responsive means or by the manually controlled means.

14. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a fluid motor for varying the speed ratio of the power transmission, and means including a valve operably connected to said motor whereby said controlling member may control operation of said motor.

15. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a fluid motor for varying the speed ratio of the power transmission, means including a valve whereby said controlling member may control operation of said motor, and an additional manually operable valve for controlling the motor independently of said controlling member.

16. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a fluid motor for varying the speed ratio of the power transmission, means including a valve whereby said controlling member may control operation of said motor, an additional manually operable valve for controlling the motor independently of said controlling member, and a selector valve for manually rendering said motor responsive either to said first valve or said second valve.

17. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a rotary table for rotating said drill string, means independent of said prime mover for driving said rotary table, and means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, and means responsive to a failure of said prime mover for stopping said rotary table.

18. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, means responsive to variations in torque imposed on the draw-works drum for controlling the speed ratio of the power transmission to feed the drill string downwardly at a rate to maintain a constant proportion of its weight suspended by the draw-works drum, and means responsive to a failure of said prime mover for preventing said drill string from dropping into the hole.

19. In a well drilling rig the combination of a drill string, a draw-works drum, a prime mover, a variable speed power transmission connected in driving relation between the prime mover and the draw-works drum, a controlling member movable in accordance with variations in torque imposed on the drum by the drill string, a fluid motor for varying the speed ratio of the power transmission, means whereby said controlling member may control operation of said motor, and means effective upon failure of said prime mover for bringing said power transmission to a drill string sustaining position.

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