

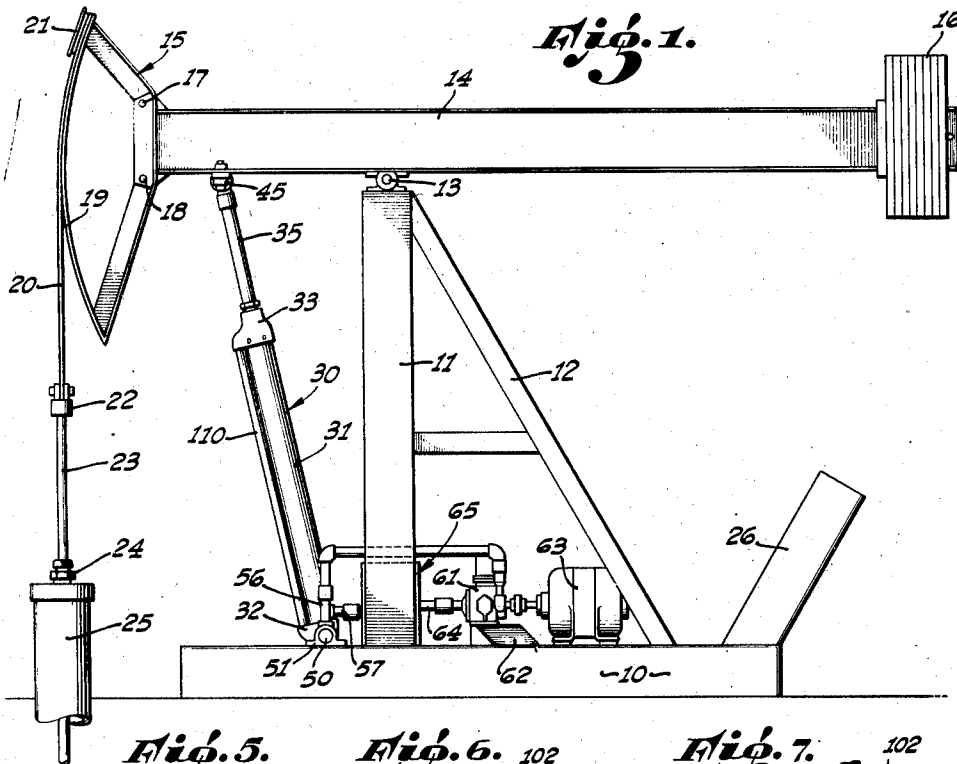
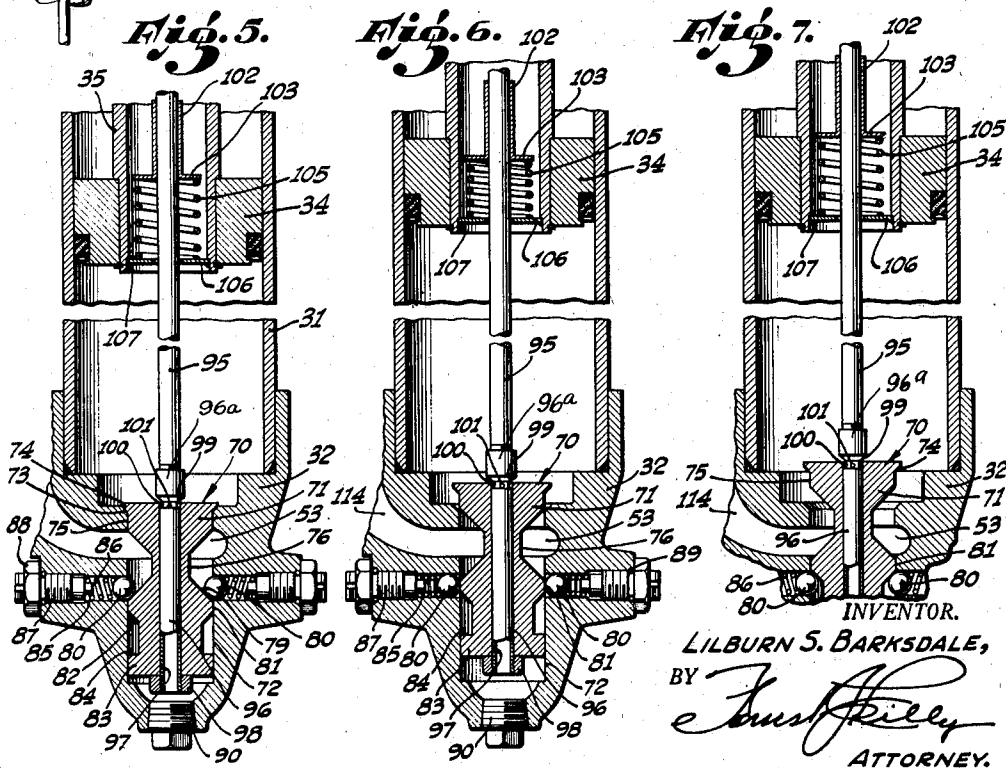
July 26, 1949. L. S. BARKSDALE 2,477,359
EXPANSIBLE CHAMBER MOTOR WITH OSCILLATING CYLINDER
AND PISTON ACTUATED DISTRIBUTING VALVE
Filed Jan. 24, 1945 2 Sheets-Sheet 1

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2 Sheets-Sheet 2

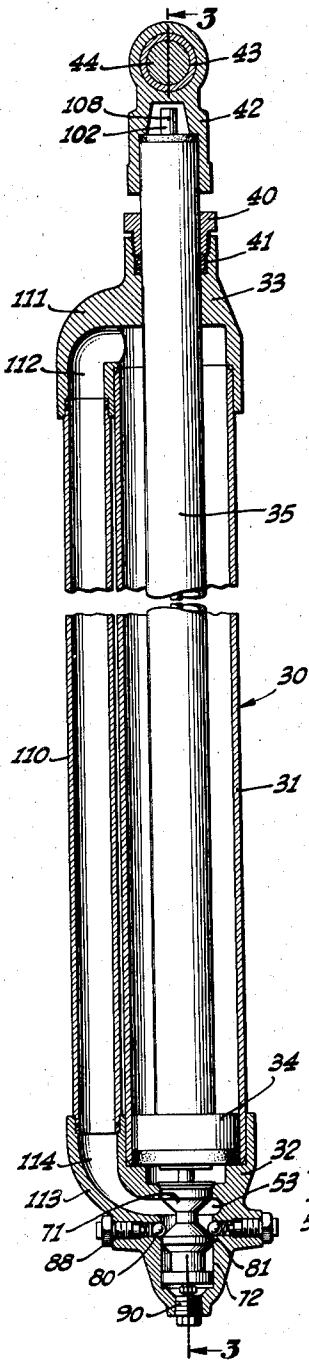


Fig. 2.

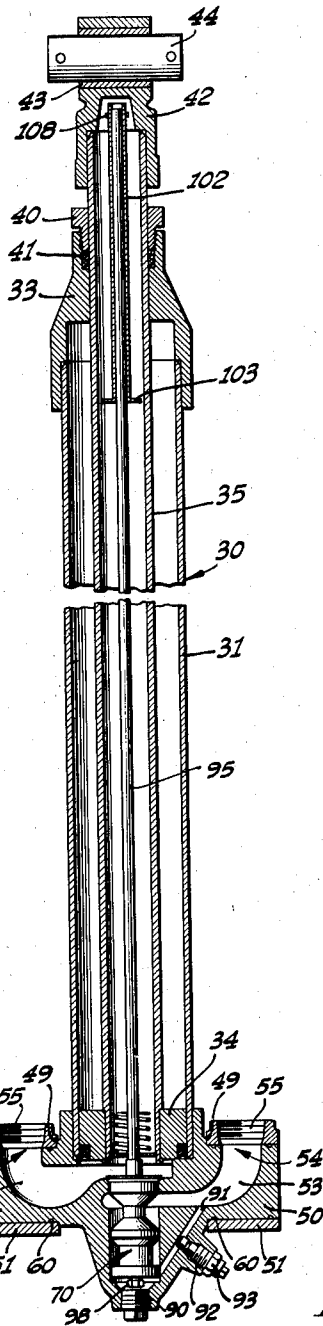


Fig. 3.

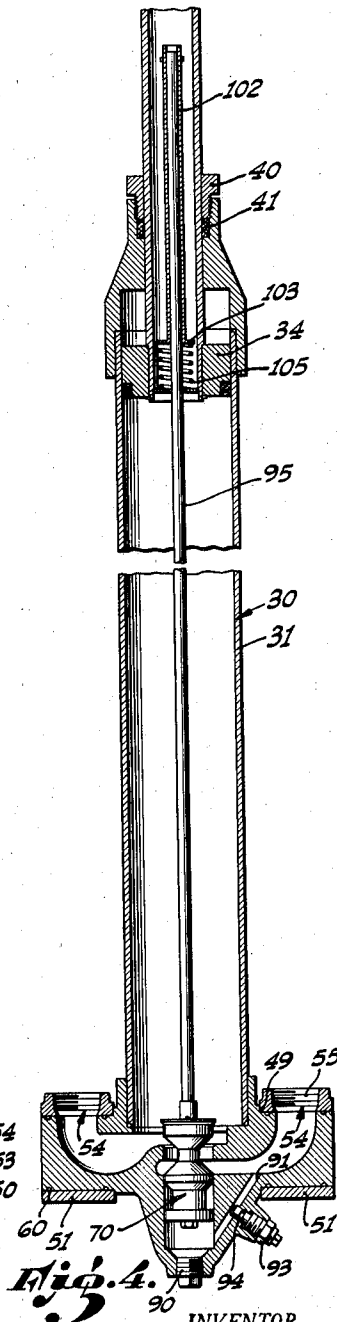


Fig. 4.

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UNITED STATES PATENT OFFICE

2,477,359

EXPANSIBLE CHAMBER MOTOR WITH
OSCILLATING CYLINDER AND PISTON
ACTUATED DISTRIBUTING VALVE

Lilburn S. Barksdale, Burbank, Calif.

Application January 24, 1945, Serial No. 574,274

17 Claims. (Cl. 121-164)

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This invention relates in general to oil well pump operating mechanism, and the principal objects of the invention are directed toward the provision of a novel and effective hydraulic pump jack, operating in conjunction with the usual walking beam pump gear. Certain aspects of the invention are applicable to use in other fields, however, and the invention should not be construed as limited solely to oil well pumping equipment.

The usual form of oil pumping equipment comprises a vertically reciprocating pump element at the bottom of the well actuated from a walking beam at the head of the well through a long string of sucker rods. Prior pumping units of the walking beam type have been mechanically driven through the agency of a crank and reduction gearing, and the motion produced thereby is characteristically non-uniform throughout the length of the stroke, with equal up and down stroke speed. Another characteristic of the average mechanically driven unit is that it operates with a relatively short, fast stroke.

It has been found that the maximum volumetric pump efficiency at reduced power cost, together with greatly reduced wear and breakage of the equipment, are obtained with long, slow strokes of uniform velocity. Among the advantages in favor of the long, slow stroke are the following: (1) The smooth, more uniform motion of plunger and rod tends to reduce the formation of emulsions; (2) there is less tendency for "gas lock" within the pump; (3) the plunger travel necessary to maintain production is obtained with fewer stress reversals on sucker rods, reducing rod breakage and pumping interruptions; (4) more positive valve action and better filling of the pump on the upstroke usually results; and (5) surface equipment usually shows less wear and greater power economy.

The use of a long, slow stroke is particularly desirable in areas having low-pressure oil sands and small daily well production where, in order to obtain the maximum amount of recovery, constant fluid levels and constant rates of drainage through the sand must be maintained. The oil should be pumped at a rate that will assist in maintaining constant and uniform drainage within the reservoir sand, and to this end the pumping cycle should be adjustable to suit the characteristics of the individual well. Thus, where the rate of drainage through the formation is low, a long, slow upstroke and a fast downstroke with the rods falling as fast as gravity will permit is called for, whereas with extremely viscous oil, an appreciable length of time is required for the pump plunger to complete its return stroke and a moderately slow downstroke is necessary in order to achieve maximum production. The crank-driven beam pumping unit, however,

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with its equal up and downstroke speed, can only be regulated to suit the requirements of the stroke in one direction at a sacrifice in the efficiency of the stroke in the other direction.

The long, constant velocity stroke is also advantageous in the case of a well producing appreciable quantities of sand, since it greatly reduces surges and agitation at the well pump suction, which causes excessive quantities of sand to be drawn into the pump mechanism. This excessive intake of sand results in binding of the pump mechanism, which necessitates a laborious and costly pulling of the pump.

The disadvantages of the mechanically driven unit may be summarized as follows: (1) The average unit operates with a short, fast stroke, resulting in low volumetric pump efficiency, high power consumption, and low recovery rates; (2) the crank accelerated motion sets up wavelike stresses in the string of rods, resulting in a pronounced whip which causes premature failure in the rods; (3) the lack of independent control over the up and downstroke speeds makes it impossible to meet the particular pumping requirements of a given well; and (4) there is no pause at the end of the downstroke to permit the rods to stretch out from inertia forces and then to recover, but instead, an immediate reversal of motion resulting in high peak stresses and frequent breakage in the rod string.

It has long been realized that the smooth, uniform action of hydraulic jacks as ideally suited to the requirements of oil well pumping, but the many attempts which have heretofore been made to apply the principles of hydraulic operation to pumping equipment have failed to achieve commercial success because of their complexity, initial cost, lack of counterbalancing, and difficulty of servicing.

A primary object of the present invention, therefore, is to provide a hydraulically operated well unit capable of delivering a long, constant velocity stroke at any desired speed so as to realize the many advantages obtainable thereby, and having independent control over the speed of up and downstroke to suit the individual requirements of a particular well. This object has been achieved by providing a simple, fool-proof hydraulic jack which is operatively connected to a counterweighted walking beam in a manner whereby the advantageous features of both elements are combined. Thus, any proportion of the weight of the rod string can be counterweighted to relieve the hydraulic jack of excessive loads, while the smooth, uniform action of the hydraulic jack is imparted to the rod string to secure the most efficient pump operation.

Another object of the invention is to provide a pumping unit that will bring the sucker rods to a gradual stop at the end of the downstroke, re-

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ardless of pumping speed, and pause for any desired length of time before starting on the up-stroke, thereby eliminating rod whip and greatly increasing the service life of the rods and boxes and also of the surface equipment.

Another object of the invention is to provide a hydraulic pumping unit that is simple and rugged in construction, positive in operation, extremely portable owing to its lighter weight, lower in first cost than a mechanically driven unit of comparable capacity and stroke range, and capable of being readily serviced in the field.

Another object of the invention is to provide a hydraulic jack and valve gear therefor which is particularly adapted to the working conditions under which most oil well pumping equipment operates. This object is attained by connecting the hydraulic jack to a walking beam independently of the operating rod of the well pump, which enables repairs or other operations on the pumping equipment to be made without disturbing the hydraulic jack or its associated equipment.

Another object of the invention is to provide a hydraulic jack embodying means for equalizing the discharge of exhaust fluid so as to eliminate hydraulic hammer in the jack.

Another object of the invention is to provide a low cost and simply automatically operated hydraulic jack unit that is particularly suitable for operating the old standard end wooden walking beam, thus providing for efficient operation of these units which have been obsoleted by their high power requirements.

Still a further object of the invention is to provide a hydraulic jack having a novel and improved valve mechanism which is positive in its action and which is operated by motion of the piston and rod.

Other objects and advantages of the present invention will become apparent to those skilled in the art after consideration of the following detailed description of the preferred form thereof, reference being had to the drawings in which:

Fig. 1 is a side elevation of a pumping unit constructed according to the principles of my invention;

Fig. 2 is an enlarged, partially sectioned view through the hydraulic pump jack;

Fig. 3 is a sectional view taken along the line 3-3 in Fig. 2, showing the piston at the bottom of its stroke;

Fig. 4 is a view similar to Fig. 3, but with the piston at the top of its stroke;

Fig. 5 is an enlarged fragmentary sectional view showing the initial operation in the opening of the valve;

Fig. 6 shows a later stage in the operation of the valve; and

Fig. 7 shows the valve in its fully open position.

In Fig. 1 of the drawings, the reference numeral 10 indicates a supporting platform, upon which is mounted a Samson post 11 braced by suitable struts 12. Journaled in bearings 13 at the upper end of the post for oscillating movement in a vertical plane is a walking beam 14 having a horse head 15 at one end and a counterweight 16 at the other end thereof. The horse head 15 is attached to the end of the walking beam by vertically spaced pins 17 and 18, and comprises the usual arcuate portion 19 around which is trained a bridle 20. The bridle is secured at its upper end to a saddle 21 and is secured by a clamp 22 to the upper end of a polished rod 23 which extends through suitable packing

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24 into the casing head 25 of the well. The polished rod 23 is attached to the usual string of sucker rods which are connected to a pump piston in the bottom of the well. The pump is operated in the well known manner by oscillating the walking beam 14 to reciprocate the polished rod 23 and sucker rods, the counterweight 16 serving to counterbalance the weight of the sucker rods. A bumper post 26 is mounted on the platform 10 and is positioned to catch the counterbalance 16 in the event of breakage of the sucker rod line, thereby preventing damage to the equipment mounted on the platform.

The walking beam 14 is oscillated by means of a hydraulic jack which is indicated in its entirety by the reference numeral 30. The jack 30 comprises a cylinder 31 having a head or base casting 32 attached to one end thereof, and a cap 33 at the other end. A piston 34 is slidably disposed within the cylinder 31, and attached to the piston is a tubular piston rod 35 which extends slidably through the cap 33. A packing nut 40 is threaded into the end of the cap 33 and compresses packing material 41 to seal the piston rods against leakage.

Mounted on the upper end of the piston rod 35 is a fitting 42 which is apertured to receive a sleeve bearing 43. Extending through the sleeve bearing 43 and journaled for rotation therein is a pin 44 which is secured by suitable brackets 45 to the walking beam 14 at a point spaced outwardly from its axis of rotation.

The hydraulic jack 30 is supported at its lower end on trunnions 50 which project laterally from opposite sides of the base casting 32 and are journaled in bearing blocks 51 bolted to the platform 10. Fluid for operating the jack is introduced into the cylinder and exhausted therefrom through the trunnions, and to this end the base casting 32 is provided with ducts or passageways 52 and 53 which communicate with the interior of the cylinder and extend axially through the trunnions. The passageways 52, 53 pass through the walls of the trunnions at their top surfaces and communicate with corresponding openings 54 in the bearing blocks 51, said openings 54 being threaded at 55 to receive inlet and outlet pipes 56 and 57, respectively. Ring seals 60 prevent leakage of the hydraulic fluid while permitting relative rotation between the trunnions and their bearing blocks. This arrangement of the passageways 52, 53 opening radially through the peripheral surfaces of the trunnions 50 eliminates side thrust against the shoulder 49 which would otherwise be produced if the passageways opened axially through ends of the trunnions, and provides a construction that is hydraulically balanced about the centerline of the cylinder 30.

The inlet pipe 56 is connected to the discharge port of a pump 61 which is mounted on a suitable bracket 62 on the platform 10 and which is driven by an electric motor 63 or other suitable source of power. Fluid is supplied to the pump through a pipe 64 from a reservoir tank 65 built into the base of the Samson post 11, and the exhaust from the hydraulic jack is emptied through the outlet pipe 57 to the reservoir.

Valve mechanism, indicated generally by the reference numeral 70, is provided for control of the hydraulic fluid actuating the jack, said mechanism comprising a valve member or plunger 71 which is slidably disposed within a cylindrical bore 72 in the base casting 32, which as here

shown serves as the valve body. The bore 72 is concentric with the cylinder and is closed at its lower end, the upper end thereof being shaped to provide an upwardly facing valve seat 73, preferably conical, for a presently described poppet valve element. The outlet duct 53 opens into the bore 72 at a point spaced somewhat below the valve seat 73, and is opened or closed with respect to the cylinder 31 by the action of the valve, whereas the inlet duct 52 opens into the cylinder 31 above the valve and is in communication therewith at all times.

The valve member 71 is provided at its top end with a poppet valve element comprising a downwardly facing face 74, preferably conical, which is adapted to seat on the valve seat 73, and below this face is a slide valve element embodying a cylindric "skirt" or piston portion 75 extending down into the bore for a certain distance. A generally V-shaped groove 76 is formed in the valve member 71 below the skirt 75, the bottom surface 79 of said groove providing an upwardly inclined cam surface which cooperates with spring-loaded detent balls 80 to hold the valve member in closed position.

Below the bottom edge of the groove 76 is a cylindrical land 81, and below this is a downwardly and inwardly inclined cam surface 82 which cooperates with the detent balls 80 to hold the valve member in its raised or open position, as illustrated in Fig. 7. A cylindrical skirt or piston portion 83 is provided at the lower extremity of the valve member to afford additional bearing surface on the walls of the bore 72 for the purpose of stabilizing the valve member, and also to control a later described fluid return passageway, said skirt having a square shoulder at 84 to prevent its passage beyond the detent balls. The detent balls 80 are disposed within diametrically opposed holes 85 and are urged inwardly against the valve member by springs 86 which are confined by adjustable screw plugs 87, the latter being locked in adjusted position by lock nuts 88 which compress ring seals 89. A plug 90 is screwed into a threaded hole extending through the bottom of the base casting 32 into the bores 72, and is removable therefrom for the purpose of draining the bottom of the bore 72 and to provide an access hole for inspection or adjustment.

Extending diagonally through the base casting 32 to connect a point near the bottom of the bore 72 with the outlet duct 53 is a fluid discharge passageway 91 which is intersected by a threaded hole into which is screwed an adjusting screw 92. As the screw 92 is turned in, the passageway 91 is gradually closed, producing an orifice which restricts the flow of fluid which is displaced from the bottom of the bore during the downward closing movement of the valve member to slow the latter appreciably, the purpose of which will be described in more detail presently. A lock nut 93 locks the screw 92 in adjusted position, and a ring seal 94 seals the screw against leakage.

The valve member 71 is shifted between open and closed position by means of piston controlled valve actuating means including an actuating rod 95 which extends up through the center of tubular piston rod 35 to the upper end of the cylinder. The lower end of the rod 95 is screwed into a preferably tubular extension member 96 extending slidably through a longitudinal axial bore 97 in the valve member 71, this bore forming a pressure fluid passageway between the

pressure fluid inlet means and the bottom end of the valve bore 72, and the member 96 forming a liner therein. A self-locking nut 98 is threaded onto the bottom end of the tubular member 96 to provide a shoulder engageable with the bottom of the valve member 71 for limiting the upward movement of the rod 95 relative to valve 71. The upper end 96a of the tubular member 96 is enlarged in diameter and has a valve face at 99, preferably conical which seats on the top edge of the bore 97 to close the latter. Below the face 99 is a groove 100 having holes 101 in the bottom thereof extending through to the hollow center of the tubular member. The distance between the face 99 and limit stop nut 98 is somewhat greater than the length of the valve member 71, providing a limited amount of travel for the tubular member relative to the valve member to enable the valve face 99 to open or close the bottom of bore 72 to the fluid in the cylinder.

The valve actuating means referred to in the preceding paragraph includes also an actuating sleeve 102 fixed to and extending down over the top end of the actuating rod 95 and having a radial flange 103 at its bottom end, positioned at a point where it is engageable by a coil spring 105 carried by the piston 34 as the latter approaches the top of its stroke. The spring 105 is carried on a washer 106 which is inserted into the bottom end of the tubular piston rod 35 against a shoulder 107 and welded in place. The washer 106 is apertured centrally to pass the actuating rod 95 and has sufficient clearance for unrestricted flow of hydraulic fluid around the rod. The sleeve 102 is secured to the actuating rod 95 by a pin 108 which is removable to permit replacement of the sleeve by another of greater length if a shorter piston stroke is desired. Replacement of the sleeve is accomplished by removing the fitting 42 which is secured to the end of the piston rod by means of set screws or the like. The top ends of the actuating rod 95 and sleeve 102 project above the top of the piston rod, so that the pin 108 and sleeve 102 are readily accessible.

The operation of the hydraulic jack is as follows: Assume first that the valve member 71 is seated and that the piston is at the bottom of the cylinder, as shown in Figs. 2 and 3. Assume also that the tubular member 96 is in its lowermost (closed) position. The outlet duct 53 is closed off from the cylinder by the valve 70, and the incoming pressure fluid from the inlet duct 52 moves the piston up on its working stroke. As the piston approaches the top of its stroke, the spring 105 engages the flange 103 of sleeve member 102, raising the actuating rod 95 to take up the lost motion relative to valve member 71 and thereby move tubular member 96 so as to open valve 99 from its seat, permitting the pressure fluid to communicate through the holes 101 and the center of tubular member 96 to the bottom of bore 72 (see Fig. 5). This equalizes the pressures on both ends of valve member 71 so that it is not necessary to overcome the high fluid pressures on the top of the valve member 71 in order to raise the latter. This pressure fluid so communicated to the bottom of bore 72 cannot escape via passageway 91 because the latter is covered by piston portion 83 of valve 71. Opening movement of valve member 71 by the upward force exerted through rod 95 and its extension 96 is resisted by the detent balls 80, however, and continued upward travel of the piston 34

causes the spring 105 to be compressed until a sufficient spring load is obtained to overcome the detent balls 80 and cause them to ride up on cam slope 79 to land 81. The skirt or piston section 75 on valve member 71 prevents the bore 72 from being opened and the pressure in cylinder 31 relieved until the detent balls are completely up on the land 81 and spring 105 is compressed sufficiently to complete the tripping action. At this point, the valve member 71 cracks open, as shown in Fig. 6, and pressure in the cylinder is relieved, causing the piston 34 to come to a stop. Energy stored in the deflected spring 105 then acts on the actuating rod 95, moving the latter up sufficiently to raise the valve member to its fully open position (see Fig. 7). As the bottom edge of the land 81 passes above the centerline of the detent balls 80, the latter advance against the inclined cam face 82, camming said face upwardly and so aiding the spring 105 in opening the valve member and thereafter yieldingly holding it open. The square shoulder 84 on valve member 71 limits the upward travel of valve in case of excessive load on spring 105.

With the valve 71 in its fully opened position, pressure in the cylinder 31 drops substantially to zero, and the piston 34 is pushed down to the bottom of the cylinder by the unbalanced portion of the weight of the sucker rods.

As the piston 34 approaches the bottom of the cylinder, piston washer 106 engages the upper end of tubular member 96, forcing it down to close valve 99 and then pushing the valve member 71 down until the skirt 75 enters bore 72. During this portion of the closing movement of the valve member 71, the detent balls 81 are forced back into their holes by the cam face 82. As skirt 75 approaches bore 72, the fluid flow becomes increasingly restricted between the valve 71 and valve seat 73, thus causing the fluid pressure to build up in cylinder 31, while the pressure at the lower end of valve bore 72 is substantially reduced, since the lower end of valve bore 72 is now cut off from pressure fluid through tubular member 96 by the valve closure at 99, and is open to return not only via duct 91 but also around the valve 71 to passageway 53. The hydraulic pressure acting on the top of the valve member 71 forces the latter down to its fully seated position, with the detent balls 80 bearing against cam surface 79. The jack is now in condition to begin the next working stroke.

The passage 91 and orifice adjusting screw 92 are provided for the purpose of slowly and controllably discharging the fluid trapped below the valve plunger 71 during the downward travel of the latter from its fully open position at least until its skirt portion 75 has substantially entered bore 72, thereby cushioning or damping the said downward travel of said valve plunger 71. The purpose of this damping action is to slow the piston 34 to a gradual stop, regardless of its downward speed, and to provide a "dwell" period at the bottom of the piston stroke, said dwell period being controllable by the adjusting screw 92 which governs resistance to flow of the fluid which must be displaced from the bottom of the bore 72 in order to allow the valve 71 to seat. When valve 71 does seat, its lower piston portion 83 has closed the passageway 91, so that pressure fluid later introduced to the bottom of bore 72 via tubing 96 will not immediately escape.

It will be seen from the foregoing that the flow of fluid through the exhaust duct system is in-

termittent, and that the column of fluid is subject to abrupt acceleration and deceleration which tends to produce hydraulic hammer in the system. In order to prevent the occurrence of such hydraulic hammer, I have provided a tube 110 which is arranged alongside the cylinder 31 and extends from one end thereof to the other. The top end of tube 110 is inserted into a suitable projection 111 on cap 33 and communicates with a passage 112 which opens into the top of the cylinder. The bottom end of tube 110 is inserted into a projection 113 on base casting 32 and communicates with a passage 114 which opens into the outlet duct 53. The purpose of the tube 110 is to smooth out the flow of fluid through the outlet duct 53 by discharging fluid from the top of the cylinder on the upstroke of piston 34, during which period the valve member 71 is closed and there would otherwise be no flow of fluid through the outlet duct. On the downstroke of the piston, the volume of fluid passing through the open valve 70 is the combined volume displaced by the piston on its downward travel together with the volume entering the cylinder from the pump 61 through inlet duct 52, and the tube 110 provides means for carrying a portion of this combined volume of fluid up to the top end of the cylinder to fill the void left by the downwardly moving piston 34. Thus, it is seen that the volume of fluid discharged through the outlet duct 53 on the up and downstroke of the piston is equalized to a considerable extent, eliminating the tendency for hydraulic hammer.

The hydraulic jack shown and described herein is simple and rugged in construction, and the action of the valve 70 is positive. The construction is such that it is readily disassembled in the field, and the absence of small or delicate parts requiring precise adjustment eliminates one of the principal sources of trouble experienced with hydraulic pump jacks.

When it is necessary to pull the string of rods or tubing from the well, the pump jack is extended to the top of its stroke and stopped in this position. The lower pin 18 connecting the horse head 15 to the walking beam 14 is then withdrawn, and the horse head allowed to swing down about the pivot pin 17. In this position of the horse head, there is ample clearance for working on the rods and tubing without further dismantling of the pumping rig.

The speed of the upstroke is controlled by the delivery of the rotary pump which supplies the pressure fluid. This pump is directly connected to the power source, thereby eliminating the fire hazard of slipping V belts and the power lost through a V belt drive or other speed reduction means, and the output of the pump is regulated by an adjusting screw (not shown) on the bottom of the mounting flange. The pump is also provided with an overload device whereby the delivery automatically becomes zero when the operating pressure exceeds a given value, as in the case of the well pump sanding up. The downstroke speed is controlled by the amount of counterbalance, and is regulated by increasing or decreasing the counterweight 16 on the walking beam. Thus, for a fast downstroke, the amount of counterbalance is decreased, while for a slow downstroke the amount of counterbalance is increased.

While I have shown and described with some particularity the specific details of the preferred form of my invention, it is to be understood that

such details are not restrictive, but that instead, widely differing structure and arrangements might be employed within the scope of the appended claims.

I claim:

1. A well pumping rig comprising a supporting structure, a counterweighted walking beam journaled on said structure for oscillating movement in a vertical plane, means connecting said walking beam to the operating rod of the pump, a hydraulic jack comprising a cylinder having a pair of laterally extending trunnions journaled on said supporting structure, a piston slidably disposed within said cylinder and having a piston rod pivotally connected at its outer end to said walking beam at a point spaced outwardly from the axis of rotation thereof, a source of fluid pressure, inlet duct means for carrying fluid from said pressure source to one end of said cylinder through one of said trunnions, including a passage opening through the peripheral wall of the trunnion, discharge duct means for carrying exhaust fluid through the other of said trunnions including a passage opening through the peripheral wall of the trunnion, and valve means operative to close said discharge duct means during the working stroke of the piston and to open said discharge duct means during the return stroke of the piston.

2. A well pumping rig comprising a counterweighted walking beam supported for oscillatory movement in a vertical plane, means connecting said walking beam to the operating rod of the pump, a hydraulic jack comprising a cylinder, a piston slidably arranged within the cylinder, and a piston rod connected to the piston and to said walking beam at a point spaced outwardly from the axis of rotation thereof, a source of fluid pressure, inlet duct means connecting said source of pressure with the bottom end of said cylinder, outlet duct means also connected to said bottom end of the cylinder, valve means operative to close said outlet duct means during the working stroke of the piston and to open the same during the return stroke of the piston, and passage means connecting the top end of said cylinder with said outlet duct means whereby on the working stroke of the piston fluid displaced from said top end of the cylinder is discharged into said outlet duct means and on the return stroke of the piston a portion of the combined fluid displaced from the bottom end of the cylinder together with the fluid delivered by said inlet duct means from said pressure source is conveyed to the top of the cylinder, the balance of said fluid being discharged through said outlet duct means.

3. A hydraulic jack of the type adapted to deliver a power stroke in one direction only, said jack comprising a cylinder having a head at one end thereof, a piston slidable within said cylinder and having a piston rod connected thereto, inlet duct means communicating with the head end of said cylinder and adapted for connection to a source of fluid pressure, valve means including a closed-end, cylindrical bore in said cylinder head having its axis parallel to the axis of the cylinder, a valve member slidable within said bore between open and closed positions, outlet duct means communicating with said bore, said valve member being shaped intermediate its ends to provide a path for the flow of fluid from said cylinder to said outlet duct means when the valve member is in open position, a passageway extending through said valve member from one end to the other, a valve actuating rod disposed within said passageway and having limited movement with respect there-

to, said actuating rod functioning as a valve to close said passageway when in its lowermost position and to open said passageway when in its uppermost position, means on said piston operative to engage said actuating rod as the piston approaches the top of its stroke and to carry said rod with it to the end of the piston stroke, the initial movement of said actuating rod acting to open said passageway in the valve member to equalize the pressures on both ends thereof and continued movement of the actuating rod acting to raise said valve member to open position, and means for holding said valve member open during the return stroke of the piston.

4. A hydraulic jack of the type adapted to deliver a power stroke in one direction only, said jack comprising a cylinder having a head at one end thereof, a piston slidable within said cylinder and having a piston rod connected thereto, inlet duct means communicating with the head end of said cylinder and adapted for connection to a source of fluid pressure, valve means including a cylindrical bore in said cylinder head, said bore having a seat at its upper end, a valve member slidable within said bore between open and closed positions, said valve member having a face at its upper end adapted to bear downwardly on said seat and a downwardly extending cylindrical skirt portion arranged below said face, outlet duct means communicating with said bore, spring-biased detent means for yieldingly holding said valve member in either open or closed position, and valve actuating means operable by movement of said piston during the end portion of its power stroke to shift said valve member to open position, said actuating means including a spring which is deflected by the force required to overcome said detent means in moving said valve member to a position intermediate said open and closed positions, said skirt functioning to close said bore and maintain operating pressure within the cylinder until said detent means has been overcome, said spring thereafter supplying actuating force to move said valve member the balance of the distance to its fully opened position.

5. A well-pumping rig comprising a supporting platform, a counterweighted walking beam supported on said platform for rocking movement in a vertical plane, means connecting said walking beam to the operating rod of the pump, a hydraulic jack connected to said walking beam at a point spaced outwardly from the pivot axis thereof, said jack having a pair of laterally extending trunnions journaled on said supporting platform, a source of fluid pressure, inlet duct means for carrying fluid from said pressure source to said jack through one of said trunnions, including a passage opening through the peripheral wall of said trunnion, discharge duct means for carrying exhaust fluid through the other of said trunnions including a passage opening through the peripheral wall of the trunnion, and valve means operative to control the flow of fluid through said duct to actuate said jack.

6. A well-pumping rig comprising a counterweighted walking beam supported for oscillatory movement in a vertical plane, means connecting said walking beam to the operating rod of the pump, a hydraulic jack comprising a cylinder, and a piston slidably arranged within the cylinder, and a piston rod connected to the piston and to said walking beam at a point spaced outwardly from the axis of rotation thereof, a source of fluid pressure, inlet duct means connecting said source of pressure at the bottom end of said cylinder, out-

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let duct means also connected to said bottom end of the cylinder, valve means operative to close said outlet duct means during the working stroke of the piston and to open the same during the return stroke of the piston, and means for diverting part of the displaced fluid from the bottom end of the cylinder to the top end thereof during the return stroke of the piston and for discharging said diverted fluid from the top of said cylinder into said outlet duct means during the power stroke of the piston.

7. A hydraulic jack comprising a cylinder and a piston slidable therein, a valve including a body having a cylindrical valve bore, pressure fluid inlet means communicating with one end of said valve bore and also with one end of said cylinder, said one end of said valve bore having an outwardly facing valve seat therearound, a valve plunger slidable in said bore between open and closed positions, said valve plunger having at one end a poppet valve element adapted to seat on said valve seat in said closed position, and having inwardly of said poppet valve element a piston element, and inwardly of said piston element a reduced section to permit pressure fluid flow into and longitudinally of said bore when said valve plunger is in said open position, fluid outlet means communicating with said bore at a point spaced longitudinally thereof from said one end, and so located as to receive said fluid flow, yieldable spring-biased means for initially resisting movement of said valve plunger from said closed position to a position intermediate said closed and open positions, and valve actuating means interconnected between said piston and said valve plunger operable to move said valve plunger from closed to open position by movement of said piston during an end portion of its power stroke, said actuating means including a spring deflected during said end portion of said power stroke to establish an increasing force applied to said valve plunger to gradually overcome said spring-biased means and thereby move said valve plunger from said closed to said intermediate position, and thereafter to quickly move said valve plunger on to said open position, said piston element being of a length to maintain said valve bore closed during said travel of said valve plunger between said closed and intermediate positions but to separate from said valve bore in said open position of said valve plunger.

8. A hydraulic jack comprising a cylinder and a piston slidable therein, a valve including a body having a cylindrical valve bore, fluid inlet means communicating with one end of said valve bore and also with one end of said cylinder, a valve plunger slidable in said bore between open and closed positions, said valve plunger having a piston element movable into and out of said one end of said bore, and having inwardly of said piston element a reduced section to permit liquid flow longitudinally of the bore when said valve plunger is in said open position, fluid outlet means communicating with said bore at a point spaced longitudinally thereof from said one end and so located as to receive said liquid flow, yieldable spring-biased means for initially resisting movement of said valve plunger from said closed position to a position intermediate said closed and open positions, and valve actuating means interconnected between said piston and said valve plunger operable to move said valve plunger from closed to open position by movement of said piston during an end portion of its power stroke, said actuating means including a spring deflected dur-

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ing said end portion of said power stroke to establish an increasing force applied to said valve plunger to gradually overcome said spring-biased means and thereby move said valve plunger from said closed to said intermediate position, and thereafter to quickly move said valve plunger on to open position, said piston element being of a length to maintain said valve bore closed during said travel of said valve plunger between said closed and intermediate positions but to separate from said valve bore in said open position of said valve plunger.

9. A hydraulic jack comprising a cylinder and a piston slidable therein, a valve including a body having a cylindrical valve bore, fluid inlet means communicating with one end of said valve bore and also with one end of said cylinder, said one end of said valve bore having an outwardly facing valve seat therearound, a valve plunger slidable in said bore between open and closed positions, said valve plunger having at one end a poppet valve element adapted to seat on said valve seat in said closed position, and having inwardly of said poppet valve element a reduced section to permit liquid flow longitudinally of the bore when said valve plunger is in said open position, fluid outlet means communicating with said bore at a point spaced longitudinally thereof from said one end and so located as to receive said liquid flow, yieldable spring-biased means for initially resisting movement of said valve plunger from closed position toward open position, and valve actuating means interconnected between said piston and said valve plunger to move said valve plunger from said closed position to said open position by movement of said piston during an end portion of its power stroke, said actuating means including a spring deflected during said end portion of said power stroke to create a force applied to said valve plunger to overcome said spring-biased means and thereafter to move said valve plunger to said open position.

10. A hydraulic jack comprising a cylinder, a piston slidable within said cylinder and having a central opening formed therein, a tubular piston rod attached to said piston in communication with said opening, fluid inlet means for supplying fluid under pressure to an end of said cylinder, fluid outlet means for exhausting fluid from said end of said cylinder, a control valve disposed coaxial with said cylinder between said fluid inlet and fluid outlet means and movable between open and closed positions, yieldable spring-actuated means for initially resisting movement of said valve from closed to open position, an actuating rod connected to said valve and extending lengthwise of said cylinder through said tubular piston rod, a projection on the end of said rod distant from said valve, and a spring carried by said piston and engageable with said projection during an end portion of the power stroke of the piston, said spring being deflected during said end portion of said power stroke to create a force applied to said valve to overcome the resistance of said spring means and thereafter to move said valve quickly to open position.

11. The subject matter of claim 7, including also a pressure fluid passageway between the pressure fluid inlet means and the other end of said valve bore, and a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston.

12. The subject matter of claim 7, including also a pressure fluid passageway between the

pressure fluid inlet means and the other end of said valve bore, and a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston, and closed by the piston during the return stroke of the piston.

13. The subject matter of claim 7, including also a pressure fluid passageway between the pressure fluid inlet means and the other end of said valve bore, a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston, and closed by the piston during an end portion of the return stroke of the piston, and a restricted fluid discharge passageway between a point near said other end of said valve bore and said fluid outlet means, said valve plunger including a piston portion which uncovers said last mentioned passageway in said open position of said valve plunger, and closes said passageway as said valve plunger moves into its said closed position.

14. The subject matter of claim 7, including also a pressure fluid passageway extending through the valve plunger between the pressure fluid inlet means and the other end of said valve bore, and a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston.

15. The subject matter of claim 7, including also a pressure fluid passageway extending through the valve plunger between the pressure fluid inlet means and the other end of said valve bore, a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston, and closed by the piston during an end portion of the return stroke of the piston, and a restricted fluid discharge passageway between a point near said other end of said valve bore and said fluid outlet means, said valve plunger including a piston portion which uncovers said last mentioned passageway in said open position of said valve plunger, and closes said passageway as said valve plunger moves into its said closed position.

16. A hydraulic jack comprising a cylinder and a piston slidable therein, a valve including a body having a cylindrical valve bore, pressure fluid inlet means communicating with one end of said valve bore and also with one end of said cylinder, said one end of said valve bore having an outwardly facing valve seat therearound, a valve plunger slidable in said bore between open and closed positions, said valve plunger having at one end a poppet valve element adapted to seat on said valve seat in said closed position, and having inwardly of said poppet valve element a piston element, and inwardly of said piston element a reduced section to permit pressure fluid flow into and longitudinally of said bore when said valve plunger is in said open position, fluid outlet means communicating with said bore at a point spaced longitudinally thereof from said one end and so located as to receive said fluid flow, valve actuating means interconnected between said piston and said valve plunger operable to move said valve plunger from closed to open position by movement of said piston during an end portion of its power stroke, said piston portion of said valve plunger being of a length to maintain said valve bore closed during

a portion of the travel of said valve plunger from closed to open position, a pressure fluid passageway between the pressure fluid inlet means and the other end of said valve bore, and a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston.

17. A hydraulic jack comprising a cylinder and a piston slidable therein, a valve including a body having a cylindrical valve bore, pressure fluid inlet means communicating with one end of said valve bore and also with one end of said cylinder, said one end of said valve bore having an outwardly facing valve seat therearound, a valve plunger slidable in said bore between open and closed positions, said valve plunger having at one end a poppet valve element adapted to seat on said valve seat in said closed position, and having inwardly of said poppet valve element a piston element, and inwardly of said piston element a reduced section to permit pressure fluid flow into and longitudinally of said bore when said valve plunger is in said open position, fluid outlet means communicating with said bore at a point spaced longitudinally thereof from said one end and so located as to receive said fluid flow, valve actuating means interconnected between said piston and said valve plunger operable to move said valve plunger from closed to open position by movement of said piston during an end portion of its power stroke, said piston portion of said valve plunger being of a length to maintain said valve bore closed during a portion of the travel of said valve plunger from closed to open position, a pressure fluid passageway between the pressure fluid inlet means and the other end of said valve bore, a valve controlling said passageway movable between closed and open positions by said valve actuating means near the end of the power stroke of the piston, and closed by the piston during an end portion of the return stroke of the piston, and a restricted fluid discharge passageway between a point near said other end of said valve bore and said fluid outlet means, said valve plunger including a piston portion which uncovers said last mentioned passageway in said open position of said valve plunger, and closes said passageway as said valve plunger moves into its said closed position.

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