

No. 726,111.

PATENTED APR. 21, 1903.

J. C. SWAN.
DRILLING APPARATUS.
APPLICATION FILED JAN. 17, 1902.

NO MODEL.

5 SHEETS—SHEET 1.

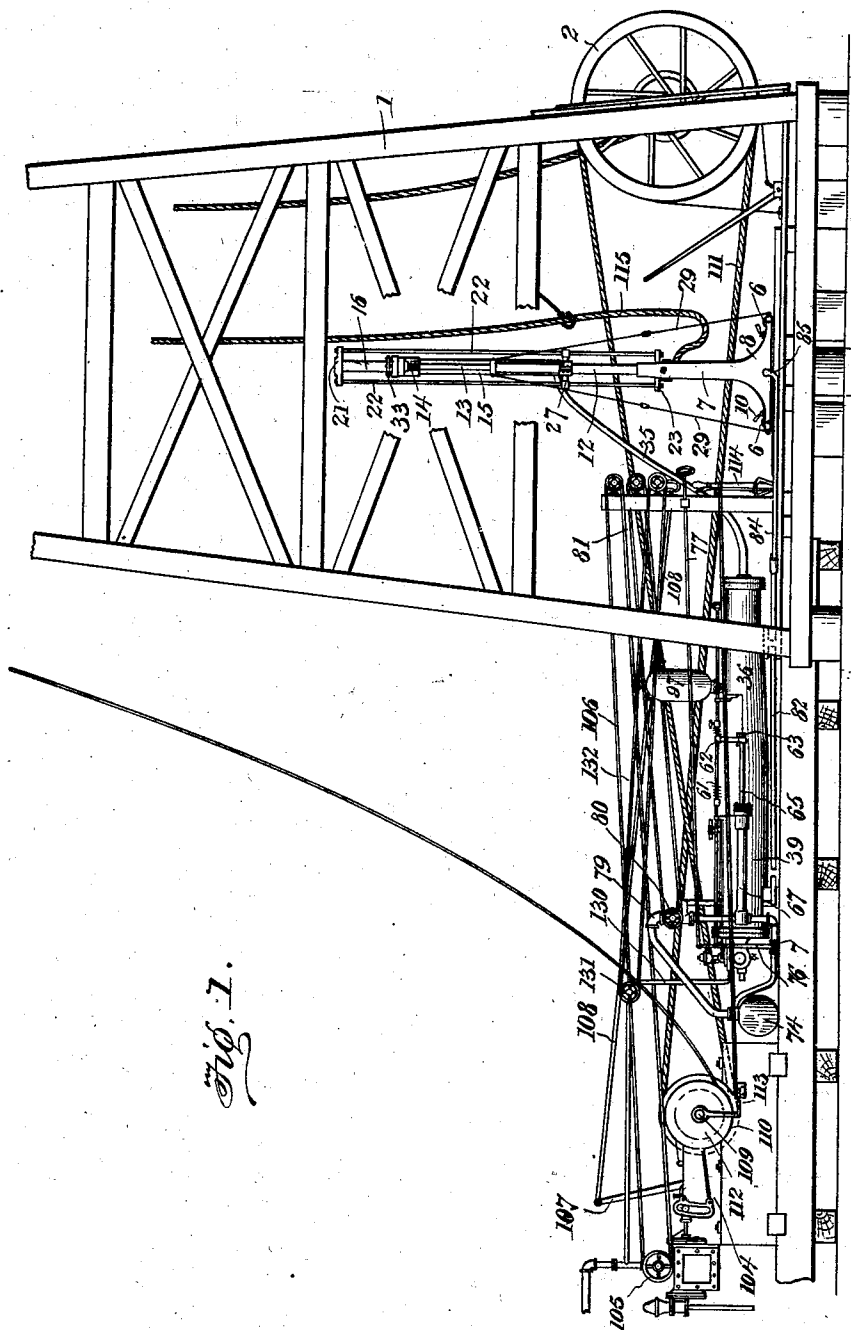


Fig. 1.

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5 SHEETS—SHEET 2.

Fig. 10. Fig. 11.

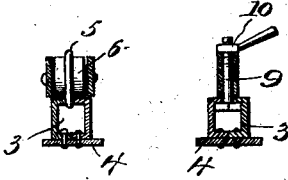


Fig. 2.

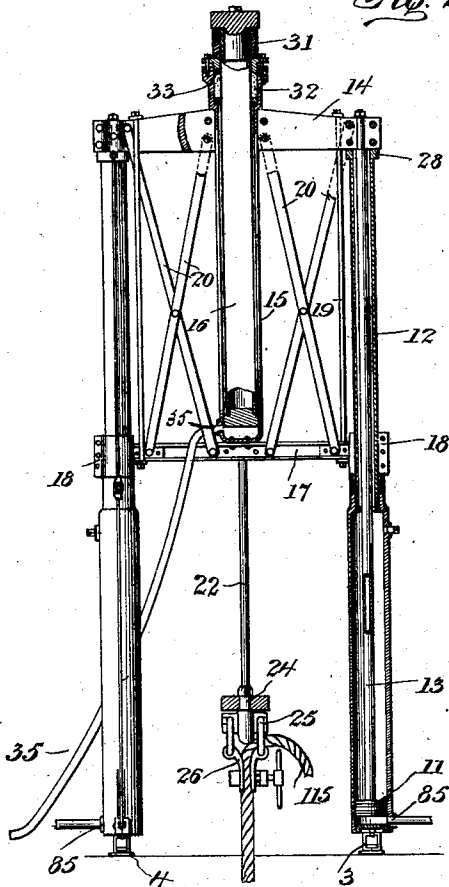
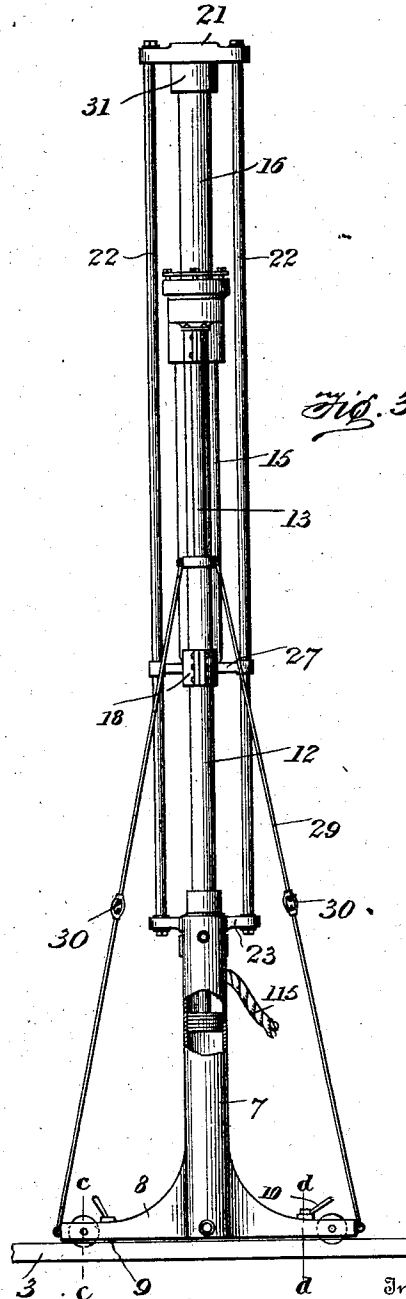


Fig. 3.



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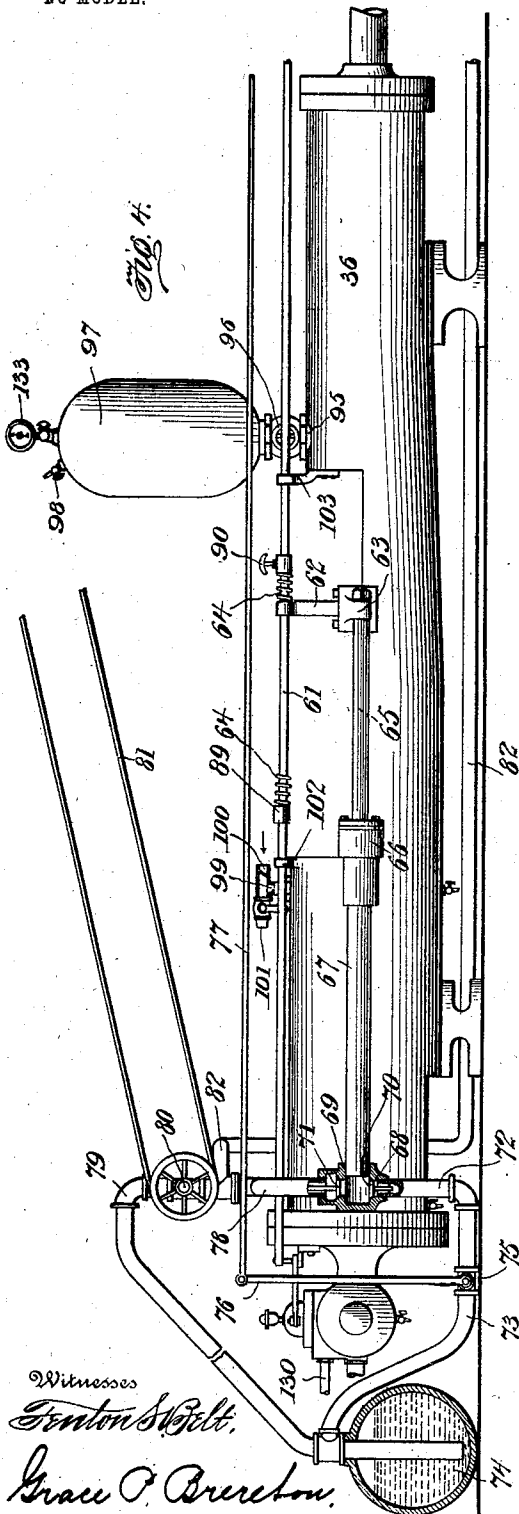
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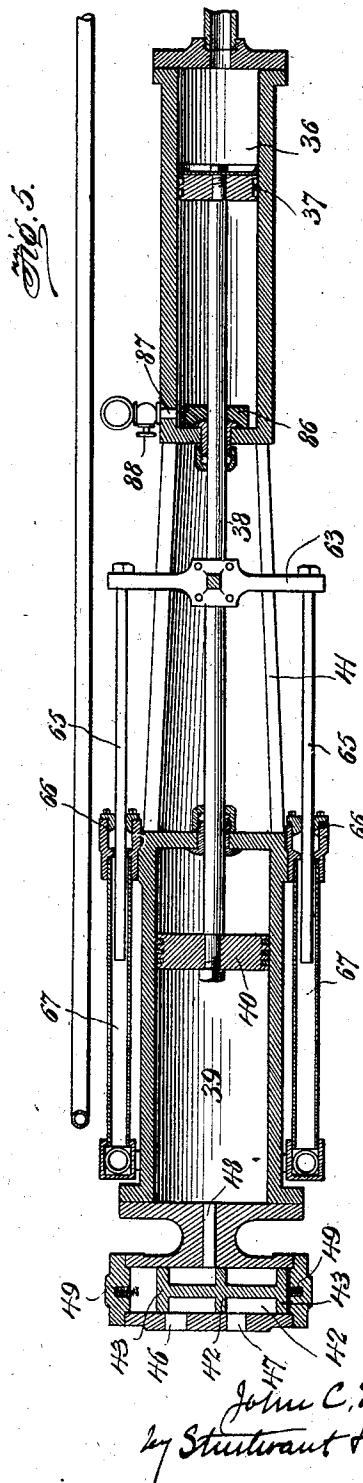
5 SHEETS—SHEET 3.



Witnesses

Gen. S. B. B.

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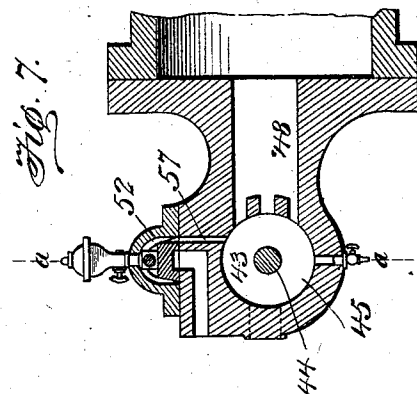
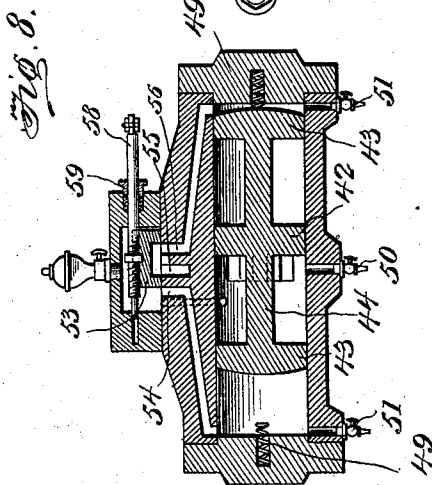
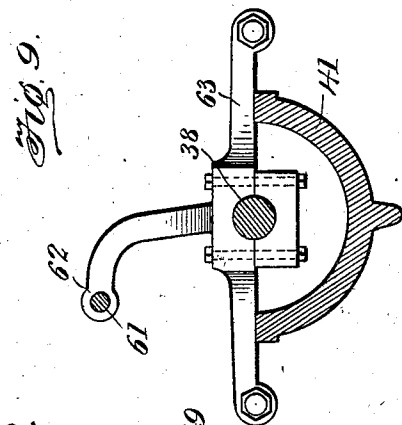
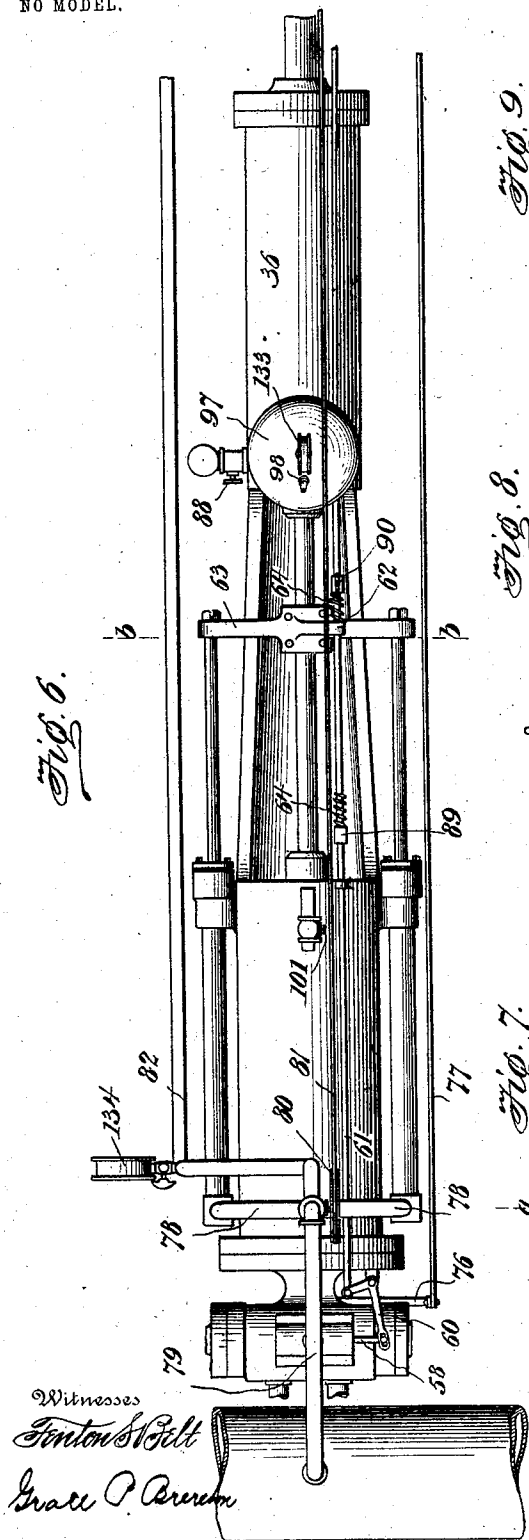
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5 SHEETS—SHEET 4.



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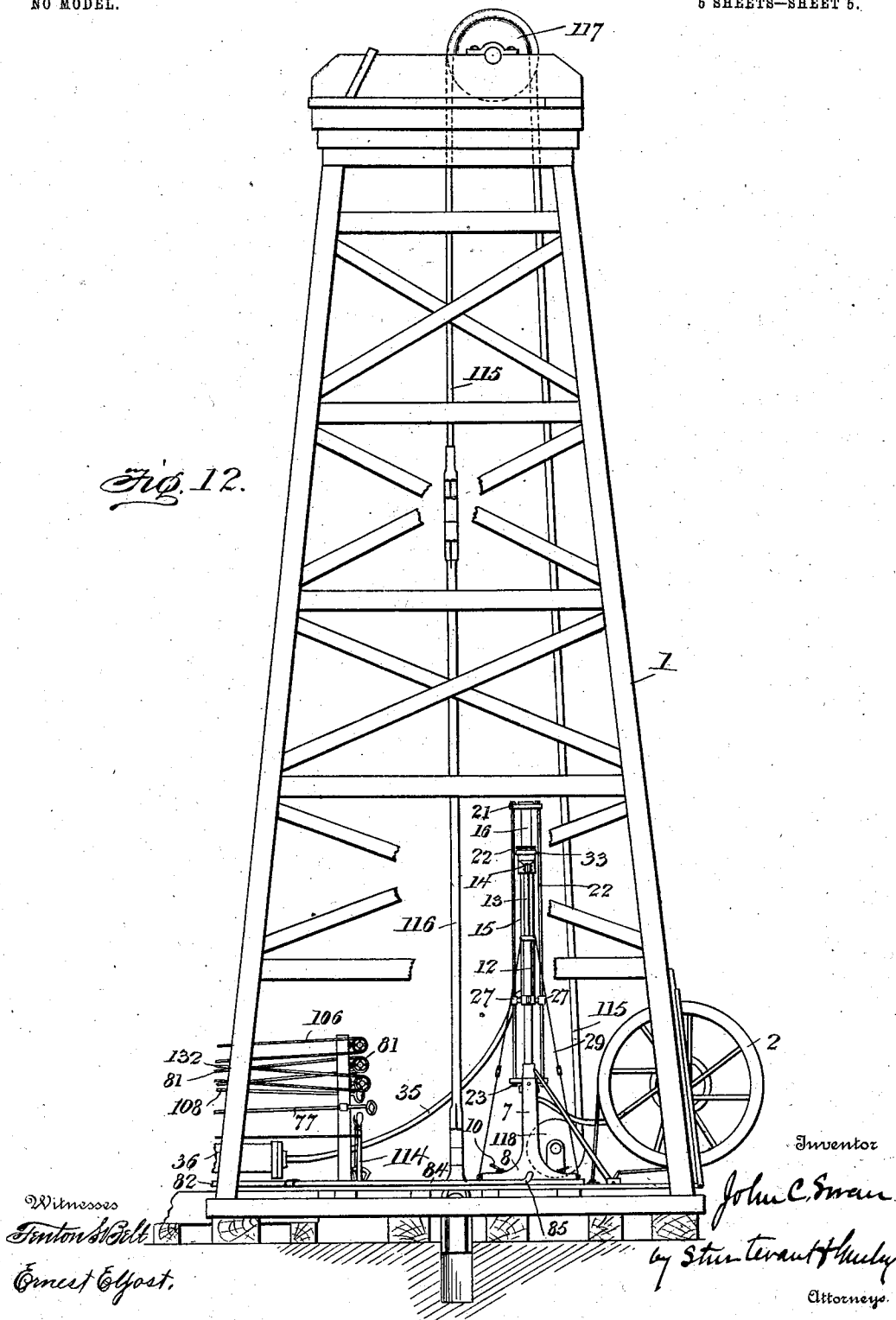
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NO MODEL.

5 SHEETS—SHEET 5.

Fig. 12.



UNITED STATES PATENT OFFICE.

JOHN C. SWAN, OF MARIETTA, OHIO.

DRILLING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 726,111, dated April 21, 1903.

Application filed January 17, 1902. Serial No. 90,176. (No model.)

To all whom it may concern:

Be it known that I, JOHN C. SWAN, a citizen of the United States, residing at Marietta, in the county of Washington, State of Ohio, have invented certain new and useful Improvements in Drilling Apparatus, of which the following is a description, reference being had to the accompanying drawings and to the characters of reference marked thereon.

My invention relates to apparatus for drilling oil, Artesian, or other wells, and has for its object to provide an apparatus for such purposes which shall be capable of effecting all the operations necessary in drilling, shall be simple and comparatively inexpensive in construction and economical in operation, which shall be readily manipulated and controlled by the driller, which shall be sufficiently light to be readily transportable, and shall be capable of drilling a number of wells.

The drilling-rig commonly in use of the walking-beam or allied type, known in the art as the "standard" rig, is with comparatively slight changes the same that was in use forty years ago. It is heavy and cumbersome, involving in its construction thousands of feet of lumber and heavy and expensive rig-irons, and requiring several days and the labor of a number of workmen to set it up. It occupies a considerable ground space, and wherever, as is very often the case, the surface about the well is uneven this ground space must be cleared and graded. It requires an engine of large power for the drilling operation and expensive belting for connecting the engine with the drilling apparatus. Much of the energy necessary for raising the drilling-tools is stored in the balance-wheel on the downstroke, and when the tools stick while drilling at any point near the surface the drilling-cable is apt to be parted before the engine can be stopped. The wear on the working parts is such that belting and other parts are in frequent need of repair and often must be replaced by new parts in order to finish a single deep well. Such a rig can seldom be used for drilling more than one well and cannot be moved for more than a short distance without taking it to pieces. As the rig is largely constructed of timber, it is not adapted for use in regions

where by reason of lack of moisture in the atmosphere timber becomes dried to such an extent as to impair its strength.

The invention hereinafter described is intended to obviate the above disadvantages and difficulties, as well as many others which are inseparable from the use of the drilling-rig commonly used.

The apparatus hereinafter described is intended to be made almost wholly of metal and is therefore not readily affected by climatic or weather conditions and may be used under climatic conditions where timber construction cannot be used and may be operated under weather conditions which would necessitate the shutting down of the ordinary rig. Among the other features of the apparatus hereinafter described are the direct vertical lift given to the tools, its rapidity of operation, the ready change of length of stroke without stopping the drilling operation, the freedom of the apparatus from machine momentum, permitting the instantaneous stopping of the drilling operation, the unlimited stroke which may be used, the possibility of either accelerating or retarding the downstroke, and the certainty of indication which it gives of the conditions under which the tools are operating.

Other features of the invention will be hereinafter pointed out.

In the drawings, Figure 1 is a general view showing the drilling apparatus arranged in position in a derrick. Fig. 2 is an elevation, partly in section, showing the portion of the drilling apparatus by which the drilling-tools are operated. Fig. 3 is a side view of the same apparatus, showing the parts in a different position. Fig. 4 is a side elevation of the apparatus for supplying liquid to the tool-actuating and uptake cylinders. Fig. 5 is a horizontal section showing the same apparatus as Fig. 4, the view being taken on the plane of the center of the cylinders. Fig. 6 is a plan view of the apparatus shown in Figs. 4 and 5. Fig. 7 is a vertical sectional detail view on a longitudinal plane showing the valve which controls the admission of steam to the main cylinder. Fig. 8 is a sectional view taken on the line *a a* of Fig. 7. Fig. 9 is a sectional view taken on the line *b b* of Fig. 6, showing the cross-head and

trough connecting the steam-cylinder with the fluid-cylinder. Fig. 10 is a detail showing the track and roller on which the drilling apparatus is carried, the view being taken on the line *c c* of Fig. 3; and Fig. 11 is a detail view showing the means for locking the drilling apparatus in position and is taken on the line *d d* of Fig. 3. Fig. 12 shows the drilling apparatus arranged in position to begin the drilling of a well.

Referring to the drawings, 1 is a derrick of usual construction, carrying the usual bull-wheels 2 in bearings secured to the framework in any suitable manner. Mounted on the sills of the derrick, so as to be level with the floor, are tracks 3, preferably constructed, as shown in detail in Figs. 10 and 11, of two channel-beams placed with their flanges inward and secured by bolts to a lower plate 4, their upper flanges being so arranged as to leave a space between them for the guiding-flange 5 of the rollers 6, carried by the drilling apparatus. The drilling apparatus comprises two side cylinders 7, each having connected therewith or preferably cast integral therewith a base 8 of sufficient length to give the apparatus a firm support. In this base are journaled the wheels 6, above referred to, and each base is provided with one or more locking-bolts 9, which extend between the flanges of the plates which form the track and have heads adapted to engage the under side of these flanges. Nuts 10 on the upper end of these bolts serve to draw the heads of the bolts into contact with the under faces of the flanges, and thus lock the drilling apparatus in position.

The side cylinders 7 for a portion of their length are made of sufficient diameter to receive pistons 11. To the upper end of these cylinders are secured tubular extensions 12. To the pistons 11 are secured piston-rods 13, preferably made hollow to avoid excessive weight. These piston-rods extend through and are guided by the tubular extensions 12. To the upper ends of these piston-rods 13 is secured a cross-head 14. This cross-head is preferably made in two parts, bolted together, the parts being so shaped as to form a clamp, in which is secured the upper end of a cylinder 15, in which is carried the main plunger 16, by which the tools are actuated. The lower end of the cylinder 15 is secured to a cross-bar 17, provided at its ends with collars 18, which surround and are adapted to travel on the tubular extensions 12, secured to the cylinders 7. The cross-bar 17 is connected with the cross-head 14 by rods 19 and diagonal braces 20, so as to form with the cross-head a rigid structure.

To the upper end of the main plunger 16 is secured a cross-head 21, arranged at right angles to the cross-head 14, to which are secured on opposite sides the vertical rods 22. These rods extend a sufficient distance below the cross-bar 17 to permit of a full stroke of

the plunger and at their lower ends are secured to a cross-head 23. Through this cross-head 23 extends a pin 24, on the end of which is carried, by means of a swivel 25, a rope-clamp 26, which may be of the usual construction employed in well-drilling apparatus.

For the purpose of guiding and steadying the movement of the vertical rods arms 27 are secured to the cross-bar 17, provided with collars through which the rods move freely. For the purpose of bracing the framework against movement the tubular extensions 12 are provided, preferably at their upper ends, with collars 28, preferably formed integrally therewith, and to these collars are secured the upper ends of brace-rods 29, the lower ends of which are secured to the outer ends of the base 8. For the purpose of tightening these brace-rods 29 they are preferably provided with turnbuckles 30.

Immediately below the cross-head 21 a spring 31, preferably of rubber, is provided, surrounding the plunger, and adapted to strike the upper end of the cylinder, so as to prevent the possibility, through breakage of any part of the apparatus, of injury to the lower end of the cylinder by making it impossible for the lower end of the plunger to strike the bottom of the cylinder. At the upper end of the cylinder and surrounding the plunger packing 32, compressed by a gland 33, is provided. The packing and gland may be of any desired construction, but must be of such character as to sustain the pressure and prevent leakage of the liquid introduced into the cylinder below the plunger.

Near the bottom of the cylinder 15 a port 34 is provided, through which fluid may be forced to lift the plunger in the cylinder. To this port is connected a flexible tube or hose 35. This flexible tube leads from the fluid-cylinder 36. Within the fluid-cylinder 36 is a piston 37, to which is connected a piston-rod 38, the other end of which extends into a steam-cylinder 39 and is provided with a piston 40. The fluid-cylinder 36 and steam-cylinder 39 are arranged in line and are preferably formed in one piece, the portion between them being cut away, as shown in Figs. 4 and 5, to form a trough 41.

The steam-cylinder and fluid-cylinder are preferably arranged horizontally. At its end farthest from the fluid-cylinder the steam-cylinder 39 is provided with a valve 42, by which steam may be admitted to force the piston 40 toward the fluid-cylinder, carrying with it, by means of the rod 38, the piston 37, forcing the fluid contained in the fluid-cylinder through the flexible tube 35 into the cylinder 15 beneath the lower end of the plunger 16, lifting the plunger and, through the cross-head 21 and rods 22, the rope-clamp 26. As the valve 42 is shifted, permitting the steam to be exhausted from the cylinder 39, the piston 40 and piston 37 will be free to re-

turn, permitting the fluid forced into the cylinder 15 to return through the flexible tube 35 into the fluid-cylinder.

The valve 42 is steam-operated in order to insure its quick operation. The valve is provided at either end with a head 43, connected with the valve 42 by rods 44, the heads being preferably of the same diameter as the valve 42. The valve is carried in a cylindrical casing 45, having an inlet-port 46 connected with the steam-supply 130 and exhaust-port 47, also connected by port 48 with the steam-cylinder 39. The ends of this casing 45 are provided with springs 49 to take up the shock of the heads 43 as the valve is shifted. The casing is also provided with a central drainage-cock 50 and also near its ends with drainage-cocks 51.

Above the casing 45 is arranged a valve-casing 52, in which is located a D-valve 53. The D-valve 53 is arranged to slide over ports 54, 55, and 56, of which the port 54 leads to one end of the main valve-casing 45, the port 56 leads to the other end of the main valve-casing, and the port 53 leads to an exhaust-port. Steam is admitted to the valve-casing 52 from the main valve-casing by a passage 57. The D-valve 53 is operated by a rod 58, extending through a stuffing-box 59, as shown in detail in Fig. 8. As the D-valve 53 is shifted by means of the rod 58 steam from the main valve-casing through the passage 57 entering the valve-casing 52 will be directed alternately to the opposite ends of the main valve-casing through the ports 54 and 56, causing the valve 42 to be quickly shifted to put the port 48 in communication alternately with the steam-port 46 and the exhaust 47.

The valve-rod 58 is operated through a bell-crank lever 60 and rod 61 by a tappet 62, carried by a cross-head 63, secured to and traveling with the piston-rod 38. The rod 61 carries two collars 89 and 90, adapted to be struck by the tappet 62 to cause the movement of the valve-rod 58. The collar 89 is fixed on the rod 61 and, if desired, may be welded to it. The collar 90 is made adjustable by means of a set-screw 91, which is preferably provided with a large head or handle to permit the collar to be readily shifted while the apparatus is in operation. The position of the collar 90 determines the length of the forward stroke of the piston 40, and consequently determines the distance to which the plunger 16 is actuated in lifting the tools. The collar 89 being fixed on the rod 61 insures the necessary movement of the valve-rod 58 to admit steam to the steam-cylinder 39 at the end of the rearward movement of the piston 40.

The cross-head 63 is preferably made in two parts, as shown, secured together by bolts to clamp it firmly on the piston-rod 38. The cross-head preferably slides on the upper edges of the trough 41, extending between the steam-cylinder 39 and fluid-cylinder 36. To the steam-cylinder 39 are bolted auxiliary pump-cylinders 67, provided at their rear

ends with ports 68 and 69. The lower port 68 is provided with an inwardly-opening check-valve 70, and the upper port is provided with an outwardly-opening check-valve 71. At their forward ends the auxiliary pump-cylinders are provided with stuffing-boxes 66, and through these stuffing-boxes move the plungers 65, which are secured at their forward ends to the ends of the cross-head 63.

From each of the ports 68 and 69 a pipe 72 leads to a point preferably below the steam-cylinder 39, and the two pipes 72 are there connected to a pipe 73, which leads to the bottom of a storage-reservoir 74. The pipe 73 is provided with a valve 75, operated by a lever 76, to which is connected a rod 77, leading to a point within the derrick in convenient reach of the driller. To the upper port 69 of the auxiliary pump-cylinders are connected pipes 78, which in turn are connected at a point above the steam-cylinder 39 with a main pipe 82, to which are connected flexible tubes 84, which lead to ports 85 at the base of the cylinders 7 beneath the pistons 11.

To the main pipe 82 is connected a by-pass pipe 79, leading from the bottom of the storage-reservoir 74. A by-pass valve 80 is provided in pipe 79, and this valve is arranged to be operated by means of a cord 81, which leads to a position within the derrick in convenient reach of the driller.

When the valve 75 is open, the fluid contained in the storage-reservoir 74 is free to enter the auxiliary pump-cylinders through ports 68 as the plungers 65 are moved forward by the cross-head 63. As the plungers move rearward on the return stroke the fluid which has entered the pump-cylinders will be forced through the ports 69 into the main pipe 82 and through the flexible tubes 84 will enter the cylinders 7, lifting the pistons 11 and through their connections lifting the drilling apparatus a distance corresponding with the length of stroke given to the plungers 65 as measured by the displacement area of the plunger 65 compared with the area of the cylinder 67.

When it is desired to lift the drilling apparatus to any desired distance within the limits of its travel, the tool being disconnected and the apparatus at rest, the by-pass valve 80 is opened, permitting fluid from the reservoir 74 to enter the main pipe 82 and through its action on the pistons 11 elevating the apparatus to the point desired.

The fluid contained in the storage-reservoir 74 is maintained constantly under pressure. If the fluid used is a liquid, the pressure is maintained by means of air or gas compressed above the surface of the liquid. Instead of compressed air or gas steam-pressure may be used, if desired. If preferred, the fluid may be air or gas or steam under pressure.

The pressure maintained within the storage-reservoir should be sufficient to raise the drilling apparatus when the drilling-tools are disconnected from it without the use of the aux-

iliary pump 67. The fluid-cylinder 36 is provided at its rear end with a spring or cushion 86, preferably of rubber, unless the liquid used in this cylinder, as hereinafter described, is of such character as to injuriously affect rubber. This cushion or spring takes up the shock of the piston 37 as it moves rearwardly to the limit of its stroke, and thus prevents injury to the head of the cylinder.

10 Near its rear end the cylinder 36 is provided with an opening or port 87. This opening or port is preferably arranged on the side of the cylinder. Connected with the opening or port 87 is a pipe provided with a stop-cock 88. This pipe is preferably extended upward beyond the stop-cock 88 to form a funnel for the introduction of liquid, as hereinafter described. The fluid-cylinder also has preferably on its upper side near its rear end a port or opening 95, to which is connected a short pipe provided with a stop-cock 96. To the upper end of this pipe is connected a pressure-tank 97, preferably provided on its closed upper end with an escape-cock 98. In the operation of this fluid-cylinder, if desired, the stop-cock 88 may be left open, in which case as the piston 37 is reciprocated it will alternately draw in air at atmospheric pressure and force it out through the cock. 30 If the stop-cock 88 is closed when the piston has reached the forward limit of its stroke, the air between the piston and the rear end of the cylinder will be compressed, resisting to some extent the rearward motion of the piston, and consequently resisting the return of fluid from the cylinder 15, checking the rapidity of the drop of the plunger 16 and the string of tools connected with it. If it is desired to still further increase the resistance to rearward movement of the piston 37, liquid of any kind desired may be introduced into the cylinder through the stop-cock 88, and, if desired, air under pressure may be introduced into the pressure-tank 97. The cock 45 96 being opened, the rearward movement of the piston 37 will force the liquid into the pressure-tank as the piston moves to the rear on its return stroke. By properly adjusting the pressure any desired resistance may be given to the rearward movement of the piston 37.

The steam-cylinder is provided near its forward end with a port or opening 99. With this port or opening is connected a pipe provided at one end with an inwardly-opening check-valve 100 and at the other end with a stop-cock 101. If it is desired to resist the forward movement of the piston 40 in the steam-cylinder, the stop-cock 101 will be closed, and as the air contained in the cylinder in front of the piston 40 is prevented from escaping by the check-valve 100 it will as it is compressed by the movement of the piston tend to resist this movement, and as the valve 65 42 is shifted, as before described, to open the exhaust the air compressed in front of the piston will act as a spring to aid in returning

the piston 40 to place. If it is not desired to thus resist the movement of the piston 40, the stop-cock 101 will be opened, and as the piston is reciprocated air will be drawn in and forced out freely. 70

Guides 102 and 103 are provided on the ends of the cylinders 39 and 36, respectively, to guide the rod 61. 75

At a convenient point, preferably in rear of the steam-cylinder 39 and the parts connected with it, a steam-engine 104 of any convenient type is placed. This engine will be provided with the usual throttle-valve 105, 80 arranged to be operated by a cord 106, extended to a point within the derrick in convenient reach of the driller. It will also be provided with the usual reversing-lever 107, arranged to be operated by a rod 108, extended to a position within the derrick in convenient reach of the operator. The shaft 109 of the engine will be provided with a pulley 110, connected by belt or rope 111 with the bull-wheel 2. Also on the shaft of the engine will be arranged the sand-reel 112, to which may be connected the usual sand-line running to a pulley at the top of the derrick. The sand-reel will be provided with the usual controlling means 113, arranged to be operated by a lever 114, located within the derrick in convenient reach of the driller. The drill-rope 115 will, as in the usual drilling-rig, be led over a pulley at the top of the derrick and thence downward to the bull-wheel 2. 100

Fig. 12 shows the arrangement of the drilling apparatus for "spudding in"—that is, drilling the first few feet of the well. For this purpose the drilling apparatus is shifted on the tracks to a position out of line with the hole to be drilled and locked in position by the locking-bolts 9. The drill-rope 115, carrying the string of drilling-tools 116, is led over a pulley 117 at the top of the derrick 1, which is shown of reduced height for convenience of illustration, and thence down under a pulley 118, preferably so constructed that the rope may be readily inserted from the side, as in what is known as a "snatch-block," secured to the sill of the derrick or to other permanent support and upward to the clamp of the drilling apparatus. The drilling apparatus in spudding in will be operated in the same manner as in the subsequent drilling. 120

As soon as the spudding-in operation is completed by drilling the hole sufficiently deep to permit the drilling-tool to be buried below the derrick-floor the drill-rope is removed from pulley 118, and the drilling apparatus is shifted to its normal position directly above the hole and secured in position by means of the locking-bolts 9, which also serve to prevent the possible upsetting of the apparatus whether in position or in its movement to and from position. By opening the by-pass valve 80 fluid is admitted to the cylinders 7 to elevate the framework which carries the drilling-cylinder 15 and its plunger 16, 125 130

preferably to the full limit of the movement of the pistons 11. The extent of movement of the pistons 11 preferably corresponds with the length of the main screw of the "temper-screw" commonly in use in drilling apparatus. The framework being thus elevated, the drill-rope is secured in the rope-clamp 26, and the apparatus is ready for the drilling operation.

The apparatus being in position, the driller by means of the cord 132 opens the throttle 131, admitting steam to the steam-cylinder 39, the valve 42 being open. The steam entering the steam-cylinder forces the piston 40 forward and with it the piston 37 of the fluid-cylinder 36. As the piston 37 moves forward it forces fluid through the flexible tube 35 into the cylinder 15 of the drilling apparatus beneath the plunger 16, lifting the plunger and through its connections to the drill-rope lifting the drilling-tools. As the piston 40 continues to move forward fluid is forced into the cylinder 15 until the tools are lifted the desired distance, the movement of the plunger being regulated by the position of the adjustable collar 90 on the rod 61. As the tappet 62 strikes the collar 90 the valve-rod 58, carrying the D-valve, is shifted, permitting steam to enter the valve-chamber 45 through the port 54, causing the valve 42 to be shifted, opening the exhaust-port, and instantly relieving the piston 40 from pressure and permitting the piston 37 of the fluid-cylinder to return to initial position. The plunger 16 being no longer sustained by pressure on the fluid in the fluid-chamber begins instantly to descend under the weight of the drilling-tools and drill-rope, permitting the tools to drop freely by force of gravity. The downward movement of the plunger 16 forces the liquid in the cylinder 15 back through the flexible tube 35 into the fluid-cylinder 36, returning the piston 37 and piston 40 to initial position. The piston 37 as it reaches the limit of its rearward movement strikes the cushion or spring 86 and is brought to rest before the plunger 16 reaches the bottom of the cylinder 15, the volume of fluid being such that a portion of it remains in the cylinder 15 when the plunger 16 has reached the limit of its downward movement, the admission of steam to the cylinder 39, as hereinafter described, also serving as a cushion to bring the piston 37 to rest. Just before the plunger 16 reaches the limit of its downward movement, forcing the pistons 37 and 40 back to initial position, the tappet 62, carried by the cross-head 63, strikes the fixed collar 89 on the rod 61, causing the valve 42, through the controlling means above described, to be shifted to again admit steam to the steam-cylinder 39, causing, as above described, fluid to be again forced into the cylinder 15 to again lift the plunger 16, and with it the drilling-tools, without appreciable pause. As the drilling progresses a suitable portion of the fluid in the cylinders 7, which, through the pistons 11, sustains the framework carrying the cylinder 15 and plunger 16, is permitted to return to the storage-reservoir 74 by opening the by-pass valve 80, the weight of the tools and drilling-rope being sufficient to overcome the pressure in the storage-reservoir. As the fluid passes out from below the pistons 11 the position of the cylinder and plunger and the drilling-tools is lowered the distance desired. The cylinders 7 in the operation of lowering the tools correspond to and take the place of the main screw on the temper-screw used in the ordinary drilling-rig. The descent of the plunger 16 is retarded to some extent by the resistance of the pistons 37 and 40 and by the resistance to the passage of fluid through the flexible tube 35, due to the fact that it forms a restricted passage; but this retardation will not under ordinary circumstances be sufficient to prevent the tools from following in their drop the well-known law of falling bodies. If for any reason it is found desirable to lessen this retardation, the stop-cock 101 at the end of the steam-cylinder 39 may be closed, in which case the forward movement of the piston 40 will compress the air in front of it, and when the valve 42 is shifted to open the exhaust the air so compressed will act as a spring to force the piston rearward, drawing with it the piston 37 of the fluid-cylinder 36, and by causing a partial vacuum in the fluid-cylinder exert suction on the fluid in the cylinder 15.

Ordinarily it will be found desirable to increase rather than lessen the retardation of the downward movement of the plunger 16. Such retardation may be caused by closing the stop-cock 88 when the piston 37 of the fluid-cylinder is at the limit of its forward movement, so that as the piston 37 returns it will compress the air contained in the cylinder and by the resistance of the air to compression will be checked in its rearward movement. Still greater retardation may be produced by introducing liquid into the fluid-cylinder 36 in rear of the piston 37, closing the stop-cock 88, and opening the stop-cock 96. In such case the piston 37 on its rearward movement will force the liquid contained in the cylinder in its rear into the pressure-tank 97 against the force of the air contained therein. By closing the cock 96 when the piston 37 is at its rearward position and opening the cock 88 air will be drawn into the cylinder as the piston moves forward, and by closing the cock 88 and opening the cock 96 when the piston reaches the limit of its forward movement the pressure in the pressure-tank 97 may be increased to any amount desired.

In any case the retardation of the plunger 16 will not be such as to prevent, as above stated, the drilling-tools from following the well-known law of falling bodies, for the reason that at no time would a practical driller interpose such counter-pressure as, taken

with the frictional resistance of the reciprocating parts, would more than counterbalance the weight of the drill-rope or other connecting means between the drilling-tools and the drilling apparatus.

By means of a pressure-gage 133, connected with the pressure-reservoir 97, the driller is informed of the pressure upon the back of the piston 37 and may reduce this pressure by opening the relief-cock 98 or increase it in the manner above described.

In order to elevate the drilling-tools against obstruction in the well-hole above them, as in what is known as "jarring up," the valve 75 will be opened by means of the lever 76, permitting fluid from the storage-reservoir 74 to enter the auxiliary pumps 67, and as the plunger 16 descends on its return stroke it will cause these pumps to force fluid into the cylinders 7, elevating the framework carrying the cylinder 15 and plunger 16, so that the next upward stroke will start from a higher point, the cylinders 7 and their connections being thus adapted to take the place of the temper-screw used in the ordinary rig both for "taking-up screw" in the jarring-up operation as well as, as above described, for "letting-out screw" as the drilling-tool advances in the ordinary operation of drilling. In thus operating the auxiliary pumps 67 the plunger 16, carried down on its return stroke by the weight of the drilling-tools and drilling-rope, forcing the piston 37 rearward, as above described, and carrying with the piston the piston-rod 38 and cross-head 63, drives the plunger 65 into the pump-cylinders 67, forcing the fluid contained in these pump-cylinders into the main pipe 82 and through the flexible tubes 84 into the cylinders 7 beneath the pistons 11.

A pressure-gage 134, arranged at any convenient point on or in connection with the main pipe 82, serves to inform the driller of the pressure effected on the fluid in the cylinders 7 by the weight of the drilling-tools and drill-rope when the tools are hanging free in the clear hole and by its changes to indicate positively and clearly the conditions under which the tools are operating at any period of their stroke.

In the use of the ordinary form of drilling-rig the driller is unable to know with certainty the conditions under which the drilling-tools are operating and must depend for such information upon observation of the working of the drilling-engine and the movement of the drill-rope. The gage 134 thus gives certain information as to conditions which it has been possible heretofore only to estimate.

By shifting the position of the collar 90 on the rod 61 the stroke of the plunger 16 in the cylinder 15 may be regulated as desired, and by means of the set-screw the length of the stroke may be changed without stopping the operation of drilling, which cannot be done in the drilling-rig in ordinary use.

The cylinder 15 and piston 16 being located directly above and in line with the well-hole, the drill-rope is given direct vertical movement instead of movement in the arc of a circle, as in the ordinary drilling-rig, in which the drilling-rope is secured to the end of a walking-beam oscillating upon a pivot. By reason of this direct vertical movement wear of the drilling-rope on the top of the casing is avoided.

In the use of the drilling apparatus as above described the reversal of movement of the plunger 16 is practically instantaneous at both ends of its stroke, and it attains its full rate of movement immediately upon reversal. In its upward stroke its rate of movement is gradually slower as it approaches the highest point of the stroke, and in its downward stroke its rate of movement may be varied by regulation of the retarding means, as described; but the change of rate of movement will in any case be constant. In the ordinary drilling-rig, in which the walking-beam is actuated by means of a crank rotating about its axis at substantially the same angular velocity throughout a single rotation, the rate of movement of the walking-beam at the extremities of the stroke is less than at the middle of the stroke by reason of the fact that the movement of the crank through a given angle as it approaches and passes the opposite ends of a vertical diameter produces less vertical movement of the walking-beam than it does when approaching and passing the ends of a horizontal diameter. Thus in the ordinary drilling-rig the tools are lifted slowly from bottom and are prevented from dropping quickly as they are permitted to fall.

In the apparatus above described the drilling-tools are raised quickly from bottom and are free to fall instantly upon the plunger 16 reaching the limit of its upward stroke. By reason of this fact it will be found possible to use a substantially inelastic means, such as a wire rope, for connecting the drilling-tools with the apparatus.

The drilling apparatus being mounted on a movable carriage, it may be readily shifted out of line with the well-hole to permit the bailing out of the hole by means of the ordinary bailing devices carried by the sand-line or to permit of the insertion or withdrawal or coupling up of casing.

As the drilling devices are not driven by the engine 104, this engine need be of only sufficient power to operate the bull-wheel for hoisting and pulling out the drilling-tools or casing and to operate the sand-reel. The engine may consequently be of much less power than the engine needed in connection with the ordinary drilling-rig and may be of any desired type of hoisting-engine.

While I have described the framework carrying the vertically-arranged cylinder 15 and plunger 16 as mounted on tracks laid on a level with the derrick-floor, it will be under-

stood that these tracks may be on any suitable level and may be of any suitable construction. If desired, the tracks may be dispensed with and the framework arranged to be movable directly upon the derrick-floor or other suitable support within the derrick. So, too, if desired, the framework may be pivoted at any point of its base, so as to swing upon its pivot into and out of position.

10 The fluid-cylinder and steam-cylinder, while preferably arranged horizontally, as shown, may be arranged vertically or otherwise, if desired.

It will be understood that the details of construction may be varied from those shown and described. For instance, any other suitable form of valve for alternately opening and closing the admission and exhaust ports of the steam-cylinder may be used in place of the valve shown, a piston may be used in place of the plunger 16, and plungers may be used in place of the pistons 37 and 40. Instead of having the cylinder 15 fixed and the plunger 16 movable the arrangement may be reversed, in which case the drilling-rope would necessarily be connected with the cylinder. Many other changes in construction and arrangement may be made without departing from the spirit of the invention.

30 Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a well-drilling apparatus, a vertically-arranged cylinder, having one end closed, a plunger arranged within the cylinder, means for supporting one of these parts, the other being movable, means for introducing fluid under pressure between the plunger and the closed end of the cylinder to raise the movable part relative to the other, and a rope-clamp connected to the movable part and located below its lower end in line with its center; substantially as described.

2. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, means for raising the movable part relative to the other by fluid-pressure, and a rope-clamp connected to the movable part and located below its lower end in line with its center, and a movable carriage for sustaining the cylinder and plunger; substantially as described.

3. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, means for raising the movable part relative to the other by fluid-pressure, and a rope-clamp connected to the movable part and located below its lower end in line with its center, a movable carriage for sustaining the cylinder and plunger, and means for locking the carriage against movement; substantially as described.

65 4. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these

parts, and means for raising the movable part relative to the other by fluid-pressure, comprising a fluid-cylinder connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, and means for operating the piston to force fluid into the vertically-arranged cylinder, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center; substantially as described.

5. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts and means for raising the movable part relative to the other by fluid-pressure comprising a fluid-cylinder of larger cross-sectional area than that of the vertically-arranged cylinder, connected with the vertically-arranged cylinder, a piston within the fluid-cylinder and means for operating the piston to force fluid into the vertically-arranged cylinder, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end; substantially as described.

6. In well-drilling apparatus, the combination of a vertically-arranged cylinder, and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part relative to the other by fluid-pressure, comprising a fluid-cylinder connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston to force fluid into the vertically-arranged cylinder and means for releasing the pressure on the piston at the end of its stroke to permit the drop of the tools; substantially as described.

7. In well-drilling apparatus, the combination of a vertically-arranged cylinder, and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part relative to the other by fluid-pressure, comprising a fluid-cylinder of larger cross-sectional area than the vertically-arranged cylinder, connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston to force fluid into the vertically-arranged cylinder and means for releasing the pressure on the piston at the end of its stroke to permit the drop of the tools; substantially as described.

8. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger supported by a movable carriage,

means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part relative to the other by fluid-pressure comprising a stationary fluid-cylinder connected with the vertically-arranged cylinder by a flexible tube, a piston within the fluid-cylinder, and means for operating the piston to force fluid into the vertically-arranged cylinder; substantially as described.

9. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger supported by a movable carriage, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part relative to the other by fluid-pressure comprising a stationary fluid-cylinder of larger cross-sectional area than the vertically-arranged cylinder, connected with the vertically-arranged cylinder by a flexible tube, a piston within the fluid-cylinder, and means for operating the piston to force fluid into the vertically-arranged cylinder; substantially as described.

10. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part by fluid-pressure comprising a fluid-cylinder connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston to force fluid into the vertically-arranged cylinder and means for regulating the stroke of the piston; substantially as described.

11. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, and means for raising the movable part by fluid-pressure, comprising a fluid-cylinder of larger cross-sectional area than the vertically-arranged cylinder, connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston to force fluid into the vertically-arranged cylinder and means for regulating the stroke of the piston; substantially as described.

12. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these

parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure comprising a fluid-cylinder, connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston in one direction to force fluid into the vertically-arranged cylinder and means for yieldingly resisting the return movement of the piston; substantially as described.

13. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure comprising a fluid-cylinder of greater cross-sectional area than the vertically-arranged cylinder, connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, means for operating the piston in one direction to force fluid into the vertically-arranged cylinder and means for yieldingly resisting the return movement of the piston; substantially as described.

14. In well-drilling apparatus, the combination of a vertically-arranged cylinder and piston, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure, and means for adjusting the vertical position of the cylinder and piston by fluid-pressure; substantially as described.

15. In well-drilling apparatus, the combination of a vertically-arranged cylinder and piston, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure, means for reducing the fluid-pressure to permit the drop of the tools and means for raising the cylinder and piston as the tools are dropped; substantially as described.

16. In well-drilling apparatus, the combination of a vertically-arranged cylinder and piston, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure, means for reducing the fluid-pressure to permit the drop of the tools

and means for raising the cylinder and piston by fluid-pressure as the tools are dropped; substantially as described.

17. In well-drilling apparatus, the combination of a vertically-arranged cylinder and piston, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, means for raising the movable part by fluid-pressure, means for reducing the fluid-pressure to permit the drop of the tools and means for raising the cylinder and piston by fluid-pressure as the tools are dropped, comprising cylinders and pistons and means for forcing fluid into the cylinders; substantially as described.

18. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, and means for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, the connection between the two cylinders being such that the fluid forced from the fluid-cylinder will be returned thereto by the drop of the drilling-tool; substantially as described.

19. In well-drilling apparatus the combination of a vertically-arranged cylinder and plunger, means for supporting one of these parts, a drilling-tool and flexible suspending means for the drilling-tool, the flexible suspending means being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, a piston within the fluid-cylinder, and means for moving the piston in one direction to force fluid from the fluid-cylinder into the vertically-arranged cylinder, to lift the drilling-tools, the arrangement of the two cylinders being such that the drop of the drilling-tools will return the fluid to the fluid-cylinder, so that the same fluid may be used repeatedly; substantially as described.

20. In well-drilling apparatus in combination with a drilling-tool and flexible suspending means therefor, means for lifting the drilling-tools comprising a vertically-arranged cylinder and plunger, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder, a connection between the two cylinders, means for maintaining pressure upon a body of fluid within the fluid-cylinder, means for increasing the pressure in the fluid-cylinder to force fluid into the vertically-arranged cylinder to effect the lifting of the tools and for reducing the pressure to permit the tool

to drop and the fluid to return to the fluid-cylinder; substantially as described.

21. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder, means connecting the two cylinders, a piston within the fluid-cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, comprising a steam-cylinder in line with the fluid-cylinder, means for admitting steam to the steam-cylinder to operate the piston of the fluid-cylinder in one direction and for releasing the steam-pressure to permit the return of the piston of the fluid-cylinder; substantially as described.

22. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder, means connecting the two cylinders, a piston within the cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, comprising a steam-cylinder in line with the fluid-cylinder, and of greater cross-sectional area than the fluid-cylinder, means for admitting steam to the steam-cylinder to operate the piston of the fluid-cylinder in one direction and for releasing the steam-pressure to permit the return of the piston of the fluid-cylinder; substantially as described.

23. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder, means connecting the two cylinders, a piston within the fluid-cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, means for operating said piston, comprising a steam-cylinder in line with the fluid-cylinder, a piston in the steam-cylinder connected with the piston in the fluid-cylinder, a steam-supply and a steam-operated means controlling the admission and exhaust of steam to the steam-cylinder; substantially as described.

24. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a

point below its lower end and in line with its center, a fluid-cylinder, a connection between the two cylinders, a piston within the fluid-cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, means for operating said piston, comprising a steam-cylinder in line with the fluid-cylinder, a piston in the steam-cylinder, connected by a piston-rod with the piston in the fluid-cylinder, means for controlling the admission and exhaust of steam from the steam-cylinder, and means for actuating the controlling means from the piston-rod connecting the two pistons; substantially as described.

25. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, means operated by a steam-cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, and means for regulating the amount of fluid forced into the vertically-arranged cylinder; substantially as described.

26. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means for the tool, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, means operated by a steam-cylinder for forcing fluid from the fluid-cylinder into the vertically-arranged cylinder, and means for regulating the amount of fluid forced into the vertically-arranged cylinder, capable of operation while the parts are in motion; substantially as described.

27. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and plunger for lifting the drilling-tool, means for supporting one of these parts, comprising a vertically-adjustable framework, fluid-pressure devices for adjusting and sustaining the framework, and a pressure-gage connected with said fluid-pressure devices, means for raising the movable part relative to the other by fluid-pressure, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center; substantially as described.

28. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a fluid-pressure device for lifting the drilling-tool, comprising a cylinder and plunger, one of which is movable relative to the other, carried by a framework, and fluid-pressure devices for adjusting and sus-

taining the framework, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, means actuated in one direction to force fluid into the device for lifting the tool, and actuated in the other direction by the drop of the tool to force fluid into the devices for adjusting and sustaining the framework; substantially as described.

29. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a fluid-pressure device for lifting the drilling-tool, comprising a cylinder and piston, one of which is movable relative to the other, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, means actuated in one direction to force fluid into the device for lifting the tool arranged to be returned to initial position by the drop of the tool, and means for accelerating the return of the actuating means to initial position; substantially as described.

30. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a fluid-pressure device for lifting the drilling-tool, comprising a cylinder and piston, one of which is movable relative to the other, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, means actuated in one direction to force fluid into the device for lifting the tool, arranged to be returned to initial position by the drop of the tool, and means for retarding the return of the actuating device to initial position; substantially as described.

31. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and plunger one of which is movable relative to the other for lifting the drilling-tool, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a vertically-adjustable framework carrying said cylinder and plunger, fluid-pressure devices for adjusting and sustaining the framework, means for forcing fluid into the vertically-arranged cylinder, and means for forcing fluid into the fluid-pressure devices for adjusting and sustaining the framework actuated by the drop of the drilling-tool; substantially as described.

32. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and plunger one of which is movable relative to the other for lifting the drilling-tool, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, means for supporting the vertically-arranged cylinder and plunger, com-

prising a vertically-adjustable framework carried by pistons movable in vertically-stationary cylinders, a storage-reservoir containing fluid under pressure, and connections between the storage-reservoir and the vertically-stationary cylinders for admitting fluid to the cylinders to raise the framework; substantially as described.

33. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and plunger one of which is movable relative to the other for lifting the drilling-tool, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, a piston in the fluid-cylinder, arranged to be driven in one direction to force fluid into the vertically-arranged cylinder and to be returned to initial position by the drop of the tool, and a cushion or spring arranged to receive the impact of the piston on its return to initial position; substantially as described.

34. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and plunger one of which is movable relative to the other for lifting the drilling-tool, the flexible suspending means for the drilling-tool being connected to the movable part at a point below its lower end and in line with its center, a fluid-cylinder connected with the vertically-arranged cylinder, a piston in the fluid-cylinder, arranged to be driven in one direction to force fluid into the vertically-arranged cylinder and to be returned to initial position by the drop of the tool, and a cushion or spring within the fluid-cylinder, arranged to receive the impact of the piston on its return to initial position; substantially as described.

35. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a driving-piston, a driven piston moving synchronously therewith, a plunger and means for connecting the plunger with the flexible suspending means for the drilling-tool, and a confined body of fluid between the driven piston and plunger, whereby the plunger and driven piston are caused to move synchronously; substantially as described.

36. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and a plunger, movable in the cylinder, and connected with the flexible suspending means for the drilling-tool at a point below its lower end and in line with its center, means for forcing the plunger upward to lift the drilling-tool, and a cushion or spring arranged to receive the impact of the downward movement of the plunger to prevent injury to the cylinder; substantially as described.

37. In well-drilling apparatus, the combina-

tion of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and a plunger, movable in the cylinder, and connected with the flexible suspending means for the drilling-tool at a point below its lower end and in line with its center, means for forcing the plunger upward to lift the drilling-tool, and a cushion or spring secured about the upper end of the plunger and arranged to receive the impact of the downward movement of the plunger to prevent injury to the cylinder; substantially as described.

38. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged cylinder and a plunger movable in the cylinder, a cross-head carried by the plunger, and connections between the cross-head and the flexible suspending means for the drilling-tool at a point below the lower end of the plunger, means for forcing the plunger upward to lift the drilling-tool, and a cushion or spring interposed between the cross-head and the top of the cylinder adapted to receive the impact of the downward movement of the plunger to prevent injury to the cylinder; substantially as described.

39. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged vertical cylinders, pistons movable in these cylinders, means for forcing fluid into these cylinders beneath the pistons, and connections between the pistons and the cross-head; substantially as described.

40. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged vertical cylinders, pistons movable in said cylinders, means for forcing fluid into these cylinders beneath the pistons, piston-rods connecting the pistons with the cross-head, and tubular extensions secured to the cylinders surrounding the piston-rods; substantially as described.

41. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged vertical cylinders, pistons movable in said cylinders, means for forcing fluid into these cylinders beneath the pistons, piston-rods connecting the pistons with

the cross-head, and tubular extensions secured to the cylinders surrounding the piston-rods, and means for bracing the tubular extensions against sidewise movement; substantially as described.

42. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged vertical cylinders, each provided with a broad base, pistons movable in said cylinders, means for forcing fluid into these cylinders beneath the pistons, piston-rods connecting the pistons with the cross-head tubular extensions secured to the cylinders surrounding the piston-rods, and braces secured at their lower ends to the bases of the cylinders, and at their other ends to the tubular extensions; substantially as described.

43. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and for sustaining the cylinder, comprising a cross-head to which the cylinder is secured near one end, a cross-bar to which the cylinder is secured near the other end, connections between the cross-head and cross-bar, forming a rigid framework, means connected with the cross-head for vertically adjusting and sustaining the framework, and means connected with the cross-bar for preventing horizontal movement of the lower end of the cylinder; substantially as described.

44. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured near one end, a cross-bar to which the cylinder is secured at the other end, oppositely-arranged vertical cylinders, pistons movable in said cylinders, piston-rods connecting the pistons with the cross-head, tubular extensions secured to the cylinders surrounding the piston-rods, collars secured to the cross-bar, and adapted to slide on the tubular extensions, and means for forcing fluid into the vertical cylinders; substantially as described.

45. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured near one end,

a cross-bar to which the cylinder is secured at the other end, connections between the cross-head and cross-bar forming a rigid framework, oppositely-arranged vertical cylinders, pistons movable in said cylinders, piston-rods connecting the pistons with the cross-head tubular extensions secured to the cylinders surrounding the piston-rods, collars secured to the cross-bar, and adapted to slide on the tubular extensions, and means for forcing fluid into the vertical cylinders; substantially as described.

46. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured near one end, a cross-bar to which the cylinder is secured at its other end, oppositely-arranged vertical cylinders provided with bases, pistons movable in said cylinders, piston-rods connecting the pistons with the cross-head, tubular extensions secured to the cylinders surrounding the piston-rods, collars secured to the cross-bar and adapted to slide on the tubular extensions, braces secured at their lower ends to the bases of the cylinders, and at their upper ends to the tubular extensions, and means for forcing fluid into the vertical cylinders; substantially as described.

47. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured near one end, a cross-bar to which the cylinder is secured at its other end, connections between the cross-head and cross-bar forming a rigid framework, oppositely-arranged vertical cylinders provided with bases, pistons movable in said cylinders, piston-rods connecting the pistons with the cross-head, tubular extensions secured to the cylinders surrounding the piston-rods, collars secured to the cross-bar and adapted to slide on the tubular extensions, braces secured at their lower ends to the bases of the cylinders, and at their upper ends to the tubular extensions, and means for forcing fluid into the vertical cylinders; substantially as described.

48. In well-drilling apparatus, the combination of a vertically-arranged main cylinder and a plunger movable in the cylinder, means for sustaining and adjusting the cylinder, comprising a framework to which the cylinder is secured, oppositely-arranged vertical cylinders, pistons movable in said cylinders and connected with the cross-head, and means for forcing fluid into said cylinders, a cross-head secured to the plunger, vertical rods secured to said cross-head, extending below the

framework carrying the main cylinder, and a rope-clamp secured to the vertical rods, and means for forcing fluid into the main cylinder to lift the plunger; substantially as described.

49. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger, movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged cylinders provided with bases, pistons movable in said cylinders, connections between the pistons and the cross-head, and means for forcing fluid into said cylinders, the cylinder-bases being provided with wheels; substantially as described.

50. In well-drilling apparatus, the combination of a vertically-arranged cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for forcing the plunger upward to lift the drilling-tools, and means for sustaining the cylinder, comprising a cross-head to which the cylinder is secured, oppositely-arranged cylinders provided with bases, pistons movable in said cylinders, connections between the pistons and the cross-head, and means for forcing fluid into said cylinders, the cylinder-bases being provided with wheels and locking devices, and a track on which the wheels are adapted to run and with which the locking devices are adapted to cooperate to lock the apparatus in position; substantially as described.

51. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged main cylinder and a plunger, movable in the cylinder, the flexible suspending means for the drilling-tool being connected to the plunger at a point below its lower end and in line with its center, means for sustaining the cylinder, a fluid-cylinder connected to the main cylinder, a piston in the fluid-cylinder for forcing fluid into the main cylinder to lift the drilling-tools, an opening in the fluid-cylinder near its rear end, and a stop-cock controlling said opening; substantially as described.

52. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged main cylinder and a plunger, movable in the cylinder, the flexible suspending means for the drilling-tool being connected to the plunger at a point below its lower end and in line with its center, means for sustaining the cylinder, a fluid-cylinder connected to the main cylinder, a piston in the fluid-cylinder for forcing fluid into the main cylinder to lift the drilling-tools, an opening in the fluid-cylinder near its rear end, a stop-cock controlling said opening, a second opening in the fluid-cylinder also near its rear end, a pressure-reservoir connected with said second opening, and a stop-cock be-

tween the fluid-cylinder and the pressure-reservoir; substantially as described.

53. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged main cylinder and a plunger movable in the cylinder, the flexible suspending means for the drilling-tool being connected to the plunger at a point below its lower end and in line with its center, means for sustaining the cylinder, a fluid-cylinder connected with the main cylinder, a piston in the fluid-cylinder for forcing fluid into the main cylinder to lift the drilling-tools, an opening in the fluid-cylinder near its rear end, a pressure-reservoir connected with said opening, and a cock between the pressure-reservoir and the fluid-cylinder; substantially as described.

54. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged main cylinder and a plunger movable in the cylinder, the flexible suspending means for the drilling-tool being connected to the plunger at a point below its lower end and in line with its center, means for sustaining the cylinder, a fluid-cylinder connected with the main cylinder, a piston in the fluid-cylinder for forcing fluid into the main cylinder to lift the drilling-tools, an opening in the fluid-cylinder near its rear end, a pressure-reservoir provided with an escape-cock, connected with said openings, and a cock between the pressure-reservoir and the fluid-cylinder; substantially as described.

55. In well-drilling apparatus, the combination of a drilling-tool and flexible suspending means therefor, a vertically-arranged main cylinder and a plunger movable in the cylinder, the flexible suspending means for the drilling-tool being connected to the plunger at a point below its lower end and in line with its center, means for sustaining the cylinder, a fluid-cylinder, connected with the main cylinder, a piston in the fluid-cylinder for forcing fluid into the main cylinder to lift the drilling-tools, an opening in the fluid-cylinder near its rear end, a pressure-reservoir, provided with an escape-cock, and a pressure-gage, connected with said opening, and a cock between the pressure-reservoir and the fluid-cylinder; substantially as described.

56. In well-drilling apparatus, the combination of a vertically-arranged main cylinder and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder, means for admitting steam to the steam-cylinder to operate the piston in one direction, and means for causing the piston of the steam-cylinder to compress air when driven forward to accelerate its return; substantially as described.

57. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder, means for admitting steam to the steam-cylinder in rear of the piston to operate the piston in one direction, an opening in the steam-cylinder near its forward end, and an inwardly-opening check-valve controlling the opening; substantially as described.

58. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder, means for admitting steam to the steam-cylinder in rear of the piston to operate the piston in one direction, an opening in the steam-cylinder near its forward end, an inwardly-opening check-valve controlling the opening, and a stop-cock connected with the opening; substantially as described.

59. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder, means for admitting steam to the steam-cylinder to operate the piston in one direction, comprising a valve-casing provided with supply and exhaust ports and connected by a port with the steam-cylinder, a steam-actuated valve in the valve-casing adapted to alternately connect the supply and exhaust ports with the cylinder, an auxiliary valve controlling the admission of steam to the valve-casing to effect the movement of the main valve, and means for shifting the auxiliary valve; substantially as described.

60. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder by a piston-rod, a steam-actuated valve adapted to connect the

steam-cylinder alternately with the steam-supply and with the exhaust, an auxiliary valve controlling the movement of the main valve, and means for shifting the auxiliary valve, comprising a rod provided with collars, and means carried by the piston-rod adapted to contact with the collars; substantially as described.

61. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder by a piston-rod, a steam-actuated valve adapted to connect the steam-cylinder alternately with the steam-supply and with the exhaust, an auxiliary valve controlling the movement of the main valve, and means for shifting the auxiliary valve, comprising a rod provided with collars, each having a spring connected therewith, and means carried by the piston-rod adapted to contact with the collars; substantially as described.

62. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder by a piston-rod, a steam-actuated valve adapted to connect the steam-cylinder alternately with the steam-supply and with the exhaust, an auxiliary valve controlling the movement of the main valve, and means for shifting the auxiliary valve, comprising a rod provided with a fixed collar and an adjustable collar, means by which the adjustable collar may be shifted while the apparatus is in operation, and a tappet carried by the piston-rod adapted to contact with the collars; substantially as described.

63. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder by a piston-rod, a steam-actuated valve adapted to connect the steam-cylinder alternately with the steam-supply and with the exhaust, an auxiliary valve controlling the movement of the main valve, and means for shifting the auxiliary valve, comprising a rod provided with a fixed

collar and an adjustable collar, and a tappet carried by the piston-rod adapted to contact with the collars; substantially as described.

64. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder, a fluid-cylinder connected with the main cylinder, a piston movable in the fluid-cylinder, a steam-cylinder, a piston movable in the steam-cylinder connected with the piston in the fluid-cylinder by a piston-rod, a steam-actuated valve adapted to connect the steam-cylinder alternately with the steam-supply and with the exhaust, an auxiliary valve controlling the movement of the main valve, and means for shifting the auxiliary valve, comprising a rod provided with collars, and a tappet carried by the piston-rod adapted to contact with the collar, the rod being also provided with a handle for moving it to shift the auxiliary valve; substantially as described.

65. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder and adjusting its position, comprising fluid-pressure devices, means for supplying fluid to the fluid-pressure devices, comprising a storage-reservoir for fluid under pressure, a main pipe connected with the fluid-pressure devices, and an auxiliary pump connected with the storage-reservoir and arranged when operated to force fluid into the fluid-pressure devices to lift the main cylinder and plunger, and means for operating the auxiliary pump; substantially as described.

66. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder and adjusting its position, comprising fluid-pressure devices, means for supplying fluid to the fluid-pressure devices, comprising a storage-reservoir for fluid under pressure, a main pipe connected with the fluid-

pressure devices, and an auxiliary pump connected with the storage-reservoir and arranged when operated to force fluid into the fluid-pressure devices to lift the main cylinder and plunger, a valve controlling the admission of fluid from the storage-reservoir to the pump, and means for operating the auxiliary pump; substantially as described.

67. In well-drilling apparatus, the combination of a vertically-arranged main cylinder, and a plunger movable in the cylinder, connections between the plunger and the well-drilling tools, means for sustaining the main cylinder and adjusting its position, comprising fluid-pressure devices, means for supplying fluid to the fluid-pressure devices, comprising a storage-reservoir for fluid under pressure, a main pipe connected with the fluid-pressure devices, and an auxiliary pump connected with the storage-reservoir and arranged when operated to force fluid into the fluid-pressure devices to lift the main cylinder and plunger, a valve controlling the admission of fluid from the storage-reservoir to the auxiliary pumps, means for operating the auxiliary pumps, and a by-pass pipe connecting the main pipe directly with the storage-reservoir, and a valve controlling the by-pass pipe; substantially as described.

68. In well-drilling apparatus, the combination of a vertically-arranged cylinder and plunger, movable in the cylinder, means for sustaining the cylinder in position, means for forcing fluid into the cylinder beneath the cylinder, and means for connecting the plunger with the drilling-tools, comprising a rope-clamp and drilling-rope, a pulley fixed in position below the level of the cylinder and plunger, and a guide-pulley adapted to receive the drilling-rope, and a second guide-pulley above the drilling apparatus, also adapted to receive the drilling-rope; substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

JOHN C. SWAN.

Witnesses:

GRAFTON L. MCGILL,
R. P. GUNLEY.