Jan. 16, 1945. H. F. VICKERS ET AL 2,367,248

OIL WELL PUMPING MACHINERY

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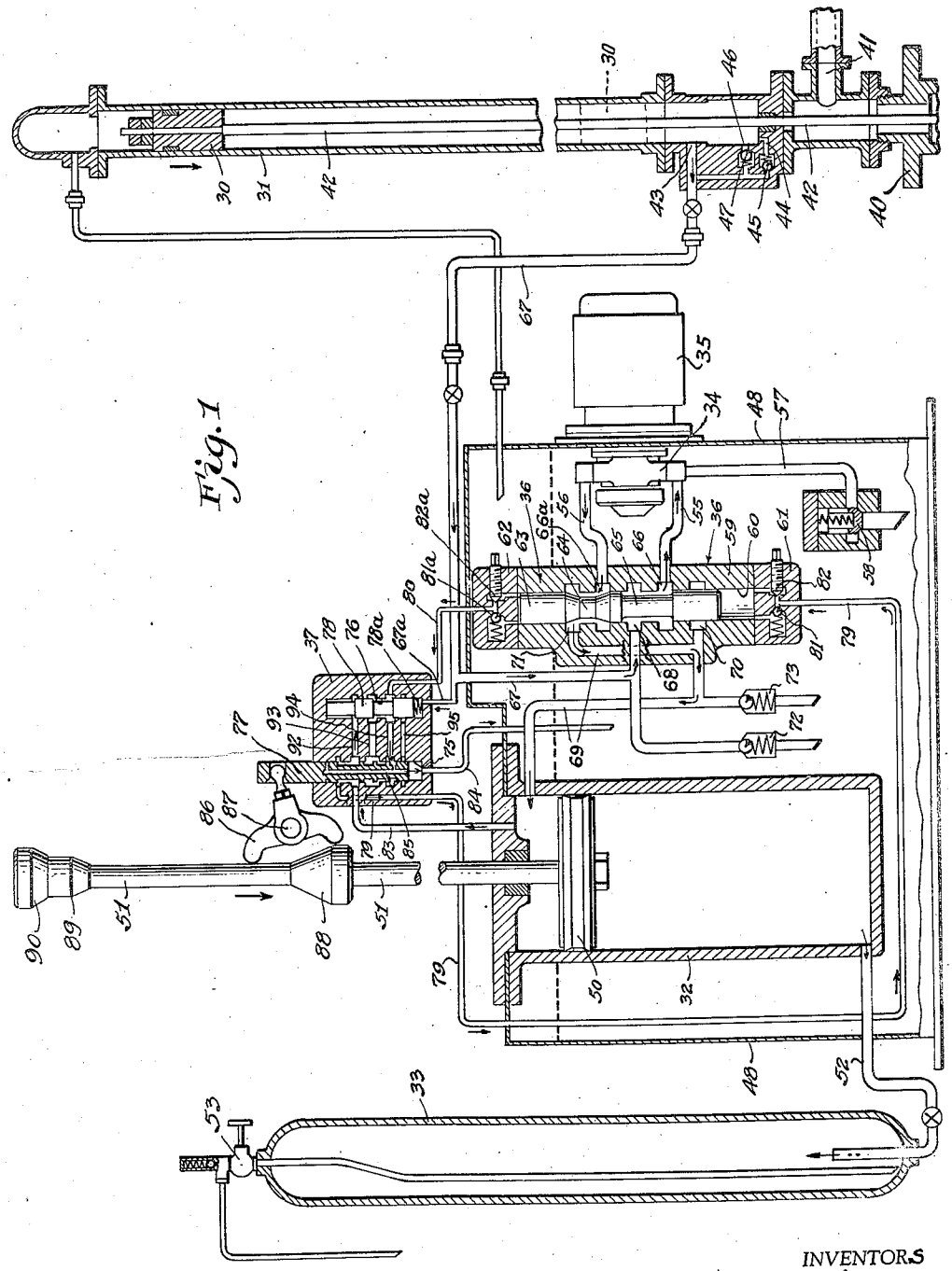


Fig. 1

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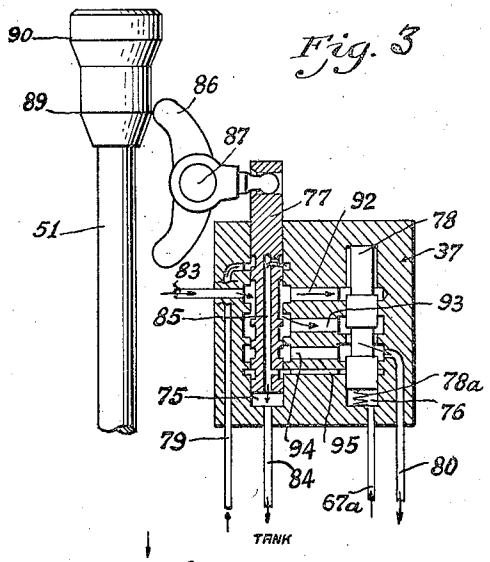


Fig. 3

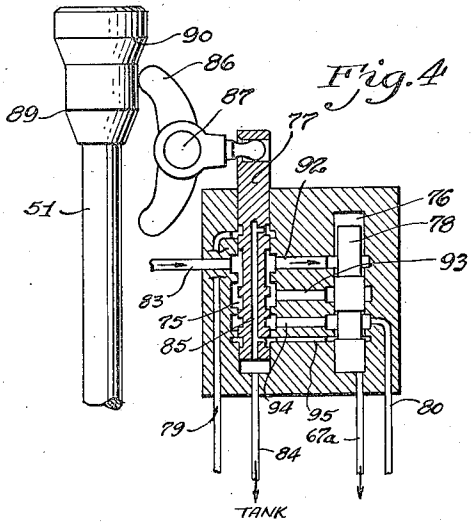


Fig. 4

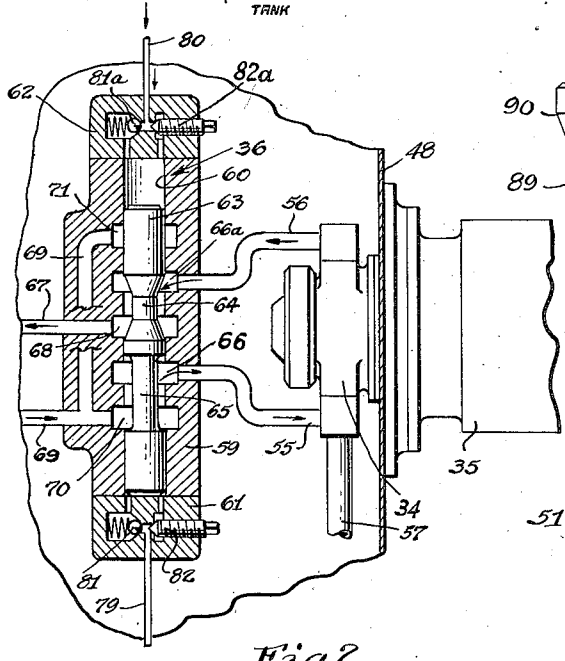


Fig. 2

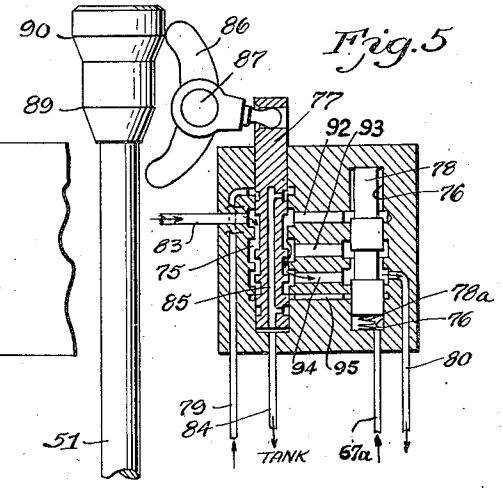


Fig. 5

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OIL WELL PUMPING MACHINERY

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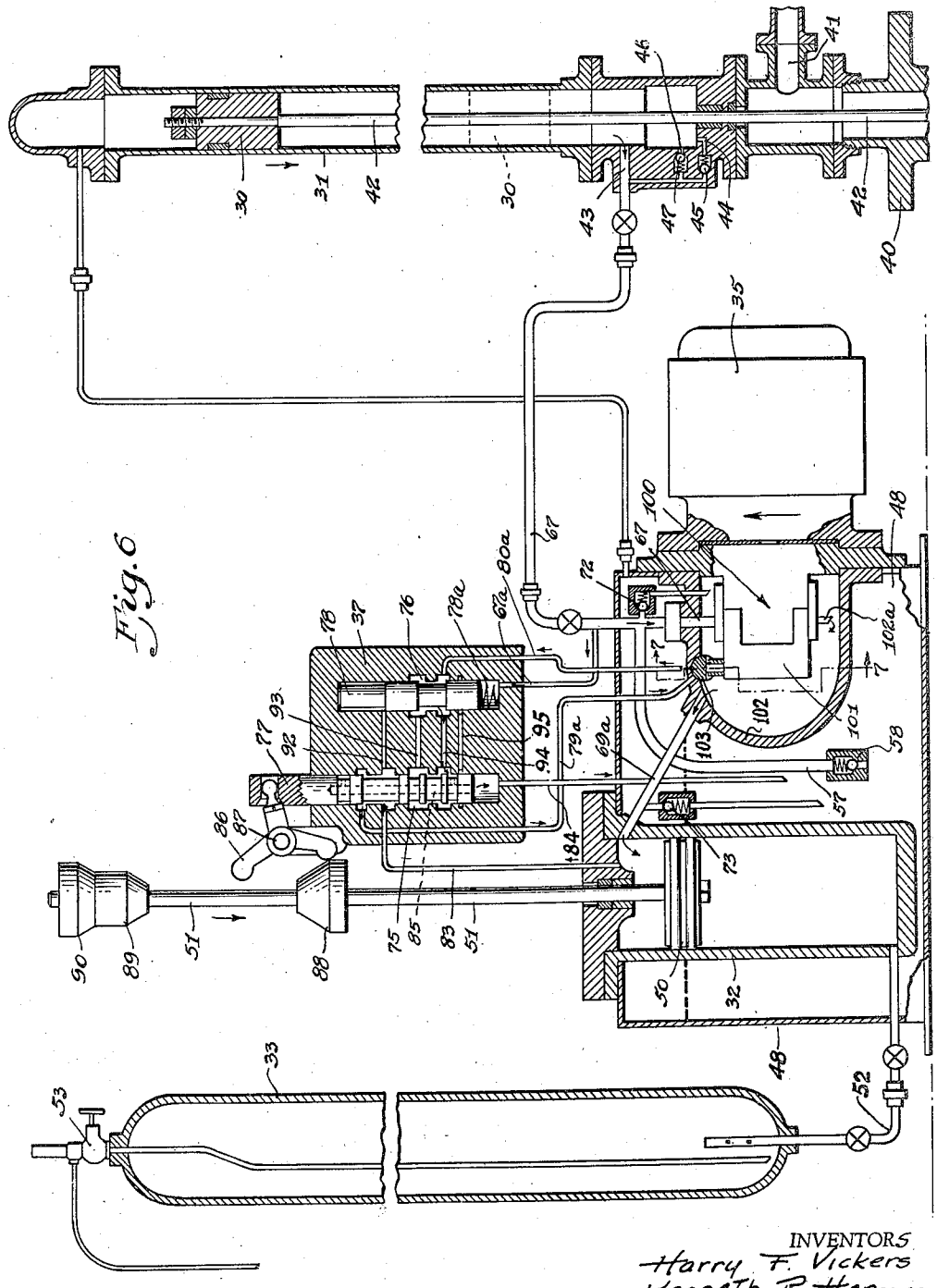


Fig. 6

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OIL WELL PUMPING MACHINERY

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Fig. 8

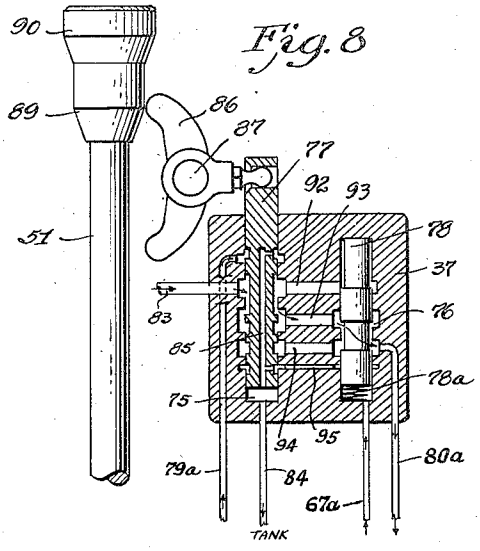
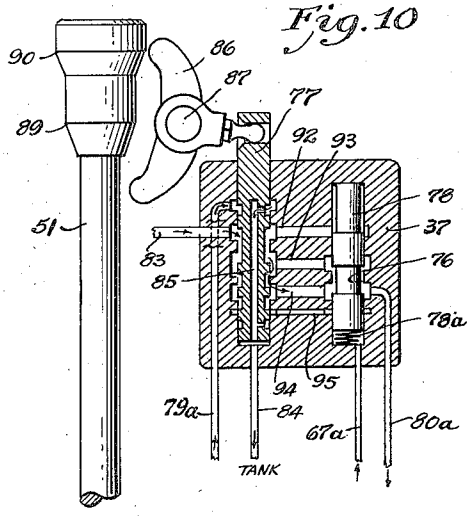


Fig. 10



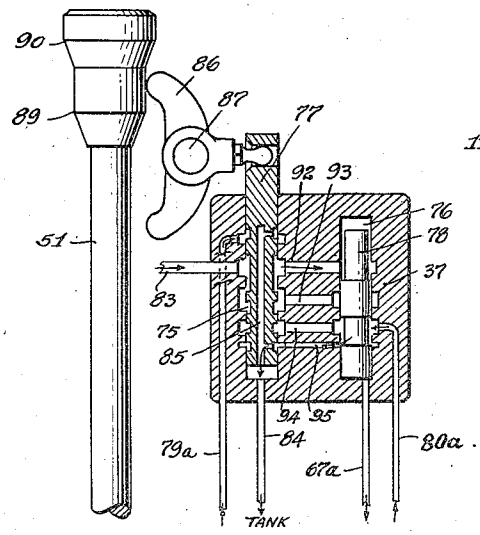


Fig. 9

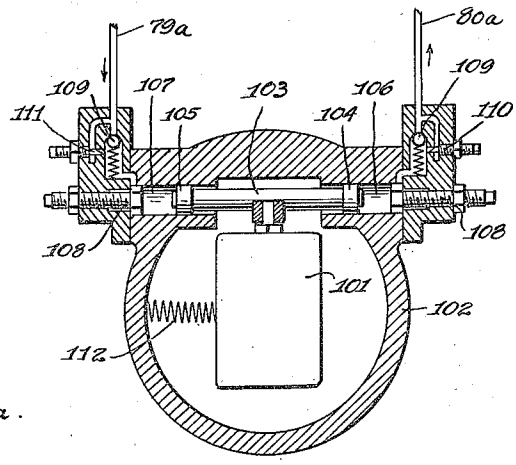


Fig. 7

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OIL WELL PUMPING MACHINERY

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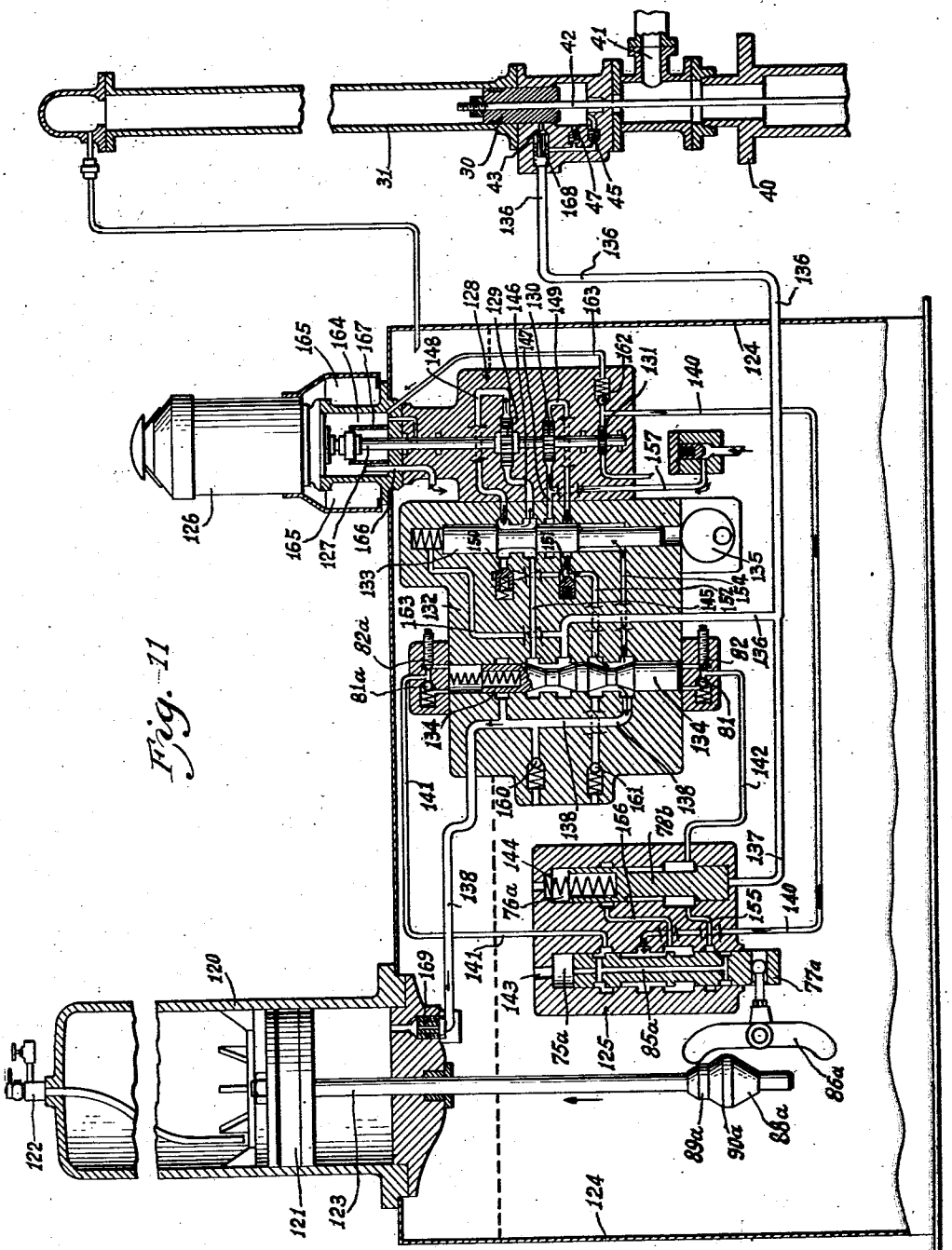


Fig. 11

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OIL WELL PUMPING MACHINERY

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Fig. 12

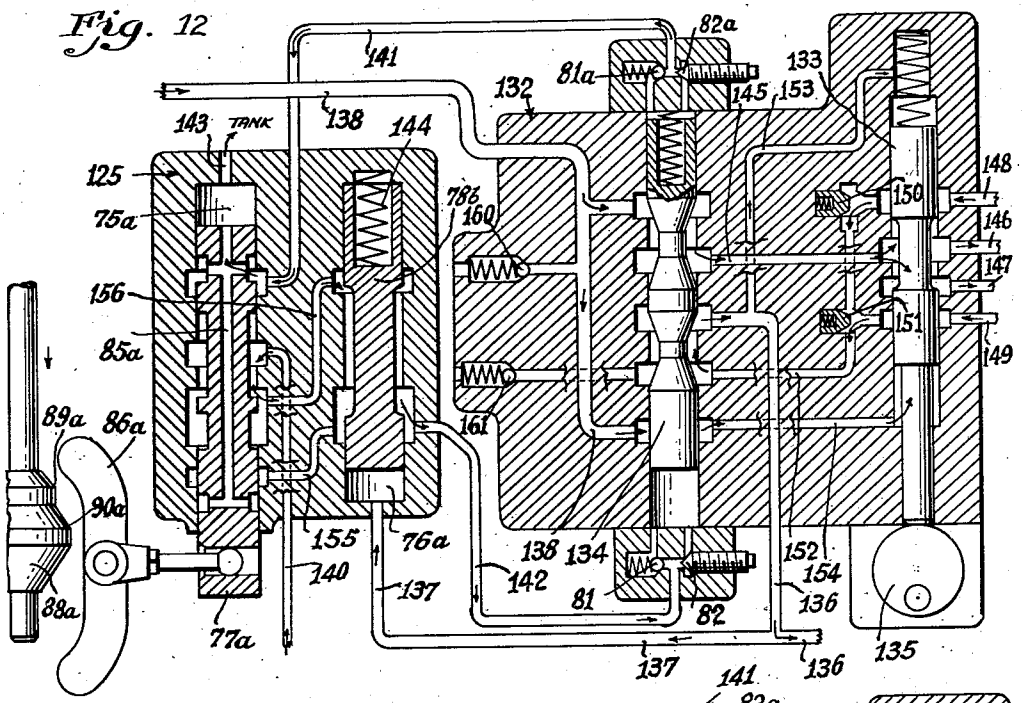
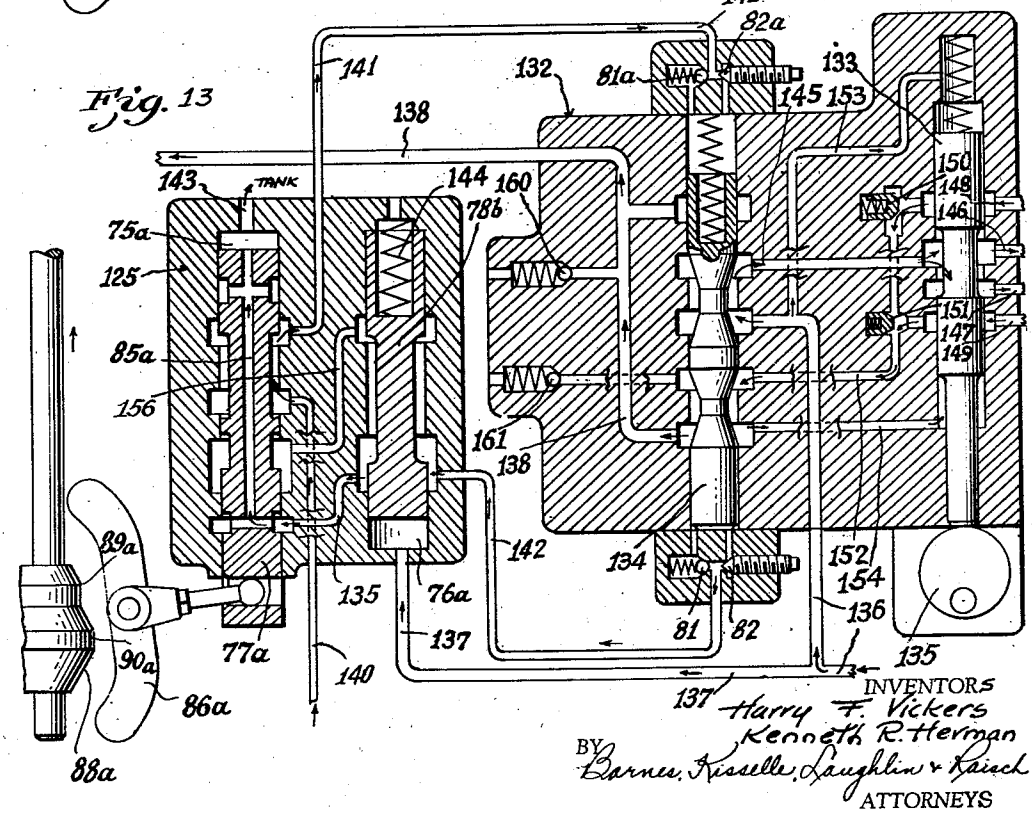


Fig. 13



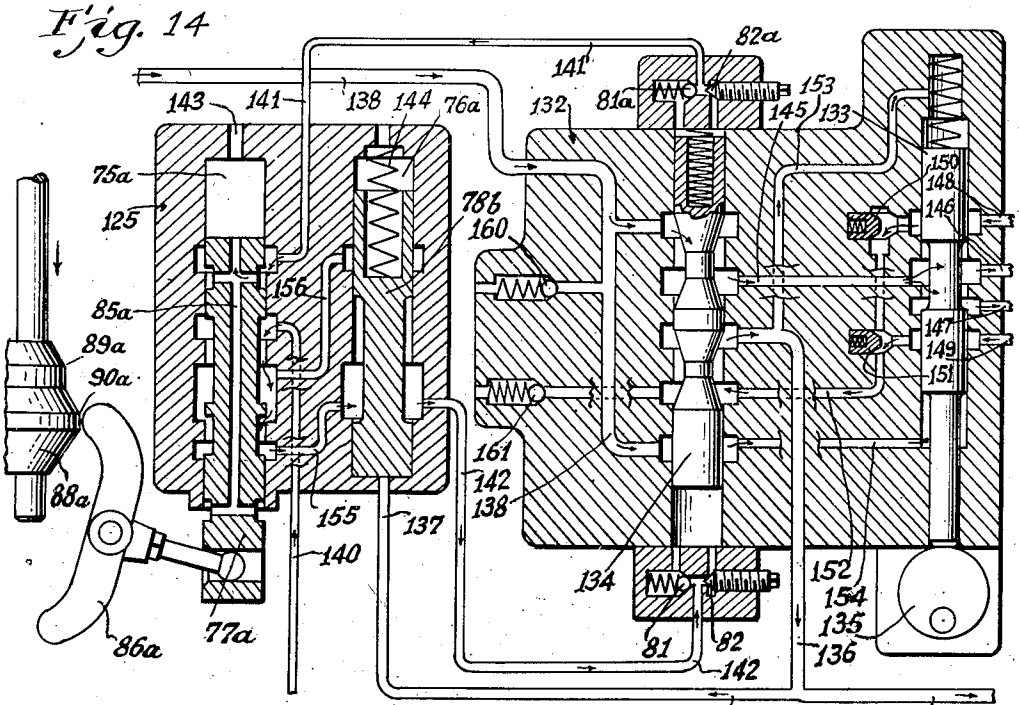
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OIL WELL PUMPING MACHINERY

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Fig. 14



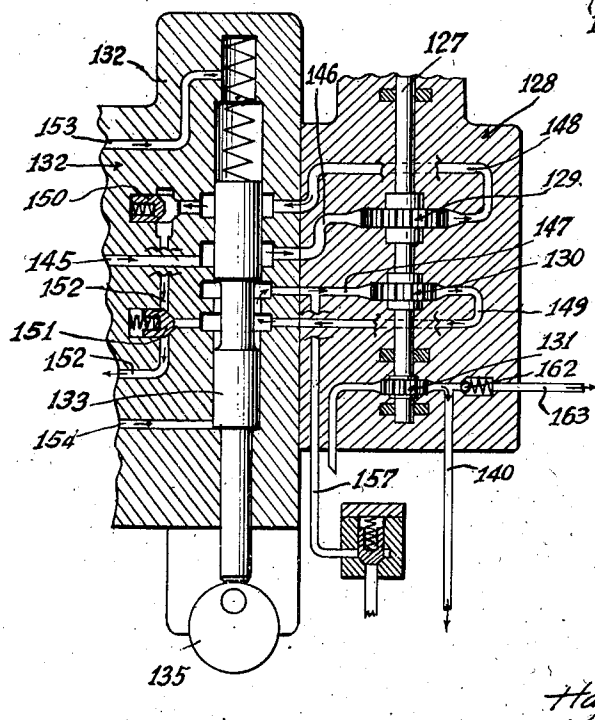


Fig. 15

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OIL WELL PUMPING MACHINERY

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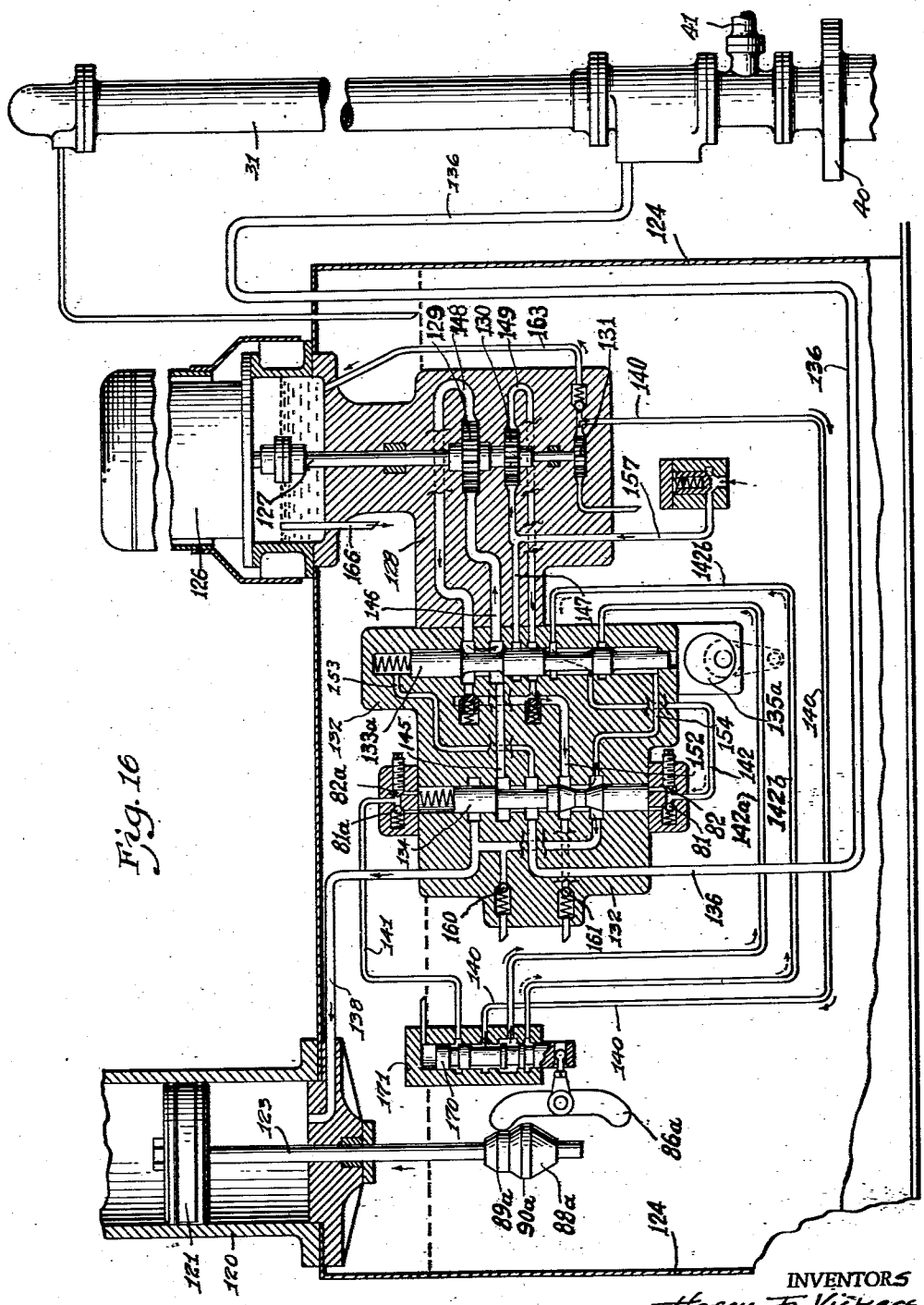


Fig. 16

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OIL WELL PUMPING MACHINERY

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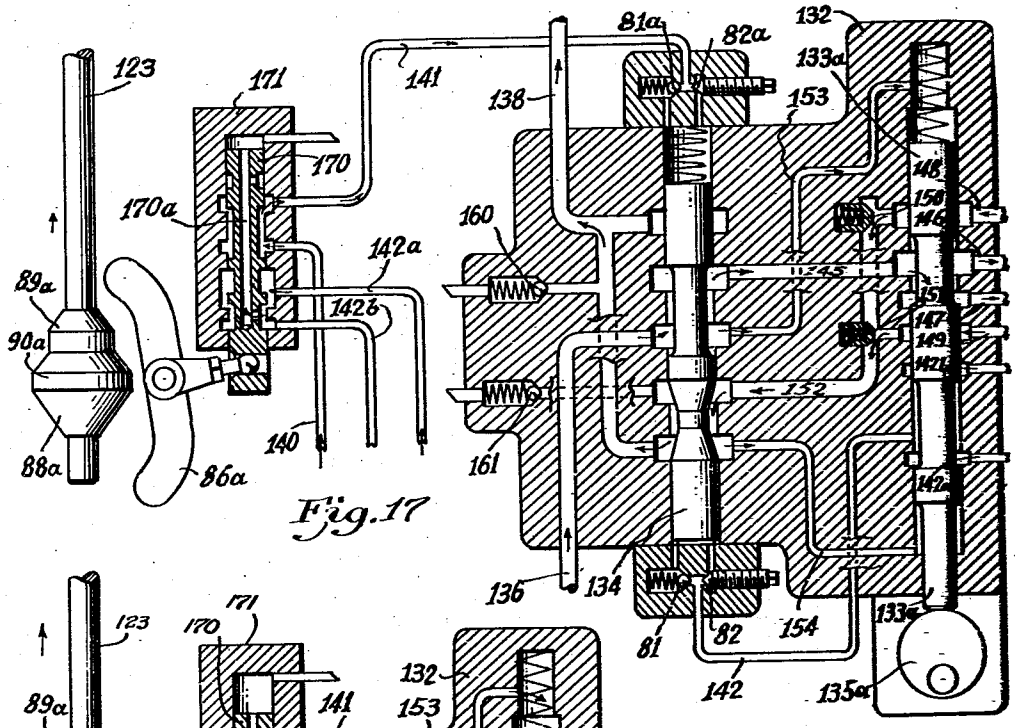


Fig. 17

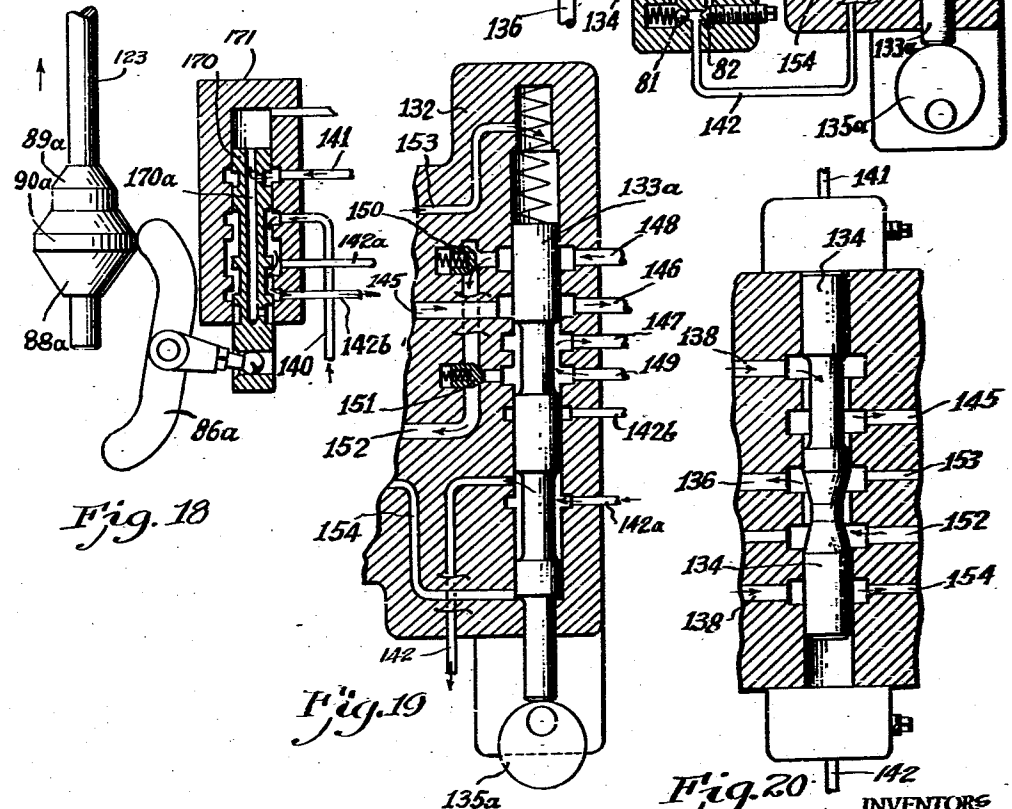


Fig. 18

Fig. 19

Fig. 20

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UNITED STATES PATENT OFFICE

2,367,248

OIL WELL PUMPING MACHINERY

Harry F. Vickers and Kenneth R. Herman, Detroit, Mich., assignors to Vickers, Incorporated, Detroit, Mich., a corporation of Michigan

Application June 29, 1939, Serial No. 281,926

22 Claims. (Cl. 60—52)

The present invention relates to oil well pumping machinery.

It is common in the design of oil well machinery to provide a reciprocating member and cylinder therefor positioned directly over the well so that the sucker rod of the well may be connected directly to the reciprocal member. Liquid under pressure is directed to a cylinder to raise the member and, in many cases, during the lowering stroke of the reciprocal member, the liquid is directed from the pumping cylinder to an accumulator cylinder in which a fluid is compressed or a weight lifted so that energy is stored as a result of the downstroke of the pumping element. Later on the upstroke of the pumping element this stored energy may be utilized to aid a pressure forming member in directing liquid under pressure to the reciprocal pumping element.

According to the present invention a pressure forming means is located between the pumping cylinder and the storage cylinder, which may be called an accumulator cylinder, and a means is provided to control the flow of liquid from one of the cylinders to the other in either direction, the flow in each case being through the pressure forming means. In this way there is a substantially closed system between the two cylinders. However, due to inevitable leakage in the system, it is necessary to provide a means for replenishing the system at certain points in the reciprocal movement of the pumping element.

An object of the present invention is to provide a mechanism which is responsive to the movement of a reciprocal member either in the pumping cylinder or the accumulator cylinder or both which will permit the operating liquid to be taken by the pressure forming means from an independent supply and injected into the closed system to replenish the supply of operating liquid. This replenishing apparatus is intended to operate automatically and is responsive to the quantity of liquid in the system.

Because of the extremely heavy loads which are applied to the reciprocal pumping member and because of the resulting high pressure which must be used to move the member, it is necessary that some means be provided to cause the proper acceleration and deceleration of movement of the pumping member. Sudden movements of the reciprocal pumping member are to be avoided.

A further object of the invention is to provide a means for controlling this rate of acceleration or deceleration so that the strain on the sucker rods to the pump will be at a minimum at all times. The invention contemplates also a novel valve arrangement adapted to effect normal reversal of the system and to effect a delayed reversal during a replenishing cycle, this reversal being delayed automatically.

Another object of the invention has to do with the provision of a means for changing the operating speed of the reciprocal pumping element. A further object of the invention has to do with a pressure forming means formed of a plurality of pumps, one of which may be used for pilot pressure and others of which may be used singly or jointly to furnish pressure to the system whereby the speed of the system may be varied.

Means is also provided for cooling the operating liquid used in the system. Other objects of the invention having to do with various embodiments and details of construction and operation thereof, will be further brought out in the following description and claims.

In the drawings:

Fig. 1 is an illustration, partially diagrammatic and partially in section, of one oil well circuit embodying the present invention.

Fig. 2 is a view of a portion of Fig. 1 showing a valve in a shifted position.

Figs. 3, 4 and 5 are additional views of a portion of Fig. 1 showing the parts in different relative positions.

Fig. 6 is an illustration of a second oil well circuit in which a variable displacement pump is used.

Fig. 7 is a section taken on the lines 7—7 of Fig. 6.

Figs. 8, 9 and 10 are additional views of a portion of Fig. 6 showing the parts in different relative positions.

Fig. 11 is a sectional view of a third circuit in which a plurality of pumps are used.

Figs. 12, 13, 14 and 15 are additional views of portions of Fig. 11 showing the parts in different relative positions.

Fig. 16 is an illustration of a modification of the circuit shown in Fig. 11.

Figs. 17, 18, 19 and 20 illustrate portions of the circuit of Fig. 16 showing the relationship of the parts in different positions.

In Fig. 1 the simplest of the circuits embodying the invention is illustrated. The main elements of the circuit consist of a piston-cylinder motor 30—31, an accumulator tank 32, an air flask 33, a pump 34 driven by a motor 35, a

directional control valve 36, and an auxiliary control valve block 37.

The piston-cylinder motor 30—31 is an upright type of motor mounted on a casing 40 directly above an oil well (not shown). The top part of the casing 40 has an outlet 41 from which the oil from the well will flow. The lower part of the cylinder 31 is sealed and a polish rod 42 passes upwardly from the housing 40 through the lower part of the cylinder 31 to the piston 30 where it is fastened. The lower part of the cylinder 31 is provided with a main entrance port 43. A supplementary entrance port 44 leads from the port 43 to the bottom of the cylinder 31 and a check valve 45 permits passage to the cylinder only. A port 46, normally closed by a relief check valve 47, permits fluid to flow from the bottom of the cylinder 31 to the port 43.

A tank 48 is provided to contain a supply of operating liquid and to facilitate the mounting of certain of the elements of the combination. The accumulator 32 consists of a vertical cylinder supported at the top by the tank 48. Within the accumulator 32 is a piston 50 which is connected to a vertical piston rod 51 passing through the top of the accumulator cylinder. A conduit 52 connects the lower part of the accumulator 32 with the lower end of the air flask 33 which consists of a vertically positioned cylinder. The air flask is provided with a blow-off cock and an air filler valve 53.

The pump 34, which is a positive displacement vane type pump, is mounted on the inside of a wall of the tank 48 and the motor 35 is mounted on the outside of the tank. Pump 34 has a main inlet conduit 55 and an outlet conduit 56. A supplementary inlet conduit 57 is provided and a check valve 58 normally keeps this supplementary conduit closed.

Also within the tank 48 is the directional control valve 38 which consists of a housing 59 provided with an axial recess 60, each end of which is closed by caps 61 and 62, respectively. Within the recess 60 is a slide valve 63 which is adapted to be pilot operated within the recess and which is provided with narrowed portions 64 and 65. The recess of the directional control valve is provided with ports 66 and 66*a* which are connected respectively with conduits 55 and 56, leading to and from the pump 34. A conduit 67 connects the ports 43 and 44 in the cylinder 31 with a port 68 in the valve recess 60. A conduit 69 connects the top of the accumulator 32 with ports 70 and 71 formed in the recess 60. Relief valves 72 and 73 are provided in conduits 67 and 69 to prevent excessive pressures from developing.

Referring now to the valve block 37, this block is provided with two parallel cylindrical recesses 75 and 76 in which is located, respectively, a cam actuated valve 77 and a pressure operated valve 78. The valve 63 is pilot operated and the pressure for operating this valve is controlled by the valves 77 and 78 in the valve block 37. A conduit 79 leads from the valve recess 75 to the end cap 61 on valve housing 59 and a conduit 80 leads from valve recess 76 to end cap 62. Each end cap 61 and 62 is provided with a check valve 81 and 81*a* so that pressure may flow freely into the axial recess 60. Each end housing is also provided with a needle valve 82 and 82*a* arranged so that liquid passing from the recess 60 to either conduit 79 or 80 will be restricted in its flow. Pilot pressure is furnished to valve recess 75 by a conduit 83 which leads from the top of the accumulator cylinder 32. A tank conduit 84 is also connected to the valve recess 75 and the valve 77 is provided with an axial passageway 85 which opens to the tank conduit 84. A conduit 67*a* connects the conduit 67 with the lower end of the valve recess 76 in valve block 37. A spring 78*a* urges the valve 78 to an upward position, as shown in Fig. 1.

The valve 77 in the valve block 37 is to be actuated by a bell crank 86 which is pivoted at 87. The piston rod 51 is provided with cams 88 and 89 which are adapted to shift the valve 77 to reverse the system at each end of the stroke of the pistons 30 and 50. An additional cam 90 is provided directly above the cam 89 to effect a delayed reversal after the operating liquid in the system has been replenished. Each of the valve recesses 75 and 76 is provided with spaced enlarged ports and these recesses are connected by passageways, the functions of which will appear as the operation of the circuit is described.

Referring now to the operation of the circuit just described, as the parts are shown in Fig. 1, the bell crank 86 has just been shifted so that piston 30 and piston rod 51 are each starting a downward stroke. When the system is first started, of course, the air flask 33 will be charged with a predetermined pressure of air and the operating lines must be filled with oil before operation will start. As shown by the arrows on the drawings, pressure is being furnished from the top of the accumulator 32 through conduit 83 and past a restricted portion of the valve 77 to the conduit 79. This conduit 79 leads to the bottom of directional control valve housing 59 so that the directional valve 63 is shifted upwardly, as shown. With valve 63 in this position, continuously operating pump 34 receives liquid from cylinder 31 through port 43, conduit 67, ports 68 and 66 in valve housing 59, and inlet conduit 55. This liquid being received by the pump is under pressure because of the fact that the weight of the sucker rods on the polish rod 42 is being exerted on the operating liquid in the cylinder 31. This liquid passes through pump 34 and to the accumulator cylinder 32 through outlet conduit 56, ports 66*a* and 71 in housing 59, and conduit 69. At this time, since there is pressure in conduit 67, there will be pressure in conduit 67*a* exerted against the lower portion of valve 78 and there is also pressure on the top of valve 78 from conduit 83 and cross passageway 92 in valve block 37.

During normal operation the valves will remain in the position shown in Fig. 1 until the piston 30 has reached a lower position shown by the dotted lines and until the piston rod 51 has reached a position illustrated in Fig. 3. In this position, it will be seen that the cam 89 has acted on the bell crank 86 to shift the valve 77 to a new position. In this new position the conduit 83 is blocked from the conduit 79 but is connected to the conduit 80 past restrictions in valves 77 and 78 and through a cross passageway 93 in valve block 37. Pressure through conduit 80 will be exerted on top of the valve 63 to shift it downwardly. Liquid from the lower portion of the recess 60 will flow past the restriction needle valve 82 into the conduit 79, this conduit being connected to the tank at this time through the axial passageway 85 in valve 77 and the conduit 84.

The pressure on the top of valve 63 exerted from conduit 80 will shift the valve to the posi-

tion shown in Fig. 2. As the valve 63 is shifted, the tapered portion above the restricted portion 64 on the valve, gradually cuts off the outlet conduit 56 from conduit 69 leading to the accumulator. At the same time the tapered portion below the restriction 64 gradually opens the conduit 56 to conduit 67. Meanwhile, the shifting of the valve has cut off the conduit 67 from the conduit 55 and opened the conduit 69 to the conduit 55. The rate of movement of this change can be positively controlled by regulation of needle valve 82. With the valve 63 in the position shown in Fig. 2, the outlet of the pump will be connected to the cylinder 31 and the accumulator cylinder 32 will be connected to the inlet of the pump so that the flow of liquid is reversed in the system and the pressure from the otulet of the pump is exerted on the piston 30 to raise the same.

In any hydraulic system there is inevitable leakage especially when the system is operating under the high pressures which are necessary when pumping oil from deep wells. The present circuit provides a means for replenishing the operating liquid which normally circulates back and forth between the cylinder 31 and the cylinder 32 in a closed system. In the present circuit the leakage in the system would be directly evidenced by the lowermost position of piston 30 since any decrease in the quantity of operating liquid in the system would permit the piston 30 to reach a lower position than that shown by the dotted lines before the cam 89 could operate to reverse the system. The port 43 in the lower part of cylinder 31 is positioned in the side wall of the cylinder so that when piston 30 reaches the port it will close it off. When this happens a replenishing is necessary.

Normally, of course, on the downstroke of piston 30, the pump 34 is receiving liquid under pressure from cylinder 31 through conduit 67. If the port 43 is closed, the conduit 67 will soon be drained of liquid and there will be a definite lowering of pressure in conduit 67 and in connecting conduit 67a. In view of the fact that the top of valve 78 is always subject to pressure from conduit 83 through cross passageway 92, the valve 78 will be shifted to the position shown in Fig. 4 when pressure in conduit 67a is lowered. With the valve 78 in this position, it will be seen that the cross passageway 93 is blocked from the conduit 80. Consequently, when the bell crank 86 and the valve 77 is shifted by cam 89 to the positions shown in Figs. 3 and 4, the pilot pressure from conduit 83 will not reach the valve 63 to shift the same. Instead, both conduits 79 and 80 are connected to the tank. Valve 77 connects conduit 79 to the tank through axial passage 85. Conduit 80 connects to the tank past valve 78, through a cross passage 95 in valve block 37, and through axial passage 85 in valve 77. The pump 34, therefore, will continue to direct liquid under pressure to the accumulator 32, but this liquid will be coming from the supplementary inlet 57 which is open to the independent supply of operating liquid in the tank 48. Because of this action, the piston rod 51 will continue in its downward movement until the cam 90 actuates the bell crank 86 and the valve 77 to the position shown in Fig. 5. With the valve 77 in this position, pressure may pass from conduit 83 past various restricted portions in valve 77 to a cross passageway 94 which leads to the conduit 80. There will thus be a belated shifting of valve 63 after the liquid in the system has been replenished. As soon as the valve 63 is shifted, pressure will again be exerted in conduit 67 and conduit 67a so that the valve 78 will be again shifted upwardly to the position shown in Fig. 5. During the reversal stroke, after replenishment, valves 77 and 78 will maintain the position shown in Fig. 5 until the cam 88 again contacts the lower arm of the bell crank 86 to shift it to the position shown in Fig. 1. At this time pressure will be again directed from pilot conduit 83 through conduit 79 to the lower part of valve 63. The valve 63 will be shifted upwardly, the rate of shifting in this case being controlled by the setting of restriction needle valve 82a.

The relief valve 47 in the lower part of cylinder 31 is provided in the event of live failure to release liquid trapped in the bottom of the cylinder after the piston 30 passes the port 43, in other words, to provide relief for the dashpot action of the base of the cylinder. Similarly, at the beginning of the reversal, after replenishing, liquid will be first furnished to the lower part of piston 30 past the check valve 45.

In the circuit shown in Fig. 6 many of the elements are the same as illustrated in, and described in connection with, Fig. 1. In this circuit, however, a variable displacement pump 100 is substituted for the vane type pump in Fig. 1 and there is no necessity for a directional control valve. The pump 100 may be any well known type of variable displacement pump having a movable head 101 for varying the displacement of the pump and also the direction of the flow of liquid through the pump. A pressure dome 102 surrounds the pump and this dome is adapted to receive and deliver liquid to an opening 102a in the pump which serves alternately as an inlet and an outlet. This pressure dome 102 is connected to the top of the accumulator 32 by a conduit 69a. The other opening of the pump which is adapted to serve alternately as an inlet and an outlet is connected to the conduit 67 and a supplementary inlet conduit 57 is provided as before.

Referring to the sectional view of the pump shown in Fig. 7, it will be seen that the movable head 101 is adapted to be shifted by a pilot operated rod 103. Pistons 104 and 105 at the respective ends of the rod are located respectively in cylinders 106 and 107. Adjustable stops 108 are provided at each end of the cylinders to limit the movement of the rod 103. When the movable head 101 is shifted to the right to its extreme position, the pump 100 will be delivering liquid from the cylinder 31 to the accumulator 32 as will be described later. When the movable head is shifted to the left to its extreme position, the pump will be delivering liquid under pressure from the accumulator to the cylinder 31.

Pilot pressure is directed to the respective pistons 104 and 105 through conduits 80a and 79a which lead from the valve control block 37. Check valves 109 admit pressure directly to the cylinders 106 and 107 from conduits 80a and 79a and needle valves 110 and 111 control respectively, the flow from cylinders 106 and 107. It will thus be seen that the control rod 103 is shifted by pilot pressure in the same manner as the directional control valve was shifted in Fig. 1. A spring 112 is placed in the pressure dome 102 to tend to shift the movable head to the right, as viewed in Fig. 7, so that, in starting, liquid will be directed to the accumulator cylinder 32.

In the operation of the circuit shown in Fig. 6,

assuming that the air flask 33 is charged and the system is normally operating with a specified amount of operating liquid, when the parts are in the position shown in Fig. 6, the piston 30 is ready to start a downward stroke. The bell crank 86 and the valve 77 have been moved, to the position shown, by the cam 88 thereby connecting pilot pressure conduit 83 with control conduit 79a. Pressure is thus directed to cylinder 107 to shift the movable head 101 to the right and the rate of this movement is controlled by the needle valve 110. Liquid passes from the cylinder 106 to the tank through the conduit 80a past valve 78, through conduit 94 and through the axial passageway 85 in valve 77. With the pump head thus moved to the right (Fig. 7) liquid under pressure will be directed to the pump 100 from the cylinder 31 through conduit 67. The pump at this time discharges liquid under pressure from opening 102a into the pressure dome 102 and it passes from the dome through the conduit 69a to the accumulator 32. This movement will continue until the top arm of bell crank 86 contacts cam 89 to shift the bell crank and valve 77 to the position shown in Fig. 8. If no replenishment is necessary there will be a normal reversal, pilot pressure passing from line 83 past valve 77, through cross passageway 93 and past valve 78 to conduit 80a. This will shift the control rod 103 to the left and liquid will pass out of cylinder 107 through the needle valve 111 to the tank through conduit 79a and the axial passageway 85 in valve 77. The direction of flow of operating liquid will thus be reversed.

In case the system is in need of replenishment of operating liquid, as described in connection with Fig. 1, the port 43 will be cut off from the cylinder 31 by the piston 30. This will cause a reduction of pressure in conduit 67a and the result will be that valve 78 is shifted downwardly by pressure on its top surface and the pump will start to draw liquid from the supplementary inlet 57. The shifting of the valve 78 to the position shown in Fig. 9 will block the above described normal reversal due to valve 78 cutting off conduit 93 from conduit 80a. Reversal will be delayed until the accumulator is filled with enough liquid to cause the cam 90 to contact the top arm of bell crank 86, as shown in Fig. 10. At this time the shifting of valve 77 to the position shown in Fig. 10 will permit pilot pressure to pass from conduit 83 past various restricted portions of valve 77 to cross passageway 94 where it is connected to the control conduit 80a. As soon as reversal is affected, pressure will rise in conduit 67 so that the valve 78 will again be shifted to its uppermost position and the upward stroke of piston 30 after the replenishment, will take place with valves 77 and 78 in the positions shown in Fig. 10.

After either a normal reversal by cam 89 or a delayed reversal by cam 90, the piston 30 and the piston rod 51 will rise until the cam 88 contacts the lower arm of the bell crank 86. At this time the valve 77 will again be shifted to the position shown in Fig. 6 and the operation will continue as described.

In Fig. 11 is shown a third oil well circuit embodying the invention. The main difference between the circuit of Fig. 11 and the circuits shown in Figs. 1 and 6 lies in the pressure forming means, though there are other differences in detail which will be brought out. The pressure forming means includes a plurality of pumps, three in number, one of which is to be used as a pilot pump and the remaining two to be used as power pumps for the system. The two main pumps are designed so that they will have different volume ranges so that two speeds can be achieved by using one or both of them. Two speeds are desirable since the operator may desire to determine, at various times, if the well can supply more oil than is being delivered by one pumping unit.

Referring to Fig. 11, the piston-cylinder motor 30—31 is the same as previously described. An accumulator 120, in Fig. 11, is formed as one cylinder, a piston 121 being located therein to separate compressed air in the top of the cylinder and operating liquid in the lower portion. A relief and charging valve 122 is provided at the top of the accumulator to control the air charge. A piston rod 123 extends downwardly from the piston 121 and on the end of the rod is formed a cam member which has three cam surfaces 88a, 89a and 90a.

The accumulator 120 is mounted on a tank 124 in which is mounted a valve block 125. This valve block is provided with two parallel valve recesses 75a and 76a in which are mounted, respectively, a cam actuated valve 77a and a pilot operated valve 78b. A bell crank 86a is operably connected to the valve 77a.

Mounted on the top of the tank 124 is a motor 126 provided with a drive shaft 127 which extends downwardly into the tank. A pump housing 128 surrounds the drive shaft 127 and in the housing are pumps 129, 130 and 131. Directly adjacent the pump housing 128 is a valve housing 132 in which are housed a pump control valve 133 and a directional control valve 134.

The pump control valve 133 is adapted to be operated by pressure acting on one or both ends and the valve is arranged to have two lowermost positions depending on the position of a cam member 135 positioned directly beneath the valve. The directional control valve 134 is similar to the directional control valve described in connection with Fig. 1. This valve is pilot operated and is arranged to control the direction of flow of operating liquid between the cylinder 31 and the accumulator 120. The operation of valve 134 is to be controlled by valves 77a and 78b. The rate of movement of the directional control valve 134 is controlled by needle valves 82 and 82a, check valves 81 and 81a being provided to admit pressure to the valve recess at each end, as in Fig. 1.

The cylinder 31 is connected to the recess of valve 134 by a conduit 136. The lower end of the valve 78b is connected to conduit 136 by a conduit 137. The lower part of the accumulator 120 is connected to the recess of valve 134 by a conduit 138. Various interconnecting passageways are provided in housings 128 and 132 and these passageways will be described in connection with the operation of the system. The pilot pump 131 delivers pilot pressure to valve recess 75a in valve block 125 through a conduit 140. Valve recess 75a is connected to the top of valve 134 by a conduit 141 and is connected to the lower end of valve 134 past valve 78b through a conduit 142. Valve 77a is provided with an axial tank recess 85a and the upper end of recess 75a is connected to the tank by a port opening 143. A spring 144 urges the valve 78b to its downward position.

As the parts stand in Fig. 11, the operating liquid in the system is being replenished. Just prior to this point in the operation, the valves

were in the positions shown in Fig. 13, and the piston 30 was descending. Referring to Fig. 13 it will be seen that liquid under pressure is passing from conduit 136 and the cylinder 31 to the directional control valve 134 where a restriction in the valve permits the liquid to enter passageway 145 leading to pump control valve 133. A restriction in valve 133 permits the liquid from cylinder 31 to pass to inlet conduits 146 and 147 of power pumps 129 and 130, respectively. This liquid will pass through the pumps and enter the respective outlets 148 and 149. These outlets lead around the valve 133 past check valves 150 and 151 to a common conduit 152. This conduit 152 leads to the valve 134 and with the valve in the position shown in Fig. 13, liquid from the pumps may pass a restriction in the valve to the accumulator conduit 138. At this time it will be seen that pressure from conduit 136 is exerted on the top of valve 133 through a conduit 153. The pressure passing from conduit 152 to the accumulator conduit 138 is exerted on the lower end of valve 133 through a conduit 154. The pressure in conduit 136 coming from the cylinder 31 is also exerted on the lower end of valve 78*b* so that the valve is held in its uppermost position against the action of spring 144. Bell crank 86*a* and the valve 77*a* had been shifted to the position shown in Fig. 13 by cam 88*a* as the piston 30 reached the top of its stroke and the piston 121 reached the bottom of its stroke. With valve 77*a* in this position, pilot pressure from conduit 140 passes a restriction in valve 77*a* to conduit 141 where it is exerted against the top of valve 134 to maintain the same in the position shown in Fig. 13. Conduit 142, leading from the lower end of the recess of valve 134, is connected to the tank past valve 78*b* through a cross passageway 155 in valve block 125. This passageway connects to the axial passageway 85*a* in valve 77*a*, this passageway leading to the tank through port 143 in the top of the valve recess.

With valve 133 in the position shown in Fig. 13, it will be seen that both pumps 129 and 130 are functioning to pass liquid through the system. If cam 135 is shifted to the position shown in Fig. 15, valve 133 would be in its lowermost position, as shown. With the valve in this position, the outlet passageway 149 of pump 130 is connected to the inlet passageway 147 past a restricted portion in the valve so that the pump 130 is bypassing. The outlet 148 of pump 129 is, however, still connected to the common outlet conduit 152.

If there were to be a normal reversal of the system, as piston 30 approached a lowermost position, just above port 43, the cam 89*a* would contact the upper arm of bell crank 86*a* to shift the valve 77*a* to the position shown in Fig. 12. With the valve in this position, pilot pressure passes from conduit 140 past a restriction in valve 77*a* to a passageway 156 leading to valve recess 76*a*. Since valve 78*b* is in its uppermost position, the pilot pressure may pass around a restriction in the valve to conduit 142 from which it will be directed to the lower end of directional control valve 134. The directional control valve will thus be shifted to its uppermost position, as shown in Fig. 12, the liquid from the top of the valve passing through conduit 141 to the tank via the tank passage 85*a* and port 143. With reference to Fig. 12, it will be seen that the accumulator conduit 138 is now connected past valve 134 to passageway 145. Due to the position of valve 133, liquid will pass from the passage 145 to the inlets of pumps 129 and 130 and through the pumps to the common outlet conduit 152. The conduit 152 is connected past a restriction in valve 134 to conduit 136 leading to cylinder 31. With such an arrangement the accumulator piston will descend and the pumping piston 30 will rise.

If the quantity of operating liquid in the closed system becomes decreased due to leakage, when the piston 30 descends in its lowering stroke, it will pass the port 43 and block the same. This will happen when the valves are in the position shown in Fig. 13 and since the pumps can no longer draw liquid from conduit 136, there will be a decrease in pressure in this conduit and in conduit 153, and, consequently, a decrease in pressure on the top of valve 133. The pressure on the bottom of valve 133 is still exerted from the accumulator through conduit 154. The result would be a shifting upward of the valve 133 to the position shown in Fig. 11. The decrease in the pressure in conduit 136 will also have its effect on the pressure in conduit 137 so that the valve 78*b* will be urged to its lowermost position by spring 144, as shown in Fig. 11. With valves 133 and 78*b* in these positions, when the cam 89*a* contacts the upper arm of bell crank 86*a* and shifts the valve 77*a* to the position shown in Fig. 11, there will be no reversal as would occur normally due to the fact that pilot pressure from conduit 140 will be blocked from conduit 142 by valve 78*b* which closes conduit 156. A shifting of valve 133 upward will connect the outlet 148 of pump 129 with the inlet 146 so that this pump will be bypassed. The normal inlet 147 of pump 30 is blocked by valve 133 and the pump 130 will now receive its inlet liquid from a supplementary inlet conduit 157 which leads to the lower part of the tank 144. Consequently, liquid from tank 144 will be directed from pump 130 through conduits 149 and 152 to the accumulator 138. The operating liquid in the system will consequently be increased in quantity and the piston 121 will continue to rise until the cam 90*a* moves the bell crank 86*a* to the position shown in Fig. 14. This shifts the valve 77*a* to its lowermost position and in spite of the fact that valve 78*b* is still blocking passage 156, pilot pressure may pass from conduit 140 past various restrictions in valve 77*a* to the cross passage 155 and around valve 78*b* to control conduit 142. Valve 134 will again be shifted upward and the system will be reversed with liquid passing from the accumulator to the cylinder 31.

A relief valve 160 is connected to conduit 138 and a relief valve 161 is connected to conduit 152 to prevent excessive pressures from developing in the system. Pilot pump 131 is a continuously operating pump and since its total volume is not needed at all times in the system a check valve 162 leading to a conduit 163, takes care of the overflow. The conduit 163 leads to a small chamber 164 which is surrounded by cooling fins 165. Here the oil may be cooled and will pass again to the tank through a conduit 166. A baffle plate 167 prevents the oil being cooled from coming into contact with the coupling between the motor and the shaft 127.

Deceleration safety valves 168 and 169 are provided at the cylinder ends of conduits 136 and 138 respectively. These safety valves are so arranged that if flow from the cylinders exceeds a certain quantity, the valves will be shifted against biasing springs to restrict the flow. In case of power failure, for example, the system will not get out of control to cause breakage or damage.

In Fig. 16 is illustrated an oil well circuit which is a modification of the oil well circuit shown in

Fig. 11. This circuit differs from that illustrated in Fig. 11 in that a valve 170 in a block 171 is provided to control the pilot pressure to and from valve 134 and a valve 133a is substituted for valve 133 of Fig. 11, to perform the functions of valve 133 and also to serve as an interrupter valve in the place of valve 78b found in Fig. 11. Pilot pressure is furnished to the valve block 171 through conduit 140 from pilot pump 131. This pilot pressure will be directed to the top of valve 134 through a conduit 141 when valve 170 has been moved by cam 88a and bell crank 86a to the position shown in Fig. 17. A tank passage 170a is located in valve 170.

When the valve 170 is shifted by the cam 89a to the position shown in Fig. 16, reversal of the system will normally take place with pressure being directed from pilot conduit 140 to conduit 142a which leads past valve 133a in the position shown in either Fig. 17 or Fig. 19 to conduit 142 which leads to the bottom of valve 134. Delayed reversal is caused by valve 133a being shifted to the position shown in Fig. 16. As described in connection with Fig. 11, this shifting will occur when the conduit 136 is blocked by the piston 30 and the pressure beneath the valve 133a will urge the valve upwardly. Conduit 142a will then be blocked and reversal cannot be effected until cam 90a shifts the bell crank 86a and the valve 170 to the position shown in Fig. 18. Pilot pressure from conduit 140 may then be directed to a conduit 142b leading to the valve 133a and when the last named valve is in the position shown in Fig. 16, pilot pressure may pass to conduit 142 to cause a delayed reversal of the system. Consequently, the replenishment of the operating liquid is accomplished during this interrupted or delayed reversal. The path of pilot liquid to effect delayed reversal is shown by the dotted arrows in Fig. 16. In Fig. 19 the valve 133a is illustrated in its lowermost position when the cam 135a is rotated 180 degrees. In this position, pump 130 will be bypassed and pump 129 will be operating. In Fig. 20 the valve 134 is shown in its shifted position to cause a lowering of piston 120 and a raising of piston 30.

Since the operation of the circuit shown in Fig. 16 is very similar to that of Fig. 11, except for the differences above noted, the details of the flow of operating liquid and the shifting of the valves will not be repeated.

We claim:

1. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means, a pilot operated shiftable means adapted to control the direction of liquid under pressure through said pressure forming means and to and from said cylinders, a supply of operating liquid, unidirectional valve means connecting said supply with the inlet of said pressure forming means, valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated means to shift the same, and additional valve means responsive to abnormal movement of one of said reciprocal members resulting in closure of the outlet port of one of said cylinders adapted to delay the shifting of said pilot operated means, and thereby cause a replenishing of liquid from said supply to said system during said delay.

2. In combination, an auxiliary cylinder for containing an operating liquid, means for resisting the entrance of liquid thereto, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means, conduits connecting said cylinders with said pressure forming means, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders alternately in a closed system, a supply of operating liquid, a source of pilot pressure, valve means responsive to the quantity of operating liquid in said auxiliary cylinder adapted to direct pilot pressure to said shiftable means to control the position thereof, and an auxiliary valve normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means when said reciprocal member has moved through a given distance whereby reversal of movement of said reciprocal member is delayed, and means responsive to the movement of said reciprocal member arranged to cut-off the inlet of said pressure forming means from said motor cylinder and to open it to said supply of operating liquid to permit a replenishment of liquid in said closed system, and a passageway permitting flow to the operating side of said reciprocal member when said inlet is cut off.

3. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means, conduits connecting said cylinders with said pressure forming means, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders alternately in a closed system, a supply of operating liquid, a source of pilot pressure, valve means responsive to movement of one of said reciprocal members adapted to direct pilot pressure to said shiftable means to control the position thereof, and an auxiliary valve normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means when the other of said reciprocal members has moved through a given distance whereby reversal of movement of said reciprocal members is delayed, and means responsive to the movement of one of said reciprocal members arranged to cut-off the inlet of said pressure forming means from said motor cylinder and to open it to said supply of operating liquid to permit a replenishment of liquid in said closed system, and a passageway permitting flow to the operating side of said reciprocal member when said inlet is cut off.

4. In combination, an accumulator cylinder for containing an operating liquid, an accumulator reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means, conduits connecting said cylinders with said pressure forming means, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders alternately in a

closed system, a supply of operating liquid, a source of pilot pressure, valve means responsive to movement of one of said reciprocal members adapted to direct pilot pressure to said shiftable means to control the position thereof, and an auxiliary valve normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means when the other of said reciprocal members has moved through a given distance, whereby reversal of said reciprocal members is delayed, and means responsive to the movement of one of said reciprocal members arranged to cut-off the inlet of said pressure forming means from said motor cylinder and to open it to said supply of operating liquid to permit a replenishment of liquid in said closed system, said valve means being responsive to additional movement of said accumulator reciprocal member to connect said shiftable means to said pilot pressure to reverse the system after a predetermined replenishment of the closed system, and a passageway permitting flow to the operating side of said motor member when said inlet is cut off.

5. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor comprising a cylinder having an inlet, and a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, and a passage in said motor to permit flow thereto when the inlet is closed, a pressure forming means having inlet and outlet ports, a pilot operated directional valve adapted to direct liquid under pressure to and from said cylinders through said pressure forming means in a closed system, a supply of operating liquid, a unidirectional valve means connecting the inlet of said pressure forming means with said supply, valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated valve to shift the same, means to control the rate of movement of said pilot operated valve to control the acceleration and deceleration of said reciprocal members, closing means for said motor inlet operable as a consequence of a reduced quantity of liquid in said closed system, and additional valve means responsive to the closing of said closing means to delay the shifting of said pilot operated valve, and thereby cause a replenishing of liquid to said closed system by reason of said pressure forming means drawing liquid from said supply through the unidirectional valve means during said delay.

6. In combination, a cylinder for containing an operating liquid and means including a reciprocal member for resisting the entrance of liquid thereto, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a variable displacement pump, a movable member on said pump arranged by its movement to control the direction and volume of output of said pump, conduit means connecting said pump with said cylinders, means including a unidirectional valve connecting said pump to a supply of replenishing fluid, pilot operated shiftable means operably connected to said movable member to shift the same, a source of pilot pressure, valve means responsive to movement of one of said reciprocal members for directing pilot pressure to said pilot operated means to shift the same, valve means responsive to movement of one of said reciprocal members adapted to close the inlet to said one reciprocal member, and additional valve means similarly responsive to delay the shifting of said pilot operated means and thereby cause additional operating fluid to be supplied to one of said cylinders to replenish the system.

7. In combination, an accumulator cylinder for containing an operating liquid, a reciprocal member adapted to be shifted by changes in quantity of operating liquid in said cylinder, means resisting the entrance of liquid into said cylinder whereby liquid therein will be under pressure, a motor cylinder, a motor member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a conduit leading to an entrance port at one end of said accumulator cylinder, a conduit leading to an entrance port at one end of said motor cylinder, a pressure forming means having inlet and outlet ports, means disposed in said conduits and arranged to direct operating liquid from one of said cylinders to the other through said pressure forming means, and means for causing the replenishing of the supply of operating liquid normally passing between said cylinders comprising a unidirectional valve means connecting the inlet of said pressure forming means with a supply of liquid, and a shiftable valve means exposed at one end to pressure in the conduit leading to the motor cylinder, said last named valve means normally permitting reversal of the system but arranged to shift to delay reversal when the supply of operating liquid in the system is diminished to the extent that said motor member may pass and close the conduit port leading to the motor cylinder, said replenishment taking place automatically during said delayed reversal by reason of said pressure forming means drawing liquid through said unidirectional valve from said supply, and a passageway permitting flow to the operating side of said motor member when said conduit port is closed by said motor member.

8. In combination, an accumulator cylinder for containing an operating liquid, a reciprocal member adapted to be shifted by changes in quantity of operating liquid in said cylinder, means resisting the entrance of liquid into said cylinder whereby liquid therein will be under pressure, a motor cylinder, a motor member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a conduit leading to an entrance port at one end of said accumulator cylinder, a conduit leading to an entrance port at one end of said motor cylinder, a pressure forming means having inlet and outlet ports, valve means disposed in said conduits and arranged to direct operating liquid from one of said cylinders to the other through said pressure forming means, means for replenishing the supply of operating liquid normally passing between said cylinders comprising a unidirectional valve means connecting the inlet of said pressure forming means with a supply of liquid, and a shiftable valve means exposed at one end to pressure in the conduit leading to the motor cylinder, said last named valve means normally permitting reversal of the system but arranged to shift to delay reversal when the supply of operating liquid in the system is diminished to the extent that said motor member may pass and close the conduit port leading to the motor cylinder, said replenishment taking place automatically during said delayed reversal by reason of said pressure forming means drawing liquid from said supply through said unidirectional valve and passing it to said accu-

mulator cylinder, and means responsive to the movement of said reciprocal member by reason of the flow of replenishment liquid to said accumulator cylinder to effect a delayed reversal upon the operation of said replenishing means, including a passage permitting flow to said motor when its inlet is closed by the motor member.

9. In combination, an accumulator cylinder for containing an operating liquid, a reciprocal member adapted to be shifted by changes in quantity of operating liquid in said cylinder, means resisting the entrance of liquid into said cylinder whereby liquid therein will be under pressure, a motor cylinder, a motor member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a conduit leading to an entrance port at one end of said accumulator cylinder, a conduit leading to an entrance port at one end of said motor cylinder, a passageway permitting flow from said motor cylinder conduit to said motor cylinder when said entrance port is closed, a pump having inlet and outlet ports adapted to be connected alternately to said conduits and having an inlet port connected to an independent supply of operating liquid, connecting means operative to connect said closed system with said supply, a first means to effect normal reversal of flow between said tank and cylinder when the quantity of operating liquid is above a predetermined volume, a second means operative to delay the effect of said last named means, said second means and said connecting means being pressure responsive members subject to pressure at the pump inlet during one stroke of said motor member and being rendered operative by reduction in such pressure, and means to close said pump inlet from the motor cylinder upon predetermined reduction in the quantity of said body of liquid thereby causing said reduced pressure.

10. In combination, an accumulator cylinder for containing an operating liquid, a reciprocal member adapted to be shifted by changes in quantity of operating liquid in said cylinder, means resisting the entrance of liquid into said cylinder whereby liquid therein will be under pressure, a motor cylinder, a motor member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a conduit leading to an entrance port at one end of said accumulator cylinder, a conduit leading to an entrance port at one end of said motor cylinder, a pressure forming means having inlet and outlet ports adapted to be connected alternately to said conduits and having an inlet port connected through an unidirectional valve to an independent supply of operating liquid, valve means for directing liquid to and from said conduits through said pressure forming means, cam means on said reciprocal member for shifting said valve means at the end of a normal stroke to cause reversal of the flow through said conduits, a valve responsive to movement of said motor member for blocking the reversal effect of said valve means and thereby causing an amplified stroke of the reciprocal member by reason of liquid being drawn from said supply and passed to said accumulator cylinder, said cam means being formed to impart an additional movement to said valve means when the stroke of said reciprocal member is amplified by reason of the delayed reversal whereby reversal of the system may be effected.

11. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a plurality of pumps, a pilot operated directional control valve, a selector valve for directing the delivery of one or more of said pumps to said control valve whereby it may be further directed to one of said cylinders, a supply of operating liquid, means connecting the inlet of one of said pumps to said supply, valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated valve to shift the same, and additional valve means responsive to prolonged movement of one of said reciprocal members resulting in the closure of the outlet port of one of said cylinders adapted to delay the shifting of said pilot operated valve and thereby effect a replenishing of operating liquid from said supply to said system during said delay.

12. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a plurality of pumps, a pilot operated directional control valve, a selector valve for directing the delivery of one or more of said pumps to said control valve whereby it may be further directed to one of said cylinders, a supply of operating liquid, means connecting the inlet of one of said pumps to said supply, valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated valve to shift the same, and additional valve means adapted to delay the shifting of said pilot operated valve, said additional valve means and said selector valve being responsive to prolonged movement of one of said reciprocal members resulting in the closure of the outlet port of the respective cylinder whereby operating liquid in said system will be replenished by one of said pumps from said supply during said delay.

13. A pumping system combining a motor member and a balancing member each to be shifted, a relatively high volume pumping mechanism for imparting movement to said members, a second pumping mechanism for imparting a different rate of movement to said members, a shiftable control mechanism for said pumping mechanisms comprising an element shiftable within a casing adapted in one shifted position to direct fluid from said first mentioned pump to impart movement to one of said members and to bypass the other of said pumps, adapted in a second position to direct fluid from both of said pumps to one of said members, and adapted in a third position to bypass said first mentioned pump and direct pressure from said second pump to one of said members, a main valve for determining the action of said pumping mechanisms, conduits connecting said balancing member and motor member through said main valve to inlets and outlets of said pumping mechanisms so as to permit reversible flow between said members, a control valve for determining the action of said main valve, means actuated by the movement of one of said members for mechanically shifting the control valve, means hydraulically actuable by fluid passed by the control valve for operating the main valve, and means responsive to reduc-

tion in pressure in the motor supply conduit for delaying the movement of the main valve, said shiftable control mechanism being also responsive to reduction in pressure in the motor supply conduit whereby it will be shifted to its third position to effect replenishing of operating fluid in the system.

14. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a closed operating circuit including a pressure forming means comprising a plurality of pumps, a pilot operated directional control valve, a selector valve for directing the delivery of one or more of said pumps to said control valve whereby it may be further directed to one of said cylinders, a supply of operating liquid, means connecting one of said pumps to said supply, and valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated valve to shift the same, said selector valve being normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means, means to cut off the motor inlet from the inlet of said pressure forming means when said motor reciprocal member has moved through a given distance, and means responsive to consequent reduced pressure at said pressure forming means inlet to open said inlet to said supply of operating liquid to permit a replenishment of liquid in said closed system.

15. In combination, a cylinder for containing an operating liquid, a reciprocal member in said cylinder, means acting on said member for resisting the entrance of liquid to said cylinder, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a closed operating circuit including a pressure forming means comprising a plurality of pumps, a pilot operated directional control valve, a selector valve for directing the delivery of one or more of said pumps to said control valve whereby it may be further directed to one of said cylinders, a supply of operating liquid, valve means responsive to movement of one of said reciprocal members for directing pressure to said pilot operated valve to shift the same, said selector valve being normally biased to one control position but arranged in said closed circuit to be shifted in response to excessive movement of one of said reciprocal members to a second position to by-pass one of said pumps and block pilot pressure from said control valve thereby delaying reversal, means to cut off the motor inlet from the inlet of said pumps also responsive to the excessive movement of said one reciprocal member, and means responsive to consequent reduced pressure at said pump inlet to open said inlet to said supply of operating liquid to permit a replenishment of liquid in said closed system.

16. In combination, an auxiliary cylinder for containing an operating liquid, means for resisting the entrance of liquid thereto, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a continuously operated motor and a plurality of pumps driven thereby, one of said pumps being adapted to serve as a pilot pump, a selector valve for directing the output of the other of said pumps, conduits connecting said cylinders with said selector valve, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders in a closed system, a supply of operating liquid, means connecting one of said pumps to said supply, valve means responsive to flow of operating liquid to and from said auxiliary cylinder adapted to direct pilot pressure from said pilot pump to said shiftable means to control the position thereof, an auxiliary valve normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means, means to cut off the motor inlet from the inlet of said pressure forming means when said reciprocal member has moved through a given distance, means responsive to consequent reduced pressure at said pressure forming means inlet to cause shifting of said auxiliary valve to its second position, and means responsive to consequent reduced pressure at said pressure forming means inlet to open said inlet to said supply of operating liquid to permit a replenishment of liquid in said closed system.

17. In combination, an auxiliary cylinder for containing an operating liquid, means for resisting the entrance of liquid thereto, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a continuously operated motor and a plurality of pumps driven thereby, one of said pumps being adapted to serve as a pilot pump, a selector valve for directing the output of the other of said pumps, conduits connecting said cylinders with said selector valve, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders in a closed system, a supply of operating liquid connected to but normally closed from the inlet of one of said pumps, valve means responsive to flow of operating liquid to and from said auxiliary cylinder adapted to direct pilot pressure from said pilot pump to said shiftable means to control the position thereof, said selector valve being normally biased to one position, and adapted to be shifted to a second position to block pilot pressure from said shiftable means when said reciprocal member has moved through a given distance to close an inlet of said motor cylinder and thereby reduce the pressure in the inlet of one of said pumps by cutting off supply of liquid from said motor cylinder, and means responsive to said reduction in pressure to open said supply of operating liquid to said pump to permit replenishment of liquid in said closed system.

18. In combination, an auxiliary cylinder for containing an operating liquid, means for resisting the entrance of liquid thereto, a motor cylinder, a reciprocal member in said motor cylinder adapted to be operably connected to the sucker rod of a pump in a well, a pressure forming means comprising a continuously operated motor and a plurality of pumps driven thereby, one of said pumps being adapted to serve as a pilot pump, a selector valve for directing the output of the other of said pumps, conduits connecting said cylinders with said selector valve, means shiftable to direct operating liquid from one of said cylinders to said pressure forming means and from said pressure forming means to the other of said cylinders in a closed system, a supply of

operating liquid connected to but normally closed from the inlet of one of said pumps, valve means responsive to flow of operating liquid to and from said auxiliary cylinder adapted to direct pilot pressure from said pilot pump to said shiftable means to control the position thereof, said selector valve being normally biased to one position, and adapted to be shifted to a second position to bypass one of said pumps and block pilot pressure from said shiftable means when said reciprocal member has moved through a given distance to close an inlet of said motor cylinder and thereby reduce the pressure in the inlet of another of said pumps by cutting off supply of liquid from said motor cylinder, and means responsive to said reduction in pressure to open said supply of operating liquid to said pump to permit replenishment of liquid in said closed system.

19. In a well pumping system, a motor cylinder, an inlet thereto, a reciprocal motor member in said cylinder arranged to close said inlet when positioned adjacent thereto, a passageway permitting flow to the operating side of said motor member when said inlet is closed, a balancing tank to be connected to said cylinder, a pump arranged between said tank and cylinder for directing operating liquid from one to the other alternately in a closed system, an independent supply of liquid, and pressure responsive connecting means operable by reduced pressure caused by a closing of said cylinder inlet by said motor member to open said supply to said closed system to effect replenishing.

20. In a well pumping system, a motor cylinder, an inlet thereto, a reciprocal motor member in said cylinder arranged to close said inlet when positioned adjacent thereto, a passageway permitting flow to the operating side of said motor member when said inlet is closed, a balancing tank to be connected to said cylinder, a pump arranged between said tank and cylinder for directing operating liquid from one to the other in a closed system, a first means to effect normal reversal of flow between said tank and cylinder when the quantity of operating liquid in the closed system is above a predetermined amount, a second means to delay the effect of said last named means when said cylinder inlet is closed by said motor member by reason of a reduced quantity of operating liquid, an independent supply of liquid, and connecting means responsive to the closing of said cylinder inlet to open said supply to said closed system to effect replenishing of the liquid therein during said delay.

21. In a well pumping system, a motor cylinder, an inlet thereto, a reciprocal motor member in said cylinder arranged to close said inlet when positioned adjacent thereto, a passageway permitting flow to the operating side of said motor member when said inlet is closed, a balancing tank to be connected to said cylinder, a pump arranged between said tank and cylinder for directing operating liquid from one to the other in a closed system, a first means to effect normal reversal of flow between said tank and cylinder when the quantity of operating liquid in the closed system is above a predetermined amount, a second means to delay the effect of said last named means when said cylinder inlet is closed by said motor member by reason of a reduced quantity of operating liquid, an independent supply of liquid, and connecting means responsive to the closing of said cylinder inlet to open said supply to said closed system to effect replenishing of the liquid therein during said delay, said first means being arranged to nullify the delay effect of said second means in response to an increase in the quantity of liquid in said closed system.

22. In a well pumping system, a motor cylinder, a balancing tank, a pump and conduits for passing a body of liquid from said cylinder to said tank and vice versa in a closed system, a reciprocal motor member in said cylinder, the stroke of which is responsive to the quantity of said body of liquid, a first means to effect normal reversal of flow between said tank and cylinder when the quantity of operating liquid is above a predetermined volume, a second means operative to delay the effect of said last named means, an independent supply of liquid, connecting means operative to connect said closed system with said supply, said second means and said connecting means being pressure responsive members subject to pressure at the pump inlet during one stroke of said motor member and being rendered operative by reduction in such pressure, and means to close said pump inlet from the motor cylinder upon predetermined reduction in the quantity of said body of liquid thereby causing said reduced pressure.

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