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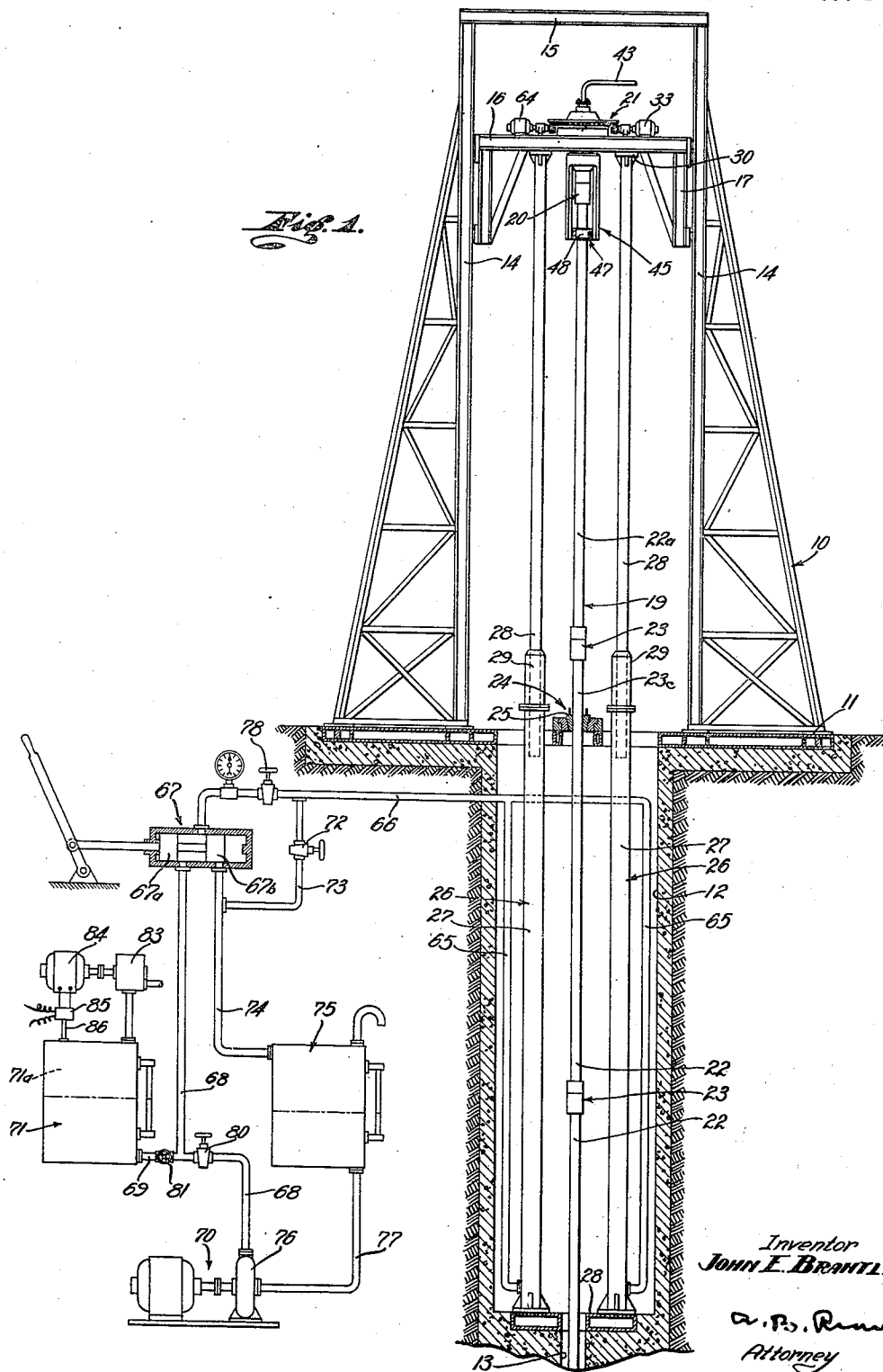
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HYDRAULIC WELL-DRILLING APPARATUS

Filed March 22, 1940

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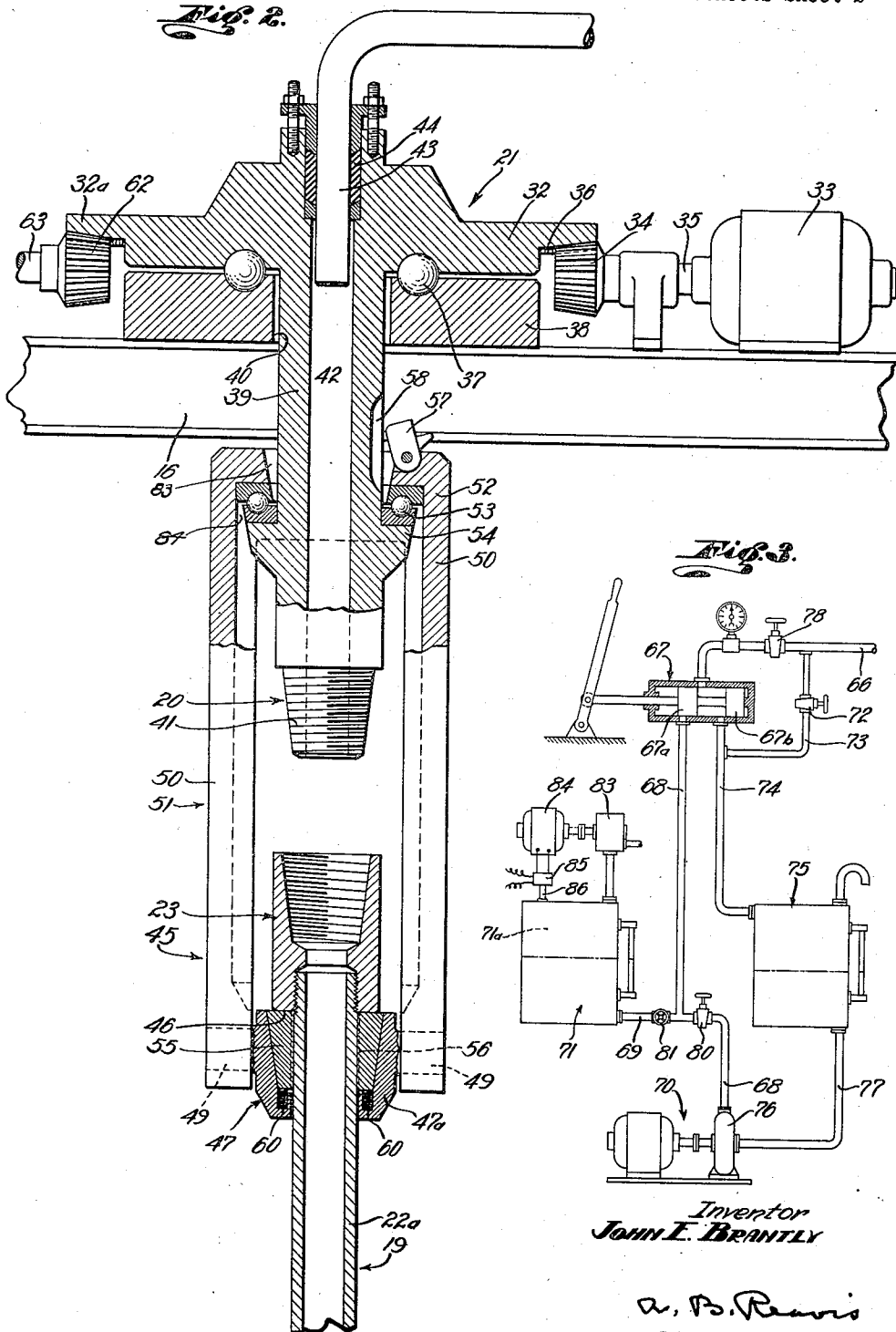
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UNITED STATES PATENT OFFICE

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HYDRAULIC WELL-DRILLING APPARATUS

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9 Claims. (Cl. 255—22)

This invention relates generally to well drilling apparatus, and has for its primary object to provide improved fluid pressure operated and controlled equipment for raising and lowering well pipe strings in the normal operations of withdrawing or making up the string, as well as for rotating and controlling the rate of pipe feed during drilling. The invention is characterized by the fact that it eliminates the necessity for such customarily used equipment as the standard derrick, draw works, suspension cable, swivel and hook, which involve relatively great expense and operating hazards, and provides instead a relatively compact and unitized apparatus having many advantages from standpoints of both construction and operation.

The invention may be described generally as providing for the utilization of fluid pressure or hydraulically applied power for elevating the pipe string and for hydraulically controlling the downward movement of the pipe string while it is made up and lowered, as well as during drilling. It has been proposed in the past to utilize hydraulic feed controls during drillings, but the present invention is believed to mark the first instance in which a fluid or hydraulic type of control, including the individual sections making up the string, but also in apparatus for handling the pipe in the normal raising and lowering operations. The invention contemplates other general departures from past practices of raising and lowering the pipe independently of the pipe rotating mechanism, in that, preferably, during all normal operations in which the entire pipe string is raised or lowered by the present apparatus, the pipe rotating mechanism moves vertically with the pipe string. In this manner the rotating mechanism becomes a part of the raising and lowering equipment, permitting, as will later appear, rotation of the pipe for purposes of drilling, and raising and lowering of the pipe string for the addition or removal of individual pipe sections or stands, by the same unitized apparatus.

In its preferred form, the invention comprises a suitable support or platform for carrying the pipe rotating mechanism, such as a rotary table having a threaded connection with the upper end of the pipe string, and a hydraulic power source below the platform operable to elevate the table above a stationary support for the pipe string, a distance sufficient to permit addition or removal of individual pipe stands in making up or pulling the pipe string. Thus during the operation of withdrawing the pipe from the well,

the apparatus operates under hydraulically applied power to elevate the pipe string, and while the latter is being lowered to drilling position in the well, to control the rate of descent by regulating the release of fluid under the pressure of the pipe string load. During drilling, the rate of descent of the pipe string is similarly controllable in a manner permitting proper rate of feed for any particular conditions encountered.

A further feature of the invention is the provision of means whereby energy created by lowering of the pipe string as each stand of pipe is added and lowered, may be utilized in returning the platform and rotary table to elevated position for receiving the next successive pipe stand to be added. In accomplishing this object, I may provide a pressure vessel or accumulator communicable with the hydraulic lift for the rotary table and platform, and within which air or other gas is compressed by the displacement of liquid during descent of the table and platform, and suitable valve control whereby the accumulator pressure is thereafter used to return the table to its normal elevated position. A suitable pumping plant or unit for supplying liquid under the required high pressure for operation of the hydraulic table lift, and a receptacle or reservoir for receiving liquid displaced by the hydraulic lift and from which the pump takes suction, may be connected with the accumulator and the assembly provided with operating valves, all in a manner permitting simplified and absolute control of the apparatus during all operations.

The invention embodies various additional features and details such as the later described rotary table and drive tube assembly, but these will be more readily explained and understood to better advantage without necessity for further preliminary discussion, from the detailed description to follow. Reference is had throughout the description to the accompanying drawings in which:

Fig. 1 is a general view, diagrammatical in parts, illustrating a typical embodiment of the invention;

Fig. 2 is an enlarged sectional view taken vertically through the rotary table, drive tube and elevator assembly;

Fig. 3 is a view of the accumulator, reservoir and pump assembly, with the position of the control valve changed from that of Fig. 1.

Referring to the general view of Fig. 1, the apparatus comprises a suitable frame structure 10 supported on a floor or base 11 above an enlarged diameter pit 12 which preferably is ex-

tended a substantial distance below the ground surface at the top of the well bore 13. The frame structure 10 comprises a pair or any suitable number of parallel vertical guides 14 interconnected by cross-brace 15, and between which a platform 16 is confined for vertical movement. The well pipe string 19, herein shown typically as drill pipe, is rotatably driven and raised and lowered within the well by a connection at 20 with a rotary table generally indicated at 21, carried by the platform 16. The pipe string is shown to be made up of standard length sections 22 interconnected by the usual couplings 23 or other threaded joints, the string at times being vertically supported below the uppermost section 22a by suitable means, conventionally illustrated at 24, comprising for example a plurality of wedge slips 25 adapted to grip and support the pipe below the bottom coupling 23 of the pipe section 22a above.

The platform 16 and the parts carried thereby are operated or controlled in their vertical movement by hydraulic pressure actuated means, preferably in the form of a plurality of cylinder and plunger assemblies 26 of which there may be any suitable number arranged at opposite sides of the pipe string 19, a pair of such assemblies being shown for purposes of simplicity in illustration. Each of the assemblies 26 comprises an elongated cylinder 27 of seamless drawn tubing, the base of which rests on a support 28 at the bottom of the pit 12. The plunger 28, which may also be formed of seamless drawn tubing, extends through a stuffing box 29 at the top of the cylinder and engages or is connected at 30 to the platform 16. As will later appear, plungers 28 are operated to raise and lower the platform 16 within the limits of its vertical travel, by fluid introduced to or released from cylinders 27 below the plungers, the length of the plunger strokes being such as to elevate the platform 16 above the stationary pipe support 24 a distance sufficient to permit addition to or removal from the pipe string of the upper section 22a. Ordinarily, of course, the height to which the platform 16 may be elevated should be such as to permit addition to or removal from the pipe string of standard pipe sections or stands, the length of which in present day practice exceeds 20 feet.

Referring now to Fig. 2 the drive 21 comprises a circular rotary table 32 driven by a suitable motor or engine 33 supported on the platform 16, the drive connection with the rotary table being of the usual type consisting of a pinion 34 on the motor shaft 35 and meshing with a ring gear 36 on the under side of the table flange 32a. The table may be supported on its base 38 by any of the usual types of roller bearings, which are conventionally illustrated at 37. A drive tube 39, formed integrally with or rigidly attached to the rotary table 32, extends downwardly through a central bore 40 in the base 38 and a lower threaded pin end 41 for connection with the box end or coupling 23 of the pipe section 22a below. Circulating fluid is discharged to the drill pipe through the rotary table and drive tube bore 42 from a non-rotatable pipe 43 extending through a stuffing box 44 at the top of the table bore. As will be understood without necessity for specific illustration, circulating fluid will be discharged by the usual mud pumps to pipe 43 through flexible hose permitting full range vertical travel of the rotary table.

Supported by the platform 16, and preferably directly on the drive tube 39 is a suitable pipe

elevator, generally indicated at 45, adapted to engage shoulder 46 of coupling 23 in the handling of pipe sections 22a as they are added to or removed from the pipe string. As will be understood, the elevator proper, particularly shown at 47, may be of any of the usual types having a gate 48, see Fig. 1, adapted to be opened or closed for engaging or disengaging the pipe within the elevator. The elevator is shown to be pivotally mounted on trunnions 49 terminating within the lower ends of the arms 50 of a support 51, the upper end 52 of which is full circular and is rotatable on suitable bearings 53 supported on the drive tube flange 54. Being thus supported for rotation relative to the drive stem, and mounted for tilting on the trunnions 49, the mouth of the elevator may be rotated and inclined to any position for receiving or disengaging the pipe stand 22a.

In the operation of adding pipe lengths to the drill string, with the upper end of the string vertically supported by the slips 25, the pipe section 22a to be added is brought in beneath the platform (for example on a suitable carriage, not shown) with the platform in a lowered position. The elevator 47 is turned on bearings 53 and tilted on its trunnions 49 to the proper angles to receive the pipe, the elevator gate 48 then closed and the platform raised to align the section 22a with the pipe string below. The platform then is lowered to engage the parts of the coupling 23 directly above the support 24. As previously indicated, the elevator 49 may be of a slip type, many particular forms of which are well known, and is shown conventionally to comprise a body 47a containing wedge slips 55 having vertically extending pipe engaging teeth 56 adapted to grip and rotate the pipe upon rotation of the elevator. With the pipe sections aligned as described, the point at 23 above the support 24 may be made up to the point of bringing the threads into snug engagement, by clockwise rotation of the table 32 and elevator assembly. In all operations when the elevator is used to rotate the pipe in making up or breaking joints, the elevator assembly may be suitably locked to the drive tube 39 for rotation therewith, as by means of a normally released key 57 adapted to be thrust into a complementary way 58 in the drive tube. After the joint is snugly made up using the elevator for rotation of the pipe section 22a, the elevator then may be released from gripping engagement with the pipe by lowering the platform 16 and elevator body 47 to the point at which the slips 55 will be raised by the action of springs 60. The joint 23 then may be finally and tightly made up by the use of tongs in the ordinary manner, one set of tongs being applied to the pipe at 23c below the coupling, and a second set applied to the pipe above the coupling.

In the pipe lowering operation, the joint at 20 between the drive tube and the upper end of the pipe string is not made up until the last pipe section 22a is to be connected to the string. In this final operation, the elevator 47 is used to raise and align the pipe section 22a within the coupling 23 below, and then the platform 16 is lowered to engage the parts of the joint at 20, with key 57 removed from recess 58 as in Fig. 2, to permit rotation of the drive tube relative to the elevator assembly. By clockwise rotation of the table 32 and drive tube, both joints at 20 and 23 may be made up simultaneously and in the same operation.

In pulling the pipe string from the well, assume

that the parts are in the position of Fig. 1, with the joint at 20 engaged and the pipe string held by the support 24. The joint 20 first may be disconnected by applying tongs to the pipe section 22a to hold it against rotation, and then rotating the table 32 and drive tube 39 in a counter-clockwise direction. Due to the fact that the normal table drive transmitted through pinion 34 is insufficient to supply the high torque required to initially break the joint, an auxiliary drive may be applied to the table for this purpose, as by a second pinion 62 on shaft 63 powered by a second motor or engine 64 mounted on the platform 16. (It may be mentioned that this same auxiliary drive through pinion 62 may be employed, whenever desirable, in the making or braking of joints where the table rotation is transmitted to the pipe through the elevator 47.) After engagement of the parts of joint 20, the joint at 23 then may be disconnected by use of tongs applied to the pipe above and below the joint as in the previously described joint making operation. By now lowering the platform 16, the disconnected pipe section 22a may be removed by displacing the lower end from beneath the platform on a suitable carriage, not shown, as the section is lowered, and finally disengaging the elevator 47. Then the platform may be further lowered to permit engagement of the elevator beneath the shoulder of coupling 23 and the platform then raised to elevate the pipe string and bring the next coupling 23 above the support 24. It will be understood that while the pipe string is being thus raised, it is supported by the elevator 47, without connection between the pipe and the drive tube. Accordingly, after disconnection of the joint at 20 with the first pipe section, subsequent top sections 22a are disconnected from the pipe string below by using tongs to initially break the joint at 23, and then completing disengagement of the joint by rotation of the pipe section 22a by the elevator 47.

A suitable operating fluid, preferably a fairly low viscosity oil, is delivered to and discharged from the lower portions of cylinders 27 through pipes 65 connecting with a header 66. The latter is communicable under control of a suitable valve mechanism, generally indicated at 67, through pipe 68 and 69 with a suitable high pressure pumping unit or plant 70 and an accumulator 71 comprising one or a plurality of high pressure vessels adapted to receive liquid displaced from cylinders 27 at times during down travel of the platform 16. Line 66 also is communicable under control of valve 67, or if desired by an independent valve 72 in a by-pass line 73, with pipe 74 connecting with reservoir 75 from which the operating liquid is taken by pump 76 through line 77.

In describing the operation of the system, assume first normal drilling conditions with the rotary table in raised position and driving the drill string, as typified by Fig. 1, slips 25 of course being removed. The drill string is lowered into the formation in accordance with the desired and proper rate of drilling by controlled release of fluid from line 66 into the reservoir 75. During this time, the control valve 67 may be thrown to the position of Fig. 3 and the release of fluid from line 66 controlled by valve 78, or the valve 67 may be thrown to an intermediate position in which the sections 67a and 67b close off both lines 68 and 74, and the fluid release directed to the reservoir through by-pass line 73 under control of valve 72. As will be understood, valves 78 and

72 may be of any suitable types capable of such close regulation of the fluid release as to maintain accurate control of the rate of downward movement of the drill string.

Assume next that the apparatus is being operated for pulling the pipe string from the well and that the control valve 67 is thrown to the position shown in Fig. 1. Valve 80 in line 68 is opened, valve 81 in line 69 closed and operating fluid is discharged from reservoir 75 by pump 76 through lines 68, 66 and 65 to the cylinders 27 under sufficient pressure to elevate the platform 16 and the supported pipe string. After the platform has become elevated to its upper position, slips 25 are set, pipe section 22a removed as previously described, and the control valve 67 is thrown to the position of Fig. 3 to place line 66 in communication with the reservoir 75 through pipe 74. The platform 16 and its supported parts then may be permitted to descend at a rate controllable by valve 78 (or valve 72 in the by-pass line.) After engagement of the elevator 47 with the pipe string just above the support 24, the control valve 67 is returned to the position of Fig. 1 and the described operation repeated. Ample clearance is provided at 83 and 84 between the elevator support and the drive tube to permit rocking the support on its bearings 53 to an angle that will permit application of the elevator 47 to the pipe.

In making up and lowering the pipe string in the well assume the platform 16 to be in the position of Fig. 1 and the rotary table to be connected to the pipe string either by the joint 20 or elevator 47. With the control valve positioned as in Fig. 1, valve 80 is closed, valve 81 opened and the rate of descent of the platform and pipe string is controlled by valve 78 regulating the discharge of liquid from line 66 through pipes 68 and 69 into the accumulator 71. Liquid displacement from the cylinders 27 into the accumulator 71 operates to compress air or other gas within the upper chamber 71a of the accumulator above the liquid level L, the maximum pressure developed in chamber 71a when the plungers 28 reach the limit of their down strokes, being determinable in accordance with the volume of the chamber and also an initial gas pressure maintained in the chamber by a compressor 83 driven by motor 84. The motor and compressor assembly may automatically be controlled to maintain a predetermined lower pressure limit in the chamber 71a by a pressure operated switch 85 in the motor circuit connected with the accumulator by pipe 86.

By maintaining the proper and determinable relationship between the volume of chamber 71a and gas pressure therein at the start of the plunger down strokes, the pressure increase in chamber 71a resulting from the displacement of liquid from cylinders 27 during lowering of the pipe string, may be sufficient to return the platform 16 to its raised position after lowering and disconnection from the drill string. After disconnecting the lowered platform from the drill string, valve 80 is closed, valve 81 opened, the control valve 67 thrown to the position of Fig. 1, and the accumulator pressure released to the cylinders 27 through lines 68 and 66 under control of valve 78. As will be understood, this method of operation utilizing the pressure developed in the accumulator for elevating the platform, may be employed after initial make up of the pipe string to a length at which the weight of the pipe, together with the weight

of the platform and its supported parts, will compress the gas in the accumulator chamber to the pressure required for subsequent elevation of the platform and a stand of pipe.

I claim:

1. In apparatus for rotating and raising and lowering a well pipe string made up of connected sections, means operated by hydraulic pressure for elevating and controlling lowering of the pipe string, a releasable connection between said means and the pipe string, means for independently vertically supporting the pipe string below a top section thereof, said hydraulic pressure operated means being movable vertically above said supporting means a distance sufficient to permit removal from or insertion of said top section between said connection and the pipe string supported by said supporting means, and means for utilizing energy created by lowering of the pipe string for raising the first mentioned means after disconnection from the lowered pipe string.

2. In apparatus for rotating and raising and lowering a well pipe string made up of connected sections, means operated by hydraulic pressure for elevating and controlling lowering of the pipe string, a releasable connection between said means and the pipe string, means for independently vertically supporting the pipe string below a top section thereof, said hydraulic pressure operated means being movable vertically above said supporting means a distance sufficient to permit removal from or insertion of said top section between said connection and the pipe string supported by said supporting means, and means for compressing a gas by lowering of the pipe string and for utilizing the pressure of the compressed gas for raising the first mentioned means after disconnection from the pipe string.

3. In apparatus for rotating and raising and lowering a well pipe string made up of sections, a vertically movable platform, a rotary drive for said pipe string carried by the platform, a releasable connection between said drive and the pipe string, means operated by hydraulic pressure for elevating and controlling the lowering of said platform and pipe string, means for independently vertically supporting the pipe string below a top section thereof, said platform being movable by said hydraulic pressure operated means above said supporting means a distance sufficient to permit removal from or insertion of said top section between said connection and the pipe string supported by said supporting means, and means for compressing a gas by lowering of the pipe string and for utilizing the pressure of the compressed gas for raising the platform after disconnection of said rotary drive from the lowered pipe string.

4. In well-drilling apparatus, a platform; a rotary drill table carried by the platform; driving means for the rotary drill table and carried by the platform; a drill tube including a top section fixedly connected to the drill table, a plurality of main sections, and couplings for connecting the sections in end-to-end relation; stationary means for supporting coupled main sections of the drill tube independently of the rotary drill table; expansible chamber hydraulic motor means for raising and lowering the platform such that, with the latter in uppermost position, a plurality of said couplings will be positioned in intervening relation with respect to the platform and the stationary supporting means, whereby, with the latter in supporting

relation with respect to the coupled main sections, a pair of said intervening couplings may be operated to provide for connection or disconnection of sections incident to lengthening or shortening the drill tube; passageway means providing for the admission of liquid to and the discharge thereof from the hydraulic motor means; means providing a source of high-pressure liquid; means providing a discharge space; valve means operable to place said passageway means in communication selectively with said source or space; and means for controllably bleeding liquid from the motor means to provide for feeding of the drill tube with a desired drilling pressure.

5. In well-drilling apparatus, a platform; a rotary drill table carried by the platform; driving means for the rotary drill table and carried by the platform; a drill tube including a top section fixedly connected to the drill table, a plurality of main sections, and couplings for connecting the sections in end-to-end relation; means including said top section for supporting and driving the drill tube from the rotary drill table; stationary means for supporting coupled main sections of the drill tube independently of the rotary drill table; expansible chamber hydraulic motor means for raising and lowering the platform such that, with the latter in uppermost position, a plurality of said couplings will be positioned in intervening relation with respect to the platform and the stationary supporting means, whereby, with the latter in supporting relation with respect to the coupled main sections, a pair of said intervening couplings may be operated to provide for connection or disconnection of sections incident to lengthening or shortening the drill tube; passageway means providing for the admission of liquid to and the discharge thereof from the hydraulic motor means; a pump; means providing inlet and discharge passages for the pump; valve means operable to place said passageway means in communication selectively with said discharge passage or with said inlet passage, and an accumulator in communication with said discharge passage.

6. In well-drilling apparatus, a platform; a rotary drill table carried by the platform; driving means for the rotary drill table and carried by the platform; a drill tube including a top section fixedly connected to the drill table, a plurality of main sections, and couplings for connecting the sections in end-to-end relation; means for supporting coupled main sections of the drill tube independently of the rotary drill table; expansible chamber hydraulic motor means for raising and lowering the platform such that, with the latter in uppermost position, a plurality of said couplings will be positioned in intervening relation with respect to the platform and the supporting means, whereby, with the latter in supporting relation with respect to the coupled main sections, a pair of said intervening couplings may be operated to provide for connection or disconnection of sections incident to lengthening or shortening the drill tube; means for controllably supplying high pressure liquid to and discharging liquid from the hydraulic motor means, the last mentioned means comprising a pump and a control valve mechanism, and an accumulator adapted to receive fluid displaced by said motor means during assembly and insertion into a well of a drill tube without the pump being in operation, the energy stored in the accumulator on

downstrokes of the platform under the influence of the weight of the drill tube being sufficient to raise the platform detached from the drill tube.

7. In apparatus for drilling wells by means of a pipe string comprising pipe sections and couplings joining the sections and provided by cooperating pipe section terminal coupling portions, a rotary table aggregate comprising a vertically-movable platform and a rotary table carried thereby, a drive tube depending from and carried by the rotary table and provided with a coupling portion for cooperating with a pipe string section coupling portion in order that the pipe string may be suspended from the rotary table and be rotated by the latter, stationary means below the platform and operative to support the pipe string so that a section thereof and the coupling connecting such section to the adjacent section may be disposed thereabove in top position, and means arranged below the platform and operative in response to hydraulic pressure to raise and lower the rotary table aggregate to such an extent that a pipe section may be located in said top position between such aggregate and the stationary supporting means, whereby the rotary table aggregate may, with said stationary means released from the pipe string, be raised and lowered to raise and lower the pipe string and may, with said stationary means supporting the pipe string, be raised and lowered to provide for the addition of a section in top position to the pipe string for the removal of a section in that position from the pipe string.

8. In apparatus for drilling wells by means of a pipe string comprising pipe sections and couplings joining the sections and provided by cooperating pipe section terminal coupling portions, a rotary table aggregate comprising a vertically-movable platform and a rotary table carried thereby, a drive tube depending from and carried by the rotary table and provided with a coupling portion for cooperation with a pipe string section coupling portion in order that the pipe string may be suspended from the rotary table and be rotated by the latter, stationary means below the platform and operative to support the pipe string so that a section thereof and the coupling connecting such section to the adjacent section may be disposed thereabove in top position, means arranged below the platform and operative in response to hydraulic pressure to raise and lower the rotary table aggregate to such an extent that a pipe section may be located in said top position between such aggregate and the stationary supporting means, whereby the rotary table aggregate may, with said stationary means released from the pipe string, be raised and lowered to raise and lower the pipe string and may,

with said stationary means supporting the pipe string, be raised and lowered to provide for the addition of a section in top position to the pipe string or for the removal of a section in that position from the pipe string, and means carried by the rotary table aggregate for raising and lowering the pipe string when the latter is uncoupled from the drive tube and for raising and lowering uncoupled sections incident to location thereof in said top position and removal thereof from said position.

9. In apparatus for drilling wells by means of a pipe string comprising pipe sections and couplings joining the sections and provided by cooperating pipe section terminal coupling portions, a platform, a rotary table carried by the platform, a driving motor carried by the platform, means for transmitting motion from the motor to the table, a drive tube depending from and carried by the rotary table and provided with a coupling portion for cooperation with a pipe string section coupling portion in order that the pipe string may be suspended from the rotary table and be rotated by the latter, stationary means below the platform and operative to support the pipe string so that a section thereof and the coupling connecting such section to the adjacent section may be disposed thereabove in top position, means arranged below the platform and operative in response to hydraulic pressure to raise and lower the rotary table aggregate to such an extent that a pipe section may be located in said top position between such aggregate and the stationary supporting means, whereby the rotary table aggregate may, with said stationary means released from the pipe string, be raised and lowered to raise and lower the pipe string and may, with said stationary means supporting the pipe string, be raised and lowered to provide for the addition of a section in top position to the pipe string or for the removal of a section in that position from the pipe string, means including a swivel connection for supporting the elevator from said drive tube, said elevator being operative to engage the pipe string to raise and lower the latter when uncoupled from said drive tube and to raise and lower uncoupled sections incident to location thereof in said top position and removal thereof from said top position, and releasable torque transmitting means between the depending drive tube and the elevator and providing for transmission of motion from the rotary table to the pipe section engaged by the elevator to facilitate connection or disconnection of the coupling connecting such section to the adjacent section.

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