Aug. 18, 1936. C. R. EDWARDS 2,051,249

ELECTRICAL DRIVING MACHINE

Filed Jan. 9, 1925 4 Sheets-Sheet 1

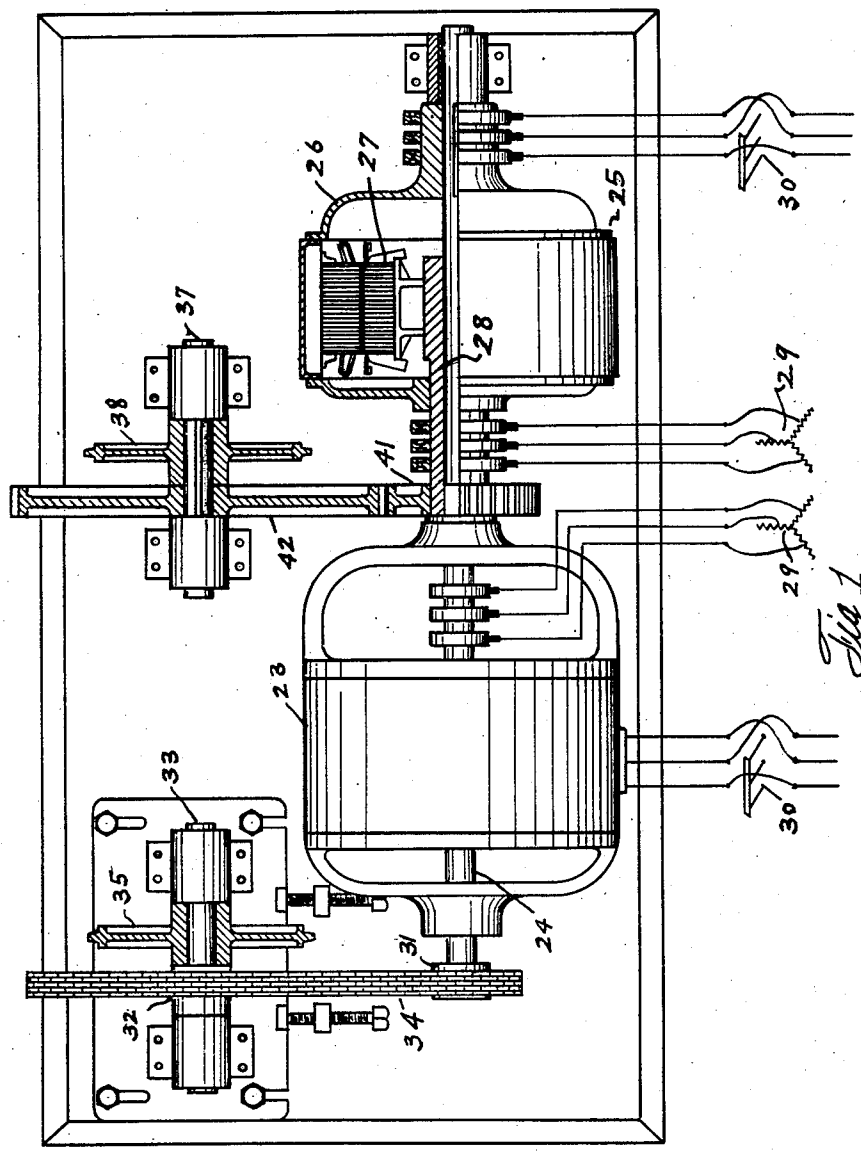

Fig. 1.

INVENTOR.
Charles R. Edwards

BY

Hardway & Carter
ATTORNEYS.

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Filed Jan. 9, 1925 4 Sheets-Sheet 2

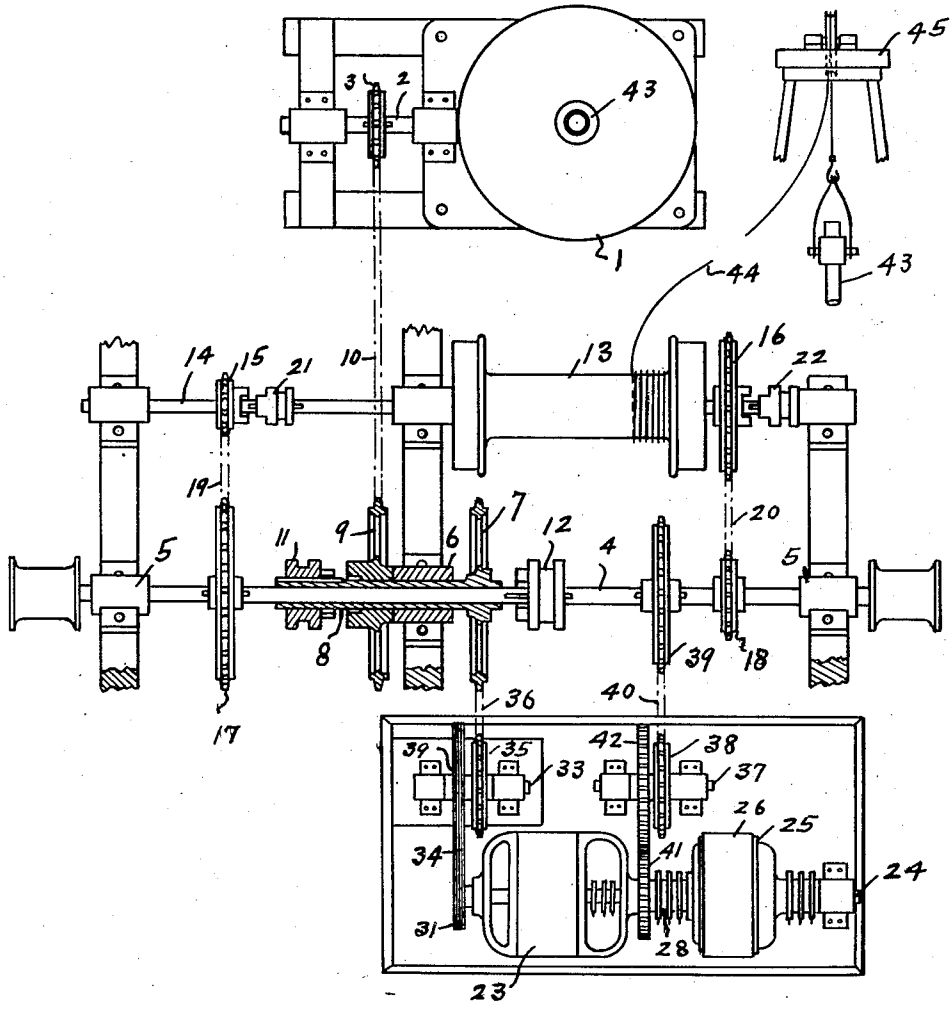

Fig. 2.

INVENTOR.
Charles R. Edwards,
BY
Hardway & Cathey,
ATTORNEYS

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Filed Jan. 9, 1925 4 Sheets-Sheet 3

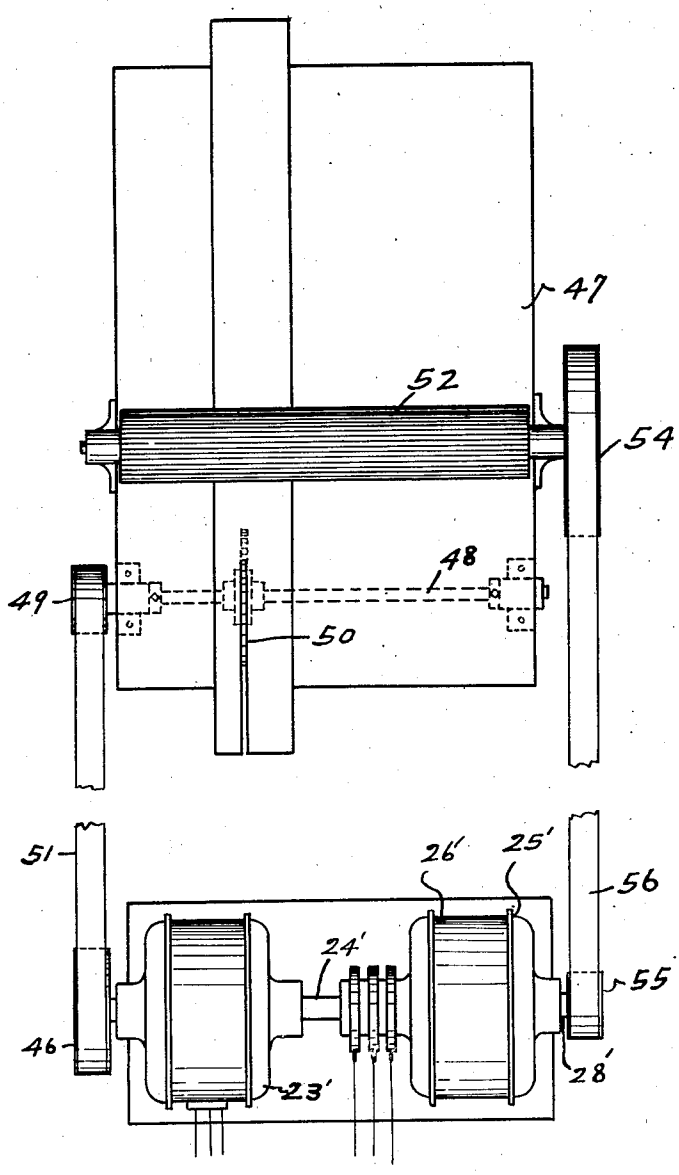

Fig. 3.

INVENTOR.
Charles R. Edwards
BY
Hardway & Cathy
ATTORNEY.

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ELECTRICAL DRIVING MACHINE

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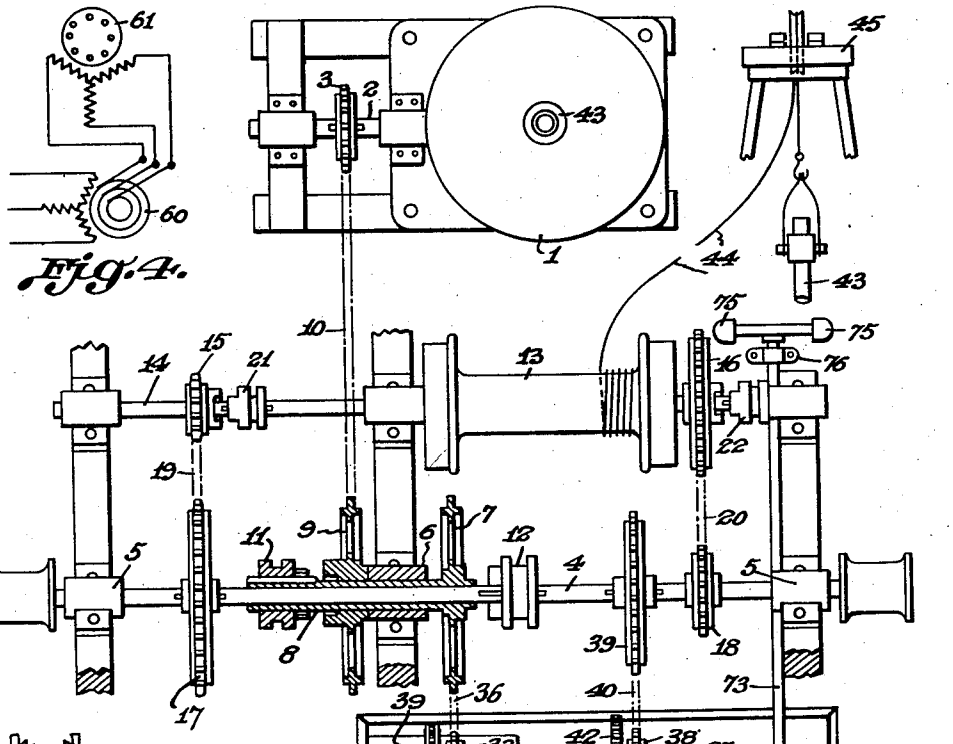

Fig. 7.

Fig. 4.

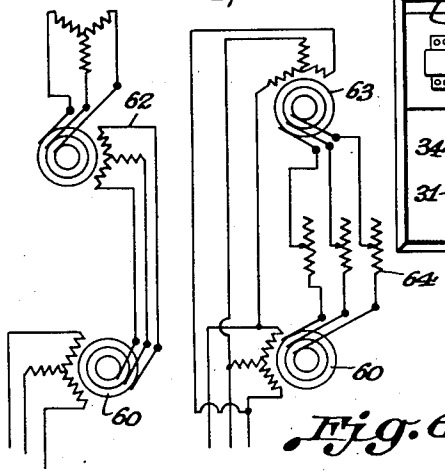

Fig. 6.

Fig. 5.

Charles R. Edwards
Inventor:
by Jesse R. Stone
Lester B. Clark
Attorneys

Patented Aug. 18, 1936 2,051,249

UNITED STATES PATENT OFFICE

2,051,249

ELECTRICAL DRIVING MACHINE

Charles R. Edwards, Houston, Tex.

Application January 9, 1925, Serial No. 1,492

59 Claims. (Cl. 255—19)

This invention relates to new and useful improvements in an electrical driving machine.

One object of the invention is to provide an electrical power unit adapted to control its own load and capable of a wide range of speed and torque.

Another object of the invention is to produce an electrical differential machine which may be specially adapted for use, in well drilling, to drive and manipulate the drill stem, and accomplish certain well drilling operations, and which will automatically accommodate itself to the many varying conditions incident to the performance of such work. The principle involved may be applied, through an electrical mechanism, such as illustrated, for the performance of various other kinds of work.

With the above and other objects in view this invention has particular relation to certain novel features of construction, operation and arrangement of parts examples of which are described in this specification and illustrated in the accompanying drawings, wherein:—

Figure 1 shows a plan view of the driving mechanism, partly in section.

Figure 2 shows a plan view thereof, as applied to a rotary well drilling rig, the latter being shown partly in section.

Figure 3 shows a plan view of a modified form of electrical driving mechanism as applied in driving a power-feed saw.

Figures 4, 5 and 6 illustrate diagrammatic views of various electrical hookups of the electrical units employed.

Fig. 7 is another form of the invention as seen in Fig. 2, but showing a double rotor motor with a brake for each rotor.

Referring now more particularly to the drawings, wherein like numerals of reference designate similar parts in each of the figures, the numeral 1 designates a well drilling rotary, of conventional type, having the driving shaft 2 with the sprocket 3, fixed thereon. The numeral 4 designates the counter shaft of the drilling rig, which is mounted to rotate in suitable bearings as 5, 5, 6 of the framework of said rig. There is a sprocket 7 loosely mounted on said shaft 4, on one side of the bearing 6, and formed with an extended sleeve 8, on said shaft, which runs in the bearing 6 and loosely mounted on said sleeve, on the other side of the bearing 6, there is a sprocket 9 in alignment with the sprocket 3, and operating over said sprockets, and establishing a driving relation between them, there is a sprocket chain 10. A clutch 11 is splined on the sleeve 8, through which the sprocket 9 may be clutched with, and declutched from, the sleeve 8.

Splined on the shaft 4 there is a clutch 12 through which the sprocket 7 may be clutched with and declutched from said shaft 4.

Incorporated in the drilling rig there is a conventional cable winding drum 13 which is fixed on the transverse shaft 14 and loosely mounted on this shaft are the small and large sprockets 15 and 16 which are driven from the large and small sprockets 17 and 18, respectively, fixed on the shaft 4, through the respective chains, 19 and 20. The sprockets 15 and 16 may be clutched with and released from the drum shaft 14, through the respective clutches 21 and 22 splined on said drum shaft. Provision is thus made for rotating the drum fast or slow as occasion may require.

Referring to the power unit the numeral 23 designates an electrical motor, which may be an ordinary induction motor with a fixed stator and a wound rotor which is fixed on the motor shaft 24. The numeral 25 designates, as a whole, another electrical motor, similar to the motor 23, so far as electrical operation and control are concerned, but is mechanically different in that the stator 26 is fixed to the shaft 24 and the rotor 27 is fixed in a sleeve 28, which is rotatable on the shaft 24 and which is extended beyond the stator 26, and hence the stator and rotor, of the motor 25, both are capable of rotation.

The rotor circuits have the usual variable resistances 29, 29 and reversible switches 30, 30 which, in practice, are usually incorporated into a simple conventional controller.

Fixed on the shaft 24 there is a sprocket 31 which drives an aligned sprocket 32, fixed on the stub shaft 33 through the driving chain 34. Fixed on the shaft 33 there is also a sprocket 35, aligned with the sprocket 7, and driving the same through the sprocket chain 36. The shaft 24 thus may be brought into and out of driving connection with the counter shaft 2 through the clutch 11 or with the shaft 4 through the clutch 12, or if desired both the clutches 11 and 12 may both be engaged at the same time and power from both motors or motor 25 only be applied to the drill 43 through chains 36 and 40, or if desired clutch 12 and either clutch 21 or clutch 22 may be engaged (leaving clutch 11 disengaged) and the power from both motors or motor 25 only be applied to drum 13 through chains 36 and 40, or if only motor 25 be energized in each of the last two events the power from motor 25 will be applied through both chains 36 and 40 in which

event the actual speed of each of shafts 24 and 22 will be about one half the normal speed of motor 25.

The sleeve 28 is geared to a stub shaft 37 which has a fixed sprocket 38 in alignment with a sprocket 39 fixed on the counter shaft 4 and arranged to be driven from the sprocket 38 through the sprocket chain 40. The secondary member of the motor 25 thus has a driving connection with the counter shaft 4. The gearing between the sleeve 28 and the stub shaft 37 may consist of the intermeshing spur gears 41, 42, fixed respectively on said sleeve and shaft, and since the secondary member 27 rotates in a direction the opposite of the rotation of the shaft 24 the counter shaft 4 will be driven in same direction by the shaft 24 and the sleeve 28.

In operation:—assuming that clutch 12 is engaged with the sprocket 7 if current be applied to the motor 25 the counter shaft 4 will be driven at about one half of the reduced speed of the motor 25, since the secondary member 27 and the stator 26, of the motor 25, rotate in opposite directions and are mechanically connected, respectively to the sprockets 39 and 7 which must revolve together, shaft 4 rotating opposite to the direction of the field produced in the rotating primary member 26 of the motor 25.

If current be now applied to the motor 23 so that the direction of rotation of the field produced in the primary member of the motor 23 is in the opposite direction of the rotation of the field produced in the now rotating primary member 26 of the motor 25 the torque of the shaft 4 will be increased by additional energy from the motor 23, but as both members in the motor 25 are rotating the torque in shaft 4, produced by the energy in motor 25 is about twice as great as would be produced by motor 23, provided both motors are of the same horse power and the same number of poles, hence the torque of shaft 4, in this case, is about three times as great as would be produced by the motor 23; if the current be now cut off from the motor 25 the speed of the counter shaft 4 will be increased but the torque decreased.

If the clutch 12 be disengaged and current be applied to both motors 23 and 25 so that the directions of rotation of the fields produced in the primary members of the motor 23 and motor 25 shall be the same the counter shaft 4 will then be driven at the sum of the speeds of the two motors, less the reduction of the gearing of the motor 25.

The objects and various operations of the invention, herein described, may be well illustrated in the application thereof to well drilling operations now to be described:—The numeral 43 designates a conventional drill stem which is engaged and rotated by the rotary 1, and whose lower end carries the conventional drill bit. A cable 44 is wound around the drum 13 and operates over the sheaves of the crown block 45, forming the top of the derrick. The end of this cable is connected to the drill stem, in the usual way, so that said stem may be lifted and lowered, and handled, as desired, through the drum 13. If the clutch 11, and either clutch 21 or 22 (accordingly as fast or slow speed is desired) be engaged and current be supplied to both motors so that the direction of the rotation of the fields produced in the two motors are opposite and the direction of rotation of the field produced in the motor 23, is the usual forward direction used in drilling, the current to motor 25 being only sufficient to partly sustain the weight of the stem and the current to the motor 23 being sufficient to supply the proper speed and torque to the stem for drilling as the formation is cut away by the bit, the weight of the stem on the motor 25 will increase and said motor will rotate slower, or against its extra load, or backwardly, and in this it will be assisted by the motor 23 which speeds up on account of its lightened load—all of which tends to bring the secondary member 27 into synchronous speed with the primary member 26 and as a result its torque, on the shaft 14 is lessened and the stem is permitted to descend against the work. Should the work of the bit become too heavy, that is should the weight of the stem hold the bit too firmly against the work and cause it to cut too fast and tend to overload the drilling motor 23, this motor, along with the primary member of the motor 25 will slow up with the result that the torque of the motor 25 on the shaft 14 will be increased and the drill stem raised until the load on the drilling motor 23 permits it to run at the desired speed and torque.

As the hole is deepened, and the drill stem lengthened, by the addition of more joints of stem more current is turned onto motor 25, or less current is supplied to the motor 23.

In case the weight of the drill stem becomes very great and the desired torque on said stem consequently becomes very small the current, supplied to the motor 23 may be reversed, converting the same into a generator, and conversely in certain applications of the invention where it is desired to force the feed of the driven working tool, the current supplied to the motor 25 might be reversed and this motor converted into a generator.

As is usual in well drilling operations it often is necessary to withdraw, or by otherwise than drilling, to operate, the drill or other tool for reasons well known to those skilled in the art of well drilling. If for instance it be desired to "spud" the drill as in drilling a sticky formation that balls up the bit while drilling this can be very easily done with my apparatus. For instance if the current to motor 23 is lessened or cut off the torque load of the drill is transferred to motor 25 and this also increases the lift on the drill or picks the drill up and again applying current to motor 23 will spud the bit. Spudding can be done if drilling with motor 25 only by simply increasing the torque effort to exceed the lift effort.

In breaking out or making up pipe it is very desirable that the rotation of the pipe in the coupling be slow, but it often requires very great torque on the parts to complete these operations; such conditions of operation are not satisfactorily performed with present field equipment. In the present device such operations, because of its ability to transmit power to a single purpose through both chains 36 and 40, can substantially cut the speed in half and at the same time substantially double the torque over other rigs.

It is also very desirable when pulling on stuck pipe to apply a very slow steady powerful pull. The present device, for the above reasons, is much better suited for pulling than the usual rig.

It is often also very desirable when handling light loads or an empty hook to greatly increase the speeds. In the present device not only may the torque be pyramided but the speed may also be pyramided as is also herein explained.

It sometimes happens that the engine or other motor power used to operate the drill manipulating devices fails through breakage. If this occurs with the ordinary equipment while the drill

bit is on bottom, a stuck drill is the usual result. With the present apparatus unless both motors fail at the same time, operations may be continued or the drill be withdrawn and the drill stem be broken out with either motor alone.

In the ordinary rig to pull and break pipe with the rig requires shifting a number of clutches with loss of time and energy; with the present rig if clutch 11 and either clutch 21 or 22 be maintained in gear, then these operations can be alternated by merely alternating the transmission of motion through chains 40 and 36 by controlling the movement of shafts 28 and 24 and without shifting clutches.

Other obvious advantages of the present apparatus over the usual well drilling equipment are as obvious as the above enumerated advantages, and those skilled in this art need no further instructions in order to use the same.

In Figure 3 the principle of the invention is illustrated in its application to a saw mill, wherein the numeral 23' designates an ordinary three phase alternating induction motor having a pulley 46 fixed on the shaft 24' thereof. The numeral 47 designates a bed, or table, having a transverse shaft 48 rotatable in aligned bearings thereof, on which the pulley 49 and the circular saw 50 are fixed. A belt 51 operates over the pulleys 46 and 49 and transmits rotation to the latter. A feed roller 52, is rotatably mounted above the bed 47 and its shaft 53 has the pulley 54 fixed thereon.

The motor 25' has its stator 26' fixed to the shaft 24', so as to rotate therewith, and the shaft 28' of the rotor of this motor has a pulley 55, fixed thereon, and in alignment with the pulley 54, and operating over these pulleys, and transmitting rotation from the former to the latter, there is the drive belt 56.

Ordinarily the speed of the motor 23' will be greater than that of the motor 25' the difference in these speeds measuring the speed of the pulley 55. Should the load of the saw decrease the speed of the driving motor 23' the speed of the feed roller 52 will accordingly be retarded so as to feed the work more slowly to the saw. Should the speed of the motor 23' decrease until it is synchronous with the motor 25, the feed pulley 55, and the feed roller 52, will stop and if the speed of the motor 23' should be further relatively decreased the pulley 55 and the feed roller will be reversed so as to completely relieve the saw of its load.

It is obvious that there are many other possible applications of the principle of the invention herein described, and that the mechanical principles of an electrical differential may be applied to any system of electric current and to either motors or generators, or a combination of both. For instance a most obvious mechanical change consists in making the secondary member 27 of motor 25 to revolve with shaft 24 instead of revolving the primary 26 with the shaft 24. Numerous other changes are obvious and those skilled in the art may make many such changes as their judgments or fancies dictate, but such changes are within the essence of the present invention.

It is further obvious that a single motor, with both stator and rotor connected to the work, and controlled by suitable brakes, may in many cases be found preferable to the use of two motors, applied as above described:—as for example, such a single motor, with a revolving stator as well as revolving rotor, may be advantageously used, as a differential in lieu of the geared mechanical differential.

There may also be instances in which it may be found desirable to inter-connect the two electrical machines so as to use the induced current in the rotor of a motor such as 23 as the primary current in the other motor as 25, such uses as are specifically defined herein as well as the variations thereof adverted to, and others comprehended within the scope of the appended claims are intended to be comprehended hereby.

Referring particularly to Figures 4, 5 and 6 the numeral 60 refers to a conventional diagrammatical view of the wiring that may be included in the motors 23, 25 or 23', 25'. Said wiring 60 being any suitable wiring such as is adaptable for use in the principal or work motor. The numerals 61, 62 and 63 designate different forms of conventional wiring diagrams, the wiring of what may be preferably, though not necessarily, a primary motor.

In Figure 4 the secondary wiring 60 of the motor is directly connected to and becomes the primary wiring of the induction motor 61. The illustration disclosed in Figure 5 shows the same lay out as that of Figure 4 excepting the wiring, as 62 is that of an induction motor with a wound rotor and a variable resistance in the secondary which may be similar to that shown at 29 in Figure 1. The construction illustrated by Figure 6 may be considered similar to that illustrated by Figure 5 excepting that the unit indicated by the numeral 63 is rotatable against the current. A variable resistance 64 similar to that indicated by the numeral 29 of Figure 1 is shown as located between the secondary line 60 and the primary or excitor line indicated by the numeral 63. Each of the revolving elements of motor 25 may in some instances be equipped with a brake. Such brakes are shown conventionally in Figure 7 wherein the numeral 70 designates an ordinary brake flange secured to the shaft 24 and the numeral 71 designates any suitable conventional type of brake for retarding, stopping or holding the brake flange 70 and its shaft 24 against rotation. The revolving primary 26 of the motor 25 may be formed, in a well known way, around its periphery to include a brake flange. A suitable well known brake may be installed as 72 for retarding, stopping or holding the revolving primary 26 of the motor 25. Any suitable form of well known brake control, or controls, may be installed for controlling the brakes 71, 72 such for instance as that suggested in Figure 7 by the rock shaft 73 together with the rocker 74, 74 and pedals 75, 75 suitably mounted in bearings as 76, 76.

The pedals 75 and rocker arms 74 are secured to the shaft 73 and the rocker arms are oppositely connected to said brakes. It is of course obvious that by suitably manipulating a pedal 75 the corresponding brake will be set. It is of course obvious that separate shafts may be operatively connected with the separate brakes and manipulated as above indicated.

What I claim is:—

1. A rotary well drilling device including electromagnetic motorized elements, operative means for varying the electro magnetic energies in said motorized elements, a drilling bit, connecting means, operatively connecting one of said elements to the drilling bit so as to impart torsion to said bit, connecting means, operatively connecting another of said elements to the said drilling bit so as to impart longitudinal movements to said bit, an electromagnetic differential

between at least two of said elements to control the direction and values of the said movements of said bit, said differential being conditioned on predetermined valves of torsion consistent with the varying weight of said bit and cosuspended parts, and shiftable means suitable for varying and changing the upward longitudinal speeds of said bit and varying cosuspended parts so as to utilize practically the full unrestricted power of said motorized elements.

2. A device including driving elements, a driven element, connecting means between one of said driving elements and the said driven element for imparting a work motion to said driven element, operative means connecting another one of said driving elements to the driven element whereby there is produced relative motion between said driven element and some other object, an electrical differential operating between at least two of said driving elements whereby the energy applied to the said driven element in the said first instance will remain substantially a constant and whereby said relative motion may be reversed if said energy rises above a predetermined value.

3. A device including, driving elements, a driven element, connecting means between one of said driving elements and said driven element for imparting motion of one kind to said driven element, operative means connecting one of said driving elements to the driven element whereby relative motion is set up between said driven element and another object, said relative motion differing in effect from the first said mentioned motion of said driven element, an electrical differential operating between at least two of said driving elements whereby the energy transmitted by said first connecting means is maintained within predetermined limits and whereby said relative motion may be reversed.

4. A device, including, a driving means, a driven element, a connecting means between said driving means and said driven element whereby movement is imparted to said driven element, operative means between said driving means and said driven element whereby another movement in kind is produced in said driven element, an electrical differential whereby the energy transmitted by said first connecting means is maintained within predetermined limits and whereby said last movement may be reversed and shiftable means whereby practically the full torque and speed of the driving means can be utilized at all times in moving the driven element.

5. A device including, a driving means, a driven element, a connecting transmitting means between said driving means and said driven element, whereby a rotary movement is imparted to said driven element, an operative transmitting means connecting said driven element to said driving means whereby a movement other than rotative is relatively applied to said driven element, a differential, controlled primarily by the torque applied to said driven element and which, through the said connecting, and said operative means, determines the value and direction of the said other than rotative movement of said driven element and a shiftable means whereby both said transmitting means may be utilized to transmit one of the above movements to the driven element.

6. The combination of a work device, means for feeding the work device relatively toward and from its work, driving means for said work device, driving means for said feeding means, an electrical differential between the two driving means adapted to drive the feeding means in either direction in accordance with the resistance offered the work device.

7. In combination a motor characterized by a multiple of independently rotatable elements, a work device, means for feeding the work device, connecting means between one of said elements and the work device to operate the work device, connecting means between a second one of said elements and the feeding means to operate the feeding means, and means to vary the power flow between said two elements whereby said second element varies its rotation from zero in either direction to start, stop and reverse the feeding means proportionally as resistance is offered the work device.

8. A motive power unit for driving a cutting tool comprising a main driving motor, a cutting tool adapted to be driven by said motor, a means for controlling the feed of the cutting tool, a second motor having its rotor directly connected to the rotor of said first motor for regulating the feed of said cutting tool with respect to the work, and means whereby the stator of said second motor can rotate with respect to its rotor to thereby control the feed controlling means of said cutting tool.

9. A motor power unit for driving a cutting tool comprising a driving motor, a cutting tool adapted to be driven by said motor, a means for controlling the feed for the cutting tool, a second motor having two independently rotatable members and having one of said members connected to the rotor of the first motor for regulating the feed for said cutting tool relative to the work, and means whereby the other of said rotating members of the second motor can rotate with respect to said first rotating member to thereby control the feed controlling means for said cutting tool.

10. A motive power unit for driving a device comprising a driving motor, a device adapted to be driven by said motor, means for controlling another relative movement for the device, a second motor having two rotatable members and having one of said members connected to the rotor of the first motor for regulating said other movement of the device with relative respect to work, and means whereby the other of said rotating members of the second motor can rotate to control said other movement of the device.

11. A motive power unit for driving a device comprising a motor, a device adapted to be driven by said motor, means for controlling the feed for the device, said motor including two independently rotatable members, one of said members being connected to said device so as to drive said device, the other of said two members being connected to the feed controlling means to thereby control the feeding for said device.

12. A well drillling apparatus comprising a single motor including two rotatable members, a drill, connecting means between the drill and one of said rotatable members to transmit work motion to the drill, feed controlling means connecting the other said rotatable member and the drill to thereby control the feed of said drill.

13. An electro-mechanical motor power unit for driving and feeding a drill comprising a motor for driving the drill, a means for controlling the feed of the drill, a second motor for driving the feed controlling means of said drill, one rotatable member of said second motor being mechanically connected with the rotor of said first motor and having a second rotatable member of

said second motor mounted to freely rotate with respect to said first member and connected with the feed controlling means for said drill whereby the feed of the drill will be determined by the speed of said first motor.

14. A unit for driving and feeding a device comprising a driving means for driving the device, a means for controlling the feed for the device, means for driving said feed control, said means including two movable members, the first of said movable members being connected to, and so as to move in constant accord with, said driving means for driving the device, the second of said movable members being connected with the feed controlling means for said device whereby the feed for said device will be determined by the speed of said driving means for driving the device.

15. An electro-mechanical motive power unit for driving and feeding a device comprising a motor having two independently rotatable members for driving and feeding the device, means for controlling the feed of the device driven by one of said rotatable members of said motor, the other said rotatable member of said motor being connected to said device to drive said device.

16. A well drilling device, including a single motor having two independently rotatable members one of which drives the device and the other of which controls the feeding of the device.

17. A motive power unit for driving drills and the like, comprising a pair of induction motors having their rotors mounted upon a common shaft, one of said motors having its stator mounted upon said shaft so as to freely rotate about its rotor, means for transmitting power from said shaft to said drill whereby the same will be turned, a feed controlling device for the drill and means connecting the rotatable stator of one of said motors, with the drill feed controlling device whereby the feed of said drill will be regulated.

18. A power unit for driving a well drill comprising a pair of motors, each motor having a rotatable member mechanically connected to a rotatable member of the other motor of said pair so as to revolve said members in accord one with the other, one of said motors also having a second rotatable member which is independently rotatable with reference to the first, means for transmitting power from said motors to said drill whereby the same will be turned, a feed control for said drill including means connecting said motors with said drill whereby the feed of said drill will be regulated.

19. A power unit for driving a device, comprising a pair of motors, each of which motors include a movable member connected to a movable member of the other motor of said pair so as to move said members one in accord with the other, one of said motors also having a second movable member which is independently movable with reference to the first movable member of said motor, means for transmitting motion to the device from the movable members whereby the device be given a work motion and also a relative feeding motion so as to tend to apply a constant force to the work motion of the device.

20. A power unit including only a single motor for driving and controlling the feed for a device comprising a single motor having two movable members, operative means between said members and the device for transmitting the drive and for transmitting the feed control from said members to the device, releasable means operative to apply the power of the motor to the device either through said drive only or through said feed control only or through both the drive and the feed control.

21. A power unit including only a single motor for driving and controlling the feed for a device comprising a single motor having two movable members, operative means between said members and the device for transmitting the drive and for transmitting the feed control from said members to the device, releasable means operative to apply the power of the motor to the device.

22. In an electro-magnetic motive power unit for driving well drilling equipment and the like, a main driving motor for rotating the drill, a second motor of the induction type having its rotor directly connected to said main motor, means whereby the stator of said second motor may rotate about its rotor, and means operated by the movement of said stator for controlling the feed of the drill.

23. In a power unit for driving well drilling equipment and the like, a driving motor for rotating the drill, a second motor having two rotatable members one of which members is directly connected to said driving motor, means whereby the other said member of the second motor may rotate relatively to said first member of the second motor and means operated by the movement of said second member of said second motor for controlling the feed of the drill.

24. In a power unit for operating a device, a driving unit for producing work motion in said device, a controlling unit having two movable members, one of said members being so associated with said driving unit as to move in accord with the actuating element of said driving unit, the second movable member of said controlling unit being so associated with said first movable member of said controlling unit and with said device whereby said second member of said controlling unit can move relative to said first movable member and controls the feed of said device by its movements.

25. In a power plan including only a single energized motor for operating the work motion and the relative feed motion of a device, an energized motor including two relatively movable members, the first of said members being so connected to said device as to impart work motion to said device, the second of said members being so connected to said device as to control the feed motion of said device proportionally to the quantity of resistance to the power applied in said motor.

26. In a power plan including only a single energized motor for operating the work motion and the relative feed motion of a device, an energized motor including two relatively movable members, the first of said members being so connected to said device as to impart work motion to said device, the second of said members being so connected to said device as to control the feed motion of said device proportionally to the quantity of resistance to the power applied in said motor, and control means whereby the motion of said device may be restricted to only a forward or reverse work motion, or only a forward or reverse feed motion.

27. In an electro-magnetic motive power unit for driving well drilling equipment and the like, the combination of a main driving motor for rotating the drill, a drill feed determining means, and an electro-magnetic differential means com-

prising an induction motor having its primary and secondary windings mounted rotatably and mechanically connected with said driving motor and the drill feeding means whereby the feed of said drill is determined by the speed of said driving motor.

28. In a motive power unit for driving well drilling equipment and the like, the combination of a motive power device for rotating the drill, means for controlling the feed of the drill and a means for driving the means for controlling the feed of the drill comprising a pair of rotatable electro-magnetic elements adapted to rotate with respect to each other when energized, one of which is mechanically connected to and rotatable with said motive power device and the other with the drill feed controlling means, whereby the drill will be raised and lowered in response to changes in the speed of said motive power device.

29. In a motive power unit for driving well drilling equipment and the like, the combination of a motive power device for rotating the drill, means for driving the feed of the drill, a means for controlling the means for driving the feed of the drill comprising an induction motor unit having rotatable primary and secondary elements, means for mechanically connecting one of said rotatable elements with said motive power device whereby it will rotate therewith, and means connecting the other of said elements with a drill feed controlling device whereby the slip between said elements will determine the feed of said drill.

30. In a motive power unit for driving well drilling equipment and the like, the combination of a motive power device for rotating the drill, means for determining the feed of the drill, a means for controlling the means for determining the feed of the drill comprising an induction motor unit having rotatable primary and secondary elements, means for mechanically connecting one of said rotatable elements with said motive power device whereby it will rotate therewith, means connecting the other of said elements with a drill feed determining device so that the slip between said elements will determine the feed of said drill, and means whereby the slip between said elements may be varied.

31. In a motive power unit for well drilling rigs and the like, the combination of a main power unit for operating the drill, a mechanism for controlling the feed of the drill, and an induction motor element mechanically connected to said main power unit having means whereby it will operate to drive the drill feed controlling mechanism when said main power unit is operating and operate to hoist the drill when said main power unit is stationary.

32. In an electro-magnetic motive power unit for driving well drilling equipment and the like, the combination of a main driving motor for rotating the drill, a drill feed controlling means, and a gearless electro-magnetic differential means mechanically connected between said driving motor and the drill feed controlling means whereby the feed of said drill is determined by the speed of said driving motor.

33. In a motive power unit for drill driving, hoisting, and regulating, the combination of a main driving motor, a drill feed controlling means, a second motor mechanically connected to said main motor for driving the drill feed controlling means, means operated by said main motor for hoisting, and means whereby the torque of said second motor can be applied when desired with the torque of said main motor in hoisting.

34. In a system for earth drilling, the combination of a drilling tool, a motor therefor, said motor having a rotor for rotating the tool and a second rotor for hoisting said tool, and electroresponsive means for differentially connecting said rotors.

35. In a system for earth drilling, the combination of a drilling tool and a motor therefor, said motor having a rotor for rotating the tool and a second rotor for hoisting said tool and windings for controlling the effect of said rotors.

36. In a system for earth drilling, the combination of a drilling tool, a motor therefor, said motor having a stator primary winding, a rotor secondary winding cooperating therewith to operate the tool, a second primary winding carried by said rotor and a second rotor having a secondary winding, and means comprising the tool for restraining the first named rotor.

37. In a system of earth drilling, the combination of a drilling tool, a motor therefor, said motor having a stator primary winding, a rotor secondary winding cooperating therewith, means for operatively connecting said rotor to said tool, a second rotor operatively connected to said tool, and means for rendering said rotors effective to simultaneously control said tool.

38. In a system of earth drilling, the combination of a drilling tool and a motor therefor, said motor having a stator primary winding, a rotor secondary winding cooperating therewith, means for operatively connecting said rotor to said tool, and a second rotor controlled by the first-named rotor for also controlling said tool.

39. In a system of earth drilling, the combination of a drilling tool, a motor therefor, said motor having a stator primary winding, a rotor secondary winding cooperating therewith, means for operatively connecting said rotor to said tool, a primary winding carried by said rotor, a second rotor operatively connected to said tool, and means for rendering said rotors effective to simultaneously control said tool.

40. In a system of earth drilling, the combination of a drilling tool, a motor therefor, said motor having a primary winding, a rotor secondary winding cooperating therewith, means for operatively connecting said rotor to rotate said tool, a second rotor operatively connected to said tool for effecting longitudinal movement of said tool, and means for rendering said rotors effective to simultaneously control said tool.

41. In a system of earth drilling, the combination of a drilling tool, a motor therefor, said motor having a rotor for rotating the tool and a second rotor for hoisting said tool, electroresponsive means for differentially connecting said rotors, and means for restraining said rotation when hoisting said tool.

42. In a system of earth drilling, the combination with a rotary drilling tool and an electric motor therefor, said electric motor having rotatable primary and secondary members, of means for operatively connecting the primary and secondary members to control said tool.

43. In a system of earth drilling, the combination with a rotary drilling tool and an electric motor therefor, said electric motor having rotatable primary and secondary members, of means comprising the suspended weight of said tool for restraining the rotation of said primary member, and means for operatively connecting said secondary member to rotate said tool.

44. In a drilling system, the combination with

a drilling tool, of an electric motor having two rotatable members respectively adapted to impart longitudinal and rotary motions to said tool.

45. In a drilling system, the combination with a drilling tool, of an electric motor having two rotatable members respectively adapted to impart a rotary and hoisting movement to said tool.

46. In a drilling system, the combination with a rotary drilling table and a tool hoist, of an electric motor having two rotatable members respectively adapted to operate said table and said hoist.

47. The combination of a work device, means for feeding the work device, an electric motor having both armature and field elements rotatable, and means operatively connecting the work device to one element and the feeding means to the other element.

48. The combination of a rotary drilling device, means for feeding the drilling device, an electric motor having both armature and field elements rotatable, means connected to one of said elements for turning the rotary device against its working resistance, and means connected to the other element for varying automatically the feeding means in accordance with the resistance encountered by the drilling device.

49. The combination of a rotary drilling device, means for feeding the drilling device, an electric motor having both armature and field elements rotatable, means connected to one of said elements for turning the rotary device against its working resistance, and means connected to the other element for varying automatically the feeding means in accordance with the resistance encountered by the drilling device and for automatically causing the feed of the drilling device to be reversed when the said resistance reaches a predetermined value.

50. The combination of a work device, means for feeding the work device, an alternating current motor of the slip-ring type having both armature and field elements rotatable, and means operatively connecting the work device to one element and the feeding means to the other element.

51. In combination with a rotary drill, an electric motor, said electric motor having two major movable members, one of said members being adapted to rotate the drill and the other adapted to regulate the longitudinal feed of the drill.

52. In combination with a rotary drill stem, an electric motor, said motor having two relatively rotatable driving members, one of said members being connected to the drill stem for rotating the same, and the other connected to the drill stem for regulating the longitudinal feed of the drill.

53. In combination with a rotary drill stem, an electric motor having two freely revolvable members adapted to have imposed thereon proportional forces by the electromagnetic field of the motor, means connecting one of such members to effect rotation of the drill stem, and means connecting the other member to regulate the feed of the drill stem.

54. In combination with a rotary drill, an electric motor, said electric motor having two major mutually actuating movable members, one of said members being adapted to rotate the drill and the other adapted to regulate the longitudinal feed of the drill.

55. In an automatic well drilling apparatus, the combination with a drill stem, rotating means for the drill stem and suspending means for the drill stem, of an electric motor having two rotatable parts connected to the suspending means and rotating means respectively, the motor being operative to apply balanced forces for operating such parts.

56. In a rotary well drilling apparatus, the combination of a drill stem, rotating means for the drill stem, suspending means for the drill stem, an electric motor having two winding-carrying parts mounted for independent rotation, a connection from the suspending means to one of such last mentioned parts and a connection from the rotating means to the other part.

57. In an apparatus for drilling wells, the combination of a drill stem, drill stem suspending means, drill stem rotating means, and a source of power embodying two mutually actuating members each receiving its power from a force reacting upon the other member, one of said members being connected to the suspending means, and one of said members being connected to the rotating means.

58. In a drilling apparatus the combination of: a drill column having a tool at the lower end thereof, said tool being adapted to engage the lower end of a well; rotating mechanism for rotating said drill column; supporting mechanism for supporting a portion of the weight of said drill column; and a motor, said motor having a rotor connected to said rotating mechanism for actuating same, and a second rotor connected to said supporting mechanism for actuating same in a manner to control the pressure of engagement of said tool on the bottom of the well.

59. In a drilling apparatus the combination of: a drill column having a tool at the lower end thereof, said tool being adapted to engage the lower end of a well; rotating mechanism for rotating said drill column; supporting mechanism for supporting a portion of the weight of said drill column; and a motor, said motor having a rotor connected to said rotating mechanism for actuating same, and a second rotor connected to said supporting mechanism for actuating same in a manner to feed said drill column in proportion to the pressure of engagement of said tool on the bottom of the well.

CHARLES R. EDWARDS.