Aug. 30, 1960 A. ANDREWS 2,950,704

PUMP JACKS AND THE LIKE

Filed Dec. 1, 1958 4 Sheets-Sheet 1

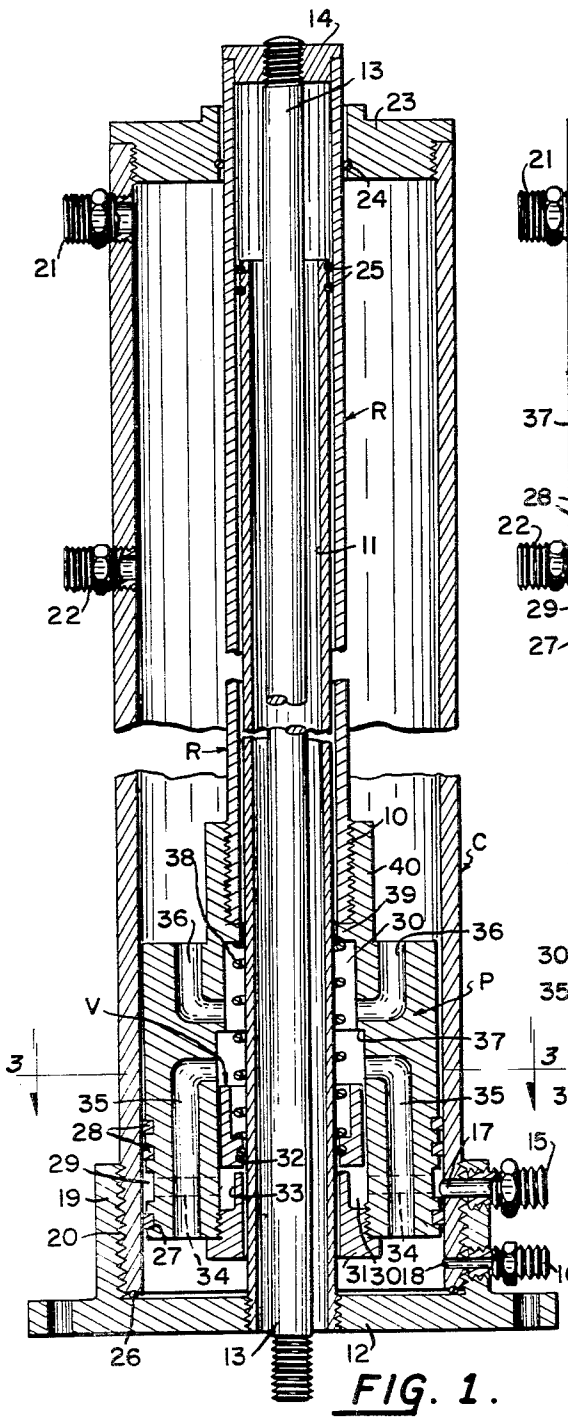


FIG. 1.

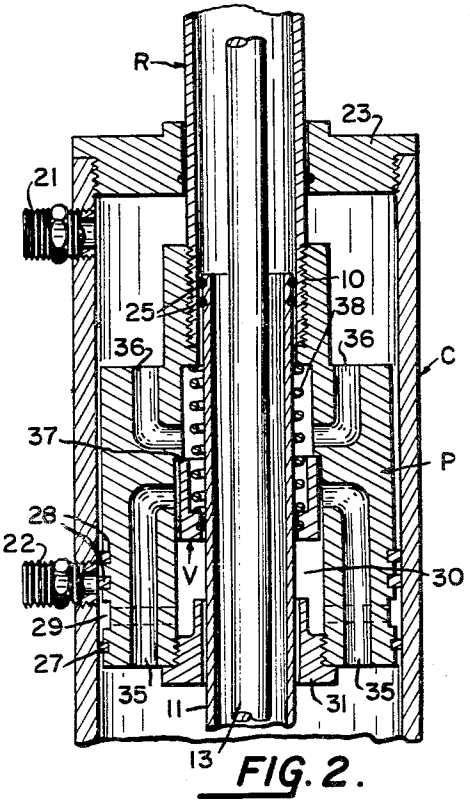


FIG. 2.

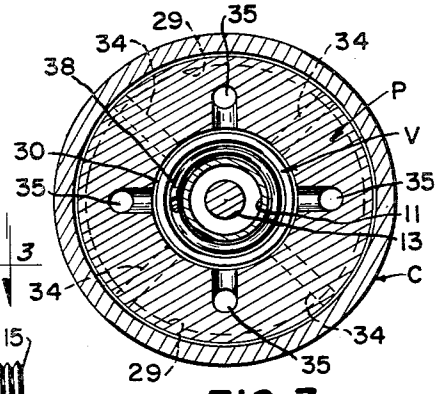


FIG. 3.

INVENTOR.
ALBERT ANDREWS
Deceased
BY HELEN ANDREWS
Heir

Aug. 30, 1960 A. ANDREWS 2,950,704

PUMP JACKS AND THE LIKE

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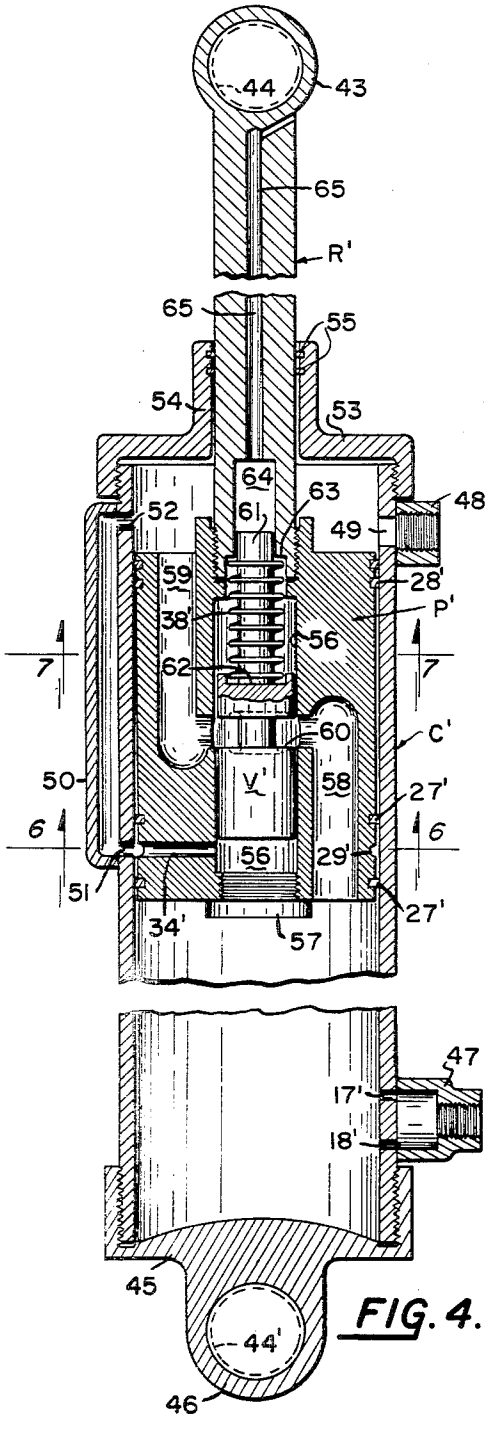


FIG. 4.

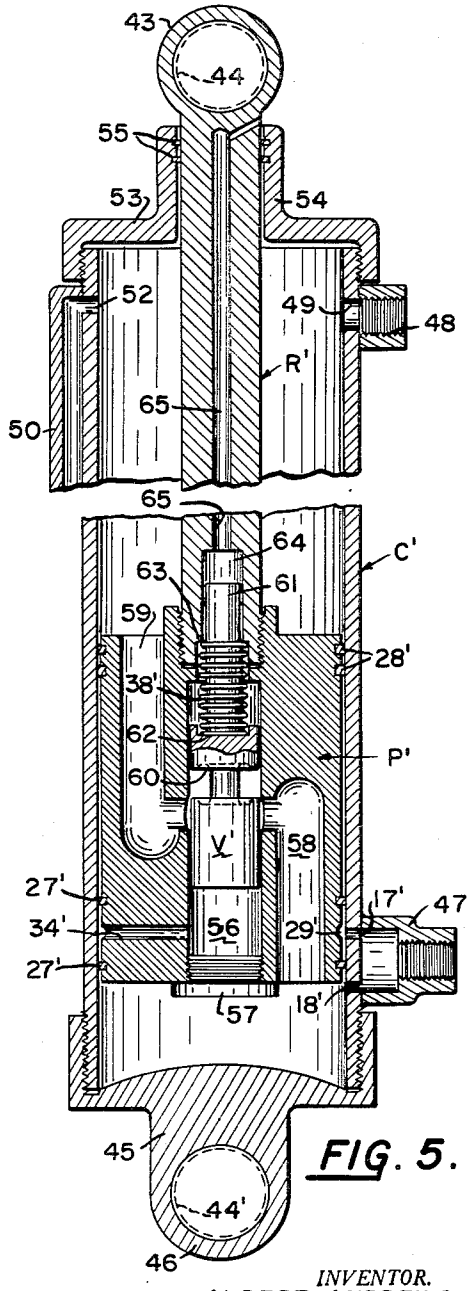


FIG. 5.

INVENTOR.
ALBERT ANDREWS
Deceased
BY HELEN ANDREWS
Heir

Aug. 30, 1960 A. ANDREWS 2,950,704

PUMP JACKS AND THE LIKE

Filed Dec. 1, 1958 4 Sheets-Sheet 3

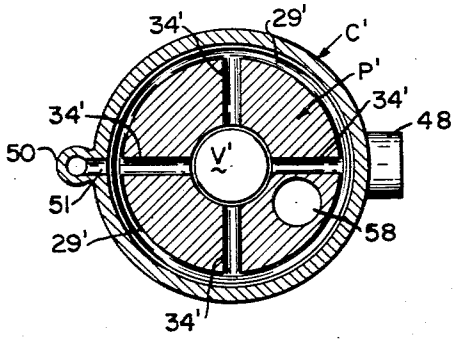


FIG. 6.

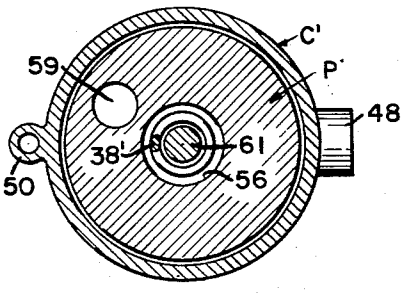


FIG. 7.

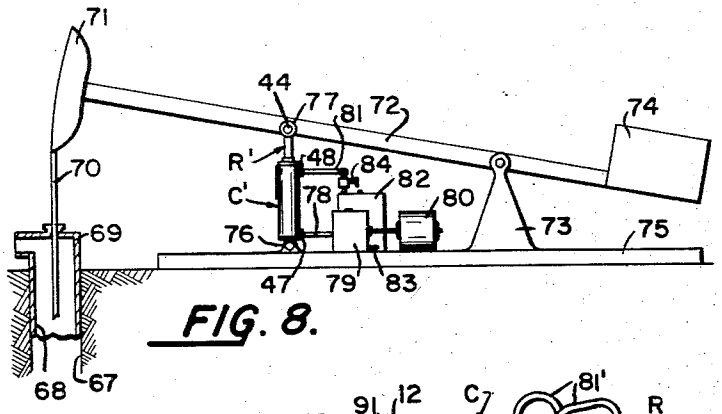


FIG. 8.

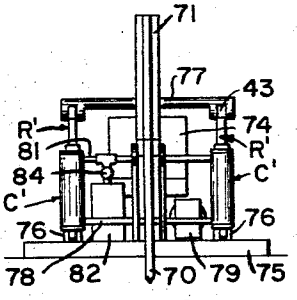


FIG. 9.

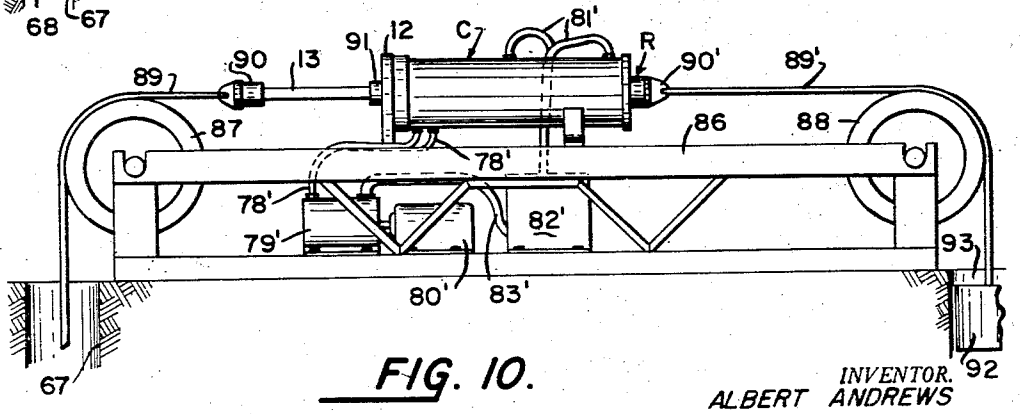


FIG. 10.

INVENTOR.
ALBERT ANDREWS
Deceased
BY HELEN ANDREWS
Heir

Aug. 30, 1960 A. ANDREWS 2,950,704

PUMP JACKS AND THE LIKE

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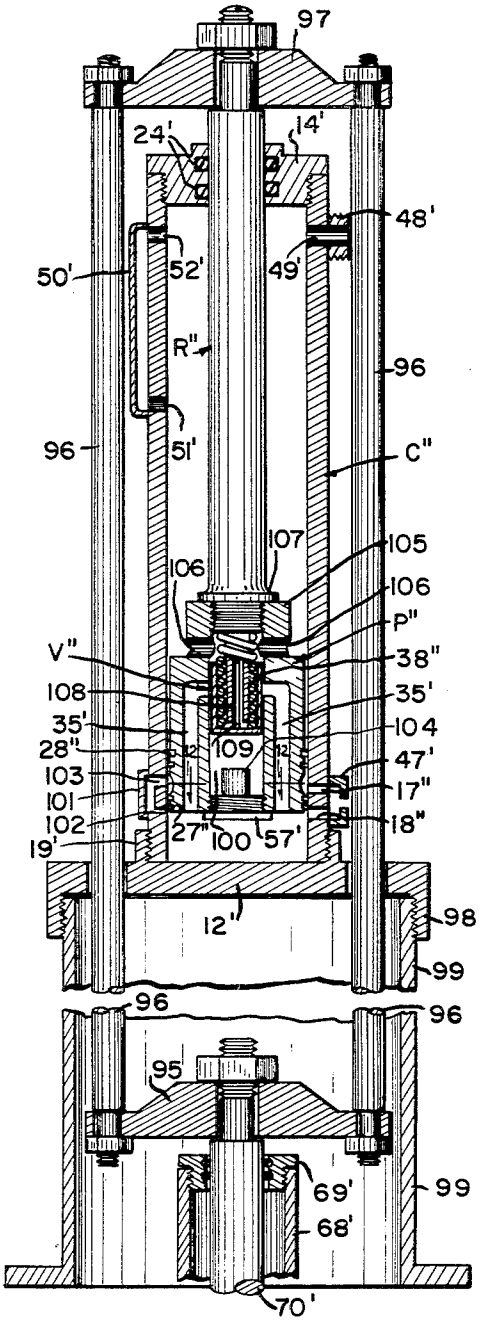


FIG. 11.

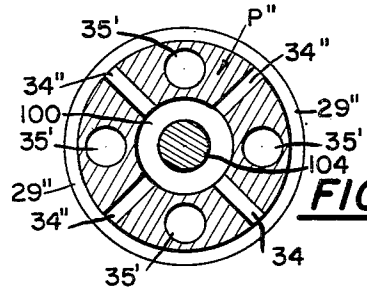


FIG. 12.

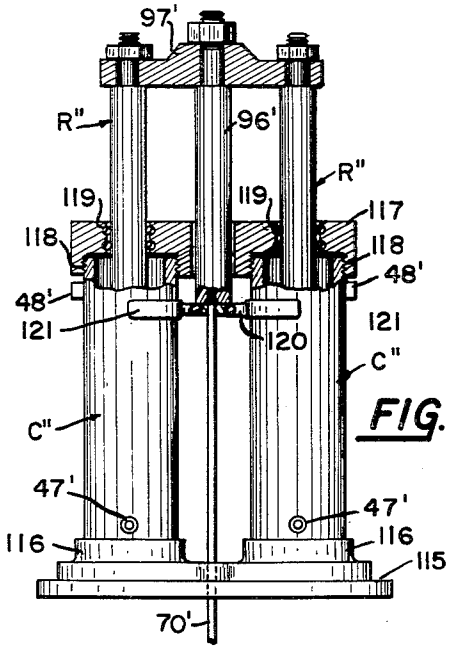


FIG. 13.

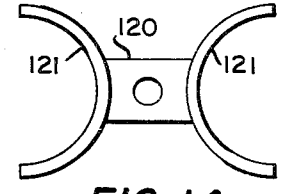


FIG. 14.

INVENTOR.
ALBERT ANDREWS
Deceased
BY
HELEN ANDREWS
Heir

United States Patent Office

2,950,704

Patented Aug. 30, 1960

2,950,704

PUMP JACKS AND THE LIKE

Albert Andrews, deceased, late of Larimer County, Colo., by Helen Andrews, heir, Loveland, Colo., assignor to Horace B. Van Valkenburgh, Denver, Colo.

Filed Dec. 1, 1958, Ser. No. 777,475

16 Claims. (Cl. 121—123)

This invention relates to hydraulic apparatus for producing reciprocatory motion, such as a pump jack, the term pump jack being used for brevity to refer to apparatus for producing upward and downward reciprocatory movement of a pump rod in an oil or water well, or any other type of apparatus in which such type of movement is desired. This invention is an improvement on the subject matter of copending application Ser. No. 466,898, filed November 4, 1954, entitled "Pump Jack", now U.S. Patent No. 2,852,001, issued Sept. 16, 1958.

In pumping oil from oil wells, a reciprocating pump is placed in the well at a depth such that the oil will flow into the pump and the pump is reciprocated by means of a pump rod which extends upwardly through the pumping tube to the collar or top of the well. Due to the depth of oil wells, such as from several hundred to several thousand feet, the weight of the pump rod itself, in addition to the weight of the oil in the pumping tube, is often considerable, such as several tons, and this weight must be lifted at each stroke of the pump. The stroke of the pump normally used for pumping oil wells may vary between one foot and five feet, depending upon the lift required at each stroke to produce the desired rate of flow, and the number of strokes per minute are relatively small, such as from five to fifteen per minute. Previously, extremely heavy and cumbersome gear driven apparatus has been used to reciprocate oil well pump rods. Such apparatus conventionally includes a large heavy walking beam, moved upwardly and downwardly by a crank actuated from a motor or engine through a gear train. In addition, the crank is formed as part of or attached to a heavy counterweight which tends to balance the weight of the pump rod and the oil in the well. Even with the use of a counterweight, the force required to lift the pump rod at each stroke of the pump is considerable, and such apparatus is therefore usually quite expensive, each such apparatus or pump jack often costing several thousands of dollars. In addition, the problems of adequate lubrication and wear require constant attention and considerable sums for upkeep.

In the pump jack of aforesaid application Ser. No. 466,898, a cylinder is provided with an inlet at one end and two spaced connected outlets adjacent the opposite end, with hydraulic fluid continuously supplied to the inlet. A valve, conveniently connected to another outlet at the same end as the inlet, permits the fluid to flow into the cylinder and then out of the cylinder, during the down stroke of the piston when the weight of the pump rod pulls the cylinder downwardly. The piston is adapted to uncover the lower port or outlet at the upper end so that the position of the valve may be changed by fluid pressure, the valve being closed to cause the full pressure of hydraulic fluid to be exerted against the piston for the upstroke. In the present invention, the valve is located within the piston itself and the apparatus is thus considerably simplified, while the fluid, during the down or return stroke, flows through the piston itself and the piping

arrangement is thus considerably simplified. Also, the operating parts, being within the piston, are more adequately protected against rough usage.

Among the objects of the present invention are to provide a novel and improved apparatus for producing reciprocating movement, as in a pump jack for an oil well; to provide such apparatus which is hydraulically operated and thereby permits use of a small driving unit of nominal horsepower which, in an oil well pump jack, operates against the heavy but slow moving load imposed upon the pumping rod in operation; to provide such apparatus which may be adjusted to a desired rate of stroke and is thereby adapted to control the rate of reciprocation of the well pump rod for any desired optimum period of time; to provide an improvement upon the pump jack of application Ser. No. 466,898; to provide such an improvement in which the operating parts are simplified; to provide such an improvement in which the operating parts are protected from rough usage; to provide such apparatus which is easy to set up and readily adjusted for operation; to provide such apparatus which is effective, dependable and economical to operate and requires a minimum of maintenance; and to provide such apparatus which is compact, light in weight and constructed simply of relatively few parts so that it may be easily disassembled for maintenance and repair.

Additional objects of this invention and the novel features thereof will become apparent from the description which follows, taken in connection with the accompanying drawings, in which:

Fig. 1 is a condensed vertical section taken through the longitudinal vertical axis of a pump jack constructed in accordance with this invention, with the operating parts in a lower position, at the end of a down stroke;

Fig. 2 is a similar vertical section, but of the upper portion only, with the operating parts in an upper position, at the end of an up stroke;

Fig. 3 is a horizontal section, taken along line 3—3 of Fig. 1;

Fig. 4 is a condensed vertical section of a modified form of pump jack, also constructed in accordance with this invention, showing the operating parts in an upper position, at the beginning of a down stroke;

Fig. 5 is a similar vertical section, showing the operating parts in a lower position, at the beginning of an up stroke;

Fig. 6 is a horizontal section, looking upwardly from line 6—6 of Fig. 4;

Fig. 7 is a horizontal section, looking upwardly from line 7—7 of Fig. 4;

Fig. 8 is a partly diagrammatic, side elevation of a pair of pump jacks of Fig. 4 and associated parts at the top of an oil well being pumped;

Fig. 9 is an end elevation of the same;

Fig. 10 is a side elevation of a pump jack of Fig. 1 mounted in a horizontal position and associated parts at the top of an oil well being pumped;

Fig. 11 is a vertical section of another modified form of pump jack, also constructed in accordance with this invention;

Fig. 12 is a cross section taken along line 12—12 of Fig. 11;

Fig. 13 is a side elevation, on a reduced scale, of an installation which includes two pump jacks constructed as in Fig. 11; and

Fig. 14 is an enlarged plan view of a guide shown in Fig. 13.

Referring to the drawings, a pump jack constructed in accordance with this invention, as in Figs. 1 and 2, may include a cylinder C, a piston P within the cylinder and a piston rod R attached to the piston and extending through the upper end of cylinder C. The piston rod

R may be a tubular sleeve, connected at its lower end to the piston P, as by threads 10, and surrounding a tube 11 which extends upwardly and preferably coaxially with the cylinder C, from a base 12 for the cylinder C. A central rod 13, which may be part of or connected to the pump rod, is disposed centrally within the tube 11 and connected at its upper end to the upper end of the piston rod R, as by a cap 14. The cylinder C may be provided at its lower end with a pair of vertically spaced inlet fittings 15 and 16, which are connected to a source of hydraulic fluid under pressure, such as a pump, and adapted to supply fluid to a pair of vertically spaced ports 17 and 18, which may be drilled or otherwise formed in the wall of cylinder C, which may be conveniently formed from tubing. The inner ends of the inlet fittings 15 and 16 conveniently extend through an annular flange 19 of base 12, in which cylinder C is mounted, as by a threaded connection 20. A vertically spaced pair of outlet fittings 21 and 22 are connected to a tank or other receptacle, from which the pump receives its supply of fluid, and may be connected to the upper end of cylinder C in positions to provide vertically spaced outlet ports. An upper cap 23, which closes the upper end of cylinder C, may be provided with a central hole which accommodates the piston rod R and in which a sealing ring 24 may be installed. Sealing rings 25 may also be installed on tube 11 adjacent its upper end, and a sealing ring 26 at the lower end of the cylinder and against base 12, for sealing purposes. The piston P may also be provided with an annular groove adjacent the lower end to receive a packing ring 27 and annular grooves spaced therefrom to receive spaced packing rings 28, for sealing purposes both above and below an annular groove 29 in the piston.

Piston P is provided with an interior valve, such as a piston valve V movable upwardly and downwardly within a cylindrical chamber 30, which conveniently extends axially of piston P and the lower end of which may be closed by a plug 31. The piston valve V may be generally cup-shaped and the lower flange thereof provided with a sealing ring 32, which engages the tube 11, while the piston valve V may also be provided with sealing rings, if desired, in the event that the fit between valve V and chamber 30 is not sufficiently tight to prevent undue leakage of fluid around the valve. The plug 31 may also be provided with an upstanding annular flange 33, adapted to act as a stop for the lower end of the valve V. A series of spaced radial holes 34 in piston P, as shown also in Fig. 3, provide communication between groove 29 and chamber 30 and, as will be evident, stop 33 of plug 31 prevents the valve V from closing the inner ends of holes 34. The valve V controls the flow of fluid through the piston from a series of lower passages 35 to a series of upper passages 36, which communicate with the chamber 30 at respective spaced positions adjacent the center of the latter and lead respectively from the lower and upper ends of the piston. Chamber 30 may be provided with a shoulder 37 which acts as a stop to restrict upward movement of the valve V.

When valve V is in the position of Fig. 1, the upper end of the valve will be below the point of connection of passages 35 with the chamber 30, so that flow of fluid from the lower portion of cylinder C, through passages 35 to passages 36 and thence to the upper end of cylinder C, is permitted. Valve V is normally held in the open position of Fig. 1 by a coil spring 38, the lower end of the spring 38 conveniently being received in the well formed in valve V. The upper end of spring 38 conveniently abuts against an inwardly extending flange 39 at the lower end of an upwardly extending flange 40, the upper edge of flange 39 acting as a stop for piston rod R when threaded into the piston and the threads for piston rod R being tapped in flange 40.

The valve V may be moved upwardly against the pressure of spring 38 by fluid pressure supplied to the lower end of chamber 30 through the lateral holes 34, as when groove 29 registers with inlet port 17 after piston P has moved downwardly to the position of Fig. 1. The vertical spacing between inlet ports 17 and 18 is equivalent to or greater than the distance between groove 29 and the lower end of piston P, so that fluid pressure will always be supplied through inlet port 18 to the lower end of cylinder C and beneath piston P, particularly when the latter has moved to the position of Fig. 1. Thus, when port 17 is uncovered by groove 29, valve V will then be moved upwardly to closed position and the piston P will be started upwardly by pressure of fluid supplied through port 18 and, shortly thereafter, also through port 17.

During the up stroke, or time that the piston P is moved upwardly by the pressure of fluid supplied through the ports 17 and 18, valve V will be in the closed position shown in Fig. 2, being maintained in that position by the pressure of fluid maintained in the lower portion of chamber 30 by the closed valve V and the rings 27 and 28. During upward movement of the piston P, with the valve V in closed position, any fluid in the upper portion of the chamber will be expelled through the outlet fitting 21 and also through the outlet fitting 22 until the piston rings 28 close the same. When groove 29 reaches the position of outlet fitting 22, the fluid pressure beneath the valve V will be relieved, i.e., through holes 34 and groove 29, for discharge through outlet fitting 22. Then, spring 38 will move valve V downwardly to the position shown in Fig. 1, which will be the beginning of the return stroke.

The weight of the pump rod, and other weight associated therewith, provides a force acting downwardly on piston rod R, through the rod 13, thus tending to force the piston P downwardly within cylinder C. Thus, when valve V is open, as in the position shown in Fig. 1, the fluid pressure which previously moved piston P upwardly will be relieved through the piston passages 35 and 36, so that the fluid supplied through inlet port 18 or also port 17 will merely circulate through the cylinder and piston, for discharge through outlet fitting 21 and also outlet fitting 22, while the piston is being moved downwardly by the force normally exerted on the piston rod. As soon as the piston P has moved downwardly to a position in which groove 29 is in alignment with inlet port 17, the pressure of fluid supplied to the lower end of chamber 30 through holes 34 will again move valve V to the position of Fig. 2, against the pressure of spring 38. Valve V will thus close chamber 30 between passages 35 and 36, so that fluid pressure supplied to the lower end of cylinder C through the inlet port 16 will move piston P upwardly against the force at rod 13, thereby moving the pump rod upwardly, so that the reciprocatory movement of piston P and rod R will continue automatically. The rate of upward movement of the piston P may be regulated by varying the pressure of fluid supplied to inlets 15 and 16, as by pump control or by placing a flow adjusting valve in the inlet line from the pump, while the rate of downward movement may be regulated by varying the rate of flow of fluid discharged through outlets 21 and 22, conveniently by placing an adjustable flow restricting valve in the discharge line from outlets 21 and 22 to the fluid supply tank or the like.

A modified form of pump jack constructed in accordance with this invention, as in Figs. 4 and 5, may include a cylinder C', a piston P' within the cylinder and a piston rod R' attached to the piston and extending from the upper end of cylinder C'. The upper end of the piston rod R' may be provided with a bearing 43 adapted to engage a shaft or pin 44, indicated in dotted lines, while a lower cap 45, which closes the lower end of cylinder C', may be provided with a bearing 46, simi-

larly adapted to engage a shaft or pin 44', also indicated in dotted lines. The cylinder C' may be provided with an inlet fitting 47 adapted to supply fluid to a pair of vertically spaced inlet ports 17' and 18', which may be drilled or otherwise formed in the wall of cylinder C, which may be conveniently formed from tubing. The inner end of the inlet fitting 47 may be shaped to conform to the outside of cylinder C and welded thereto around its edges. An outlet fitting 48 may be similarly welded to cylinder C in a position to communicate with an outlet port 49, also conveniently drilled in the cylinder wall. A transfer passage may be provided by a substantially semi-cylindrical pipe section 50, conveniently closed at each end and welded to the outside of the cylinder around its edges, so as to provide communication between a lower transfer port 51 and an upper transfer port 52, each conveniently drilled through the cylinder wall. An upper cap 53, which closes the upper end of cylinder C, may be provided with an upstanding sleeve 54 to accommodate the piston rod R, while packing rings 55 may be placed in annular grooves suitably formed on the inside of sleeve 54, for sealing purposes. The piston P may also be provided with annular grooves adjacent the upper end to receive packing rings 28' and annular grooves adjacent the lower end to receive spaced packing rings 27', for sealing purposes.

Piston P' is provided with an interior valve, such as a piston valve V' movable upwardly and downwardly within a cylindrical chamber 56, which conveniently extends axially of piston P and the lower end of which may be closed by a plug 57. The piston valve V' may also be provided with packing rings, if desired, in the event that the fit between valve V' and chamber 56 is not sufficiently tight to prevent undue leakage of fluid around the valve. The valve V' controls the flow of fluid through the piston from a lower passage 58 to an upper passage 59, each of which communicates with the chamber 56 at opposed positions adjacent the center of the latter, valve V' being provided with an annular groove 60 which, at certain times, provides communication between passages 58 and 59 through the chamber 56, as with valve V' in the position of Fig. 4. However, when valve V' is moved to the position of Fig. 5, the groove 60 will be above the point of connection of passages 58 and 59 with the chamber 56, so that the flow through passage 58 to passage 59 and thence to the upper end of cylinder C' is prevented. Valve V' is normally held in the open position of Fig. 4 by a coil spring 38' which surrounds a valve stem 61, the lower end of the spring 38' conveniently being received in a well 62 in the valve V' adjacent the lower end of the stem 61 and the upper end of spring 38' conveniently abutting against a shoulder 63 surrounding a guide well 64 in the rod R for the valve stem 61. An air passage 63 may extend upwardly within the piston rod R, from well 64 to a point near bearing 43, to maintain substantially atmospheric pressure in the upper portion of chamber 56, i.e., above valve V', for a purpose described later.

The valve V' may be moved upwardly against the pressure of spring 38' by fluid pressure supplied to the lower end of chamber 56 through a series of lateral holes 34', which extend inwardly from an annular groove 29', as in Fig. 6, as when groove 29' registers with inlet port 17', as in Fig. 5, after piston P' has moved downwardly from the position of Fig. 4 to the position of Fig. 5. Preferably, the vertical spacing between inlet ports 17' and 18' is equivalent to or slightly greater than the distance between groove 29' and the lower end of piston P', so that fluid pressure will always be supplied to the lower end of cylinder C' and beneath piston P', particularly when the latter has moved to the position of Fig. 5. Thus, as soon as port 17' is uncovered by groove 29', valve V' will be moved upwardly to closed position and the piston P' will be started upwardly by pressure of fluid supplied through port 18' and, shortly thereafter, also through port 17'.

During the up stroke, or time that the piston P' is moved upwardly by the pressure of fluid supplied through the ports 18' and 17', valve V' will be in the closed position of Fig. 5, but when groove 29' reaches the position of transfer port 51, the fluid pressure beneath the valve V' will be relieved, i.e., through port 51 and transfer pipe 50 to transfer port 52 and into the upper end of the cylinder, above the piston P', for discharge through outlet port 49. Then, spring 38' will move valve V' downwardly to the position of Fig. 4, which is at the beginning of the return stroke. Normally, the pressure at transfer port 52 will be in excess of atmospheric pressure, so that there will normally be a pressure differential between the upper and lower portions of chamber 56, i.e., above and below valve V', but the residual pressure in the lower portion of chamber 56 will balance the force exerted by spring 38', when in the extended position of Fig. 4. If desired, plug 57 may be provided with an upwardly extending stop to limit downward movement of valve V'. Normally, of course, a weight or force is acting through the shaft or pin 44, on piston rod R, and tends to force piston P' downwardly within cylinder C'. Thus, when valve V' opens, as in the position of Fig. 4, the fluid pressure which previously moved piston P' upwardly will be relieved through the piston passages 58 and 59, so that the fluid supplied through inlet ports 17' and 18' will merely circulate through the cylinder and piston, for discharge through outlet port 49, while the piston is being moved downwardly by the force exerted on the piston rod at shaft or pin 44. As soon as the piston P' has moved downwardly to a position in which groove 29' is in alignment with inlet port 17', the pressure of fluid supplied to the lower end of chamber 56 through passages 34' will again move valve V' to the position of Fig. 5, against the pressure of spring 38'. Valve V' will thus close chamber 56 between passages 58 and 59, so that fluid pressure supplied to the lower end of cylinder C' through the inlet port 18' will move piston P upwardly against the force at shaft or pin 44, thereby moving the pump and rod upwardly, and the reciprocatory movement of piston P' and rod R' will continue automatically.

During the downward movement of piston P', the groove 29' and lower end of chamber 56 will remain at the fluid pressure of transfer port 51 until the lower seal ring 27' moves across the port 17'. Also, as piston P' begins to move upwardly from the lower position, as the lower seal ring 27' passes inlet port 17', the fluid under pressure in chamber 56 will be trapped against ingress or egress, until piston P' has moved upwardly to a position at which the upper seal ring 27' uncovers the transfer port 51 and the pressure within chamber 56 below valve V' will be relieved so that valve V' can be moved downwardly and to open position by spring 38'. In order to prevent an accumulation of air above valve V', which might produce a compression force against the upward movement of the valve, air pressure is relieved through hole 65 in rod R. Air traveling up hole 65 may be vented through a hole in the side of piston rod R communicating with passage 65 just below bearing 43.

The pump jack of Figs. 1–3 may be used in a manner similar to that disclosed in aforesaid application Serial No. 466,898, while the pump jack of Figs. 5–7 may be used in the pumping apparatus of Figs. 8 and 9, for pumping oil from a well 67, for instance, through a casing 68 having a casing head 69 from which oil pumped out of the well is discharged, and through which a pump rod 70 extends. The pump rod 70 may be provided at its upper end with a cable attached to the upper end of an arcuate guide 71, in turn attached to one end of a beam 72 pivoted on a standard 73 and provided with a counterweight 74 on the opposite end. The standard 73 may be mounted on a foundation 75, while a pair of pump jacks, con-

structed as described above, may each be mounted between a bracket 76 on the foundation 75 and a yoke 77, extending to each side of the beam 72, as in Fig. 9, and attached to the beam between standard 73 and guide 71. As in Fig. 8, the inlet fitting 47 of each cylinder C' may be connected by a reinforced hose 78 with a pump 79 which may be driven by an electric motor 80, or by an internal combustion engine or the like, if desired. Each outlet fitting 48 of a cylinder C' may be connected by a reinforced hose 81 with a tank 82, in which a supply of fluid for pump 80 may be stored and connected with pump P by a pipe 83. As will be evident, pump rod 70 is moved upwardly during each upward stroke of the piston and piston rod R' of each pump jack through the beam 72, while the downward pressure exerted by the pump rod 70 on the beam 72 will force each piston and piston rod R' downwardly within the respective cylinder C' during each downward stroke. The rate of upward movement of the pistons and piston rods R' may be adjusted by increasing or decreasing the pressure produced by pump 79. Thus, an adjustable pressure pump may be used, or the pump may be driven by an adjustable speed electric motor or by a gas or oil engine. Also, the downward rate of movement of the pistons and piston rods R' may be adjusted by regulating the rate of discharge from exhaust ports 49, as by a valve 84 in the exhaust line 81. In general, an increase in pump pressure will increase the rate of upward movement, and vice versa, while an increase in the rate of discharge from the cylinder exhaust port will increase the rate of downward movement, and vice versa. Thus, the number of strokes per unit of time is readily adjusted.

The pump jack of Figs. 1–3 may also be used in the manner illustrated in Fig. 10, for pumping oil from a well 67, while the pump jack of Figs. 4–7 may be similarly utilized. Thus, the cylinder C of the pump jack of Figs. 1–3 may be mounted in horizontal position on a platform 86, which also supports sheaves 87 and 88 at the opposite ends thereof. A cable 89 runs over sheave 87 and is connected to rod 13 of the pump jack, as by a connector 90, the rod 13 being extended, if desired, so that the outer end thereof and particularly the connector 90 will not enter the cylinder C when the piston rod R is moved to its fullest extent to the right. Also, a guide or bearing 91 for the rod 13 may be mounted on the base 12 for cylinder C. The outer end of the piston rod R may be attached to a cable 89', as by a connector 90', with cable 89' running over sheave 87 to a weight 92 adapted to move upwardly and downwardly in a shallow hole 93 drilled for that purpose. As will be evident, the weight 92 tends to counterbalance the weight of the pump rod and the oil being lifted in the well 67, although some weight should be left uncounterbalanced, so that the piston rod R will be moved to the left by such weight when the valve V is shifted to the position of Fig. 1, at the beginning of the return stroke, which corresponds to the downstroke described in connection with Figs. 1 and 2. A motor 80' for driving a pump 79', as well as a sump tank 82', may be installed beneath platform 86, or in any other convenient position, while piping or reinforced hoses may connect the various parts, such as hoses 78' from the pump to the inlets of cylinder C, hoses 81' from the outlets of cylinder C to the sump tank 82' and a hose 83' from the sump tank to the pump.

In a further modified form of pump jack illustrated in Figs. 11 and 12, a piston P'' is movable upwardly and downwardly within a cylinder C'', while a piston rod R'' is attached to the piston P'' and extends upwardly through an upper cap 23' for the cylinder, which may be provided with annular grooves in which seal rings 24' for the piston rod are disposed. The pump rod 70' may extend through a casing head 69' of casing 68' and may be connected at its upper end to a yoke 95 in turn connected at its outer ends to a pair of pull rods 96 which extend upwardly and alongside the cylinder C'' for connection to a transverse bar 97, in turn connected to the piston rod R'', which may also be considered a push rod. That is, when the piston P'' is moved upwardly in the cylinder C'', the push rod R'' moves upwardly with it and the pull rods 96 pull the pump rod 70' upwardly. However, the weight of the pump rod will be exerted through the pull rods 96 and push piston rod R'' downwardly to move the piston P'' back down in cylinder C'', during the down or return stroke. A base 12', which also provides a lower cap for the cylinder C'', may be provided with an interiorly threaded, upwardly extending circular flange 19' engaged by the lower threaded end of cylinder C'', as well as a downwardly extending circular flange 98, conveniently of a larger diameter than flange 19' and interiorly threaded so as to be attached to the upper end of a cylindrical support 99. The pull rods 96 extend through appropriate holes in base 12', while the support 99 may be mounted on a foundation and may also be provided with an aperture for the pipe (not shown) from which fluid being pumped from the well is discharged at the upper end of casing 68', as well as additional apertures, as desired, for access to the parts within the support 99.

The cylinder C'' may be provided with an inlet connection 47', which may be welded to the cylinder C' so as to cover spaced inlet ports 17'' and 18'', while cylinder C'' may also be provided with an outlet connection 48' conveniently welded to cylinder C'' around an exhaust port 49'. A transfer pipe 50' may also be closed at each end, except for openings which overlie a lower transfer port 51' and an upper transfer port 52', respectively, transfer pipe 50' being conveniently welded to cylinder C''. As before, piston P'' may be provided with sealing rings 28'' and 27'' disposed in annular grooves above and below an annular groove 29'' connected by a series of radial passages 34'', as in Fig. 12, with a central chamber 100 which extends axially through the piston P'' and to which a series of passages 35' lead from the lower end of the piston. The cylinder C'' may further be provided with a semi-cylindrical, lower transfer pipe 101 which may be closed at the ends and welded to cylinder C'' on the outside, conveniently opposite the inlet connection 47', so as to connect vertically spaced inlet transfer ports 102 and 103.

A valve V'', which may be cup-shaped, as shown, is movable upwardly within chamber 100 by fluid pressure in the lower portion of the chamber and downwardly by a spring 38'', the lower end of chamber 100 being conveniently closed by a plug 57' having an upwardly extending stop 104, adapted to limit downward movement of valve V''. At its upper end, piston P'' may be provided with an upwardly extending annular flange 105, which is interiorly threaded above outlet passages 106 which communicate with the upper end of chamber 100 above valve V'', while the lower end of piston rod R'' may be threaded below a shoulder 107 adapted to abut against the upper end of flange 105 when the piston rod is attached to the piston. A stem 108 may extend downwardly from piston rod R'', so as to form a guide for spring 38'', while, if desired, the piston rod stem 108 may be hollow and the valve V'' provided with a central upstanding stem 109 received in and guided by the stem 108, which also reduces the cross-sectional area against which the pressure of fluid in the upper portion of the chamber 100 is exerted, so as to permit inlet fluid pressure, when introduced into the lower portion of chamber 100, to move valve V'' upwardly more quickly.

As will be evident, the pump jack of Fig. 11 may operate in a manner similar to the pump jack of Figs. 4–7. Thus, in the lower position shown in Fig. 11, the piston P'' is at the start of an up stroke, valve V'' having just previously been moved upwardly by inlet fluid pressure introduced into the lower portion of chamber 100 through passages 34'' when groove 29'' registered with inlet port

17" and transfer port 103. With the valve V" closing off passages 35', as shown, the piston P" will be moved upwardly by inlet fluid pressure, thereby moving the piston and push rod R" upwardly and pulling pump rod 70' upwardly through pulling rods 96. When piston P" reaches an upper position, in which groove 29" registers with outlet transfer port 51', the fluid pressure beneath valve V", in the lower portion of chamber 100, will be relieved through transfer pipe 50' and port 52', thereby permitting spring 38" to move valve V" downwardly against stop 104. Due to the flow of fluid through piston passages 35' and thence through passages 106 for ultimate discharge through outlet port 49', the weight of the pump rod 70', transmitted through pull rods 96 to piston rod R", will move piston P" downwardly in the cylinder until the lower position is reached, i.e., with groove 29" again registering with ports 17" and 103. The valve V" will then be moved upwardly and piston P" thus also again moved upwardly, so that the upward and downward movement of piston P" takes place automatically.

In the installation illustrated in Figs. 13 and 14, a pair of pump jacks, each including a cylinder C" and a piston or push rod R" may be mounted in side by side relation on a base 115 formed with a pair of rotatable heads 116 adapted to be threaded onto the lower end of the respective cylinder C". The upper ends of cylinders C" may be connected to an upper head 117 provided with interiorly threaded wells 118, into which the upper ends of the cylinders may be threaded prior to attachment to lower heads 116. Upper head 117 is provided with sealing rings 119 for piston rods R", while base 115 is conveniently provided with a hole disposed centrally between cylinders C" to accommodate the pump rod 70'. The piston rods R" may be connected at their upper ends to a transverse bar 97', which is connected at its center to a pull rod 96', in turn connected at its lower end to pump rod 70'. The downward force of the pump rod 70' is transmitted through pull rod 96' to the piston rods R" for moving the pistons downwardly within the cylinders C", while the upward force produced by upward movement of the pistons is transmitted through pull rod 96' to the pump rod 70'. If desired, a guide 120 may be attached to the lower end of the pull rod 96' and provided at each end with an arcuate half ring 121, as in Fig. 14, which move upwardly and downwardly along the cylinders C". Each of the cylinders C" is provided with an inlet connection 47' and an outlet connection 48', the former receiving fluid under pressure through an inlet line from a hydraulic pump and the latter discharging through an outlet line to a fluid storage tank, in a manner similar to Figs. 8 and 9. If desired, a valve may be placed in the discharge line for regulating the rate of discharge from the outlet connection 48' and thereby adjusting the time of the downward stroke, while the pump may be a variable pressure pump or be driven by a variable speed prime mover to permit adjustment of the rate of the upward stroke of the pistons within the respective cylinders C", as before.

As will be evident, a pump jack or the like constructed in accordance with this invention fulfills to a marked degree the requirements and objects hereinbefore set forth. The pump jack is adapted to reciprocate automatically when a downward force is exerted thereon and also may be used in connection with a walking beam, as in Figs. 8 and 9, or to act substantially directly on the pump rod, as in Figs. 10, 13 and 14. By placing the control valve within the piston, numerous exterior parts are eliminated and the construction of the apparatus is considerably simplified. Also, the valve within the piston may be controlled readily by registry of a groove or the like communicating with the chamber in which the valve is disposed, through registry with properly placed ports in the cylinder. Also, all of the interior parts are accessible merely by removal of the piston and without disturbing the cylinder itself. The adjustment of the rate of the upward and downward strokes is readily accomplished, as in the manner previously described, while the weight of the pump rod in the well is used to advantage in moving the piston downwardly. Such pump jacks may also be readily incorporated in other types of hydraulic apparatus.

While several embodiments of this invention have been illustrated and described, including pump jacks for oil wells and the like, it will be understood that other embodiments may exist and various changes may be made, all without departing from the spirit and scope of this invention.

What is claimed is:

1. Apparatus for producing reciprocatory movement of a member such as a pump rod in an oil well, said member being subject to a force tending to move said member in one direction, comprising a cylinder having adjacent a first end an inlet adapted to be connected with a source of fluid under pressure and adjacent the opposite end an outlet adapted to be connected to a receiver for said fluid; a reciprocable piston within said cylinder and having a generally axial passage therethrough; a valve within said piston for controlling the flow of fluid through said passage, said cylinder being provided with a control port intermediate said inlet and outlet, said control port being adapted to be connected in fluid communication with said receiver; and said piston being provided with means for closing said valve when said piston moves to a predetermined position of registry with said control port; a piston rod extending through said opposite end of said cylinder and connected to said piston; means for connecting said piston rod with said member; and means operable in response to the movement of said piston for controlling said valve and constructed and arranged to close said valve when said piston nears said first end of said cylinder and thereby permit fluid flowing into said cylinder to move said piston away from said end and move said member in a direction opposite to said force, and to open said valve when said piston moves a selected distance within said cylinder to permit such force on said member to move said piston back to a position near said first end of said cylinder.

2. Apparatus as defined in claim 1, wherein said cylinder is provided with a transfer port adjacent said opposite end and means connecting said control port with said transfer port.

3. Apparatus as defined in claim 1, wherein said control port is adapted to be connected to said receiver.

4. Apparatus as defined in claim 1, wherein said piston is provided with an axial chamber, at least a portion of said chamber forming a portion of said passage through said piston, said valve being movable axially in said chamber; resilient means tending to move said valve in a direction to close said passage; and said piston is provided with a general lateral, separate passage for supplying fluid under pressure to said chamber and against said valve in opposition to said resilient means, said lateral passage being constructed and arranged to communicate with said inlet when said piston nears said first end of said cylinder and to communicate with said control port when said piston approaches said opposite end of said cylinder, said lateral passage thereby supplying fluid under pressure to move said valve to close said axial passage when said lateral passage is in communication with said inlet and such fluid pressure being relieved when said lateral passage is in communication with said control port.

5. Apparatus as defined in claim 4, wherein said inlet includes at least two ports spaced axially of said cylinder.

6. Apparatus as defined in claim 4, wherein said piston is provided with a circumferential groove and a series of spaced passages leading radially from said groove to said chamber.

7. Apparatus as defined in claim 4, wherein said generally axial passage through said piston includes a first

series of radially spaced, axially extending passages leading from the end of said piston facing said one end of said cylinder and connecting with said chamber generally centrally of said piston; and a second series of radially spaced, axially extending passages connecting with said chamber at a position spaced axially from said first series of passages and leading to the opposite end of said piston.

8. Apparatus as defined in claim 4, wherein said generally axial passage through said piston includes a first axial passage extending from the end of said piston facing said one end of said cylinder and connecting with said chamber generally centrally of said piston; and a second axial passage connecting with said chamber opposite the connection point of said first passage and extending to the opposite end of said piston.

9. Apparatus as defined in claim 4, wherein said generally axial passage through said piston includes a series of radially spaced, axially extending passages leading from the end of said piston facing said one end of said cylinder to a point of connection with said chamber spaced from the opposite end of said piston, said opposite end of said piston being reduced in diameter; and a series of spaced passages extending outwardly from said chamber through the reduced end of said piston.

10. Apparatus as defined in claim 4, wherein said chamber is formed by a well extending axially into said piston from the end of said piston facing said one end of said cylinder; and a plug closing the outer end of said well, said plug being provided with a stop extending axially into said chamber and said stop having a lateral extent less than said well.

11. Apparatus for producing reciprocatory movement of a member such as a pump rod in an oil well, said member being subject to a force tending to move said member in one direction, comprising a cylinder having adjacent a first end a pair of inlet ports disposed in axially spaced relation and adjacent the opposite end an outlet, said cylinder having a control port disposed in axially spaced relation to said outlet, said inlet ports being adapted to be connected with a source of fluid under pressure and said outlet port and control port being adapted to be connected to a receiver for said fluid; a base closing said first end of said cylinder; a cap closing the opposite end of said cylinder; a reciprocable piston within said cylinder and having therein a central, axially disposed chamber formed by a well closed at its outer end by a tubular plug having an axially extending flange, a first series of spaced passages extending axially from the end of said piston facing said base, a second series of spaced passages extending axially from the opposite end of said piston, said first and second series of passages connecting with said chamber at axially spaced points, a series of radially extending passages interspaced with said first series of axial passages and communicating with said chamber opposite said plung flange, and a circumferential groove in which said radial passages terminate; a tubular piston rod connected to said opposite end of said piston and extending through said cap; a central tube mounted on said base and extending through said piston and into said piston rod; a pull rod connected to the outer end of said piston rod and extending through said tube; a valve within said piston chamber and adapted to control the flow of fluid between said first and second series of passages; and a spring surrounding said tube and engaging said valve, said spring tending to move said valve to open position, whereby fluid under pressure admitted to said chamber when said piston groove registers with said inlet port farther from said base moves said valve to closed position to terminate flow of fluid between said first and second series of passages and thereby permits fluid flowing into said cylinder through said inlet port closer to said base and subsequently through both inlet ports, to move said piston away from said base, and said spring moves said valve to open position when said groove registers with said control port and relieves the pressure of

fluid against said valve, to permit flow of fluid through said first and second passages and into said cylinder beyond said piston and thence through said outlet, thereby permitting such force to move said piston back to a position near said first end of said cylinder.

12. Apparatus for producing reciprocatory movement of a member such as a pump rod in an oil well, said member being subject to a force tending to move said member in one direction, comprising a cylinder having adjacent a first end a pair of inlet ports disposed in axially spaced relation and adjacent the opposite end an outlet, said cylinder having a control port disposed in axially spaced relation to said outlet, a transfer port adjacent said opposite end and means connecting said control port with said transfer port, said inlet ports being adapted to be connected with a source of fluid under pressure and said outlet being adapted to be connected to a receiver for said fluid; a first cap closing said first end of said cylinder, said first cap being provided with a trunnion; a second cap closing the opposite end of said cylinder; a reciprocable piston within said cylinder and having a central, circular, axial passage closed at the end facing said first cap by a plug, a first offset axial passage leading from the end of said piston facing said first cap and connecting with said central passage adjacent the axial center thereof, a second offset axial passage leading from the opposite end of said piston and connecting with said central passage opposite the point of connection of said first axial passage, said first and second axial passages being offset radially from said central axial passage, a series of spaced radial passages extending laterally to said central passage adjacent said plug, and a circumferential groove in which said radial passages terminate; a piston rod extending through said second cap and connected at its inner end to the corresponding end of said piston, said piston rod being provided at its outer end with a trunnion and having a passage therethrough terminating adjacent its outer end; means constructed and arranged to connect one of said trunnions with said member; a valve within said central passage of said piston and provided with a cylindrical body having an axially extending stem and an annular groove adapted to register with the point of connection of said first and second axial passages with said central passage to permit flow of fluid through said piston in an axial direction; a spring surrounding said stem and bearing against said valve body and tending to move said valve in a direction to terminate flow of fluid through said piston, said circumferential groove of said piston being adapted to register with said inlet port farther from said first cap when said piston moves toward and near said first end of said cylinder, so that fluid under pressure supplied through said radial passages to said central passage between said plug and said valve will move said valve against the pressure of said spring, to terminate flow generally axially through said piston and thereby permit the pressure of fluid supplied through said inlet port closer to said first cap and subsequently through both inlet ports, to move said piston away from said first cap, and said spring moving said valve to open position when said groove registers with said control port and relieves the pressure of fluid against said valve, thereby permitting fluid to flow axially through said piston and into said cylinder beyond said valve and thence through said outlet to permit such force to move said piston back to a position near said first end of said cylinder.

13. Apparatus for producing reciprocatory movement of a member such as a pump rod in an oil well, said member being subject to a force tending to move said member in one direction, comprising a cylinder having adjacent a first end a pair of inlet ports disposed in axially spaced relation and adjacent the opposite end an outlet, said cylinder having a control port disposed in axially spaced relation to said outlet and a transfer port adjacent said opposite end and means connecting said control port

with said transfer port, said inlet ports being adapted to be connected with a source of fluid under pressure and said outlet being adapted to be connected to a receiver for said fluid; a piston reciprocable within said cylinder and having a central axial passage closed at the end facing said first end of said cylinder by a plug having an axially extending stop within said central passage, said stop having a lateral dimension less than said central passage, a series of axial passages surrounding said central passage and extending from the end of said piston facing said first end of said cylinder and connected with said central passage at points spaced from the opposite end of said piston, said opposite end of said piston having a substantially smaller lateral dimension than the remainder of said piston, a first series of radial passages interspersed with said series of axial passages and connected with said central passage adjacent said plug, a circumferential groove in which the outer end of said first radial passages terminate, and a second series of radial passages extending outwardly from said central passage through the reduced opposite end of said piston; a piston rod connected to said opposite end of said piston and closing the corresponding end of said central passage, the inner end of said piston rod being provided with a hollow stem extending axially into said central passage of said piston; a cup-shaped valve having a central stem extending into the hollow stem of said piston rod and adapted in open position to permit flow of fluid through said piston passages and in closed position to terminate flow of fluid through said piston passages; a coil spring surrounding said piston rod stem and bearing against said valve, said spring tending to move said valve to open position; and means connecting said piston rod with said member.

14. Apparatus for producing upward and downward reciprocatory movement of a pump rod in an oil well, said pump rod being subject to a force tending to move said pump rod downwardly, including a pivoted walking beam connected to said pump rod and provided with a weight at the opposite end, means for supplying fluid under pressure and means for receiving fluid, the improvement comprising a generally upright cylinder having a closed lower end provided with a trunnion, said cylinder having an inlet adjacent its lower end and an outlet adjacent its upper end; means connecting said means supplying fluid under pressure with said inlet; means connecting said means for receiving fluid with said outlet; bearing means for said trunnion; a reciprocable piston with said cylinder, said piston having a passage therethrough; a piston rod connected to said piston and extending through the upper end of said cylinder, the upper end of said piston rod being provided with a trunnion pivotally connected to said walking beam; a valve within said piston for controlling the flow of fluid through said passage; and means operable in response to the movement of said piston for controlling said valve and constructed and arranged to close said valve when said piston nears the lower end of said cylinder and thereby permits fluid flowing into said cylinder to move said piston upwardly, and to open said valve when said piston moves a predetermined distance upwardly in said cylinder to permit the fluid supplied to said inlet to flow through said piston and thence out said outlet, the force on said pump rod thereby moving said walking beam in a corresponding direction and moving said piston downwardly to a position near the lower end of said cylinder.

15. In apparatus for producing upward and downward reciprocatory movement of a pump rod in an oil well, said pump rod being subject to a force tending to move said pump rod downwardly, including means for supplying fluid under pressure and a receiver for said fluid, the improvement comprising a cylinder mounted in horizontal position and having adjacent one end an inlet connected to said fluid pressure means and adjacent its opposite end an outlet connected to said receiver; a reciprocable piston within said cylinder having a passage therethrough; a hollow piston rod connected to said piston and extending through one end of said cylinder; a tube extending centrally of said cylinder within said hollow piston rod; a pull rod connected to the outer end of said hollow piston rod and extending centrally through said tube and outwardly from the opposite end of said cylinder; means connecting said pull rod with said pump rod; means connecting said piston rod with a counterbalancing movable weight; a valve within said piston for controlling the flow of fluid through said passage; and means operable in response to the movement of said piston for controlling said valve and constructed and arranged to close said valve when said piston nears said one end of said cylinder and thereby permit fluid supplied to said cylinder through said inlet to move said piston away from said end and move said pump rod upwardly, and to open said valve when said piston approaches the opposite end of said cylinder to permit fluid to flow through said piston and said cylinder and to be discharged through said outlet, thereby permitting the force on said pump rod to move said piston back to a position near said end of said cylinder.

16. In apparatus for producing upward and downward reciprocatory movement of a pump rod in an oil well, said pump rod being subject to a force tending to move said pump rod downwardly, including a pump for supplying fluid under pressure and a receiver for said fluid, the improvement comprising a pair of cylinders mounted in laterally spaced, upright relation, each said cylinder having an inlet adjacent the bottom thereof and an outlet adjacent the top thereof, each said inlet being connected to said pump and each said outlet being connected to said receiver; a base closing the lower end of each said cylinder; a head closing the upper ends of both said cylinders and provided with a hole between said cylinders; a pull rod extending through the central hole in said head and connected to said pump rod; a guide for the lower end of said pull rod and provided with a pair of oppositely disposed, arcuate sections engaging said cylinders; a yoke connected to the upper end of said pull rod and extending outwardly to each side therefrom; a pair of spaced piston rods connected at their upper ends to said yoke and extending through said head and into the respective cylinder; a reciprocable piston within each said cylinder and connected to the corresponding piston rod, each said piston having a passage therethrough; a valve in each said piston for controlling the flow of fluid through the respective passage; and means operable in response to the concurrent movement of said pistons for controlling the respective valve and constructed and arranged to close said valve as said piston nears the lower end of said cylinder to permit fluid supplied to said inlet to move said piston upwardly and thereby move said pump rod upwardly, and to open said valve when said piston approaches the upper end of said cylinder so that fluid supplied through said inlet will flow through said cylinder and piston and out of said outlet, thereby permitting the force on said pump rod to move said piston downwardly to a position near the lower end of said cylinder.

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