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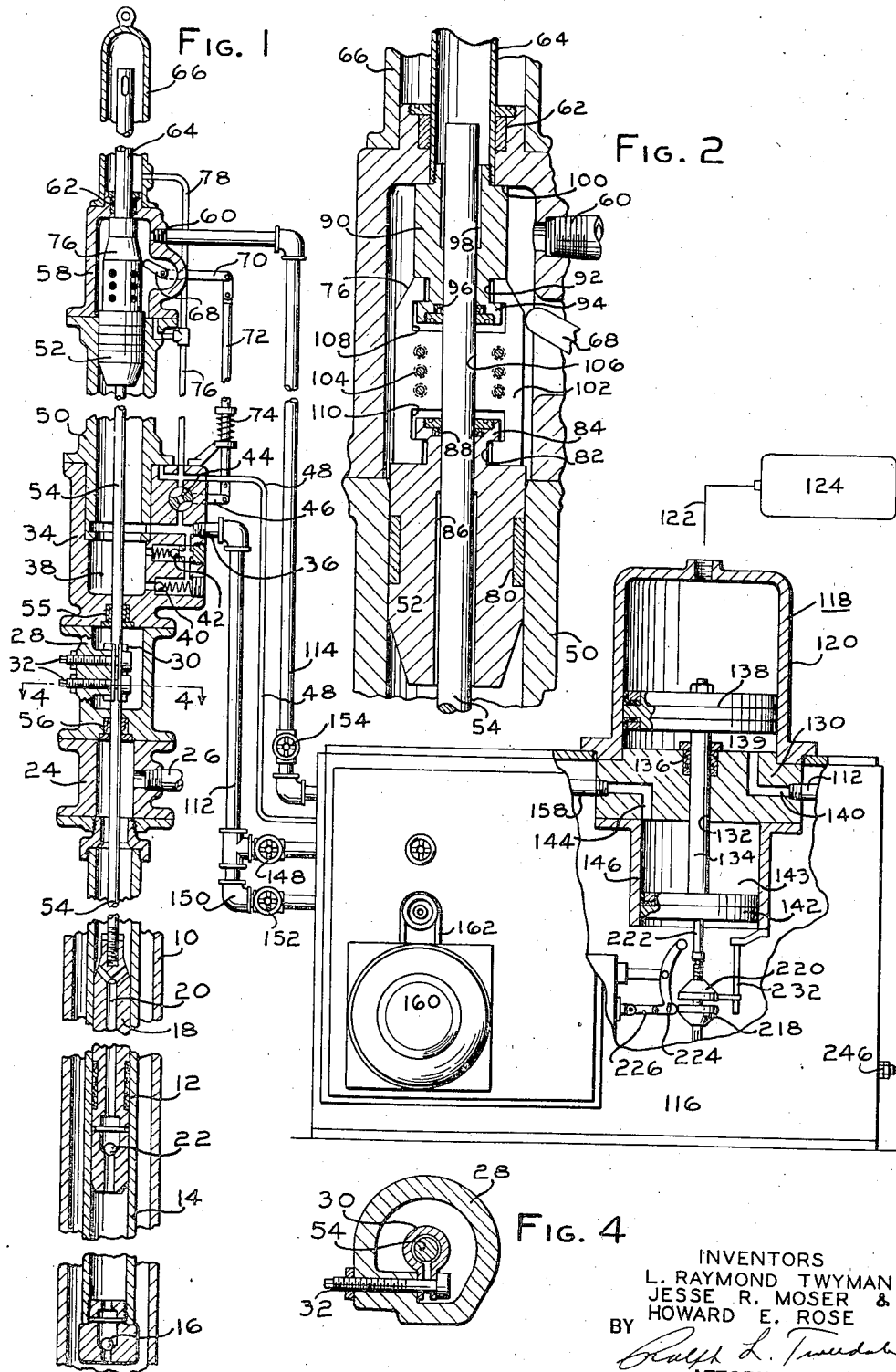
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POWER TRANSMISSION

Filed April 22, 1940

2 Sheets-Sheet 1



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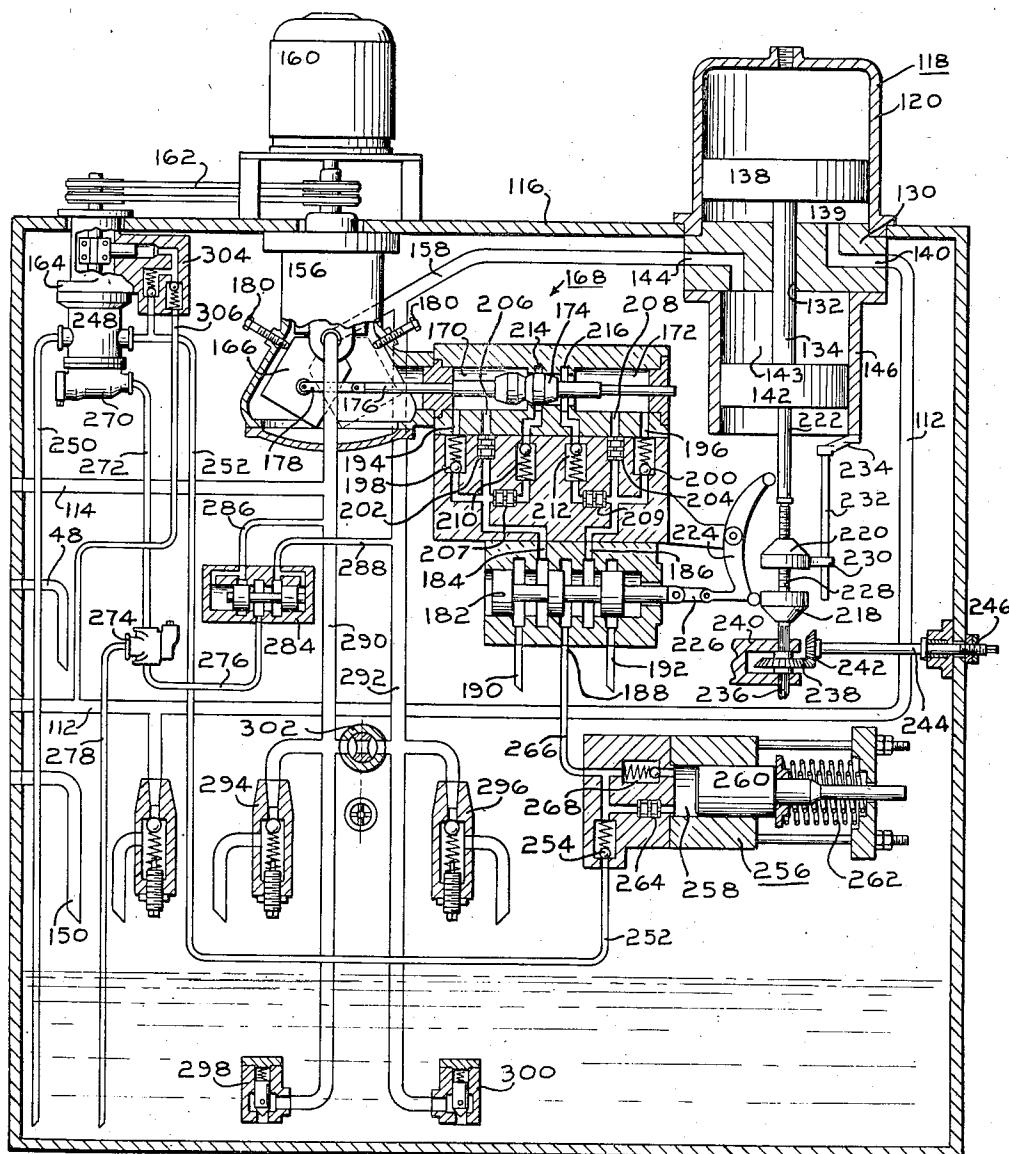
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FIG. 3



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POWER TRANSMISSION

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This invention relates to power transmissions, particularly to those of the type comprising two or more fluid pressure energy translating devices one of which may function as a pump and another as a fluid motor.

The invention is more particularly concerned with a power transmission system for use in oil well pumping for operating the type of pump in which a sucker rod string is utilized in the well to operate the pumping plunger or barrel at the bottom of the well. Hydraulically operated well pumping units of this class have been known for many years and have recently come into more extensive use. Pumping units of this class provide many advantages over the conventional walking beam type of pump jack, among them being a greater length of stroke and consequent reduction in the pump losses due to stretching of the sucker rod as well as the advantage of more precisely controlled acceleration and deceleration at opposite ends of the stroke resulting in longer sucker rod life due to less violent shock imposed upon the sucker rod string at reversal.

Hydraulic pumping units of this class have heretofore been constructed with hydraulic counterbalancing means either of the air-loaded type or of the weight-loaded type. It has been found that with units of the weight-loaded type the inertia of the tremendous weight required to counterbalance a long string of sucker rods in a deep well presents a serious limitation upon the maximum possible speed of operation of the pumping unit due to the difficulties in accelerating the large mass involved. The air-loaded counterbalancing means, however, has heretofore been capable of use only in hydraulic circuits wherein the fluid pressure generating means, usually a rotary pump, is connected in a hydraulic pipe line between the work cylinder at the top of the well and the hydraulic counterbalancing cylinder. This means that both the inlet and outlet connections of the pressure generating means are under very high pressures and necessitates rather expensive construction in order to withstand the high pressures upon both sides of the pressure generating means at the same time.

It is accordingly an object of the present invention to provide a hydraulic power transmission system adapted for operating an oil well pump wherein an air-loaded counterbalancing means may be utilized without requiring the application of high pressure to both sides of the pressure generating means which drives the pumping equipment.

Another problem which has presented itself in

hydraulic well pumping units as previously constructed involves the desirability of keeping the clearance volume of the pumping mechanism at the bottom of the well to a minimum, particularly in wells where a large gas content is present in the oil being pumped. It is readily understood that any gas entrained in the oil within the pumping chamber when its volume is at a minimum is under high compression at the end of a pumping stroke and acts as a resilient cushion which must be decompressed on the suction stroke before any oil can flow into the pumping chamber. This problem has been solved to some extent in the walking beam type of pump jack by the provision of convenient adjusting means between the pump jack and the sucker rod. Hydraulic well pumping units as previously constructed have involved somewhat difficult and time consuming procedure in making adjustment of the connection between the hydraulic operating mechanism at the top of the well and the sucker rod.

It is an object of the present invention to provide means whereby adjustment of the minimum clearance volume within the pumping chamber at the bottom of the well may be readily made at the top of the well.

A further object is to provide means whereby such adjustment may be made while the weight of the sucker rod is supported hydraulically by the pumping mechanism.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of the present invention is clearly shown.

In the drawings:

Figure 1 is a diagrammatic view of a power transmission system incorporating a preferred form of the present invention.

Figure 2 is a fragmentary cross section of the work motor piston construction illustrated in Figure 1.

Figure 3 is a diagrammatic sectional view of the power unit incorporated in Figure 1 showing the internal hydraulic circuit thereof.

Figure 4 is a cross section taken on line 4—4 of Figure 1.

Referring now to Figure 1, there is shown a well comprising a casing 10 having a pump 12 at the bottom thereof. The latter may be of any conventional type and, for example, may consist of a stationary barrel 14 having the usual check valve or "standing valve" 16 at the bottom and a reciprocable plunger 18 having the usual

central passage 20 and check valve 22 at the bottom thereof. At the top of the well there is secured to the top of the casing a discharge head 24 having the usual outlet 26 for the discharge of the oil delivered by the well pump. Immediately above the discharge head 24 there is secured a clamp casing 28 having a rod clamp 30 therein adapted to be tightened by means of two bolts 32 extending to the outside of the casing 28.

Positioned on top of the casing 28 is a cylinder head casting 34 having a connection 36 for hydraulic operating fluid extending into cylinder end chamber 38 at a point somewhat above the bottom thereof. A suitable spring-loaded relief valve 40 permits discharge of oil out of the chamber 38 to the connection 36 when the piston, later to be described, has closed off the point of communication between connection 36 and the upper part of chamber 38. A check valve 42 permits free flow from connection 36 into chamber 38 when the piston is below the normal inlet connection. The end casting 34 is also provided with a rotary replenishing control valve 44 operable by means of a lever 46 and linkage, later to be described. The valve 44 is normally closed and prevents communication between connection 36 and a drainage connection 48 provided for draining seepage along the top surface of the end casting 34.

Rigidly secured in the casting 34 is a long operating cylinder 50 having a piston 52 slidably mounted therein. The latter is normally rigidly connected to the sucker rod 54 which extends down through the mechanism previously described and is connected to the pump plunger 18 for operation of the same. Suitable packing means are provided at 55 in the cylinder casting 34 and at 56 in the clamp casing 28 for sealing the operating oil in chamber 38 and the well fluid in discharge head 24.

On top of the cylinder 50 there is mounted an upper end casing 58 having an operating fluid connection 60. The casting 58 is provided with a packed opening 62 through which a tubular tail rod 64 extends which performs the function of reducing the net effective area on top of the piston 52. A suitable enclosure tube 66 is mounted on top of the end casting 58. The latter is also provided with a trip dog 68 pivoted in a side wall of the casting 58 and having an operating shaft extending outwardly through said wall to connect with an operating lever 70. The lever 70 is connected by means of a link 72 to the lever 46 of the valve 44, a spring 72 normally biasing the levers 46 and 70 upwardly in Figure 1. Whenever the piston 52 reaches the upper limit of its stroke a cam surface 76 provided on the piston mechanism contacts the dog 68 to rotate the levers 70 and 46 clockwise to the position illustrated.

The joint between the cylinder 50 and the upper end casting 58 may be drained by means of a drain conduit 76 connecting with the drain conduit 48. The conduit 76 may have an upward extension 78 for draining any seepage past the packing 62.

The construction of the piston 52 is illustrated in detail in Figure 2 from which it will be seen that the latter comprises a large cylindrical member having grooves 80 for the reception of suitable piston packing means, and, at its upper portion, is provided with a groove 82 surmounted by a head portion 84. The piston 52 is provided with a central bore 86 within which the sucker rod 54 is slidably mounted. Suitable packing means at 88 are provided for preventing leakage of oil

through the bore 86. Also slidably mounted on the sucker rod 54 is a cylindrical member 90 having a groove 92 at its lower end surmounted by a head 94. Suitable packing means at 96 are provided for preventing seepage through the central bore 98 of the member 90. The member 90 carries rigidly secured thereto the tubular tail rod 64 and has a shoulder 100 which is adapted to abut against the upper end of the casing member 58 to limit the maximum stroke of the piston 52.

Intermediate the members 52 and 90 there is provided a split clamp member 102 the two halves of which are secured together by bolts 104. The internal bore 106 of the member 102 is preferably slightly smaller than the diameter of the sucker rod 54 so that the member 102 may be securely clamped frictionally to the rod 54. The member 102 is provided with shouldered recesses 108 and 110 at its top and bottom ends which interfit with the grooves and heads 92-94 and 82-84, respectively, to provide a rigid connection in an axial direction between members 52, 102 and 90 while permitting some slight adjustment in a radial direction of each member relative to the other.

The hydraulic work cylinder mechanism is connected by means of a conduit 112 communicating with the connection 36 and a conduit 114 communicating with the connection 60 to a hydraulic power and counterbalancing unit generally designated 116. The latter may be remote from the well and is connected with the work cylinder mechanism solely by means of the conduits 112 and 114. The drain conduit 48 may also connect to the unit 116 which serves in addition as a reservoir for a supply of hydraulic power fluid.

Incorporated in the unit 116 is an air-loaded counter-balance mechanism generally designated 118 and comprising a closed cylinder 120 in which a confined body of air or other elastic fluid may be kept under a predetermined pressure. Conveniently the cylinder 120 may communicate through an open conduit 122 with a conveniently located air bottle 124 for the purpose of providing a larger volume of confined air than the cylinder 120 alone provides. The lower end of the cylinder 120 is provided with a closure wall 130 having a bore 132 through which a piston rod 134 extends. Suitable packing 136 is provided at one end of the bore 132. The rod 134 carries at its upper end a piston 138 reciprocable in the cylinder 120 and provides with the wall 130 a chamber 139 for hydraulic operating fluid which has a connection 140 for the inlet and outlet of such fluid.

At the lower end the rod 134 is provided with a second piston 142 forming with the wall 130 a second chamber 143 for operating fluid which has a connection 144 in the plate 130. Secured to the lower side of the plate 130 is a short cylinder 146 within which the piston 142 is reciprocable.

Referring now to Figure 3, the internal construction of the unit 116 is there illustrated diagrammatically with particular attention to the hydraulic circuits involved. It will be seen that the conduit 112 connects through the interior of the casing of unit 116 with the connection 140 in the plate 130. This connection is permanently open except for a shut-off valve 148 (Figure 1) outside the unit 116 which may be closed manually when the unit is shut down, as will later be described. During normal operation the valve 148 is open so that the chamber 38 at the lower end of the cylinder 50 is in permanently open com-

munication with the chamber 139 beneath piston 138. This circuit comprising the conduit 112 and the chambers 38 and 139 is hereinafter termed a secondary circuit, and it will be seen that the pressure within the lower end of cylinder 50 is transmitted through this circuit to the piston 138 and is counter-balanced by the air pressure in cylinder 120. Normally the pressure in cylinder 120 is maintained at a value such that it will counter-balance the full weight of the sucker rod string 54 plus a portion, preferably one-half, of the weight of the oil column carried on the upper side of the plunger 18 of the pump at the bottom of the well. A bypass conduit 150 (Figure 1) connects with the end of conduit 112 adjacent the cylinder 50 and is provided with a manual shut-off valve 152 which is normally closed and prevents escape of hydraulic operating fluid from the conduit 112 to the reservoir of unit 116. The valve 152 may be manually opened at such times it is desired to drain the oil from the lower end of cylinder 50.

The conduit 114 extends through a normally open shut-off valve 154 (Figure 1) to one port of a rotary piston pump of the reversible type and designated 156. From the other port of the pump 156 a conduit 158 extends to the connection 144 and to chamber 143. Thus there is provided a circuit, termed hereafter the power circuit, extending between the upper end of cylinder 50 and the chamber 143, the power circuit including the pump 156 in series therein. The pump 156 may be driven by a suitable electric motor 160 secured to the outside of the casing of unit 116 and having a belt drive connection 162 for operating a replenishing and supercharging pump unit generally designated 164. The pump 156 is of the type having a swinging yoke 166 which may be swung to either side of a neutral position in alignment with the axis of the pump shaft for reversing the direction of flow of fluid delivered by the pump 156.

The position of the yoke 166 is determined by means of a reversing motor generally designated 168 and comprising a pair of cylinders 170 and 172 in which a double-tapered piston 174 is reciprocable. The latter has a rod 176 connected by a link 178 to the yoke 166 and is adapted to swing the yoke between the two extreme positions illustrated in the drawing which are determined by means of adjustable stop screws 180. Shifting of the piston 174 is controlled by a pilot valve 182 of the customary four-way type adapted to selectively connect two ports 184 and 186 either with a pressure oil inlet 188 or with one of two tank outlets 190 and 192.

Conduits 184 and 186 lead to inlet ports 194 and 196 at the opposite ends of cylinders 170 and 172. Suitable check valves 198 and 200 permit free flow into the chambers but prevent return flow out through the ports 194 and 196. Ports 184 and 186 also communicate through fixed resistances 202 and 204 with ports 206 and 208 which also communicate with the opposite ends of chambers 170 and 172. The ports 184 and 186 further communicate with the chambers 170 and 172 through fixed restrictors 207 and 209 and through check valves 210 and 212 which open only to flow out of the respective cylinder chambers. This communication is established through ports 214 and 216 which are controlled by the tapered portions of piston 174 in such a manner that as the yoke 166 passes through neutral, both ports 214 and 216 are closed gradually and then reopened. Likewise, as the piston 174 reaches

either extreme position of its movement, one of the tapered sections gradually closes the corresponding port 214 or 216.

It will be seen that shifting of the pilot valve 182, for example, to the left into the position illustrated in Figure 3, admits pressure from port 188 to port 186 and through restriction 204 and check valve 200 freely into the chamber 172. Piston 174 is accordingly propelled to the left discharging oil through restriction 202 and check valve 210 and restriction 207 to port 184 and port 190 to tank. As the piston 174 passes through neutral position, port 214 is gradually closed thus forcing the oil discharging from chamber 170 to pass only through the restriction 202 and thus slowing down temporarily the speed of travel of the piston 174. As the latter passes beyond neutral position the port 214 is again opened up permitting increased speed of travel of the piston 174 until the latter reaches its extreme lefthand position, when the port 214 is again shut off. When the pilot valve 182 is shifted to the opposite position a similar cycle of movement takes place in the rightward direction.

The shifting of pilot valve 182 is controlled in response to movement of the piston rod 134 by means of a pair of tripping cams 218 and 220 which are carried by an extension 222 of the rod 134. These cams are of a conical shape and are adapted to rock a lever 224 clockwise and counterclockwise at the lower and upper extremes of movement of the piston rod 134. The rocking lever 224 is connected by a link 226 to the operating stem of pilot valve 182. The cam 218 may be formed integrally with a rod 228 which is pivotally secured to the extension 222. The upper portion of the rod 228 is screw threaded and carries the cam 220 threaded thereon. The latter has an extension 230 provided with a perforation so that it may slide upon a stationary pin 232 secured by a bracket 234 to the lower end of cylinder 146. The lower end of the rod 228 is provided with splines at 236 and carries slidably mounted upon the splines a bevel gear 238. The latter is positioned between the two arms of a stationary support 240 so as to prevent vertical movement of the gear 238. A meshing bevel gear 242 is carried by a shaft 244 mounted in one wall of the casing of unit 116. The rod 244 has a squared head and suitable lock nuts 246 whereby the latter may be manually adjusted to drive the bevel gearing 242 and 238 and may be locked in any adjusted position. Thus it will be seen that by rotating the shaft 244 from outside the unit 116 the shaft 228 may be rotated to screw the cam 220 up or down upon the shaft 228 and thus determine the upper limit of stroke of the piston rod 134 by determining the point in such stroke at which the cam 220 trips the rocking lever 224 to shift the pilot valve 182 to the right.

Fluid for operating the pump reversing motor 168 is supplied by a supercharging pump 248 which forms one unit of the pump 164. The pump 248 may be of the well-known rotary vane type having a constant displacement and is provided with a suction conduit 250 and a delivery conduit 252. The latter extends through a check valve 254 to an accumulator unit 256. The accumulator comprises a cylindrical chamber 258 in which a piston 260 is reciprocably mounted. Suitable springs 262 urge the piston 260 inwardly in the cylinder 258. Beyond the check valve 254 a restricted inlet 264 is provided from the conduit 252 to the cylinder 258. In addition an outlet conduit 266 is provided having a check

valve 268 open to free flow out of the cylinder 258. The conduit 266 extends to the inlet connection 188 of the valve 182. Thus the accumulator 256 maintains a reserve volume of operating fluid for shifting the piston 174 at a greater rate than would be possible by utilizing merely the normal discharge volume of the pump 248.

The pump 248 is provided with an integrally mounted relief valve 270 which receives oil delivered by the pump 248 in excess of the volume taken by the conduit 252 and bypasses such excess through the relief valve to a conduit 272. The conduit 272 leads to one port of a relief valve 274 which provides free communication between conduit 272 and a second conduit 276. The relief valve 274 is adapted to bypass any excess oil to the tank through a conduit 278 whenever a predetermined pressure in conduits 272 and 276 is exceeded. The relief valves 270 and 274 may be similar to that disclosed in the patent to Harry F. Vickers, 2,043,453.

The conduit 276 leads to a shuttle valve 284 which communicates by means of branch conduits 286 and 288 with the conduits 114 and 158. The shuttle valve is arranged in the well-known manner to shift in response to pressure in one of the conduits 286 or 288 so as to connect the other conduit with the conduit 276 and thus admit supercharging oil from the conduit 276 to whichever of the conduits 114 or 158 happens to be the low pressure conduit at any given time. The conduits 114 and 158 may be connected by means of branch conduits 290 and 292 with customary relief valves 294 and 296 and with check valves 298 and 300 for the purpose of admitting oil to charge the system before initially operating the same.

A bypass including a hand-operated shut-off valve 302 connects between the conduits 290 and 292 and provides a means whereby the pumping unit may be stopped and started while the motor 160 continues to run. The bypass valve 302 further provides a means for warming up the oil when starting in cold weather by setting the valve at a partial opening and causing the energy of the pump 156 to be dissipated as heat through the throttling action at valve 302.

The replenishing and supercharging unit 164 also includes a small plunger pump 304 which takes oil from conduit 252 and delivers it through a conduit 306 to the secondary circuit 112. This pump delivers oil constantly into the secondary circuit as long as the electric motor is running, but the quantity thus delivered may be very small so long as it is slightly greater than the maximum leakage out of the secondary circuit.

In operation, with the system filled with oil and with the motor 160 running, when bypass valve 302 is open, as shown in Figure 3, the pump 156 delivers oil against negligible resistance through conduit 290, valve 302 and conduit 292 back to the pump inlet. With the parts in the position shown in the drawing and with valve 302 closed, this bypass path is closed and the pump delivery is directed through conduit 114 to the upper end of cylinder 50. The pump 156 withdraws oil for this purpose from the chamber 143 through connection 144 and conduit 158, thus effectively transferring oil from chamber 143 to the upper end of cylinder 50. The piston 52 accordingly moves downwardly discharging oil from the lower end of cylinder 50 through connection 36 and conduit 112 to chamber 139.

During this stroke the weight of the column of well fluid is supported on the check valve 16 at the bottom of the well. The air pressure in cylinder

120 being somewhat higher than the pressure required to support the weight of the sucker rod string 54, it follows that the work which must be done by the pump 156 on this stroke is the work required to move the piston 138 upwardly against the excess pressure in cylinder 120 over and above the pressure which balances the weight of the sucker rod 54.

During the downward stroke the pump 248 is delivering oil through conduit 252 and check valve 254 and resistance 264 to the cylinder chamber 258 of accumulator 256. When the latter becomes filled the delivery of pump 248 bypasses over the relief valve 270 and through conduits 272 and 276 to the shuttle valve 284 where it is distributed through conduit 288 to the suction conduit 158 of pump 156. The relief valve 274 acts to limit the pressure available in this conduit, and any excess oil above that required to keep the suction circuit of pump 156 completely filled is discharged to tank through conduit 278.

Likewise the replenishing plunger pump 304 delivers a predetermined quantity of oil continuously through the conduit 306 to the secondary circuit 112. This quantity is rather small, but, nevertheless, causes the piston 138 to complete its upward stroke somewhat sooner than the piston 52 completes its downward stroke.

When the piston rod 134 has moved upwardly sufficiently so that the cam 220 contacts the rocking lever 224, the latter is shifted as is the pilot valve 182 thus transferring the pressure inlet 198 to the port 184 and connecting port 186 to the tank conduit 192. Piston 174 accordingly shifts to the right as previously described, slowing down near neutral position and continuing on to increase the stroke of the pump 156 in the opposite direction to that previously maintained. The delivery of oil through the power circuit 114-158 is accordingly reversed so that oil is withdrawn from the upper end of cylinder 50 and delivered into chamber 143. Thus the piston 52 and sucker rod string 54 move upwardly while the pistons 138 and 142 move downwardly. During this stroke the excess pressure in cylinder 120 above that required to counterbalance the weight of the rod 54 assists the pump 156 and reduces the amount of work otherwise required to lift the entire column of well fluid carried by the check valve 22 and plunger 18.

As the piston 52 approaches the top of its stroke the cam surface 76 contacts lever 68 shifting the levers 70 and 46 and opening the bypass valve 44, thus exhausting oil from the secondary circuit 112. The piston 52 accordingly stops its upward movement somewhat before the pistons 138 and 142 complete their downward stroke, due to the action of replenishing pump 304 so that the pistons 138 and 142 continue downwardly a short distance until cam 218 contacts lever 224 to shift the parts into the position shown in Figure 3.

During this interval when piston 52 has stopped and before piston 142 reaches its lower limit of stroke, the pump 156 withdraws oil from the tank through conduit 290 and check valve 298, since the normal rate of delivery of pump 248 is insufficient to supply the full volume of requirements of pump 156. Thus, at this point in each stroke of the mechanism the relative positions of the two pistons 52 and 142 are synchronized. The replenishing pump 304 insures by constantly delivering a small quantity of oil into the secondary circuit 112 that the piston 52 will be ahead of the piston 142, that is, it will reach its upper limit of stroke before the latter

reaches its lower limit. The by-pass valve 44 stops the piston 52 when it reaches the upper limit, and the piston 142 continues downwardly until the cam 218 contacts the lever 224 and reverses pump 156 in the manner previously described. The cycle is again repeated and so on continuously as long as the by-pass valve 302 remains closed.

In installing a pump in a new well with a new set of sucker rods, it is found that the sucker rods take a permanent stretch over a period of several months, and if, when the pump is initially installed, the sucker rod length is adjusted so that the pump plunger 12 has a small clearance above the standing valve 16, that the rods soon stretch to the point where the plunger is bottoming on the valve 16 at each stroke. Such bottoming is easily detected by workers familiar with the operation of such wells, and by the present construction adjustment can be readily made to prevent such contact while maintaining also a minimum clearance in the pumping chamber. Thus when it is found that the rod has stretched sufficiently to contact the standing valve, the stroke of piston 52 may be adjusted by means of the screw shaft 244 which adjusts the position of cam 220 with respect to the piston 142. In this way the upper limit of stroke of piston 142 may be moved downwardly, so to speak, by moving the cam 220 upwardly.

Since the stroke of piston 52 is synchronized with that of piston 142 at the top of the stroke of the latter, it follows that by dropping the upper limit of stroke of piston 142 the lower limit of stroke of piston 52 is correspondingly raised while the upper limit thereof remains fixed. In this way small adjustments can be made from time to time to compensate for permanent stretch of the sucker rods by merely giving the shaft 244 a partial turn or more. This adjustment may be made while the entire weight of the sucker rods is supported hydraulically by the piston 52 and without disassembly of any of the parts of the apparatus and, in fact, may even be made while the pump unit is in continuous operation.

It will be noted, of course, that as each such adjustment is made the total stroke of the piston 52 is shortened, and since it is desirable to maintain as long a stroke as possible, it is found expedient, after a certain amount of the sucker rod stretch has been taken up by adjusting the rod 244, to take time to adjust the piston 52 on the sucker rod 54 so as to again utilize the full stroke capacity of the hydraulic pumping apparatus. When the stroke has been sufficiently shortened to justify making such an adjustment, the apparatus may be shut down with the piston 52 preferably at or near the top of its stroke. The sucker rod may then be clamped to the casing by tightening up the screws 32, and after this is done the shut-off valve 148 may be closed and the by-pass valve 152 opened to relieve the oil under pressure beneath the piston 52. Thus the weight of the sucker rod string is transferred from the piston 52 to the clamp 30.

The upper structure of the pumping cylinder may then be disassembled by removing the closure tube 66 and the end casting 58 after which the cylinder tube 50 may be lifted upwardly off from the piston 52. A suitable chain fall or other hoisting mechanism may then be attached to the upper end of tube 64 to support the latter and the piston 52 against falling downwardly on the sucker rod 54. The clamp member 102 may then be loosened on the sucker rod 54, and the entire

piston and tail rod assembly may be lowered on the sucker rod by an amount which is considered sufficient to enable the full stroke capacity of the pump unit to be utilized. It will be noted that, during the time the clamp 102 is loosened, the tail rod assembly is connected with the piston independently of the sucker rod by means of the grooves 82 and 92 coacting with the heads 84 and 94. The clamp 102 may be again tightened and the apparatus reassembled.

Thereafter, with the valves 148 and 152 again opened and closed, respectively, with the adjusting rod 244 restored to its original position, and with the clamp 30 again loosened, the apparatus may be started as previously described and its operation continued.

The oil which was discharged from the secondary circuit through the by-pass valve 152 may be replenished by operating the motor 160 and leaving the by-pass valve 302 open for an interval sufficient to fill the secondary circuit.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a hydraulic pumping system for an oil well having a sucker rod string extending to the top of the well, the combination of hydraulic work ram means connected to the sucker rod string, hydro-pneumatic counterbalancing means, a closed coupling circuit connecting the counterbalancing means in free communication with the work ram means, a power circuit operatively connected with at least one of said means, distinct from the coupling circuit and including a pressure generating means arranged to cause displacement of fluid in either direction through the power circuit, means for reversing the flow of fluid delivered in the power circuit by the pressure generating means and responsive to the volume of fluid displaced into or out of the counterbalancing means, said reversing means being adjustable to vary one limit of such volume, replenishing means for the secondary circuit, and valve means controlled by the work ram means at one limit of its stroke for controlling the replenishing means to keep said one limit of its stroke at a substantially fixed point whereby the other limit thereof may be determined by adjustment of said reversing means.

2. In a hydraulic pumping system for an oil well having a sucker rod string extending to the top of the well, the combination of a hydraulic motor comprising a cylinder supported at the top of the well, a piston reciprocable in the cylinder and having a central bore, clamping means above the piston engageable with the sucker rod and supporting the weight thereof on the piston for securing the latter to the sucker rod in various longitudinal positions of adjustment, a tubular tail rod surrounding the sucker rod above the clamping means, means associated with the clamping means for connecting the tail rod with the piston independently of the sucker rod, and means forming a fluid-tight enclosure at the upper end of the cylinder and engaging said tail rod with a sealing fit, said last means extending above the cylinder and being removable to expose the clamping means while leaving the piston in the cylinder.

3. In a hydraulic pumping system for an oil well having a sucker rod string extending to the top of the well, the combination of double-acting

hydraulic work ram means connected to the sucker rod, means for counterbalancing the sucker rod weight plus a portion of the producing oil column weight, said counterbalancing means comprising three expansible chambers, piston means interconnected with each other to place the fluid pressure in two of said chambers in opposition to the fluid pressure in the third chamber, a body of elastic fluid confined under pressure and communicating with one of said two chambers, a working circuit including reversible pressure generating means connecting one side of the work ram means with the other of said two chambers, and a secondary circuit connecting the other side of the work ram means with the third chamber.

4. In a hydraulic pumping system for an oil well having a sucker rod string extending to the

top of the well, the combination of hydraulic work ram means connected to the sucker rod string, air-loaded hydraulic counterbalancing means including a pressure chamber having a piston therein, a closed coupling circuit connecting said piston with the work ram means, pressure generating means effective to deliver fluid alternately in either direction, and means forming a power circuit isolated from the coupling circuit and including said generating means, said power circuit including oppositely acting ram areas, one of which is mechanically connected to said piston to displace fluid in the coupling circuit.

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