

Feb. 20, 1968

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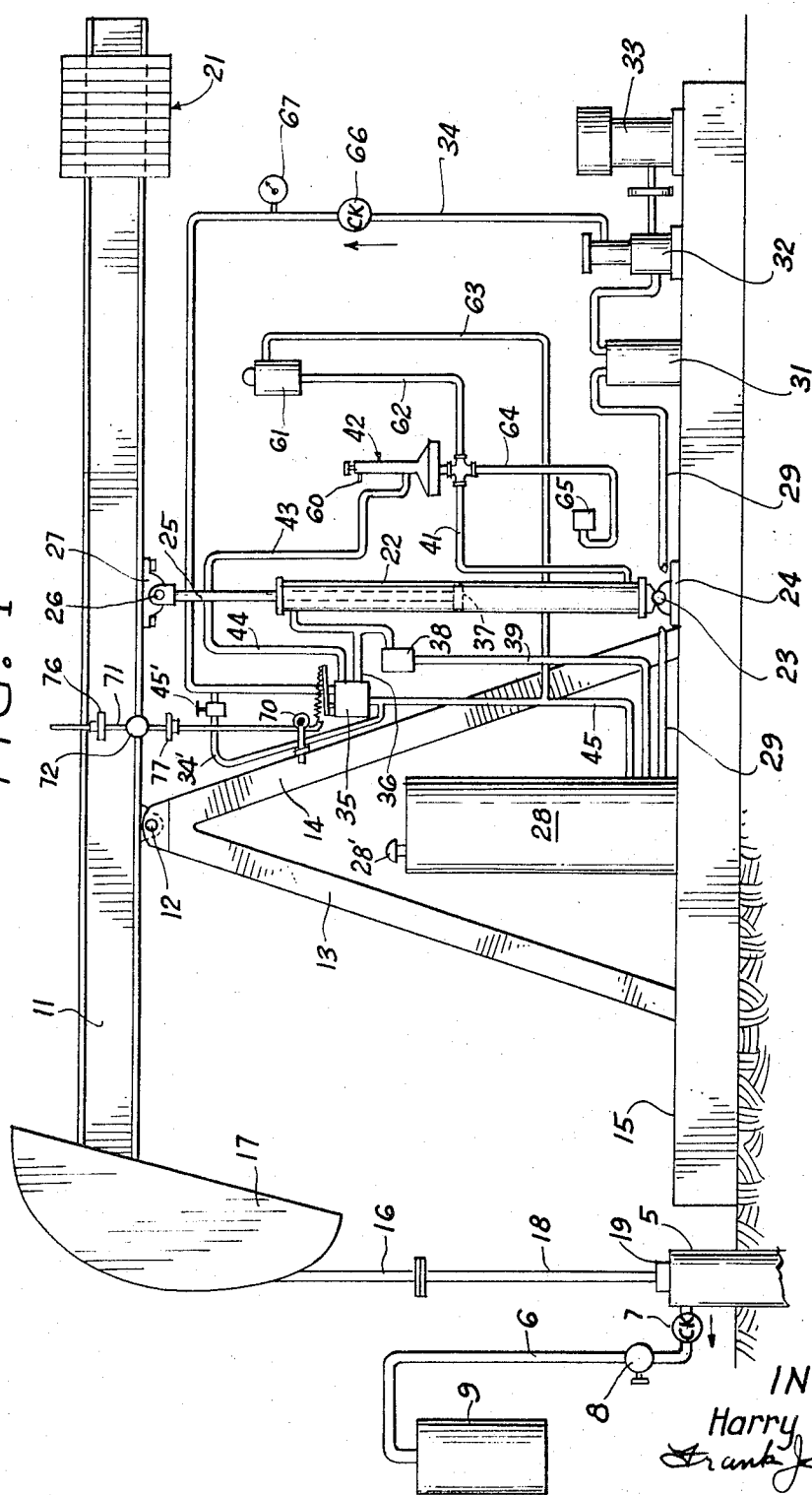
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PUMPING APPARATUS

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4 Sheets-Sheet 1

FIG. 1



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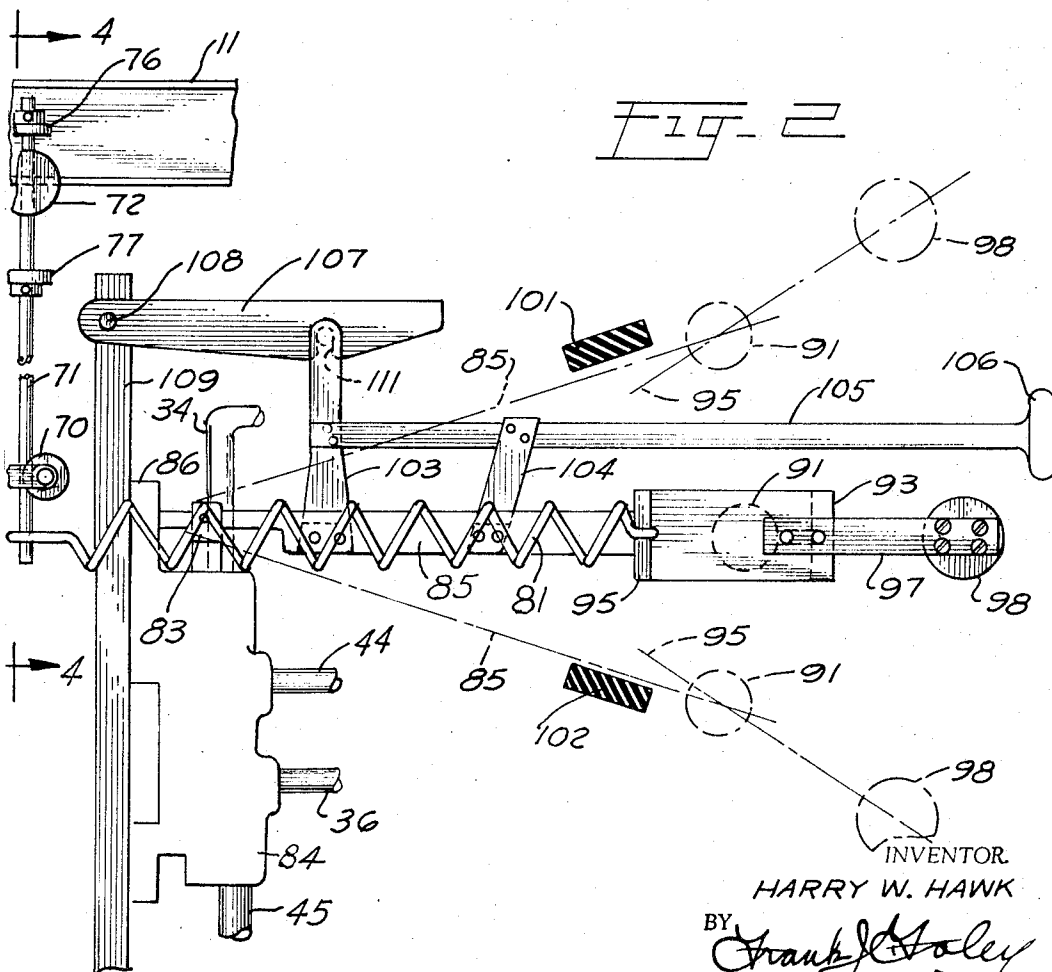
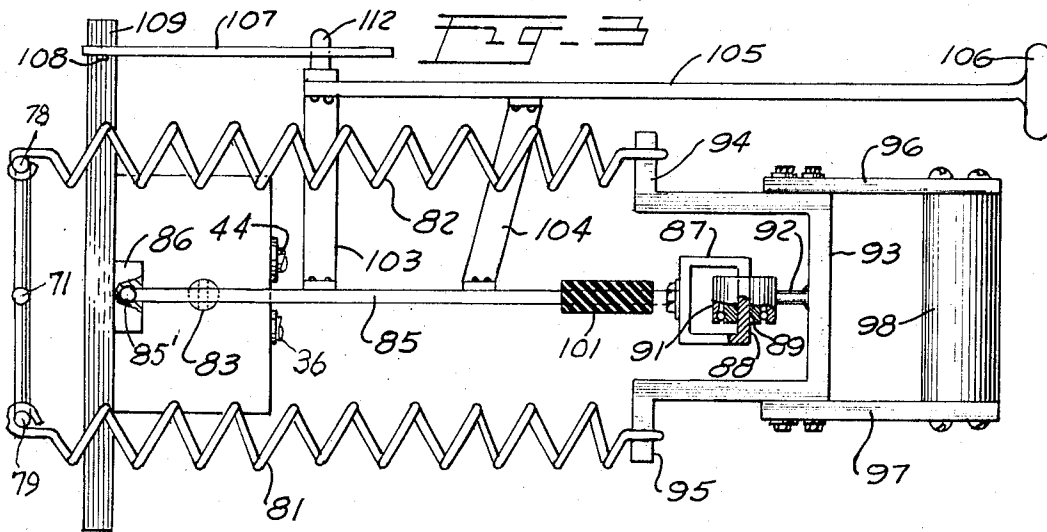
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PUMPING APPARATUS

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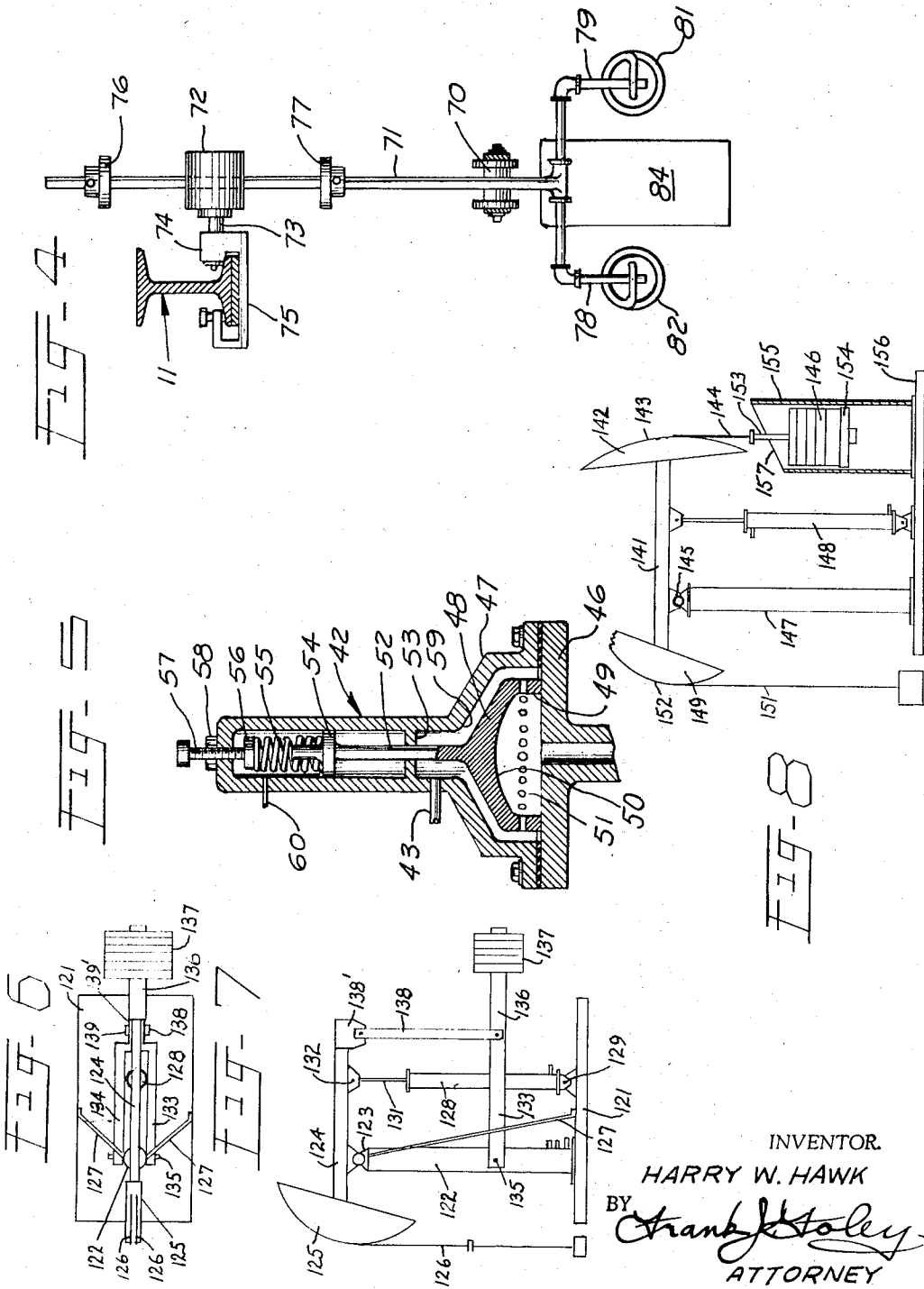
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PUMPING APPARATUS

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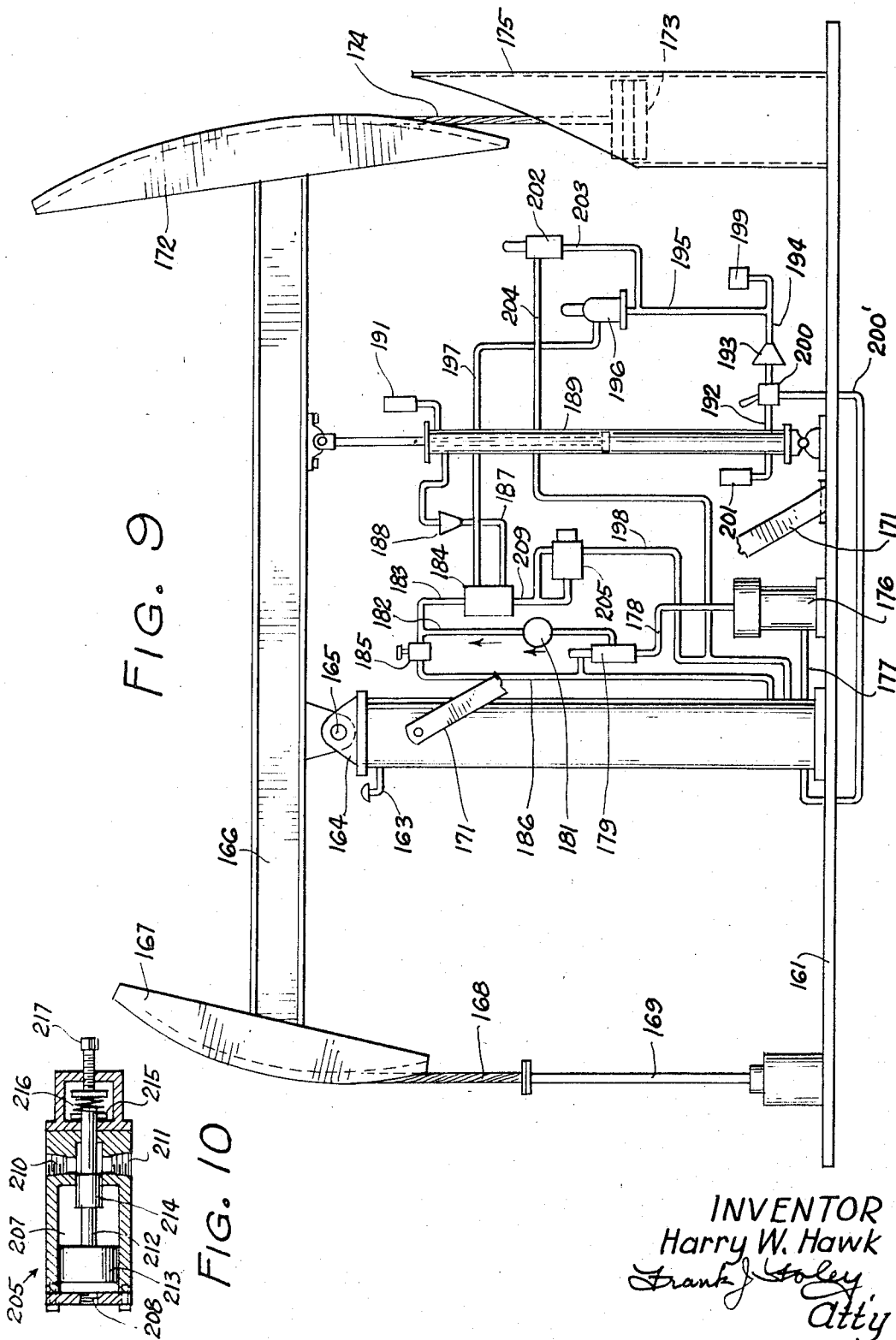
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PUMPING APPARATUS

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4 Sheets-Sheet 4



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3,369,490

PUMPING APPARATUS

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Continuation-in-part of application Ser. No. 334,267,
Dec. 30, 1963. This application Aug. 4, 1966, Ser.
No. 554,628

18 Claims. (Cl. 103—33)

ABSTRACT OF THE DISCLOSURE

An hydraulically operated well pumping apparatus having mechanism and controls for positively raising and lowering the well pump and at selectively variable speeds without varying the pump speed, and having controls operated by abnormal high pressures in hydraulic lines to stop the operation of the apparatus.

This application is a continuation-in-part of application Ser. No. 334,267 filed Dec. 30, 1963, now abandoned.

This invention relates generally to improvements in oil well pumping apparatus.

For decades it has been the common practice in the pumping of a petroleum well to operate the well pump by connecting it to one end of a counter-weighted pivoted walking beam and rocking the beam about its pivot by means of a pitman rod driven by a gear train powered by an internal combustion motor or by an electric motor.

Some efforts have been made heretofore to substitute an hydraulic cylinder and piston as the driving force for the beam, but it is understood that such efforts have not been commercially successful for various reasons.

The general object of this invention is to employ an hydraulic cylinder and piston to drive a counter-weighted walking beam, in conjunction with such other apparatus and controls as will assure efficient, safe and economical operation of the entire apparatus.

Another object of the invention is to provide an hydraulic powered oil well pumping apparatus having controls which permit of easy and quick adjustment to vary the rate of pumping by varying the length of the pump stroke.

Another object of the invention is to provide in an hydraulic oil well pumping apparatus means for reversing the well pump stroke smoothly and without causing undue wear and periodic excessive power loads such as have been common in prior well pumping apparatus.

Another object of the invention is to provide a valve mechanism which will, when a sucker rod parts, become operative automatically to protect the apparatus from damage resulting from the sudden unbalancing of forces which occurs during operation.

FIGURE 1, in the drawings, is a schematic showing of an oil well pumping apparatus constructed in accordance with this invention. FIGURE 2 is a side elevation of the operating mechanism for the hydraulic control valve. FIGURE 3 is a top plan view of the same mechanism. FIGURE 4 is a vertical sectional view taken on line 4—4 of FIGURE 2. FIGURE 5 is a vertical sectional view of a stabilizer valve used in the apparatus. FIGURE 6 is a diagrammatic top view, on a reduced scale, of a modification of the invention. FIGURE 7 is a diagrammatic side view of the same modification. FIGURE 8 is a diagrammatic view, on a reduced scale, of another modification of the invention. FIGURE 9 is a diagrammatic view, on a reduced scale, of another modification of the invention. FIGURE 10 is a schematic showing of a modification of the invention. FIGURE 11 is a sectional view of a modified form of valve which may be substituted for the valve 42 of FIGURE 1, either in FIGURE 1 or FIGURE 9.

Referring further to the drawings, there is shown in

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FIG. 1 a well pipe 5 extending above the ground from the well, a petroleum discharge pipe 6 equipped with a check valve 7 and a shut-off valve 8, the pipe 6 leading to a conventional oil and water separator 9. Such a separator is customarily sufficiently elevated to deliver the separated petroleum by gravity through pipes to one or more storage tanks (not shown), all of which is conventional.

The apparatus of the invention includes the walking beam 11, usually an I-beam, pivoted at 12 on any suitable support such as the legs 13 and 14, secured to a base 15, which may be a concrete or wrought iron platform. One or more cables 16 are secured to the horsehead 17 and are connected to a conventional polish rod 18, the latter extending through a stuffing box 19 into the well pipe and therein connected in an appropriate manner to a conventional or suitable well pump (not shown), which lifts the petroleum during its vertical reciprocation.

Counterweights 21 are secured near one end of the beam in such number and position as to counter balance the total weight or load supported on the other end of the beam. Usually the total weight of sucker rod components and weight of the well pump is greater than the total weight of the components and liquid weight during the downstroke. Hence, if desired, the counterweights may be selected and adjusted to balance the median between these two total weights.

In place of the hitherto conventional pitman rod and gear train, this invention provides an hydraulic cylinder 22 whose lower end is pivotally supported at 23 on a plate 24 which may be secured at any of several points on the platform more or less remotely from a vertical plane passing through the beam pivot 12, as desired by the operator. The piston rod 25 is connected at the pivot 26 to a shoe 27, which also may be secured as desired to the walking beam at points more or less remote from the pivot of the beam, but usually directly above the pivot 23. Thus, the operator may vary the leverage at which he applies the hydraulic power to the beam.

An oil reservoir 28 vented to atmosphere stores the hydraulic fluid, which is delivered through pipe 29 through oil filter 31 to pump 32, preferably a gear pump or vane pump, driven by any suitable motor 33, such as an internal combustion motor or an electric motor.

During operation of the apparatus, the gear pump 32 operates continuously and delivers oil through pipe 34 to a conventional hydraulic flow reversal valve 35. Control valve 35 during the upstroke of the well pump is constructed to deliver oil into pipe 36 which leads to the upper end of cylinder 22, whereby the piston 37 is enabled to rock the beam and raise the polish rod 18. Should some unusual obstruction to this movement of the beam arise, a resultant rise in the pressure in line 36, if sufficient will cause the pressure relief valve 38 to open, and the pressure may be relieved through pipe 39 to the reservoir.

During the downstroke of piston 37, the hydraulic fluid is expelled from the lower end of the cylinder through pipe 41, upwardly through the stabilizer valve generally indicated as 42 in FIG. 1, thence through pipes 43 and 44, through the reversing valve 35, and through pipe 45 to the reservoir.

A manually adjustable by-pass valve 45' is connected to pipe line 34, as shown and the by-passed hydraulic fluid is diverted through pipe 34' into pipe 45 for return to storage tank 28, which is equipped with a conventional air vent 28'.

As seen in FIG. 5, the stabilizer valve 42 includes a base 46, a housing 47, and a movable valve member in the housing consisting of the bell 48 whose annular skirt 49, depending from the domed ceiling 50, normally seats

on base 46 and is provided with perforations 51 through which the hydraulic fluid normally flows to pipe 43 during the downstroke of piston 37. The valve stem 52 extends up through a perforated guide web or spider 53, and carries a fixed collar 54 on which is seated a spring 55 held under adjustable compression by disc 56 fixed on the end of a manually adjustable screw 57 which may be locked at a desired position by lock nut 58. The spring 55 will be adjusted so that normal operating pressures in the oil flowing from pipe 41 to pipe 43 through the small ports 51 spaced throughout the entire skirt 49 will not unseat the skirt from its seat on 46.

However, should the sucker rod part while being raised, the weight and leverage of the counterweights 21, no longer being counterbalanced by the weight on the polish rod 18, will force piston 37 down at an abnormally high velocity, producing a sudden abnormal increase in the pressure under the bell 48 to unseat its skirt 49 from the base 46 and raise the bell against the auxiliary valve seat 59, thus stopping the piston and the beam.

A conventional pressure relief valve 61 may be adjusted so that it will be opened by this abnormal pressure and bleed off the excess pressure through pipes 41, 62, 63, and then by way of pipe 45 to the reservoir, allowing the beam and weights to fall slowly, or the valve 61 may later be opened by an operator.

The valve housing 47 may have a small bleed line 60 connectable to the reservoir 28.

Whenever the pressure in pipes 41 and 64 exceeds a predetermined normal pressure range, as may occur when a sucker rod parts or when gas lightens the load on the horsehead, a conventional pressure actuated switch 65 will be operated to cut off ignition to motor 33. Likewise, if the pressure on switch 65 falls below that selected normal range, for example, due to hydraulic fluid leakage or hydraulic pump failure, the switch will also operate to cut off motor 33. Once actuated, the switch must be restored manually to allow starting of the motor. Thus the valve 42 and the switch 65 may be relied upon as guardians for a well when unattended.

A check valve 66 in pipe 34 protects the pump 32 from damaging effects of abnormally high back pressures. The indicating gauge 67 informs the operator of existing pressures. During normal operations the upstroke of piston 37 is effected by oil under pressure from the pump through pipe 34, through the flow control valve 35, pipe 44, pipe 43, down through valve 42 and its perforations 51, pipe 41 and into the cylinder. While hydraulic fluid is being pumped into the lower end of the cylinder, the fluid expelled from the upper end exits through pipe 36, the control valve 35 and pipe 45 to the reservoir.

The valve 35 preferably is a conventional four way directional flow open center type valve having a sliding spool valve therein. In one end position of this valve, pump discharge is directed to the upper end chamber of cylinder 22, in the other end position, it is directed to the lower end chamber. In each case the fluid being expelled from the cylinder is directed by the valve to the reservoir through pipe 45. In the neutral position of the valve all flow to and from the cylinder is blocked, but the pump may continue to operate and discharge through the valve to the reservoir. For actuating this valve, rod 71 slidably extends through block 72 rotatably mounted on pin 73 fixed in bracket 74 which is clamped by yoke 75 on the I-beam. Stop collars 76 and 77 are adjustably fixed by set screws on rod 71 to be engaged by block 72 as it moves up or down with the beam.

The lower end of the rod has a bifurcation in the form of two rigid fingers 78 and 79. Above the fingers the rod is guided by a roller 70 between the flanges thereof, the roller being supported suitably on the machine frame. Fingers 78 and 79 are connected to springs 81 and 82.

The valve 35 is a conventional spool type valve, in which the spool slides longitudinally of its axis through neutral position to one or the other of its operating end

positions. One end 83 of this spool valve extends from the valve housing 84, and to it is pivotally connected an arm 85, one end of which arm is pivoted on a ball 85' in the ear 86 extending from the valve housing 84. The other end of the arm 85 has fixed on it a loop 87, one side leg 88 of which is secured non-rotatably to the center of the inner race 89 of a ball bearing, the outer race 91 of which is welded to pin 92, the latter being integral with a yoke 93 having one of its legs 94 connected to spring 82, while its other leg 95 is connected to spring 81. Secured also to yoke 93 is a pair of straps 96 and 97 which support between them a heavy metal block 98.

Assuming that the apparatus as shown in FIG. 1 is engaged in effecting an upstroke of the polish rod 18, the hydraulic fluid is being pumped into the upper end of cylinder 22, the spool valve having, at the end of the previous down stroke of the polish rod, been elevated to direct such flow. As the beam approaches the pre-set limit of its lifting of the polish rod, the block 72 will strike the lower collar 77 and then carry the rod a short distance downwardly and past the dead center of its associated toggle springs. This action will cause the springs to pull the unpivoted end of arm 85 downwardly, reversing the position of the spool valve, and immediately applying the oil pressure to the lower end of the cylinder. This will cause the polish rod to start on its downward travel.

It will now be perceived that just before the polish rod reaches the predetermined limit of its down stroke the block 72 will strike the upper collar 76, and raise the rod 71 enough for the toggle springs to again reverse the position of the spool valve.

It is desirable that the shifting of the spool valve be not only rapid but that any rebound tendency of it be eliminated. Accordingly, rubber bumpers 101 and 102 are supported in any suitable manner (not shown), and in the path of the arm 85, so that when the arm is being pulled upwardly by the toggle springs to the upper dotted line position shown in FIG. 2, it will strike and rest against bumper 101 and in the opposite movement will strike and rest against bumper 102. As this is occurring, the pivotally supported block 98 will be carried by momentum to the dotted line positions therefor shown in FIG. 2 and aid in preventing rebound of the arm 85 and possible reverse movement of the spool valve. The bumpers also limit the travel of the spool valve and prevent it from noisy operation.

Another advantage afforded by the present invention resides in the simplicity with which the walking beam may be locked at an intermediate position. Rigidly secured to the arm 85 and extending laterally therefrom and thence upwardly are brackets 103 and 104 on which is rigidly supported an arm 105 equipped with a suitable handle 106. A dog 107 is pivoted at 108 on the frame member 109, and is normally rotated up out of the way. It is provided with a downwardly opening notch 111 which the operator may engage with the pin 112 carried by bracket 103 by downward rotation of the dog. By means of the handle 106 the pump operator may move the arm 85 to the position shown in FIG. 2, whether or not the apparatus is in operation at the time. This shifting of the reversing spool valve to neutral position prevents any movement of hydraulic fluid through the reversing valve to or from the upper or lower cylinder chambers, thus locking the piston 37 and the beam wherever they happened to be at this time when the arm 85 was shifted. While this takes place the pump may still be allowed to run. The operator may quickly make an inspection, repair or adjustment, and resume operations merely by unlocking and shifting arm 85 again.

For example, with the walking beam held stationary, the operator may in a few minutes make a vertical adjustment of the collars 76 and 77 for the purpose of changing the length and hence the frequency of the well pump strokes, and do this without stopping the pump or

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changing the motor speed to change the rate of the strokes. A need for such a change will arise when the oil sands are not releasing petroleum to the well pump fast enough, and gas is collecting in the pumping mechanism.

The spring 55 in the stabilizer valve 42 can be so adjusted that the valve 48 will rise and seat against the valve seat 59 upon the occurrence of as little as a 10 to 20 pound increase above the normal maximum pressure in the hydraulic fluid coming from the lower chamber of the cylinder. At his option, the operator may adjust the spring 55 to yield at some other selected pressure increase. In any event, it is desirable that this valve react instantaneously to objectionable pressure rises, so that when the weights start moving down at abnormal velocity, they not be allowed to acquire any substantial acceleration before they are stopped.

FIGURES 6 and 7 show, diagrammatically on a reduced scale, modified form of the invention which includes a form of walking beam which is especially well suited for association with the hydraulic drive and control system of the invention.

This modification includes the rigid base 121, made of any suitable material which may be much lighter than the heavy concrete base often found in gear driven pump jacks. On the base is mounted a Samson post 122, which in this case, preferably, but not necessarily, is a pipe sealed at the bottom end but vented to atmosphere at the upper end in any suitable or conventional manner, not shown. The upper end supports a saddle 123, on which is pivotally supported the walking beam 124. A conventional horsehead 125 is provided, from which depend two conventional cables 126 connected with the well pump rod assembly. Any suitable bracing such as one or more rigid rods 127 may be secured to the post and the base.

The hollow post 122 is preferably used also as a storage reservoir for the hydraulic fluid, and should have a conventional air vent (not shown) above the maximum liquid level.

A double acting hydraulic cylinder 128, which may be substantially identical in function with cylinder 22 of FIG. 1, is pivotally connected to the base at 129, and its piston rod 131 is connected at 132 to the beam 124.

The entire hydraulic system of FIGS. 1 to 5 including pump, valves, controls and pipe connections are to be used in the apparatus of FIGS. 6 and 7, hence need no further description here.

This form of the invention provides an auxiliary walking beam to which the counterweights are attached. A pair of steel channel members 133 and 134 are pivoted in any suitable manner on opposite sides of post 122 on an axis vertically below the axis of saddle 123, and extend rearwardly past cylinder 128. They are bent and united as by welding to each other and to a tail beam 136 upon which are adjustably fixed the counterweights 137. The beam 136 is pivotally connected by the vertical link 138 to bracket 138' on beam 124, and by link 139 to bracket 139' secured on the opposite side of beam 124. The weights 137 will be adequate to exactly counter balance all of the weight supported by the beam 124 forward of the saddle axis. The weights will be high enough not to strike the ground during the longest expected pump stroke, but it is apparent that by shifting the pivotal support at 135 higher on the Samson post and then using shorter links 138 and 139, a longer stroke with the same apparatus can be achieved. As the weights are close to the ground, it is advisable to surround the beam 136 and weights with a safety box or screen (not shown), to eliminate danger to men and animals. It should be noted in FIG. 7 that lines drawn through the pivotal connections and supports of the upper and lower beam constitute a parallelogram.

All of the apparatus thus far described operates quietly, smoothly and without any of the vibration usually found in the prior known gear driven pump jacks. Furthermore, the hydraulic system as here employed and controlled

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does not cause any overheating of the oil, as sometimes occurs in hydraulic systems operating continuously for very long periods, as this apparatus is intended to operate.

An additional modification of the counterbalancing mechanism, especially suitable for coaction with the hydraulic equipment of the invention, is shown on a reduced scale diagrammatically in FIGURE 8.

Instead of mounting the counterweights directly on the walking beam, a horsehead 142 is fixed on beam 141 and on its conventional arcuate surface 143 a pair of cables 144 is secured in a conventional manner. The arcuate surface 143 lies in an arc of a circle whose center is the axis of the saddle 145 on which the walking beam is pivoted. Hence, the counterweights 146 supported on the cables are constrained to move in a vertical path parallel to the Samson post 147. This post, like post 122 of FIG. 7, may be a pipe closed at the lower end and vested at the upper end and serving also as the storage reservoir for the hydraulic fluid.

A hydraulic cylinder 148 is pivotally connected to the beam and bar, as shown. The remainder of the hydraulic system of FIGS. 1 to 5 will be connected to the reservoir and to the cylinder 148 of FIG. 8, and will function in this modification in the manner heretofore described for that system.

As is conventional, the horsehead 149, to which are attached the well pump cables 151, has an arcuate cable supporting surface 152 which lies on an arc of a circle whose center is the pivotal axis of the beam in the saddle 145. Horseheads of conventional construction may be used.

The individual counterweights 146, in order to be placed centrally on cables 144, need only be slotted at one point from their peripheral edges to the center, as is common practice in slotting weights for ordinary weighing scales.

If desired, a rod 153 may be affixed to depend from the cables and extend through the slotted counterweights for attachment to a suitable heavy or reinforced steel plate 154, on which the counterweights are supported. These weights, preferably, will be made of concrete poured in molds, as a matter of economy. Being subject to no vibration, they may thus supplant the more expensive conventional prior cast iron beam weights. One man alone can place them on the cables or rod, as compared with the usual two man crew, using a ladder when placing weights on an overhead beam.

A cylindrical shell 155 may be placed around the counterweights as a safety shield and may be dimensioned to guide the steel plate 154, thus damping any swing tendency which might arise under any conditions. A lubricated guiding fit between the shell and plate 154 may be provided, if desired.

The shell should be firmly secured to the base 156, and may be formed as two hinged together halves (not shown), affording access to the weights, but capable of being locked when closed, to prevent tampering. Should it be desired to extend the shell higher than the lowest point of travel of the horsehead 142, the top margin 157 of the shell may be formed on a suitable angle, as shown.

It will be noted that in both modifications of the counterbalancing mechanism, the weights are close to the ground, rather than overhead where they would constitute a serious safety menace to man and a possible source of damage to the power equipment, especially if it were gear driven equipment. Large and menacing overhead counterweights are a recognized serious hazard in the oil fields, and in recent years regulations restricting their use have become prevalent.

Though one double acting hydraulic cylinder in the system has been described herein, it should be apparent that two single acting cylinders connected to the walking beam at opposite sides of its pivotal support may be used, an upward thrust only being applied to each piston,

and two cylinders in some installations may be advantageous. However, whether one or two cylinders be employed, the principles of operation and control of the system would remain unchanged.

In FIGURE 9 there is shown schematically another modified form of the invention. On base 161 is mounted a hollow Samson post 162 having an air vent 163 at its upper end, and having a saddle 164 on which is pivotally supported on pivot 165 the walking beam 166. Attached to the horsehead 167 are one or more well pump cables 168, which are secured to the polish rod 169, the latter being connected to the sucker rod which extends into the well for connection to the well pump. The face of the horsehead is an arc of a circle whose center is the pivot 165.

The hollow Samson post 162 also serves as a reservoir for the hydraulic fluid and is braced on the platform by one or more braces 171.

At the rear end of the beam is fixed a horsehead 172 having an arcuate surface concentric also with the pivot 165. This pair of horseheads have the same functions as those of FIG. 8, as heretofore described. Counterweights 173 are suspended from the rear horsehead on a cable 174, this cable always moving in a vertical path as the beam rocks, as does the cable 168. A guard housing 175, similar to the housing of FIG. 8, serves as a safety shield and to shield the weights from the possible effects of high winds.

An hydraulic pump 176, which may be a gear, vane or other suitable pump, and which is driven by any suitable motor (not shown), is connected by the pipe 177 to the storage tank or reservoir. The pump may be of the type adapted to deliver hydraulic fluid at constant pressure through pipe 178, the pressure relief valve 179, check valve 181, pipes 182 and 183 into an hydraulic directional control valve 184, which may be the same in construction and function as the control valve 35 of FIG. 1. A hand operated by-pass valve 185 controls the volume of fluid delivered into the control valve and directs the by-passed fluid through pipe 186 to the reservoir.

A lost motion mechanism operated by the beam for shifting the spool valve in the control valve 184 may be the same mechanism as is shown in FIGS. 1 to 4.

The by-pass valve 185 may be employed in increasing or decreasing the strokes per minute of the well pump. The stops 76 and 77, shown in FIG. 4, may be employed to regulate the stroke lengths, as heretofore described. The valve 200, later described, is useful for stopping the action of the hydraulic piston in any position thereof when the operator wishes to change the stroke length, and the hand valve 185 may be operated while the apparatus is running to vary the strokes per minute.

During the up stroke of the well pump, the control valve 184 will direct the hydraulic fluid received from the pump through pipe 187 and through a valve 188 of known construction which will have a manually variable orifice permitting restricted flow into the top of the cylinder 189, but permitting free, unrestricted flow out of the cylinder to the pipe 187 during the opposite pump stroke. By means of valve 188 the operator may thus, at will, modify the speed of the upstroke while the pump is running, without affecting the speed of the downstroke.

An accumulator 191, having a free floating piston therein separating the hydraulic fluid from an inert gas, such as nitrogen, is connected as shown to the upper end of hydraulic cylinder 189.

During the upstroke of the well pump, as the hydraulic cylinder piston is descending, the fluid being expelled from the lower end of the cylinder will exit through pipe 192 in a free flow manner through a valve 193 identical with the valve 188, thence through pipes 194 and 195, through a stabilizer valve 196, which may be identical in structure and function with the valve shown in FIG. 5. The fluid emerging through valve 196 flows through pipe 197 into the control valve 184, and thence to be

returned by pipe 198 to the reservoir. There may be interposed in this return line, if desired, another form of stabilizer valve 205, shown in FIG. 10 and later described. This valve could be substituted for valve 196, but not ordinarily in addition to it.

In the apparatus of FIG. 9, as is true of that shown in FIG. 1, the well pump is positively driven on both the up and down strokes. In FIG. 9 the down drive of the well pump is effected by the beam actuating a trip mechanism such as is shown in FIGS. 1 to 4, causing the control valve 184 to be reversed, after which the pump 176 will deliver fluid through pipe 197, valve 196, and pipe 194, valves 193 and 200 into the bottom of the cylinder.

A pressure actuated switch 199, identical in function with the switch 65 of FIG. 1, may be provided to cause the hydraulic pump motor to be stopped upon the occurrence of a predetermined abnormally high pressure or abnormally low pressure in pipe 194, as described heretofore.

The lower end of the hydraulic cylinder is provided with an accumulator 201, which may be identical with the accumulator 191, to give an assist to the initiation of the upstroke of the cylinder piston.

A hand operated normally open valve 200 in pipe 192 enables the operator at will to stop the fluid flow through that valve into or out of the cylinder 189, thus to stop the beam. Preferably the valve 200 is constructed to close pipe 192 and divert into pipe 200' any fluid flowing toward the valve from pipe 194, as would occur if the beam were at the time on the upstroke, that is, of the beam weights.

A pressure relief valve 202 is interposed between pipes 203 and 204 to serve the same purpose as does the relief valve 61 of FIG. 1.

FIGURE 10 shows an alternative form of pressure actuated valve or stabilizer valve which may be substituted for the valve 196, either in the location shown for valve 196 in FIG. 1, or in the pipe 198, as shown, to respond to a predetermined abnormal pressure increase in pipe 198 to cut off flow through that pipe and stop the motion of the hydraulic cylinder piston and the beam. This valve, generally indicated as 205 is provided with a casing 206 having a large chamber 207 whose port 208 may, by proper pipe connections, be subjected to the same fluid pressure as may exist in a fluid flowing freely through the valve. In the FIG. 10 this is accomplished by connecting the pipe 209 to port 208 and to port 210, and connecting port 211 to the fluid return pipe 198.

The reciprocable rod 212 carries a large diameter piston 213 and a smaller diameter plug valve 214 sized to fit the bore in which it slides. The other end of the rod carries a disk 215 against which the adjustable compression spring 216 is pressed by the manually adjustable screw 217. When the fluid flowing through the ports 210 and 211 is within a normal low pressure or predetermined pressure range, the spring 216 will hold the valve in the open position as shown in FIG. 10. But should an abnormally high pressure arise due, for example, to the parting of a sucker rod on either the up or down strokes of the well pump, or for other reason, if the pressure is adequate to overcome the spring pressure the piston 213 will slide the plug valve 214 across the passage connecting the ports 210 and 211, which will cut off the flow through the valve. This valve 205 could, by appropriate spring adjustment, partially throttle the high pressure flow, instead of cutting it off completely. But when the valve is normally wide open it presents little restriction to the fluid flow.

When the double acting cylinder of FIG. 1 or FIG. 9 is used, the cylinder space occupied by the piston rod lessens the fluid capacity of that end of the cylinder, relatively to the space in the other end, hence, with a constant volume fluid output coming from the hydraulic pump, the up stroke of the well pump will have a higher

velocity than the down stroke will, which is an advantage as a time saver.

The rear horsehead supporting the counter weights as shown maintains a constant moment arm for the application of counter weight forces acting on the beam pivot, and with no possibility of the weights swaying the Samson post is thus protected against the vibration which has heretofore been caused by fixed beam weights.

This invention is not limited to any special range of hydraulic pressures to be applied to the power cylinder. Various pressures ranging from less than 100 lbs. to several hundred pounds have shown the system to operate smoothly, without substantial vibration, and with no objectionable heating of the hydraulic fluid.

While preferred embodiments of the invention are herein described and shown in considerable detail, it should be understood that the invention is not limited to the details of construction disclosed, but embraces all variations and modifications which fall within the scope of the appended claims.

I claim:

1. In a petroleum well pumping apparatus, a base, a walking beam pivotally supported on the base, a well pump supported operatively on the beam forwardly of the beam pivot, counterweights connected to the beam rearwardly of the beam pivot completely gravitationally counterbalancing the forces downwardly acting on the beam forwardly of its pivot, a double acting hydraulic cylinder pivotally supported on the base and having its piston pivotally connected to the beam rearwardly of the beam pivot, means including an hydraulic pump, conduits and a directional flow control valve adapted for supplying hydraulic fluid through the valve alternately to and returning the fluid to the valve from the upper and lower end chambers of the cylinder for rocking the beam, and valve means actuated by pressure greater than a predetermined pressure occurring in the hydraulic fluid flowing from said lower end chamber to said valve adapted instantly to terminate further fluid flow from said lower chamber to thereby immobilize said beam.

2. In a petroleum well pumping apparatus, a base, a walking beam pivotally supported on the base, a well pump supported operatively on the beam forwardly of the beam pivot, counterweights connected to the beam rearwardly of the beam pivot completely gravitationally counterbalancing the forces downwardly acting on the beam forwardly of its pivot, a double acting hydraulic cylinder pivotally supported on the base and having its piston pivotally connected to the beam at a point apart from the beam pivot, means including an hydraulic pump, conduits and a directional flow control valve adapted for supplying fluid through the valve alternately to and returning the hydraulic fluid to the valve from the upper and lower end chambers of the cylinder for rocking the beam, valve means actuated by abnormal pressure greater than a predetermined pressure occurring in the hydraulic fluid flowing from one end chamber to said control valve adapted to instantly terminate further fluid flow from said one end chamber to thereby immobilize said beam.

3. In a petroleum well pumping apparatus, a base, a walking beam pivotally supported on the base, a well pump supported operatively on the beam at the forward side of the beam pivot, counterweights connected to the beam at the rear side of the beam pivot completely gravitationally counterbalancing the forces downwardly acting on the forward side of the beam pivot, a double acting hydraulic cylinder pivotally supported on the base and having its piston pivotally connected to the beam on the same side as the counterweights, means including an hydraulic pump, conduits and a directional flow control valve adapted for supplying hydraulic fluid through the valve alternately to the upper and lower end chambers of the cylinder and returning the fluid to the control valve from said chambers adapted for rocking the beam, and means actuated by pressure greater than a predetermined

pressure occurring in the hydraulic fluid flowing from said lower end chamber adapted instantly to terminate the hydraulic fluid flow from said cylinder through said control valve and thereby immobilize said beam.

4. In a petroleum well pumping apparatus, a base, a rockable walking beam pivotally supported on the base, a well pump supported operatively on the beam forwardly of the beam pivot, counterweights connected to the beam rearwardly of the beam pivot adapted for achieving gravitational counterbalancing of the forces acting downwardly on the forward end of the beam, an hydraulic mechanism for rocking the beam including a double acting hydraulic cylinder pivotally supported on the base and having its piston pivotally connected to the beam at a point apart from the beam pivot, an hydraulic pump, conduits and a directional flow control valve adapted for supplying hydraulic fluid through said valve to one end chamber of said cylinder for rocking the beam to lower the well pump and alternately to the other end chamber through said valve during raising of the well pump, and means actuated by the beam as it approaches pre-selected limits of its angular rocking movement and mechanically connected to said valve adapted to shift said control valve to effect the aforesaid alternate control of said fluid flow.

5. In a petroleum well pumping apparatus, a base, a rockable walking beam and means pivotally supporting the beam between its forward and rear ends on and well above the base, a well pump operatively supported on the forward end of said beam, an auxiliary beam having one end pivotally supported directly below said first beam support and extending rearwardly therefrom parallel to and below the first beam, a link pivotally connecting the two beams at points equidistant rearwardly of their pivots, counterweights secured on the auxiliary beam positioned and proportioned to coact with the first beam for counterbalancing the forces downwardly acting on the forward end of the first beam, and an hydraulic mechanism for rocking the walking beam including at least one hydraulic cylinder mounted on the base rearwardly of said pivots and forwardly of the counterweights and having its piston pivotally connected with the first beam, an hydraulic pump, conduits and a directional flow control valve adapted for alternately supplying hydraulic fluid to the lower end chamber of said cylinder to cause said cylinder to rock the first beam to lower the well pump and enabling the discharge of the fluid from said chamber to said valve during reverse rocking of the walking beam during raising of the well pump.

6. In a petroleum well pumping apparatus, a base, a rockable walking beam, means pivotally supporting said beam between its ends on said base, a vertically reciprocable well pump operatively supported on the forward end of said beam, counterweights connected to said beam rearwardly of its pivot positioned and adapted for completely gravitationally counterbalancing the forces acting downwardly on the beam forwardly of its pivot, an hydraulic mechanism for rocking said beam including at least one hydraulic cylinder supported on the base and whose piston is connected to the beam at such a position that downward movement of the rear end of the beam causes said piston to expel hydraulic fluid from one end chamber of said cylinder, an hydraulic pump, conduits and directional flow control means adapted for alternately supplying hydraulic fluid to said end chamber for effecting downward movement of the well pump and conducting the discharge of the fluid from said chamber through the said flow control means during upward movement of the well pump and valve means actuated by abnormal pressure greater than a predetermined pressure occurring in the hydraulic fluid discharging from said chamber adapted to shut off said fluid flow and stop further movement of said piston.

7. In an oil well pumping apparatus having a base and a walking beam pivoted thereon, a well pump supported on the forward end of the beam and adjustable

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counterweights fixed on the rear end of the beam, an hydraulic cylinder having an end chamber and a piston connected to the beam adapted for rocking the beam, a directional fluid control valve, an hydraulic pump, conduits connected to deliver hydraulic fluid from the pump to said valve and thence to alternately admit fluid to said chamber and control the withdrawal of fluid from the chamber to the control valve, a valve casing interposed in the conduit connecting said control valve to said chamber, said casing having a valve element mounted therein for reciprocation, stop means limiting the movement of the valve in one direction without blocking passage of fluid therethrough, adjustable resilient means normally urging said element against said stop means, said element and casing providing for a normal but somewhat restricted flow of fluid past the valve in either direction between the control valve and said chamber during normal rocking of the beam, and a valve seat in the casing against which a portion of the element seats opposed by said resilient means responsive to an hydraulic fluid pressure rise exceeding a predetermined pressure in the fluid flow from the chamber to the control valve to thereby block further fluid flow through the casing.

8. In an oil well pumping apparatus having a pivoted walking beam, a well pump connected to the beam at one side of the pivot and adjustable counterweights connected to the beam at the opposite side of the pivot, the improvement comprising an hydraulic cylinder having a chamber and having a piston connected to the beam adapted for rocking the beam, a directional fluid control valve, an hydraulic pump and driving means therefor, conduits connected to deliver hydraulic fluid from the pump to said valve and thence to said chamber, means for actuating said valve adapted to alternately admit fluid under pressure to said chamber in the cylinder and control the withdrawal of fluid from said chamber, a valve casing interposed in the conduit connecting said control valve to said chamber, a resiliently mounted valve element in said casing adapted to permit fluid flow through the casing in either direction between the control valve and said chamber during the existence of fluid pressures within a predetermined pressure range, said casing having a valve seat against which said element seats to block the flow of fluid upon the occurrence of an abnormal conduit pressure between the casing and cylinder exceeding said predetermined pressure.

9. In an oil well pumping apparatus, a base, a walking beam pivotally supported on said base, an oil well pump supported on one end of said beam, counterweights mounted on the beam at the other side of said pivotal support, an hydraulic fluid pump and a motor connected thereto for driving the pump, a double acting hydraulic cylinder supported on said base, a piston slidable in the cylinder and pivotally connected to said beam between said pivotal support and said counterweights, an hydraulic fluid storage tank, a flow reversing control valve, conduits constructed and arranged for conducting hydraulic fluid from the pump to the control valve and thence to either end chamber of the cylinder in accordance with the operational position of the control valve, a stabilizer valve interposed in the conduit leading from the control valve to the lower end chamber of said cylinder, the last said valve having a casing, a valve member reciprocable in the casing, a bell-shaped valve head on said valve having a depending skirt, a valve seat in the casing against which the skirt normally seats, said valve head having perforations therethrough for the normal passage of fluid in both directions through the valve casing between the control valve and said lower chamber while said skirt is seated, a second valve seat in the casing against which said valve head may seat and shut off all flow through the valve casing, adjustable resilient means normally holding said skirt upon the first valve seat during the flow of fluid through said perforations to and from the lower end chamber of the cylinder, said resilient means being

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adjusted to yield and allow the valve head to seat against the second seat upon the occurrence of a predetermined abnormal high pressure in the conduit delivering oil from said lower chamber to said valve casing for passage through said perforations, and means operated by the rocking of the walking beam adapted to actuate said control valve to direct hydraulic fluid alternately to the upper and lower end chambers of the cylinder.

10. In a petroleum well pumping apparatus, a base, a walking beam pivotally supported on the base, a well pump supported operatively on the forward end of the beam, counterweights supported on the beam rearwardly of its pivot counterbalancing the forces acting downwardly on the forward end of the beam, an hydraulic mechanism for rocking the beam including hydraulic cylinder means supported on the base and connected to the beam adapted for alternately raising and lowering the well pump, said mechanism including an hydraulic pump, conduits and a directional control valve shiftable from one position at which it directs the hydraulic fluid to the cylinder means to lower the well pump and to another position at which it directs the fluid to the cylinder means to raise the well pump, a lever connected to the valve for shifting said valve from one to the other of said positions, a rod depending from the beam and means slidably mounting it on said beam, toggle springs connected to said lever and to the lower end of said rod, spaced apart trip means adjustably mounted on said rod, means carried by said beam engageable with said trip means as the beam approaches its predetermined limits of up and down rocking movement adapted to shift the rod to cause the toggle springs to move the lever and shift the valve from one to the other of said positions and thereby effect reversal of the rocking of the beam.

11. In a petroleum well pumping apparatus, a base, a walking beam pivotally supported on the base at an elevated position thereabove, a well pump supported operatively on the beam forwardly of the beam pivot, a horsehead secured to the rear end of the beam and having an arcuate surface centered on said pivot, counterweights supported flexibly on said arcuate surface for vertical reciprocation in a fixed path of movement and depending from the beam a substantial distance but short of contact with the base or ground during normal maximum rocking of the beam, and an hydraulic mechanism for rocking the beam including at least one hydraulic cylinder connected to the base and having its piston connected to the beam between the pivot and the counterweights, a directional control valve, conduits and an hydraulic pump adapted for delivering hydraulic fluid through the valve to an end chamber of the cylinder to effect lowering of the well pump and alternately from said end chamber through said valve during the raising of the well pump, and toggle action means controlled by the beam as it approaches predetermined limits of its rocking movement about its pivot constructed and arranged to quickly reverse said control valve and thereby reverse the rocking movement of the beam, said counterweights completely gravitationally counterbalancing the forces downwardly acting on the first beam forwardly of its pivot.

12. A well pumping apparatus in accordance with claim 5, in which the forward end of the auxiliary beam is formed of two spaced parallel rigid members between which the hydraulic cylinder extends upwardly from the base.

13. A well pumping apparatus in accordance with claim 11, in which there are means actuated by abnormal pressure greater than a predetermined pressure occurring in the hydraulic fluid flowing from said end chamber through said control valve adapted when actuated to instantly shut off said fluid flow and thereby stop further movement of the piston.

14. A well pumping apparatus in accordance with claim 6, in which the beam is pivotally supported on a

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vertical tube closed at both ends and constituting a reservoir in which is stored hydraulic fluid for supplying the hydraulic pump and which receives the hydraulic fluid returned from the hydraulic cylinder through the directional control means.

15. In a well pumping apparatus, a base, a beam pivotally supported on the base, a well pump supported operatively on the forward end of the beam, counterweights supported on the beam rearwardly of its pivot counterbalancing the forces acting downwardly on the forward end of the beam, an hydraulic mechanism for rocking the beam including a double acting hydraulic cylinder supported on the base and connected to the beam adapted for alternately raising and lowering the well pump, said mechanism including an hydraulic pump, conduits and a directional control valve shiftable from one position at which it directs the hydraulic fluid to the lower end of the cylinder to lower the well pump and to another position at which it directs the fluid to the upper end of cylinder to raise the well pump, and a valve through which the fluid normally freely enters into and exits from the lower end of the cylinder but is adapted to be closed by an abnormal pressure greater than a predetermined pressure occurring in the fluid exiting from the lower end of the cylinder, and means adapted for automatically shifting said control valve from said one position to said other position.

16. A pumping apparatus in accordance with claim 15, in which an accumulator containing a gas is in constant communication only with the upper end of the hydraulic cylinder and another accumulator in constant communication only with the lower end of the hydraulic cylinder and subjected to compression immediately after each shifting

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of the control valve and before reverse movement of the well pump begins.

17. A well pumping apparatus in accordance with claim 15, including manually adjustable means for selectively varying the rate of hydraulic fluid flow to one end of the cylinder without varying the outflow therefrom in one position of the control valve independently of the rate of fluid flow to the other end of the cylinder in either position of the control valve.

18. In a hydraulic pumping apparatus, a valve assembly having a normally open liquid duct therethrough for normal liquid flow therethrough, and means including a valve slidable to blocking position across said duct responsive to a predetermined abnormally high pressure in the liquid entering the duct from either direction adapted for actuating said valve to blocking position.

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