

Feb. 7, 1928.

1,658,262

R. A. SPERRY ET AL  
MEANS FOR AUTOMATIC DRILLING

Filed June 25, 1924

4 Sheets-Sheet 1

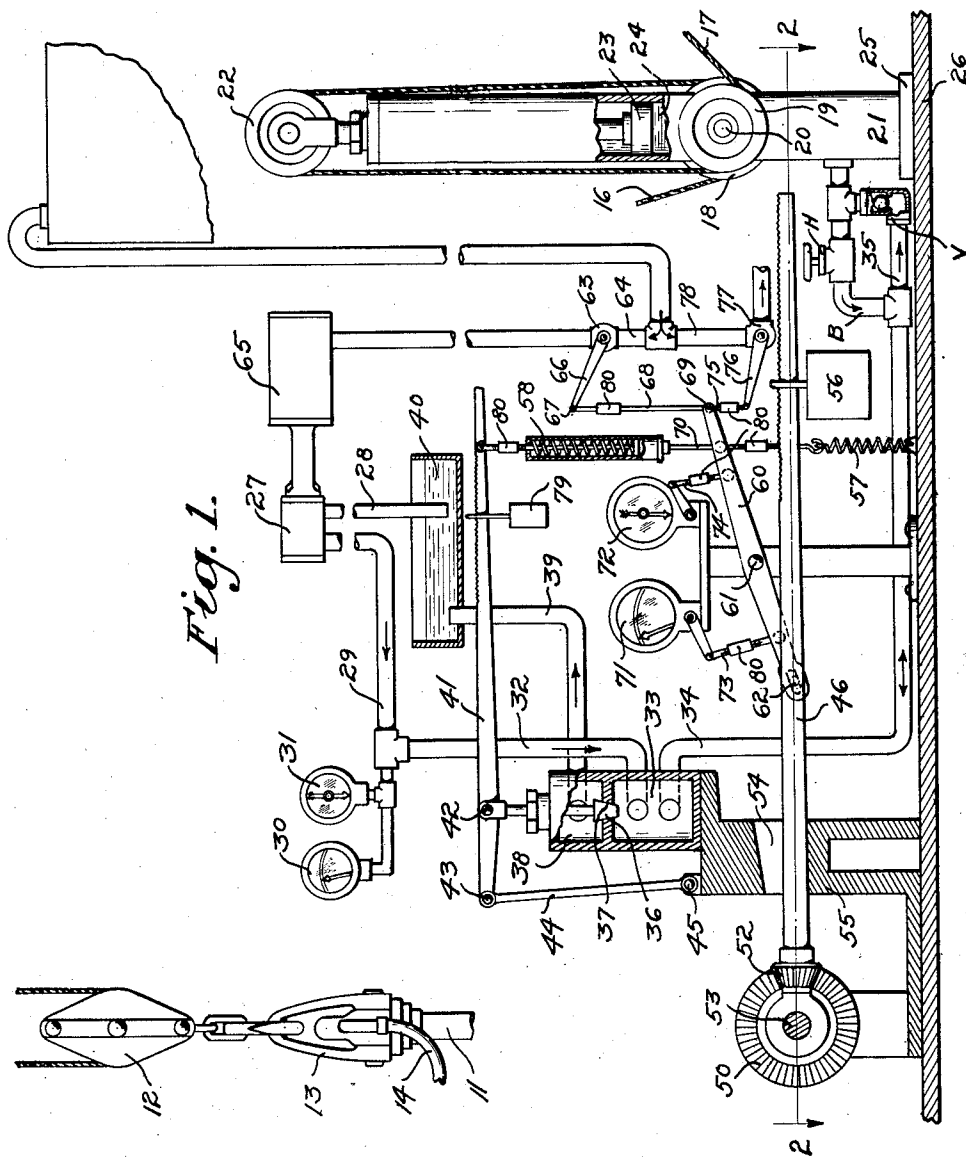


Fig. 1.

INVENTORS:  
RICHARD A. SPERRY,  
SAMUEL J. DICKEY,  
JOHN A. ZUBLIN.

BY  
*Graham & Lewis*  
ATTORNEYS.

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4 Sheets-Sheet 2

Fig. 2.

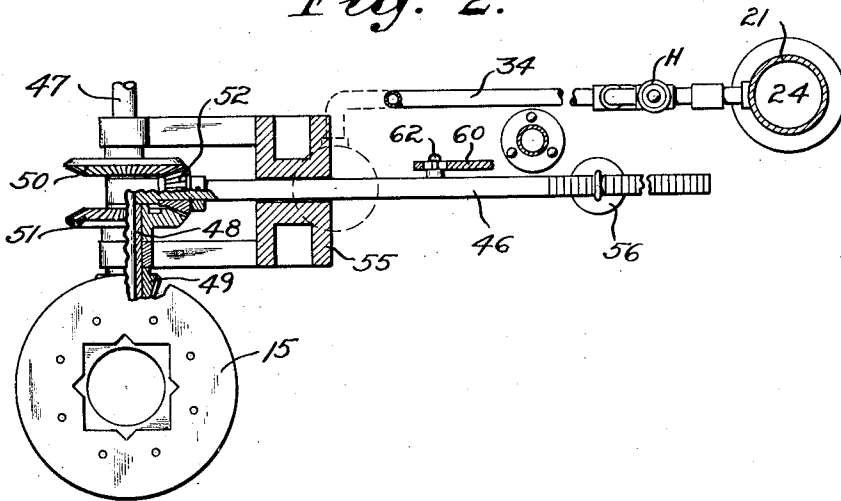
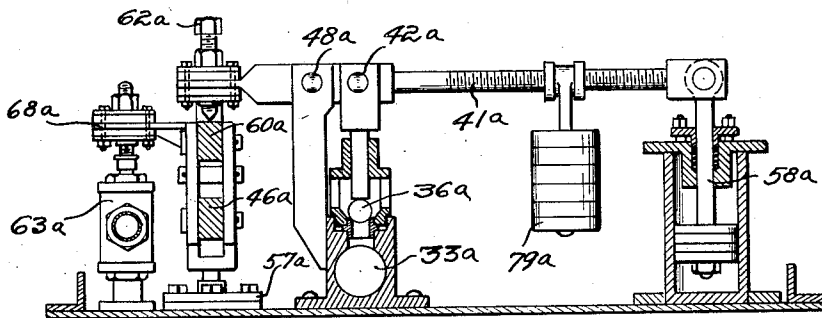


Fig. 7.



INVENTORS:  
RICHARD A. SPERRY,  
SAMUEL J. DICKEY,  
JOHN A. ZUBLIN,  
BY  
*Graham & Kinnic*  
ATTORNEYS.

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4 Sheets-Sheet 3

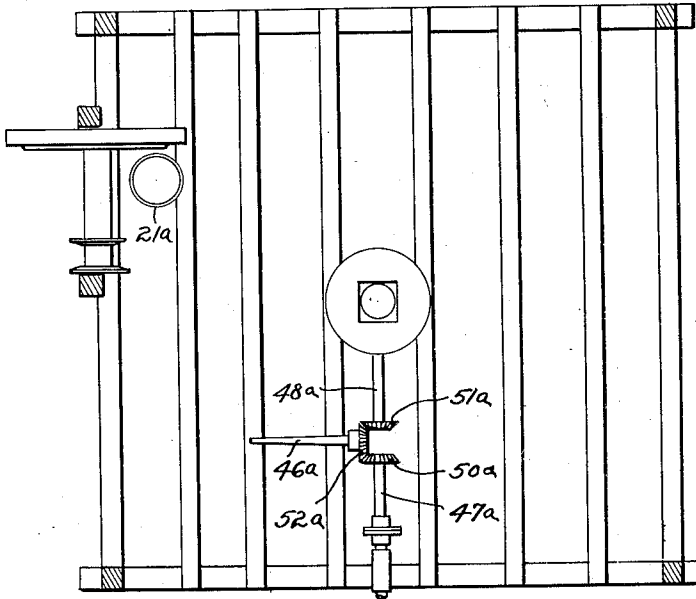


Fig. 3.

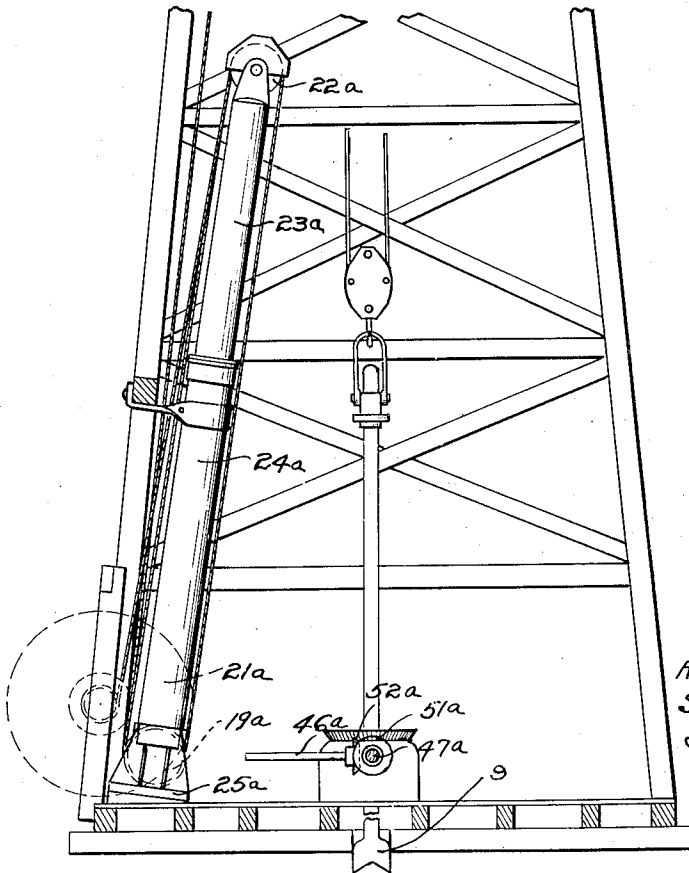


Fig. 4.

INVENTORS:  
RICHARD A. SPERRY,  
SAMUEL J. DICKEY,  
JOHN A. ZUBLIN,  
BY  
*Graham & Lewis*  
ATTORNEYS.

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Fig. 5.

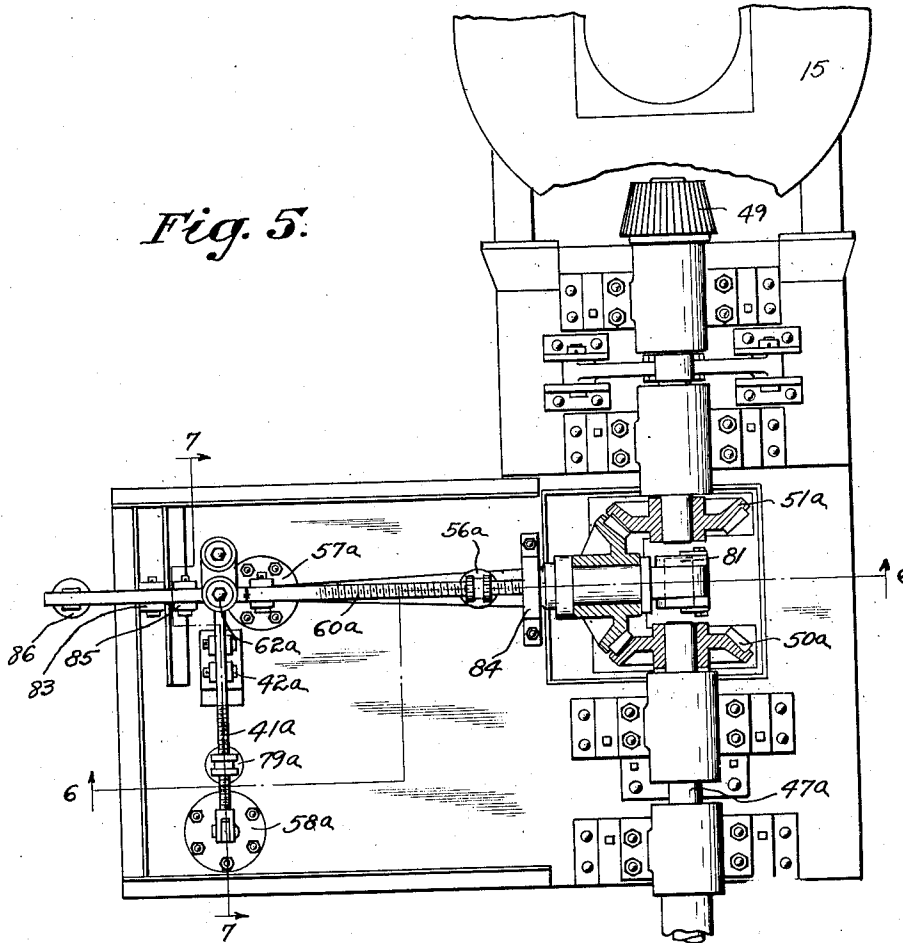
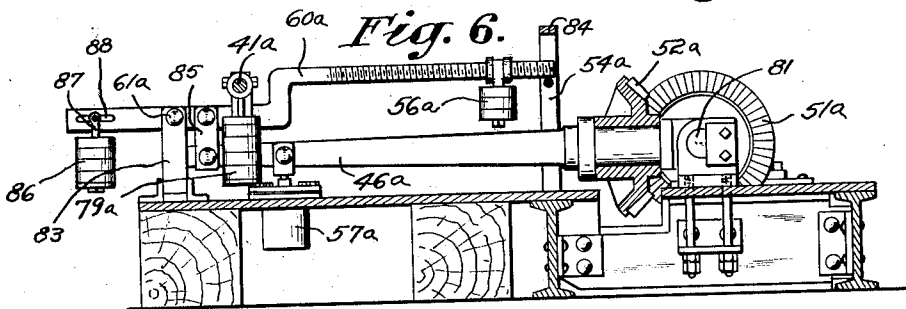


Fig. 6.



INVENTORS:  
RICHARD A. SPERRY,  
SAMUEL J. DICKEY,  
JOHN A. ZUBLIN,  
By *Graham & McMei*  
ATTORNEYS.

# UNITED STATES PATENT OFFICE.

RICHARD A. SPERRY, SAMUEL J. DICKEY, AND JOHN A. ZUBLIN, OF LOS ANGELES, CALIFORNIA, ASSIGNORS TO GENERAL PETROLEUM CORPORATION OF CALIFORNIA, A CORPORATION OF DELAWARE.

## MEANS FOR AUTOMATIC DRILLING.

Application filed June 25, 1924. Serial No. 722,338.

Our present invention includes a method of and means for automatic drilling; and it is a special object of this invention to provide an efficient and reliable organization  
5 whereby either the pressure of a rotary drill or the torque to which a string of drill pipe is subjected, or both said pressure and said torque, may be automatically regulated.

In a co-pending application (Serial No. 10 722,337, filed June 25, 1924), we have disclosed and claimed a fluid operated cable-handling drill jack suitable for use in predetermining the bottom pressure of a drill, during operation; in another co-pending  
15 application (Serial No. 722,339, filed June 25, 1924), we have disclosed and claimed a device for the measurement and control of torsional strains in drill pipe; and it is an object of our present invention to utilize  
20 certain principles of the above mentioned devices in a complete system of automatic drilling by means of a rotary drill.

To obviate the necessity of reference to our mentioned copending applications, we here-  
25 describe such features thereof as are pertinent to our present invention,—a preferred embodiment of which may comprise, as a feeding device, a fluid operated jack, and, as rotating means, a torque-responsive device  
30 including a planetary transmission comprising an intermediate rotary element. The translatory movement of this intermediate element may, in case of undue resistance, impart motion to a lever controlling a valve  
35 by which the pressure in said jack and the consequent movements of a piston therein, and thereby the pressure on a drill, may be controlled.

It will be understood to be vitally necessary, in the automatic control of drilling  
40 operations, to keep the torsional moment of a drill pipe within a limit of safety; and the maximum efficiency of drilling operations may require a constant approximation to  
45 said limit without danger of surpassing the same; and it is accordingly an object of our invention to provide torque-responsive means for the control of the admission or  
50 exit of a fluid from a rotary drill jack, our preferred means for this purpose comprising a lever movable by a rotary element constituting part of a planetary transmission interposed in the driving means employed to

rotate a string of drill pipe, and said lever may be employed not only to control an outlet valve through which a fluid may be normally circulated by means of a pump but also to control the supply of a motor fluid to said pump, or even that to an engine rotating said drill pipe.

In general, it is an object of our invention to provide means and methods for maintaining in drilling, a constant bottom pressure, such as may be suitable for use in a specific formation; and we may use therein any preferred means for predetermining a maximum torsional strain on drill pipe; and we aim to adapt our novel means and methods to any type, make, length, or size of drill pipe.

Other objects of our invention will appear from the following description of an advantageous embodiment thereof, taken in connection with the appended claims and the accompanying drawings, in which

Fig. 1 is a diagrammatic elevational view partially in section.

Fig. 2 is a corresponding horizontal sectional view, on a slightly reduced scale, this view being taken substantially on the line 80 2—2 of Fig. 1.

Fig. 3 is a plan view, with details omitted, showing the lay-out of an alternative installation, as actually constructed.

Fig. 4 is an elevational view showing only 85 the hydraulic jack of the same installation in its relation to frame and platform elements.

Fig. 5 is a somewhat enlarged plan view, with parts broken away, showing optional 90 details not disclosed in preceding figures.

Fig. 6 is a vertical section substantially on the line 6—6 of Fig. 5.

Fig. 7 is a vertical section substantially on the line 7—7 of Fig. 5. 95

Referring to the details of that specific embodiment of our invention chosen for purposes of illustration, in Figs. 1 and 2, 11 may be a string of drill pipe supported by means of a block 12, a swivel 13 being interposed, 100 and the pipe 11 being fed with water or slush in a usual manner, as by a hose 14. The drill pipe 11 also carries a suitable bit 9 at its lower end.

The pipe 11 may be rotated by means of 105 a usual table 15, within which the pipe 11

may be secured in a usual or preferred manner; and the feed of the pipe 11 may be controlled by the movement of a cable 16, the end 17 of which may be connected with, for example, a calf wheel not shown. Although, the block 12 may be moved by a calf wheel, or the like, we interpose, as best shown in Fig. 1, one or more pairs of fixed sheaves 18 and 19, shown as pivoted at 20 upon the body of a fluid operated jack 21; and we interpose between the fixed sheaves 18 and 19, a movable sheave or sheaves 22, shown as supported by means of a piston 23, movable under fluid pressure within the cylinder 24 of the jack 21, this jack being shown as supported upon a base 25 rigidly secured to a foundation 26.

To impart movement to the piston 23, we may employ means such as a pump 27, having a feed pipe 28 and a delivery pipe 29. The delivery pipe 29 (which may optionally be provided with gauges 30 and 31 adapted to indicate respectively the fluid pressure within the pipe 29 and the pressure on the drill at the lower end of the drill pipe 11) may lead, as by a pipe 32, to a chamber 33, provided with an outlet pipe 34 leading, by way of a valved pipe 35, into the bottom of the cylinder 24 of the jack 21; and the chamber 33 may be provided with an additional outlet 37 containing a pressure controlled valve 36, the opening of which may permit fluid to escape into a secondary chamber 38 or otherwise into an over-flow pipe 39, by which water (or other fluid employed to operate the jack 21) may be permitted to return to a tank 40, for re-use by the pump 27. It will be obvious that, by the described construction, we provide means whereby a constantly-operated pump may be enabled either to produce a desired pressure within the jack 21, thereby increasing the distance between the mentioned fixed sheaves and the movable sheave 22 and elevating the block 12, and we also provide means whereby this elevating effect may be dependent upon the position of the valve 36, the complete opening of which is intended to be effective to prevent upward movement of the piston 23.

Excessive pressure produced by continuous operation of the pump 27 is intended to be relieved by automatic opening of the valve 36; and to control this valve, we may employ means such as a lever 41, pivoted thereto at 42 and shown as fulcrumed at 43 on a link 44, provided with a fixed pivot 45. For the automatic manipulation of the lever 41, we consider it advantageous to provide a mechanical connection between this lever and a torque-responsive lever 46, to which movement may be imparted whenever the torsional strain upon the drill pipe 11 shall exceed a predetermined maximum, as herein-after described.

In order to control the admission and

egress of fluid from the cylinder 24 of our fluid operated jack, and to make the vertical movements of the drill pipe 11 dependent upon both an automatic opening of the valve 36 and a manual adjustment, we may interpose in the pipe 35 an upwardly or inwardly opening check valve V; and we may also provide a by-pass B around this valve with a regulating hand-valve H, the construction here referred to being such that, although fluid may enter the cylinder 24 at a rate predetermined by the operation of the pump 27 and the extent to which the valve 36 is opened, the egress of fluid from said cylinder, and the consequent maximum rate of lowering of the drill pipe 11, may be predetermined by a suitable adjustment of the regulating valve H. Obviously either a closing of the regulating valve H or a closing of the automatic valve 36 may be effective, even assuming a continued operation of the pump 27, to limit the rate of descent of the drill pipe 11 and the consequent pressure exerted by the drill carried thereby.

In order to impart suitable movement to the lever 46, or its equivalent, we consider it advantageous to rotate the table 15 by driving means comprising a planetary transmission interposed between a driving shaft 47 and a driven shaft 48, the latter being shown as carrying a beveled gear 49 having direct engagement with said table. The planetary transmission may comprise a driving gear 50 and a driven gear 51, between which we may interpose a rotatable element such as the small gear 52, rotatably mounted upon the lever 46, which may be pivoted on an extension 53 of the drive shaft 47, the construction here referred to being such that any slowing of the driven gear 51, such as may result from an undue pressure on the drill point and a consequent undue torsional strain in the drill pipe, must result in an upward pivotal movement of the lever 46. Instead of transmitting movement directly from this lever to the lever 41, controlling the valve 36 and thereby the movement of the block 12 and drill pipe 11, we may optionally interpose resilient connections and any preferred system of links and levers.

Suitably to guide and restrain the lever 46, or its equivalent, we may employ means such as a guide opening 54 in a block 55 and an adjustable or variable weight 56; and the position of this weight may predetermine the maximum torsional strain required to produce an upward movement of the lever 46. With these means we may optionally associate resilient restraining means such as dash pots or springs 57 and 58; and, instead of securing these means directly to the lever 46, we may optionally secure them to an intermediate or secondary lever 60, shown as pivoted at 61 and as having, at 62, a pin and slot connection with the lever 46; and

the mentioned secondary lever 60, or its equivalent, may serve also as a means for controlling the extent of opening of a valve 63 in a steam line 64, leading to the pump engine 65. The relationship between the levers 46 and 60 may be such that, whenever an excessive torsional strain upon the drill pipe 11 causes the lever 46 to rise, the upward movement thereof may cause a downward movement of the remote end of the lever 60, thereby opening the valve 63 by means of the lever 66, the outer end of this lever being pivoted at 67 to a link 68, shown as pivoted also at 69 to the secondary lever 60; and the mentioned downward movement of the remote end of the lever 60 may also be effective, as by means of a link 70 by which connection may be made with the lever 41, in controlling the valve 36, the mentioned spring 58 being optionally interposed in this link.

Either the torque-responsive lever 46 or the secondary lever 60 may optionally be connected with indicators such as are shown at 71 and 72, these indicators being illustrated as respectively connected by links 73 and 74 with the secondary lever 60; and this secondary lever may optionally be connected, as by an additional link 75, with a lever 76 controlling the throttle valve 77 in a branch 78 of the steam line leading to the drilling engine. The lever 41, controlling the valve 36 may be normally held down not only by its described connection with the secondary lever 60, but by variable means such as a weight 79, mounted on either arm thereof; and, in order to permit of any necessary relative adjustments between the parts referred to, turn buckles 80, or their equivalent, may be interposed at any suitable points.

As to the operation of our above described organization, a "set" having been obtained, and assuming the movable sheave 22 to be in its elevated position and the pump 27 to be in operation at all times, the valve 36 may be so adjusted, by the means described, as to permit of a continuous re-circulation of water or other fluid through the pipe 39 and a simultaneous slow delivery, through the valve H in by-pass B, of a regulated outflow permitting a gradual and controlled descent of the piston 23. Whenever, as by reason of the encountering of a harder stratum of rock, the torsional strain upon the string of pipe 11 shall rise above a predetermined maximum, the elevation of the torque-responsive lever 46, causing a downward movement of the remote end of the secondary lever 60, may produce a downward movement of the lever 41, thereby closing the valve 36 and necessitating an inward flow through the pipes 34 and 35, past the check valve V, thereby promptly raising the piston 23 and elevating the block 12, to relieve the

strain upon the pipe 11. By the mentioned additional connection between the secondary lever 60 and the valve 63, an increased supply of steam may be simultaneously delivered to the pump engine; and, if desired, the same upward movement of the secondary lever 60 may be effective, as by means of the lever 76, to reduce the delivery of steam to the drilling engine. We believe, however, that the drilling engine may preferably be permitted to continue to rotate the table 15 under uniform steam pressure, the elevation of the pipe 11 being immediately effective to reduce the torsional strains thereon, permitting the levers 46 and 41 both to drop promptly to their normal positions, and permitting the drill pipe 11, constantly rotated, gradually and cautiously to descend, and the drilling to continue.

In the form of our invention illustrated in Figs. 3 to 7 inclusive, it will be noted that the jack 21<sup>a</sup> (Fig. 4) comprises telescoping sections 23<sup>a</sup> and 24<sup>a</sup>, the latter serving as a piston to which the movable sheaves 22<sup>a</sup> are secured, the fixed sheaves 19<sup>a</sup> being shown as secured at the base 25<sup>a</sup> of the jack, and all details of piping being omitted as sufficiently indicated in the preceding figures.

In this embodiment of our invention, the torque-responsive lever 46<sup>a</sup> is shown as carrying an intermediate gear 52<sup>a</sup> of substantially the same size as the gears 50<sup>a</sup> and 51<sup>a</sup>, respectively secured to the driving shaft 47<sup>a</sup> and the driven shaft 48<sup>a</sup>; and the lever 46<sup>a</sup> is shown as fulcrumed on a short shaft 81, substantially concentric with the shafts 47<sup>a</sup> and 48<sup>a</sup>. The secondary lever 60<sup>a</sup> is shown as pivoted at 61<sup>a</sup> to a post 83 serving also as a guide; and, in this embodiment, the mentioned secondary lever carries the counterweight 56<sup>a</sup>, and inner guide 54<sup>a</sup> is integral with a stroke stop 84 for said secondary lever. The two mentioned levers are shown as connected by a link 85, and a dash pot 57<sup>a</sup> is shown as connected directly beneath a lever 46<sup>a</sup>.

In this embodiment of our invention, the valve control lever 41<sup>a</sup>, pivoted at 42<sup>a</sup> is shown as movable by the contacting of an adjustable pin 62<sup>a</sup>, resiliently supported, with the secondary lever 60<sup>a</sup>, and as carrying an adjustable and variable counterweight 79<sup>a</sup>, the end of this lever being provided with a dash pot 58<sup>a</sup>, all of the mentioned parts being the functional equivalents of corresponding parts previously described.

By means, such as we have described, we may get a full automatic control of the drilling operation, maintaining the torsional moment of the drill pipe at all times within a limit of safety. Any necessary withdrawal of the drill from the bottom of the hole may take place very rapidly; and

the lowering of the bit to its original position may take place very slowly for the purpose of enabling the whole system to recover, with full caution, its original state of equilibrium. Except as readjustment may be required by reason of conditions encountered, a constant pressure may normally be maintained at all times within the drill jack or on the drill, irrespective of the weight, length or size of the drill pipe; and a drill string may nevertheless be manipulated from a calf wheel or spooling drum in a usual way.

The valves 63<sup>a</sup>, controlling the steam supply to the pumping engine (or equivalent means controlling any alternative source of power) may be connected, as by slightly resilient means comprising an arm 68<sup>a</sup>, with the secondary lever 60<sup>a</sup>; and the outer end of this lever may optionally be extended, as best shown in Figs. 5 and 6, to carry an adjustable and variable weight 86, this weight being hung by means comprising a stirrup 87, movable within a slot 88 in the mentioned extension of the lever 60<sup>a</sup>. The units comprised in the weights 56 (or 56<sup>a</sup>) and 79 (or 79<sup>a</sup>) and also the units comprised in the weight 86, when employed, may be identical and interchangeable in use; and the weight 86 may be employed to put the entire lever system initially in balance with reference to the dead weight of its component parts, the other mentioned weights being readjusted from time to time according to variations in the weight of a string of drill pipe, a preferred bottom pressure of the drill, or other considerations.

Although we have herein described one complete embodiment of our invention, it will be understood that various features thereof might be independently employed and also that various modifications might be made, by those skilled in the art, without the slightest departure from the spirit and scope of our invention, as the same is indicated above and in the following claims.

We claim as our invention:

1. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; means operated by the pressure of a molecular fluid for feeding said supporting means; torque responsive means associated with said drive means and means connecting said torque responsive means to said feeding means in such manner as to affect the feed thereof.

2. In a rotary drilling organization comprising a string of drill pipe, the combination of: means comprising a fluid-operated jack for supporting said pipe, operating means for rotating said pipe, control means

responsive to excessive torque interposed in said operating means, and means operated by said torque-responsive means for varying the fluid pressure within said jack.

3. In a rotary drilling organization comprising a string of drill pipe, the combination of: means comprising a fluid-operated jack for supporting said pipe, operating means for rotating said pipe, control means responsive to excessive torque interposed in said operating means, a valve connected to said fluid-operated jack for controlling the operation thereof, and means operated by said torque-responsive means for controlling the operation of said valve.

4. In a rotary drilling organization comprising a string of drill pipe, the combination of: means comprising a fluid-operated jack for supporting said pipe, operating means for rotating said pipe, control means responsive to excessive torque interposed in said operating means, pumping means for supplying fluid to said fluid-operated jack, and means operated by said torque-responsive means for controlling a rate of pumping of said pumping means.

5. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; means operated by the pressure of a molecular fluid for feeding said supporting means; torque-responsive means associated with said drive means, and means connecting said torque responsive means to said feeding means in such a manner as to reduce the feed of said drill pipe when the torque in said drill pipe increases above a certain amount.

6. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; means operated by the pressure of a molecular fluid for feeding said supporting means; operating means whereby the operation of said means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said feeding means; torque responsive means associated with said drive means; and means connecting said torque responsive means to said operating means in such manner as to cause said operating means to function in accordance with the torque of said drill pipe.

7. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said

drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a valve; and torque-responsive means associated with said drive means and with said operating means in such a manner as to actuate said valve in order to cause said operating means to function in accordance with the torque of said drill pipe.

8. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a valve; and torque-responsive means associated with said drive means and with said operating means in such a manner as to actuate said valve so that said operating means will function to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

9. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a pump; and torque-responsive means associated with said drive means and with said operating means in such a manner as to affect the operation of said pump so that said operating means will function to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

10. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a valve and a pump; and torque-responsive means associated with said drive means and with said operating means in such a manner as to actuate said valve and affect the operation of said pump so that said operating means will function

to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

11. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means in the form of a fluid-operated jack for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means; and torque-responsive means associated with said drive means and with said operating means in such a manner as to cause said operating means to function in accordance with the torque of said drill pipe.

12. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means in the form of a fluid-operated jack for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a valve; and torque-responsive means associated with said operating means in such a manner as to actuate said valve so that said operating means will function to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

13. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means in the form of a fluid-operated jack for feeding said supporting means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a pump; and torque-responsive means associated with said drive means and with said operating means in such a manner as to affect the operation of said pump so that said operating means will function to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

14. In a rotary drilling organization, the combination of: a string of drill pipe; drive means for rotating said drill pipe; supporting means for supporting said drill pipe; fluid-operated means in the form of a fluid-operated jack for feeding said supporting

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means; operating means whereby the operation of said fluid-operated means for feeding said supporting means and said drill pipe is controlled, said operating means controlling the supply and egress of fluid to and from said fluid-operated means, said operating means having a valve and a pump; and torque-responsive means associated with said drive means and with said operating means in such a manner as to actuate said valve and affect the operation of said pump so that

said operating means will function to decrease the feed of said drill pipe when the torque therein increases above a certain amount.

In testimony whereof, we have hereunto set our hands at Los Angeles, California, this 17th day of June, 1924.

RICHARD A. SPERRY.  
JOHN A. ZUBLIN.  
SAMUEL J. DICKEY.